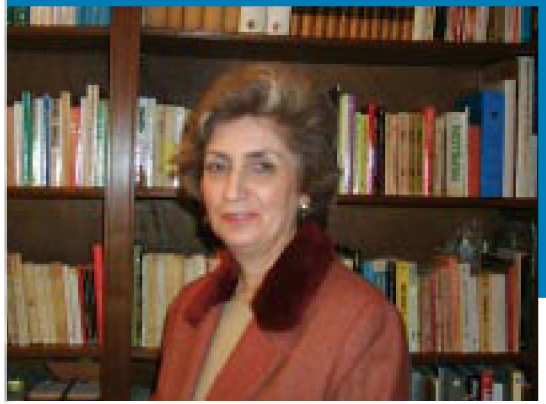
IEA-OCEAN ENERGY SYSTEMS ANNUAL REPORT 2002

MESSAGE FROM THE CHAIR



Teresa Pontes
Chair, IEA-OES
Executive Committee

I am pleased to bring to your attention this new international research and development programme on Ocean Energy Systems.

The oceans contain an enormous source of energy that can be exploited contributing in a sustainable manner to meet the increasingly global energy demand. The most developed conversion systems concern tidal energy, ocean thermal energy conversion (OTEC), ocean waves and marine currents. This IEA-OES programme focuses on ocean waves and marine currents technologies as a starting option since these are the technologies that have deserved most attention during the last 15 years. However, their development is still at prototype stage.

The potential of ocean waves and marine currents is estimated to be 1-10 TW and 5 TW, respectively, which is of the order of the present global electrical energy consumption.

Research and development on wave energy technologies started 30 years ago. Together with marine currents, they have been the object of the greatest R&D effort in about half of the IEA member-countries and in other countries including China, India and Mexico. This has been supported by national and regional R&D programmes and other support measures, and investment by an emerging industry.

The first eight (and most of the tested) wave energy prototypes rated up to 0.5 MW are of the Oscillating-Water-Column (OWC) type. They have been erected mostly on the shoreline, although two were deployed in the nearshore and one offshore. The larger offshore resource and the apparently fewer environmental constraints are leading to serious consideration of

the offshore concepts. Prototypes of various systems rated up to 2 MW are being tested, are ready for deployment or their construction is planned. No consolidation in the technology has been reached yet.

Marine currents prototypes started to be tested recently. The exploitation of this more predicable resource is similar to that of the wind energy, but various device types are being developed.

After the first year of the IEA-OES activity, the perspectives for the near future can be considered promising. Started by Denmark, Portugal and UK at the end of 2001, in 2002 Ireland and Japan joined our group, and Canada and the European Commission will sign the agreement at the beginning of 2003. Companies from Australia and Netherlands have been observing the IEA-OES activities, and USA and Italy are also showing interest in the results obtained. Information collection and dissemination through our website, the Newsletters and the Executive Committee annual report and other reports are a major objective of this programme. In addition to the development of standards for model and prototype testing, it is expected to start in 2003 joint work on resource assessment and market facilitation issues. The close collaboration with the European Commission R&D Programmes is expected to continue namely through the EC networks. Most importantly, we hope that in 2003 the testing of wave and tidal currents prototypes developed by industry reinforce the momentum of this newly renewable energy technology.

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) was established in 1974 and is managed within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

The IEA fosters co-operation amongst its 26 member countries, and with other countries, in order to increase energy security by improved efficiency of energy use, development of alternative energy sources and research, development and demonstration on matters of energy supply and use. This is achieved through the activities undertaken by the 40 current Implementing Agreements.

Implementing Agreements cover a wide range of energy technologies in fossil fuels, renewable energy, nuclear fusion research, energy end-use, electricity and transport. Most Implementing Agreements involve information exchange together with formal or informal co-ordination of R&D activities. Several IEA energy technology information centres or services have been set up to disseminate research and demonstration results in various fields.

The **IEA Ocean Energy Systems** is one of these Implementing Agreements. Presently the member countries are:

> Denmark
> Ireland
> Japan
> Portugal
> United Kingdom

The present report gives an overview of the status and progress of the work programme of this Implementing Agreement during the year 2002.

CONTENTS

1 IEA OCEAN ENERGY SYSTEMS

1.1 The Implementing Agreement on Ocean Energy Systems and its Members

The IEA Implementing Agreement on **Ocean Energy Systems** (IEA-OES) is the most recently established of the nine implementing agreements on Renewable Energy Technologies. The others are:

- Bioenergy
- Geothermal energy
- Hydrogen
- Hydropower
- Photovoltaic Power Systems
- Solar Heating and Cooling
- Solar Power and Chemical Energy Systems
- Wind Energy

The IEA-OES was set up in October 2001 with the signature of three contracting Parties:

- Ministry of Environment and Energy, Danish Energy Agency on behalf of the Government of **Denmark**
- Instituto Nacional de Engenharia e Tecnologia Industrial (INETI) designated by the Government of **Portugal**
- Department of Trade and Industry (DTI) on behalf of the Government of the **United Kingdom**

From 2002 the contracting party of Denmark has changed to Ministry of Economic and Business Affairs, Danish Energy Authority.

During 2002 **Japan** and **Ireland** have joined this Implementing Agreement. The Government of Japan has designated Japan Marine Science and Technology Centre (JAMSTEC), which have a recognised Marine Technology Department conducting research and development on wave energy systems since the 70's. The government of Ireland has designated the Sustainable Energy Ireland (formerly Irish Energy Centre), which is engaged in a range of activities to assist and promote the development of a sustainable energy economy.

It is expected that in early 2003 the **European Commission**, that has participated from the beginning in the establishment of this Implementing Agreement will join it. Preparatory work to secure the participation of the European Commission has been completed with the signature by the director general of DG Research, nominating a representative in the EC delegation to the OECD to sign the agreement.

After the Government of **Canada** has also agreed to join this Implementing Agreement, its formal entry might be accomplished within a short period of time. It is expected that the Canadian Government designates Powertech Labs Inc. (BC Hydro) as a contracting party to the Implementing Agreement.
Contacts to Italy, Mexico, France, New Zeeland and USA are sustained.

The Work Program to be undertaken by the contacting parties is established under Annexes to the Implementing Agreement, setting out a Task and describing an agreed set of activities to be undertaken by the Participants in the Task. The terms Task and Annex are often used interchangeably. The overall program is monitored by the Executive Committee consisting of one representative from each of the member countries and an alternate member. The Tasks leadership is the responsibility of Operating Agents. The following table lists the Contracting Parties at the end of the year 2002, with respective Executive Committee Members and their

COUNTRY	CONTRACTING PARTY	EXCO MEMBER	EXCO ALTERNATE MEMBER
DENMARK	MINISTRY OF ECONOMIC AND BUSINESS AFFAIRS, DANISH ENERGY AUTHORITY	JAN BÜNGER	KIM NIELSEN
IRELAND	SUSTAINABLE ENERGY IRELAND (SEI)	KATRINA POLASKI	GODFREY BEVAN
JAPAN	JAPAN MARINE SCIENCE AND TECHNOLOGY CENTRE (JAMSTEC)	YASUSHI TSURITANI	HIROYUKI OSAWA
PORTUGAL	INSTITUTO NACIONAL DE ENGENHARIA E TECNOLOGIA INDUSTRIAL (INETI)	TERESA PONTES	ANTÓNIO FALCÃO
UNITED KINGDOM	DEPARTMENT OF TRADE AND INDUSTRY (DTI)	DAVID BRAMBLE	

Table 1 | Contracting Parties to the Agreement IEA-OES (status: end 2002)

Alternates. Corresponding addresses and contact numbers are given in Chapter 6 of this report. Good progress has been made during the year 2002 on the work program and the members of the Executive Committee will continue their efforts to bring together and to coordinate the work on their countries. Efforts to expand participation in the Agreement and in the individual Annexes will continue.

1.2 Objectives and Strategies

Mighty Whale Prototype, Japan
(Courtesy of JAMSTEC)

This Implementing Agreement was established with a mission of enhancing international collaboration to make ocean energy technologies a significant energy option in the mid-term future. Through the promotion of research, development, demonstration and information exchange and dissemination, the Agreement's objective is to lead to significant deployment and the commercialization of these Technologies.

The Programme to be carried out by the Contracting Parties within the framework of this Agreement consists of research, development, demonstration, analysis and information exchange related to ocean energy systems.

The present Work Programme focuses on ocean waves and marine currents which are the ocean energy technologies that have been the object of the greatest R&D and Demonstration effort in the last decade and are considered to present better prospects for competitive deployment in the short to medium-term.

The Strategy of IEA Ocean Energy Programme is based on the following Objectives:

1 > To actively encourage and support the development of networks of participants involved in research, development, demonstration, prototype testing and deployment, and to provide for the effective exchange of information on ocean energy.

2 > To promote the development and utilisation of technologies for enhanced sustainable energy production from the ocean.

3 > To promote the involvement of industry and utilities in the IEA Ocean Energy Systems Programme.

4 > To promote interactions with other global, multilateral and national energy implementation programmes.

Work Program 1.3

The Work Program of the Implementing Agreement on Ocean Energy Systems was established under the operation of two Annexes:

> Annex I: Review, Exchange and Dissemination of Information on OES (4 Subtasks).

The Work Plan of Annex I is designed for a period of five years.

The Instituto Nacional de Engenharia e Tecnologia Industrial (INETI) is designated as the Operating Agent for this Annex acting through ADENE (Portuguese Energy Agency).

> Annex II: Development of Recommended Practices for Testing and Evaluating OES (4 Subtasks).

The Work Plan of Annex II is designed for two years.

The Ministry of Economic and Business Affairs, Danish Energy Authority acting through RAMBOLL, Denmark, is designated as Operating Agent of this Annex.

SUBTASK	TITLE
I/1	Collation, Review and Publication of Information on Ocean Waves and Marine Current Energy Systems
I/2	Exchange of Information on Ocean Energy Systems
I/3	Analysis and Dissemination of Information on Ocean Energy Systems
I/4	Website Creation and Maintenance

Table 2 | Description of Subtasks under Task I

Commercial, government and utility activities	related to waves and currents systems, including (where available) the description of the activities and the budgets involved
Demonstration schemes already deployed in the sea	including a description and performance of the device, its components, the capital and operating costs, its current status and the lessons learned from its design, deployment and operation
Systems under development for deployment	within the next two years, including a description of the device, principles of design, method of energy capture, predicted performance and current status
General technologies	employed in waves and currents systems, including methods of energy capture, structural design, emplacement and mooring as well as energy transformation, storage and integration
Available resources	including average wave power levels and currents velocity, sources of information and methods of description and prediction
Legal and institutional factors	affecting the adoption of waves and currents systems, including incentives and regulations
Public perceptions	of installed and planned waves and currents energy systems
Impacts of manufacture and installation	of waves and currents energy systems on the environment

Table 3 | Items for collection of information on OES under Task I

A general description and notable achievements of the program's work during 2002 are mentioned on Chapter 2. The details of the work undertaken under the two annexes are covered by the individual reports.

Work Program of Annex I

The objective of Task I set on Annex I 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 Task leads to the aim of facilitating further development and adoption of cost-effective ocean energy systems through the access to available information. Ocean waves and marine currents energy systems ("waves and currents systems") are the current priority. The work program is organized according to the following Subtasks presented in Table 2. Information on Ocean Waves and Marine Currents Energy Systems is collected and reviewed according to the items presented in Table 3.
Participants in this Task update the information on ocean energy systems and exchange this information at annual meetings. Participants further analyse this information to develop joint summary assessments of trends in ocean energy exploitation including incentives and regulations.

Work Program of Annex II

The objective of Task II set on Annex II is to develop recommended practices for testing and evaluating ocean energy systems and, in this way, to improve the comparability of experimental results. This is done by collecting and analysing information on testing facilities and testing procedures. Standards for presentation of technical design and data, and for assessment of system performance, are produced. Ocean waves and marine currents energy

systems are also the current priority.

To pursue this Task information was collected from experts and institutes in the Participants countries and in other IEA Member and non-Member countries, previously and presently engaged in the technologies. The work has been undertaken according to the Subtasks presented in Table 4.

SUBTASK	TITLE	DESCRIPTION
II/1	Testing Facilities and Test Sites	Compilation of a database describing the existing testing facilities and test sites for ocean energy systems in the Participants' and other countries.
II/2	Testing Procedures	Collection of standards for testing wave energy systems to form the basis for general standards.
II/3	Presentation of Results	Definitions of the relevant ocean parameters and ocean energy converting systems parameters, and standard format proposal for the presentation of results.
II/4	Performance Assessment	Use of the standardized presentation of the performance defined in Subtask II/3 to calculate the annual energy production of various ocean energy systems at different sites.

Table 4 | Description of Subtasks under Task II

Nature and scope of cooperation 1.4

A major part of the co-operative activity is focused on current and potential status and markets for ocean energy systems. In addition, the co-operative activity includes work on aspects of ocean energy systems, which are relevant in these markets, such as operational performance of ocean energy schemes and components, as well as information exchange on ocean energy technology, economics, and impacts. The work is closely coordinated with the work of the Wave Energy Network (a European Thematic Network funded by the European Communities under its Energy, Environment and Sustainable Energy Programme).

The involvement of the Participants in the two current Annexes is shown in Table 5. Two financial mechanisms exist to conduct the work programme. Task sharing, in which participants devote specified resources and personnel to conduct part of a common work programme is the mechanism used by this Implementing Agreement. The other mechanism available is cost sharing in which participants contribute to a common fund for activities. □

		CONTRACTING PARTIES				
	TASKS	DK	IR	JAP	PT	UK
	Operating Agent: INETI acting through ADENE (Agência para a Energia)					
ANNEX I	I Review, Exchange and Dissemination of Information on OES	X	X		X	X
	I.1 Collation, review and publication of information on ocean waves and marine currents energy systems					
	I.2 Exchange of information on OES					
	I.3 Analysis and dissemination of information on OES					
	I.4 Website creation and maintenance					
	Operating Agent: Danish Energy Authority (Energistyrelsen) acting through RAMBOLL					
ANNEX II	II Development of Recommended Practices for Testing and Evaluating OES	X		X	X	X
	II.1 Testing facilities and test sites					
	II.2 Testing procedures					
	II.3 Presentation of results					
	II.4 Performance assessment					

Table 5 | Participation in OES Tasks (Status: end 2002)

2 ACHIEVEMENTS DURING 2002 AND PROSPECTS

2.1 Task 1: Review, exchange and dissemination of information on OES

Achievements

During the year 2002 the Subtask I.1 – "Collation, review and publication of information on ocean waves and marine currents energy systems" – has been completed.

The outcome of this is the report "Wave and Marine Current Energy" which includes an overview of the technical, economic, environmental and social aspects of ocean energy systems (wave and tidal currents), and proposes Research and Development (R&D) priorities for these technologies. This report has been prepared by AEA Technology Future Energy Solutions for the United Kingdom Department of Trade and Industry.

Information has been collected by means of published materials and consultation with over 100 interested parties including the majority of developers worldwide. This activity has been in close co-operation with the Wave Energy Network. Its draft has been submitted for the approval of the Participants and updated according to their comments.

In Chapter 3 an executive summary of the report "Wave and Marine Current Energy" is presented. The report will be published and made available through the Website.

Further means of exchange and dissemination of information on Ocean Energy Systems undertaken during the year 2002 are presented in section 2.3. Those include (i) the description of the IEA-OES Website creation and actual maintenance as well as further developments planned to be implemented on the page during the next year; (ii) the International Workshop jointly organized by this Implementing Agreement and the United Kingdom Department of

Trade and Industry to promote the dissemination on current ocean energy status including a briefly description of the presentations and (iii) outline of the two annual meetings of the Executive Committee in 2002 with relevant exchange of information.

Prospects for 2003

In 2003 the work programme of this Annex will proceed with the following developments integrated in the subtasks:

> Subtask I.2 - Development of standard format for collection of information on national activities.

> Subtask I.3 - Analysis and summary of trends on national activities, the organisation of meetings and publication of a Newsletter.

> Subtask I.4 - Website maintenance and development of a member area for exchange of information between members.

"Stingray" tidal current system in Yell Sound off the Shetland Islands (Courtesy of The Engineering Business, Ltd.)

Task 2: Development of Recommended Practices for Testing and Evaluating OES 2.2

Achievements

Compilation of standards for tank testing of wave energy device models has been done by Kim Nielsen, Operating Agent of this Task. All other participants in the Task and experts on ocean energy systems were asked to give their contribution. The outcome of this work is a detailed report on recommended practices for testing and evaluating OES. See chapter 5 for general conclusions.

LIMPET power plant at Islay, Scotland
(Courtesy of Wavegen)

The report is organised according to the following subtasks of Annex II:

> II.1 Institutions
> II.2 Testing procedures
> II.3 Presentations of results
> II.4 Performance assessment

In II.1 a list of facilities suitable for testing ocean current and wave energy model systems provides an overview of available facilities in various countries. This list includes:

> Type of facility (wave basin, flume, towing tank or cavitation tunnel)
> Dimensions
> Selected parameters for characterizing waves and currents

Prospects for 2003

In 2003 within Task II the activity will continue focusing on prototype tests.

2.3 Exchange and dissemination of information

Dissemination of information is a key objective of the Work Programme of this Implementing Agreement. During the year 2002 exchange and dissemination of information was mainly carried out by the following:

> i. Website IEA-OES
> ii. International Workshop with an overview of the work undertaken under the IEA-OES.

> iii. Annual Meetings of the Executive Committee

From 2003 on two Newsletters for dissemination of recent information on Ocean Energy are envisaged to be published yearly.

2.3.1 Website

The IEA-OES website has been developed as a tool for information and promotion. Its address is: http://www.iea-oceans.org and the index page is shown in figure 1.
The IEA-OES website intends to facilitate the exchange of information especially regarding work programmes and new initiatives and to serve as a vehicle of circulation of documents among the members.

The website includes the following areas:

> About IEA-OES _ description of the Implementing Agreement, its background, mission and strategy, the vision for Ocean Energy, as well as the objectives.
> Tasks _ objectives, subtasks, time schedule, operating agent and participants.
> News & Events _ news and events on Ocean Energy such as the ExCo meetings, Seminars, Workshops and Conferences.
> Contact us _ how to reach Executive Committee Members, Executive Secretary and Operating Agents.
> Publications _ available online papers, reports and other documents
> Links _ to other related sites.

Further developments in 2003 will include a FAQ & Forum area and a Members Area with restricted access via an internal password-protected tool.

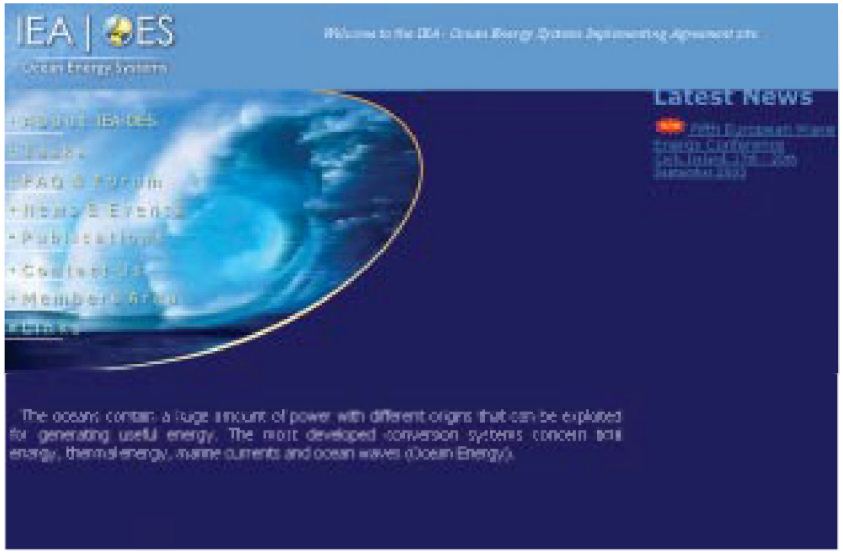


Figure 1 | Home Page of Website

1. The IEA Implementing Agreement on Ocean Energy Systems
The IEA|OES Achievements and Prospects **Teresa Pontes, Chair, Portugal** Teresa Pontes has described the aim of the IEA under which a framework for the collaborative R&D programmes (Implementing Agreements) is provided. A general overview of the IEA-OES, its objectives and tasks were presented. **Wave and Marine Current Energy - Status and R&D Priorities** **Richard Boud, Future Energy Solutions, UK** This presentation was based on the results of the work developed under the scope of the Subtask I.1 described above. It focused on the conclusions on the actual status of Ocean Energy exploitation, the R&D Strategies and presented a list of opportunities for international collaboration. **General Overview of Recommended Practices for OES Model Testing** **Kim Nielsen, RAMBØLL, Denmark** Results of the work developed under the scope of the Task II starting by a proposal for evaluating and comparing Ocean Energy Systems with, also the indication of the comparable parameters and focused on recommendations for tank testing procedures for ocean energy device models. **The Hydraulics Maritime Research Centre Experience** **Tony Lewis, University College Cork, Ireland** The presentation has focused on the HMRC facilities in Cork showing a series of wave energy device tests undertaken by this laboratory. **Mighty Whale Open Sea Testing** **Hiroyuki Osawa, JAMSTEC, Japan** The wave tank experiments of the scale model of Mighty Whale prototype were initially presented. This was followed by an outline of the open sea tests of the prototype, including results of the total energy conversion efficiency and examples of time series of wave height, rotational speed and generated output. Main conclusions on the efficiency of conversion and estimation of the generated output were presented.
2. The EC FP6 Programme
The EC FP6 Programme **Phillippe Schild, European Commission DG Research** The main components and basic principles of the Sixth Framework Programme were presented focusing on the general rules for participation. **New Instruments: Integrated Projects and Networks of Excellence** **Phillippe Schild, European Commission Research DG** This presentation has focused on the main topics of the new instruments, including its purpose, integration, scale, activities, financial regime and contract (general details, negotiation and management)
3. UK Projects in Ocean Energy Systems
The UK Programme in Wave and Tidal Energy **David Bramble, DTI** An overview of the Renewable Energy Incentives in the UK was presented followed by a description of the aims of the Wave Energy Programme, how the programme aims are to be achieved and the call for proposals process. A description of what has been achieved in the UK on wave and tidal energy concluded the presentation. **Developing Standards for a New Industry** **By John Griffiths, JWG Consulting Ltd** This presentation included an explanation on the necessity of developing standards for assessment of wave energy converters performance, followed by a description of the required standards for both scale models and open sea testing. **The Stingray Tidal Stream Energy Device: lessons from its first marine deployment** **Tony Trapp, The Engineering Business** The Stingray concept was described as well as the design, construction and installation of a prototype.

Table 7 | Presentations on the IEA-DTI workshop

2.3.2 Workshop

A one-day workshop entitled "OCEAN ENERGY - The International Energy Agency, United Kingdom and European Commission Programmes" was jointly organised by this Implementing Agreement and the UK Department of Trade and Industry (DTI).

This workshop was held in Brigthon, UK, on October 30, 2002, following the Open Day Meeting on future research and development (R&D) in the ocean energy field, organised by the European Thematic Network on Wave Energy (WAVENET).

It was attended by approximately 60 participants coming from industry, utilities, research institutions and universities from 10 countries.
The speakers were technology experts and key regional representatives who described programs on Ocean Energy in UK, Europe and Japan. The workshop program is presented in Appendix 1.
The presentations were made available on the IEA-OES Website (http://www.iea-oceans.org/news/02/index.htm).
The presentations cover the three topics presented in table 7.

2.3.3 Meetings of the ExCo

Participation in the ExcO meetings is a means for dissemination among member countries. The list of the current ExCo members and alternates is presented in Chapter 6. Two ExCo meetings were held in 2002:

> 2nd Meeting - Harwell, UK, 21-22 March 2002
> 3rd Meeting - Brigthon, UK, 31 October 2002

In both meetings all the contracting parties participated as well as observers belonging to countries and the European Commission planning to became members of the IEA-OES.

Highligths From The 2002 Executive Committee Meetings

2nd ExCo Meeting
Harwell, UK, 21-22 March 2002

Participants

Members		
Teresa Pontes	INETI (Chair)	Portugal
David Bramble	DTI	UK
Kim Nielsen	Ramboll	Denmark

Observers		
Cynthia Rudge	Global Business Development	Australia
Hans Breugel	Teamwork	Netherlands
Katrina Polaski	Irish Energy Centre	Ireland
Philippe Schild	European Commission	EU
Tony Lewis	University College Cork	Ireland

Figure 2 | Attendees of the 2nd Executive Committee Meeting | 21 March 2002, Harwell, UK
From left to right:
David Bramble (UK ExCo member)
Katrina Polaski (Ireland ExCo observer)
Hans Breugel (Netherlands ExCo observer)
Philippe Schild (EU ExCo member)
Tony Lewis (Ireland ExCo observer)
Teresa Pontes (Portugal ExCo member, chair)
Kim Nielsen (Denmark ExCo member)
Cynthia Rudge (Australia ExCo observer)

> The situation for renewable energy as conceived by the participants was presented and discussed.
> The major topic at this meeting was the discussion of the draft of Annexes I and II and the budget.
> The draft IEA-OES website was presented and approved.

Figure 3 | Attendees of the 3rd Executive Committee Meeting | 31 October 2002, Brigthon, UK
From left to right:
Behind:
David Bramble (UK ExCo member)
Godfrey Bevan (Ireland ExCo member)
Philippe Schild (EU ExCo observer)
Tony Lewis (Ireland ExCo observer)
Cynthia Rudge (Australia ExCo observer)
Richard Boud (UK ExCo observer)
Kim Nielsen (Denmark ExCo member)
Gouri Bhuyan (Canada ExCo observer)
At front:
Hiroyuki Osawa (Japan ExCo member)
Yasushi Tsuritani (Japan ExCo member)
Teresa Pontes (Portugal ExCo member, chair)
Ana Brito Melo (ExCo secretary)

3rd ExCo Meeting
Brigthon, UK, 31 October 2002

This meeting has been realized following the WAVENET Open Day Meeting on 29 October, and the DTI/IEA workshop on 30 October.

Participants

Members		
Teresa Pontes	INETI (Chair)	Portugal
David Bramble	DTI	UK
Godfrey Bevan	Sustainable Energy Ireland	Ireland
Yasushi Tsuritani	JAMSTEC	Japan
Hiroyuki Osawa	JAMSTEC	Japan
Kim Nielsen	Ramboll	Denmark

Observers		
Cynthia Rudge	Global Business Development	Australia
Gouri Bhuyan	Powertech Labs Inc.	Canada
Philippe Schild	European Commission	EU
Tony Lewis	University College Cork	Ireland
Richard Boud	DTI	UK

Secretariat	
Ana Brito-Melo	IA-OES ExCo Secretary
Rick Sellers	Head of IEA Renewable Energy Unit

> In this meeting the governments of Australia and Canada and the European Commission have been invited by the ExCo to participate in the Implementing Agreement on Ocean Energy Systems.

> New members – Japan and Ireland – that have joined this Implementing Agreement during the year 2002 were welcome by the chair.

> The document produced by the CERT "Outline for Discussion on The Future of IEA Implementing Agreements" has been submitted for discussion on the meeting. The head of the IEA Renewable Energy Unit expressed the wish of the IEA secretariat to enhance collaboration with the Implementing Agreements.

> The document "Criteria and Review Process for the Extension of Implementing Agreements" developed by the IEA Committee on Energy Research and Technology (CERT), to be used as a guideline for the orientation of the Implementing Agreement activities, has been submitted for discussion

> Suggestions for new Annexes have been made.

2.3.4 Newsletter

A biannual 4-page Newsletter will be produced as another tool for improving dissemination of information on wave and marine currents energy projects, providing highlights on recent developments.

At the 3rd ExCo meeting Japan and Canada were invited to provide information on the floating OWC Mighty Whale prototype and on the Vancouver Island project, respectively.

The Newsletter will be disseminated through the IEA-OES website. A printed version will be mailed to a wide list of stakeholders and parties potentially interested on Ocean Energy Systems utilisation and it will be distributed at conferences and meetings. □

Pico Power Plant at Azores, Portugal

3 REPORT ANNEX I: EXECUTIVE SUMMARY

Richard Boud
Future Energy Solutions
AEA Technology
UK

The attraction towards ocean energy is clear. There is a massive known resource and huge market potential for a clean renewable energy source. The opportunities for investment and technology are great. The technology to exploit this market and to contribute to sustainable world energy demand is still at the prototype stage. This report considers the status of the technology and research and development (R&D) requirements of the emerging industry.

There are two forms of ocean energy considered in this study:

- Tidal streams are mainly caused by the movements of oceans and are driven by the interaction of the gravitational fields of the earth, sun and moon. The potential resource for tidal stream is estimated as 5 TW.
- Wave power is derived from winds blowing across large expanses of sea. These winds generate sea waves that contain significant quantities of energy. The total world wave energy resource is estimated to be 1-10 TW.

This report details the status of three generic tidal stream concepts and four prototypes—the Marine Current Turbines rotor, the ENERMAR design, the Engineering Business Stingray concept and the Edinburgh University rotor. Even in such a conceptually straightforward resource as marine currents, there is considerable variety of device concept.

There are even more concepts proposed for wave energy extraction. Over twenty prototype designs are discussed and detailed here. With the exception of shoreline oscillating water

columns there is very little consolidation onto a few good ideas. There is great variety and each prototype developer faces an almost unique set of engineering and environmental challenges.

Several countries in the world have supported ocean energy development through R&D programmes and other support measures. Details of the programmes run in eighteen countries worldwide are included. Most of the activity is concentrated in Europe although there is ongoing work in Japan and Australia and elsewhere. The European Commission is playing an important part in coordinating the development of the technologies.

With such variety in ocean energy technologies, it is difficult to make many generic recommendations for the R&D requirements. However, all the technologies need support in establishing good resource assessments and market size predictions. All of the technologies will require testing and eventually certification if they are to attract the investment needed to exploit the markets fully. This report contains several proposals for mechanisms and activities to support this.

If exploited fully these technologies will be deployed in large numbers in a marine environment. The environmental implications of this can currently only be estimated. As the technology develops and prototypes and commercial schemes are deployed, due care should be paid to the environment. Research into the main impacts and how these might be predicted for future schemes needs to continue and understanding of the environmental impacts developed.

There are some issues that are common to all the technologies but for which generic research is difficult. These issues include mooring technology, electrical connection, power conditioning, power forecasting, operation and maintenance methods. Whilst the issues themselves are common the problems manifest themselves in different ways for each of the wide variety

Archimedes Wave Swing Prototype towed to be installed offshore Portugal

of concepts. Generic research for these issues is of limited applicability and therefore of limited worth.

It is important to enable concept developers to prove their devices. They must be allowed to work through the complex design and economic assessments and tackle the many technical challenges they will face. They also need to be afforded sufficient freedom and support to be able to develop technologies that make optimum use of materials, technology, resource and financing to enable the development of economic technologies. It is therefore recommended that emphasis be placed on supporting the development of individual device concepts rather than only on generic studies.

Of critical importance in this is the ability to be able to assess designs for their merits and to establish which designs and developers are credible and which to pursue. Assessment of the different technologies therefore needs to be consistent and reliable. It is therefore recommended that robust assessment methodologies be developed and applied to device concepts prior to their full support.

This report concludes by summarising a number of key aspects of ocean energy, stating where the potential lies and how the R&D priorities suggested can help the development of this promising technology. □

REPORT ANNEX II: MAIN CONCLUSIONS

4

Kim Nielsen
RAMBOLL, Denmark
Work reported by Operating Agent of Task II

How can we help comparisons between different Ocean Energy Systems

One of the main challenges within the development of Ocean Energy Systems is the fact that there is presently no leading technology and several different approaches are trying to attract funding and investors. The common goal to develop technologies able to produce power from the Ocean Waves and Tidal Currents at a low cost seems only possible if developers on an international level can be motivated to provide and share comparable data and results.

Up to now it has been difficult to compare different systems, as the underlying assumptions with regards to power production, generator capacity and cost are based on very different assumptions. In order to overcome this problem the Annex II of the IEA OES Implementing Agreement is focused to provide guidelines that could become standards for:

> Testing
> Preliminary cost assessment
> Presentation of results

The costing procedures are based on a costing methodology originally developed as part of the preliminary actions on wave energy under the EU 1991-93, simplified and combined with standard test procedures developed during the Danish Wave Energy Program 1997 – 2002. Unlike any other wave energy program the Danish program encouraged generation of new ideas and the need for standard routines for testing and evaluation was essential in order to compare results.

It is the hope that the introduction of common guidelines at an international level can help unite the efforts in the development of cost effective Ocean Energy Systems.

Topics to debate

Reference distribution of sea conditions

The first basic condition for comparing different systems is to define and agree on a reference distribution of sea conditions. This will make the comparison of results possible in terms of annual energy production and survival design (and does not exclude additional testing if required for projects located at a specific site with a different distribution of sea conditions.)
The short term conditions of the ocean waves on the surface can be defined in terms of two parameters, the significant wave height Hs and the average wave period Tz.
Averaged over the year the number of hours sea states within certain limits occur can be described in so-called scatter diagrams. A scatter diagram shows how many hours or percent per year a certain combination of the significant wave height Hs and the average wave period Tz occurs within set limits. The limits are typically intervals of one second of the average wave period and intervals of one metre for the significant wave height.

Introduction of Power Curves

Power Curves with reference to the defined combinations of significant wave height Hs and average wave period Tz are introduced to further simplify comparisons between systems and to define the maximum average power output from the systems.
In order to present a power curve a number of sea states with a specific relation between Hs and Tz is required. Tz is chosen as the central estimate within each interval of Hs. For the Danish part of the North Sea a linear relationship has been found in the form:

Tz = Hs *[s/m] + 3 [s]

This means that if the significant wave height is 1 meter then the average wave period is 4 seconds, however at other locations (i.e. where swell is dominating) the average wave period might be longer for the same significant wave height.

Annual energy production, E

From the reference scatter diagram the annual distribution of sea states can be expressed only in terms of Hs associated with the central estimate of the period. The annual energy production can be calculated combining the power curve and the wave distribution. The power curve is related to a specific device design and this design forms the basis for the estimation of the weight of construction.

Rated Power, P

Rated power P is defined as the average absorbed power in sea state Hs = 5m over a period of 20 minutes (in full scale). This definition is chosen for comparative reasons and the actual generator might in some cases be larger in order to cope with peak power depending on the storage options.

Capital cost, K

The system design associated with the power curve has a structural weight and in full scale it will be built typically in steel or concrete. This can be expressed in terms of cost, provided that we agree on unit costs reflecting reality as a preliminary assessment. Depending on the stage of development the structural design of the full-scale structure can be more or less accurate. To provide a basic idea of the cost of the specific device design, the weight and materials included in the structural design are combined with standardised unit costs.

Comparative figures

These figures are useful in order to establish a comparable and systematic presentation of the results in the form of:

> K/E "Energy cost"
> K/P Cost per kW rated power
> E/P Full load hours per year □

Steel construction of the Prototype Wave Dragon ready for deployment (Courtesy of SPOK)

5 FUTURE PROJECTS

The following proposal for further Annexes have been discussed in the 3rd Executive Committee Meeting in Brigthon, 31 October 2002.

1 > **Power Take-Off Equipment**

With a general focus on power-take-off systems incorporating a review of wave-energy extracting systems (hydraulic, pneumatic, mechanical, electri cal converters).

2 > **Market Facilitation**

Analysis of the technical, market and policy barriers to the commercialization and broad uptake of Ocean Energy Systems and recommend strategies to overcome the barriers. □

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APPENDIX 1

OCEAN ENERGY

The International Energy Agency,

United Kingdom and European Commission Programmes

WORKSHOP

Thistle Hotel, Brighton, UK
Wednesday, 30th October 2002

The Implementing Agreement on Ocean Energy Systems

9.00	Welcome and Introduction	Teresa Pontes, INETI, PT (Chair)
9.10	The IEA|OES Achievements and Prospects	Teresa Pontes
9.30	Wave and Marine Current Energy - Status and R&D Priorities	Richard Boud, Future Energy Solutions, UK

IEA|OES - Recommended Practices for OES Model Testing

10.00	General Overview of Recommended Practices for OES Model Testing	Kim Nielsen, Ramboll, Denmark
10.30	Tea|Coffee	
10.50	The Hydraulics Maritime Research Centre Experience	Tony Lewis, University College Cork, Ireland
11.20	*Mighty Whale* Open Sea Testing	Hiroyuki Osawa, JAMSTEC, Japan
11.50	Open Discussion	

The EC FP6 Programme

12.05	The EC FP6 Programme	Phillippe Schild, European Commission DG Reserch
12.30	Lunch	
13.50	New Instruments - Integrated Projects and Networks of Excellence	Phillippe Schild, European Commission DG Reserch
14.15	Open Discussion	
14.35	Tea|Coffee	

UK Projects in Ocean Energy Systems

14.55	The UK Programme in Wave and Tidal Energy	David Bramble, DTI
15.25	Developing Standards for a New Industry	John Griffiths, JWG Consulting Ltd
16.10	The Stingray Tidal Stream Energy Device lessons from its first marine deployment	Tony Trapp, The Engineering Business
16.55	Concluding Comments	Teresa Pontes