Rising tide

Global trends in the emerging ocean energy market

Building a better working world

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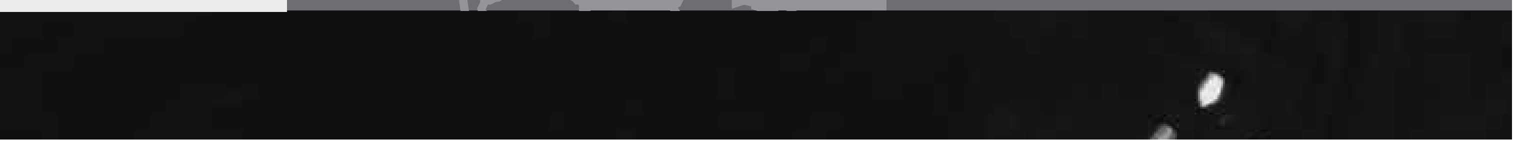
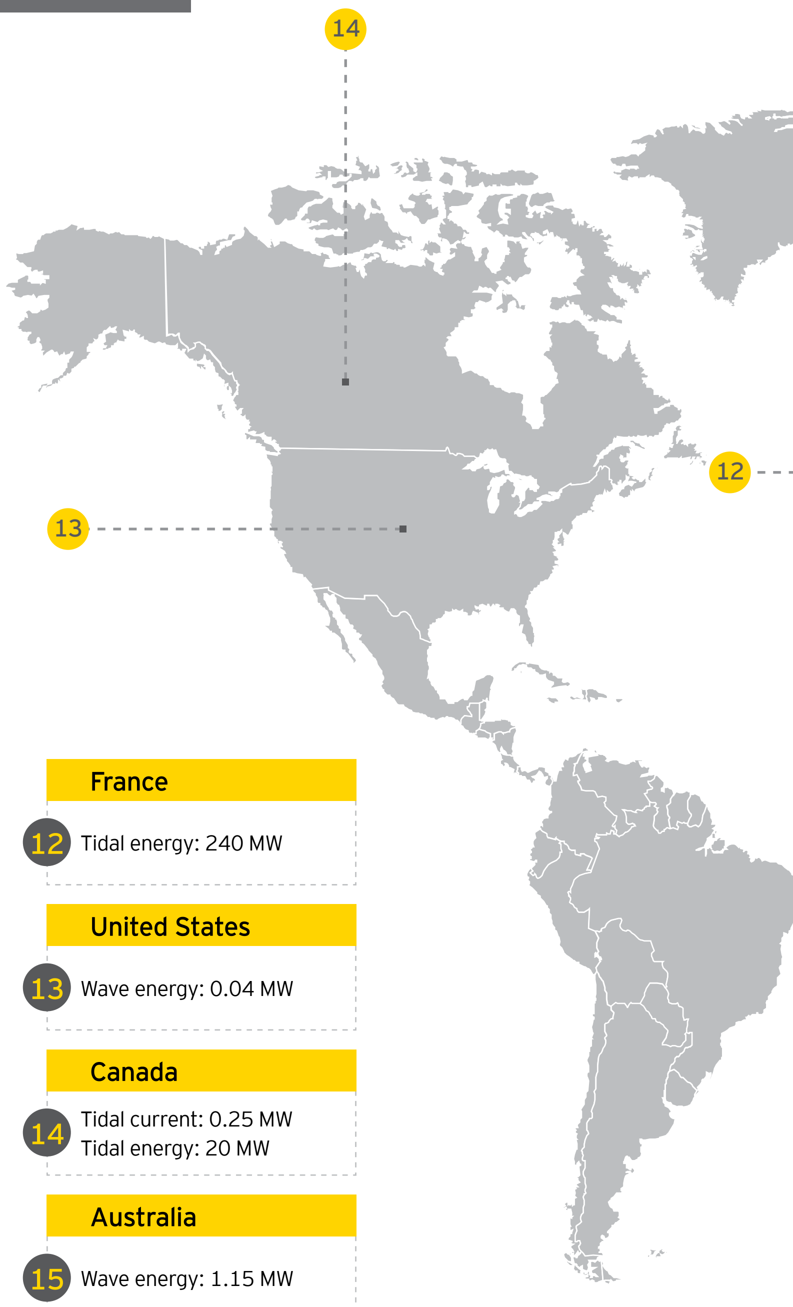


Global view

Worldwide ocean power installed capacity



United Kingdom
1 Tidal current: 6.7 MW
Wave energy: 4.3 MW

Norway
2 Salinity gradient: 0.004 MW

Sweden
3 Wave energy: 0.15 MW

Denmark
4 Wave energy: 0.25 MW

Netherlands
5 Tidal current: 0.1 MW
Salinity gradient: 0.01 MW

South Korea
6 Tidal current: 0.11 MW
Tidal energy: 254 MW

New Zealand
7 Wave energy: 0.02 MW
(+0.02 MW in Oregon)

China
8 Tidal current: 0.11 MW
Tidal energy: 3.9 MW
Wave energy: 0.19 MW

Italy
9 Tidal current: 0.1 MW
Tidal energy: 0.006 MW

Spain
10 Wave energy: 0.296 MW

Portugal
11 Wave energy: 0.7 MW

France
12 Tidal energy: 240 MW

United States
13 Wave energy: 0.04 MW

Canada
14 Tidal current: 0.25 MW
Tidal energy: 20 MW

Australia
15 Wave energy: 1.15 MW

An emerging market

Ocean energies can be extracted with a large variety of technologies that exploit the composition of the water or the power obtained from the kinetic energy of large bodies of moving water. These include tidal range, wave and tidal current technologies, thermal and salinity gradient technologies, and floating wind turbines.

To date, ocean energies represent only 0.01% of electricity production from renewable sources. Except for the tidal range technology, no technology is widely deployed as most of them are still at an early stage of development. According to Ocean Energy Systems (OES), the international technology collaboration initiative on ocean energy under the International Energy Agency (IEA), total worldwide installed ocean power was about 530 MW in 2012, of which 517 MW from tidal range power plants. Technologies to exploit tidal range power are today the only ones to have reached commercialization stages in the ocean energy group although they also involve high investment costs and considerable environmental impacts. Only four tidal range power plants exist in the world: two major plants, one in South Korea (254 MW) and one in France (240 MW), and two smaller plants, one in Canada (20 MW) and one in China (3.9 MW). This technology could also undergo further developments as several projects are under development in the UK (Severn tidal) and especially in South Korea.

Source: EY, adapted from OES, Annual report 2012

The development of other forms of ocean energy (tidal current, wave, thermal, salinity gradient and floating wind technologies) has accelerated in the past five years, and some of them could reach commercial maturity by 2020. Wave power devices are currently being demonstrated, and underwater tidal turbines driven by currents are close to commercialization. Overall, 22 MW of wave and tidal current devices were installed in 2012.

OES estimates a worldwide potential of up to 337 GW of wave and tidal energy capacity by 2050, and possibly a similar contribution from ocean thermal energy conversion. The European Ocean Energy Association estimates a European potential of 188 GW by 2050, which would satisfy 15% of European electricity demand and, in some countries, up to 20% of national demand.

Several countries have recently developed national strategies to support the ocean energy sector. For instance, after various supporting programs, such as the Marine Energy Accelerator of the Carbon Trust, the UK Government established a new marine energy program in 2011 that is focusing on enhancing the UK marine energy sector's ability to develop and deploy wave and tidal energy devices on a commercial scale. In June 2011, the UK Department of Energy and Climate Change (DECC) announced it was investing up to £20m in wave and tidal power to help develop marine energy technologies to support the Marine Energy Array Demonstrator (MEAD) Scheme. The DECC also supports these developments through feed-in tariffs: the UK and Scottish Governments confirmed in July 2012 the incentives for wave and tidal energy at 5 ROCs per MWh for projects up to 30 MW capacity that are installed and operational prior to 1 April 2017. In 2012, Scotland also produced its Marine Energy Action Plan detailing key elements around which it would further develop and support the marine renewables industry.

The last two years also saw other countries launch various initiatives aimed at developing the ocean energy sector: a new Danish strategy for development of wave energy was initiated in 2011; Japan established its Ocean Energy Technological Development Research Center, which aims to promote ocean renewable energy; and the Spanish Government officially approved the Renewable Energy Plan 2011–2020. In 2012, the French Government presented a roadmap for the development of tidal energy. Canada is also investing in the sector, especially the Nova Scotia region, which put in place a demonstrator site for tidal energy in the Bay of Fundy and released its Marine Renewable Energy Strategy in 2012. The US, China and Korea have also developed specific strategies targeting marine energy.

Private actors are also investing in marine energy technologies. Investments have become more sustained in recent years with the positioning of multinational companies in this sector. Since 2011, an increasing number of acquisitions have taken place. This is the case in France, with Alstom's acquisition of shares in AWS Ocean Energy Ltd. in May 2011 and of Rolls-Royce Tidal Generation Limited in January 2013, as well as the finalization of DCNS's acquisition of Open Hydro Group Ltd., to be finalized in 2013. Siemens AG also reinforced its participation in Marine Current Turbines Ltd. by acquiring a 55% additional stake in this Bristol-based tidal stream technology developer in February 2012. In March 2012, Andritz Hydro GmbH acquired a 22.1% stake in Hammerfest Strom AS, a Norway-based developer of marine current turbines. Investments in the ocean energy sector also involve fund-raising. For instance, in December 2012, Scotrenewables Tidal Power Ltd., an Orkney Island-based renewable energy research company for the wind, wave and tidal energy sectors, raised £7.6m (US$12.3m) in a private equity funding round. ABB, the global power and automation technology group, also led a US$12m investment in this company in March 2013 through its venture capital unit, ABB Technology Ventures (ATV).

This recent development of marine energy should expand in coming years. Indeed, the IEA believes that ocean energy technologies could start playing a sizable role in the global electricity mix around 2030. According to the agency's technology initiative OES, ocean energy may experience similar rates of rapid growth between 2030 and 2050 as offshore wind has achieved in the last 20 years. The IEA estimates the worldwide potential power of each type of energy as follows:

- Wave power: 29,500 TWh/year
- Tidal range power: 1,200 TWh/year
- Ocean thermal energy: 44,000 TWh/year
- Salinity gradient power: 1,650 TWh/year

Future developments could create about 1.2 million direct jobs by 2050, according to OES. For instance, tidal energy could potentially create 10 to 12 direct and indirect jobs per MW installed, and wave energy could potentially create about 8 to 9 direct and indirect jobs per MW installed. Regarding recent developments and demonstrators actually being tested, tidal and wave energy should be the first emerging ocean technologies to be commercialized in coming years.

A public consultation held in September 2012 by the European Commission showed strong consensus over the potential of ocean energy. The European Commission has identified "blue energy" as one of the five focus areas that could deliver sustainable long-term growth and jobs in the "blue economy." The same consultation also highlighted the constraints that need to be addressed to allow further development, such as the length and complexity of authorization, certification and licensing procedures in individual Member States. A large majority of respondents also think that there should be a specific policy supporting ocean energy development at the EU level, as well as long-term visibility. Regarding technical barriers to grid connection, the lack of agreed standards and technical specifications and of construction and installation vessels were the barriers most frequently cited by stakeholders to the development of ocean energy. A large-scale deployment of ocean energy will thus depend on the sector's ability to address these technological and economic challenges.

£1 = €1.17

Floating offshore wind turbines

What are they?

Floating offshore wind turbines are mounted on a floating structure, so they are not constrained by the same depth limitations as fixed-base turbines. They can be towed into deep water well away from the shore, where winds are stronger and steadier. Undersea cables are used to take the electricity onshore. Floating wind turbines can be towed far out to sea, minimizing their impact on landscapes. In the future, they could become a growth driver for the wind power sector by adding to the potential of fixed-base turbines.

Technologies

There are many different designs and concepts, suited to sites' specificities and depth characteristics, for this rather new technology. However, none of them has reached the commercial stage yet. Many projects are under way to develop and test technical innovations (e.g., spar buoys, semi-submersible floating platforms, tension-leg platforms).

Tests on Hywind, the world's first full-scale floating wind turbine, developed by Statoil, began off the Norwegian coast in September 2009. Statoil continued to test throughout 2011 and 2012 in order to gain further data for optimizing the next generation of Hywind. In early December 2011, Windfloat, a semi-submersible wind turbine, was moved into position off the coast of Portugal by EDP Renewables. The 2 MW offshore floating turbine has been generating power to the grid – 2.5 GWh at the end of 2012. The company that owns this prototype, Principle Power, was awarded a grant from the U.S. Department of Energy at the end of 2012 to support a 30 MW floating offshore wind farm near Oregon's Port of Coos Bay.

In April 2012, the UK and the US agreed to collaborate on the development of floating wind technology. In the UK, the Energy Technologies Institute (ETI) plans to invest £25m in a 5-7 MW floating offshore wind demonstrator.

Tidal current energy

What is it?

Tidal turbines are designed to convert the kinetic energy of ocean and tidal currents into electricity or into a second pressurized fluid. The energy of tides is highly predictable but also highly localized, the most suitable sites being those where ocean currents are particularly strong.

Technologies

Several prototypes are now being developed. The UK and France are the two European countries with the most important resources of tidal energy. Therefore, various projects are being developed in these countries. In France, EDF is testing a tidal energy farm using OpenHydro technology (acquired by DCNS as of January 2013) at Paimpol-Bréhat on the Brittany coast, with a total capacity of 2 MW to be fed into the grid by the second half of 2013. In the UK, five tidal devices totaling 4 MW were deployed in 2012 for testing by the European Marine Energy Center (EMEC), and Alstom is also currently operating a 1 MW tidal stream unit of Tidal Limited Generation at EMEC, in partnership with the ETI. Italy and Norway have also installed first prototypes (Hammerfest Strøm, Hydra Tidal) in water for testing. In Canada, the Open Hydro/DCNS technology is also being tested. These developments clearly point to an imminent market launch and commercial deployment as early as 2015.

Wave power

What is it?

Waves offer a large source of energy that can be converted into electricity by a wave energy converter (WEC). There are several principles for converting wave energy using either fixed onshore devices or mobile devices at sea.

Technologies

Many onshore projects are operating, such as the Pico Island plant in the Azores and the Islay plant in Scotland. In the same way as tidal technologies, various wave power projects have been implemented in the past two years. In the UK, 14 wave devices totaling 3.6 MW were deployed in 2012 for testing by EMEC. In South Korea, the Yongsoo 500 kW oscillating water column (OWC) pilot plant at Jeju Island is expected to start operation in 2013. In Norway, the Lifesaver, a 16-meter-diameter point absorber concept developed by Fred Olsen, has been undergoing sea trials off the coast of Cornwall in the UK for six months, with a total installed capacity of 400 kW. In Denmark, Wavestar is currently testing its prototype with two floaters at DanWEC, Hanstholm. To date, the maximum production measured is 39 kW. In Portugal, the WaveRoller prototype (300 kW) was installed in the summer of 2012 and connected to the grid. In Spain, two wave energy demonstration projects are progressing: the Mutriku OWC plant (200 MWh of energy production after one year of operation) and the WELCOME – Wave Energy Lift Converter Multiple España (150 kW prototype at 1:5 scale) developed by PIPO Systems, installed on the Canary Islands. In the US, Oregon State University and the Northwest National Marine Renewable Energy Center deployed the Wave Energy Technology-New Zealand (WET-NZ), a 1:2 scale wave energy conversion device, during August 2012.

The diversity of concepts (in-stream or oscillating water column systems, floating platforms, integrated systems) and uncertainty as to those that will eventually come onto the market make it difficult to assess their costs or market schedule.

Ocean thermal energy conversion

What is it?

Ocean thermal energy conversion (OTEC) technology relies on a temperature difference of at least 20°C between warm surface water and cold deep water. This means that only tropical waters have the right conditions for its deployment.

OTEC has the advantage of producing renewable energy on a continuous (non-intermittent) basis. Implementing OTEC demands systems-engineering competencies and industrial capacities that limit the number of players that can be involved in its development.

Technologies

This technology has real potential to contribute to energy self-sufficiency on islands, where energy costs are very high. Today, DCNS (France) and Lockheed Martin (US) are the leading industrial players. After completing feasibility studies in La Réunion and Tahiti, DCNS signed export agreements and set up an onshore prototype on La Réunion in 2012. DCNS is also working in partnership with the regional authority of La Martinique and STX France on an OTEC 10 MW pilot, which should be commissioned in 2016.

Salinity gradient energy

What is it?

Osmotic energy technology uses the energy available from the difference in salt concentrations between seawater and freshwater. Such resources are found in large river estuaries and fjords. The system uses a semi-permeable membrane that allows the salt concentrations to equalize, thus increasing pressure in the seawater compartment.

Technologies

The technology is still in the early research and development stages. Statkraft is one of the few industrial players in this sector, having set up the world's first prototype osmotic power plant in Norway. The key to further development lies in optimizing membrane characteristics. Today, the membranes generate only a few watts per square meter. The small number of players working on this technology and the need to improve membrane performance and reduce costs therefore point to development prospects in the longer term. Research and development on osmotic power is also being carried out at the Tokyo Institute of Technology to develop new efficient membranes and by RedStack in the Netherlands.

Global point of view

Adam Brown

EY: What is the IEA's role in facilitating the uptake of ocean energy?

Adam Brown: The Renewable Energy Division within the IEA is focusing on technology and market studies, providing analyses on markets and policies, as well as market integration issues.

In addition, the IEA facilitates implementing agreements that provide collaboration frameworks between countries. A total of 10 implementing agreements on renewable energy are currently effective, one of which is on ocean energy and currently involves 19 countries. This implementing agreement, called Ocean Energy Systems (OES), provides a forum to share experience and knowledge on ocean energy issues such as research and development (R&D), policy initiatives and financing mechanisms.

EY: What is OES's outlook on future development of ocean energy?

Adam Brown: In its 2012 *International Vision for Ocean Energy*, OES estimates a worldwide potential of up to 337 GW of installed capacity by 2050 for wave and tidal, making the growth rate of these energies comparable to the rate of growth of offshore wind over the last 20 years. This deployment would create 1.2 million direct jobs and generate carbon savings of 1 GT of CO_2. In this scenario, ocean energy would represent 2% of global electricity production in 2050.

EY: Where do you see the strongest potential for the emergence of ocean energy?

Adam Brown: Since the first ocean energy plants are just entering the stage of commercialization, there is still much uncertainty as to where future market leaders will be.

A number of countries are leading the development and demonstration of the technologies. For example, the UK is addressing both development and deployment issues.

EY: Which ocean energy technology do you believe has the most potential for growth?

Adam Brown: The long-term potential for wave energy is high, with worldwide natural potential; however, the technology is very challenging. Tidal stream energy may have stronger short-term potential because the technology is more readily available; however, its long-term growth may be more restricted because of geographical constraints and available natural potential.

EY: What are the main barriers to the development of ocean energy?

Adam Brown: The first challenge is to demonstrate that the technology can operate reliably and efficiently and without unacceptable environmental impacts. Some demonstration-scale projects are now in operation, but much remains to be done. There is also a need for cost reduction to make the technology more financially competitive. Governments can assist by providing long-term policies with clear objectives to create an environment in which project and technology developers can operate with confidence.

Senior Energy Analyst
International Energy Agency (IEA)

EY: What policies do you believe could accelerate the marine renewable market?

Adam Brown: Good policies should generally provide a clear vision of national targets, planning regime and financing mechanisms. The UK is rather advanced in setting a solid regulatory framework and attractive investment environment, without which entrepreneurs would not take any risk.

With regard to financing mechanisms, an analysis of different schemes that have been used for offshore wind does not clearly identify a single most-effective scheme. In the end, a balance between capital support and revenue support is best adapted in the early stages of development. But getting the financial engineering right remains a great challenge.

EY: What bottlenecks do you identify in the private sector?

Adam Brown: Research and development is still often focused within small companies working with early-stage funding. The involvement of larger players, especially utility companies, may well be necessary to ensure larger-scale investments, provide operation and maintenance services and deploy ocean energy on a larger scale.

Future development of ocean energy will also depend on synergies with other sectors, such as offshore wind energy, so as to share technology developments, infrastructure (e.g., common platforms for wind/tidal hybrid systems), supply chain and policies.

EY: To conclude, how do you perceive the development of non-conventional sources of fossil fuel and their competition against renewable energy?

Adam Brown: Globally, the market for renewable energy is continuing to grow, especially in non-OECD and emerging economies where renewable energy policies are being put in place. The benefits of energy security and access to energy make renewable energy a key aspect of future economic development. However, the extent of their development will also depend on future decisions on climate change policies and regulation.

Country focus

Australia

Current status

Australia is developing several ocean energy projects, with 25 MW of wave energy projects proposed over the next decade and 535 MW of tidal projects at the early planning stage. With the award of approximately AU$110m by federal and state governments, Australia could see the first commercial demonstration plants in the wave energy sector by the end of 2013. Notwithstanding Australia's world-class resource potential in the wave energy sector and policy targets for renewable energy and the reduction of greenhouse gas emissions, the Australian ocean energy sector is largely underdeveloped compared with those of Europe and North America.

With less than 1 MW of capacity installed and tested during the past decade, Australia is now at a turning point with more than 10 proposed wave and tidal energy projects in the pipeline, as presented in Table 1. The project pipeline is led by Victorian Wave Partners Pty Ltd., Carnegie Wave Energy Limited, Oceanlinx Limited and BioPower Systems Pty Ltd. The projects use different technologies, including a floating device (i.e., PowerBuoy), a partially submerged device (e.g., Oscillating Wave Column, BioWAVE) and a fully submerged device (e.g., CETO). The 535 MW of tidal energy projects is led by Tenax Energy Pty Ltd. and Atlantis Resource Corporation (a company incorporated in the United Kingdom), which both use horizontal-axis turbine devices. If these projects are implemented, 2013 will see the Australian ocean energy sector transitioning to the commercial demonstration stage.

AU$1 = €0.81

Table 1. Wave- and tidal-energy project pipeline in Australia

Project proponent	Technology	Location	Maturity	Capacity	Development stage	Government support (AU$)
Wave-energy projects						
Victorian Wave Partners Pty Ltd.	PowerBuoy Wave Energy Systems	Victoria	Commercial demonstration	19 MW	Early-stage development	ARENA*: $66.5m
Carnegie Wave Energy Limited	CETO 5	Western Australia	Commercial demonstration	Up to 2 MW	Early-stage development. Scheduled completion end of 2013	ARENA*: $9.9m WA Govt: $12.5m
Oceanlinx Limited	Oscillating water column	South Australia	Commercial demonstration	1 MW	Early-stage development. Scheduled completion end of 2013	ARENA*: $3.9m
BioPower Systems Pty Ltd.	BioWAVE	Victoria	Demonstration	0.25 MW	Early-stage development. Scheduled completion end of 2013	ARENA*: $5.6m Victorian Govt: $5m
AquaGen Technologies Pty Ltd.	SurgeDRIVE	Victoria	Demonstration	0.15 MW (scaled up to 5 MW)	Installed 2010	Information not available
Wave Rider Energy Pty Ltd.	Wave Rider	South Australia	Pilot	Up to 1 MW	Installed 2011	Information not available
			Total	23.4 MW		
Tidal-energy projects						
Tenax Energy Pty Ltd.	Marine-current turbine developed by Open Hydro Ltd.	Northern Territory	Proposed	200 MW	Early-stage planning	Seeking government support
Tenax Energy Pty Ltd.	Marine-current turbine developed by Open Hydro Ltd.	Tasmania	Proposed	302 MW	Early-stage planning	Seeking government support
Tenax Energy Pty Ltd.	Marine-current turbine developed by Open Hydro Ltd.	Victoria	Proposed	34 MW	Early-stage planning	Seeking government support
Atlantis Resource Corporation	Marine-current turbine (AN-400)	Victoria	Pilot	0.15 MW	Installed 2006	Information not available
			Total	536.15 MW		

** ARENA = Australian Renewable Energy Agency*
Source: EY study

A range of public organizations and ocean energy companies have been performing R&D activities related to wave and tidal technology for a number of years. For example, Carnegie Wave Energy Limited has developed a test center in Perth, Western Australia, while the University of Queensland has conducted testing in a purpose-built wave tank to validate technological developments.

In 2012, the Commonwealth Scientific and Industrial Research Organization's (CSIRO) Wealth from Oceans Research Flagship was commissioned by the Federal Department of Sustainability, Environment, Water, Population and Community to produce maps of Australia's various ocean energy resources. This study has determined that Australia's natural wave resources are very significant. In particular, the resources located along Australia's western and southern coastlines offer the greatest potential. According to the CSIRO, Australia's wave energy sources could produce over 1,300 TWh per year of energy. This represents approximately five times Australia's current energy demand.

The CSIRO has also estimated that wave energy could supply about 10% of Australia's energy by 2050, but there are many factors that will determine its place in Australia's future energy mix.

Policy developments

Two major federal government policies — the Renewable Energy Target (RET) and Carbon Pricing Mechanism (CPM) — can potentially contribute to the development of the Australian ocean energy sector. Two funding vehicles have also been created under the Clean Energy Futures scheme to provide direct and targeted financial assistance to renewable energy projects via the Australian Renewable Energy Agency (ARENA) and the Clean Energy Finance Corporation (CEFC).

The RET was established in 2001 to increase the production of renewable electricity in Australia by 45,000 GWh by 2020, or to 20% of Australia's total electricity production in 2020. The RET was designed to encourage AU$20b of investment in renewable energy by 2020 by creating a market for Renewable Energy Certificates (RECs); however, current REC pricing is considered insufficiently high to support the development of ocean energy projects.

From 2012, the CPM will impose a cost on the emission of greenhouse gases for the largest emitting sectors in the Australian economy (e.g., stationary energy sector, transport, industrial processes, non-legacy waste and fugitive emissions). The nature of the cost imposed by the CPM is likely to encourage investment into market-ready and commercially deployable technologies that rely on wind and gas. However, in the short term, it is not likely that the CPM will encourage the development of ocean energy technologies due to the short-term pricing constraints. In addition, the political uncertainty of the CPM means that it is unlikely — at least on its own — to support the development of the Australian ocean energy sector.

To date, the ARENA has awarded approximately AU$86m in direct cash grants to support the development of ocean energy projects. Of this total, approximately one-fifth has been awarded via ARENA's Emerging Renewables Program, a AU$126m program that is designed to support the development of renewable energy technologies in Australia throughout the innovation chain. ARENA continues to seek applications for funding from all renewable energy technologies, including those relating to the ocean energy sector.

The CEFC's objective is to invest its AU$10b budget in businesses seeking funds to develop innovative clean energy projects and technologies, commencing from 1 July 2013. Its investment focus is on innovative technologies in the latter stages of market demonstration, commercialization and market growth. It is envisaged that the CEFC will offer debt and provide equity on commercial and concessional terms; however, during the early stages of the investment phase, it is anticipated the majority of its investments will be loans rather than equity with limited room for loan guarantees.

Early-stage commercialization projects can also receive financial assistance from Commercialization Australia. The federal government has funded Commercialization Australia to the value of AU$278m over the five years to 2014, with ongoing funding of AU$82m a year thereafter. Although ocean energy projects have been awarded grants under Proof of Concept programs, the level of assistance (capped at AU$250,000 per project) is not likely to assist in the scale-up of the ocean energy sector.

In addition to the support provided by the federal government, a number of states have also provided funding to ocean energy projects. These funding programs include:

- Western Australia's Low Emissions Energy Development Program, which provides financial support for the demonstration and commercialization of innovative low greenhouse-emission energy technologies in Western Australia
- The Victorian Sustainable Energy Pilot Demonstration Program, a AU$20m program supporting pilot-scale demonstration plants for renewable energy

Overview of the sector

Although there are over 20 companies active in the sector, including technology developers, project developers and consulting companies, Australian ocean energy has seen limited entry of traditional utilities companies, engineering companies and offshore engineering companies. A number of public organizations, including the CSIRO and Australian universities, have performed R&D activities.

The Ocean Energy Industry Australia (OEIA) association was established in March 2012 to promote research, development and deployment of ocean energy in Australia. The OEIA is in charge of promoting public understanding and adoption of ocean energy technologies, practices and systems and is also involved in compiling and disseminating research and information about ocean energy.

As they move toward the pre-commercial stage, ocean energy projects will require Power Purchase Agreements (PPAs). Carnegie Wave Energy Limited has signed a PPA for its Perth Wave Project with the Department of Defense for HMAS Stirling naval base on Garden Island. The PPA covers the exclusive purchase of all the electricity generated from the project and connection into the base's electrical infrastructure. Further, certain Australian ocean energy companies have implemented partnerships with utilities and engineering companies that will assist in moving toward full-scale, commercial projects in the future, including:

- The 2010 memorandum of understanding between Carnegie Wave Energy Limited, French companies EDF Energies Nouvelles (EDF EN) and French marine defense contractor DCNS. As part of this relationship, Carnegie Wave Energy Limited and EDF EN agreed to develop a wave power project on the French overseas territory of Réunion Island. DCNS will play a role in engineering, procurement and management of the wave project.
- The Victorian Wave Partners Pty Ltd. is a joint venture between Leighton Contractors Pty Ltd. and Ocean Power Technologies Pty Ltd. (which is itself a subsidiary of the US-listed Ocean Power Technologies Inc.).

Perspectives

The vast potential of Australia's ocean energy resources places Australia in an enviable position in the international context. However, Australia's resource potential contrasts with the current state of development of its ocean energy sector.

In order to address this challenge, public authorities are providing targeted financial support so that technology and project developers may move rapidly from R&D to demonstration, commercialization and integration into Australia's electricity grid. In this regard, ARENA and the CEFC offer useful financial mechanisms to support emerging ocean energy technologies. Effective financial support is critical for ocean energy technologies to be pushed down the technology cost curve, enabling them to compete with other alternative technologies. From this stage, the RET and CPM will provide the necessary regulatory and market forces to enable the Australian ocean energy sector to grow. However, the political uncertainty surrounding the CPM and related clean energy schemes may hinder the potential for significant investment in the Australian ocean energy sector.

Australian ocean energy developers may also overcome the difficulties in accessing capital by exporting their services internationally and creating partnerships with utilities and engineering companies. This will allow ocean energy ventures to move toward full-scale projects, become commercially viable and attract interest from larger and more financially robust companies in Australia and overseas.

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Point of view

Dr. Michael Ottaviano

EY: Could you provide an overview of Carnegie Wave Energy Limited (CWE), its technology and its position in the Australian ocean energy sector?

Michael Ottaviano: In 2009, CWE became the sole owner and developer of the CETO technology, which is designed to harness wave energy to produce electricity. CWE's CETO technology is unique within the wave energy sector.

Unlike other developed wave technologies, the CETO wave power converter was the first unit to be fully submerged and to produce high-pressure water from the power of waves, which allows electricity to be generated either onshore or offshore.

CWE is currently developing the fourth and fifth generation of its CETO technology by deploying these technologies in projects in Perth, Western Australia, and La Réunion, respectively. The Perth Wave Energy Project is a commercial demonstration expected to be delivering electricity by the end of 2013.

As a company, CWE is unique within the Australian ocean energy landscape as it is one of only a few publicly listed wave technology developers in the world. This means that the pools of capital that CWE can access are different from those that a private company is able to access.

EY: What were the principal barriers that CWE encountered in developing its project in Perth (e.g., technical, political or financial)?

Michael Ottaviano: The largest barrier that CWE has encountered in developing its Perth project has been gaining access to capital. The reason for this is that there is currently very little risk capital available in Australia and overseas. In addition, the capital-intensive nature of wave energy technologies – which might require approximately AU$100m before commercialization – has also made it difficult to obtain the capital required to develop a project.

A further barrier has been the reluctance among Australia's large power utilities and engineering companies to become involved in the commercialization of new renewable technologies.

EY: How did CWE address those barriers?

Michael Ottaviano: To address the identified barriers, CWE has had to look overseas to assist in the development of its capital base. This has led to CWE raising some AU$50m in development capital, as well as establishing joint venture and licensing agreements with EDF Energies Nouvelles and an engineering relationship with French marine defense contractor, DCNS.

Managing Director
Carnegie Wave Energy Limited

The benefit of these relationships is that they have provided CWE (and its CETO technology) with further capital, capability and credibility. For example, DCNS carried out wave tank testing of a CETO prototype at the University of Nantes, France, under the supervision of EDF, and EDF is now installing the CETO 4 generation off Réunion Island in the Indian Ocean.

In addition, some AU$18m in financial support is being provided by the federal and the Western Australian Governments — from the Australian Renewable Energy Agency and Western Australia's Low Emissions Energy Development Program — which has provided CWE with additional resources to develop its technology.

EY: What do you see as CWE's primary advantage when compared with other technology producers of wave-based technology in Australia and overseas?

Michael Ottaviano: CWE's primary advantage is its technology. The CETO technology is substantially different from the other wave energy technologies that are available or under development.

Two features of the CETO technology are regarded as particularly advantageous. First, the electricity generation component of the technology is separated from the in-water component. This feature is designed to minimize the cost of electricity production (as offshore electricity generation technology represents a substantial cost) and ensure the long-term survivability and serviceability of the technology.

The second advantage of the CETO technology is that it is fully submerged and therefore does not impose any aesthetic barriers, and it does enhance storm survivability.

EY: What are CWE's growth perspectives in Australia and overseas during the next 10–20 years?

Michael Ottaviano: CWE's immediate task is to finalize the grid-connected demonstration plant that is currently under development in Perth. Once this is complete, CWE will focus on developing array projects that can be connected to the electricity grid. CWE also aims to have its first commercial wave energy project developed and connected to the electricity grid in 2015–16.

Over the longer term, CWE will continue to develop its technology so that it is capable of being scaled up, as this is the only way that the technology will be able to be moved down the cost curve and compete effectively with other renewable energy projects. This will require CWE to develop facilities with a capacity of approximately 100 MW by the end of the decade, so that it can compete successfully on Australian and international energy markets.

Point of view

Alan Major

EY: What is Ocean Energy Industry Australia's role or position in the ocean energy sector?

Alan Major: OEIA was established in March 2012 and has 20 members, including technology developers, project developers and governments. OEIA is designed to promote research, development and deployment of ocean energy in Australia.

EY: What support does OEIA provide to ocean energy project and technology developers?

Alan Major: OEIA aims to achieve its broad ambition by facilitating public understanding and adoption of ocean energy technologies, practices and systems. OEIA is also there to engender greater knowledge of Australia's ocean energy sector among all levels of government in Australia, as well as industry and the supply chain, in order to support the sector. Examples of activities that OEIA is undertaking include:

- Preparation of a submission in which OEIA requested funding from the Australian Renewable Energy Agency for support for an Australian representative to participate in the International Energy Agency's Ocean Energy Working Group and the International Electrotechnical Commission's standard-setting for ocean energy
- Arranging forums for its members that will enable participants to enter into a dialogue about the various issues, barriers and opportunities confronting the ocean energy sector in Australia

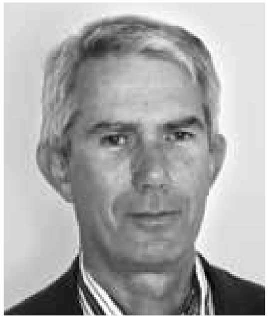
EY: What competitive advantages does Australia have in the international ocean energy market?

Alan Major: Australia's ocean energy sector has two principal advantages when compared with its international competitors. First, Australia has world-leading ocean energy resources. Second, Australia is one of the world leaders in developing new designs and technologies to harness wave and tidal energy from the ocean in a cost-effective manner.

EY: What are the principal barriers facing the development of the ocean energy sector in Australia?

Alan Major: Despite Australia's relative resource and intellectual strength in the global ocean energy sector, Australia's current policy and regulatory framework inhibits the Australian sector from realizing its potential. In particular, OEIA has identified that one of the major barriers in this regard is that the route to commercialization of ocean energy technologies is made difficult by the lack of integration among the federal and state government policy settings.

That barrier is compounded by the fact that the major policies and programs that are designed to support renewable energy — particularly the Renewable Energy Target — are not designed specifically to support the development of emerging renewable energy such as ocean energy technologies. This is in contrast to the regulatory frameworks that exist in a number of Australia's competitors, such as Scotland and Canada, where government support encourages the development of the local ocean energy sectors through a broad range of integrated policies.



Director
Ocean Energy Industry Australia

EY: In light of these barriers, what are the requirements to accelerate the development of the ocean energy market?

Alan Major: OEIA considers that the most critical requirement to address the principal barriers facing Australia's ocean energy sector is an effective, integrated and well-financed funding and regulatory approach that enables industry advancement from desktop design to deployment. If such an approach were implemented, participants in Australia's ocean energy sector could avoid much of the administrative burden that they currently face in obtaining funding, while the regulatory framework would also offer project developers sufficient financial incentive to encourage projects toward commercialization and large-scale deployment.

EY: What are the growth perspectives of the ocean energy sector in Australia during the next 10–20 years?

Alan Major: Exponential. Australia possesses some of the best ocean energy resources of any country in the world, and a population that consistently supports clean energy. We simply need to address the principal barriers that are limiting this growth from occurring.

In addition to the potential growth of the technology and project facets of the ocean energy sector, there is also a tremendous opportunity for Australia's ocean energy sector to become a leader in the export and ongoing maintenance of these technologies. From an economic perspective, OEIA considers that the opportunities associated with the long-term operation and maintenance of ocean energy projects represent a substantial opportunity for the ocean energy sector in Australia, particularly given the strong history of innovation and technical capability already exhibited by this sector in Australia.

Canada

Current status

With borders on three oceans and near-limitless waterways, Canada possesses extensive marine resources, which could satisfy more than 25% of Canada's electricity demand.

Table 2. Wave-energy potential in Canada

	In-stream tidal	River-current	Wave	Total
Extractable mean potential power	~6,300 MW	> 2,000 MW	~27,500 MW	~35,800 MW
Provinces with potential power	• Nova Scotia • New Brunswick • Quebec • British Columbia • Arctic	• Quebec • Ontario • Manitoba • British Columbia • Arctic	• British Columbia • Nova Scotia • Newfoundland and Labrador	5 MW
Canadian electricity demand (rated capacity, 2010)				134,000 MW

Source: Marine Renewable Energy Technology Roadmap, October 2011

CA$1 = €0.78

Policy developments

In 2011, Canada's marine industry established national capacity targets of 75 MW by 2016, 250 MW by 2020 and 2,000 MW by 2030. These targets are expected to generate CA$2b in annual economic value to the Canadian marine sector in 2030 and beyond.

Following the development of Nova Scotia Power's 20 MW Annapolis Tidal Power Plant in 1984, no commercial marine projects have reached commercial operation in Canada. However, marine energy activity in Canada is being driven forward once again in Nova Scotia, on Canada's east coast. The Nova Scotia Government established a feed-in tariff procurement mechanism for tidal power. To date, 3.9 MW of feed-in tariff contracts have been awarded for five projects. A further round of contracts is being developed in Nova Scotia for large-scale projects connected to the transmission system. The direct connection to transmission allows the development of larger projects.

Overview of the sector

Canada has an active developer community clustered around the available natural resources. Augmenting Canadian developers, the Ocean Renewable Energy Group is a network of marine research centers supporting technology and policy development across Canada. The image below shows a selection of Canada's R&D resources and clearly illustrates R&D clustering on Canada's most accessible coasts.

Perspectives

Canada's marine sector presents a range of near-term opportunities: developing wave energy technologies on British Columbia's Pacific coast; developing hydro-kinetic/river-current technologies across the country; and developing tidal energy generation on Nova Scotia's Atlantic coast.

Apart from those mentioned, no new calls for projects are expected; however, R&D activities continue on both coasts to present Canada with the opportunity for a diverse portfolio of electricity generation sources and the related security this diversity provides.

Canada's marine energy is well placed to compete on the international stage, having many base industries in marine engineering and related sectors co-located close to some of the best global resources. Domestically, Canada is also endowed with conventional energy resources, creating policy challenges to increase focus on emerging renewable energy technologies, including marine technologies, despite their potential. A lack of market pricing in many of Canada's electricity markets because of continued public ownership has turned electricity pricing into a highly political issue and a view that any changes to the historic cost of power is unacceptable. These factors could contrive to serve as a constraint on Canada's marine energy industry's growth prospects.

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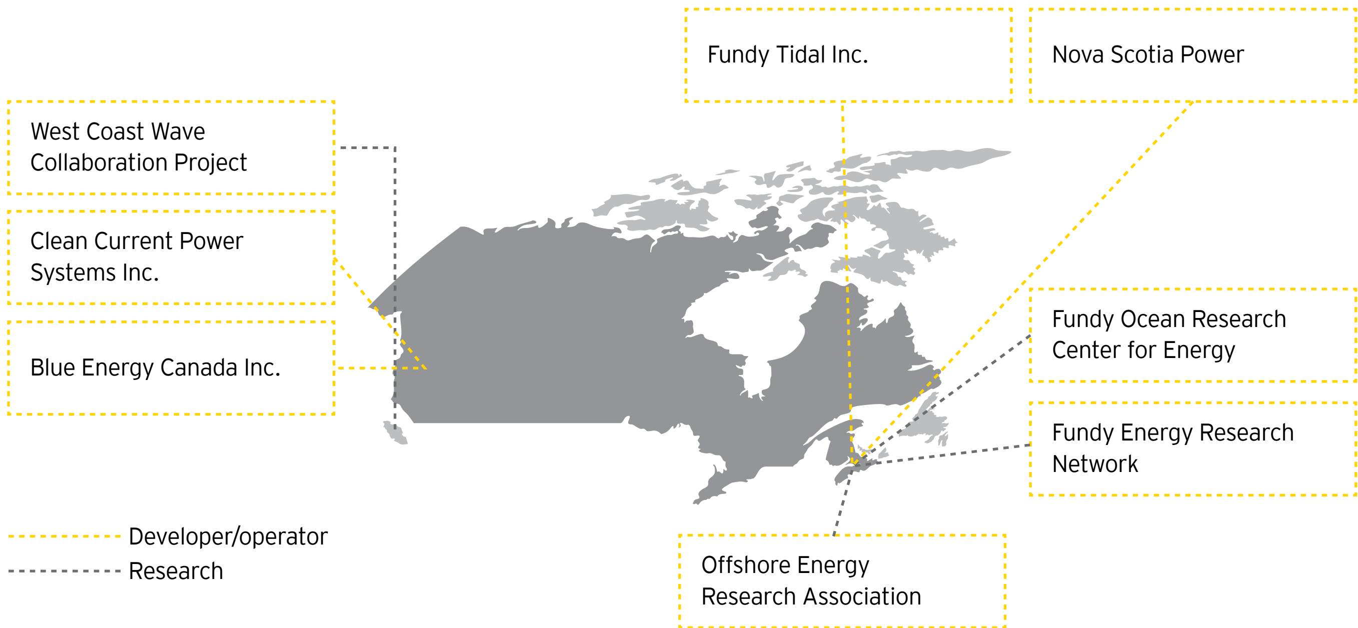
Chart 1. Key Canadian players in the ocean energy sector



Point of view

Melanie Nadeau

EY: Please introduce your company.

Melanie Nadeau: Emera is an energy and services company based in Halifax, Nova Scotia, Canada. Traded on the Toronto Stock Exchange, Emera has approximately CA$7.5b in assets and interests in northeastern North America, and in three Caribbean countries. Emera is involved in generation, transmission and distribution activities and derives around 80% of its earnings from regulated investments. Emera employs about 3,000 employees across all regions.

EY: What is your company's role or position in the ocean energy value chain?

Melanie Nadeau: Emera's focus is the transformation of electricity generation to clean energy and the ability to distribute clean energy to load sources. Emera and its subsidiaries may have different roles within this sector.

- Strategic investor: Emera has invested in the turbine supplier OpenHydro.
- Project developer: Through its subsidiary Nova Scotia Power, Emera has deployed a tidal stream turbine in the Bay of Fundy.
- Customer: Emera, through Bangor Hydro, is involved with the first grid-connected tidal stream generator in the US.

Emera considers itself a strategic partner, having been involved with the sector since the early 1980s through the development of the Annapolis Tidal Power Station, a barrage-style plant, and being involved in many points of the value chain.

Emera sees tidal power as an opportunity for Atlantic Canada – there's a role for the region to tap into the global market, given the excellent local resource and a strong marine sector.

EY: Who are your main competitors? Your key partners?

Melanie Nadeau: Emera's main competitors are the other energy stocks listed on the Toronto Stock Exchange. We have many partners across the energy industry landscape and plan to work with them to further Atlantic Canada as a tidal energy hub.

EY: What is your technology segment?

Melanie Nadeau: Emera's interests are focused on tidal, given the significant resource that lies close to our existing operations.

EY: What are your growth perspectives?

Melanie Nadeau: This is an opportunity to build an industry – it's still early days, but Atlantic Canada can be one of the leaders in this global market. The market for tidal is significant. We expect to install commercial-scale tidal-stream power plants in 2020 and beyond.

Senior Manager
Sustainability, Emera Inc.

EY: What are the main barriers facing the sectors? What are the requirements to accelerate the development of the ocean energy market?

Melanie Nadeau: First, technology reliability. The sector holds significant technology risk given that it is operating in the open ocean environment.

Second, connection infrastructure — working on effective subsea deployment of array interconnection and transmission infrastructure while keeping the costs manageable remains unresolved.

Third, deployment — a progressive deployment strategy will be required, in order to manage investment risk through de-risking projects by targeting progressively higher energy-yield sites.

Finally, cost competitiveness — reduction in cost of energy, including operation and maintenance. This will come with economies of scale, innovation and experience in deployments.

EY: What type of support do you expect from policy-makers?

Melanie Nadeau: A public sector-led comprehensive direction on marine renewable energy should be developed, providing gravitas to the sector and giving investors some comfort over long-term outcomes. Policy-makers can provide a development pathway, allowing for project development clarity through streamlining policy direction, including land access, permitting and so forth.

EY: What is your vision of the market in the next 20 years?

Melanie Nadeau: The Bay of Fundy would contain multiple devices in the water, providing experience of deployed and demonstrated technology. This is together with a strong understanding of resources available in the Bay of Fundy, how it is best accessed, and the associated grid-management processes for integration with the onshore grid. We should be seeing a commercial market with tidal farms on the order of 50 MW plants or more in the Bay of Fundy and around the world.

EY: From your point of view, which country presents the most promising growth opportunities in the next years?

Melanie Nadeau: Canada, which possesses world-class resources, practical marine/offshore knowledge and a history in tidal energy.

The UK has gone into the sector with considerable public investment, and policies and targets put in place have spurred industry growth.

And France, which has an industrial approach to develop/secure manufacturing and R&D.

The sector contains many questions to be answered. As such, the industry should focus on collaboration rather than competition — success at any point of the value chain will benefit the rest of the industry.

Point of view

Dana Morin

EY: Please introduce your company.

Dana Morin: Fundy Tidal Inc. (FTI) was established in 2006 to take advantage of local interest in opportunities to generate renewable energy from the tidal currents of the Digby Gut and Grand and Petit Passages located in Digby County, which borders the Bay of Fundy. FTI's mission is to serve as a vehicle for community-led, in-stream tidal energy projects throughout Nova Scotia; establish Digby County, Nova Scotia, as a focal point for marine renewable energy industry development for commercial and R&D activities; and maximize profits and economic opportunities for shareholders, partners and the community.

EY: What is your company's role or position in the ocean energy value chain?

Dana Morin: Fundy Tidal is focused on tidal in-stream energy conversion devices as the appropriate technology to generate electricity from the swift-moving currents of project locations in Digby County and Cape Breton.

The company has several key roles in the value chain:

- Project developer in the Bay of Fundy via the small-scale tidal Community Feed-in Tariff Program (COMFIT)
- Provider of consulting services and technical expertise
- Leader in research activities with an aim of commercializing new products and services
- Active in policy and industry development through participation in Marine Renewables Canada, the Fundy Energy Research Network and federal and provincial strategies

EY: Who are your main clients? Is your market mainly domestic or international?

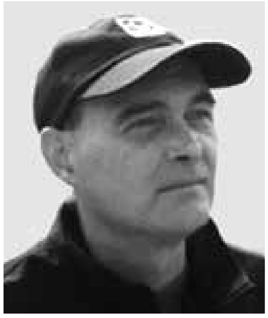
Dana Morin: FTI expects to sell its product to purchasers of renewable energy generated from tidal currents and provide engineering and consulting services to the marine renewable energy industry. The primary focus is on conducting business in Nova Scotia by selling renewable energy to Nova Scotia Power Inc. via the small-scale tidal COMFIT and generating additional revenues by providing expertise to project developers and research and development initiatives. Long-term goals are to expand sites currently under development and establish new renewable energy projects in other jurisdictions and to provide services and/or products to the industry internationally.

EY: Who are your main competitors?

Dana Morin: There are currently no other companies involved in small-scale tidal development in Nova Scotia. FTI holds five small-scale tidal COMFITs awarded by the Province of Nova Scotia.

EY: Who are your key partners?

Dana Morin: FTI is in discussion with multiple technology providers, seeking sub-500 kW devices (Nova Scotia requirements). Device conversations have included Torcado (Netherlands), Clean Current Power Systems (British Columbia), New Energy Corporation (Alberta), Nautricity (UK) and Ocean Renewable Power Company.



Director of Business Development
Fundy Tidal Inc.

EY: What are your growth perspectives?

Dana Morin: Upon the completion of the COMFIT projects, the company will seek to expand these sites. A second developmental tidal array FIT is currently being finalized in Nova Scotia for large-scale projects connected to the transmission system and represents a significant opportunity for Fundy Tidal. New Brunswick represents the next opportunity for growth though it currently lacks a procurement mechanism for tidal power.

EY: What are the main barriers facing the sector? What are the requirements to accelerate the development of the ocean energy market?

Dana Morin: The main barriers relate to availability of funding and access to markets.

Regarding funding, investment and debt financing for the marine renewable energy industry are challenged by lack of technology track record and established capital and operating cost values.

Regarding access to market, the Nova Scotia market has been opened through feed-in tariff mechanisms. Other Canadian provinces have significant resource potential but lack any form of market mechanism to sell tidal power in these jurisdictions.

EY: What type of support do you expect from policy-makers?

Dana Morin: Canadian federal and Nova Scotia provincial policies have been very supportive to date. The development of the Canadian Marine Renewable Energy Technology Roadmap in October 2011, reinforced by supportive provincial strategy, has helped create both targets and a process to progress projects and the industry.

Recent strong examples of political support include:

- The small-scale tidal COMFIT rate of CA$652 per MWh
- The planned development this year of a tidal array feed-in tariff for large-scale transmission-connected projects at the Fundy Ocean Research Centre for Energy

EY: What is your vision of the market in the next 20 years?

Dana Morin: FTI's vision is for Canada to become a global leader in the delivery of clean wave, in-stream tidal and river-current energy-production systems and technologies.

Canada will be demonstrating leadership in technical solutions and services, such as assessment, design, installation and operation, to provide value-added goods or services to 30% of all global marine renewable energy projects by 2020 and to 50% of all projects by 2030.

EY: From your point of view, which country presents the most promising growth opportunities in the next years?

Dana Morin: The most attractive markets are additional Canadian provinces and the UK.

France

Current status

With more than 11 million square kilometers of ocean surface under its jurisdiction (mainland and overseas), France is endowed with major natural potential with regard to renewable ocean energy. This potential includes wave power, tidal power, tidal currents and thermal gradient. Based on current knowledge, the aggregate potential capacity is evaluated by the Government in a range of 3 to 5 GW.

Within the framework of the European climate and energy policy package and through the Grenelle law, explained in more detail later, France has set a target to increase the share of renewable energy to 23% of its total energy consumption by 2020, with a contribution of various types of marine energy estimated at 3%. France thereby expects to generate benefits in terms of economic development and employment while keeping overall costs for electricity consumers under control.

This commitment was reinforced during a meeting held in Cherbourg on 25 February 2013, where the French Environment Minister announced several measures to support the ocean energy sector, in particular a call for projects aiming at establishing demonstrators, as well as several studies contributing to creating a sustainable framework for commercial deployment. Ocean energy players in France are also expecting a potential call for tender within the next two years for a tidal current project in the Raz Blanchard area.

France has acquired exceptional industrial experience from the tidal range energy power plant in the Rance estuary, which has been in operation since 1966. It is currently the world's second-largest tidal energy plant, with a power capacity of 240 MW. A number of technology prototypes and demonstrators are currently being developed in France (see Table 3), such as the tidal energy turbine installed in Brittany by EDF and DCNS (OpenHydro). France can build upon the recognized capabilities of its engineering firms specialized in marine installations, its industrial companies, which manufacture power generation equipment, and offshore construction companies. Research organizations and laboratories in the country also have the necessary skills and expertise to foster the development of a marine energy industry.

Table 3. Ocean energy projects in France

Project consortium	Technology	Location	Maturity	Capacity	Development stage	Total cost and financial support
Floating offshore wind-energy projects						
EDF, Technip, Nenuphar, Converteam (GE)	VertiMed (based on Vertiwind project)	Fos-sur-mer (Mediterranean Sea)	Demonstration site with 13 floating wind turbines under preparation	26 MW	Early stage of development. Scheduled completion end of 2016	Total cost: €130m Support: EU under NER300 Fund (€37m), Idinvest Partners (€3m), ADEME
Nass & Wind, DCNS, Vergnet, IFREMER, ENSTA Bretagne	WinFlo	Atlantic Coast	Semi-submersible free-floating platform combined with a large wind turbine	5 MW	Early stage of development. Scheduled completion end of 2014	Total cost: more than €35m Support: ADEME (€13,4m)
Tidal-current energy projects						
EDF DCNS (OpenHydro) STX	OpenHydro	Atlantic Coast (Pimpol-Bréhat)	Tidal-turbine prototype Pilot tidal-energy farm and test site for the French sector	0.5 MW 2 MW	Tested Early stage of development. Scheduled completion in 2014	Total cost: €40m Support: Public sector (€7,2m)
Sabella, IFREMER, Veolia Environnement, Bureau Véritas	Sabella 10	Atlantic Coast (Fromveur, Brittany)	Prototype D10	0.5 MW	Tested. The next phase will be a tested farm, still in early stages of development (scheduled for completion in 2016)	Total Cost: NC Support: ADEME
ALSTOM, EDF, SECTOR, STX, IFREMER	ORCA	Atlantic Coast (Pimpol-Bréhat)	Large tidal turbine	1 MW	Tests scheduled end of 2013	Support: ADEME
GDF Suez, Voith Hydro, CMN, Cofely Endel, ACE	HyTide – Voith Hydro	Atlantic Coast (Raz Blanchard, Normandy)	Pilot tidal-energy farm (3 to 6 turbines)	3 to 12 MW	Early stage of development. Scheduled completion in 2016	Total Cost: NC
GDF Suez, Sabella	Sabella	Atlantic Coast (Fromveur, Brittany)	Tidal-energy farm	NC	Early stage of development	Total Cost: NC
Wave-energy project						
SBM Offshore	SEM REV (S3)	Atlantic Coast (Brittany)	Multiple technologies test site		Early stage of development. Scheduled completion in 2015	Total cost: €18m Support: ADEME

Sources: *EY, various press releases*

Policy developments

Several R&D supporting instruments have been put in place in France, such as research funding grants and demonstrator financing. A total of nearly €80m has been invested in the development of ocean renewable energies. Other initiatives have aimed at creating a favorable environment for the emergence of these technologies. Several examples can be mentioned:

- The construction of five demonstrators co-financed up to €40m by the Investing for the Future program, under the management of ADEME, the French agency for energy and the environment – two floating offshore wind energy projects (WinFlo and VertiMed/Vertiwind), two tidal current energy projects (Orca and Sabella 10) and one wave energy project (S3)
- The creation of the Institute France Energies Marines in 2012, labelled as an Institute of Excellence for Carbon-Free Energies (IEED), and financed by the French Government up to €34.3m over a 10-year period. Led by the French Research Institute for Exploitation of the Sea (IFREMER), France Energies Marines brings together a wide range of relevant stakeholders: private companies, research organizations and higher education institutions with R&D and demonstration objectives, such as the creation and management of shared test sites
- Support to small and medium enterprises (SMEs) and innovative start-ups granted through other public mechanisms, with the support of competitiveness clusters such as Pôle Mer Bretagne and Pôle Mer PACA
- The adoption of a feed-in tariff to encourage the development of marine renewable energy since 2007 (€150/MWh)

- Following the publication of a roadmap in 2009 and an environmental conference that brought together major international industrial players (energy companies, developers, research organisms) to reaffirm the commitments established during the French Grenelle Process for the environment in late 2012, the French Government announced the preparation of a national strategic action plan on marine renewable energy, to be released in April 2013

The French renewable marine energy sector also benefits from European R&D support mechanisms. France participates in FP7 programs, presented three marine technology projects at the NER 300 European call and received funding for the VertiWind project from the EU.

Overview of the sector

France's marine energy assets (natural resource potential, industrial experience, economic fabric), together with the implementation of French Government policy to support R&D activities, open up possibilities for the development of a French industrial ocean energy sector. France benefits from a strong network of researchers active in this field (mainly from IFREMER, SATIE laboratory [CNRS-ENS Cachan Bretagne], the universities of Centrale Nantes, Navale Brest, ENSTA Bretagne and IFP Energies nouvelles) and from the rising involvement of major French utilities and industrial companies (Alstom, EDF, DCNS, GDF Suez in particular). These multinational companies contribute to scaling up projects and innovative technical solutions developed by SMEs in France and abroad and to progress toward commercialization stages.

The recent designation as an Institute for Carbon-Free Energy and the associated Government financing (€34m over a 10-year period) will allow France Energies Marines to strengthen and develop the structure and organization of the sector. The clearly stated objective of the cluster is to support ongoing research projects by focusing public and private funding. Fifty-five stakeholders constitute the public-private partnership, with 33 private organizations (including nine large corporate groups). The proposed organization is also the outcome of a dynamic partnership set up on the basis of demonstration projects of various energy-harnessing devices at sea, as well as prospective studies to determine upcoming market trends, technological obstacles, criteria for environmental integration and compatibility of uses.

Perspectives

France has huge potential for exploiting marine renewable energy, coupled with strong R&D and industrial capabilities to develop these technologies for the market. In 2009, the French authorities launched the "Grenelle de la Mer," a stakeholder dialogue to identify objectives and actions to promote the development of ocean energy. Recent developments have focused on identifying the conditions required (such as grid-connection issues) for the launching of a possible call for tender for a tidal power plant in Normandy, expected by some to take place by 2014. The intense technology development carried out by French energy leaders is focusing on readiness to address this first large-scale commercial project in France.

Renewable marine energy represents a significant opportunity for overseas territories to contribute toward energy self-sufficiency. In these regions, renewable energy is structurally more competitive than in mainland France due to high fossil fuel and electricity prices. The leading technology tested overseas is ocean thermal energy conversion relying on a temperature difference of at least 20°C between warm surface water and cold deep water. A partnership is under discussion between DCNS, the regional authority of La Martinique, and STX France on an OTEC 10 MW pilot, which would be commissioned in 2016.

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Ireland

Current status

The following initiatives are currently under way for developing ocean energy in Ireland:

- The Westwave Project is being developed as a collaborative initiative among developers and technology providers to generate 5 MW of capacity by 2015.
- The Hydraulics and Maritime Research Centre (HMRC) at University College Cork has recently been formed to become a world-class center of excellence for ocean energy technology. It is a core hub for Europe's FP7 Marinet program for testing facilities for European ocean energy technology companies.
- Two 100 MW tidal projects were recently awarded in Northern Ireland, one to a venture between OpenHydro and Bord Gais and the other to a venture between DP Marine Energy and DEME Blue Energy.
- A 600 MW offshore wind project in Northern Ireland was recently awarded to a consortium consisting of Dong, RES and B9.
- Dong and Siemens have set up offshore wind turbine assembly facilities in Belfast in Northern Ireland to supply the UK market.
- The Irish Government is currently evaluating suitable grid-connected locations for pre-commercial wave-technology test sites.
- A Memorandum of Understanding (MoU) has recently been agreed between the UK and Irish Governments to facilitate the export of renewable energy from Ireland to the UK.

Policy developments

Ireland has committed to a 2020 target of 40% of all electricity consumed to be from renewable sources after reaching 18% in 2012. The Strategy for Renewable Energy 2012–20 has reaffirmed this 40% penetration commitment. One of the key objectives of the strategy is a commitment to realizing the economic potential of Ireland's wave and tidal resources.

Within this context, the 2007–20 Energy Policy Framework makes a commitment of 500 MW of ocean energy installed by 2020. The Irish Government has sponsored the establishment of the HMRC and Westwave facilities, and a €220/MWh feed-in tariff has been proposed for the ocean industry.

Overview of the sector

Renewable energy resources are seen as a key competitive advantage by many stakeholders in Ireland, given the potential to generate significantly more renewable energy than the domestic market needs and thus create an export opportunity. A range of ocean energy technology companies are currently active in Ireland, including Aquamarine, MCT, OpenHydro and Wavebob. Local utilities ESB, Bord Gais and SSE Renewables are also active participants in the ocean energy sector.

Perspectives

Recent emphasis by the Irish Government on the country's becoming a world leader in this sector has highlighted the potential the country can offer, given the research and development capabilities, the notable renewable energy targets, the mature and experienced domestic renewable energy sector and the very significant wave and tidal resources available.

These strengths are reinforced by Ireland's need to increase energy security. Government departments are focusing on simplifying and accelerating the foreshore licensing process to enable the rapid development and deployment of ocean energy technology. The integrated Marine Plan for Ireland outlined in the recent Government publication *Harnessing our Ocean Wealth* has highlighted for the first time the required actions to fast-track the development of the ocean energy sector in Ireland. This has been demonstrated by the MoU between the UK and Irish Governments mentioned earlier, and the development of the ISLES project to increase interconnection between Ireland and the UK and capitalize on the offshore wind, wave and tidal energy resources.

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South Korea

Current status

South Korea is surrounded by the water of three seas — Yellow Sea, East Sea and Korea Strait — which endows Korea with significant ocean energy resources. By utilizing favorable geographical conditions, feasibility assessments and research, development and demonstration investments in ocean energy technologies are taking place with a strong focus on tidal range power, following the completion in 2011 of the Sihwa tidal power plant.

Table 4. Total potential of ocean energy in South Korea (tonnes of oil equivalent [toe])

	Potential energy that can be produced with current technologies
Tidal	2,599,000
Tidal stream	288,000
Total	**2,887,000**

Source: New and Renewable Energy Report, Ministry of Knowledge Economy, Korea Energy Management Corporation 2012

Wave power is also considered an important resource, with estimated energy potential of 3,500,000 toe, but has not materialized yet. According to the Government's fifth plan for long-term electricity, the share of ocean energy potential is estimated to be 15.86% of the total estimated installed capacity of all new and renewable energy sources by 2024 (19.2 GW). This means that the installed capacity of ocean energy could reach almost 3 GW by 2024, mainly driven by tidal technologies.

Two tidal power plants are expected to be constructed, at Inceon Bay and at Ganghwa, with a capacity of 1,320 MW and 840 MW, respectively, by 2017. Additionally, one tidal-stream power project with a generating capacity of 53 MW is expected to be developed in Wando. The Ahsan Bay tidal power project is not mentioned in the fifth plan, but it has been announced that it will be developed by a consortium of Korea East-West Power Co. and Daewoo E&C with a capacity of 254 MW. Besides these power plants, a few additional tidal projects along the west coast are currently under feasibility assessments.

Table 5. Expectations of ocean energy facility construction over the period 2010–24 (MW)

Year	Ocean energy	Name of power station
2011	254	Sihwa tidal power plant
2014	50.5	Uldolmok tidal stream power plant
2015	520	Garorim Bay tidal power plant
2017	1,320	Incheon Bay tidal power plant
2017	840	Ganghwa tidal power plant
2017	53	Wando tidal stream power plant
Total	3,037.5	

Source: The Fifth Basic Plan for Long-Term Electricity Supply and Demand, Ministry of Knowledge Economy, South Korea

Most ocean energy projects in South Korea are being developed on the west and south coasts, due to the high tides and strong tidal currents in these regions. Ocean energy development in South Korea is mostly focusing on tidal power stations and is led by six power generators and conglomerates in engineering and construction, among them POSCO, Hyundai Heavy Industry and Daewoo E&C.

Sihwa tidal power plant, the world's largest tidal power station, was completed in 2011 by Korea Water Resource Corporation (K-water) and Daewoo E&C with a total capacity of 254 MW. Uldolmok tidal-stream power plant was built in 2009 with a capacity of 1.5 MW. The Government plans to increase the capacity of Uldolmok station to 90 MW by the end of 2013, enough to satisfy the demand of 46,000 households. There has also been ongoing development of a tidal power plant in Garorim Bay under the supervision of Korea Western Power Co. and POSCO. It is still in the process of receiving Government approval. Once it is built, it will generate capacity of 520 MW.

Six power generators exist in South Korea: Korea South-East Power Co. (KOSEPCO), Korea Southern Power Co. (KOSPO), Korea Midland Power Co. (KOMIPO), Korea Western Power Co. (KOWEPO), Korea East-West Power Co, (KEWESPO) and Korea Hydro & Nuclear Power Co. (KHNP). Since the west coast of South Korea has vast tidal energy resources, KOWEPO and KEWESPO have competitive advantages over others to develop tidal power. For instance, KOWEPO and KEWESPO are the main players for both the Garorim Bay and Uldolmok tidal projects. There are also private enterprises involved in ocean energy R&D; for instance, Daewoo E&C and POSCO are engaged in the construction of tidal power projects as EPC contractors.

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Sweden

Current status

Sweden has relatively good potential for ocean energy; for wave energy, it is estimated at 10–15 TWh. Sweden's Seabased is currently setting up the world's largest wave-energy plant on the west coast of Sweden, and several other technology developers are establishing pilot projects in Sweden and abroad.

The Swedish Energy Agency is responsible for Sweden's national energy research program. It finances energy research, technological development and demonstration activities in parallel with private capital and the industry. In 2011, the agency granted support of approximately €100m for R&D and innovation projects in the energy sector as a whole. In addition, Vinnova (Sweden's innovation agency) invests about €200m per year in early-stage innovation companies. Several ventures are connected to universities and technological institutions, thereby finding funding support in the early stages of their projects.

Seabased, a developer of a wave-power technology originating from the University of Uppsala, received €15m in support from the Swedish Energy Agency for its 10 MW pilot project, which will be funded with Finnish utility company Fortum. Other early-stage developers have received smaller grants for pilot installations.

Policy developments

Sweden introduced an electricity certificate system in 2003 to support the building of renewable electricity generation. Norway joined the Swedish electricity certificate system in 2012, creating a larger certificate market with the clear intention to increase liquidity, lower volatility and reduce the political risk in the system. The joint target is to stimulate new renewable energy production corresponding to 26.4 TWh by 2020, mainly from wind, biomass and hydropower. There is no separate target for ocean energy in Sweden, but ocean energy projects benefit from the same support system as other technologies.

In addition, renewable energy producers can apply for Guarantee of Origin certificates, which can be sold on the market. Currently these add a small amount of additional revenue.

Overview of the sector

There are several developers of wave-power technology in Sweden, with Seabased the most advanced. Seabased has developed a technology based on small units with all parts deployed on the seabed, except for a buoy on the surface. This technology safeguards the power plant and avoids issues experienced when the wave energy converter is placed on the surface.

Seabased is in the process of setting up the world's largest wave-energy plant (10 MW), with the sea cable and the first MW being put in place during 2013 and the remaining 9 MW during 2014. In total, approximately 400 units will be deployed off the coast of Lysekil on the Swedish west coast.

Commercial deliveries are expected from 2015. At an estimated cost-of-energy of €5 cents per kWh, the solution will be commercially viable without any subsidies. In 2011, Japanese trading house Mitsubishi entered as an owner, which will provide access to global distribution channels.

Other Swedish developers of wave technology include:

- Waves4Power, a developer of a wave energy converter placed in a buoy. The company is in the process of setting up a test park before entering into commercial production. Waves4Power is currently in a fund-raising process
- Vigor Wave Energy, which bases its technology on 400-meter-long hoses that float on the surface, developed in partnership with Chalmers University of Technology
- CorPower Ocean, with a wave energy converter of the point-absorber type, with a buoy on the ocean surface and the WEC between the surface and the bottom. CorPower Ocean has the Royal Institute of Technology as a development partner and is also in the process of raising additional development capital during 2013
- Ocean Harvesting Technologies, developer of a power take-off technology, in a partnership with E.On and Fred Olsen for development, will now shift focus from developing a complete WEC to marketing its power take-off solution to other WEC developers
- Minesto, which has developed a tidal-energy device named Deep Green. The device converts energy from tidal-stream flows into electricity by way of a novel principle, somewhat similar to the posture of a wind kite, and is based on technology originally developed by SAAB

In addition to companies engaged in developing wave-energy technology, Swedish Hexicon has developed large-scale floating platforms for offshore wind-energy production. Hexicon's platform technology includes a centralized swivel anchoring system that enables the platform to turn around its own axis and thereby to automatically align itself to the wind. The wind turbines of the Hexicon platform are therefore always facing the wind in an optimized configuration, leading to significantly increased efficiency in electricity production.

In addition to offshore wind turbines, Hexicon's 700x500-meter platforms can also house wave energy converters, and the total capacity can be in excess of 70 MW per platform.

The Department of Shipping and Marine Technology at Chalmers University of Technology hosts the innovation platform Ocean Energy Center, which aims to advance the ocean energy sector by initiating and coordinating joint research and development initiatives. The partner organizations are Minesto, Ocean Harvesting, Vigor Wave Energy, Waves4Power, IMCG, SP, SSPA, Chalmers and the Region of Västra Götaland.

Perspectives

As Sweden has no separate targets for installation of ocean energy, with technology-neutral public support of renewable energy, the commercial buildup of ocean energy plants is likely to be slow as it competes with other, more mature technologies, such as onshore wind and biomass. However, when wave-energy technologies become competitive, the potential for buildup is likely to increase.

In addition, ocean energy is an area of focus at several technological institutes and universities. This, together with the government support for developing new renewable energy technologies and innovation, which is relatively large as a percentage of GDP, has helped to foster an early-stage development of technologies with strong potential.

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Current status

The UK continues to be a global leader in marine energy, with more wave and tidal-stream devices installed than the rest of the world combined, according to RenewableUK. The last 12 months have seen continued technical progress: several companies are deploying full-scale single units in UK waters and embarking on test programs with a view to deploying multiple device arrays from 2015 to 2017.

In addition, the UK has benefited from a strong industrial base in shipping and offshore engineering, there is a relatively well-developed supply chain and a favorable regulatory and licensing environment, from the "5 ROCs" market-support mechanism to the approach of The Crown Estate (see "Point of view," p. 40).

This has created strong technical momentum for marine energy and the conditions to build a long-term domestic industry. But three recent trends suggest the UK will need to work hard to retain its front-running position:

1. Investment continues to be difficult to obtain from private sources in the UK, as discussed later.
2. There is increasing activity in overseas markets, as the other country surveys in this report show.
3. Electricity market reform is slowing investment decisions as the UK moves from its existing Renewables Obligation Certificates regime to a Contracts for Difference system to give greater clarity on revenue streams and stimulate investment.

£1 = €1.17

Table 6. Wave energy projects in the UK

Project	Developer	Owner	Technology	Location	Capacity	Development stage
Wave-energy projects						
EMEC Billia Croo	European Marine Energy Centre Ltd.	European Marine Energy Centre Ltd.	N/a – test site	Orkney, Scotland	Test site	Operational
FabTest	Falmouth Harbour Commissioners	Falmouth Harbour Commissioners	N/a – test site	Falmouth, England	Test site	Operational
Wave Hub	South West Regional Development Agency	South West Regional Development Agency	N/a – test site	Falmouth, England	Test site	Operational
Brough Head	Brough Head Wave Farm Ltd.	Aquamarine Power Ltd. & SSE Renewables Holdings (UK) Ltd.	Aquamarine Oyster	Pentland Firth and Orkney Waters, Scotland	200 MW	In development
Costa Head	SSE Renewables Developments (UK) Ltd. and ALSTOM UK Holdings Ltd.	SSE Renewables Developments (UK) Ltd.	AWS-III wave energy converters	Pentland Firth and Orkney Waters, Scotland	200 MW	In development
Marwick Head	ScottishPower Renewables Ltd.	ScottishPower Renewables Ltd.	Pelamis P2	Pentland Firth and Orkney Waters, Scotland	50 MW	In development
West Orkney Middle South	E.ON Climate & Renewables UK Developments Ltd.	E.ON Climate & Renewables UK Ltd.	Tbc	Pentland Firth and Orkney Waters, Scotland	50 MW	In development
West Orkney South	E.ON Climate & Renewables UK Developments Ltd.	E.ON Climate & Renewables UK Ltd.	Pelamis P2	Pentland Firth and Orkney Waters, Scotland	50 MW	In development
South West Shetland	Aegir Wave Power Ltd.	Pelamis Wave Power Ltd. & Vattenfall AB	Pelamis P2	Shetland, Scotland	10 MW	In development
Farr Point	Ocean Power Delivery Limited	Pelamis Wave Power Ltd.	Pelamis P2	Pentland Firth and Orkney Waters, Scotland	50 MW	In development
Bernera	Pelamis Wave Power Ltd.	Pelamis Wave Power Ltd.	Pelamis P2	Isle of Lewis, Scotland	10 MW	In planning
Burghead	AWS Ocean Energy Ltd.	AWS Ocean Energy Ltd.	AWS-III wave energy converters	Moray Firth, Scotland		In planning
Galson	Lewis Wave Power Limited	Aquamarine Power Ltd.	Aquamarine Oyster	Isle of Lewis, Scotland	10 MW	In planning
North West Lewis	Lewis Wave Power Limited	Aquamarine Power Ltd.	Aquamarine Oyster	Isle of Lewis, Scotland	30 MW	In planning
Siadar	Voith Hydro Wavegen Ltd.	Voith Hydro Wavegen Ltd.	Wavegen OWC device	Isle of Lewis, Scotland	30 MW	In planning
EMEC Scapa Flow	European Marine Energy Centre Ltd.	European Marine Energy Centre Ltd.	N/a – test site	Orkney, Scotland	Test site	In planning
		Total	690 MW			

Source: The Crown Estate website; developer websites

Table 7. Tidal-energy projects in the UK

Project	Developer	Owner	Technology	Location	Capacity	Development stage
Tidal-energy projects						
Strangford Lough	SeaGeneration Ltd.	Marine Current Turbines Ltd.	SeaGen	Northern Ireland	1.2 MW	Operational
EMEC Fall of Warness	European Marine Energy Centre Ltd.	European Marine Energy Centre Ltd.	N/a – test site	Orkney, Scotland	Test site	Operational
Inner Sound	MeyGen Ltd.	Atlantis Resources Corporation Pte Ltd., International Power Marine Developments Ltd. & Morgan Stanley Capital Group Inc.	Atlantis Resources Corporation AR1000/ Andritz Hydro Hammerfest HS1000	Pentland Firth and Orkney Waters, Scotland	400 MW	In development
Ness of Duncansby	ScottishPower Renewables Ltd.	ScottishPower Renewables Ltd.	Andritz Hydro Hammerfest HS1000	Pentland Firth and Orkney Waters, Scotland	100 MW	In development
Westray South	SSE Renewables Developments (UK) Ltd.	SSE Renewables Developments (UK) Ltd.	Tbc	Pentland Firth and Orkney Waters, Scotland	200 MW	In development
Ramsey Sound	Tidal Energy Limited	Tidal Energy Limited	DeltaStream	Pembrokeshire, Wales	1.2 MW	In development
Brough Ness	Sea Generation (Brough Ness) Ltd.	Marine Current Turbines Ltd. (a Siemens Business)	SeaGen	Pentland Firth and Orkney Waters, Scotland	100 MW	In planning
Cantick Head	Cantick Head Tidal Development Ltd.	SSE Renewables Holdings (UK) Ltd. & OpenHydro Site Developments Ltd.	OpenHydro Open Centre Turbine	Pentland Firth and Orkney Waters, Scotland	200 MW	In planning
Bellyherry Bay	Minesto UK Limited	Minesto UK Limited	Minesto Deep Green	Northern Ireland	120 kW	In planning
Bluemull Sound	Nova Innovation Ltd.	Nova Innovation Ltd.	Nova-I 30kW device	Shetland, Scotland	500 kW	In planning
Esk Estuary	GlaxoSmithKline Montrose plc	GlaxoSmithKline Montrose plc	Tbc	Montrose, Scotland	666 kW	In planning
Kyle Rhea	SeaGeneration (Kyle Rhea) Limited	Marine Current Turbines Ltd. (a Siemens Business)	SeaGen	Near the Isle of Skye, Scotland	8 MW	In planning
Lynmouth	Pulse Tidal Ltd.	Pulse Tidal Ltd.	Pulse-Stream	Devon, England	1.6 MW	In planning
Mull of Kintyre	Argyll Tidal Ltd.	Nautricity Ltd.	CoRMaT 500kW devices	Argyll, Scotland	3 MW	In planning
Ness of Cullivoe	Nova Innovation Ltd.	Nova Innovation Ltd. & Nova Yell Development Council	Nova-I 30kW device	Shetland, Scotland	30 kW	In planning
St David's Head	Tidal Energy Developments South Wales Ltd.	Tidal Energy Ltd. & Eco2 Ltd.	DeltaStream	Pembrokeshire, Wales	10 MW	In planning

Project	Developer	Owner	Technology	Location	Capacity	Development stage
Tidal-energy projects (contd)						
Sanda Sound	Oceanflow Development Ltd.	Oceanflow Development Ltd.	Evopod	Argyll and Bute, Scotland	35 kW	In planning
Skerries	SeaGeneration (Wales) Ltd.	Marine Current Turbines Ltd.	SeaGen tidal turbines	Anglesey, Wales	10 MW	In planning
Sound of Islay	ScottishPower Renewables UK Ltd.	ScottishPower Renewables UK Ltd.	Andritz Hydro Hammerfest HS1000	Islay, Scotland	10 MW	In planning
Isle of Islay	DP Marine Energy Ltd.	DP Marine Energy Ltd.	SeaGen, TGL 1MW device or other	Islay, Scotland	30 MW	In planning
EMEC Shapinsay Sound	European Marine Energy Centre Ltd.	European Marine Energy Centre Ltd.	N/a – test site	Orkney, Scotland	Test site	In planning
		Total	1 076 MW			

Source: The Crown Estate website; developer websites

Policy developments

Public sector and quasi-public support for ocean energy research has continued to be available from a number of sources. The funds are becoming increasingly aimed at accelerating the development of multiple-unit wave and tidal farms.

In the cases of the Technology Strategy Board and Energy Technologies Institute (a public-private partnership involving six global industrial companies and the UK Government), for example, funding has been provided for research into array cabling, subsea electrical hubs and whole-array cost of energy reduction. Others are awarding technology developers that are reaching for electricity generation and commercial milestones – such as the Scottish Government's £10m Saltire Prize and The Crown Estate's funding of up to £20m for tidal and wave arrays.

As funding becomes more targeted, it seems likely that winners and losers will emerge among technology developers, with those that can successfully deploy multiple devices in a position to drive down their cost of energy and be ready for the first orders of commercial farms under The Crown Estate's ongoing licensing regime.

Overview of the sector

An important theme of recent years has been the investment by overseas industrial companies in UK technologies. Industrial development is something to be welcomed in the sector, and the UK has long had a reputation for its open markets for foreign investment.

Nevertheless, with the sale of Tidal Generation Limited by Rolls-Royce to Alstom, it is notable that there is no UK-based global industrial company investing in marine energy technology. Other prominent UK technology developers that have looked abroad for industrial ownership or part-ownership include Marine Current Turbines (in which Siemens increased its stake to 100% in February 2012); Aquamarine (in which ABB Technology Ventures has a stake); AWS Ocean Energy (part-owned by Alstom); and TidalStream (part-owned by Schottel).

There are, however, a small number of mid-sized engineering and renewable development businesses that are supporting the development of marine energy devices. In addition, owing to its shipping and North Sea oil and gas heritage, the UK is home to a number of major businesses that have adopted a "watch-and-wait" strategy, but are interested over the medium term in forming part of the supply chain in marine energy, whether by supplying operations and maintenance services or engineering, procurement and construction.

Perspectives

A key challenge for the UK as the industry matures will be to retain its lead in technology and array deployment despite the inevitable pressures for industrial owners to deploy in their home markets.

There is also an emerging project developer market in the UK, with a handful of developers moving ahead to gain site consents and grid connections and to understand sea and seabed conditions with a view to early installation of arrays. These projects are a mix of "named technology" sites, where a particular device has been earmarked for installation, and "technology neutral" sites, where the developer has yet to commit to installing a single tidal or wave device, pending further technical and site development.

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Point of view

John Callaghan

EY: The UK has been a trailblazer in marine energy. As owner of the nation's seabed rights, what part will The Crown Estate give to marine energy over the medium term?

John Callaghan: Our business is managing national assets — whether agricultural land, commercial buildings or the UK's seabed. At the moment, offshore wind is the fastest-growing part of The Crown Estate's business. Building on this experience, we see a lot of future value for The Crown Estate in offshore energy and infrastructure — not just in wave and tidal but also, for example, in carbon capture and storage (The Crown Estate manages the storage rights on the continental shelf).

EY: How would you describe your strategy in marine energy?

John Callaghan: Our main strategic objective in wave and tidal is to support the sector's growth, to attract increasing investment and to encourage major players, such as utilities and offshore OEMs, to commit to projects and technologies. It was the entrance of utilities in the middle of the last decade, prospecting sites, that led us to the Pentland Firth leasing round — the world's first commercial leasing round for wave and tidal developments.

The Crown Estate is very keen to do what we can to help major players to make a durable commitment to the sector and to enable projects to be prepared for when technologies are ready to deploy at commercial scale. At that point, seabed rights will start to turn into commercial assets — and that is our core business.

EY: As other countries take increasing interest in the sector, do you see The Crown Estate operating in a more competitive market?

John Callaghan: In recent years, the UK has had a lead both in technology and project development — in fact, we might even be seen to be going it alone. We are finding that is changing, which is good: there is no precedent for utility-scale generation technologies being developed in just one country, so it'd be quite surprising if the UK were able to do so in isolation. So it's good that other countries, such as France and Canada, are showing increasing interest.

EY: How can The Crown Estate help the global industry develop?

John Callaghan: We are sharing our insights and experience through trade missions and other direct dialogue. The UK's experience also suggests other things that other countries can do to stimulate interest — for example, introducing feed-in tariffs, regulations that will speed up the permitting process in reasonable time frames, and processes for developers to take projects forward to construction.

EY: What is the outlook for 2013?

John Callaghan: The industry is continuing to evolve. Installing the first arrays is the next milestone, with a move from prototypes to arrays of say three to five machines — projects up to around 10 MW. There are a number of projects like that approaching investment decisions in the next financial year — and that links to our announcement in January that we are looking to invest in such projects.

Wave and Tidal Program Manager
The Crown Estate

We think deploying first arrays is very important. Crucially, it will give a perspective to the revenues of projects, which is essential to justify ongoing investment in both projects and technologies. If successful, construction and operation of first arrays could stimulate greater interest in the market.

EY: So attention will move to commercial issues?

John Callaghan: Yes, the questions will move from engineering issues, like how best to install a single prototype or what the test program should be, to how to establish commercial viability and the range of financial, contractual and practical considerations that go with that.

People will ask, for example, from which sources capital will be obtained for construction, how installation risks can best be managed, and how performance guarantees will be set up.

EY: What about the cost competitiveness of projects?

John Callaghan: As these immediate issues start to be addressed, we are also seeing developers think more strategically about the industry's steps beyond first projects, including cost reduction. Clearly, for investment in first arrays to be justified, there must be potential for future projects to have lower costs; otherwise, the strategic value in initial investments will be limited.

That said, it is to be expected, and consistent with the experience of other energy technologies in the past, that initial costs will be relatively high. Imagine, for example, the cost-per-unit installed capacity of building a 10 MW offshore wind farm — considerably higher than that for the schemes of hundreds of megawatts being built today.

The reality is that across the renewable energy industry, technologies are at different stages. Improvements in design and manufacturing, economies of scale in projects and experience in both technology and project development can lend a lot to cost reduction, but the industry needs a series of projects to see that come through.

EY: Do you see greater scope for technology collaboration — for example, deploying an array of several different tidal turbine designs?

John Callaghan: There are different schools of thought on this. Certainly, sharing infrastructure in order to improve returns for initial projects, whose costs will be relatively high, has considerable merit and is attractive to some parties. The UK has a number of facilities that offer this, mostly government funded (e.g., Wave Hub).

However, there are also reasons why developers are choosing sites on an individual basis. One is to secure their route to market — one would expect, of course, technology developers to be interested in this. Meanwhile, utility companies are often interested in the potential to scale up beyond initial schemes to larger deployments. The Crown Estate has leased sites to cater for all these interests.

Point of view (contd)

John Callaghan

EY: What else is needed to build a mature industry?

John Callaghan: The crucial thing continues to be the rate of technology investment. During the last decade, a combination of government support and private investment had a significant accelerating effect, but we think there's now an opportunity to step up further. It is great that a number of large OEMs – particularly European industrials – have entered over recent years. Given the scale of market potential, further strategic investments and acquisitions may occur in the coming years.

EY: European industrials have certainly backed a number of UK tidal businesses recently. Is there a danger that wave gets left behind?

John Callaghan: While some areas of seabed are suitable for tidal projects, others are suitable for wave projects. Each could contribute a significant amount of low-carbon electricity to UK supplies, and we would like to see both come to fruition. It may be that tidal and wave move at different paces; The Crown Estate has the flexibility to accommodate that through our leasing and support processes.

EY: Some say marine energy has been slow to develop. Is there a limit to the time Crown Estate will wait for commercial arrays to emerge?

John Callaghan: The industry's current position is understandable in the context of historic government policy and R&D support for wave and tidal, which was intermittently favorable before 2000, and commercial interest, which started to crystallize last decade.

The Crown Estate is over 250 years old – so we are used to taking a long-term view. Wave and tidal clearly offer the most value to The Crown Estate over the medium to long term. We view leasing test facilities and other small sites as a preparatory step to help technology development, looking toward commercial projects that this will enable.

We approach larger sites on a commercial basis, given the potential value to developers and The Crown Estate's obligations under law. Again, however, we are thinking about how rights provided today can lead to larger developments over time. For example, all the projects in the Pentland Firth are designed to be installed in a phased manner, starting small and gradually building up capacity.

EY: Are there issues in array projects impacting one another?

John Callaghan: The effect of one project on another is certainly something we're interested in. We wouldn't want to lease one site adjacent to another site if the energy potential of the first were to be constrained beyond economic viability, nor if the existence of two sites might make it impossible for either to obtain permits. We are working with developers to help them manage potential conflicts through a contractual approach while scientific understanding of device-resource interactions improves, and to consider cumulative impacts as part of their site environmental impact assessments.

EY: You recently announced you are considering investing up to £20m in two wave and/or tidal-stream projects. What is driving this initiative?

John Callaghan: We are keen to support the growth of the industry by bringing our capital and expertise to bear, in addition to providing seabed rights. Right now, the industry needs to move on to first arrays. What we're seeing is a number of projects that have obtained, or are close to obtaining, permits and grid-connection agreements and are getting into front-end engineering design in preparation for investment decisions.

That is a great sign for the industry, but it is clear that even with government support, these initial projects will be challenging, both in terms of their engineering and their commercial arrangements. We are hoping to catalyze investments by others by reducing the total amount that others need to invest and by sharing operational risks.

EY: So the £20m fund fills a market gap?

John Callaghan: It is intended to be complementary both to emerging interest among private investors and to government-grant support measures.

EY: What is The Crown Estate's message to developers and technologies considering doing business in the UK?

John Callaghan: Firstly, it is worth noting the degree of interest here, both in government and in various parts of the industry. The Government — at UK level, the devolved administrations and agencies — continues to support technology development, and revenue support and capital grants are on offer for demonstration projects. The industry is highly active in both technology development and project development, creating opportunities for the supply of products and services.

Secondly, The Crown Estate is very keen to support the growth of the industry. We are interested to talk to any companies that are looking for sites and keen to understand their views. Our consultation last summer on next steps in leasing received responses from across the UK and overseas, and our door is still open for dialogue. Overall, we want to help the industry make the transition from technology R&D to development of commercial assets, meeting both government objectives and industry ambitions.

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