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# Ocean Energy

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# Editorial



*By Dr. Sian George,  
CEO, European Ocean Energy Association*

The European Commission has set out a trinity of energy policy goals: our energy supplies must be **secure**; they must be **sustainable** and they must **underpin Europe's global competitiveness**.

In the future we will need a smarter and more interconnected energy system. One that will maximise Europe's ability to draw on all its available resources. It is only logical that renewable energy sources will form an increasing part of Europe's energy mix in the future. Adding new sources of untapped renewable energy will also be essential. The Strategic Energy Technology Plan (SET-Plan) will support new technologies by focusing national and private research funding on priorities for accelerating the development of new energy technologies and systems.

Europe has a long maritime heritage and strong off-shore industries. She has been a major global player in offshore fossil fuel extraction, and now leads the world in the field of offshore wind. European businesses and research institutions are now pioneering ocean energy innovation. The skills, knowledge and supply chains supporting these activities mean that Europe is well-positioned to lead the world in the exciting new field of ocean energy exploitation.

Harnessing this unused resource will increase our energy security. Bringing ocean energy into the mainstream mix will optimise our clean power supply - increasing system stability and bringing down the overall price of renewables. It will also drive industrial growth and job creation by revitalising maritime sectors; and maximising the value of investments in infrastructure, expertise and equipment in Europe's oil, gas and offshore wind sectors.

A successful ocean energy sector could make a significant contribution to decarbonising Europe's electricity supply from the mid-2020s onwards. In 1980 the global installed capacity for

wind power was 10MW; today it has exceeded 100GW in Europe alone. Estimates of the future installed capacity for ocean energy vary widely – and so much will be dependent on getting the correct blend of support and policy frameworks – but it would be reasonable for Europe to set out to install over 100GW of wave, tidal and salinity gradient ocean energy before 2050. Ocean Thermal Energy Conversion (OTEC) technology also offers significant export and development potential for tropical coastal areas, including many Cotonou agreement countries<sup>1</sup>.

The emerging ocean energy industry has an **installed capacity of 10MW** at test sites across Europe and has already attracted over **€600 million of private sector investment** in the last 7 years. Large European OEMs<sup>2</sup> and Utilities have taken stakes in a number of leading technology concepts, and now have around **2GW of sites** under development in their project pipelines.

Maintaining Europe's global lead will depend on overcoming a number of challenges and barriers facing the sector. The key to industry success will be bringing stakeholders together at the European level to develop strategic plans focused on managing the three main categories of technical, project and financial & market based risks.

The European Ocean Energy Association is a rapidly growing membership organisation. Our members represent national government agencies; large utilities & industrial companies; national trade associations and universities. They all have one thing in common: they are pioneering a new industrial sector for Europe. Our objective is to accelerate the development and commercialisation of ocean energy technologies; and we invite you to join us.

The Ocean Energy Association believes that strategic development could be supported in the future by creating a **European Industrial Initiative under the SET-Plan**. Such an initiative would be a vehicle for the industry, member states and the Commission to de-risk this emerging sector and accelerate growth.

<sup>1</sup> The **Cotonou Agreement** is a partnership agreement between developing countries and the EU. Since 2000, it has been the framework for the EU's relations with **79 countries from Africa, the Caribbean and the Pacific (ACP)**.

<sup>2</sup> Original Equipment Manufacturers

APRIL 2013

# SET-Plan update

## Ocean Energy Focus

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The European Strategic Energy Technology Plan (SET-Plan) aims to transform the way we produce and use energy in the EU with the goal of achieving EU leadership in the development of technological solutions capable of delivering 2020 and 2050 energy and climate targets.

Various events aimed at advancing technological research, increasing public awareness and promoting low-carbon technologies in the EU and worldwide have been organized since the SET-Plan was presented. The following is a list of relevant communications and on-going activities with implications for the marine energy sector.

- Following a comprehensive consultation and analysis of how Europe relates to the sea, the EU publishes **“An Integrated Maritime Policy for the European Union”** (COM(2007) 574) and also establishes a new integrated maritime policy, of which the Communication **“A European Strategy for Marine and Maritime Research”** (COM (2008) 534) is a fundamental part. The strategy highlights the importance of integration between established marine and maritime research disciplines, in order to reinforce excellence in science and reconcile the growth of sea-based activities with environmental sustainability.
- In response to the downturn in the European economy, the European Council and the European Parliament adopt the Commission’s proposal for a **European Energy Programme for Recovery** (EPR) in July 2009. This €4bn programme will co-finance projects designed to make energy supplies more reliable and help reduce greenhouse emissions, while simultaneously boosting Europe’s economic recovery.
- **‘The Ocean of Tomorrow’** is a key initiative in the 7th Framework Programme (FP7), undertaken in order to implement the European Strategy for Marine and Maritime Research. Three joint calls for proposals for research in support of the Good Environmental Status (GES) of our Seas and Oceans (FP7-OCEAN 2010, FP7-OCEAN 2011 and FP7-OCEAN 2013) have been successfully launched.
- The European Energy Research Alliance (EERA) **Ocean Energy Joint Programme** (JP) is officially launched at the SET-Plan Conference in Warsaw in November, 2011. The JP aims to develop coordinated European ocean energy research that will underpin the development of the emerging ocean energy sector.
- The Intelligent Energy Europe project, **Strategic Initiative for Ocean Energy** (SI Ocean) is officially started in June 2012. The project is coordinated by the European Ocean Energy Association (EU-OEA) in close cooperation with 6 partners and aims to engage a large number of European stakeholders in identifying practical solutions to removing a range of barriers to large scale wave and tidal energy deployment.
- At a meeting of the **Steering Group on Strategic Energy Technologies** in Brussels, in July 2012, the Commission informed the Steering Group about the need to prepare implementation plans for the period 2013-2015, in order to review priorities, actions and targets.

- The European Wind Energy association (EWEA) published its final report on the **Seanergy 2020** project to deliver offshore electricity to the EU. Funded by the EC's Intelligent Energy Europe Programme, the project was set up to formulate and promote policy recommendations on how to best address and remove obstacles to offshore renewable energy generation posed by national marine spatial planning considerations. The main policy recommendation of the programme is to draft a Marine Spatial Planning Directive.
- At a meeting of the **Steering Group on Strategic Energy Technologies** in Brussels, in September, 2012, the Commission presented a new Cohesion Policy and outlined its role in the SET-Plan framework. Within the next financing period, the Cohesion Policy frame places more emphasis on research and innovation, low-carbon energy and energy efficiency measures. In this respect, the Commission invited Member States to ensure a close link between the funds available through the Cohesion Policy, namely the Structural Funds, and the SET-Plan priorities.



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- The University of Edinburgh hosts an EERA **Ocean Energy JP Resource Workshop** in October 2012, with the aim of identifying research synergies and opportunities for collaboration across the EU, identifying gaps in ocean energy research and prioritizing research objectives.
- The European Ocean Energy Association and the Sustainable Energy Authority of Ireland (SEAI) host the **4th International Conference on Ocean Energy (ICOE)** in Dublin in October, 2012. In bringing together over 750 global industry and academic experts in marine renewable energy, the conference provides an opportunity for the top industrial players to demonstrate the latest technologies and to accelerate the development of ocean energy technology by stimulating collaboration networks between companies and research and development centres.
- In an award decision issued on 18 December 2012, the European Commission awards funding to 23 renewable energy projects under the **NER300** first call for proposals. These include three ocean energy projects: the Westwave wave energy converter project in Ireland and the Kyle Rhea Tidal Turbine Array and Sound of Islay projects, both in the United Kingdom.
- This year's **2013 SET-Plan Conference** will take place on 7-8 May. The Irish Presidency will host the conference at the Royal Hospital Kilmainham in Dublin. The two-day event will bring together a broad range of stakeholders including the research community, industry, financial community, policy-makers and a variety of international partners.
- The **European Wave and Tidal Energy Conference 2013** will take place in Aalborg, Denmark on 2-5 September. EWTEC conferences provide a global focus for all activities in wave and marine current energy conversion technologies, research, development and demonstration.

THE EUROPEAN MARINE ENERGY CENTRE:

# Testing the potential of the oceans



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***The following is a profile of the EMEC testing facilities in the Orkney Islands, Scotland, including an interview with EMEC External Liaison Officer Max Carcas.***

The European Marine Energy Centre (EMEC), which is spread across the Orkney Islands off the north coast of Scotland, is the first and only centre of its kind in the world to provide developers of wave and tidal energy technologies with purpose-built, accredited open-sea testing facilities. As such, the EMEC is a key facility for the development of cutting-edge technology in an energy sector that, although it currently accounts for a small share of European energy consumption, is nevertheless an important element in the energy balance, and is set to make an ever-increasing contribution to the meeting of the 20-20-20 targets and strengthening the security of energy supply in Europe.

Established in 2003, EMEC was set up by a grouping of public sector organisations following a 2001 recommendation by the UK House of Commons Science and Technology Committee. To date, around £30 million of public funding has been invested in the Centre by the European Union, the Scottish Government, Highlands and Islands Enterprise, The Carbon Trust, the UK Government, Scottish Enterprise, and Orkney Islands Council.

The company provides the world's only multi-berth, purpose-built, open-sea test facilities for wave and tidal energy converters. At the facility's full-scale test sites there are subsea cables which run from each test berth at sea to a substation onshore where they meet the UK national grid. EMEC also operates two scale test sites where smaller scale devices, or those at an earlier stage in their development, can gain real sea experience in less challeng-

ing conditions than those experienced at the full-scale wave and tidal test sites.

With 14 full-scale test berths, there have been more grid-connected marine energy converters deployed at EMEC than any other single site in the world, with developers attracted from around the globe. Orkney is an ideal base for the test facilities, with its excellent oceanic wave regime, strong tidal currents, grid connection, sheltered harbour facilities and the renewable, maritime and environmental expertise that exists within the local community.

In addition to device testing, the facility provides independently-verified performance assessments and a wide range of consultancy and research services, and is at the forefront in the development of international standards, having coordinated the development of 12 industry guidelines, six of which are being progressed for global adoption as the first international standards for marine energy.

The company is also involved in a variety of research projects ranging from site specific projects to national and international research projects, such as MARINET, an EC initiative, funded under the Seventh Framework Programme (FP7), which aims to accelerate the development of marine renewable energy by creating a network of world-class testing facilities to offer developers periods of free access, and the opportunity to conduct coordinated research in order to standardise testing, improve testing capabilities and enhance training and networking. EMEC is involved in a range of MARINET activities including test site standardisation, facility access and research.

EMEC also acts in a technical advisory capacity for the Intelligent Energy Europe-funded Streamlining of Ocean Wave Farm Impacts Assessment (SOWFIA) project, which aims to achieve the sharing and consolidation of pan-European experience of consenting processes and environmental and socio-economic impact assessment (IA) best practices for offshore wave energy conversion developments. Studies of wave farm demonstration projects in each of the collaborating EU nations are contributing to the findings. The study sites comprise a wide range of device technologies, environmental settings and stakeholder interests.

As such, EMEC occupies a unique position, having links with a range of different developers, academic institutions and regulatory bodies while remaining independent. The company is currently working with developers and experts in order to expand its research agenda to cover a range of industry-related environmental and operational issues. It works with regulators, government and developers alike in endeavouring to make full use of the device testing stages of the developing wave and tidal energy industries as they evolve from pre-prototype design through to commercial viability.

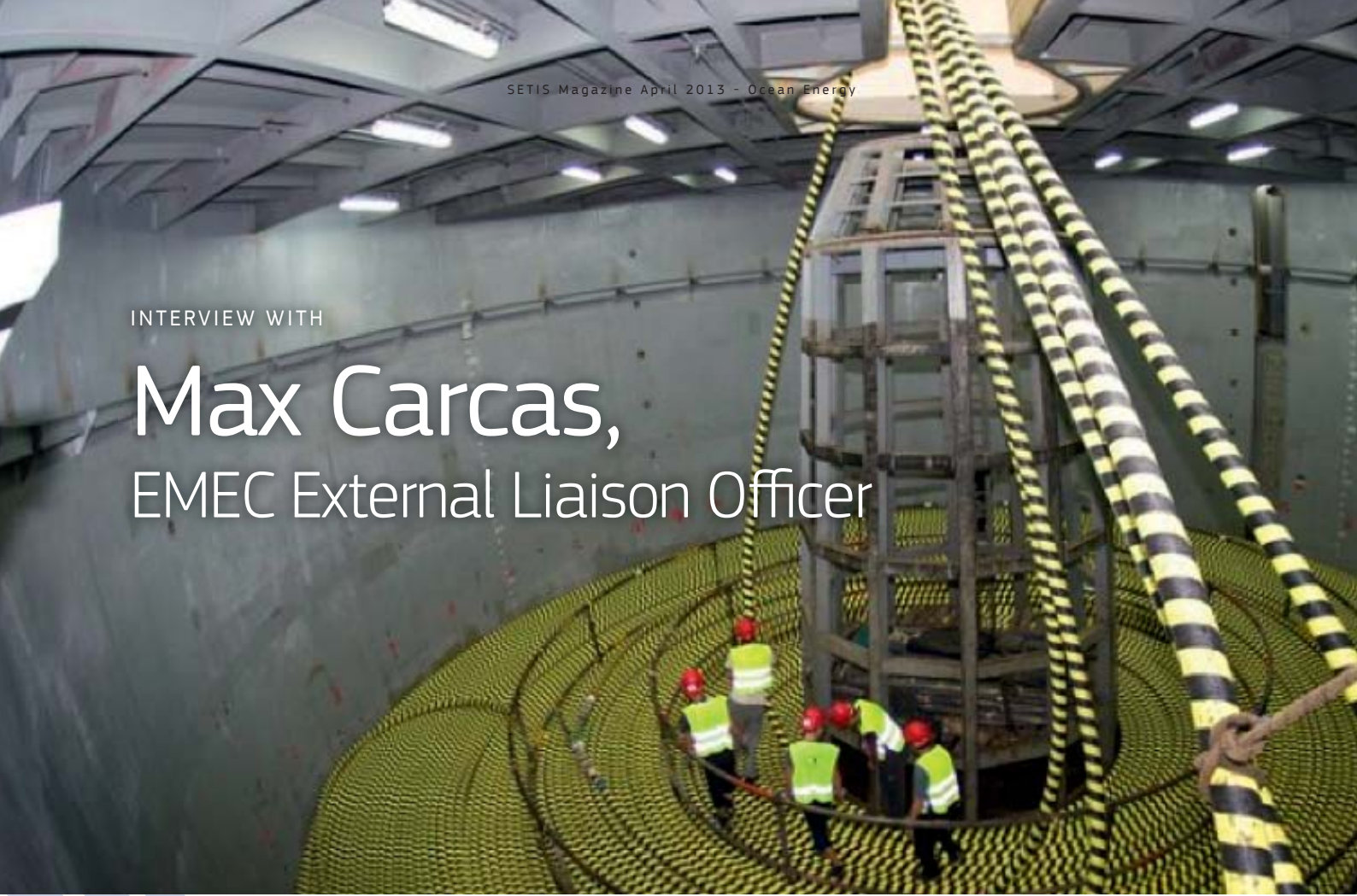
Tidal and wave energy solutions are often overshadowed by offshore wind, which attracts the lion's share of the publicity generated by renewable energy. Nevertheless, wave and tidal energy has seen some progress and, as the EMEC project clearly illustrates, these technologies are attracting the interest of major industrial companies, thereby improving the credibility of the sector and making it a truly commercial proposition. The company's clients include Europe's E.ON, Vattenfall and Voith Hydro, along with international giants such as Kawasaki Heavy Industries.



Aerial view of Fall of Warness, EMEC tidal test site © EMEC

INTERVIEW WITH

# Max Carcas, EMEC External Liaison Officer



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**Ocean energy's contribution to the overall EU energy mix is currently quite small; do you see any potential to significantly increase this share in the near future?**

M. C.: “Yes, although it would be unreasonable to expect ocean energy to increase at a faster rate than technologies such as wind and solar have in the past. It is well known that the EU has substantial ocean energy resources that are almost entirely untapped at present but that could be a significant part of the EU energy mix in the future. The speed at which this can be achieved will depend in part upon whether market enablement measures are prioritised in this area across a number of countries and the speed at which private sector investment is encouraged – the same drivers that have shaped the energy mix we have today. However it is extremely encouraging to see a range of commercial projects being developed and investment by a number of industrial companies and utilities in technologies and projects that could be the springboard for significant growth in the future.”

**A lack of competitiveness, due partly to high licensing and maintenance costs, has been cited as the main barrier to expansion for ocean energy. What can be done to overcome these obstacles?**

M. C.: “I am not sure I agree with the premise that a lack of competitiveness per se is the main barrier to expansion. Certainly it is true that ocean energy is not currently competi-

tive with more mature energy technologies such as coal, gas, nuclear, onshore wind, offshore wind or solar PV. However equally it should be remembered that all of these technologies had ‘opening costs’ that were much higher than that currently required for ocean energy at the same stage of technological maturity. Fortunately this is recognised by some countries establishing premium tariff markets for ocean energy – the main barrier to expansion in these cases will be meeting hurdle rates for investment against comparable investment opportunities once projects have been fully licensed and consented and grid connections obtained.

Licensing costs can be an issue since the legal framework that governs the lease of the sea or seabed may not have been fully established in each country for marine energy projects so projects must overcome ‘first-of-a-kind’ costs as these processes are established. Environmental conditions imposed may be more severe due to lack of knowledge and experience and application of the ‘precautionary principle’.

The cost of undertaking maintenance is a key component in any electricity generating technology. Related to this is the reliability of the technology and the ability to easily access the technology in order to perform maintenance. Whilst these are ‘issues’ there is no fundamental reason specific to ocean energy why these cannot be addressed by a mixture of design, process and experience in order to deliver progressively more competitive solutions.”



**What other challenges does the wave and tidal energy sector face in becoming more widespread?**

M. C.: “A combination of technical, commercial and political challenges have to be overcome, however none of these are insurmountable but require a clear focus and direction. Overcoming these barriers requires investment and in order to attract investment a clear route to market has to be established. This is where the establishment of an early ‘niche’ market with premium tariffs for ocean energy is very important (and across a number of countries) – just as was the case in the development of other renewables such as wind and solar.”

**At EMEC you are in constant contact with cutting-edge technology; which particular marine energy technology do you consider to be the most exciting?**

M. C.: “As an independent test centre it would be wrong for us to highlight any one technology but what can be seen is a variety of designs and techniques that address the fundamentals in ocean energy – namely to make machines that are survivable, reliable, maintainable, operable and cost effective. Continued innovation and knowledge sharing will further strengthen the variety of concepts being tested at EMEC at our fourteen grid connected full-scale test berths and two scale test sites. What is encouraging is seeing the range of industrial investment and experience being put into the sector from across the EU including countries such as Finland, Sweden, Norway, The Netherlands, Germany, Austria, France, Ireland, Spain, Portugal as well as the UK.”

**What are the key research priorities in the sector to ensure its increased commercialization?**

M. C.: “

- Technology. Continue to prove generators and their performance. Also focus on tackling the technical elements required to deliver commercial scale (e.g. 100MW) projects – electrical interconnections, installation methods and techniques, operations and maintenance tools and techniques. Better use of grid.
- Manufacturing/ logistics/ installation. The elements required in facilities, materials, methods, techniques and tools in order to drive down costs with volume.
- Operations and maintenance. Focus on increasing productivity and reducing downtime by improving reliability and maintainability and associated tools and techniques for this.
- Resource. Better techniques for resource measurement and forecasting and integration with other renewable resources.

- Environmental impacts. Continued investment in monitoring to ensure impacts are minimised.”

**The European Ocean Energy Roadmap calls for on-going financial mechanisms to support testing of ocean energy devices. Has public investment been sufficient and has industry filled any shortfall, or is increased government support required?**

M. C.: “To date the vast majority of investment has come from the private sector. Typically for every Pound or Euro invested by the public sector six to eight times this amount has been invested by the private sector. In a nascent sector such as ocean energy, public support is needed to ‘level the playing field’ for investment with more established technologies that have benefitted from many decades of investment and allowed these to reduce their costs. Given the potential multi-billion euro market size for ocean energy the level of public investment to date has been relatively small. Hence increased government support would be desirable and certainly justified when the potential economic return for such investment is evaluated.”

**More than any other renewable energy sector, the marine energy sector has a wide variety of technologies and energy harnessing systems. Is this variety a benefit, or might the industry be better served by concentrating on the development and commercialization of fewer technologies?**

M. C.: “Like many other industrial sectors that have been established in the past (e.g.: air travel, railways, computing, the internet) diversity can be a strength in that it allows a Darwinian process of evolution to take place and for the strongest concepts to succeed and for convergence to occur. This process of ‘self-selection’ will inevitably result in public/private resources being concentrated on winning concepts, particularly for commercial scale projects.

However equally it is important that sufficient diversity is maintained so as not to exclude concepts that may be able to build on early success in the sector and that may have the potential to deliver significant benefits in the longer term. An analogy can be made with the different video formats that were commercialised – V2000, Betamax and VHS – VHS was the early winner but then this was surpassed by DVD, and ultimately by Blue-ray. Providing success is seen in the sector there will always be those looking to develop a ‘better mousetrap’ and it is important that there are routes open to allow this to happen.

It should also be borne in mind that as in other sectors little innovation is ‘wasted’ – even where concepts do not prove to be successful and companies fail, the pool of knowledge and

experience is widened – for example the experience of vessel operators in installing a variety of concepts leads to knowledge of what works and what doesn't. Equally the same can be said of skilled and experienced individuals moving from company to company – the classic 'cluster' effect. Managing innovation is never straightforward but the virtue of undertaking work in an 'innovation rich' environment such as marine renewables is that in tackling particular problems solutions may also be created in other related areas – e.g. shipping, offshore wind, offshore oil and gas, CCS which can share similar issues in the offshore environment. ”

**Do some technologies have a better environmental impact / productivity balance and, if so, which technology provides the best performance with the least environmental impact, in your view?**

M. C.: “It is certainly not the case that a higher productivity necessarily implies a higher environmental impact although it would be reasonable to expect that different technologies may have different balances between these aspects and that these may also be site dependent. That said it has yet to be shown that ocean energy technologies have caused any significant adverse impacts, hence it is difficult to answer this question other than to recommend continued monitoring in order to verify that this remains the case and that best practice continues to be followed to minimise any impacts. ”

**Some marine energy forecasts predict capacity in the EU-27 of up to 10 GW by 2020 and 16 GW by 2030, accounting for 0.8% and 1.1% of the EU-27 electricity consumption projected for 2020 and 2030 respectively. Are these targets realistic?**

M. C.: “Forecasting the future with any energy technology, even established ones - is extremely difficult but even more so when forecasting rapid growth from a small starting point. The capacity levels that are forecasted are practical and realistic from the perspective of what can be achieved but the date by which they may be met is much less certain.

It should be borne in mind that preceding the build and deployment of ocean energy generating capacity, project sites have to be developed, consented and permitted. The grid has to be available to transmit the electricity. Financial hurdle rates for investment have to be met, dependent upon the prevailing market conditions and what the technology can deliver. The rate at which these conditions can be met, and capacity deployed into the market, is heavily influenced by the degree of political prioritisation for ocean energy and is no different to the factors that have influenced the deployment of other energy technologies in the past.

Nonetheless one clear opportunity is for ocean energy to compliment but also compete with offshore wind where tens of GWs are expected to be deployed over the next 15 years. Whilst the feed-in tariffs required for initial small-scale ocean energy projects are high at present it is conceivable that the costs could fall to below that of offshore wind with a sustained deployment of perhaps 1-2GW – similar in size to one conventional power station.

If this were to occur this would be a 'game-changing' situation which could place ocean energy at the heart of the EU's energy policy. It should therefore be the near term aim of EU policy to remove barriers and place incentives to achieve this aim, recognising the fact that initial small scale projects will have high costs simply due to 'diseconomies of scale' which are not present in a GW size project. ”



## Max Carcas

Max represents EMEC in its external relations, supporting its customers and stakeholders and helping to develop its strategy for the future.

Originally a graduate in Electrical & Electronic Engineering from the University of Edinburgh, he believes marine renewables have a vital part to play in meeting our energy security, environmental and economic needs and is keen to support the sector in achieving that goal.

# “Duck farms” for wave energy, but not for a while...

## Wave Power – what goes around comes around?

© Jamie Taylor

**Wind and wave power technology were both starting out in the 1970s, when you invented the ‘Duck’ design for producing wave energy. But today wind energy is a mature technology, while wave energy is about 20 years behind. The Duck is still probably the most efficient source of wave power. What happened? Why hasn’t it taken off?**

S. S.: “Wind took off because the investors were there. Back in the 1970s there were tax incentives in the United States for investment in wind energy, even though the machines didn’t ever generate any energy, had absolutely awful reliability and only about 5% efficiency. Meanwhile, in Denmark things were better organised, with local ownership of single turbines. But in the UK, wave energy was under the control of the Atomic Energy Authority, which was basically hostile to the whole concept. So there was a benign government in Denmark supporting wind and a hostile control of information flow in the UK that held wave power back.

The only problem with the Duck is that it produces far too much energy, because you need to have a lot of them to take an average of the wave amplitudes. You need lots of phases of waves. Originally, we thought that a 250 MW system was about right. We then tried to do it with small ones in the wave tank. We think that an absolute minimum is about 10 Ducks, which means you’d be developing about 60 MW. And that’s far too big for the present market. Investors want about 1 MW. They are rather cautious and want to try a small one before they try a big one. That’s why Ducks can’t raise any money for investment.

The second thing is that to make the Ducks work we needed to invent all kinds of new hydraulic technology and make it

compatible with digital control. The pumps and motors at the time didn’t have good enough part load efficiency, were hard to control and couldn’t combine energy from different places. The consultants who were selected by the Atomic Energy Research Establishment in Harwell to scrutinise the work back then didn’t have any feeling for electronics at all. They were basically engineers and thought that computers were great big things in special rooms with air conditioning and men to look after them. They didn’t realise they could be available very cheaply. Now I think the chip in the digital hydraulics controller costs less than £2.

But this situation has changed. In Edinburgh, we managed to get a little spinoff company going, called Artemis, to develop the digital hydraulics. Artemis was recently bought up by Mitsubishi. They are fitting digital hydraulics into wind turbines for power conversion and should be installing them off of Fukushima, of all places. They offer great savings in weight and also improvements in efficiency. If this builds confidence in digital hydraulics they might be tempted to do it in tidal stream technology and then in wave energy. I’m quite happy to leave the Ducks on the back burner until we really believe in the digital hydraulics.”

**So tidal stream is likely to be commercially viable first?**

S. S.: “It’s more marketable, because it’s more predictable. In the spot market, every half hour the electricity producers bid for how much they can produce in a given time for an agreed price. Knowing when you’d be able to deliver makes bidding a lot easier. Also, tidal is usually near to shore. In the UK there is already a 250 MW connector from Dounreay. So everything needed for tidal is already there.”

**So, is synergy between wave, tidal stream and wind the best way forward?**

S. S.: “Well yes, because the waves come a day or so after the wind. There’s a phase lag, so the two are less intermittent in combination with each other. Tidal streams have their own very predictable cycle. And both wind and wave are more plentiful in the winter, when the demand is greater and that’s a good thing.”

But if we did all three together, there would be times when there was too much electricity. So you’d have to find a way to use the electricity that you can’t put into the grid. One way to do this is to use synthetic chemical processing to make liquid fuels. We’re going to be short of liquid fuel and we have too much electricity. There is a chemical process, called the Fischer Tropsch process, to do this that’s well established. It needs a source of carbon, electricity and a catalyst. If you used carbon from municipal garbage you could get a credit on landfill. Anything with carbon in it can be used, especially if it has a negative cost. You can then use it to make a fuel that would substitute for diesel or natural gas. Anything that’s not used can be recycled back into the system.”

**Isn’t there another issue, in that the grid interconnections off northwest Scotland, where wave energy potential is greatest, are not yet adequate even for wind?**

S. S.: “The UK is building a DC bus down the West coast from the Hunterstone area and I’d like to have another one that went from the Pentland Firth down the east coast. You could get into it from Aberdeen, Edinburgh, Newcastle and all the way down to London. Also, there are plans for a complete joining up of the whole of Europe in one grid. One idea is to produce solar energy in North Africa and bring it up to Norway. If you produced a single European grid, a lot of the worries about intermittency vanish.”

**What are the next steps?**

S. S.: “I want to see successful digital hydraulics in wind followed by digital hydraulics in tidal streams. That’s going to give us a lot more experience and confidence. Then we can go back to the Ducks. That’s why they’re on the back burner. The quieter we leave them the better. However, Richard Yemms’s Pelamis wave power design basically started with the work on the bending sections on the spines of the Ducks. Pelamis is essentially Duck strings without any Ducks on. It’s teaching them a great deal about what they need to know about bearings and joints and rams and hydraulics. It’s very nice and a good, cheap source of electricity. But it’s wasteful of sea front. We haven’t got an infinite amount of sea front; Scotland has probably got about 400 km of sea front and each Pelamis, I think, takes about 500 metres of width. The Duck strings use every millimetre.”

**And what are the main remaining obstacles?**

S. S.: “Well, apart from investment, we still need to build a component test raft. Technology that costs EUR 20 million to put in is still failing because of an off-the-shelf component that costs EUR 2 that the manufacturers thought was OK. They’re finding that this is costing them a year’s development and lots of electricity not generated. It would be nice to have individual components being tested in large numbers in the right chemistry and biology but they don’t do it. It wouldn’t cost much. The things we’re testing aren’t expensive. What you need to do is test lots of them in parallel and find out which ones work and which don’t.”

You’d want all the information about this, – how long seals work and under what conditions and so on. Everyone would want this information. This happens with aeroplanes. You get type approval for components that go into aeroplanes and if anything doesn’t work there’s an air crash and everybody in the aircraft industry in the whole world is told about it. At the moment things are going wrong with wave energy devices and it’s all hushed up. They’re risking the whole credibility of the technology but also risking causing shipwrecks. That’s the first thing I’d try to sort out.”



© Aquamarine Power Ltd.

## Stephen Salter

is Emeritus Professor of Engineering Design at the University of Edinburgh, Scotland. In the 1970s and 80s he pioneered the first viable design for producing wave energy, called Salter’s (or the Edinburgh) Duck. Some of the innovative technology is now being used in the latest wind turbines.

# EC's new SI Ocean gives European marine energy a boost

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The potential resources of marine energy are so vast that, according to one estimate, just 0.1% of the energy in ocean waves could supply the entire world's energy requirements five times over. If developed properly, the International Energy Agency Ocean Energy Systems (OES-IA) has estimated a global wave and tidal deployment potential of 337GW by 2050. But although the basic technology to do this has been around for several decades, a vicious cycle of high costs and lack of investment from industry has prevented marine energy from taking off in the same way as wind, for example. This is why the EC's Intelligent Energy Europe (IEE), in its 2011 call for proposals, chose to back a two-year project called the Strategic Initiative for Ocean Energy (SI Ocean), that aims to identify practical solutions to the various barriers that have stood in the way of realising the full potential of wave and tidal stream energy up until now.

SI Ocean was officially launched in June 2012 and is led by a consortium of major European players in the field of marine energy research and development – DHI (Denmark), Wave Energy Centre / Centro de Energia das Ondas (WaveEC) (Portugal), Renewable Energy UK Association Limited (RenewableUK), The Carbon Trust (UK), The University of Edinburgh (UEDIN), (UK) and the EC's Joint Research Centre (JRC). The aim is to make sure that Europe is producing as much electricity as possible from tidal stream and wave energy by 2020, paving the way for exponential growth to 2050. The project will bring together a "Project Group" of over 100 members representing key European target audiences and stakeholders.

There are three main strands to the SI Ocean project. The first aims to get a more precise idea of the size of the marine energy resource in Europe and specific sites where it should be developed first. A result of this work will be a wave and tidal ocean energy map of Europe (notably the Atlantic Arc). A second strand is to indicate the timeframe and concrete options for making marine energy competitive with other mainstream renewable energy sources. An outcome will be the strategic technology agenda, identifying development priorities and ways to reduce costs. A third strand will be to develop a market deployment strategy beyond the life of the project, identifying the main barriers to market growth and policy, along with strategic initiatives to tackle them. Best practices examples from key member states will be used to help target financial support and resources, to speed up commercialisation of the technology, and to improve and standardise regulatory and administrative frameworks across Europe.

Europe's coasts – particularly the Atlantic Arc – have the lion's share of untapped marine energy potential globally, with peaks of 100 kW/m and an average in the range of 30-70 kW/m. As a concrete example, according to SI Ocean partner, the Carbon Trust, if we could harness the potential wave power from the Rockwell Trough, a 1000 km stretch of water 150 km off the northwest coast of Scotland, it would be possible to generate 100 terawatt-hours (TW/h) of electricity or about 25 % of the UK's current electricity needs. The Carbon Trust has estimated that if even half of that can be harnessed economically, wave and tidal stream energy would be able to compete with offshore wind, nuclear and other low carbon technologies.



SI Ocean document, “an aggressive deployment trajectory will be required.” And a vital part of this will involve increasing the involvement of the commercial sector, namely utilities, large industrial organizations and technology developers.

At present the UK is leading both research and investment in prototyping technology and carries out about half of all marine energy research globally. The European Marine Energy Centre (EMEC) for example, based in Orkney (Scotland), is the first and only centre of its kind in the world to provide developers of both wave and tidal energy converters, with purpose-built, open-sea testing facilities. France and Ireland are now gearing up to replicate UK conditions. And while Spain and particularly Portugal have potential for viable marine energy production, they are comparatively risk-averse as they weather austerity measures.

But, although the technology to turn wave and tidal stream energy into electricity has been around since the 1970s, a range of barriers have prevented it from being developed commercially. The cost of producing the electricity has been too high – current prototypes cost around EUR 6 450 – EUR 13 500 /kW and the first production units are expected to come in at EUR 2 500 to 7 000 /kW. Meanwhile, the technology still lacks the economies of scale that would make it commercially viable, and in a vicious cycle, there has been a conspicuous absence of serious industrial investment, which has preferred to concentrate on wind power, for example. However, a number of viable prototype devices have already been developed, essentially by academic institutions and small enterprises backed by public and EU funds. It is only very recently that major players such as Siemens, Alstom and Mitsubishi have come on board. In 2011, 3.4 MW of wave and tidal energy devices in advanced stages of technology development were being tested across Europe. But the target is to achieve 1.9 GW of installed wave and tidal stream energy by 2020, in line with action plans drafted by Member States in 2010. To reach these levels, says one

A goal is for Europe to have 15 demonstration sites operating by 2020, five commercial arrays by 2025 and for the technology to be market-ready by 2030, with cost competitive commercial farms. According to the Carbon Trust, arrays of 5 MW will be in the water by 2015 and costs could come down to 20p/kWh by 2020. This would be followed by a dramatic cost reduction as the technology becomes commercial. Europe could be generating 4.5 GW by 2030 and 60 GW by 2050, says Carbon Trust, with as many as 60 000 jobs.

According to the SI Ocean project brief published by IEE “the European Ocean Energy Roadmap 2010–2050 provided initial estimates of the industry potential and defined high-level challenges and opportunities to eliminate market barriers for ocean energy. The SI Ocean project will take this roadmap further by filling gaps in current knowledge and understanding and also by delivering specific recommendations for future actions.”

For more information see: <http://www.si-ocean.eu/en/Home/Home/>

OPEN-CENTRE TURBINES

# Invisibly harnessing the power of the oceans



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Irish company OpenHydro is a technology business that designs and manufactures marine turbines that generate renewable energy from tidal streams. The company has achieved a number of industry firsts including being the first to deploy a tidal turbine at the European Marine Energy Centre (EMEC), the first to connect to and generate electricity from tidal streams onto the UK National Grid and the first to successfully demonstrate a method of safely and economically deploying and recovering turbines directly on the seabed.

Many renewable energy technologies, such as solar, wind and wave, suffer from the difficulty of predicting when supply will be available, and what volume of electricity will be generated, due to the difficulty of accurately forecasting weather in the mid- to long-term. As it is dependent on gravitational forces rather than the weather, the tidal energy resource is reliable and easy to predict. Once tidal currents have been properly studied at a particular location, variations during the tidal cycle can be predicted with a high level of accuracy far into the future, making it possible to reliably forecast the energy supply.

OpenHydro has developed its open-centre turbine technology to take advantage of this resource and to extract energy from the oceans in an economically viable and environmentally sensitive manner. The open-centre turbine is designed to be deployed directly on the seabed. Installations are silent and invisible from the surface and, as the turbines are located at depth, they present no navigational hazard. It is the company's vision to deploy arrays of tidal turbines under the world's oceans, silently and invisibly generating

electricity at no cost to the environment, allowing communities to benefit from power supplied by the technology without ever being conscious of the turbines' existence.

The Irish company believes that the open-centre turbine is an example of a simple idea proving to be the most effective solution. The functionality and survivability of equipment in an underwater environment demands simplicity and robustness. The open-centre turbine meets these demands, with its slow-moving rotor and lubricant-free operation, minimising risk to marine life. The turbine features a horizontal axis rotor with power take-off through a direct drive, permanent magnet generator. The turbine's large open centre provides a safe passage for fish and its clean hydrodynamic lines ensure that marine life will not become entangled. The blade tips are retained within an outer housing which clearly defines the moving component, and the turbine is designed to generate energy at a slow rotational speed. The design avoids the use of oils or other lubricating fluids that could present a pollution risk. Tests have also confirmed that the unit produces very low levels of mechanical noise.

A number of factors need to be taken into consideration when selecting a site for a facility to harness tidal energy, these include tidal velocity (the speed and volume of water passing through the site) and bathymetry (the depth of the water and the geology of the seabed); and it is these that determine the position and number of turbines deployed. In addition, the distance from the proposed site to a grid access point will help determine the viability of an installation, as distance to shore can significantly influence costs.



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For an installation located at 100 km from the shore, the grid component can represent up to one third of the cost.

OpenHydro's open-centre turbine is one of the world's first tidal energy technologies to reach the development stage of permanent deployment at sea. The company's new deployment methodology, which was developed in-house, has eliminated dependency on expensive marine equipment and uses a custom-built tidal turbine deployment barge, delivering what the company believes is a step change in the economics of tidal energy. The open-centre turbine design will increase in size as development progresses. The first 6m test unit produced enough energy to supply 150 average European homes, mitigating over 450 tonnes of CO<sub>2</sub> greenhouse gas each year. OpenHydro has demonstrated that its technology is scalable by increasing the diameter of the turbine from a 10m, 1MW rated machine to a 16m, 2.2MW rated machine, generating up to 500kW. Larger diameter turbines result in higher outputs and improved economics.

However, proponents of the competing horizontal axis turbine technology have expressed some doubts about the commercial viability of open-centre turbines, arguing that open-centre turbines increase their output by increasing their size and that, in order to be highly efficient, a turbine must be smaller and cheaper to build, transport, install and operate. Rather than increasing turbine size, increases in efficiency are better achieved by optimising the blade,

which can only be done if the blade operates in a single flow direction. An open-centre turbine uses fixed pitch blades, allowing them to operate in both tidal ebb and flow. This means that there is no pitch control, which supporters of other tidal technologies see as crucial for a turbine to perform to its best advantage over the complete tidal cycle. Pitch control is also used to limit the forces that are applied to the rotor under extreme weather conditions. Yawing is another issue – this is what allows a turbine to turn directly into the flow for maximum efficiency, and this is seen as another advantage of competing technologies, as on most sites the tidal reversal is not a simple 180 degree switch. There is often an offset caused

by the shape of the seabed resulting in the reversal deviating from 180 degrees, which reduces yield and increases loads if it is not possible to adjust the turbine. The counter argument is that an open-centre turbine, with its direct drive and fixed pitch, is more reliable and therefore operating costs are lower.

While no conclusive argument has yet been made in favour of one technology or another, independent industry experts believe that it is important to maintain technological diversity at the early stages of the industry's development, so as not to exclude concepts that may have the potential to deliver significant benefits in the longer term. The market will ensure that the strongest concepts succeed. Whatever the future brings, right now OpenHydro is in a strong position. It has a commercial-scale tidal turbine with proven ability to generate electricity, the technical ability to connect successfully to a national grid and a method to deploy turbines quickly, safely and economically on the seabed. These are fundamental elements to support the commercialisation of the technology. Currently, the cost of generating electricity using an open-centre turbine is comparable to that of offshore wind. In the longer term, economics of large-scale deployment will trend costs toward those for onshore wind. As fossil fuel prices continue to increase, the case for tidal energy strengthens further. According to OpenHydro estimates, the value of energy produced from the world's identified tidal resources should exceed €16 billion per year.





**OpenHydro's Open-Centre Turbines are only one of a range of tidal technologies that includes:**

- **Horizontal axis turbines**  
Horizontal axis turbines operate on the same principle as wind turbines, extracting energy from moving water in the same way as wind turbines extract energy from the air. The tidal stream causes the rotors to rotate around the horizontal axis, thereby generating power.
- **Vertical axis turbines**  
Vertical axis turbines extract energy from the tides in a similar manner to their horizontal equivalents, except that the turbine is mounted on a vertical axis, around which the tidal stream causes the rotors to rotate.
- **Oscillating Hydrofoils**  
A hydrofoil is attached to an oscillating arm. The oscillating hydrofoil induces hydrodynamic lift and drag forces due to a pressure difference on the foil section caused by the relative motion of the tidal current. This motion then drives fluid in a hydraulic system that generates electricity.
- **Enclosed Tips (Venturi)**  
Venturi Effect devices are housed in a duct which has the effect of concentrating the flow of water past the turbine. The funnel-like collecting device sits submerged in the tidal current. The flow of water can drive a turbine directly or the induced pressure differential in the system can drive an air-turbine.
- **Archimedes Screws**  
The Archimedes Screw is a helical corkscrew-shaped device (a helical surface surrounding a central cylindrical shaft). The device draws power from the tidal stream as the water moves up/through the spiral, turning the turbines.
- **Tidal Kites**  
A tidal kite is secured to the sea bed and carries a turbine below its wing. The kite flutters in the tidal stream, describing a figure-of-eight shape, which increases the speed of the water flowing through the turbine.

# Ocean energy receives funding under NER300

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Three ocean energy companies were among the 23 renewable energy demonstration projects awarded a total of over €1.2 billion by the European Commission in December, 2012, under the first call for proposals for the NER300 funding programme. The projects, which received almost €59 million between them, will be co-financed with revenues obtained from the sale of emission allowances from the new entrants' reserve (NER) of the EU Emissions Trading System.

Irish wave energy project WestWave received €19.8 million of funding under the award. WestWave is a collaborative project between the major players in the Irish wave energy development sector, and aims to install and operate wave energy converters capable of generating 5MW of clean electricity by 2015. By building a wave farm of 5MW, the project will demonstrate Ireland's ability to construct, deploy and operate wave energy converters. It will also pave the way for commercial projects, in terms of consenting procedures, such as foreshore licensing, permitting, electrical grid access and local infrastructure.

Another recipient of NER300 funding, with an award of almost €18.4 million, was SeaGeneration (Kyle Rhea) Ltd, a development company set up by Marine Current Turbines (MCT), which is proposing to develop a tidal stream array at the Kyle Rhea site between the Isle of Skye and the west coast of Scotland. The proposed array will consist of four SeaGen devices and have a total capacity of up to 8MW. The technology used to harness the tidal energy at the site will be the SeaGen device developed by MCT. It is proposed that the turbine array will be installed and operated for up to 25 years, where it will serve as a test case for the development of the technology as part of a programme of further multiple unit arrays.

The third ocean energy project awarded funding under the NER300

programme was the Sound of Islay project to build the world's largest tidal stream energy array. Of the three ocean energy projects awarded under the programme, the Sound of Islay received the largest amount of funding, with €20.65 million awarded. The tidal array will consist of ten 1MW Andritz Hydro Hammerfest HS1000 Tidal Turbines which will be fully submerged on the seabed just south of Port Askaig. Every year, the Sound of Islay Tidal Project will generate about 30GWh of electricity. A single 1MW device was deployed at EMEC, Orkney in late 2011. Based on the success of this test, a further ten devices will be manufactured and deployed in the Sound of Islay.

The NER300 funding programme awarded a total of 23 projects, covering a wide range of renewable technologies, from bioenergy (including advanced biofuels), concentrated solar power and geothermal power, to wind power, ocean energy and distributed renewable management (smart grids).

Collectively they will increase annual renewable energy production in Europe by some 10 TWh, the equivalent of the annual fuel consumption of more than a million passenger cars. More importantly, the aim is to successfully demonstrate technologies that will help substantially scale-up energy production from renewable sources across the EU.

NER300 is implemented by the European Commission with the collaboration of the European Investment Bank (EIB) in the project selection, the sale of 300 million carbon allowances from the EU Emissions Trading System and the management of revenues. For more information:

<http://www.ner300.com/>

<http://www.westwave.ie/>

<http://www.seagenkylereha.co.uk/index.php>

<http://islayenergytrust.org.uk/tidal-energy-project/>





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