PANORAMA 2014

a look at ...

Marine renewable energies: news from the ocean front

Marine renewable energies have taken center stage in the energy transition and are no longer obscure. However, not all options are at the same stage of development. With the tidal wave of information in the field, now is an excellent time to review recent developments for the various types of renewable marine energy sources.

Developing renewable energy sources has become the focus of energy policy in many countries, particularly for electricity generation when land-based wind power is already in widespread use. In some cases, it is probably fair to say that most of the available sites and areas are now equipped. Marine Renewable Energies (MRE), including offshore wind power, represent a new avenue for complementary development.

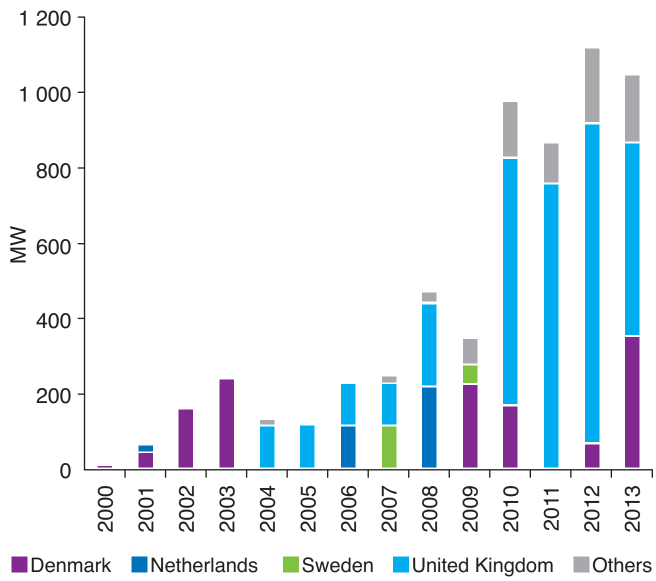
Europe has excellent deposits of recoverable energy, with the United Kingdom and France as the leading resource countries. Offshore wind power was the first MRE to be collected, while other MREs like hydrokinetic power from currents and waves are just in the early stages of development, and thermal ocean energy seems even further off.

Offshore wind power market has the wind in its sails

In early 2013, the pace at while offshore wind turbines were installed picked up considerably in Europe with the pioneering market for offshore wind power, in which 1,045 MW were connected in the first half of the year alone. It should be no feat to surpass the record of 1,120 MW set in 2012 (Fig. 1).

Without doubt, a new record should be set for power facility connections, at around 1,500 MW, and 2014 is looking even more promising: the European Wind Energy Association (EWEA) has identified 1,900 MW of planned installations for the year.

Fig. 1 – New installations in Europe between 2001 and July 2013



Source: European Wind Energy Association

Growth restarted in Denmark in 2013, with 350 MW of new capacity added after a several-year slowdown. The United Kingdom is still driving the market, after three years of construction at a constant pace. Every year, between 650 MW and 850 MW are connected to the grid there, and the country currently boasts the world's two largest offshore wind farms:

- the London Array (phase I), made up of 175 turbines, with peak production of up to 630 MW. This £1.5-billion project was implemented by E.ON, DONG Energy, and Masdar;

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- and Greater Gabbard, a wind farm with 140 turbines and a capacity of 500 MW off the coast of Suffolk. This farm will soon be expanded to include the secondary Galloper field. Greater Gabbard was financed by SSE Renewables and RWE Innogy for £1.3 billion.

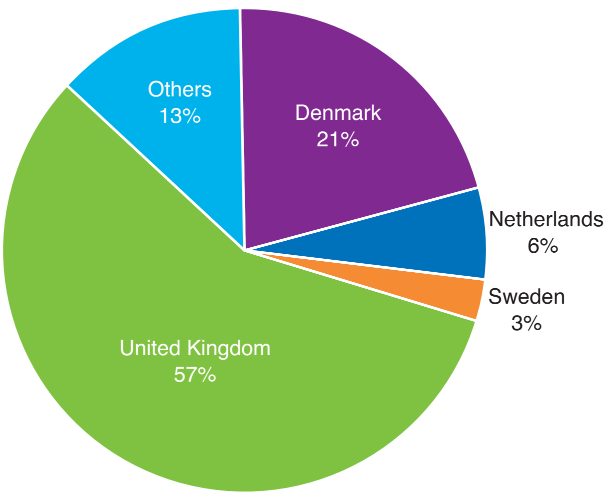
Already, other projects are on the cusp of implementation, like the Triton Knoll wind farm off the east coast of Norfolk. This offshore farm is slated to house 288 turbines with a total capacity of 1,200 MW, for an estimated investment on the order of £3.6 billion. The development of the offshore wind power industry in the United Kingdom has become one of the government's top development priorities, to ensure the country's energy security while reducing the greenhouse gas emissions of its electricity sector. To encourage investments, the Department for Energy and Climate Change has announced £20 million in financing to improve the production of offshore wind farms and £46 million to stimulate innovation in the field through corporate projects and research by British universities.

These new facilities bring the global total for offshore wind power to 5,538 MW. Naturally, Europe has the largest capacity at 4,995 MW (90% of global capacity at the end of 2012, Fig. 2), far ahead of China's 510 MW (9%) and Japan's 34 MW (1%).

France has set an ambitious goal of 6,000 MW of offshore wind capacity installed by 2020. It is ambitious since France currently has no offshore wind power and the first wind farms, following the two calls for tenders last year, will not come online for several more years.

During the first call for tenders, four sites were allocated (including three to the consortium of EDF and

Fig. 2 – Breakdown by country of offshore wind power installed capacities in Europe (July 2013)



Source: European Wind Energy Association

Fig. 3 – The result of the French offshore wind power call for tenders in 2012

Source: Ministry for the Economy

DONG/Alstom) for a total capacity of 1,928 MW (Fig. 3), for future installation of offshore wind farms and their operation by ad hoc companies:

- in Courseulles-sur-mer (450 MW), the Éoliennes Offshore du Calvados company is 85% owned by Éolien Maritime France (EMF) (60% EDF Energies Nouvelles and 40% DONG Energy) and 15% by WPD Offshore (developer of 2,500 MW of wind power worldwide);
- in Fécamp (498 MW), the Éoliennes Offshore des Hautes Falaises company is 70% owned by EMF and 30% by WPD Offshore;
- in Saint-Nazaire (480 MW), the project will be wholly operated by EMF;
- the Saint-Brieuc site (500 MW) was awarded to Iberdrola and Areva (Ailes Marines SAS).

The second call for tenders closed on 29 November 2013, and covers two sites: Le Tréport and the islands of Yeu and Noirmoutier for a combined capacity of 1,000 MW by 2020. EDF Energies Nouvelles and German company WPD Offshore partnered up once again to bid with their exclusive wind power supplier: Alstom. GDF Suez recently announced a partnership with Portuguese company EDP Renewables (3rd-largest global player in onshore wind power) to bid on this second call for tenders.

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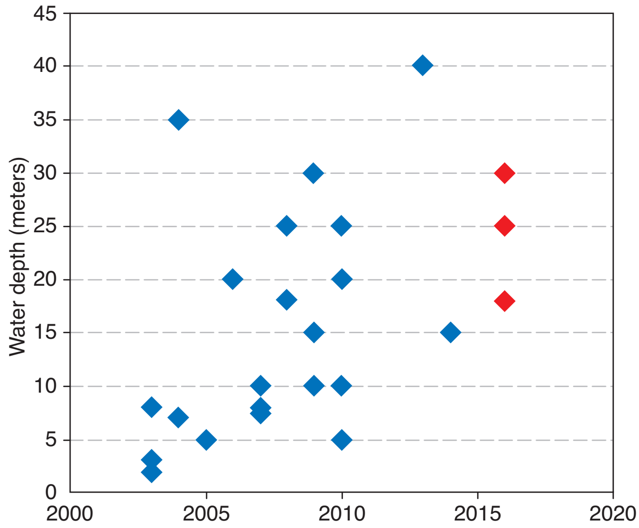
Recently, Minister for Ecology Philippe Martin mentioned that there would likely be a 3rd round for offshore wind power starting in 2014 to help meet the target (6,000 MW by 2020), although it seems more and more difficult, and to ensure the long-term future of this nascent industry in France.

Floating turbines: still waiting

More and more often, new offshore wind farms are being installed far from the coast, in increasingly deep water. This is for economic reasons: sites closer to the coast were developed first, and wind farm developers must now gradually look to deeper waters (Fig. 4), which also offer the benefit of stronger, more regular winds (adding some 500 hours of operation at full power, which is a 15% gain over the installed offshore wind equipment) while creating less disruption for other ocean users.

Fig. 4 – Water depth of wind farms, by year of installation



French projects from the marine and wind power tender are in red.

Source: IFPEN

Starting at a depth of 50 m, current wind turbine foundation technologies become too complicated and thus too expensive to use (between 10 and 40 m of water depth, there is an increase of some 35% in the cost of a wind turbine and its foundation), which opens the door to floating turbines.

The advantages and development potential of floating turbines have led several countries around the world to launch R&D projects to perfect floating technologies.

Even the most advanced projects are only at the prototyping phase, and developing differently:

- the Hywind Maine project has been shut down. Hywind, developed by Norwegian group Statoil, was the first floating wind turbine connected to a grid. The project was cancelled due to a new regulation in the state of Maine;
- also in Maine, the first floating turbine was connected to the grid in the United States. Again, this is a prototype scaled to 1/8 the size of the final turbine, which will generate 6 MW with a diameter of 130 m;
- Hitachi's 2 MW floating wind turbine, installed off Fukushima in Japan, has begun to produce electricity. Two other turbines, each 7 MW, are slated to be installed in the next phase of the project;
- In France, the Winflo project (DCNS, Nass&Wind, Vergnet, Ifremer, ENSTA Bretagne) is expected to produce a demonstrator off the coast of Le Croisic in 2014. It will be the first floating turbine in France;
- the Vertiwind project (with Nenuphar and Technip as primary sponsors) is aiming to design a floating wind turbine with a vertical axis.

Wave power projects still wavering

Wave power machines recover energy from waves and the swell. Multiple concepts are currently being studied and developed (see Panorama 2011 – Ocean renewable energies). Although wave power machines were among the first to attempt to recover energy from the oceans, many postponements and failures have caused the sector to lag:

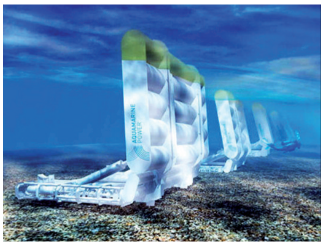
- Ocean Power Technologies has announced a delay in installing its test buoy off the Oregon coast, originally scheduled for 2013, due to administrative problems with the Federal Energy Regulatory Commission;
- due to funding issues, Blue Power Energy (Ireland) is seeking investors so it can market its technology;
- Pelamis has just lost the support of E.ON, which has announced a desire to focus on wind or solar power over marine renewable energies. Although Pelamis Wave Power has announced that this change does not threaten its project, we have cause to doubt, given the many problems and delays that have punctuated the project so far;
- more than financing and the cost of the electricity produced, mechanical problems remain the biggest challenge facing a wave power project: Aquamarine Power's Oyster ultimately managed to produce electricity that was sent to the grid for 24 consecutive hours. However, this feat was achieved after 18 months of work on the project and a series of mechanical failures and connection problems.

Fig. 5 – Illustration of several wave power concepts

Pelamis

Source: Pelamis Wave Power

Oyster



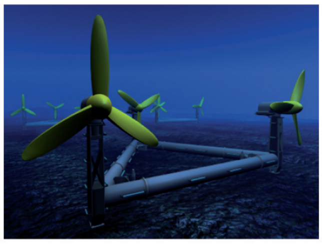
Source: Aquamarine Power

OPT buoy

Source: Ocean Power Technologies

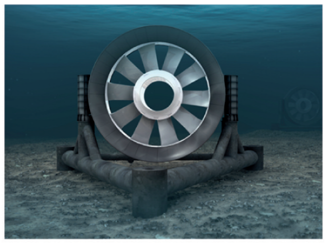
Fig. 6 – Three water turbine concepts soon to be installed

DeltaStream



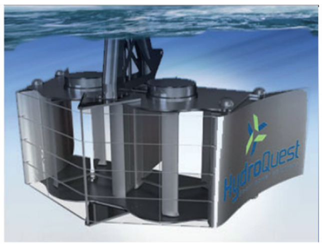
Source: Tidal Energy Ltd

OpenHydro turbine



Source: EDF

HydroQuest turbine



Source: HydroQuest

Still, not everyone faces so many complications, and some projects are producing electricity. One example is Wavestar, a platform installed in Denmark that recovers wave energy using articulated arms.

Water power projects spinning up

The news is better for the water power sector, which produces electricity by immersing propellers in ocean currents, using the same principle that applies to a wind turbine.

The first large-scale water power equipment is now being released. In Wales, Tidal Energy Ltd will immerse its DeltaStream concept, made up of three 400 kW turbines, on a triangular frame set on the sea floor. Initially, just one turbine will be installed, and the two others should be installed in 2014. Overall, the project could total 10 MW.

In France, the Paimpol-Bréhat tidal farm under EDF is moving forward. The technology used comes from OpenHydro (a British company that DCNS bought this year), and industrial go-live for the demonstration farm is slated to occur in 2014.

It is also possible to install a water turbine in a river, taking advantage of waterways that do not lend themselves to traditional hydroelectrical production. That is the aim of the HydroQuest project, which is studying the installation of a river turbine in the Loire River in Orléans at some point in 2014.

In addition, the government launched a call for tenders (Ademe AMI) in late September 2013 to establish the water turbine industry in France. Two sites will hold 3-4 farms, each with 4-10 water turbines: the first is in the Blanchard passage in the Cotentin (the English Channel), and the second is the Fromveur passage in the Finistère. Each farm will be financed up to €30 million. Several industrial companies have already indicated their interest:

- EDF, working with DCNS, for the Paimpol-Bréhat site;
- GDF Suez, in an alliance with Alstom;
- and Siemens.

High costs still a pitfall

The various marine renewable energies are currently expensive solutions (Fig. 7). For the moment, offshore wind power is the least expensive alternative, since it produces one electrical MWh for approximately €150, while water turbines have a production cost between €180 and €220/MWh and wave energy costs are even higher, at some €250/MWh.

Over the long term, the cost of marine renewable energies will need to come down below €100/MWh if they are to be competitive alternatives to the other methods for generating electricity, which also requires reining in maintenance costs; for offshore wind power projects,

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Fig. 7 - Summary of the maturity of marine equipment

Energy	Electricity production potential	Technical maturity	Market status	Production cost
Offshore wind power	20,000-30,000 TWh/year	+ +	1-2 GW/year	€150/MWh
Energy from currents	> 800 TWh/year	+	A few MW/year	€180-220/MWh
Wave power	1,000-2,000 TWh/year	–	A few MW/year	€200-300/MWh

Source: IFPEN

they can represent some 20% of the total production cost.

Ultimately, the marine energy sectors are experiencing very uneven development.

Offshore wind power technology is currently entering a consolidation and globalization phase. After a rocky start, the French industrial sector is gradually finding its footing thanks to the calls for tenders launched in 2012 and 2013.

The development of significant prototypes for water turbines and the launch of initial calls for tenders should foster the quick emergence of a new industrial sector.

However, the wave power industries are facing many technical difficulties, which have held them at the R&D phase for now.

For all these energy sources, the next step is to gradually reduce costs, both for initial investments and for the maintenance of machines installed far out at sea. This, along with integrating the intermittent energy produced into the grid, is the major challenge that marine renewable energies must meet.

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Final draft submitted in November 2013

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