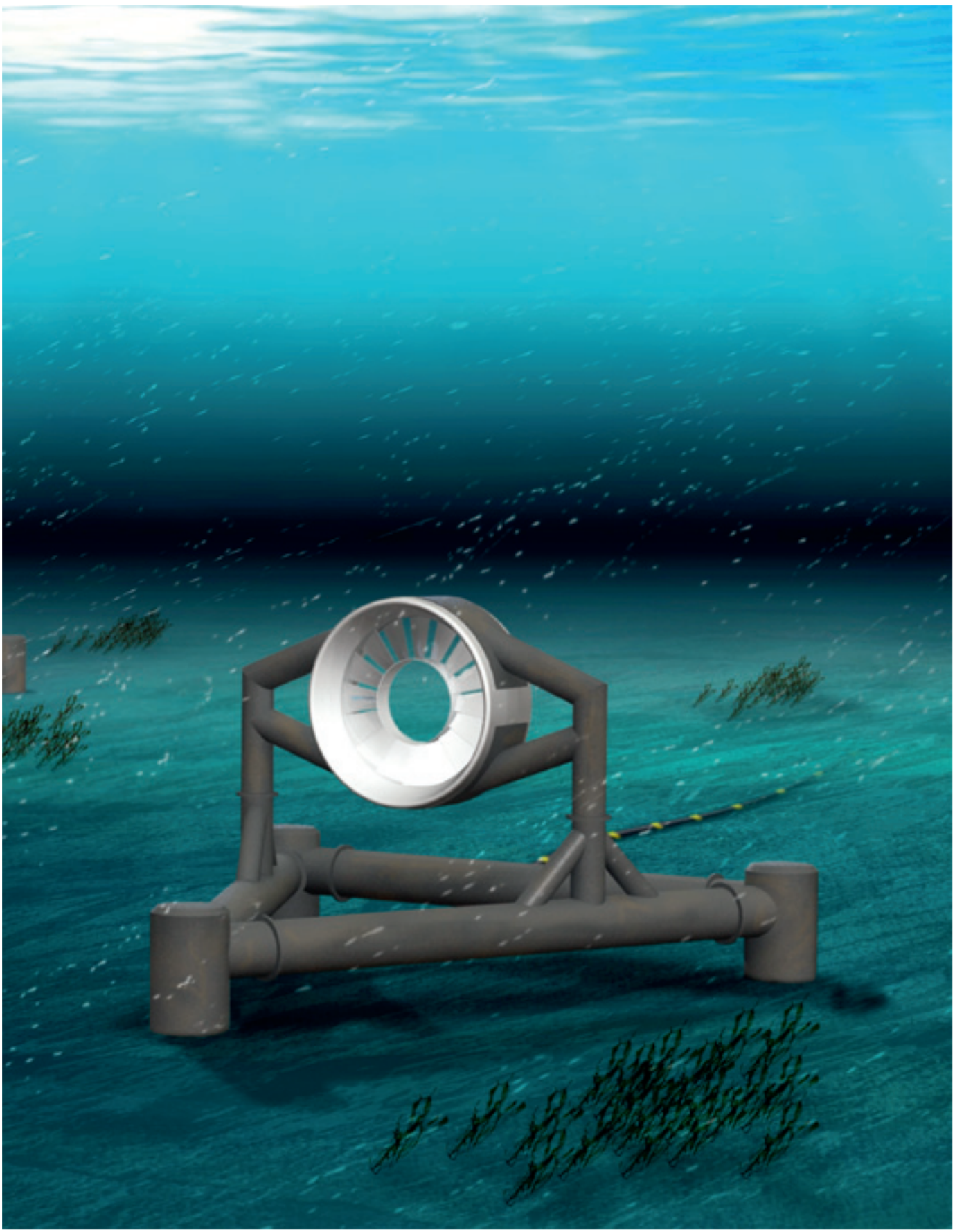


OpenHydro, the only turbine design with an open centre. Illustration: OpenHydro Group

UK hotbed for tidal power

The United Kingdom offers ideal conditions for the development of tidal power. Investors and inventors are plugging ahead, but it will probably take another ten years before tidal power can make a serious contribution to power production.

by Leen Preesman

The United Kingdom's tidal power resources have been estimated at 13 billion kWh per year, about 4% of total electricity consumption, with over 80% of the potential located in Scotland. It is therefore no surprise that the UK has become attractive to developers of tidal power technologies, particularly tidal stream.

According to the Carbon Trust, a company tasked with assisting the government with the transition to a low-carbon economy, marine power has the potential to deliver up to 20% of the UK's current electricity needs by 2020. 'We are confident that one or more devices could reach commercial and widespread market adoption within five to ten years,' says Tom Delay, Carbon Trust's chief executive.

There is still a long way to go, however. Although some designs are more advanced than others, all are at an early stage compared to other renewables. Besides further perfection of the generating technology itself (in most cases supported by grants from the government, power companies or private investors) quite a few technical issues need to be resolved, such as how to secure the devices to the seabed and how to maintain them in a harsh environment. Connecting tidal turbines to the grid is often another hurdle, particularly in remote northern Scotland. Delays in planned developments are common.

> *We need the same level of support as wind energy*

In its report Future Marine Energy (published in 2006), the trust estimated the initial costs of power from tidal stream farms at 12 to 24 eurocents per kWh: 'It is likely to be more expensive than other renewables until at least some hundreds of megawatts are installed.'

Forefront

With its commercial-scale prototype to be installed in early April, Bristol-based Marine Current Turbines (MTC) is at the forefront of tidal power developments. Its 1.2 MW turbine in Strangford Lough in Northern Ireland is expected to start supplying power to the local grid this summer.

MTC's turbine SeaGen consists of twin axial flow rotors, each 16m in diameter, mounted on wing-like extensions on either side of a steel mono-pile. The construction allows the twin turbines to be raised to the surface for maintenance. The rotor blades allow the turbine to operate in both tidal directions from the same position. Instead of the initial plan of placing a pillar three metres in diameter into a hole drilled into the seabed, the mono-pile will now be anchored by four legs into the seabed.

The €15 million project has been financed by long-term investors EDF Energy, Guernsey Electricity, Bankinvest and the hedge fund AM2. The Department of Business and Enterprise and Regulatory Reform (DBERR) gave a grant of €6.5 million. The ethical savings and investment bank Triodos also made a contribution in what is their first-ever investment in marine renewable energy.

Once SeaGen is operational, MTC will focus its attention on constructing a tidal farm off the north-western tip of Wales. The project consists of seven upgraded 1.5MW turbines and will be developed together with Npower Renewables. If all necessary permits are obtained, the tidal farm could be operational in 2011, MTC says.

After four years of testing a 300kW turbine in northern Norway, making it the world's first commercially exploited device, technology company Hammerfest Strom has teamed up with Scottish Power to form the new tidal power company Hammerfest UK. They are now developing a 1MW prototype that is scheduled to be deployed in Scottish waters in 2009. The Hammerfest concept resembles the design of a classic wind turbine.

Severn Barrage

Among the most discussed projects is a revived plan for a barrage in the Severn estuary. The Severn Tidal Power Group (STPG) would like to harvest the energy potential of a tidal range of over 14m, the second highest in the world. Their plan consists of a 16km dam containing 216 turbines, capable of generating 8.6GW, which accounts for approximately 5.5% of the electricity demand in England and Wales.

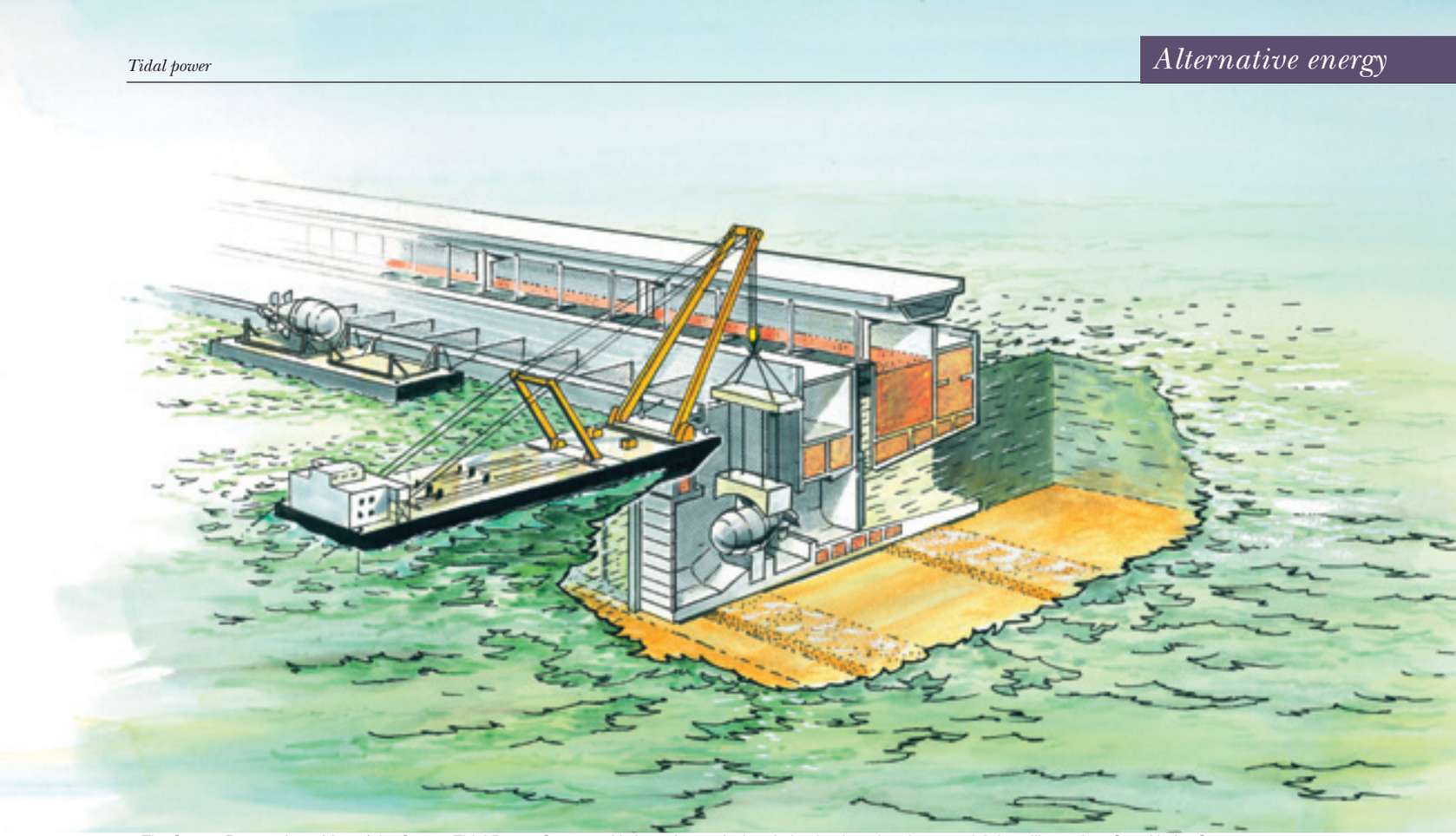
STPG – comprised of engineering and construction firms Balfour Beatty, Taylor Woodrow, Sir Robert McAlpine and the French company Alstom – expects that six years are needed to construct the €20 billion dam between Cardiff and Weston-super-Mare. Power generation could start in 2017.

The consortium has stressed, however, that it needs assurance of revenue during the coming decades. 'To make the project worthwhile for private investors, we need the same level of support as wind energy,' STPG spokesman Roger Hull explains.
According to STPG, once the capital costs of the tidal barrage have been sunk, the operational costs will be very low. It expects the initial generating costs to be on a par with offshore wind power.

Meanwhile, construction company Parsons & Brinkerhoff (PB) has come up with a much smaller design for a Severn barrage. The alternative, called the Shoots Barrage, is projected upstream and is just 4km long. It will cost €2.2 billion, contain thirty turbines and have a capacity of 1,050 MW. PB predicts the Shoots Barrage to generate 2.75 TWh a year. At a price of 7.3 eurocents per kWh, the resulting power will be 20% cheaper than power from the Severn Barrage, the company says, adding that 'moreover, connecting to the grid of the Shoots Barrage will be much easier.'

However, any barraging of the Severn estuary is highly controversial. The area is a wetland of international importance, and the Royal Society for the Protection of Birds (an organization with over a million members) claims that over 85,000 migrating and wintering water birds and waders will loose their feeding grounds, if STPG's plan goes ahead. The lobby

Top left: Swanturbine. Illustration: OpenHydro Group. Top right: Torcardo's turbine design. Bottom: Tidl design of SND. Photos: Leen Preesman



The Severn Barrage is an idea of the Severn Tidal Power Group and is based on a design dating back to the nineteen eighties. Illustration: OpenHydro Group

groups Friends of the Earth (FoE) and the World Wildlife Fund (WWF) have already expressed a preference for tidal current turbines, in order to minimize the impact on the environment. For their turn, surfers and kayakers fear that the project will end the famous Severn bore, an upriver-travelling tidal wave, which goes ahead of each incoming tide.

Supporters of the scheme point out the protection the barrage will provide against flooding and the rising sea level, and that construction of the dam will mean a huge boost to the local economy.

The Severn Barrage has the support of the Sustainable Development Commission, the government's independent watchdog, provided the project is publicly led and owned as an asset in order to avoid a short-term outlook and ensure long-term public interest. The SDC also requires the project to fully comply with the EU Habitats and Birds Directives, as well as a long-term commitment to creating compensatory habitats.

The DBERR has announced a feasibility study of barrages and tidal lagoons for power generation. A full public consultation on the final project is expected in 2010.

Tidal lagoon

In Swansea Bay, not far from the planned Severn barrage, the company Tidal Electric UK wants to create a tidal lagoon for power generation. It has successfully completed a feasibility study for a five-square kilometre basin surrounded by dykes. 24 turbines are expected to generate 60 MW from the average tidal range of 8.5m. Director Peter Ullman estimates the cost of the project to be €106 million.

> *Pentland Firth is the Saudi Arabia of green energy*

The project has been delayed for at least nine years because of a lack of cooperation from the UK government, according to Ullman. However, he has recently noticed a positive shift in the government's approach. 'If the government steps out of the way, we are ready to proceed with the necessary additional research and an environmental impact assessment,' he says. 'If subsequently everything goes according to plan, it will take over three years before we have the project up and running.'

Ullman also says he isn't worried about the barrage plans. 'It will probably be abolished, like the range of plans that have been launched since 1850,' he comments. 'And if it does go ahead, it will actually benefit us because of the expected increase in the tidal range.'

Pentland Firth

While the Severn estuary is the focus of the industry exploiting the tidal range, the Pentland Firth at Scotland's North-eastern tip is the hotspot for the tidal stream industry. Its high-velocity currents, caused by the exchange of tides between the North Sea and the Atlantic, squeezed between the mainland and the Orkney Islands, are

estimated to count for over 30% of the UK's total of tidal stream resources.

'The Pentland Firth is one of the best spots in the world for generating marine energy,' says Professor Ian Bryden, head of marine energy of Edinburgh University. 'It is the Saudi Arabia of green energy.' He estimates the firth's capacity at 8GW with an average output of 2GW.However, he is also cautious. 'The Pentland Firth is a very difficult and dangerous stretch of water and harnessing its energy is probably too dangerous at the moment. The technology is not yet available to deploy devices in the parts with the best energy potential, which have a water depth of 60 to 80 metres. The best technology currently can only operate in water depth of up to 40 metres.'

According to Bryden, the main problem still is the expensive process of installing and fixing tidal power devices. 'We need two or three years to develop good marine working practice.'

Bryden has been involved in the development of an underwater turbine for some time. After having successfully tested a 150kW model, a full-scale 600kW device could be installed next year. However, a dispute about intellectual property rights must first be resolved first, and funds need to be raised as well. 'So far, power companies seem to be mainly interested in large-capacity devices,' he says.

Bryden says he cannot provide an indication of the kWh costs of his turbine. 'But because it is cheap and simple, it will be one of the most cost-effective designs,' he stresses. He expects that it will take three to five years before this technology is competitive with offshore wind energy.

Tocardo

Pieter de Haas, project leader of the UK branch of Tocardo Tidal Energy, is more optimistic. 'In the summer of 2009 we hope to have a 650kW turbine operating and connected to the grid in the Pentland Firth, as the first of an array of 16 devices,' he says. The Netherlands-based company is part of Pentland Tidal Power, a consortium of mainly local companies that has committed itself to a 10MW demonstration project.

In 2005, Tocardo Tidal Energy successfully tested a 35kW model in the Netherlands in the sluices that drain the IJssel Lake into the North Sea. Its pre-commercial prototype will be tested at the same location this summer.

Tocardo's turbine is basically a nacelle with a fixed-pitch propeller, attached to a pylon. 'We have focused on a simple but effective design to keep the maintenance costs down,' De Haas explains. However, the company still needs to overcome a significant hurdle by developing a current-proof foundation for the Pentland Firth. 'We will seek the solution in a simplified version of systems that have been tried and tested during the past decades,' De Haas says. According to him, power from Tocardo's turbine will be cheaper than electricity from offshore wind within five to ten years.

One of the reasons why Tocardo focuses on the UK is the potential of government subsidies, its project leader points out. 'We also expect to get assistance from the Scottish government in obtaining the necessary permits,' De Haas adds. However, in order to maximise the energy potential of the Pentland Firth, the electricity grid in the north of Scotland needs to be urgently upgraded. 'At present, the grid is incapable of transmitting the power that could be produced by marine energy. Therefore, the government should make upgrading a matter of national strategic priority,' chairman Lord Maclennan of Rogart emphasized, during a major conference about the energy potential of the Pentland Firth. ■

The expert

'The development of tidal stream power is considerably lagging behind offshore wind power. The aspects of mooring and maintenance in a harsh environment in particular need further development,' says Keith Tovey, Professor of Environmental Sciences at the University of East Anglia. According to the scientist, tidal stream power can't be relied on during the next ten to fifteen years, a critical period for the direction of the future energy supply in the UK.

Tovey says he considers the designs of OpenHydro and Scotrenewables as the most promising. 'However, the mooring system of Scotrenewables' floating turbine needs further improvement, in order to resist the forces from waves against the tidal direction.' In Tovey's opinion, the costs of tidal stream power could be brought down by incorporating a tidal turbine in the foundation of offshore wind turbines. Such a combination will not only provide synergy benefits for maintenance, but can also share the connection to the grid, he argues.

As far as the Severn barrage is concerned, Tovey makes clear that he supports a two-basin design. A higher second basin placed inside the main one could be used to smooth out diurnal fluctuations by water being pumped-in by off-demand power.' Although this is a more expensive concept, it should be considered as a strategic rather than an economic approach. And as an energy storage, the second basin could offset the extra costs of construction,' he says. However, STPG is not considering a second basin because of its extra costs, its spokesman made clear.

Tidal Test Centre

A pivotal role in the development of tidal power is the European Tidal Test Centre (ETTC) near Stromness on the Orkney Islands. Since its opening in September 2007, the government-backed facility has been offering five test berths with water depths ranging from 25 to 50 metres and covering an area of eight square kilometres. The high-velocity currents, located off the island of Eday reach almost 4 metres per second during spring tides.

So far, Dublin-based OpenHydro is the only company that has installed its design for testing at the ETTC. However, at least four competitors have announced they will also take their turbines to Orkney. Supported by a €2.4 million grant from the Scottish Executive, OpenHydro is checking the performance of a slow-moving and self-contained rotor with an open centre. A solid state permanent magnet generator is encapsulated within the outer rim. According to the company, the design is considered to have no impact on marine life because of its open centre, and its lack of oil and exposed blade tips.

OpenHydro says it has already signed a major agreement with Alderney Renewable Energy that allows it to install an array of its turbines in the powerful currents off the Channel island. Depending on local planning permission, the project is scheduled to become operational in 2009 or 2010, says spokesman Andrew McLindon.

According to OpenHydro, the tidal flows around Alderney could generate 3GW that could be fed into the European grid. The company claims to have won a global public tender to deploy turbines in Canada's Bay of Fundy as part of a demonstration project. It has raised a total of €50 million for the development of its technology so far, it says.

Technical specifications of the OpenHydro turbine are not yet publicly available but according to McLindon, the cost of electricity from the open-centre turbine will be comparable to offshore wind power. 'In the longer term, economics of large scale deployment suggests costs moving towards onshore wind level,' he says.

James Orme, managing director of Swanturbines, reckons to have his design ready for testing at the ETTC this summer. Swanturbines' device reflects the classic wind turbine on top of a pylon, which is extendable for on-surface maintenance. The test model has a gearless axial-flow low-speed generator with a capacity of 350kW. However, the pre-commercial system to be commissioned in 2010 will have a capacity of over 1MW, Orme says.

Swanturbines has received an undisclosed grant from the DBERR and has been assured of corporate funding for development, Orme says. He expects his technology to be competitive with offshore wind power as soon as a few hundred megawatts have been installed.

Tidal Generation Ltd is working on a prototype of similar design to be tested at the ETTC. Its 1MW turbine is supported by a tripod construction and has a total weight of 80 tonnes. The company aims at having its device operational in 2010. It says it estimates the costs of the initial output of tidal power farms at between 10 and 12 eurocents per kWh.

Floating turbines

At least two companies have staked their future on floating tidal turbines. Orkneys-based Scotrenewables Marine Power (SRMP) expects to have its full-scale 1.2MW prototype ready for testing at the ETTC at the end of this year. Its design consists of a cylindrical buoyant tube with subsurface nacelles carrying dual counter-rotating horizontal-axis rotors attached to arms. The rotor nacelles can be retracted when the device needs to be moved. The device is anchored to the seabed. SRMP has been financially supported by both the Scottish Executive and the DBERR.

The Tidel, under development at Soil Machine Dynamics (SMD) in Newcastle-upon-Tyne, is comprised of two connected parallel floating "torpedos". Each body carries a propeller with a diameter of over sixteen metres, capable of generating 500kW. The double turbine will be anchored to the sea floor.

Based on the present planning, the full-scale prototype must be ready for testing at the ETTC in 2009, Andy Hunt of SMD says. According to Hunt, it is still too early to provide an estimate of the future costs per kWh or the moment when SMDs technology might be competitive with offshore wind power. The company has received a €3.4 million grant from the DBERR.

HydroVenturi

The company HydroVenturi has come up with a 'revolutionary' design without any moving parts. The key element of the 2MW device is a submarine venturi to accelerate the water and create a subsequent pressure drop, which then pulls air into the device. The sucked-in air can be used for driving a turbine/generator pair onshore or on a platform.

However, the project is on hold after chairman and co-inventor John Hassard and the engineering team resigned, following a dispute with the investors about the company's direction, Hassard says but adds that 'we are ready to go, as soon as the investors change their mind. We will make it work. Within a year of commissioning, the generation costs will be competitive with offshore wind power.' According to Hassard, a scientist at London's Imperial College, HydroVenturi aims at installing its device off the coast of Iceland, where the planning process is much simpler than in the UK. ■