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Section: Technology

The limited life span of wave powers wonderful creatures

Only time will tell if any of the creations designed to harness the power of the waves have the staying power to help the green electricity industry thrive

FROM giant hydraulic oysters that sit on the sea floor, to long rubber snakes that writhe in the ocean swell, there's no shortage of creatures designed to harness the power of the waves. If wave power is to emerge as a viable form of green energy, we need to put them to the test and only the most reliable can expect to survive.

While there's a veritable menagerie of strange beasts taking to the sea, most of them can expect a humdrum life, says John Chaplin, a marine engineer at the University of Southampton in the UK. "The fundamental problem facing wave-power devices is that most of the time the water is moving with rather low velocities," he says.

Just as wind turbines grind to a halt on a quiet day, wave power machines generate little power in quiescent conditions. That's the challenge for wave power - how to extract energy from lifeless waters. "Such a wide-open brief has led to an enormous range of inventions," says Chaplin.

Budding wave-power designers are getting ample opportunity to find ways to turn gently bobbing waves into energy, with new projects hitting the water with metronomic regularity. For example, last month, New Jersey-based Ocean Power Technologies confirmed it was to start work on a project to deploy 10 of its PowerBuoy machines 4 kilometres off the coast of Reedsport, Oregon. They ride on the surface, converting the up-and-down motion of the waves into electrical power.

This project and others like it will add to the growing throng of wave-power systems already in the water.

Trident Energy of Southend-on-Sea, UK, chose a system of floats that bob up and down in the waves to drive generators on a platform above. Aquamarine Power and Pelamis Wave Power, both based in Edinburgh, UK, have opted for more unusual solutions. Aquamarine Power has developed the Oyster, a hinged metallic shell that sits on the sea floor and opens and closes as waves wash over it - hydraulic cables link it to onshore hydroelectric generators. It has been powering 9000 homes in Orkney since November 2009.

The Pelamis device is a jointed mechanical snake that floats near the surface, flexing in the waves to drive hydraulics systems that power electrical generators. It has already been tried out in the North Sea off Orkney - the proximity of a populated region to an area where waves are relatively strong makes it a popular choice. It has also been tested at the world's first commercial wave farm off the Portuguese coast.

Early experience with these devices shows how difficult it is to set up a viable wave power system. The three Pelamis snakes tried out in Portugal's wave farm in 2008 had to be towed back to shore after barely two months because of buoyancy issues and a lack of cash. Trident Energy, meanwhile, is still struggling to start sea trials. Last September, the company's prototype rig capsized as it was being towed to its test site, setting the project back several months.

Although early setbacks are to be expected, says Peter Tavner, a renewable energy engineer at Durham University, UK, wave power must learn lessons from the more established wind-power industry if it is to thrive.

Unlike solar energy, where efforts have focused on making designs more efficient, successful wind-power designs are based on reliability. The ubiquitous three-blade wind turbine has a history stretching back at least 50 years to Gedser in Denmark. The Gedser Mill, as the turbine is called, hardly represents the pinnacle of turbine efficiency, says Tavner. Others in the industry, particularly engineers in the US, thought a two-blade turbine offered better aerodynamics, he says.

The trouble was that the hub at the centre of a two-blade turbine is under severe strain as the two blades rotate. That strain reduces the turbine's life expectancy; adding a third blade eases the problem.

As tweaks to the Gedser Mill design further improved its reliability, it became clear even in the US that the Danish turbine would win out. "Is a three-blade turbine optimal? No," says Tavner. "But is it functional and has the production volume risen to make it a good solution? Yes."

"I think the three-blade Gedser turbine design is a bit like a four-stroke petrol engine," Tavner says. "It worked and it was rugged."

There are signs that the wave-power industry has grasped the importance of reliability. For example, the Trident Energy system has abandoned hydraulics, which are prone to rusting, so its bobbing floats, whose movement is used to generate energy, should stay operational, says company founder, Hugh-Peter Kelly.

The Pelamis snakes are easily towed into dry dock for cheap and easy onshore maintenance, points out Tavner. Aquamarine Power claims that maintenance problems with the Oyster are minimal because it pumps pressurised water onshore to drive easy-to-reach generators there.

Chaplin, meanwhile, is a member of the team behind perhaps the most outlandish of all wave-power converters, the 200-metre-long Anaconda. Floating just below the surface, the water-filled rubber tube is squeezed by the waves. As a swell hits the front of the snake, it squeezes the tube creating a bulge that ripples along its length to power a turbine in its tail. The unusual material and general lack of moving parts should give it a long life, Chaplin claims.

At this stage in the nascent wave-power industry, no one actually knows which designs will prove to be up to the job, says Tavner. To some extent, the industry will have to "throw the machines out there" and see how long they survive.

It's only through a period of very public failures that the wave-power industry will arrive at its own version of the Gedser Mill, he suggests. When that happens, perhaps the industry will become known for its utility, rather than its oddity.

Grose, T. 2010. Surfing Energy's Next Wave. *U.S. News & World Report*, *147*(4), 50-52.

Section: LOOKING AHEAD **Surfing Energy's Next Wave**

COMPANIES ARE LEARNING HOW TO CAPTURE THE POWER OF THE OCEANS AND SEAS

For four months in 2008, the churning waters 3 miles off the north coast of Portugal were home to a test of the world's first commercial wave energy farm. To most observers, this marine power plant must have looked very odd. Each red device had four cylinders linked end to end, sausagelike and semisubmerged, with their noses pointed toward the incoming waves. The cylinders were connected by hinged joints that moved as the devices rode the waves--an action that pushed pressurized fluid through hydraulic motors, powering generators that sent a flow of electricity down to a single underwater cable.

Within the rapidly expanding renewable energy sector, wave energy farms like the one tested in Portugal are still a novelty. But not for long. As the push to develop clean alternatives to greenhouse gas-emitting, nonrenewable fossil fuels accelerates, most money, research, and development remain focused on wind and solar technologies. But marine power, particularly wave and tidal energy, might also eventually provide consumers with large amounts of affordable, renewable electricity. Essentially, the science, art, and costs of marine energy are where wind power was two or three decades ago. "It's not ready for prime time--it needs five to 10 years of technical development," says Dick K. P. Yue, a professor of ocean engineering at the Massachusetts Institute of Technology. "But it could have a huge impact in 20 years."

About 70 percent of the Earth is covered in water, and this water is the globe's biggest repository of solar energy. One need only watch waves crashing onto a rocky shore to appreciate the seas' might. If just 2 percent of the oceans' energy were converted to electricity, it would meet the world's entire power needs, according to the Northwest National Marine Renewable Energy Center in Oregon. Moreover--unlike wind and sunlight--waves, currents, and tides are highly predictable, which makes ocean power more grid friendly. With an increasing swath of the world's population living within 50 miles of the seas, marine power would not need to be transmitted great distances. The converters used to harness water power are generally environmentally benign and unlikely to harm marine life. Indeed, the environmental group Greenpeace has been lobbying heavily for ocean energy.

Far from shore. So why has it lagged other renewables, particularly wind? Mainly for technical reasons that are now largely solved. The open sea can be unforgivingly harsh, and salt water is corrosive. Creating machines that could withstand those elements for years and years was a challenge. Accordingly, most government research money and industrial investment went instead to wind and solar projects. But oil and gas companies have in recent years devised technologies that enable them to put their rigs farther from shore into deeper, rougher waters. The marine energy industry now can use that knowledge to ensure that its own devices are likewise robust. That's a big reason behind more financial support going to marine energy now.

Wave energy, more than tidal, offers the most accessible sea power. (Tidal energy uses the currents in seas, while wave energy draws power from the rise and fall of waves on the surface.) The Electric Power Research Institute conservatively predicts that wave energy could provide around 6 percent of America's electric needs (about the same as the hydropower drawn from dams), while tidal energy could provide an additional 3 percent.

Wave devices come in a variety of designs, but all work to transform the energy from the rolling motion of waves of water to electricity, usually converting aquatic motion to mechanical energy that runs a turbine or generator. The machines used in the Portugal wave farm were designed by the Pelamis Wave Power company of Scotland. Worldwide, there are around 100 competing designs for wave and tidal energy converters. But as the industry matures, there will be a necessary shakeout of the most impractical and costly designs, leaving only a handful of commercially viable machines.

Another wave energy device undergoing tests is the Oyster, developed by Aquamarine Power, also based in Scotland. Designed to capture the energy of near-shore waves, it's essentially a hinged flap connected to a base that rests on the seabed. As a wave passes over the top flap, it pushes the flap down, driving hydraulic pistons that shoot water at very high pressure through a pipeline to an onshore turbine. "The beauty of the machine is its simplicity. There are only seven moving parts," says Martin McAdam, Aquamarine's chief executive. Oyster's design also shows that it's not necessary to capture all the energy in each wave, especially if it's a massive storm wave that might otherwise overload the machine. Excess wave energy streams over the top of the flap once it is submerged. Aquamarine and the utility company Scottish and Southern Power plan to install over the next few years six to eight wave farms that together could provide 1,000 megawatts of electricity from around 1,200 Oyster devices. (One megawatt is a million watts, enough electricity to power up to 900 American homes for a year.)

Rubber made. Perhaps the most unusual wave energy converter is the Anaconda, developed by England's Checkmate Seaenergy for use in deeper waters 5 miles from shore. The aptly named device is a long, sealed rubber tube filled with water, tethered to the seabed and pointed at incoming waves. As each wave rolls over the snakelike part of the apparatus, it creates and pushes a growing bulge within the length of the tube, building pressure that operates a turbine at the other end. A full-size Anaconda tube would measure 23 feet in diameter and about 660 feet in length and could generate 1 MW of power. Checkmate put a one-twenty-fifth-scale model of the Anaconda through 10 weeks of tests last year, and a U.S. engineering firm is now independently vetting those results. Checkmate Chief Executive Des Crampton says Anaconda's strength comes from its rubber construction. "Rubber can survive for years and years in seawater."

As with wave converters, tidal devices come in a variety of designs. Some, like the idea from the OpenHydro company in Ireland, are turbines akin to those that capture wind energy. One unique technology, however, comes from Michael Bernitsas, director of the Marine Renewable Energy Lab at the University of Michigan. His VIVACE converter can not only harness the power of rapidly flowing currents but also draw energy from the more languid ones that flow at just 2 to 3 knots. That means VIVACE can work in slow-moving rivers. Engineers are aware of, and try to mitigate, a phenomenon called vortex-induced vibrations. When a current hits a flat surface, the water vortexes that occur as the liquid moves around the object create oscillations that can cause structures like bridges to fatigue and collapse. But Bernitsas's machines harness those vibrations to create mechanical energy. A full-size prototype of the VIVACE will undergo testing in the St. Clair River outside Detroit this summer.

Costs for marine power are high but could fall rapidly as capacity grows. Consider wind power. It has gone from zero electric power generation in the 1980s to 120 gigawatts today (about 1.5 percent of the total world energy consumption per year), and its costs have fallen 80 percent to a competitive 7 to 9 cents per kilowatt-hour. Manufacturers of marine energy converters estimate that their machines eventually could produce electricity at a cost of around 5 to 10 cents per kilowatt-hour. But marine energy will need government support in the early stages, just as other renewable power sources do. Some states, for instance, have programs requiring utilities to purchase a certain percentage of electricity from renewable sources. And wave and tidal producers in the United States are eligible for a 1.1-cent-per-kWh tax credit, which the industry hopes Congress will double. Pelamis Business Development Director Max Carcas defends subsidies, saying, "No new energy is competitive right out of the box." But there is a payoff, he says. Each doubling of capacity from the new energy source might bring down costs by 15 to 20 percent.

Government incentives also could encourage private investors to back new marine technologies because they help ensure the likelihood of a return on the investment. And cleanly capturing the power of the seas to light homes and offices is also the kind of technology that can capture the public's imagination. After the BBC last year ran a feature about Anaconda, Crampton says, "people began E-mailing us, asking who do they send a check to. It's been gratifying." That's the kind of wave of positive sentiment that the marine energy industry hopes it can continue to harness.

PHOTO (COLOR): At a plant in Scotland, workers build a new device that can help convert the energy of oceanic waves into electricity that can power homes.