# Ocean Power

**The seas that cover over 70 percent of our planet's surface are constantly on the move – like giant aquatic engines.** They produce a prodigious amount of energy, but harnessing that power is proving a massive and lengthy challenge. *By* MICHAEL FRANCO

PHOTO: WAVE DRAGON, © EARTH-VISION.BIZ

In October 1973, in retaliation for US assistance to Israel during the Fourth Arab-Israeli War which broke out that month, the Arab-dominated OPEC stopped or heavily restricted oil exports to many Western nations. This move by the Organization of Petroleum Exporting Countries resulted in a massive 70 percent petrol price hike and widespread rationing in both the United States and Europe. That was when Stephen Salter, a professor of engineering design at the University of Edinburgh in Scotland, conceived a wave energy converter (WEC) to take power from the sea, with the help of funding from the British government.

"In the autumn of 1973, the Western economies were given the rare chance of a ride in a time machine and saw what the world would be like when there was no longer cheap oil," he says. "Most people thought it looked rather uncomfortable."

Forward-thinking researchers, including Salter, increased their efforts to develop alternative energy sources. But according to Salter, "powerful groups set out to destroy what they saw to be a threat." Some say the groups to which Salter refers included nuclear power interests whose lobbying efforts may have caused the British government to shut down funding to his programme in 1982.

Whatever the background politics, it was only in September 2008 - 30 years after Salter's pioneering efforts to harness the power of the sea - that the world's first commercial wave farm was turned on off the coast of Portugal. There, in Aguçadoura, three long, red, steel snake-like devices are twisting, flexing and bobbing on the surface of the sea - producing clean, renewable energy with every move they make.

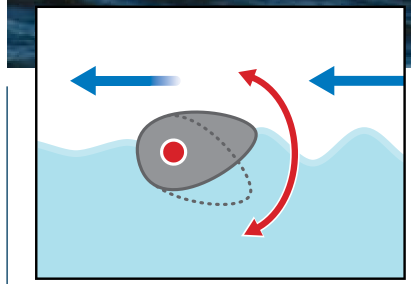
Called Pelamis, they are named after a type of sea snake and are the work of Richard Yemm, one of Salter's students.

Once testing of the units is complete, the plan is to deploy 25 more, with a total generating capacity of 21 megawatts. Max Carcas, business development director of Pelamis Wave Power, notes with cautious optimism that, "this being the first time these machines have been deployed, we have a conservative programme of operation." He points out that the company intends to build up its experience for progressively longer periods of time, and in a wider range of sea states, until the design is fully proven.

### Animal Magic

Salter's original design was known as a "Duck," for the oval shape of its floating canister. It worked by nodding on surface waves and moving an attached piston to compress hydraulic oil which then drove an electricity-producing turbine. Ironically, the Ducks were simply too good at what they did. Each one was capable of absorbing 90 percent of

**Scientist Stephen Salter's** pioneering work generating power from waves using his **Duck** contraption (left), led to the development and commercial operation by one of his students of the **Pelamis sea snake** (main picture).



## Salter's Duck

**Although invented in the 1970s**, the Duck is still one of the more efficient devices at extracting wave energy. Difficulties with maintenance, tethering and positioning meant it was never commercially deployed in any numbers. However, advances in materials technology combined with new designs might mean more bobbing ducks offshore in the near future.

PHOTOS (TOP LEFT): PHOTOLIBRARY; ILLUSTRATIONS: EMILY COOPER

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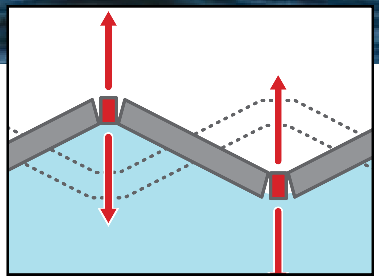


## Snakes Alive

**The "sea snakes" currently** contributing electricity to the power grid of Portugal will soon have cousins doing the same in British waters. Pelamis Wave Power is working on ventures which will see a wind farm in operation off the Orkney Islands in northern Scotland and another off the southwestern English county of Cornwall.

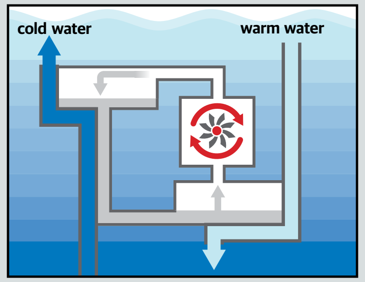
**POWER CONSUMPTION** • **Clock radio:** 4 watts • **Compact fluorescent light bulb:** 18 watts • **Laptop computer:** 45 watts • **Standard light bulb:** 60 watts • **Standing fan:** 100 watts • **Refrigerator:** 200-700 watts • **Window-unit air conditioner:** 500-1,440 watts • **Coffee-maker:** 900 watts • **Four-slot toaster:** 1,500 watts

## Warm Waters

**Every day, the surface waters** of our tropical oceans soak up the amount of heat from the sun that could be produced by 250 billion barrels of oil. Yet just below the surface, the water quickly cools. When the temperature between the upper layers of the sea differs from the deeper water by 20 degrees Celsius, Ocean Thermal Energy Conversion (OTEC) systems become viable.

These work by using the tropical waters to vaporise liquids with low boiling points, such as ammonia or propane. As the liquid becomes vapour, it turns a turbine and is then condensed back to a liquid using the deeper, cooler water. The process then begins again.

The US military is planning two OTEC facilities – one near Diego Garcia in the Indian Ocean, the other off the Marshall Islands in the Pacific.





a wave's energy, making them very efficient – but unlikely to sustain such a daily pounding from the sea. This, and the lack of ongoing financial support, were key factors in the short-lived life of the early Ducks.

But the newly deployed Pelamis devices address the over-efficiency issue. They consist of a linked series of long, cylindrical chambers about the size of small commuter trains. As they float on the sea, waves cause the sections to bob up and down and bend back and forth, activating hydraulic rams in the joints. These produce power much like the Ducks were meant to, but the Pelamis units absorb less wave energy and are therefore more durable.

Antonino Lo Bianco, European head of infrastructure at project partners Babcock and Brown, says the work at Aguçadoura outlines a positive future for ocean power: "It offers huge potential, not just for Portugal but for many countries around the world where the harnessing of an inexhaustible supply of wave energy will produce clean, zero-carbon energy domestically. We expect wave power to become a widespread renewable energy technology."

### Oil Up, Research Down

Expectations aside, the reality of ocean power is that it seriously lags behind the development of other alternative energy sources such as

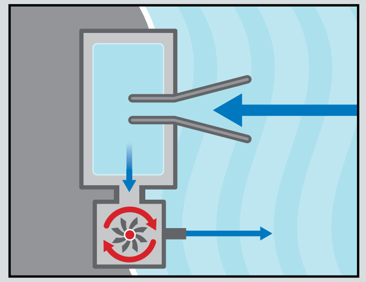
Plans are under way to build a full-scale commercial unit of the **Wave Dragon** off the coast of Wales with a 7-megawatt capacity. The machine contains a turbine which is spun by the crashing waves.

## Sea to Shore

**An average-sized wave** can hit the shore with up to 35,000 horsepower per 1.6 kilometres of coast – or the amount in approximately 93 Ferrari 355 F1 racing cars. So shorelines are the perfect place to build wave-harvesting machines.

One of the most popular is known as a tapered channel or "tapchan" device. It acts like the moat around a beach sandcastle, funnelling water from crashing waves through a channel into land-based reservoirs. As the water answers the call of gravity and drains back to the sea, it spins an electrical turbine.

A contraption called the Wave Dragon puts the tapchan principle to work in the deep sea. A prototype of this floating "overtopping" device has gone through 20,000 hours of testing in Danish waters.

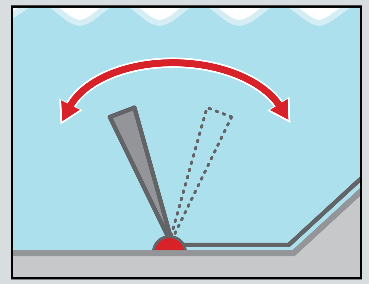


## Roll with it

**Not all wave-energy converters** work on top or alongside the sea. Some, like the WaveRoller, are fully submerged. When professional diver Rauno Koivusaari noticed a bulkhead door on a wreck flapping back and forth at the bottom of the Baltic Sea, the idea for WaveRoller was born.

Looking for a way to harness the power of "bottom waves," he developed devices that look like square sections of an airplane wing tethered to the ocean floor. As these wings sway back and forth in the undersea currents, they drive pistons that feed into a closed hydraulic system to produce energy.

Each WaveRoller can produce up to 13 kilowatts of power and can be joined to others in a field to generate even more electricity. The system is being tested in waters off the Portuguese town of Peniche.



wind and solar. The reasons are many and begin, once more, with funding.

Tom Thorpe, head of energy consultancy Oxford Oceanics, says that wave and tidal-current energy have long struggled in that department. "A lot of their funding has come from venture capital which keeps a very tight hold on how much money goes in and which expects to have phenomenal returns very quickly."

That, says Thorpe, was the wrong type of money for wave and tidal energies, which take time to produce results. Many researchers have spent as much time looking for capital as in developing their technologies.

Paradoxically, another challenge facing the wave power industry is the volatility in global oil prices. Even though the price per barrel has fallen in recent months, it soared almost out of control early in 2008. Of those price peaks, Thorpe says: "The spike in oil prices means that people (investors) can make a lot more money dragging oil out of the ground ... than they could ever make developing wave energy."

### Environment: Hostile

The ocean is a harsh place. Salt water can corrode electronics, violent storms batter equipment and the waves themselves punish moving parts. So, when it comes to WECs, new technologies are often devel-

**Electric water heater:** 3,800 watts • **Clothes dryer:** 4,400 watts • **Bird's Nest Stadium during opening ceremonies of 2008 Beijing Olympics:** 6,440,000 watts

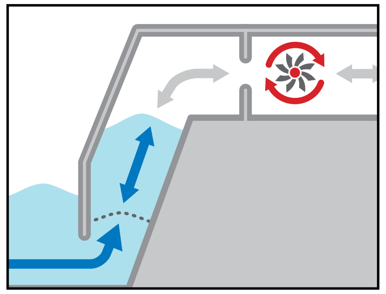
**DID YOU KNOW?** It would take **325 kilograms** of coal to power a **100-watt light bulb** that was lit continuously for **24 hours a day** for one complete year.

## Wonder of Water

**Tapping the limitless power of the oceans has** a clear advantage over other types of renewable energy:

- Because of their density, waves are more powerful than air currents, so smaller devices can be used to harness the energy.
- The seas are constantly in motion and therefore produce energy around the clock, unlike solar and wind systems which are daylight and/or weather dependent.
- Communities often fight alternative-energy arrays because they don't like the aesthetic effect. Many ocean devices can be put far enough out at sea to stay out of sight.
- A lot of cities do not have any land on which to build windmills but are near bodies of water. Wave energy converters and sea windmills do not take up space that could be used for housing or farming.

In addition to the relentless power contained in their waves, our seas and oceans also provide the perfect place to position **electricity-generating wind farms,** such as this one off the coast of England.



## Clean Air

**Making energy from water cuts** out nasty emissions. The prototype of Oceanlinx's Oscillating Water Column currently operating off the coast of Sydney, Australia, produces zero emissions of both carbon dioxide and sulphur dioxide. It is estimated that if the amount of electricity produced by a coal-fired plant is generated instead using OWCs, that one billion tonnes less of carbon dioxide will be spewed into our air in one year.

oped with an eye towards simplicity. One example of this is the Oscillating Water Column (OWC).

While jogging along the surf-smacked shores of Sydney's famous Bondi Beach, Australian inventor Tom Denniss would talk to colleagues about a simple device that could convert the ocean's kinetic energy to electricity. His chats became research, and turned into the OWC, manufactured by Oceanlinx, the company he founded.

An OWC functions like a giant air piston with a long tube capped by a generator. As waves enter the bottom of the tube, they force the air upwards and turn a turbine which produces power. As the wave recedes, air is sucked back through the tube, continuing to turn the turbine – the one moving part in the system.

To maximise efficiency, the OWC uses a sensor to sense the direction of the air flow and send an electronic signal to the turbine to change its blade pitch. "This enables an optimal angle of air flow over the blades. Obviously, the blades change in direction, but they also change in speed. So the turbine changes its characteristics to optimally extract the maximum amount of power," says Denniss.

Oceanlinx has plans to install its systems in the waters of Namibia and Australia as well as off the coast of Maui, Hawaii, where it is predicted that just three units could power up to 4,000 homes and, compared to coal, will prevent 9,000 tonnes of carbon dioxide from entering the atmosphere per annum. ■

*Write to us at* **letters@discoverychannelmagazine.com** *with your comments on this story or on wave-power developments near you.*

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Championing our Seas
**oceanenergycouncil.com**

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**DID YOU KNOW?** US electricity supplies are generated approximately **52 percent from coal, 21 percent from nuclear, 18 percent from natural gas** ... and **7 percent from renewable sources.**