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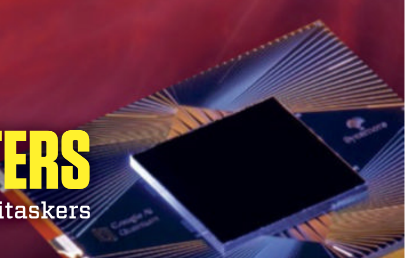

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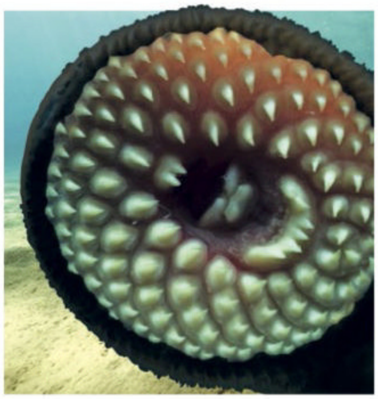

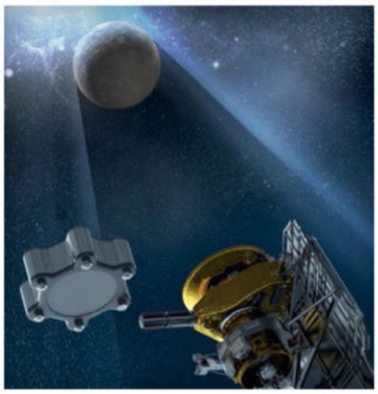

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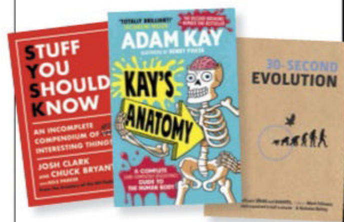

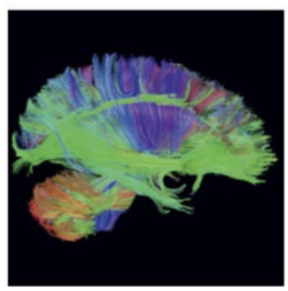

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AUSTRALIAN SCIENCE ILLUSTRATED

EDITORIAL
Editor: Jez Ford
editor@scienceillustrated.com.au

DESIGN
Art Director: Malcolm Campbell

ADVERTISING ENQUIRIES
National Advertising Manager: Richard Holliman
rholliman@nextmedia.com.au
ph: 02 9901 6171

Production Manager: Peter Ryman
Associate Publisher: Daniel Findlay
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INTERNATIONAL EDITION
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THE SCIENCE ILLUSTRATED CREDO
We share with our readers a fascination with science, technology, nature, culture and archaeology, and believe that through education about our past, present and future, we can make the world a better place.

By **Jeppe Wojcik; Jez Ford**

Many ways to harness **THE POWER OF WAVES**

From Tasmania to Portugal, scientists are seeking ways to efficiently extract energy from waves – using artificial blow-holes and power plants deep beneath the surface to harness the eternal motions of the oceans.

Adjacent to a small harbour on Tasmania's King Island at the western end of the Bass Strait, a team of engineers is working on a pilot scheme that could see an Australian innovation efficiently harness the energy within these notoriously powerful ocean waves. Melbourne-based company Wave Swell Energy has received A$4m in funding from the Australian Renewable Energy Agency (ARENA) as part of this A$12.3m project to operate a 200kW wave-energy device called the Uniwave 200. Partially submerged on the seabed, the Uniwave 200 uses 'oscillating water column' (OWC) technology to pull air through a chamber fitted with an electricity-generating turbine. The system functions like an artificial blowhole, the changes in air pressure spinning the turbine as waves fall, forcing air through an opening on one side of the device.

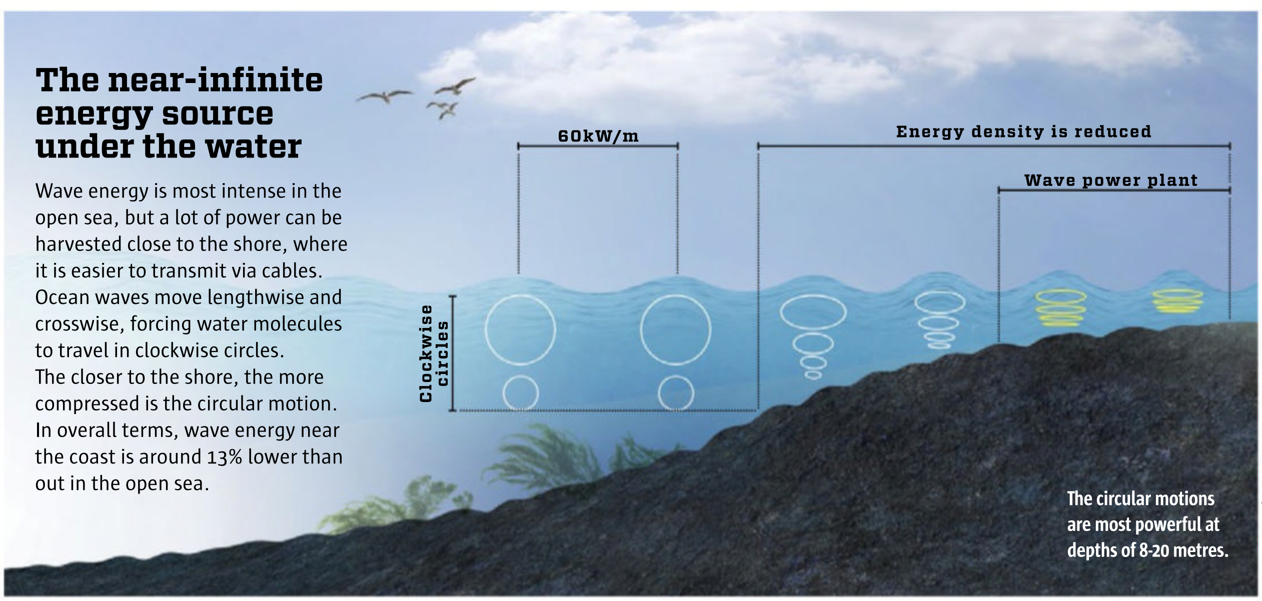
While OWCs are well-established, previous examples have all been bidirectional. The Wave Swell technology operates in only one direction, which allows a simpler, more reliable and more efficient turbine to be used. With its only moving parts being kept above the water line, the Uniwave units are also easier to maintain than wave-power technologies that go deeper.

The plan is for the Uniwave to be fed into the King Island microgrid, which sources the majority of its electricity from the Huxley Hill Wind Farm and a 470kW solar array. The combination of wind, solar and wave energy should be reliable and stable, reducing reliance on diesel generators. It might just be a blueprint for the planet.

Many ways to ride the waves

As we seek to reduce the world's reliance on fossil fuels, we will likely need a broad raft of different technologies suitable to harness the ocean's different challenges in diverse locations. Another Australian company currently riding the waves is Bombora: its 'mWave' technology began life in the barn of a Perth farmyard, but the company has since expanded to Europe with plans for a 1.5MW mWave demonstration project in Wales and a second project off the Spanish Canary Island of Lanzarote. Bombora's mWave modules use air-inflated rubber cells below the ocean's surface, angled to the incoming waves; the waves push air out of each cell through a series of valves to drive a turbine.

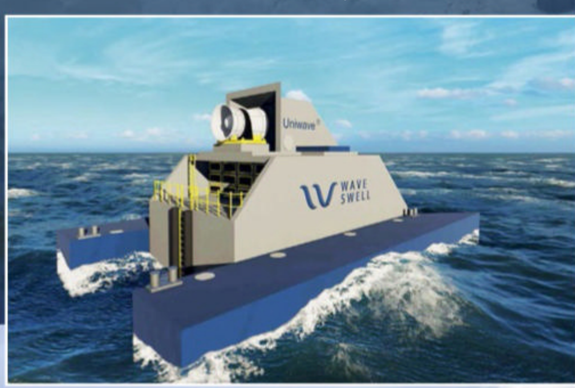
Going deeper is the WaveRoller (main image opposite) from Finnish company ▶



SHUTTERSTOCK / KEN IKEDA MADSEN

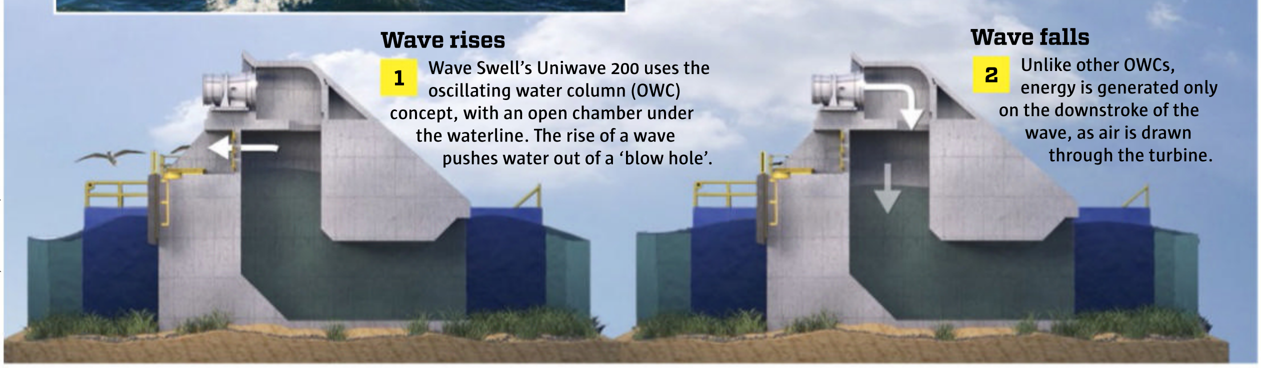
A WaveRoller panel moves with the waves, converting energy into power off the coast of Portugal. Several such plants will soon be installed on the ocean floor.

Wave Swell Energy's Uniwave 200 sits atop an artificial blowhole to harness wave energy. A pilot plant is under construction off Tasmania's King Island.



Triple renewables

Wave Swell's 200kW pilot plant will supply energy into Hydro Tasmania's King Island advanced hybrid power station, making it the world's first to generate energy simultaneously from three renewable resources: wave, wind and solar.



Wave rises

1 Wave Swell's Uniwave 200 uses the oscillating water column (OWC) concept, with an open chamber under the waterline. The rise of a wave pushes water out of a 'blow hole'.

Wave falls

2 Unlike other OWCs, energy is generated only on the downstroke of the wave, as air is drawn through the turbine.

TOP: AW-ENERGY OY ; BELOW: ARENA/WAVE SWELL ENERGY

AW-Energy, which installs steel panels 10 to 20 metres under the water surface, a few hundred metres from the coast. A test plant off the Portuguese seaport of Peniche already generates 1MW for the city via this hydraulic system, and more WaveRollers will soon be tested in Mexico and South-East Asia.

Oceans abound in energy

If you've ever been knocked over by a wave in the ocean, you'll know their power all too well. It's estimated that waves could add 500GW to world electricity generation by 2050 – about the same as the present capacity of wind turbines and solar cell panels (564 and 486GW respectively). The International Energy Agency estimates that wave energy could fill 10% of Earth's total energy requirements in 2050. Wave energy in areas close to the ocean is averagely 20-50kW per metre of waves per year. A 15-metre wave plant could generate 100kW throughout the year, enough to power 25 homes.

Ocean waves also have advantages over sun and wind. Waves are more reliable, generating power 90% of the time, compared with only 20-30% for wind and sunlight.

But very little wave energy is yet harvested. The leap from test plant to useful large-scale energy generation has proven challenging. But times are changing, with more investment and continual growth: according to the most recent EU figures, wave energy in the Union grew by 25% in 2019. Research has also been stepped up, especially tackling a major challenges facing wave energy — severe storms.

Horizontal motion

The extreme forces of nature in the open sea can destroy wave-power plants or cause periods during which they have to be shut down as a safety measure. Unlike wind turbines and solar-cell panels, wave power includes various technologies — buoys, hoses, floating cushions – all of them with different pros and cons. One of the more optimal solutions may prove to be oscillating wave surge converters, also known as OWSCs. These have been shown to have higher power capture in shallow water than existing OWC technologies by tapping into the energy generated when horizontal waves move back and forth. The waves push one or more panels, which then power and compress a cylinder pump, thereby causing pressure in either oil or ocean water. The pressure can power a generator on the ocean floor or on a platform, or it can be transmitted to dry land.

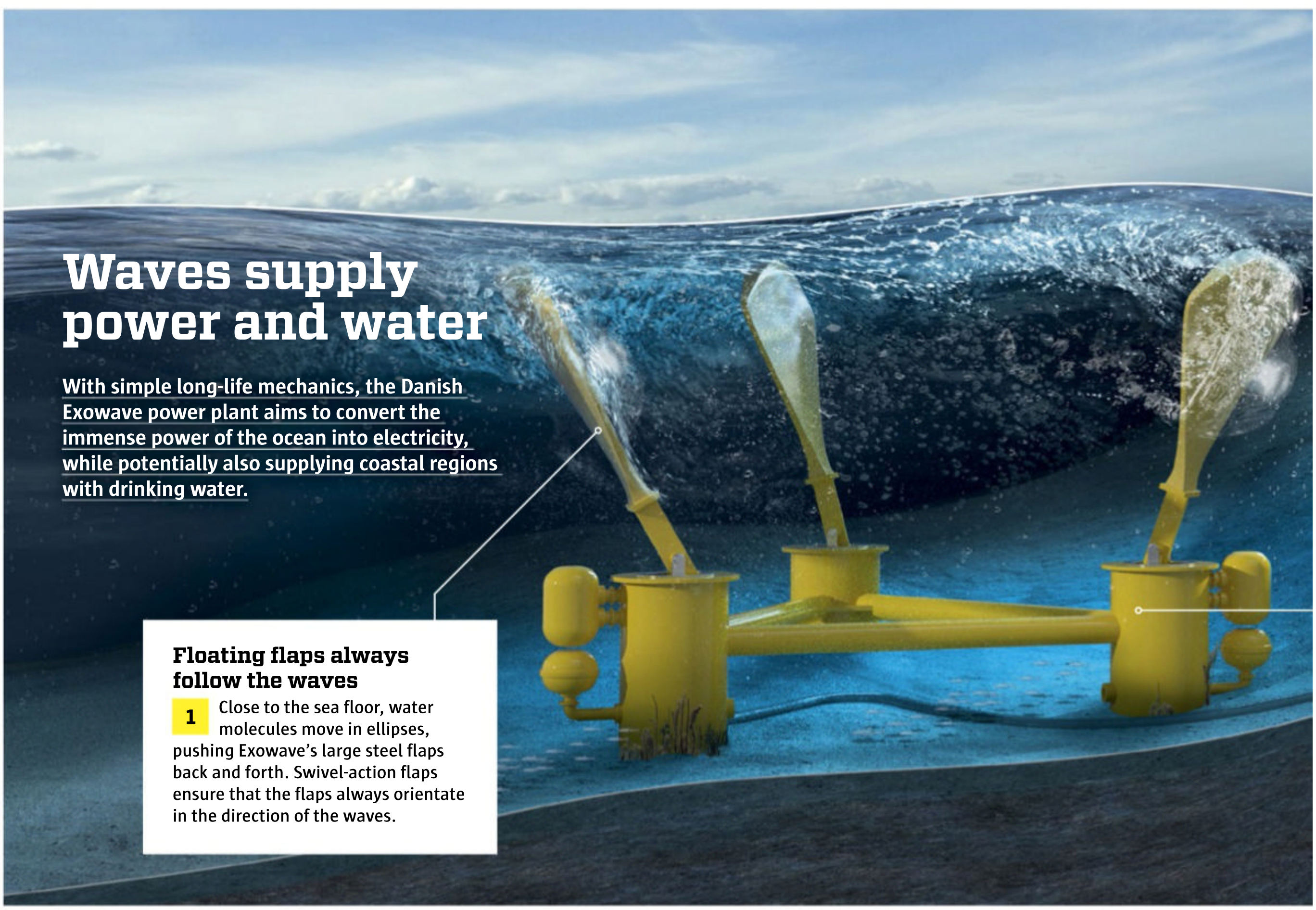
The plants can be anchored to the ocean floor close to the coast and 10 to 40 metres below the surface, where they won't interfere with views or, hopefully, affect wildlife. Two examples of OWSCs are the WaveRoller in the ocean off Peniche in Portugal, and the Danish Exowave on the North Sea floor. The Exowave consists of a series of yellow fly swatter-like flaps that move from side to side to tap the immense forces moving in the ocean beneath the surface.

Durable mechanical pump

Plants built on the ocean floor present the problem that they are harder to access than

Waves supply power and water

With simple long-life mechanics, the Danish Exowave power plant aims to convert the immense power of the ocean into electricity, while potentially also supplying coastal regions with drinking water.



Floating flaps always follow the waves

1 Close to the sea floor, water molecules move in ellipses, pushing Exowave's large steel flaps back and forth. Swivel-action flaps ensure that the flaps always orientate in the direction of the waves.

other types of wave energy plants. It is generally considered that they should have a service life of 20 years to be economically viable. As the Exowave is to operate at depths of 10 to 40 metres, where the average energy flow is some 17kW per metre of waves, its concept has been kept as simple as possible. Its design is entirely mechanical, using a ball joint that allows sea water to pass in and out of a pump house which the wave flap puts under pressure. The flap also rotates, so the plant will efficiently capture energy no matter the direction of the waves.

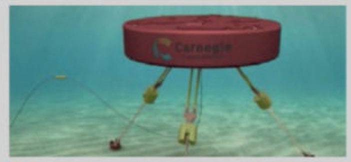
One great cost-saver would be to install the units below existing wind turbines in the oceans. Such wave plants could add 20MW of energy and use the existing cable systems to transmit power to the shore.

Wave farms can become invisible

The need to trial new wave energy ideas on a small scale could see more projects like the one off King Island in Tasmania, where small projects could provide electricity to off-grid islands that normally depend on imported coal and oil. Some designs might have an additional eco-bonus in supplying thirsty regions of the world with clean drinking water. The way Exowave works, creating pressure in a pump, could see it converted into desalination operation, turning sea water into drinking water via inverted osmosis where the water is forced through a filter that allows only water molecules to pass, while larger salt molecules are filtered out. So these and other wave power plants could also provide clean water — and more: Wave Swell notes that the design being installed in Tasmania might also be used to produce hydrogen as well as clean water, and could protect coasts against erosion.

Wave farms supplying reliable energy and drinking water, together with wind and solar energy sources — the combination might be able to speed us towards a more sustainable plan for our energy needs. But scientists need to carefully assess each method's efficiency, longevity and ecological impact before wave energy can be rolled out to save the world. SI

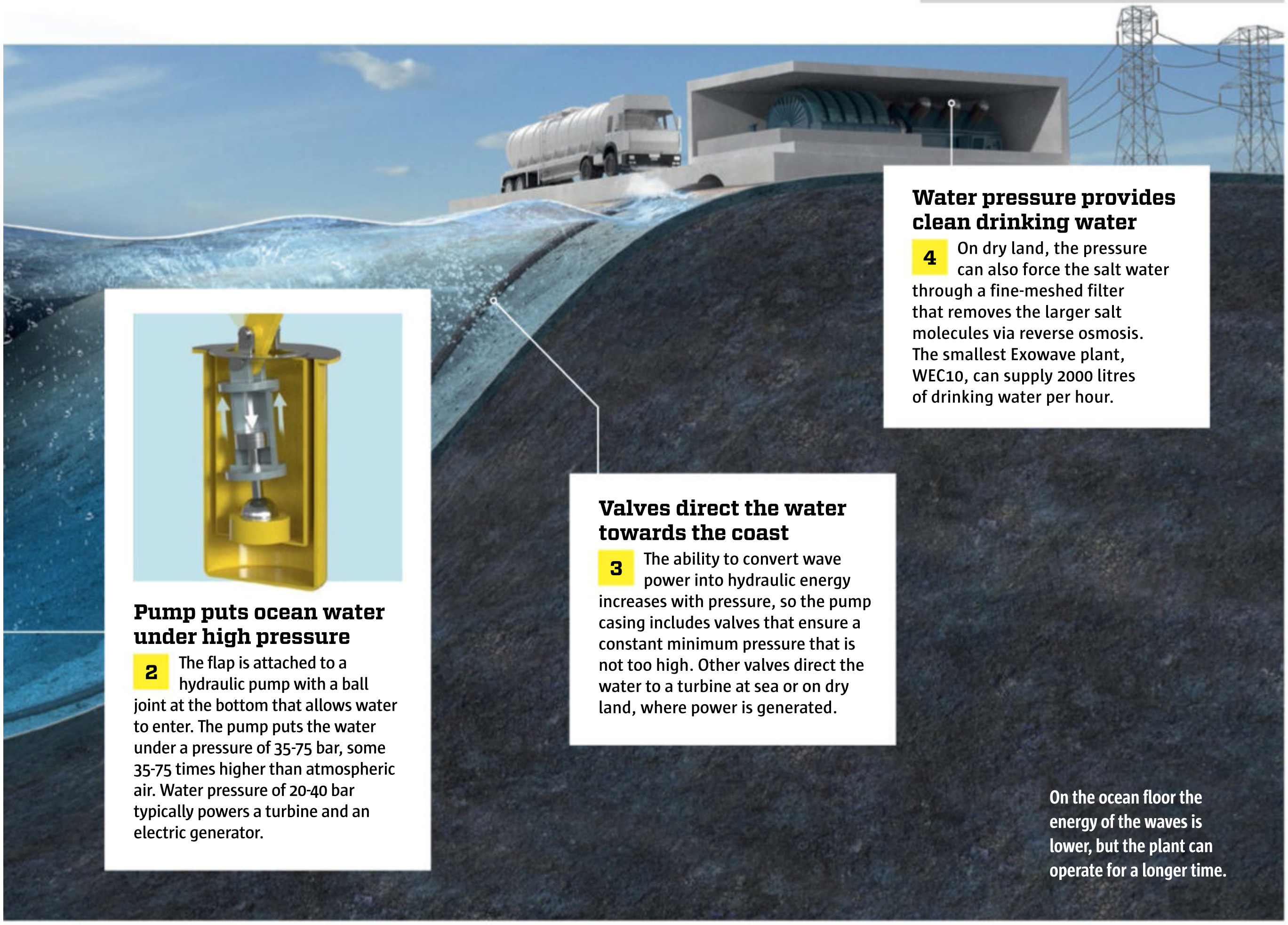
Robotic jellyfish and rubber membranes



Robotic jellyfish follows the waves: Submerged buoys from Carnegie Clean Energy move with the waves, powering a pump that pressurises ocean water.

Submerged rubber membrane causes air pressure: When the waves move past Australian company Bombora's plant, a rubber membrane drives air pressure that powers a turbine.

CARNEGIE CLEAN ENERGY / JAMESMCP



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