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create

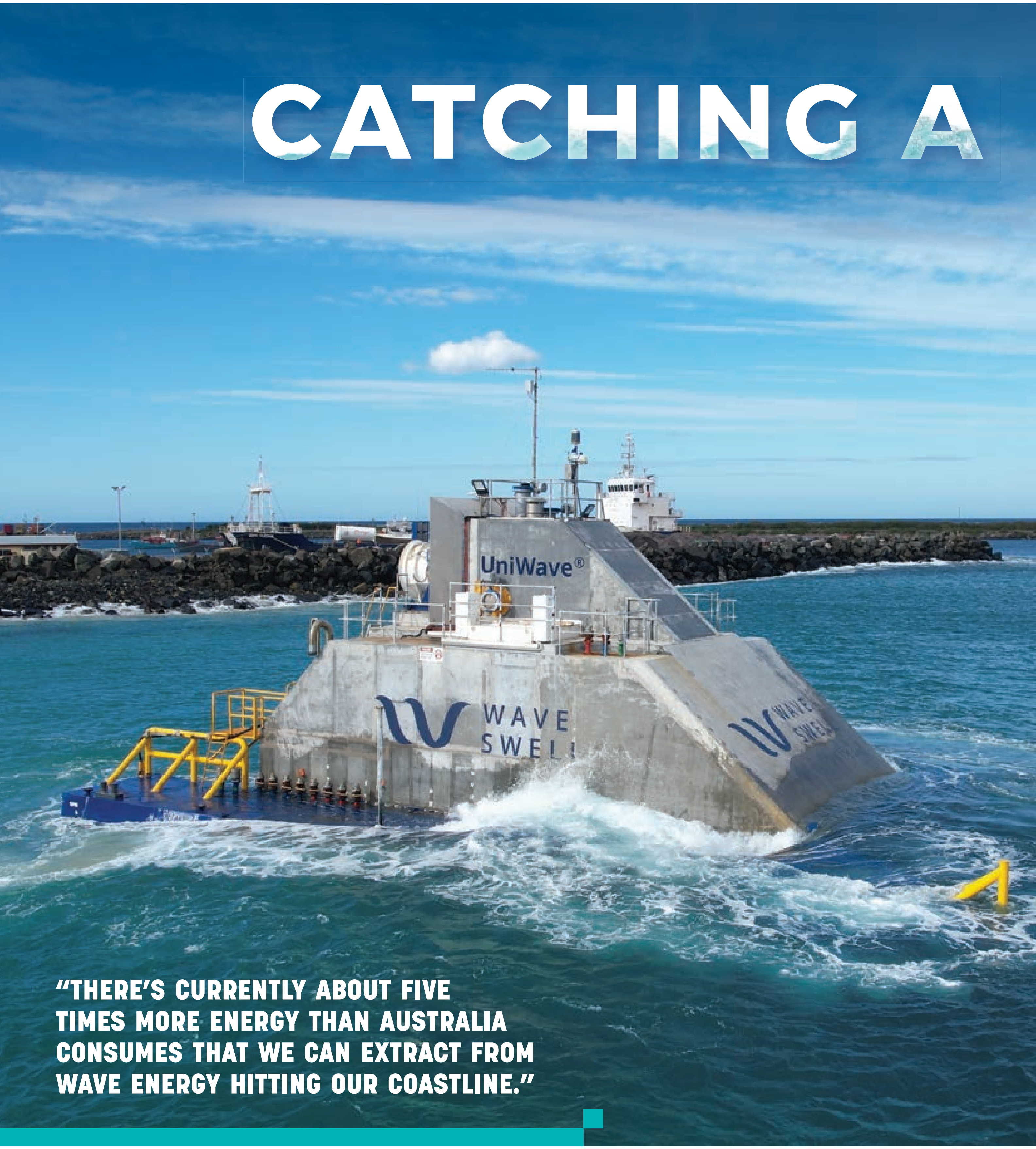
ENGINEERING IDEAS INTO REALITY

ENGINEERS AUSTRALIA

BUILDING BETTER

WHY SUSTAINABLE CONCRETE HAS BECOME A CORE CONCERN FOR THE CONSTRUCTION INDUSTRY

CATCHING A



"THERE'S CURRENTLY ABOUT FIVE TIMES MORE ENERGY THAN AUSTRALIA CONSUMES THAT WE CAN EXTRACT FROM WAVE ENERGY HITTING OUR COASTLINE."

WORDS BY **ELLE HARDY**

WAVE

THE CONSISTENCY AND PREDICTABILITY OF WAVE ENERGY MEANS IT COULD PLAY A BIG ROLE IN IMPROVING THE RELIABILITY OF GRIDS POWERED BY RENEWABLES. WHAT WILL IT TAKE TO HARNESS SUCH AN ABUNDANT RESOURCE?

ABOVE: Scott Hunter, Wave Swell. LEFT: Wave Swell Energy's project on King Island, Tasmania. RIGHT: Jonathan Fiévez, Carnegie Clean Energy.

AUSTRALIA'S 25,780 KM of coastline provides access to abundant, untapped potential energy from the sea.

Not only do waves have the highest energy density compared to other renewables – by some estimates, five to 10 times greater than wind and solar – they are more consistent and predictable.

The CSIRO's Wave Energy Atlas shows that the southern coastline of Australia has a significant wave energy resource that could provide ideal conditions for wave energy production.

The agency's research also found that wave energy could contribute up to 11 per cent of the response to Australia's energy demand – enough to power a city the size of Melbourne by 2050.

Furthermore, marine renewable energy is one of the fastest-growing sectors globally.

The "resource is undeniable", as Jonathan Fiévez, mechatronic engineer and CEO of Carnegie Clean Energy put it. And a number of recent studies from the CSIRO and other groups have proved that.

"There's currently about five times more energy than Australia consumes that we can extract from wave energy hitting our coastline," Fiévez said. "The energy is there, crashing on the shore every day of the week."

Fiévez said that wave energy provides an amazing opportunity for a country like Australia, given the "incredibly consistent resource we have to fill that gap, especially as we get towards 70 to 80 per cent solar and wind penetration".

One case in point is the 2022 research by Australia's national science agency, which was commissioned by Wave Swell Energy and concluded that harnessing wave energy off the coast of southern Australia would deliver more stability and reliability to a future clean electricity grid, as well as reduce the cost of batteries to store this renewable energy.

More predictable and consistent than solar and wind, wave power can also deliver commercial advantages, including by powering hybrid renewable models that require less than half the capital expenditure of a system with solar, offshore wind and battery storage alone.

Wave Swell's Chief Technical Officer, Scott Hunter, told *create* that the study showed that even though their technology is not currently as cheap as other

renewables, considerable savings could be made by complementing wave energy with other renewable generation. That's because it reduces the amount of storage required to meet demand.

Hunter also noted that in the future, costs will drop, "and we will be competitive in our own right".

Yet despite decades of attempts, wave energy hasn't seen large-scale commercialisation. To find out why, *create* took a deep dive into the world of wave energy.

BREAKING BARRIERS

The wave-energy process is relatively simple: waves form as wind blows across the surface of water, creating kinetic energy. Wave-energy converters then capture this clean energy and transform it into electrical power.

Yet the extensive timeframe for technology development, as well as the large associated capital funding requirement, makes it incredibly difficult for an individual company to secure the funds to scale its technologies for commercialisation, said Stephanie Thornton, General Manager of the industry-founded Australian Ocean Energy Group.

“Attracting R&D investment is also difficult,” she told *create*.

“As wave and tidal technology developers are maturing their technologies, the path to commercialisation – and customer identification – is not always clear.”

Compared to heavy government investment in other emerging energy sources, Australia lags when it comes to funding emerging wave-energy technology, especially compared to countries such as Spain and the United Kingdom.

“The geographic distribution of the ocean energy and where electricity needs to be distributed for end use are many times located far apart,” Thornton said, “leading to development challenges such as establishing a supply chain, permitting approvals, establishing shoreside infrastructure support and more.”

Australia’s wave resources are primarily distributed throughout the southern part of the continent, with the Great Southern Ocean home to some of the most potent wave power in the world. Its tidal power is almost perfectly positioned, largely along the north-eastern and north-western regions, as well as parts of Victoria and Tasmania.

BLUE ECONOMY

Thornton believes that the best near-term market for ocean energy technologies are “blue economy” end users such as ports, aquaculture, remote communities, desalination operators and integrated microgrids.

“It’s hard to compete with the scale of offshore wind production at the gigawatt level,” she said.

“AS WAVE AND TIDAL TECHNOLOGY DEVELOPERS ARE MATURING THEIR TECHNOLOGIES, THE PATH TO COMMERCIALISATION – AND CUSTOMER IDENTIFICATION – IS NOT ALWAYS CLEAR.”

ABOVE: Stephanie Thornton, Australian Ocean Energy Group.

Therefore, targeting “blue economy markets” provides the industry a more immediate opportunity to deploy wave and tidal technologies as part of a commercialisation strategy.

The cost of energy is an important metric by which the maturity of ocean energy technologies is measured.

Thornton argues that the current approach, which indicates the technology’s competitiveness in reference to a levelised cost of energy, creates an inaccurate understanding.

“Instead, a realistic measure of the cost competitiveness is to evaluate the cost of energy production from a specific technology or technology system – such as a microgrid – against an end-user’s cost of energy supply,” she said.

Energy production for a specific wave device might not be considered cost-competitive with solar or wind; however, Thornton said that on places such as islands, where there is a need to transport and store diesel to supply to end users, the energy supplied by ocean power could deliver cost savings and reduced environmental risks.

“There is no one-size-fits-all technology,” she said, because the use of ocean energy provides a wide range of solutions.

“I’d like to see our industry start to think about who the first-adopter markets are, and what types of technology are going to be best suited for solutions for those end users.”

Thornton is bullish on microgrids, which can be scaled to provide deliberative energy for particular situations.

"You can set one up to supplement an industrial port with huge energy demands by allowing ships to connect to it when they first dock," she said.

"Or, in remote communities and Indigenous communities – places that are often suffering energy poverty – these systems can be deployed."

ENGINEERING SOLUTIONS

Chris Shearer CPEng, principal engineer and technical lead at maritime-oriented consultancy firm BMT, agrees that Australia's coastal communities, which currently rely on high-cost fossil fuel generation such as diesel generators, are good candidate locations for wave energy and other renewable sources.

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However, setting on the right technology remains an issue for the industry.

"One of the challenges with wave-energy technology is the lack of convergence of the style or type of wave energy conversion technology, contrasted against wind energy which has converged on a single preferred technology style," he said.

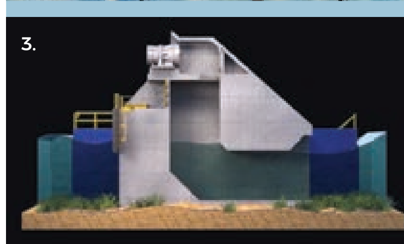
Shearer, who represents Engineers Australia on the Standards Australia national committee for marine energy converters, said that one of the most studied types of wave energy converter is the oscillating water column, which was recently used on Wave Swell's King Island project.

WAVE ENERGY CONVERTERS: A FIELD GUIDE

Wave energy converters are devices that convert the kinetic and potential energy from passing waves into mechanical or electrical energy to power the grid. There are seven main converter types currently in use worldwide:

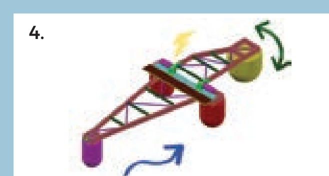
1. Point absorbers are floating buoy structures which absorb energy from any direction on the water surface, converting the wave action at a single point into electrical power.

2. Submerged pressure differential is a submerged point absorber that exploits the pressure difference between wave crests and troughs as waves pass above it. The submersion may help the devices survive storms. In Australia, Carnegie Clean Energy's core product is CETO, a submerged point absorber technology that is targeted towards utility-scale generation.



3. Oscillating water columns, featured in Australian projects such as King Island, use waves to force a column to move up and down like a piston, forcing air in and out of the chamber. The machinery is usually in an L-shape and sits out of the water.

4. Attenuators look like two modular barges linked like wings, where the flexing joints generate power. These are deployed parallel to the direction of wave travel. They can be several metres wide and hundreds of metres long and will be used in the M4 project off the coast of Albany, Western Australia.



5. Terminators, or overtopping devices, operate similarly to a hydroelectric dam. They raise a volume of water to a height above the ocean's surface and use the potential energy difference, much like the wave action found on a beach.

6. Oscillating wave surge converters sit on shallow seafloors, using a pendulum arm flap to pivot on a hinged joint as the wave rolls over them, allowing the device to oscillate back and forth. The flap can then be mechanically linked to a pump to pressurise fluid, or a generator to produce electricity.

7. Rotating mass devices usually sit on the surface and drive a rotational alternator creating mechanical energy as the device tries to reach equilibrium.

"This style of converter permits a column of water to rise and fall within a chamber, which, in turn, pushes and pulls air through an air turbine circuit," he said.

"All of the machinery is out of the water."

Internationally, oscillating water columns have been popular, and are able to be integrated into marine structures. Shearer points to the Mutriku facility in Spain which has been successfully operating since 2011, and Scotland's LIMPET project, which began in 2000 and connected to the United Kingdom's national grid.

Columns are not the only technology in play, with Australian-founded firm Bombora, which recently relocated to Europe, using a submerged pressure-differential style of wave energy converter.

"It essentially consists of a structure on the seafloor, which has integrated air bladders, which compress in sequence under wave action, driving an air turbine circuit, all underwater," Shearer said.

BMT, which has acted as an independent technical expert reviewing projects on behalf of the Australian Renewable Energy Agency (ARENA), is also getting involved with design itself as part of the Albany M4 wave energy research and development project. This will construct, deploy, operate and retrieve a 25 m long floating and articulating wave energy converter off the southernmost coast of Western Australia.

There, Shearer said, they will have to overcome one of the major engineering challenges of wave energy: successfully deploying devices.

"There's been a number of examples of failures of projects at the deployment stage," he said.

"It's important that the marine operations phase is well engineered and reviewed with the appropriate due diligence."

The reliability of electrical and mechanical equipment is another challenge, he said, as "wave energy machines are required to work in a corrosive saltwater environment, which is prone to extreme weather events".

Ocean energy also presents logistical barriers, as engineers and technicians typically can't simply go out to the machine whenever they need to.

"Obtaining suitable weather windows to enable safe access to the wave energy converter for commissioning, maintenance, operations and retrieval can be challenging," Shearer said.

"WAVE ENERGY MACHINES ARE REQUIRED TO WORK IN A CORROSIVE SALTWATER ENVIRONMENT, WHICH IS PRONE TO EXTREME WEATHER EVENTS."

"In recent years there have been issues in decommissioning various previous wave energy projects, either due to lack of funding, or challenges associated with obtaining suitable weather windows to perform the necessary decommissioning activities."

In the short term, Shearer said that wave energy's future will likely be in niche applications such as island communities, end-of-grid communities, offshore infrastructure such as aquaculture, and oil and gas operations.

"However, as the industry develops further, there may be opportunities to, for example, integrate wave energy with offshore wind, and provide a meaningful contribution to the main electricity grid," he said.

ABOVE: The Australasian Coasts and Ports Conference features a tour of the Noosa Coast.

THE AUSTRALASIAN COASTS AND PORTS CONFERENCE

The Australasian Coasts and Ports Conference on the Sunshine Coast this month brings together pre-eminent industry leaders to highlight the persisting importance of coastal engineering problems. The program includes:

- Pre-conference workshop on the feasibility of shore power to decarbonise our ports.
- A two-day coastal engineering short course conducted by UNSW Sydney's Water Research Laboratory prior to the conference.
- Three technical tours, an exploration of the Noosa Coast, including a visit to the Huon Mundy Oyster Reef, an operational and navigational tour of the Mooloolaba River and Maroochy River Groynes, and an investigation of the Bribie Island breakthrough that has reshaped the area.