Ocean energy may be at its infancy in Australia, but the increasing deployment of wave energy, tidal energy and ocean thermal energy means this energy form of power will soon be making waves in the renewable energy sphere.

Australia is a prime resource for ocean energy. With unsheltered coastlines, Australia shares similarities with the world’s most productive wave energy-producing countries.

CSIRO’s Ocean Renewable Energy: 2015–2050 report revealed that Australia has considerable wave energy resources, with the total wave energy between Geraldton and the southern tip of Tasmania coming up to over 1,300 TWh per year—around five times Australia’s energy requirements.

The Australian Renewable Energy Agency (ARENA) is an important part of the ocean energy equation, funding six projects to the tune of $431 million.

“Ocean waves are an abundant and consistent source of renewable energy. Development of Australian technologies that effectively harvest this energy could lead to employment and manufacturing opportunities in the renewable energy sector as well as increased use of wave energy as a renewable source of electricity,” ARENA says.

Out of the six ocean energy projects that ARENA has provided funding to, the Perth Wave Energy Project, Carnegie CETO 6 Technology, and the Port Fairy Pilot Wave Energy Project have received the largest funding commitments—specifically $37 million, or 86 per cent of total ARENA funding for ocean energy projects.

Carnegie Wave Energy’s role in two out of these three projects is an acknowledgement of the company’s commitment to the development of ocean energy, it is the largest employer in the Australian wave energy industry, and has raised over $80 million to fund the development of CETO wave energy technology.

Other projects that have received ARENA funding in the past include CSIRO’s Australian Wave Energy Atlas, Swinburne University’s ocean wave energy converters and Oceanlinx’s 1 MW Commercial Wave Energy Demonstrator.

**PERTH WAVE ENERGY PROJECT**

**Location:** Offshore of Garden Island, WA

**ARENA program:** Emerging Renewables Program

**ARENA funding provided:** $13 million

**Total project value:** $32 million

**Start date:** April 2012

Carnegie Wave Energy’s CETO 6 Technology is capable of producing both zero emissions power and directly desalinated water—something that will overcome the issue of high-power tariffs, freshwater scarcity, and reliance on fossil fuels to provide power in defence bases and remote islands.

On 18 February 2015, the Carnegie Perth Wave Energy Project’s onshore power station was officially switched on, feeding renewable energy into HMAS Stirling, Australia’s largest naval base.

At the time, ARENA Chief Executive Ivor Frischknecht said the project’s launch was an important milestone in the history of wave energy and the culmination of close to a decade of work.

“This is the first array of wave power generators to be connected to an electricity grid in Australia and worldwide. During the testing phase, the first 240 kW peak capacity CETO 5 wave unit operated successfully for more than 2,400 hours,” Mr Frischknecht said.

The project utilises Carnegie’s CETO 6 Technology, which consists of a fully submerged buoy—a buoyant Actuator (BA)—that is tethered to a pump on the seabed, is used to harness the enormous energy present in the ocean’s waves.

The CETO 6 buoy oscillates in harmony with the ocean’s waves, transferring energy through a tethers high-grade marine steak and causing the pump to extend and contract. The pump pressurises fluid which is then sent onshore through a subsea pipeline.

Once onshore, the high-pressure fluid is used to operate an onshore hydroelectric power plant. The resulting low-pressure water is then returned offshore in a closed loop system.

In addition to producing zero-emissions power, the CETO technology is capable of producing direct desalinated water. The high-pressure water created by the CETO units can be used to supply a reverse osmosis desalination plant, replacing or reducing reliance on greenhouse gas-emitting, electrically-driven pumps usually required for such plants.

**END GOAL**

The power produced by the Perth Wave Energy Project is clean renewable energy that reduces the reliance on fossil fuels.

**CARNEGIE CETO 6 TECHNOLOGY**

Building on the learnings of the Perth Wave Energy Project, the CETO 6 project will deploy the next generation of Carnegie’s CETO wave energy technology. Carnegie will undertake design, construction, deployment and demonstration of a grid-connected wave energy generation project with up to 3 MW peak installed capacity off Garden Island, Western Australia.

Building on the learnings of the Perth Wave Energy Project, this project aims to demonstrate the CETO technology in higher seas states and in increased wave power. It will be located offshore, where greater wave power is present.

The Australian Department of Defence will purchase the power generated by the project under its power supply agreement with Carnegie, which will provide electricity for HMAS Stirling, as part of Carnegie’s existing power supply agreement.

**TECHNOLOGY INNOVATION**

The larger size of the CETO 6 units is a key driver of lower energy costs compared to the CETO 5 units.

The CETO 6 buoy oscillates with the ocean’s waves, transferring energy to a power conversion unit located inside the buoy, generating power off shore and transmitting it onshore via a subsea cable.
A successful demonstration of the bioWAVE pilot could stimulate further use of wave energy as a source of zero emission electricity.

**CARNEGIE CETO 6 TECHNOLOGY**

**Lead organisation:** Carnegie Wave Energy

**Location:** Offshore of Garden Island, WA

**ARENA program:** Emerging Renewables Program

**ARENA funding provided/committed:** $13 million

**Total project value:** $46 million

**Start date:** June 2014

Each CETO 6 unit is expected to be capable of generating up to 1 MW—approximately four times the generation capacity of the CETO 5 technology currently being used in Carnegie’s Perth Wave Energy Project.

**END GOAL**

The CETO 6 project is expected to deliver energy at approximately half the cost of CETO 5, and aims to be cost competitive with fossil fuels in certain markets when deployed in large-scale projects.

**PORT FAIRY PILOT WAVE ENERGY PROJECT - TESTBED FOR BIOWAVE OCEAN ENERGY**

The patented bioWAVE technology was developed in Australia to extract energy from ocean waves and convert it into electricity. It efficiently converts wave energy to mechanical energy and then uses a unique mechanical-to-electrical energy converter.

The Port Fairy Pilot Wave Energy Project involves the installation and ocean testing of a pilot bioWAVE unit, which consists of a 26 m high steel structure, on the south coast of Australia. It will supply power directly to an onshore aquaculture facility and also has a retail power purchase agreement to supply electricity to the national grid.

The bioWAVE pilot is scheduled for installation in 2015, and once commissioned, it is expected to operate for at least a 12-month period before being decommissioned.

Periodic maintenance and testing will be carried out during the operating period, which will culminate with an independent assessment of the bioWAVE performance.

The project will provide key data for the design of a larger 1 MW commercial-scale bioWAVE unit, which is planned as the next development phase of the technology.

**TECHNOLOGY INNOVATION**

BioWAVE resolves the high costs associated with implementing a system that is able to survive in the harsh marine environment by allowing units to lie flat against the seabed during extreme wave events.

Both the gentle sawing motion of the bioWAVE, which is intended to move with the forces of the ocean rather than brace against them, and the ability for the unit to lie flat are features inspired by nature. The result is a unique technology that has specific performance, cost and environmental benefits.

**END GOAL**

Beyond the direct benefit of offsetting carbon emissions, the project will provide employment opportunities, local economic activity and skills development. A successful demonstration of the bioWAVE pilot could stimulate further use of wave energy as a source of zero emission electricity.
HURDLES FACING DEVELOPMENT OF OCEAN ENERGY

There has been limited progress in developing Australia's ocean energy resources, not least because of the greater potential of other renewable energy resources.

Progressive government stances also contribute to the development of ocean energy, such as in Sweden, which is driven by its policy of becoming an oil-free society.

Further, literature on ocean energy is insufficient when compared to other renewable energy forms. For instance, relatively few authorities have published data on wave energy deployments in fully operational mode, while more environmental impact studies are needed on withdrawing large amounts of wave energy.

When it comes to large-scale ocean energy power stations, CSIRO says that there are gaps in knowledge regarding the positive and negative impacts on marine protected areas, indigenous land, tourism, maintenance costs, logistics and performance testing.

Forms of ocean energy other than wave energy have also proven difficult to develop. CSIRO says non-tidal ocean currents potentially constitute a renewable energy resource, but no device has ever been built to harvest this form of energy.

“With the development of wave energy, the need is for devices to be very large, and moored in deep water (400-1000 m).”

CSIRO SAYS POTENTIAL FOR WAVE ENERGY IS “GREAT”

CSIRO says wave energy is the only ocean energy that is of massive magnitude - i.e., higher than Australia’s total consumption - and also technically feasible.

“There is a great opportunity for wave energy to be part of Australia’s energy mix, possibly up to 11 per cent - enough to power a city the size of Melbourne by 2050.”

While wind and solar may be deployed more, ocean energy displays greater predictability, availability and consistency. Tides are predictable over at times, and CSIRO says a wave forecast for 30 hours is nearly as accurate as a wind forecast for 12 hours. Additionally, unlike other renewables that require fossil fuel-based generation to balance out variations, consistent wave power results in lower CO2 emissions.

Further, Dr Ronin Warner, a Professor at the Australian National Centre for Ocean Resources and Security Professor, says Australia is cultivating a favourable atmosphere for the deployment of ocean energy.

“Finally, Australia is just beginning to address the emerging challenge of harnessing the ocean to combat climate change with the development of technology and regulatory frameworks for ocean-based energy and offshore carbon capture.”

Time will tell if the development of ocean energy will match that of solar and wind, but its future as a renewable energy source in