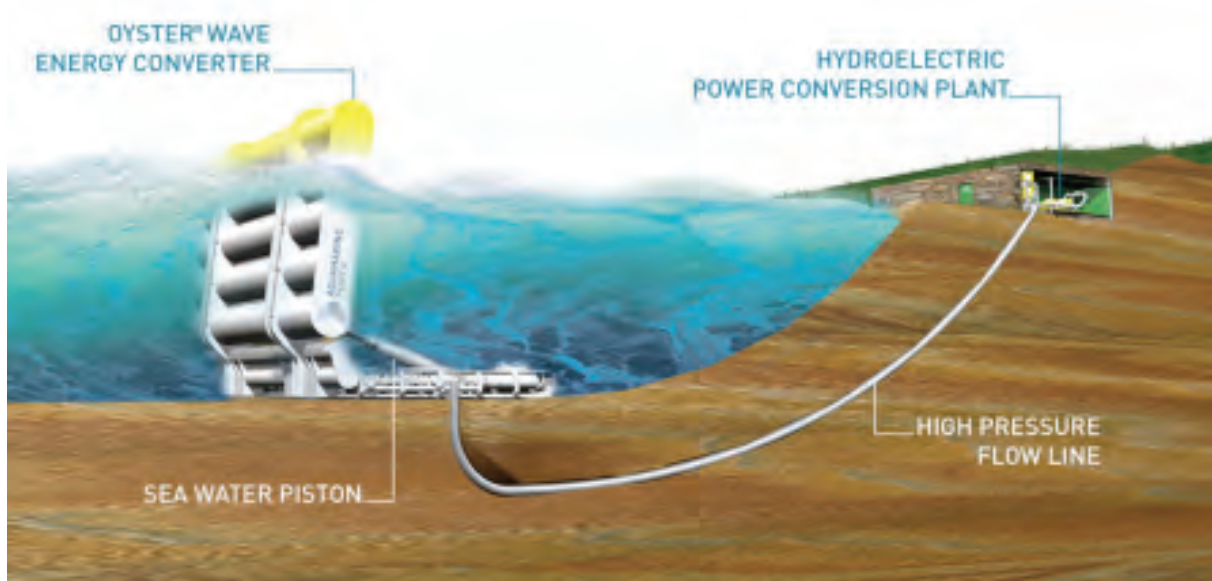


# Wave Energy Converters (WECs)

## Aquamarine Power – Oyster\*



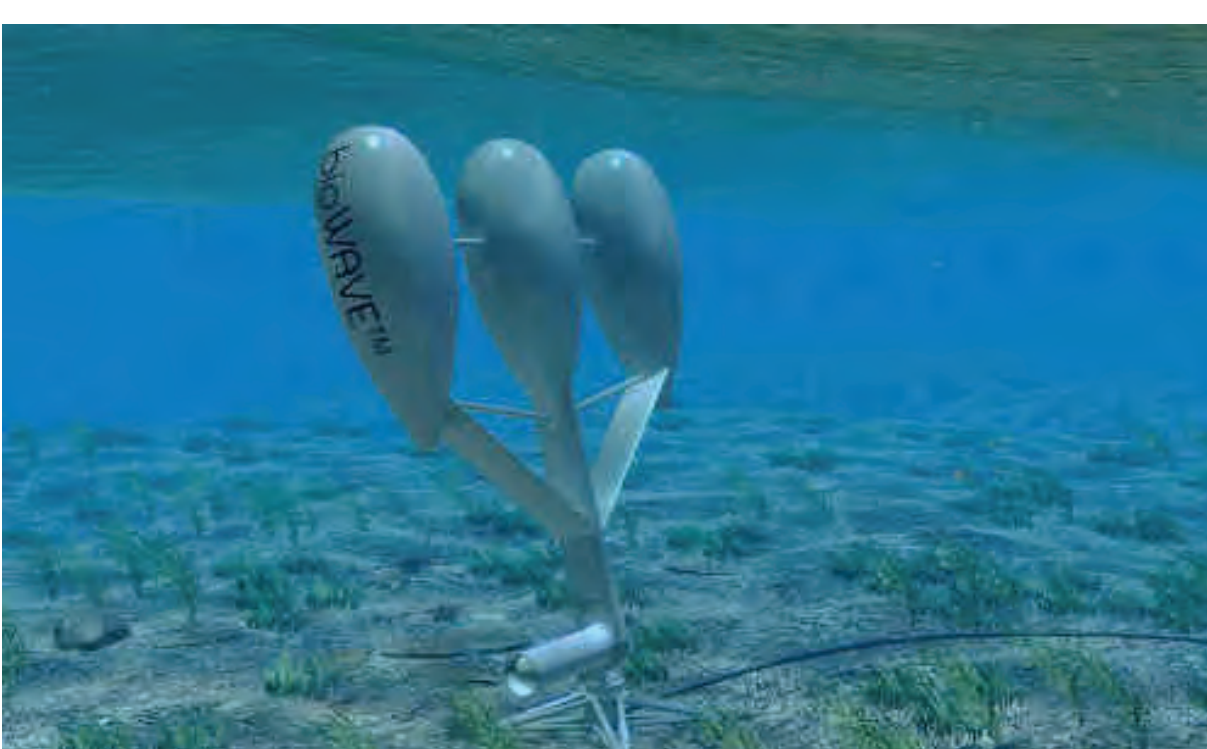
The Oyster is uniquely designed to harness wave energy in a near-shore environment. It is composed primarily of a simple mechanical hinged flap connected to the seabed at a depth of about 10 meters and is gravity moored. Each passing wave moves the flap, driving hydraulic pistons to deliver high pressure water via a pipeline to an onshore electrical turbine.

## AWS Ocean Energy – Archimedes Wave Swing™\*



The Archimedes Wave Swing is a seabed point-absorbing wave energy converter with a large air-filled cylinder that is submerged beneath the waves. As a wave crest approaches, the water pressure on the top of the cylinder increases and the upper part or 'floater' compresses the air within the cylinder to balance the pressures. The reverse happens as the wave trough passes and the cylinder expands. The relative movement between the floater and the fixed lower part is converted directly to electricity by means of a linear power take-off.

## BioPower Systems – bioWAVE™



The bioWAVE oscillating wave surge converter system is based on the swaying motion of sea plants in the presence of ocean waves. In extreme wave conditions, the device automatically ceases operation and assumes a safe position lying flat against the seabed. This eliminates exposure to extreme forces, allowing for light-weight designs.

## Centipod\*

The Centipod is a Wave Energy Conversion device currently under construction by Dehlsen Associates, LLC. It operates in water depths of 40-44m and uses a two point mooring system with four lines. Its methodology for wave energy conversion is similar to other devices. There is no data publicly available currently on the Centipod.

\* Responded to PG&E's Wave Energy Converter System Request for Information (RFI) for consideration for the Humboldt WaveConnect Pilot Project

PG&E has not selected any of these devices for the proposed WaveConnect projects



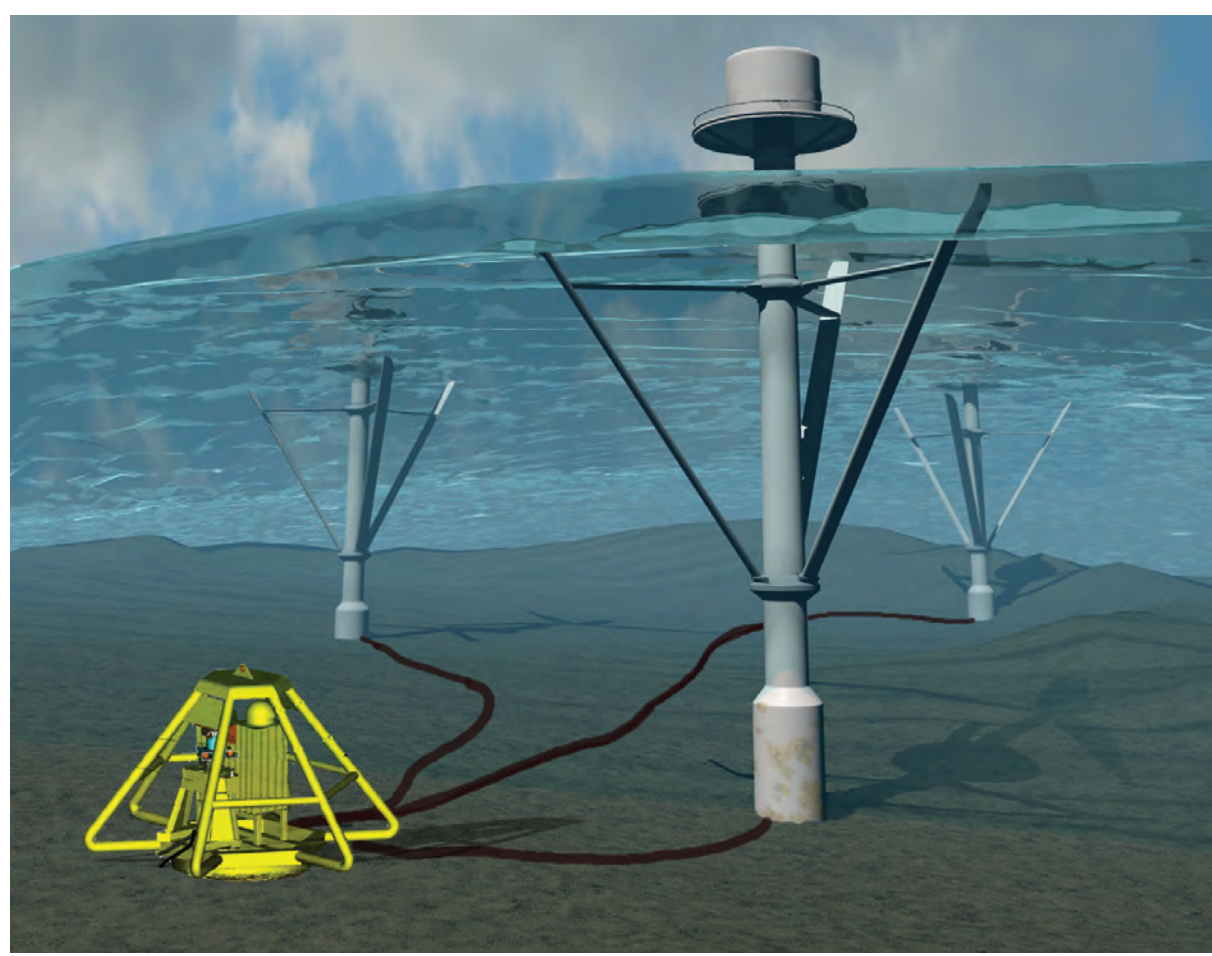
# Wave Energy Converters (WECs)

## Columbia Technologies\*



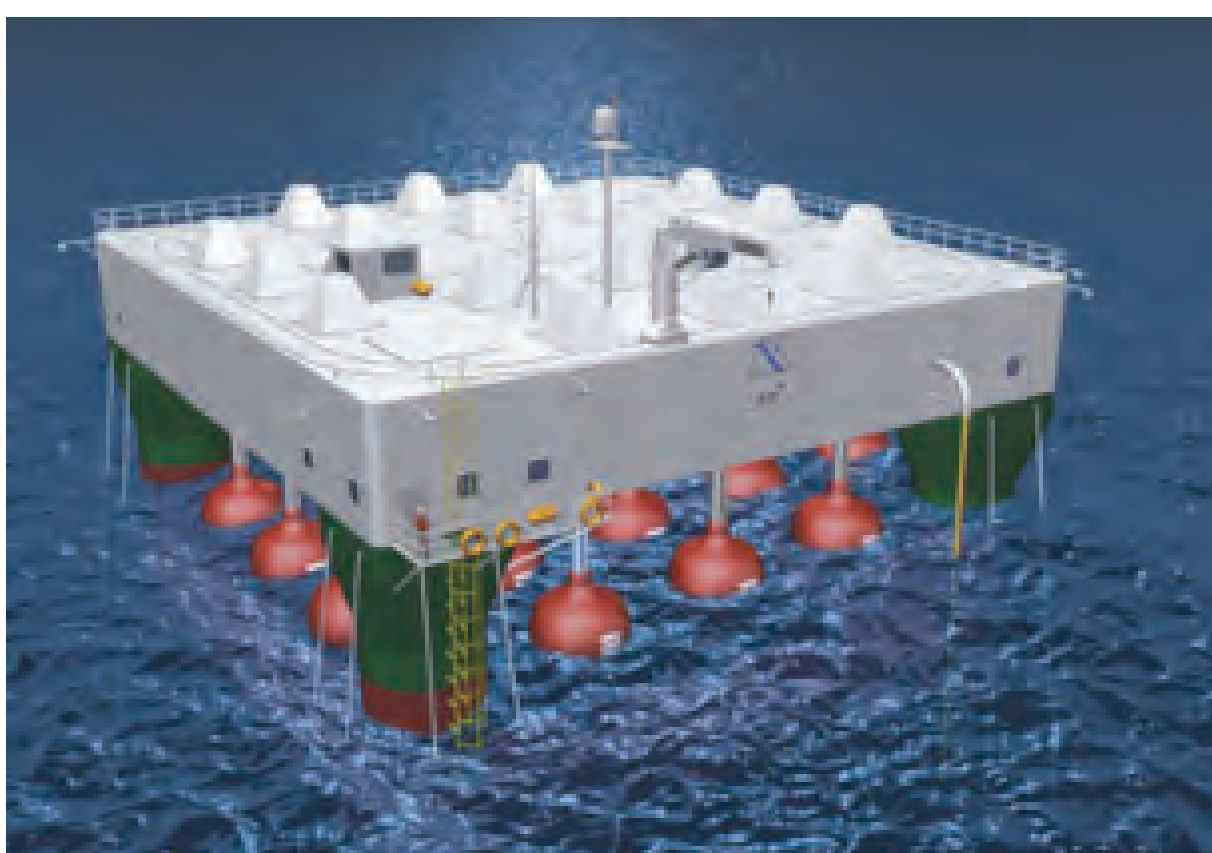
Columbia Technologies is developing a “Point Absorber” wave energy capture device. Moored two to three miles off the coast, the point absorbers use the undulation of the waves to move an outer floating sheath of magnets around an inner copper coil of wire. As the magnets move around the copper coil, the changing position of the magnetic field causes voltage to be generated. The electricity generated by the device runs via cable to shore.

## Ecofys – Wave Rotor



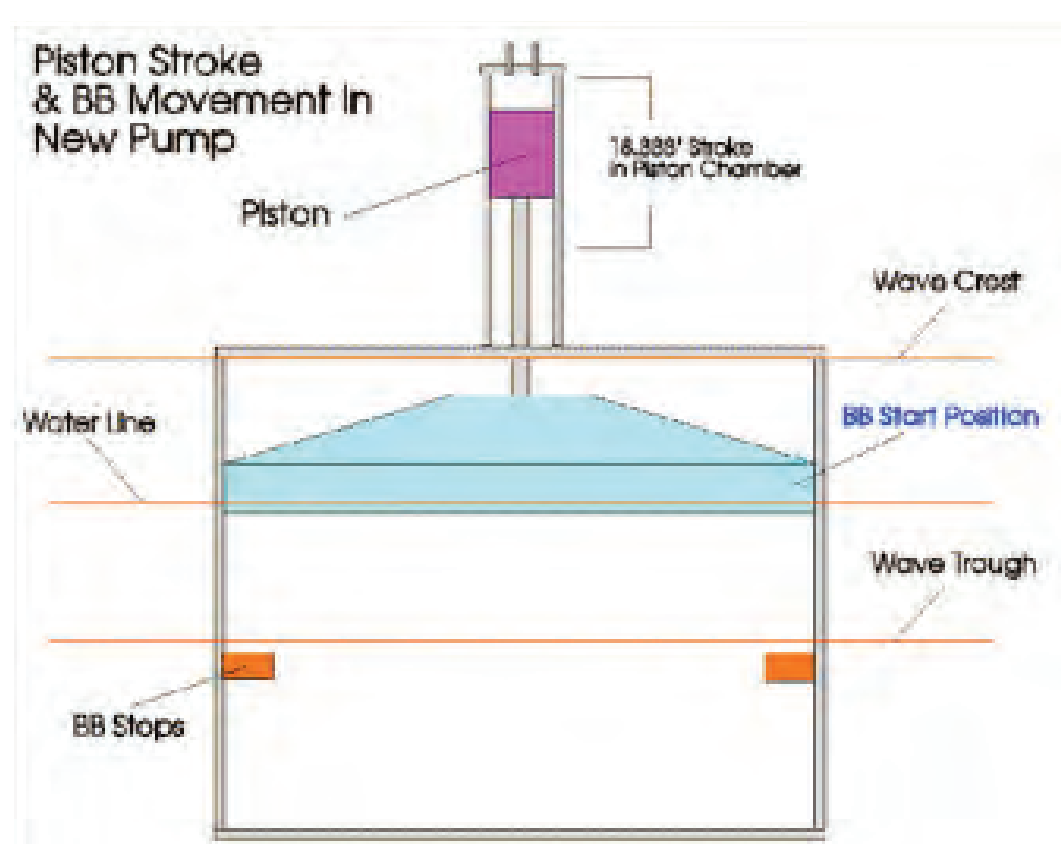
The Wave Rotor operates on principles of hydrodynamic lift and can tap the kinetic energy in waves and tidal currents. Circulating currents in waves exert forces on a set of blades that turn the rotor in one direction regardless of wave or current direction. This device consists of a vertical axis with both slanted blades and horizontal blades fixed to the same axis. The waves turn the rotor, which turns the shaft, which is coupled to a generator through a gear box. The Wave Rotor is monopile mounted.

## Fred Olsen Ltd\*



The Buldra platform uses “eggs” mounted below the platform to capture wave energy. As waves pass below the platform the “eggs” rise and fall with each wave. This mechanical energy is then converted into electricity on the platform. The platform itself floats, which allows it to be stationed in any water depth. Power generated on the platform is brought to shore via cable.

## INRI - SEADOG



The SEADOG uses a differential in float capacity to captures wave energy. As waves pass through the device it causes the center float block to move up and down relative to the exterior. This motion drives a piston which pumps sea water. The SEADOG is being developed for both seawater desalination systems and hydroelectric energy generation.

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# Wave Energy Converters (WECs)

## Ocean Energy Ltd. – OEBuoy



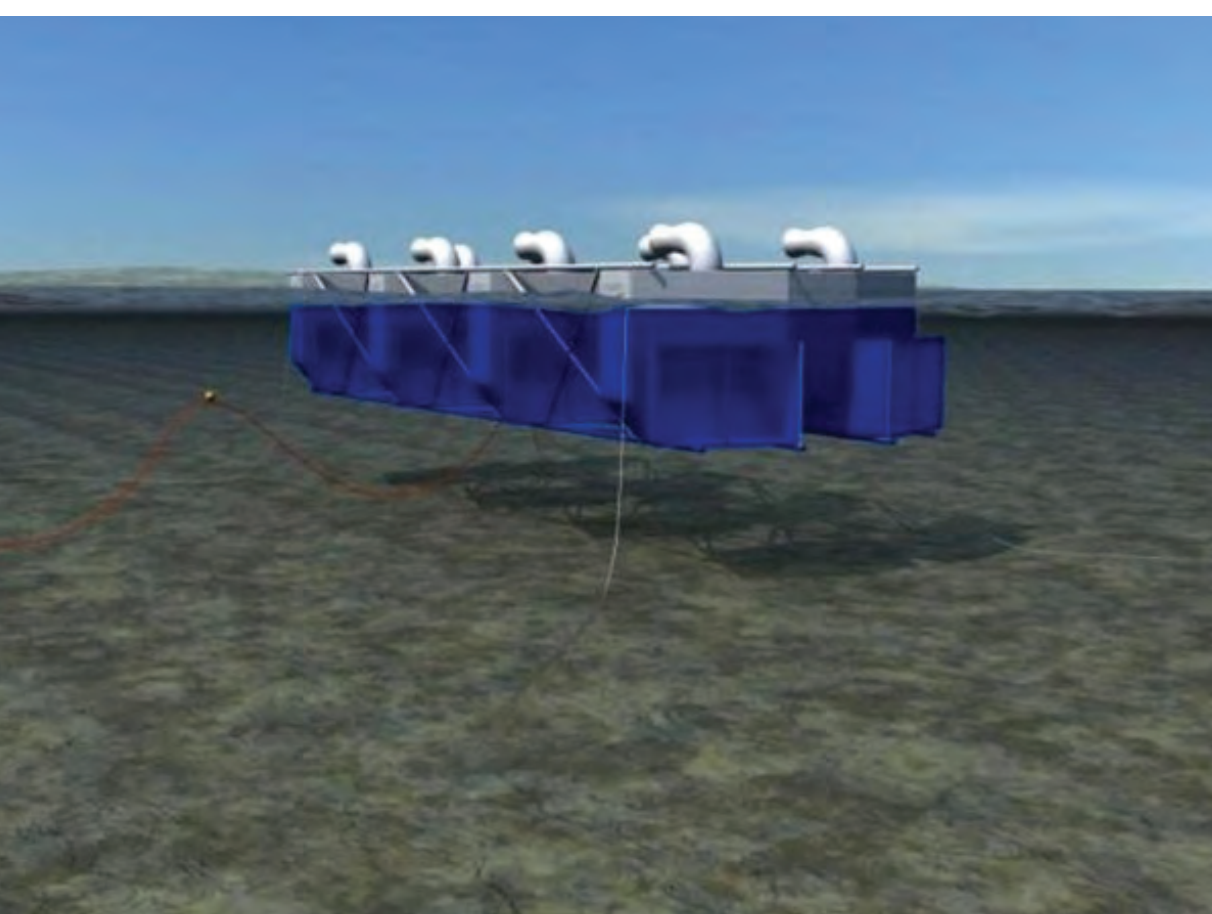
The OEBuoy is a floating, oscillating water column (OWC) that uses wave energy to compress air in a plenum chamber and pump it through an air turbine system. The mouth of the OWC faces away from the wave direction, resulting in high energy efficiencies at the operating point due to the motions of the float system relative to the waves.

## Ocean Power Technologies, Inc. – PowerBuoy®\*



The Ocean Power Technologies wave power station consists of an array of PowerBuoys typically located two to three miles offshore. A PowerBuoy is a loosely moored buoy-like structure (point absorber device) that rises and falls on the waves. The resulting mechanical energy is converted into electrical energy by the use of a power take-off device, an electrical generator and an electronic control system, all of which are sealed inside the PowerBuoy.

## Oceanlinx – Oceanlinx Device



The Oceanlinx seabed mounted version of this device, a three-sided oscillating water column (OWC) chamber, is positioned over the focal region of wave reflecting parabolic wings and converts the wave energy into pneumatic energy. Static pressure in the chamber is converted to kinetic energy in a converging/diverging duct that houses a bi-directional turbine and generator unit. A future version will include floating units. The Mk3 Pre-Commercial or Mk3PC (shown in graphic) is a demonstration scale device that will be constrained in life, operations, and scale to suit the environment at Port Kembla, Australia. Construction of the Mk3PC will commence in 2009, with deployment scheduled for early 2010. The Mk3PC has been designed for a period shorter than normal design life and has the specific objective of verifying Oceanlinx calculated and test data for the Mk3 design, in open conditions.

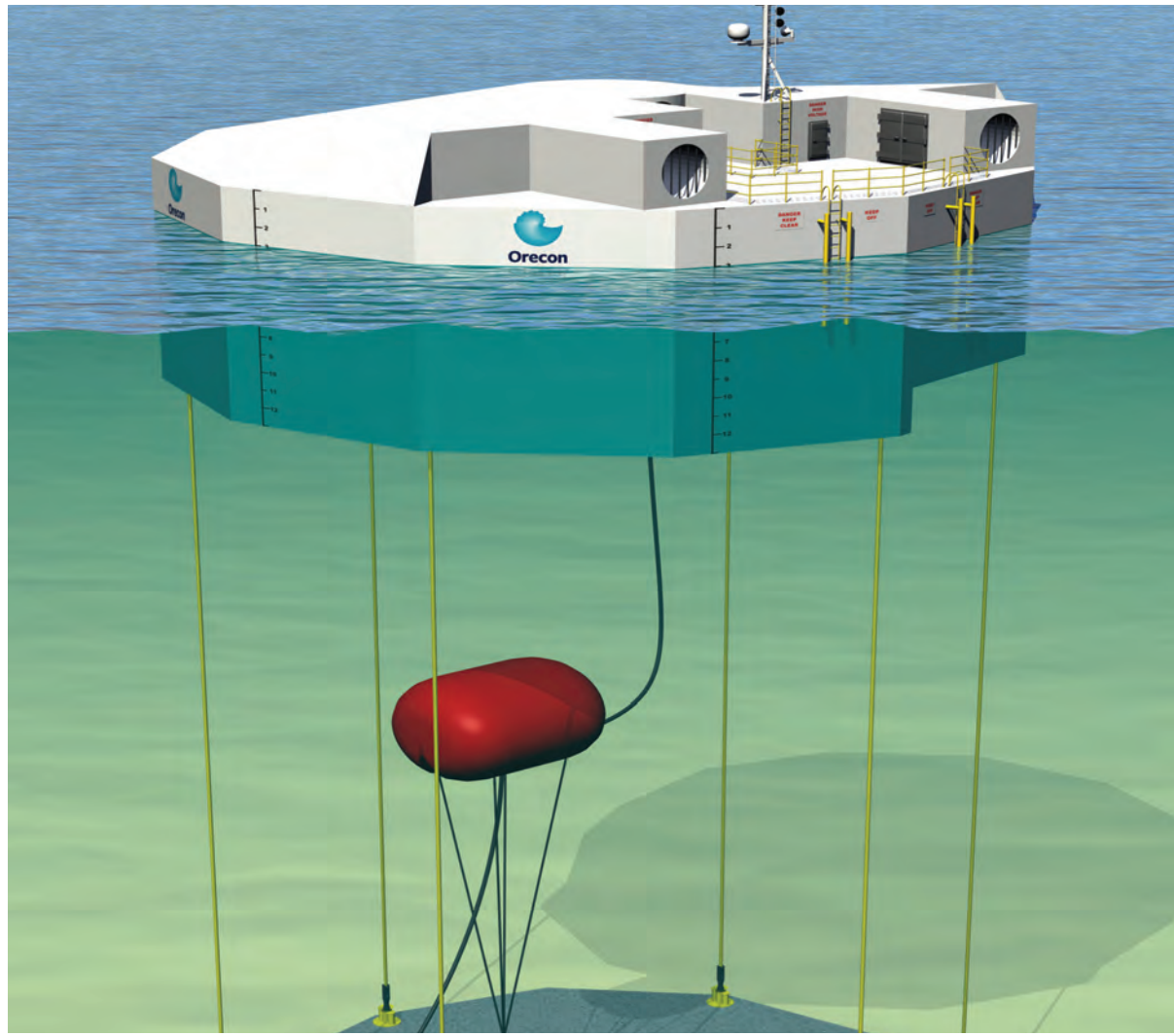
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# Wave Energy Converters (WECs)

## Orecon Ltd. – Multi Resonant Chamber



The Multi Resonant Chamber (MRC) device is a multiple-resonant chamber oscillating water column, which can be deployed as a free floating device. This device features three vertical capture chambers with various lengths, which have different oscillation frequencies (based on the length of each chamber). The independent chambers supply air to impulse air turbines. The rotary motion is converted into electrical power via a directly coupled generator. The unit is tension-moored to the seabed using a gravity anchor.

## Pelamis Wave Power – Pelamis\*



The Pelamis wave energy converter is a free floating, hinged attenuator device. This device consists of four tubular sections connected by three hinged modules, which move relative to each other. This motion is converted to power by means of a hydraulic power conversion system in each of three power conversion modules. The Pelamis is slack-moored with a compliant mooring configuration that both points the device into the waves and enhances survivability.

## PerpetuWave Power Pty Ltd\*



The PerpetuWave captures wave energy through a series of articulated arms mounted on the bottom or a larger floating craft. Each of the articulated arms has a float mounted on the end, as waves pass under the larger craft the articulated arms are forced to move up and down with the waves. The mechanical energy in the arms is converted on board into electricity.

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# Wave Energy Converters (WECs)

## Renewable Energy Wave Pump\*



The Renewable Wave Energy Pump uses a differential in float capacity to capture wave energy. As waves pass through the device it causes the center float block to move up and down relative to the exterior. This motion moves a piston which drives a small diameter reciprocating pump. Anchored to the sea floor and kept vertical by submerged pump floats, the Wave Energy Pump requires a minimum of 14 meters of water depth to operate. The Renewable Wave Energy Pump is being developed for both seawater desalination systems and hydroelectric energy generation.

## Resolute\*



Resolute is a point absorber wave energy capture device and is still in the developmental stage. The final design of the device has yet to be determined. The depth at which it will operate and the means by which it will be mounted to the sea floor are also still unknown.

## SyncWave Systems, Inc. – SyncWave Power Resonator™



The SyncWave Power Resonator device creates power by capturing the motion differential (phase lag) between two dissimilar float structures. Power is captured by a hydraulic power take-off, driving a permanent magnet DC generator. DC power from several SyncWave units in a wave farm will be collected and converted to AC power in a seabed mounted collector hub.

## Wave Dragon Ltd. – Wave Dragon



The Wave Dragon is an overtopping device, that combines a double-curved overtopping ramp and two reflector wings, which focus energy towards the ramp. The waves surge up the ramp, as if it were a beach, and behind the ramp a reservoir collects the overtopping water. Multiple variable-speed propeller turbines are used to convert this low-pressure head into electricity using standard type AC generators. The device is slack-moored and is able to swivel in order to always face the wave direction.

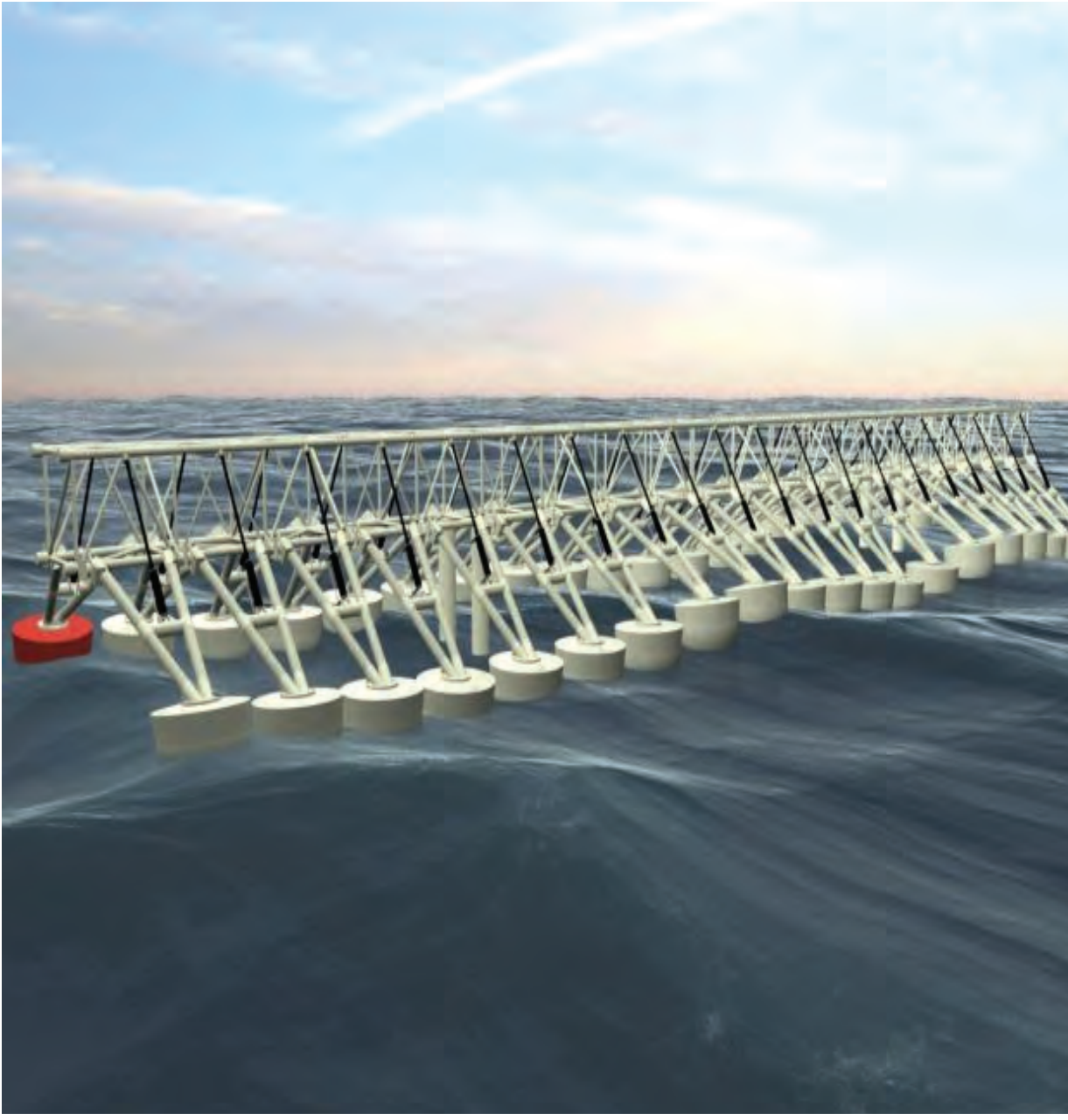
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PG&E has not selected any of these devices for the proposed WaveConnect projects



# Wave Energy Converters (WECs)

## Wave Star Energy – Wave Star<sup>©</sup>



The Wave Star machine is an attenuator device that cuts in at right angles to the direction of the wave and the waves run through the length of the machine. On either side of the oblong machine there are 20 hemisphere-shaped floats which are partially submerged in the water. When a wave rolls in, the first float is lifted upwards, and then the second and so on, until the wave subsides. The floats are each positioned at the base of their own hydraulic cylinder. When a float is raised, a piston in the cylinder presses oil into the machine's common transmission system. The pressure drives a hydraulic motor, which is connected to the generator, which produces the electricity. The device sits on piles like an offshore structure and the floats are raised above the waves for survivability.

## Waveberg\*



The Waveberg is an articulated set of connected floats that flex as waves pass under them. This bending motion is then used to pump seawater under pressure to ashore. On land, the pressurized sea water is run through a turbine which generates electricity.

## Wavebob Ltd. – Wavebob\*



The Wavebob WEC can be moored and maintained in large multi-megawatt arrays offshore. Wavebob is a free floating, self-reacting, axi-symmetric point absorber. This is tuned to the incident wave action using a system to change the device's natural resonance frequency without changing the float's draught.

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