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Wave Energy

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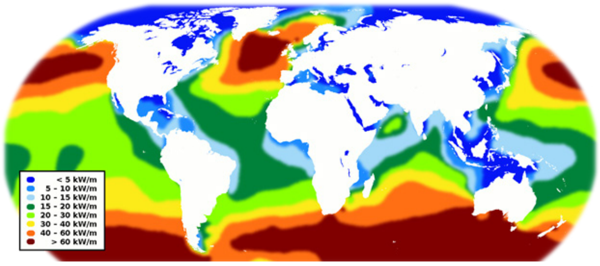
With approximately 70% of the Earth's surface covered by water, the ocean is one of our greatest resources. Water forming the very basis for human life, it is surprising that only 6% of the United States' energy supply comes from hydro power (EIA, 2104). This three-piece series will address the most competitive and developed water-based energy technologies from the perspective of optimizing their respective sustainability factors.

WAVE ENERGY

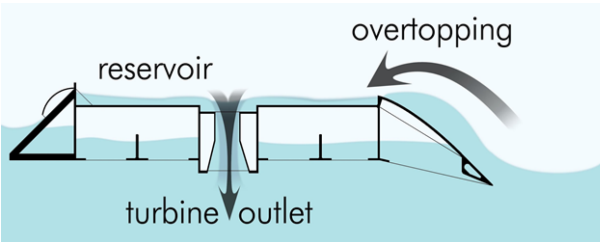
Anyone who stands on the beach and lets a four foot tall wave smash into them knows how much energy is stored in the ocean. Due to the high density of water, wave energy resources have the potential to be an extremely efficient form of renewable energy as compared with wind turbines. Although Wave Energy Converters (WECs) have been proposed for over 200 years, the technology was not implemented until the development of the 'Salter Duck' in 1974. Since then, WECs have seen some limited growth, but as of 2015, no wave based electricity systems are cost competitive with other renewables.



Getting mechanical work (and eventually electricity) from a wave is no trivial task. Fundamentally, there are four main methods of capturing this energy.

OVERTOPPING DEVICE:

The simplest method is to have a wave funnel water up a slope, and trap it above the average sea level. When this water is released, as with tidal or hydroelectric systems, it powers an electric turbine. The 'Wave Dragon'[1] was a joint EU project with several iterations between 2003 and 2007, but was eventually scrapped due to high capital costs, challenging maintenance conditions and low power output.



POINT ABSORBERS:

The first industrial scale WEC was a modified buoy whose rocking motion captured and converted incident wave energy. The vertical bobbing motion of these Point Absorbers is either used directly to generate electricity, or to pressurize and pump water to land. The specific shape of point absorber is designed to flatten large incident waves such that all the vertical motion of the wave is transferred to the WEC. The problem with Point Absorbers, such as PowerBuoy[2] or Carnegie's CETO[3], is that they perform badly in times of extreme weather; they produce no power when outside of their basic operating conditions, and can even be destroyed by the largest events.

ATTENUATOR:

By attaching multiple Point Absorbers together, one can create an 'Attenuator', which often looks like a long string of sausages. As the waves move along the attenuator, each link bends to conform. This bending motion is converted to electricity through a pair of hydraulic rams at the joints powering a small generator. Attenuator designs are often tricky to install, as the size and stiffness of each attenuator needs to be chosen specifically for the installation location. Currently, there is only one operating Attenuator: Pelamis Wave Power[4] has a prototype generating 750kW (enough for around 100 homes) off the coast of Scotland, though its future economic viability is uncertain.

OSCILLATING WAVE SURGE CONVERTERS (OWSC):

OWSC devices look similar to a massive door swaying back and forth in the ocean. The large arm, up to 50 ft wide and 30ft high, oscillates like an inverted pendulum, where the base is secured to the seafloor. The waves push the flange back and forth, driving a piston, which is further connected to a land-based turbine. While OWSCs are mechanically less complicated than other types of WECs, they are extremely disruptive to the local marine environment, trapping nearly all of the wave's energy and blocking all fish, plankton flow etc from the seafloor to the surface. However, installed systems like Oyster[5] have been proven economically feasible and remarkably resistant to inclement weather.

1. http://www.wavedragon.net/index.php?option=com_frontpage&Itemid=1

2. http://www.ocean-powertechnologies.com/powerbuoy/

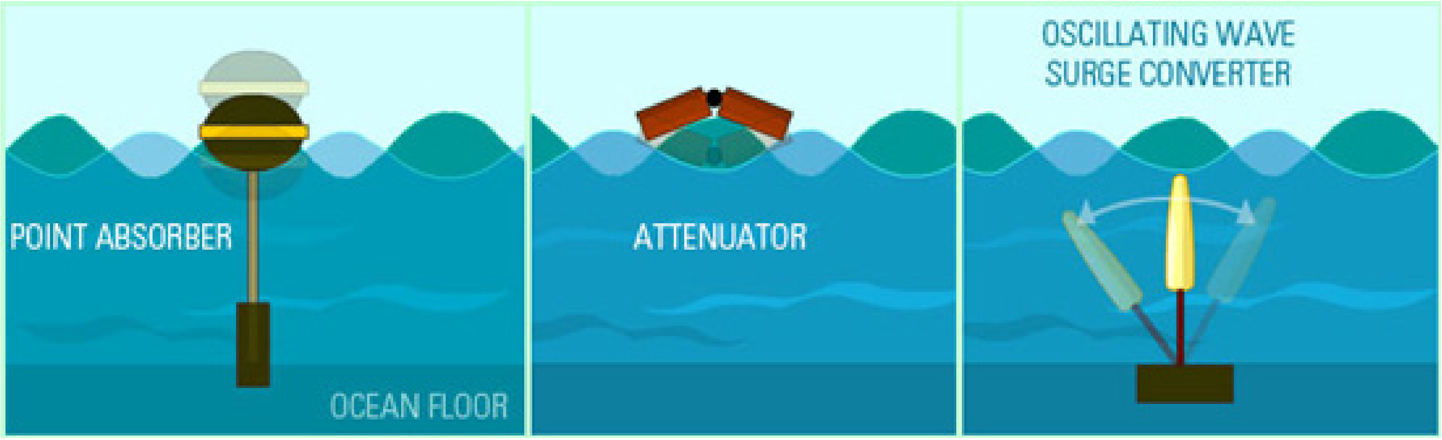
3. http://carnegiewave.com/

4. http://www.emec.org.uk/about-us/wave-clients/pelamis-wave-power/

5. http://www.aquamarinepower.com/

6. 'Ocean Wave Energy', editor Cruz, article by Salter. Springer, 2008

7. 'World Energy Outlook, International Energy Agency, 2015



BARRIERS TO ADOPTION:

The challenge with building industrial scale WECs is the unpredictability of the ocean. The founder of the Wave Energy movement, Stephen Salter, addresses the variability of the wave energy resources, stating "I can always identify a newcomer to the field because they draw the waves on both sides of the device at the same height'.[6] The ocean is a remarkably challenging environment, and many of the safety assumptions engineers make about consistent conditions for solar farms or wind turbines no longer hold true in water. Creating systems that operate reliability in both a corrosive and inaccessible environment has proven a severe impediment to their adoption.

While Wave Power is typically seen as far more expensive than other forms of alternative energy, it is worth examining three systems that have been integrated into the grid: Pelamis, Carnegie and Oyster. Each technology is generating grid-level electricity, but none are cost competitive with industrial power systems from natural gas, solar, wind etc. However, one potential benefit of Wave Power compared to tidal systems or wind turbines, is that the electricity produced will be far more consistent and predictable. Very few renewable sources can provide base load power, though Wave Energy Converters may be the best option.

All three technologies see the same key challenges: the cost and difficulty of building transmission lines, the cost of over-engineering structures to increase resilience against extreme storms, and a limited regulatory and financial system to support further development. As of yet, no technology has proven to be far superior to the others, mostly due to the limited number of operational systems. However, ocean-generated energy in their current form do not seem to have a bright future. The World Energy Outlook, 2015,[7] states: "Overall, the outlook for marine power appears limited to 2040 as opportunities to develop other renewable energy technologies remain available at lower cost."

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