Exploration of The Economic Feasibility of Wave Power

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With ever growing demand for power, diminishing natural resources and a world on the cusp of a climate change disaster; renewable energy is essential for the future. In order to meet the demand for renewable energy, we need to diversify our renewable sources. Solar and Wind power are limited by the space they require to operate and the environmental conditions. Nearly two thirds of the globe is covered by ocean. These oceans all are dominated by waves. Some of these waves carry enough energy to capsize vessels 3 football fields in length. It seems silly that in a world dependent on natural resources for power, that we do not utilize the vast amount of energy generated by the ocean. Wave power is often not thought of as a legitimate renewable energy source as solar and wind are referred to.

Wave energy is the use of waves, tides, or currents to generate electricity. Wave power machines converts mechanical energy from the ocean into electrical energy. There are two different main branches of wave power. The first is generation of power by manipulating the tides and currents. "Tide Power" as it is often nicknamed, utilizes the increase in potential energy caused by rising tides. Tide power works in a similar way to hydroelectric, but instead utilizes the ocean. When tides go from low to high, it forms a "tidal range," which is the difference in height the tide experiences during a full period of oscillation (usually 12 hours). Tide power generators work like miniature dams. A large reservoir is constructed with height close to high tide and a bottom close to low tide. When the tide rolls in, the reservoir will be filled. A few hours later when the tide recedes, the water collected in the reservoir will be drained similar to a hydroelectric dam. A hole will be opened at the bottom of the reservoir such that water will drain down to the level of the tide, turning a turbine as it flows. This method is highly efficient and easy to use, but is highly detrimental to the environment(Ferri).

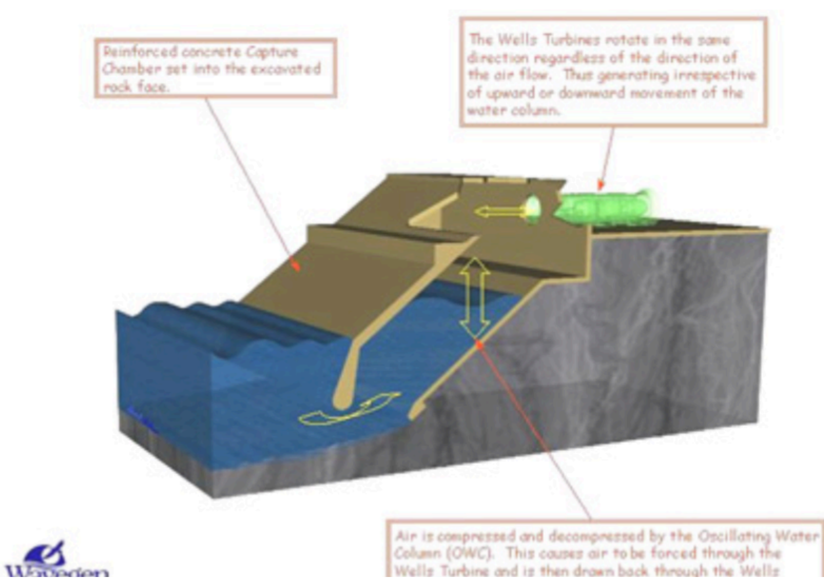
Tide power raises many hazards for wildlife. The biggest issue with reservoir tide power is the trapping of fish in the reservoir. The tide lets water freely flow into the reservoir at high tide, which also includes many marine animals, mainly fish. When the tide is then "let out" later to generate power, these marine animals can become trapped and get stuck in the turbines that turn the generator. This poses a large problem for fish safety as well as workings of the power plant. Tide power plants can use nets and grates to separate marine animals out from the water, but transporting the marine animals back to the ocean can be troublesome to the health of the animals and cost of the plant. The other harmful component of tide power is the large and invasive concrete structures needed to be completed to make tide power feasible. After the tide power plant has finished its lifecycle, it would have to be properly disposed of somehow.

The second type of wave power generates electricity by utilizing mechanical wave motion. As anyone that's ever visited a beach can attest to, water in the ocean moves in oscillating waves. The idea of wave power is to use the powerful oscillations of the waves to move hydraulic pumps, which in turn produce electricity. This type of wave power is dominated by three types of mechanisms: Attenuators, Terminator devices, and Point absorbers.

Attenuators

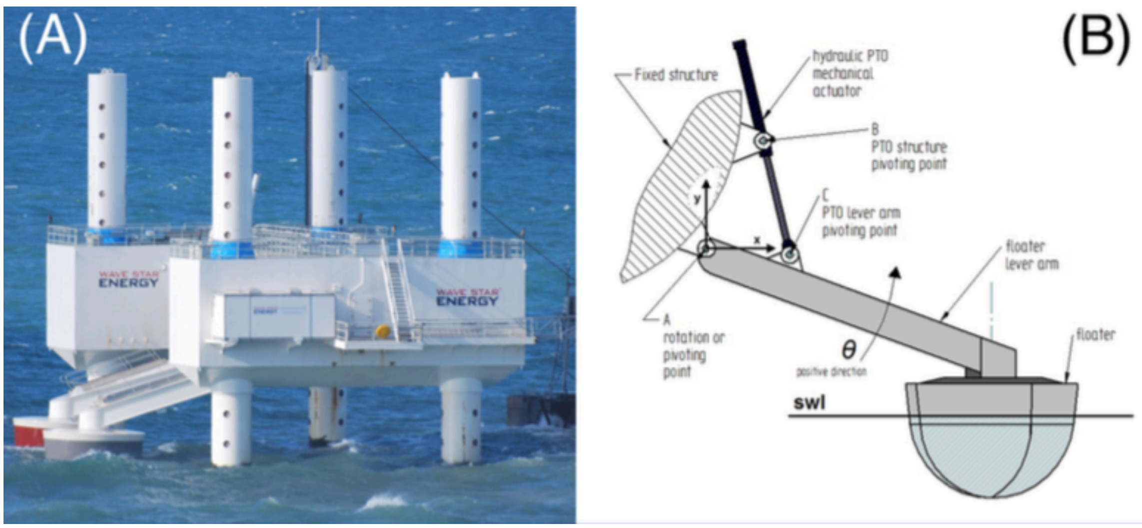
Attenuators utilize the translational motion of waves to generate power. Attenuators are long canoe like structures that can be as long as 100m in length. They have plates that shift as a waves moves along the attenuator. These plates are connected to hydraulics, which turn a generator. Like other offshore wave power devices, Attenuators require a conduit on the floor of the ocean to transport the energy produced back to land. Attenuators are usually structured in groups because each machine does not produce enough electricity to make it worth running a conduit on the bottom of the ocean. Attenuators are significant in their ease to deploy. Attenuators are built such that they can be dragged out to sea from the backs of ships. Once in their place, they can be connected to other Attenuators to make connecting the farm to shore much simpler. The removal of Attenuators at the end of their life cycle is also quite simple. The Attenuators can simply be dragged back to shore in the same way they were dragged out then pulled onto shore to be disposed of properly. The one con to the Attenuators design is that making repairs on them is incredibly intensive. Because the Attenuators lie so low in the water, they must be towed all the way back to land to be repaired. For such a sensitive mechanical device, this can become costly quickly (Ferri).

Terminator devices are onshore devices that utilize the surging motion of the waves on the shore. Terminator devices work by using the pressure caused by a wave surging forward into the terminator to turn a generator. These machines are often the least effective form of wave power. This is due to the specific



environment in which they must be placed. Not many beachfronts can produce the conditions needed for a terminator device to be feasible. Terminator devices require a large amount of concrete to be constructed in order to channel the pressure of the wave surge. The removal of huge concrete structures constitutes a large cost if done in a environmentally friendly way. The huge positive of a terminator device is that it does not harm marine life at all, but because of the costs even compared to other wave power devices, it is not feasible.

The point absorber utilizes the oscillating up and down motion of waves and tides to generate electricity. There are two types of point absorbers that exist. The first is a buoy like structure that is tied to the seabed like a buoy and transmits

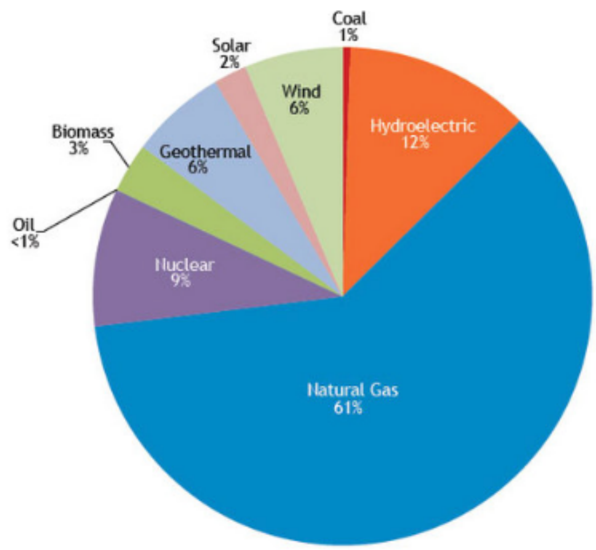


electricity back to the mainland via an underwater conduit. The other point absorber is a more sophisticated system than the buoy system. This version consists of many point absorber devices attached to a main body, allowing the machine to generate more electricity and make the running of a conduit on the seabed more worthwhile. The importance of tis design is that it is scalable. It would be entirely possible to build a longer structure with more point absorbers on the sides of it. Next generation point absorbers are still in the testing stage so they are not yet in mass use. Wave Star has projected its new power plants will out put roughly 0.5 GWH each. These plants would be configured in formations to form wave farms. Data collected from the UK indicates that a farm of these machines would provide 275 GWH with costs of 7.5 cents per KWH. For reference, the current cost of cheap fossil fuels is 2.5 KWH and the cost of wind power is 5 cents per KWH(Voorhis). The biggest plus wave power has in its favor is that the sea is open and we will never run out of possible space for wave farms. The wave power industry is also quite immature, so we can assume costs will go down as the industry expands and production goes up. The state of California currently draws 300000 GWH of energy, and is only projected to demand more in the coming decade. Because wave power cannot account for this huge of a demand, it is reasonable to diversify renewable sources of energy.

Currently, the wave power industry is not very robust. Wave power in the state of California barely accounts for any energy produced. Considering the enormous amount of coastline in the state of California, wave power is a huge potential source of energy. In fact, most of the data concerning wave power originates from the U.K. Given the availability of this resource, it is worthwhile to look into the feasibility of it and the development of technology to harness it.

Wave energy promises a clean and consistent source of power. Given the costs of wave energy and the limitations given by the environment, it is not feasible to switch all fossil fuels over to wave power. If wave power were to account for a modest yet significant 5% of California's energy, many benefits would be reaped.

Reduction of emissions is the largest positive of wave power. Currently, roughly 61% of California's energy comes from natural gas (Nyberg). While natural gas produces less emissions than coal, it is still a dirty and disappearing non-renewable resource. Natural gas releases both carbon dioxide and methane into the atmosphere, both of which are causes of climate change and pollution. If wave power were to take over 5% of the energy market in California (comparable to current wind or solar) from natural gas, natural gas prices would decrease as would pollution.



According to statistics given by the NEIA, California produces 300000GWH of electricity annually. Therefore, 5% of production is approximately 15000 GWH. Given that current wave farms produce 275 GWH of electricity, California would require 55 wave farms in order to reach 5% of demand. Ideally, these farms would be on high potential stretches of ocean along the coastline, close to shore. In reality, this would not be possible because of shipping routes and the areas of greatest energy demand. Therefore, the wave farms would have to be close to large power consumption centers. Luckily, the statistics gathered from trial farms in the U.K. were setup with the same parameters that those in California would be constrained by. Thus, the price tag put on California wave energy would be the greatest it would be, and could be possibly significantly cheaper.

Currently, one of these 275 GWH wave farms runs a price tag of 1.2 billion dollars. Therefore, 55 plants would put the state of California out 66 billion dollars. To give some perspective, 66 billion dollars is 25 % of California's budget. This can be compared to the price of a natural gas power plant of equitable power generation, which runs in the range of half a billion dollars (Sontakke). Accounting for the cost of natural gas as a fuel, natural gas is still cheaper. Staying with natural gas seems like the most economical decision, but because power plants lifecycles span multiple decades, extreme pollution and depletion of natural resources especially in the next decade will greatly affect natural gas. The same cannot be said for wave power. In fact, the costs of wave power are predicted to drop as new technology appears and wave power goes into mass production. [1911]

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