Wave & Tidal Energy

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A new solution?

As non-renewable energy sources, such as coal, are being tapped out, new and innovative ways of creating energy for our needs are being explored. Capturing energy from the water is not a novel idea (I.e. dams), doing it with less of an impact on the environment is. This is where tidal and wave energy comes in. In recent years there has been an increase in exploring ways to harness the energy of the movement of water off shore in ways that allow fish and boats to continue using the same area of water. Although tidal and wave energy both come from the ocean, there is a distinction between the two forms of technology in both how it is captured and how it is produced.

What is Wave energy?

Wave power refers to the energy of the ocean surface waves and the capture of energy to do useful work - including electricity generation, desalination and the pumping of water into reservoirs. Wave power is distinct from Tidal power in that tidal power fluctuates daily. Although wave power is not widely used only having a handful of test sites in the world it is more consistent than tidal power.

What is Tidal Energy?

Tidal Power is the power of electricity generation achieved by capturing the energy contained in moving water mass due to tides. Two types of tidal energy can be extracted: **kinetic energy** of currents between ebbing and surging tides and **potential energy** from the difference in height between high and low tides.

Wave Energy…

Wave power could potentially yield more energy than tidal power, especially because it can be exploited in many more locations. However, because wind is not predictable, waves are not predictable and therefore energy harvested from waves is not predictable.

Waves

- The larger the wave, the more power
- Determined by height, speed, length & density of the water
- Determined by wind and sea floor dimensions
- North and South temperate zones are best source for capturing wave power due to stronger winds during winter
- Wave power is strongest at surface and reduces with depth
- Wave power is expressed in kilowatts (kW) per meter

How Wave energy is harnessed

Two types of systems

- Offshore systems in deep water, more than 141 feet deep
  - Pumps that use bobbing motion of waves
  - Hoses connected to floats on surface of waves. As float rises and falls, the hose stretches and relaxes, pressurizing the water which then rotates a turbine

How Wave energy is harnessed

- Onshore systems are built along shorelines and harvest energy from breaking waves
  - Oscillating water columns are built of concrete or steel and have an opening to the sea below the waterline. It uses the water to pressurize an air column that is drawn through the turbine as waves recede.
  - A Tapchan is a tapered water system in sea cliffs that forces waves through narrow channels and the water that spills over the walls is fed through a turbine.
  - A Pendulor device is a rectangular box with a hinged flap over one side that is open to the sea. Waves cause the flap to swing back and forth and this powers a hydraulic pump and generator.

How is it used?

The energy of waves is being used for electricity. In Scotland, the Pelamis wave energy project was tied into the UK electricity grid and as of 2004 was generating a peak output of 750kW

$ Costs? $

There is no federal ocean energy program in the United States, making it very difficult to develop wave energy technology. It costs too much for companies to develop the technology without grants or investors, so many just decide not to go into this business. It is very difficult to develop the machinery that can withstand the force of the ocean, so it still remains a big risk to investors.

Conservative reports estimate the installed cost of wave energy exceeds $4000 per kW, twice that of wind energy. Because the Federal Energy Regulatory Commission requires permits for wind energy, organizations that want to pursue this technology end up spending hundreds of thousands of dollars on environmental studies, consultations and reports.

In the U.S.

Currently there are no wave energy projects in the US that are harvesting energy- they are all in the preliminary stages of testing and permitting. According to the Federal Energy Regulatory Commission (FERC) 3 US states have received wave energy permits: 8 sites in Florida, East River NY, & Puget Sound WA. There are many tidal energy permits pending, for Washington State, New Hampshire, Maine, New York, Massachusetts, Oregon, Alaska and Washington. The US Navy is currently utilizing wave energy for their marine base in Hawaii

Other locations…

A local project, the Makah Bay Offshore Wave Energy Pilot Project in Washington has completed the Preliminary Draft Environmental Assessment process in October of this year. According to a qualified FERC assessor, the project will have "no significant environmental effects on the oceanographic, geophysical and biological conditions of Makah Bay". This project could be delivering 1500 megawatt hours of electricity annually to the Clallam County Public Utility's electricity grid by the end of 2006.

In Oregon there are a couple projects in the works, off the coast of Reedsport, off the coast in Lincoln County, and off the coast in Douglas County. The Reedsport site is unique in that they will be able to utilize an existing infrastructure from an old paper mill, reducing capital costs.

Worldwide

Worldwide, there are a few operating wave energy plants. On Scotland's west coast is the Limpet, an onshore device utilizing oscillating water columns. Also in Scotland is an offshore float device called the Pelamis. Off the Australian coast is a pilot wave energy project that utilizes wave energy to force air through a chamber, increasing air speed and concentration before reaching a turbine and generator. There is also wave technology being used in sites in the UK, Denmark & the Netherlands.

Renewable & Sustainable?

Wave energy is renewable because it is replenished as it is used, in other words, the waves will always wash ashore.

Renewable sources of energy are considered sustainable resources of energy, and are not expected to be depleted w/in the human timeframe. As waves are based around wind & ocean topography, the likelihood of wave technology extending beyond the human timeframe is good.

Negative impacts

- Difficult to convert wave motion into electricity efficiently
- Difficult to design equipment that can withstand storm damage & saltwater corrosion
- Total cost of electricity is not competitive with other energy sources
- Pollution from hydraulic fluids & oils from electrical components

Positive Impacts

- Five to seven jobs created for each megawatt of installed wave energy capacity
- Wave energy leaves a small ecological footprint
- Wave energy parks are not visible from the shoreline, making communities more receptive to them than offshore wind energy projects
- In the Pacific Northwest, energy generated from the waves would be closer to the population and therefore would not overburden scarce transmission capacity
- Also specific to the Pac NW, Oregon State University in Corvallis is at the forefront of research on advanced technology for wave energy converters.

Tidal Energy

All coastal areas experience high and low tide. If the difference between high and low tides is more than 16 feet, the differences can be used to produce electricity. There are approximately 40 sites on earth where tidal differences are sufficient.
Tidal energy is more reliable than wave energy because it based on the moon and we can predict them. It is intermittent, generating energy for only 6-12 hours in each 24 hour period, so demand for energy will not always be in line with supply.

Types of tidal energy

- Kinetic energy from the currents between ebbing and surging tides
- This form is considered most feasible
- Potential energy from height differences between high and low tide

How tidal energy is harnessed

Density of water is much higher than air, so ocean currents have much more energy than wind currents.

- Barrage or Dam
  - Using a dam to trap water in a basin, and when reaches appropriate height due to high tide, release water to flow through turbines that turn an electric generator.
- Tidal Fence
  - Turnstiles built between small islands or between mainland and islands. The turnstiles spin due to tidal currents to generate energy.
- Tidal turbine
  - Look like wind turbines, often arrayed in rows but are underwater. Tidal currents spin turbines to create energy

How is it used?

Like wave energy, tidal energy is used for electricity, with the ultimate goal of connecting to local utility grids. A single 11-meter blade tidal turbine outside of Britain's Devon coast will be capable of generating 300 kW of electricity (enough to power approxiametely 75 homes)

$ Costs? $

Doesn't cost much to operate, but construction costs are high and lengthen payback periods, so the cost per kW hour is not competitive.

Locations

There are no tidal power plants in the US, although conditions for tidal power generation in the Pac NW & Atlantic NE are favorable. The first tidal power station was in France, with a 240MW installed capacity, There are also sites in Nova Scotia (20MW), Soviet Union (0.5MW) and China has four sites.
In 2003, Norway connected the first tidal power turbine into the country's power grid. Projects are being considered in Argentina, Australia, Canada, India, Korea, Mexico, United Kingdom, United States, Russia and South Africa.
According to the FERC, there is a permit pending for a tidal energy project in the Columbia river and in the San Francisco Bay

Renewable & Sustainable?

Tides are caused by mechanics within the solar system and are therefore inexhaustible. The root source of tidal energy is the earth's rotation, so as long as the earth keeps moving, we will have tidal energy.

Tidal power is sustainable because tides occur consistently four times in a 24 hour period and return even if we harness the currents for energy.

Negative impacts

- Intermittent energy production based around tides creates unreliable energy source
- High construction costs
- Barrages can disrupt natural migratory routes for marine animals
- Barrages can disrupt normal boating pathways
- Turbines can kill up to 15% of fish in area, although technology has advanced to the point that the turbines are moving slow enough not to kill as many

Positive Impacts

- Decrease reliance on coal driven electricity so less CO2 emissions
- Changing technology allowing quicker construction of turbines, which in turn increases likelihood of investment with a shorter return.
- Once constructed, very little cost to run and maintain

References

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This website provided a list of permits approved and permits pending for wave and tidal energy projects in the US.

References

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This article lists types of ocean energy, financial costs, and describes tidal and wave energy projects around the world.

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This article provided background on the tidal energy turbine off Britain's Devon coast, as well as the installation used by the US Navy in Hawaii.

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This article provided information about Oregon's dedication to sustainable energy sources and the wave projects that are in the preliminary stages in the state.

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Smith, R. (2005) “Next generation/unconventional hydropower: Wave and tidal energy decives…and more!” Accessed online at: http://www.epa.gov/cleanrgy/pdf/smith_may10.pdf

This presentation provided background on various wave and tidal energy projects around the world.

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US Department of Energy (2005) “Energy efficiency and renewable energy: Exploring ways to use ocean energy.” Accessed online at: http://www.eere.energy.gov/consumer/renewable_energy/ocean/index.cfm/mytopic=50007

This website provided practical information about the various technologies used for both tidal and wave energy.

References

Wikipedia (2006) “Tidal power.” Accessed online at: http://en.wikipedia.org/wiki/Tidal_energy

This website provided a ton of information about tidal energy, from what it is to where it’s used, to the technology necessary to harness and use it.

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Wikipedia (2006) Wave power.” Accessed online at: http://en.wikipedia.org/wiki/Wave_energy

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Thank you