Waves: An Alternative Energy Source Discussion Question Answers
Bridge Data Activity
<www.marine-ed.org/bridge>

Inshore Questions

Q. Using the data you calculated above, which inshore site (Cobscook Bay, Ocean Crest Pier, or Diablo Canyon) would make the best site for a LIMPET system? Why?

> *A. Under normal circumstances, Diablo Canyon would make the best site because it is the least protected of the three. Extraordinary circumstances, such as hurricanes, may change conditions, but only temporarily.*

Q. What does the location of each buoy within each respective cove have to do with the size of waves they reported?

> *A. Protection. Cobscook Bay is the most sheltered, or protected of the three stations, followed by Ocean Crest Pier, and then Diablo Canyon, therefore, Cobscook Bay will typically have the smallest waves.*

Q. Given that the California coast line measures 840 miles (1,351.85 km), if half of the coastline was dedicated to LIMPET systems, how much electricity would they produce?

> *A. Using the calculations for the Diablo Canyon station, multiply Energy flux or J (in kW/m) by 675,925 meters. The answer will vary according to the data from the Diablo Canyon buoy.*

Q. Would this cover your state's electricity demand (see the 1990 - 2003 US electricity usage table from the US Dept. of Energy)? If so, how much would there be left over? If not, how much more electricity would you need?

> *A. Determine your state's electricity demand from the table and subtract the amount of energy calculated in the previous question. If the result is positive, this is the left over amount; if negative, this is the amount your state still requires to meet the annual demand.*

Offshore Questions

Q. Using the data calculated for the Pelamis converter, which site, offshore New England, offshore North Carolina, offshore California, or Lake Michigan would make the best site for a Pelamis "farm"? Would all be effective sites?

> *A. At any point in time, any one site may have better wave characteristics than the rest. To accurately answer this question each station would have to be evaluated over time, not just once. If time does not allow, simply choose the station(s) with the highest energy output at the time of the activity.*

Q. Based on their locations on the maps, what is an obvious disadvantage of the offshore NC and offshore CA Pelamis farms?

> *A. Their long distances offshore would require not only additional time and resources to reach the sites for construction and routine maintenance, but a tremendous amount of materials would be needed to transmit the electricity from the offshore station to land. Also, the extraordinary depth of the water would require a very large amount of mooring (anchoring) material and present difficulty in setting those moorings.*

Q. The annual output of one Pelamis converter is approximately 2.7GWh at full capacity. Given this, how many units would be needed in one area to produce enough electricity to cover your state's demand?

> *A. Divide your states annual electricity demand (in GWh) by the annual output of a single Pelamis converter (2.7GWh). The result will vary depending on your state's annual electricity demand.*

Discussion Questions

Q. Based on what you have observed in the Data Activity, do you see wave energy as a practical alternative energy source? Why or why not?

> *A. Answer should be based on knowledge gained from the activity and should include factual evidence supporting the student's opinion.*

Q. Is it better to build bigger systems to harness storm-sized waves and run at lower efficiency the rest of the time OR build smaller, more efficient systems and a) risk destruction of the system during big storms or b) not harnessing the energy of larger storm waves? Explain.

> *A. A wave energy converter must be able to survive the worst seas likely to occur in the machines economic lifetime (otherwise it will not pay for itself). However, this survival must not come at a cost (e.g. in extra steel, etc.) that makes the machine too expensive, such that the electricity it generates is too expensive relative to other sources. All renewable energy machines (wind turbines, wave energy converters) must be sized such that they capture enough electricity to pay for themselves with some to spare - too big and their capacity is, on average, underused, too small and they are missing out on too much of the energy available. The economics of production (e.g. economies of scale, materials, careful design to minimize cost) play a big part in determining the right power rating of a machine. From: R. Henderson, Ocean Power Delivery Ltd. (Pelamis manufacturer)*

Q. Explain how refraction increases the amount of energy that can be harnessed from a single wave by a shoreline converter.

> *A. When a LIMPET converter is placed at the center of a cove, as the wave enters the cove, it will curve to mimic the shape of the cove bottom (refraction) therefore concentrating the wave energy to a central point on the shoreline.*

Q. Explain how diffraction increases the amount of energy that can be harnessed from a single wave by an offshore converter.

> *A. Because a wave in motion is transporting energy, not water, as some stationary object removes energy from a portion of the wave (such as a Pelamis converter), the remaining energy in the remaining wave will spread into the gap left by the object. Therefore as a wave moves through a Pelamis farm, some energy will be removed from the wave, but the wave will "fill in" and continue to have energy available for additional converters.*

Q. Discuss the advantages and disadvantages of each type of system and wave energy overall.

<u>Advantages of Wave Energy</u>

- *The energy is free - no fuel needed, no waste produced.*
- *Not expensive to operate and maintain.*
- *Can produce a great deal of energy.*

<u>Disadvantages of Wave Energy</u>

- *Depends on the waves - sometimes you'll get loads of energy, sometimes nothing.*
- *Needs a suitable site, where waves are consistently strong.*
- *Some designs are noisy.*
- *Must be able to withstand very rough weather.*

(Source: Andy Darvill's Wave Power)

Pelamis Advantages

- *Offshore, out of site*
- *Much higher energy potential offshore than in shallow water:*
- *Wave power at deep ocean sites can be as much as 8 times that of coastal sites*
- *Does not change wave patterns*
- *Does not disrupt wildlife*
- *Runs quieter than the other technologies*

Pelamis Disadvantages

- *High cost associated with electricity transmission from the offshore system to land*
- *Navigation hazard*

Oscillating Water Column (OWC) Advantages:

- *Low maintenance*
- *Non-polluting*

Oscillating Water Column Disadvantages:

- *Noise*
- *Not suitable for all coastal regions*
- *Requires very specific location characteristics*
- *Valuable waterfront real estate*
- *Construction requires coastal destruction*