

Ocean Power (Four Activities)

Grades: 5-8

Topic: Hydropower

Owner: National Renewable Energy Laboratory

Ocean Power

For the Teacher

The discussion of renewable energy sometimes focuses on what happens when the sun doesn't shine. What happens when the wind isn't strong enough to produce sufficient power? How can we store the energy we need? What happens when storage is not practical on a large scale, for instance, when you need to supply energy to a large energy grid? In areas of the country that have available coastline, but are limited in other renewable resources, they can use the oceans as their renewable resources. We are familiar with the large hydroelectric dams that dot our nation, creating large reservoirs and flooding millions of acres of land. By turning to the restless seas we can find a source of energy that is not affected by clouds and the scarcity of wind. By using ocean power, we can increase our need for power without having to deplete our existing non-renewable resources.

Ocean power is divided into three categories: wave energy, tidal energy, and Ocean Thermal Energy Conversion (OTEC) Systems. Ocean Energy is estimated to be able to provide 2 to 3 million megawatts of power from our world's coastlines.

National Science Education Standards by the National Academy of Sciences

Science Content Standards: 6-8
Science As Inquiry
– Content Standard A:

"Abilities necessary to do scientific inquiry"

"Understandings about scientific inquiry"

Physical Science

– Content Standard B:

"Properties and changes of properties in matter"

"Motions and Forces"

"Transfer of energy"

Earth and Space Science

– Content Standard D:

"Structure of the Earth System"

Science and Technology

– Content Standard E:

"Abilities of technological design"

"Understandings about science and technology"

Science in Personal and Social Perspectives

– Content Standard F:

"Science and technology in society"

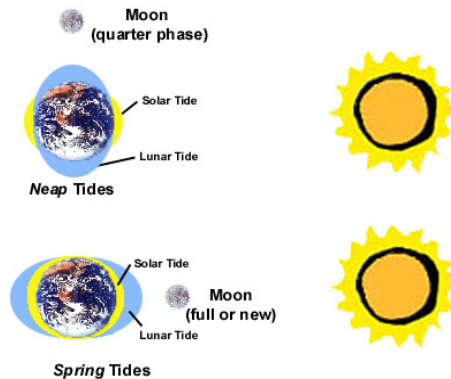
Technology Description

More than 70% of the solar radiation reaching Earth falls on the ocean, heating the upper layers of the seas. This thermal energy, combined with wind and the forces of our solar system, causes currents, waves, and tides. Together these forms of thermal and mechanical energy make up a huge energy resource.

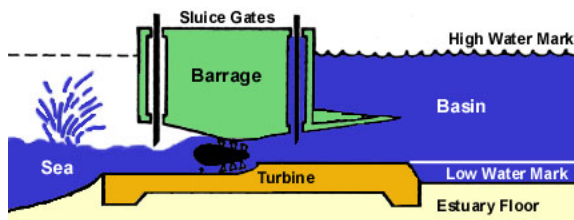
The mechanical forms of ocean energy—the tides, waves, and currents—offer significant potential energy in specific regions around the world. Several nations have tried to harness this energy, but low efficiencies and high cost have limited application in

most cases. In recent years the technology has changed the climate for this type of renewable energy. More and more countries are funding research and development.

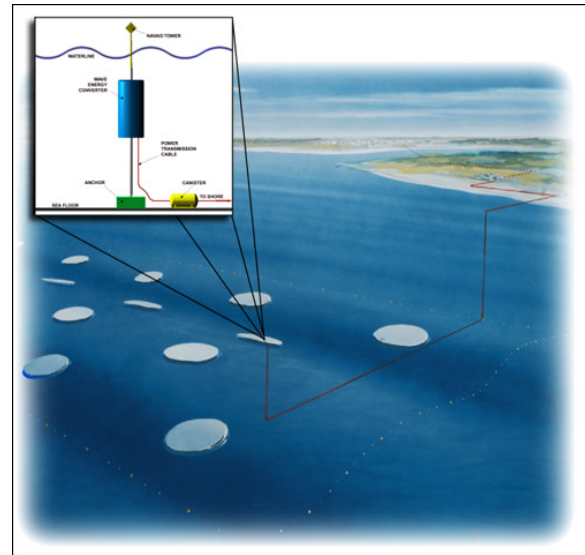
Tidal power stations utilize the twice-daily movements of the tides. Various devices use this motion to turn turbines and produce electrical power.



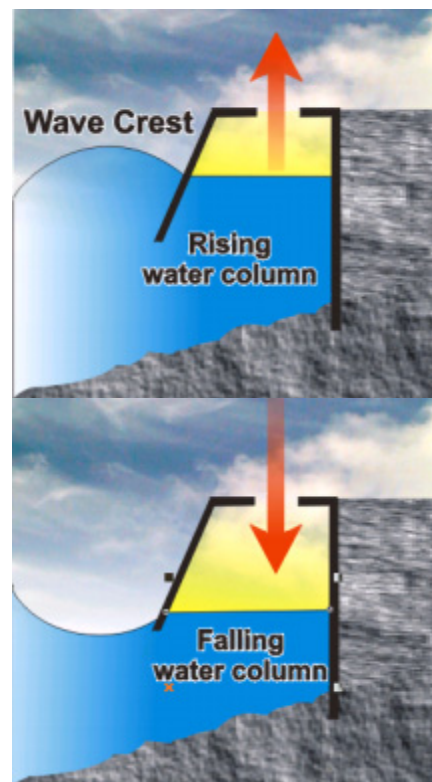
Tidal Energy involves erecting a barrage across a tidal basin. A sluice is used to direct the water into a basin. As the ocean level drops, the water is allowed to flow back into the ocean. Traditional hydroelectric technologies are used with the redirected water to produce electricity.



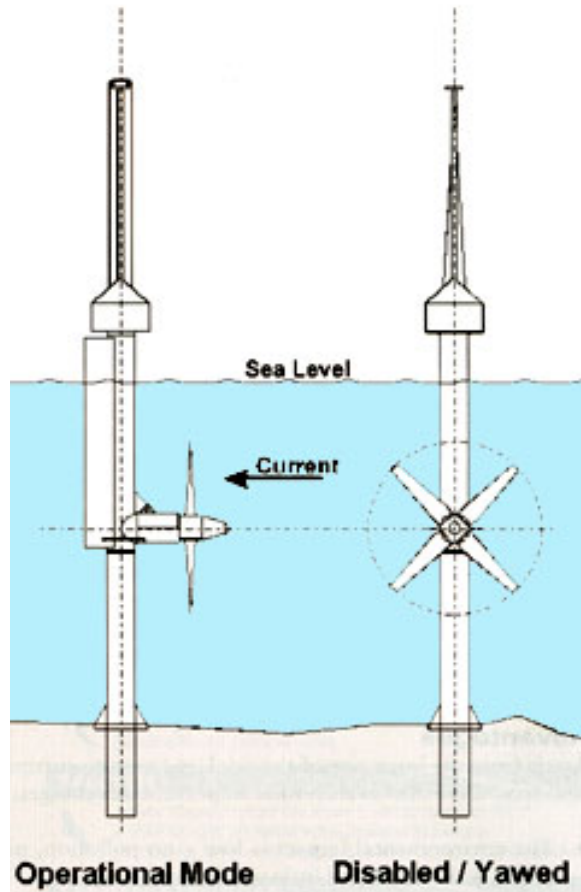
There are various means of capturing this energy. Floats or pitching devices generate electricity from the bobbing or pitching action. These can be used on a floating structure or anchored to the sea floor.



Oscillating Water columns generate electricity by the rise and fall of a vertical shaft. The rising and falling of the column of water drives air into an air turbine. Wave surges or focusing devices allow the sea to be channeled by pushing the trapped air on top of the water. The air is then forced through a turbine.



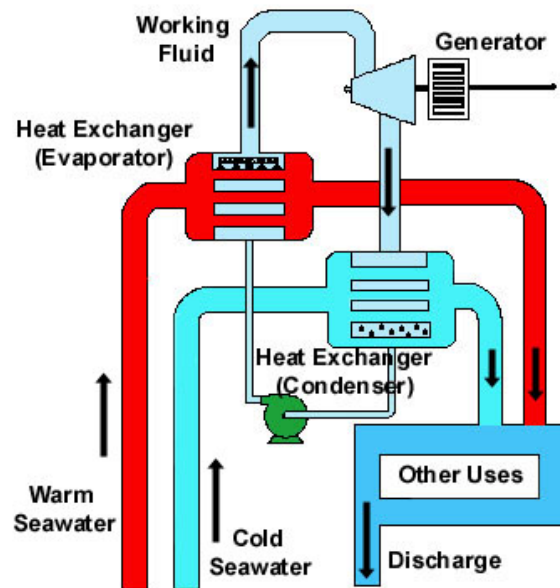
An interesting type of generator uses the idea that all fluids behave the same. Using this idea they have produced an underwater turbine that resembles a wind turbine.



The Ocean Thermal Energy Conversion (OTEC) system relies on the stored thermal energy difference in the oceans. Each day the sun provides the equivalent of 250 billion barrels of in the form of thermal energy to our oceans.

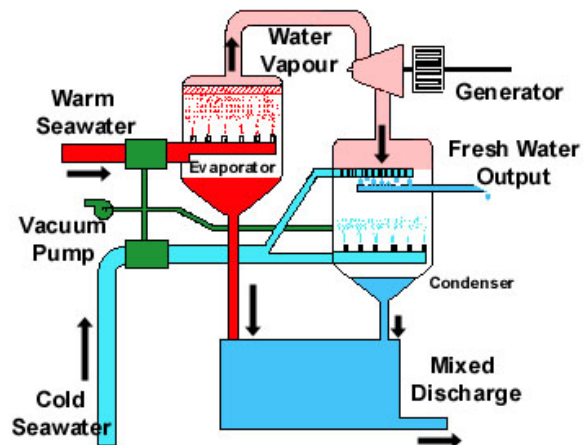
Three types of OTEC systems can be used to generate electricity:

Closed-cycle plants circulate a working fluid in a closed system, heat seawater, flash it to vapor, route the vapor through a turbine, and then condense it with cold seawater.



Closed-cycle plant

Open-cycle plants flash the warm seawater to steam and route the steam to a turbine.



Open-cycle plant

Hybrid plants flash warm seawater to steam and use the steam to vaporize a working fluid in a closed system.

Resources:

U.S. Department of Energy, Energy Efficiency and Renewable Energy
http://www.eere.energy.gov/consumer/renewable_energy/ocean/index.cfm/mytopic=50010

National Renewable Energy Laboratory
<http://www.nrel.gov/>

Ocean power technologies
[Ocean Power Technologies](#)

Resources for Following Projects:

Tubing and stoppers can be found in any scientific supply house.

<http://www.sciencekit.com/>

Project Ideas

1 How can you put the energy of ocean tides to work?

Learning Objective: What affects the way water fills and empties a tidal basin?

Controls and Variables: Volumes of different containers representing different size oceans. Different size containers representing different size basins. Changes in elevation of the ocean and basin, affecting water flow.

Materials and Equipment:

Containers

Plastic milk containers, soda pop containers, water bottles (with bottoms removed).

Stoppers

Rubber stoppers to fit the containers (one hole).

Rubber or plastic tubing

(See resource section.) Thick-walled plastic tubing can replace glass tubing inserted into stoppers.

Safety and Environmental Requirements: *None.*

Suggestions: Vary the height of the ocean bottle to see how fast it will fill the basin bottle. Vary the height of the basin to find out how fast the basin empties into the ocean. How do differences in the sizes of the ocean and the basins affect the flow between them? Use a water wheel to extract the energy from the filled basin. Calculate the efficiency and the energy produced. Vary tubing sizes to observe the effects on the efficiency and energy produced.

2 How does an OTEC (ocean thermal energy plant) work?

Learning Objective: You will be able to investigate the principles behind the OTEC.

Controls and Variables:

Variations in ocean temperature, what temperatures are needed to change liquids to gases and gases to liquids.

Materials and Equipment:***Pulse Glass***

<http://www.sciencekit.com/> (62790-00 \$16.45) How liquids can change to gases at low temperatures.

Safety and Environmental

Requirements: *The pulse glass can be fragile. Care should be used.*

Suggestions: Find the temperature range for the liquid in the pulse glass. Temperatures up to 40 degrees centigrade can be used safely.

3 Can water boil at room temperatures?

Learning Objective: How the boiling points of liquids can be changed.

Controls and Variables: Water temperature, pressure.

Materials and Equipment:***Cincinnati Form Franklin's Flask***

<http://www.sciencekit.com/> 68933-01 \$59.25 A less expensive way of

observing liquids boiling at low temperatures.

Safety and Environmental

Requirements: *As with all experiments that involve heating and pressure, you will need to wear eye protection.*

Suggestions: Try adding table salt to the liquid. Build a model of an open-cycle OTEC plant.

4 Build a wave energy device

Learning Objective: Building different models of wave energy conversion devices.

Controls and Variables: Power generated, wave height, wave period

Materials and Equipment:

If no natural source of waves is available, a wave making machine can be made with a wooden plank that one or two people push back and forth just under the surface of the water.

Safety and Environmental

Requirements: Use caution when working in a surf zone. Do not leave devices in the surf zone unattended or when high surf is expected.

Suggestions: Many different kinds of energy conversion devices have been designed and built. Build your own or design a new device.