

SUGGESTED REFERENCES

- *Southeast National Marine Renewable Energy Center*
<http://snmrec.fau.edu>
- *Aquamarine Power*
www.aquamarinepower.com
- *BioPower Systems*
<http://www.biopowersystems.com/>
- *Hydroelectric Power: How it Works*
<http://ga.water.usgs.gov/edu/hyhowworks.html>
- *Pelamis Wave Power*
www.pelamiswave.com
- *U.S. Department of Energy - Hydropower*
<http://www.energy.gov/energysources/hydropower.htm>
- *Alternative Energy Solutions for the 21st century*
<http://www.altenergy.org/renewables/hydroelectric.html>

NATIONAL SCIENCE EDUCATION STANDARDS

Grades 9 - 12
Science & Technology
Abilities of technological design
Understandings about science & technology

Grades 9 - 12
Science in Personal & Social Perspectives
Science and technology in local national and global challenges

Grades 9 - 12
Physical Science
Motions and forces
Interactions of energy and matter
Conservation of energy and the increase in disorder

Grades 9 - 12
Life Science
Matter, energy, and organization in living systems

*Source: *National Science Education Standards, 1996, National Academy Press*

CREDITS

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VOLUME 41 ISSUE 5

ENERGY - *Understanding Hydroelectric Power*

SYNOPSIS

Water constantly moves through an immense global cycle, evaporating from lakes and oceans all over the world, condensing to form clouds, precipitating as rain and snow, which then flows back to the oceans. Hydroelectric power take advantage of this water cycle to drive machinery or create electricity. Hydroelectric power uses moving water as energy. Because the water cycle is an endless and constantly recharging system, it is an excellent source of renewable energy.

Traditional hydroelectric power takes the energy of moving water to turn hydraulic turbine blades. The blades then turn a generator shaft that produces mechanical energy. The generator converts this energy into electricity. Engineers have developed innovative technologies that take advantage of other sources of energy from water including ocean currents, tides and waves.

CURRICULUM UNITS

- ECOLOGY
- ENGINEERING
- ENVIRONMENTAL SCIENCE
- PHYSICAL SCIENCE
- PHYSICS

RUNNING TIME

15 minutes



BACKGROUND

Hydroelectric power is a clean, non-polluting source of electricity. It is an essential contributor to the power grid in the United States. It has been used all over the world for centuries and is one of the most efficient methods of producing energy.

Turbines are used in dams to convert the kinetic energy from the water moving in rivers and lakes to electricity. Propelled by gravity, the water travels through a penstock, which is a pipe that leads to the turbines. Water strikes the turbine blades, which are connected to a shaft that leads to generator. As the turbine blades turn, a series of magnets inside the generator rotate past copper coils, called the stator, producing alternating current by moving electrons.

The Gulf Stream is a result of the wind patterns acting on most of the North Atlantic Ocean. It is a fast, intense current with peak velocities near 2.5 meters per second. Scientists and engineers at the Southeast National Marine Renewable Energy Center at Florida Atlantic University are studying the potential energy of this fast moving current. They are developing and testing infrastructure and protocols for components and complete generating systems. They are also setting up environmental monitoring systems so that they can better understand the nature of the Gulf Stream before there is a full-scale installation of commercial sized generators.

There are several unique devices that have been developed, some of them using biomimicry, to harness the power of the oceans waves and currents. One promising system is mounted on the seafloor and moves back and forth with wave motion. The device is strategically placed where there are constant wave patterns. It contains a hydraulic system that converts the mechanical energy of the wave motion into fluid pressure, which is used to spin a generator.

CRITICAL THINKING EXERCISES

1. Scientists and engineers have learned to efficiently use moving water to generate power in lakes and rivers using dams. Why are scientists now exploring other moving water options?
2. How will the newly designed ocean turbine systems differ from the technology currently used in dams?
3. Detail the environmentally negative aspects of hydroelectric power generation on the surrounding ecosystems. Do the newly designed ocean systems offer a less invasive option compared to dams?
4. Have students diagram and explain how a turbine generates electricity.

CAREER POSSIBILITIES

- ELECTRICIAN
- ENGINEER
- PHYSICIST
- PLANT TECHNICIAN OR MANAGER

ADVANCED ORGANIZERS

Prior to viewing this program, students should have some understanding of the following Benchmarks for Science Literacy, Oxford University Press which are excerpted and, in some cases, abbreviated below. Refer to the Benchmarks for more information.

Benchmark 3. The Nature of Technology Section A: Technology & Science, Grades 9-12

- Technological problems and advances often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.
- Mathematics, creativity, logic, and originality are all needed to improve technology.
- Technology usually affects society more directly than science does because technology solves practical problems and serves human needs (and also creates new problems and needs).

Benchmark 8. The Designed World Section B: Materials and Manufacturing, Grades 9-12

- Manufacturing processes have been changed by improved tools and techniques based on more thorough scientific understanding, increases in the forces that can be applied and the temperatures that can be reached, and the availability of electronic controls that make operations occur more rapidly and consistently.

Benchmark 8. The Designed World Section C: Energy Sources and Use, Grades 9-12

- The useful energy output of a device—that is, what energy is available for further change—is always less than the energy input, with the difference usually appearing as thermal energy. One goal in the design of such devices is to make them as efficient as possible—that is, to maximize the useful output for a given input.
- During any transformation of energy, there is inevitably some dissipation of energy into the environment. In this practical sense, energy gets "used up," even though it is still around somewhere.
- Sunlight is the ultimate source of most of the energy we use. The energy in fossil fuels such as oil and coal comes from energy that plants captured from the sun long ago.

**Benchmarks can be found at www.project2061.org/tools/bencho/bolintr.htm*

VOCABULARY

- Acoustic Doppler Current Profiler** A sonar that attempts to produce a record of water current velocities for a range of depths. They are made of ceramic materials, and contain transducers, an amplifier, a receiver, a mixer, an oscillator, a clock, a temperature sensor, a compass, a pitch and roll sensor, and computer components to save the information collected.
- Biomimicry** The copying or imitation of a natural phenomenon's or environment's efficiency and survival mechanisms in manufacturing.
- Doppler Shifts** The change in frequency of a wave for an observer moving relative to the source.
- Gulf Stream Current** The Gulf Stream is a strong, fast moving, western boundary warm ocean current originating in the Gulf of Mexico and flowing into the Atlantic Ocean. It makes up a portion of the North Atlantic Subtropical Gyre.
- Hydrofoil** A surface form creating a thrust against water in a direction perpendicular to the plane approximated by the surface.
- Kinetic Energy** The energy possessed by a system or object as a result of its motion. The kinetic energy of objects with mass is dependent upon the velocity and mass of the object, while the energy of waves depends on their velocity, frequency, and amplitude, as well as the density of the medium if there is one.
- Run-of-the-River** Hydropower that involves placing small, mini, or micro hydro turbines into waterways without large dams.
- Stator** A portion of a machine that remains fixed with respect to rotating parts.
- Subtropical Gyre** A large system of ocean currents. The center of a subtropical gyre is a high pressure zone. Circulation around the high pressure is clockwise in the northern hemisphere and counterclockwise in the southern hemisphere, due to the Coriolis effect. The high pressure in the center is due to the westerly winds on the northern side of the gyre and easterly trade winds on the southern side of the gyre. These cause frictional surface currents towards the latitude at the center of the gyre. The build-up of water in the center of the gyre creates equatorward flow in the upper 1,000 to 2,000 m (3,300 to 6,600 ft) of the ocean, through rather complex dynamics. This equatorward flow is returned poleward in an intensified western boundary current.
- Western Boundary Current** Warm, deep, narrow, and fast flowing currents that form on the west side of ocean basins due to western intensification. They carry warm water from the tropics poleward. Examples include the Gulf Stream, the Agulhas Current, and the Kuroshio.