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Renewable Energy World
Teacher's Guide

Introduction
Renewable Energy World is an activity booklet that teaches basic principles about the main renewable energy resources used in the world today, and the advantages and challenges of each of these resources. Topics include forms of energy, renewable and nonrenewable energy sources, electricity generation, electrical circuits, and energy conservation tips for home and school.

This presentation guide provides the objective for each lesson, background and ideas for classroom discussion, and activity answers.

Page 2: The Way We Use Energy Is Changing
Objective: To help students understand why our society is moving toward an increased use of renewable energy resources, as well as the distinction between renewable and nonrenewable energy resources, especially regarding their impact on climate change.

Background/Discussion: Explain to students why understanding the differences between nonrenewable and renewable resources is particularly important now. Utilities have been transitioning toward generating more of their electricity from renewables in an effort to reduce CO_2 emissions. By knowing the advantages and challenges of various renewable energy resources, students will be better equipped to make informed energy decisions when they become voters and consumers. Learning about energy may also inspire career choices in this industry.

Page 3: What Is Energy?
Objective: To familiarize students with the various forms of energy.

Background/Discussion: Explain that energy is the ability to do work. This can also be understood as the ability to change or move matter. Matter is anything that takes up space or has a mass of any kind. Any change or movement of matter requires energy. Without energy there would be no motion, no light, and no heat, and life would not exist. Ask students where they get their energy. *(Food.)* Ask them where the appliances in their homes get energy. *(Sources like electricity or natural gas.)*

This lesson helps support a common physical science content standard: Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. To better understand the concepts on this page, students will benefit from a description of the structure of the atom. (An atom is the smallest unit of matter. Everything in the world is made of different combinations of atoms. Every atom has a nucleus in the center. Tiny particles called electrons travel around the nucleus.)

Word Find Activity: The following energy words and phrases are highlighted in green throughout the booklet:
Page 3 – electrons, atoms, molecules, nucleus, fission, nuclei, fusion
Page 4 – generator, turbine
Page 5 – electrical circuit
Page 6 – uranium
Page 7 – wind power, solar energy, geothermal energy, hydropower, ocean energy
Page 8 – solar cells
Page 14 – biomass, methane gas

Page 4: How Electricity Is Made
Objective: To explain how electricity is generated at a power plant (by the turning of turbines that generate a flow of electricity), and how renewable energy sources turn turbines.

Background/Discussion: The illustration is a simplified diagram of how energy is generated and then transported to buildings. Inside the brown circle is a magnified depiction of the generator, which is housed inside the power plant (the gray building at the top right of the illustration).

Within the generator, energy is transferred from the energy source to the turbine blades. The turbine is attached to an axle and a very large magnet. The spinning of the turbine causes the axle and magnet to spin. As the magnet spins, it creates a flow of electricity in the huge coil of wire surrounding it. The mechanical energy of the spinning coil changes to electrical energy in the wire, which is then hooked up to power lines.

The electricity then travels along power lines supported by tall towers (top center), and then through substations (blue image at top left), where the strength of the electricity is reduced. From there, it travels along distribution lines (supported by power poles) to homes and other buildings. The illustration does not include a depiction of underground power lines, but in some neighborhoods power lines are not on poles but buried under the ground. Ask students if they have seen any electrical equipment in their neighborhood or town. Explain the importance of these in bringing electricity to their homes and school, and ask the class to name all of the things in their classroom that use electricity.

Puzzle Answers:
1. Wind power
2. Hydropower
3. Geothermal
4. Biomass
5. Solar power

Page 5: Which Circuits Will Work?
Objective: To teach the characteristics of an electrical circuit.

Background/Discussion: This lesson supports physical science content standards for electrical circuits. Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. They provide a means of transferring energy when heat, light, sound, and chemical changes are produced.

Before doing the activity, introduce the concept of a circuit. Explain that a circuit is a closed path, or a continuous loop. For electricity to flow, it must travel on a circuit of wires. The electricity in your school or home flows in a circuit. It goes from the power outlet to the appliance along one wire inside the appliance cord, and back from the appliance to the outlet on the other wire inside the cord. Electricity on power lines also flows in a circuit. It flows out from the power plant or substation on one power line and back on another.

Scientific Inquiry: In this activity, energy is delivered from the sun to a solar panel that, if the sun is shining and the wires are hooked up correctly in a closed circuit, will light the bulb.

A. The light bulb will light because the sun is sending energy to the panel, which in turns sends the energy through the closed circuit connected to the bulb.
B. The bulb will not light because the heat of the sun is obscured by a cloud. Thus, although the circuit is closed, there is no energy flowing through it.
C. The bulb will not light because the circuit is open. The red wire is not connected to the bulb, so although the wire is receiving energy from the panel, it will not get to the bulb.
D. The bulb will not light because the circuit is open. The red wire is not connected to the panel. No energy flows into the wire, so it will not light the bulb.

Page 6: Why Do We Need Renewable Energy?

Objective: To explain how energy is produced from fossil fuels and nuclear power, and why these nonrenewable resources cannot be relied on exclusively to provide all our energy in the future.

Background/Discussion: Coal, oil, and natural gas are burned to heat water into steam, which is pressurized and used to turn a turbine. These resources are called fossil fuels because they were formed when plants and tiny sea creatures were buried by sand and rock, then decomposed, and turned into fossil fuels. The processes that created them are no longer occurring, so fossil fuels are nonrenewable. In recent decades humans have been using fossil fuels at an increasingly faster rate, and it is getting harder to locate and bring them up through mines and wells.

Nuclear power is used to create heat that then converts water into steam, which turns a turbine. This process involves a machine called a nuclear reactor, which uses fuel rods containing uranium placed next to each other. The reactor causes the uranium atoms to split and as a result, a tremendous amount of heat is released. Uranium must be mined from the ground and, like fossil fuels, its supplies are finite and nonrenewable. Most nuclear waste is low-level radioactive waste, consisting of ordinary tools, protective clothing, and other items that come in contact with radioactive dust or particles. This waste and the highly radioactive spent fuel rods must be specially stored and disposed of so they do not harm living things or contaminate the environment.

Ask students to brainstorm how life would be different without the traditional energy sources that electrify our buildings and power our transportation. Before having them look at the conservation tips on the back cover, ask if any of them try to save energy at home, and make a list on the board of what practices they engage in. Explain that energy conservation and using renewable energy are the best ways to help reduce our dependence on nonrenewable energy resources.

Page 7: Mix It Up
Objective: To explain that access to renewable energy resources depends on climate and geography, as well as transmission systems.

Background/Discussion: Ask students what they think are the best conditions for each of the renewable energy resources listed in green on this page. *(Wind power – open, windy spaces where many wind turbines can be set up. Solar energy – lots of sunny days. Geothermal energy – places where underground heat and steam naturally flow. Hydropower – rainy climates that keep rivers, streams, and dammed lakes filled. Ocean energy – coastal access.)*

Explain that a significant constraint to developing renewable energy resources is the availability of a delivery system. Although there is great potential for generating electricity from the various renewable resources available in this country, doing so on a large scale will require improving the power line network to transport the electricity from generation sites to where it is needed.

What's Your Energy Mix? There may be some surprises regarding the types of energy resources used to generate the electricity supplied to your area. For instance, some hot, sunny locations are not ideal for solar power if there is high humidity there, because the moisture in the air condenses on the solar panels and slows the energy transfer. On the other hand, some rainy locations still have enough sun at times to make solar power viable.

Page 8: Solar Power
Objective: To explain how the sun's light energy can be converted into electricity.

Background/Discussion: Solar cells absorb sunlight and convert it directly to electricity. Solar cells are 1/100th of an inch thick. Most are rectangular or circular wafers made of silicon, but some consist of a thin film that is mounted on glass or thin metal.

When sunlight hits a solar cell, electrons are released. The electrons then flow onto wires, forming direct current (DC), which is the same kind of current that flows from a regular battery. At present, most solar cells turn between 12% and 20% of the sunlight that hits them into electricity. New cells have been tested at higher efficiencies, and scientists are developing cells that can reach 40% efficiency.

Solar Touchdown Answers: 6400 ÷ 20 = 320. So 320 modest-size houses could be powered by one football field full of solar panels. Bonus: 320,000 ÷ 320 = 100. It would take 100 football fields full of solar panels to supply the electricity needs for 320,000 houses. 3,200,000 ÷ 320 = 1,000. It would take 1,000 football fields full of solar panels to supply the electricity needs for 3,200,000 houses.

Page 9: Shine On
Objective: To explain how the sun's heat can be used to generate electricity and how this heat can be used more directly, and to explore the advantages and challenges of solar power.

Background/Discussion: Thermal solar refers to harnessing the sun's light to produce heat. Heat results when photons, or particles of light energy, strike the atoms composing a substance (such as mirrors) and excite or energize them. Concentrated thermal solar power is used at solar electric power plants, where lots of mirrors focus the sun's rays onto one central area. The heat generated is used to boil water, and then the steam produced from the boiling water is used to make electricity – just like in a coal- or natural gas-fired power plant. Thermal solar power plants produce electricity more cheaply than photovoltaic plants, at least in regions where there is little to no cloud cover. But thermal solar systems need direct sunlight, while photovoltaic systems will still work in cloudy conditions (although with reduced output).

Did You Know? The photovoltaic cell was discovered in 1954 by Bell Telephone researchers examining the sensitivity of a silicon wafer to sunlight. Beginning in the late 1950s, photovoltaic cells were used to power U.S. space satellites. Some advantages of photovoltaic systems are that they convert sunlight to electricity directly, so that no generator systems are needed; and they can be installed quickly and scaled to any size required.

Page 10: Let It Flow – Hydropower
Objective: To explain how traditional and new hydropower systems work, and to explore the advantages and challenges of this energy resource.

Background/Discussion: The movement of water from lakes and oceans to clouds, to precipitation, and back to the lakes and oceans is called the hydrologic cycle. When flowing water is captured along this cycle and turned into electricity, it is called hydroelectric power or hydropower. There are several types of hydroelectric facilities, all powered by the kinetic energy of flowing water as it moves downstream. Turbines and generators convert this into electricity, which is then fed into the electrical grid to be used in homes and businesses, and by industry.

Page 11: Ocean Energy – Surf's Up!
Objective: To explain how we can generate energy through the movement of ocean waves and tides, and to explore the advantages and challenges of this energy resource.

Background/Discussion: There is tremendous energy in ocean waves. The total power of waves breaking around the world's coastlines is estimated at 2-3 million megawatts. The west coasts of the United States and Europe and the coasts of Japan and New Zealand are good sites for harnessing wave energy. Modern advances in turbine technology may eventually see large amounts of power generated from the ocean, especially from tidal currents but also from the major thermal current systems such as the Gulf Stream.

Megawatt Math Answers:
- 240 megawatts = 240,000,000 watts (240 × 1,000,000)
- 2,080 megawatts = 2,080,000,000 watts (2,080 × 1,000,000)
- 2,080 – 240 = 1840 megawatts

Page 12: Wind Power – Let It Blow
Objective: To explain how electricity can be generated from the wind, and to explore the advantages and challenges of this energy resource.

Background/Discussion: The earliest known use of wind power is the sailboat, and this technology had an important impact on the later development of sail-type windmills. The first windmills were developed to automate the tasks of grinding grain and pumping water. People often use the terms windmill and wind turbine interchangeably. However, windmills harness the wind for mechanical power to grind wheat or pump water, while wind turbines use the wind to generate electricity. Today's wind turbines efficiently convert the force of moving air into electricity using modern design principles and high-tech materials.

Build a Pinwheel Activity: Encourage students to follow the instructions to build at least two pinwheels of different sizes. The pinwheel with the shorter blades should spin faster if blown with the same force. This is because the shorter blades have less weight and surface area for the force to set in motion. (Technically, it is the ratio of weight to surface area that makes it go faster.)

Page 13: Under Pressure – Geothermal
Objective: To explain how geothermal energy can be used to generate electricity, and to explore the advantages and challenges of this energy resource.

Background/Discussion: In geothermal power plants steam, heat, or hot water from geothermal reservoirs provides the force that spins the turbine generators and produces electricity. The used geothermal water is then returned down an injection well into the reservoir to be reheated, to maintain pressure, and to sustain the reservoir. Although it is renewable, geothermal energy has some limitations: people must be careful not to draw steam or hot water out of the earth faster than it can be replenished.

Layer It On Activity: Students should draw the core in the center of the illustration, then the mantle, the magma, and finally the crust as the outermost layer. Bonus: Geothermal activity is found in many parts of the world and is used to generate electricity in the western United States, Russia, China, France, Sweden, Hungary, Romania, and Japan.

Page 14: Growing Energy – Biomass
Objective: To explain the various types of biomass energy that can be used for electricity generation and transportation, and to explore the advantages and challenges of this energy resource.

Background/Discussion: While wood is the largest biomass resource, biomass also comes from agricultural crop waste, municipal and industrial waste, and energy farms where crops are grown specifically for energy production. Like fossil fuels and nuclear energy, biomass can be burned to heat water into steam, which is pressurized and used to turn a turbine. Biomass can also be converted to methane gas and used for fuel. Methane is created when organic waste decomposes in landfills (through the process of anaerobic bacterial digestion) and can then be siphoned off and used to power turbines that generate electricity. Biomass resources can also be used to produce liquid transportation fuels, such as ethanol and biodiesel.

Landfill in a Bag Activity: The process taking place inside the sealed bag is anaerobic digestion, which has methane gas as one of its by-products. This is one form of creating energy from leftover waste. If this bag were at a biomass power plant, the odorous gas inside the bag would be used to heat water into steam to turn a turbine!

Page 15: Inventing Our Energy Future
Objective: To motivate students to think creatively about what our energy supplies will be in the future.

Inventor's Challenge Activity: Encourage students to share their energy ideas with a partner or with the whole class.

Bonus: As a synthesizing activity to cover all the forms of renewables resources that have been discussed in the book, ask students to create a large chart describing all the pros and cons for each of the energy sources listed in the booklet. This could be done in groups or together as a class on the board.

Back Cover: Energy Saver Quiz

Objective: To teach students 10 easy ways to save energy at home, and to encourage students and their families to practice these energy-saving habits together.

Background/Discussion: Discuss with students how saving energy helps the environment and can also help families save money. Assign students the quiz for homework and ask them to do it together with a parent or other adult. Ask students to bring the completed quizzes and signed pledges back to class.

As a group, predict which energy-saving habits are most common among your class. Then review the results of the quiz. For each habit, tally the A's, S's, and N's and post them on the board in a list or chart. Which habits are most common? Which are least common? Explore with students why some energy-saving behaviors may be easier for their families to adopt than others.