Energy Sources and the Environment
Renewable and Nonrenewable Energy Sources

An Energenius® Educational Program
from Pacific Gas and Electric Company

PG&E®
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“Imagination is everything. It is the preview of life’s coming attractions.”

Albert Einstein
German-born American physicist (1879–1955)
Why Study about Energy Sources and the Environment?

We all use a great deal of energy each day to “power” our appliances, electronics, and those smart cell phones. The sources for this energy are classified as either renewable or nonrenewable. The wind, the sun, and hydroelectric power are examples of renewable energy sources. Once used, these sources can be replenished or made again by nature. However, at the present time in the U.S. and around the world, most energy comes from three nonrenewable energy sources—coal, oil, and natural gas. These three energy sources are known as fossil fuels because they come from the fossilized remains of ancient plants and animals. Oil, coal, and natural gas have taken millions and millions of years to form and cannot be easily replenished. Once they are depleted, these fossil fuels will be gone forever.

Around the world there is a growing demand for energy and a variety of energy sources will be needed to meet this demand. Renewable sources are supplying more and more of the energy that is required in the U.S. and other countries.

Making Choices for the Environment

In your study of renewable and nonrenewable energy sources you will learn that there are advantages and disadvantages to all energy sources. Some energy sources are costly and others not so expensive, and some are not always available when needed. Energy sources can have different impacts on the environment. These impacts can include pollution, greenhouse gas emissions, resource depletion, and effects on water, land, and animals.

The activities in this unit are only an introduction to topics you will study more in the future. As an adult, you will also be making “energy decisions” as a consumer and citizen that will impact the quality of the environment in which you live. Right now, there are actions you can take to use less energy, conserve natural resources, and protect the environment. Turning off lights, televisions, and computers when not in use and always reusing and recycling are some simple actions to take for the environment.
Everything We Do Takes Energy

In our life in the 21st century, we use lots of appliances, equipment, electronics, and machines to do our work. A great amount of energy is used each day to “power” all these “machines” and the way we live. Without sources of energy to produce electricity, our homes and schools would grow very quiet and dark. Without electricity, we could lose the heat to warm our homes, to heat water for our showers, and to cook our food. Without electricity to charge our cell phones, we could not call or text our friends.

Our electronics, home appliances, computers, and even battery chargers would all be useless without electricity. School buildings would lack light, computer access, and even the passing bells and intercom would not function. Street lights and traffic signals would stop working. Cash registers at the local grocery store would remain shut and silent. Getting cash at an ATM would not be possible. Our world as we know it would just stop!

Imagine a Day without Power!

Try to imagine waking up one morning to find out that during the night there had been a major power outage in your neighborhood and the city in which you live. You learn that the power outage should not last more than 24 hours. As this reality sets in, you wonder just how much battery power your cell phone or computer still has.

This disruption to the supply of electricity would certainly impact your day and that of everyone in your family and community. You or some classmates might have had personal experiences with power outages that can be discussed after completing the A Day Without Power chart.

Directions:
1. Think about a 24 hour power outage and the things that might change in your own life.
2. Use A Day Without Power chart to record ways the outage would impact you.
3. Be prepared to discuss ways you would adapt because there was no electricity.

Power Point!

Power Outages

Many power outages in the U.S. are related to the weather. Heavy rains, flooding, ice, high winds, lightning, and trees falling on powerlines can all cause outages. Power outages can also occur when there is high demand, equipment failure, or when vehicles hit utility poles.
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The electricity you use today to power a hair dryer, a computer, or to charge a cell phone has traveled a long distance. Almost all of the electricity that is used comes from power plants. In these power plants utility companies produce electricity using different energy sources. Most of the electricity generated in the United States at the present time comes from oil, coal, and natural gas. These energy sources are fossil fuels. Fossil fuels are classified as nonrenewable because they have taken many millions of years to form and cannot be easily replaced.

The Long Journey
The photos on page 5 illustrate how electricity is generated from oil. Oil, like the other fossil fuels, is found in underground reservoirs. There is a long journey from the oil in these underground reservoirs to producing electricity. First, crude oil is removed from the ground by drilling deep wells and pumping it up to the surface. Next, this crude oil goes to a refinery, where impurities are removed. From the refinery, the oil is transported by pipelines, trucks, trains, or ships to power plants. At these power plants the oil is used to generate electricity.

Follow the path on page 5 to discover more about how electricity is generated. The example is oil, but the process of generating electricity is similar no matter the energy source used.

Directions:
Your teacher will organize the class into small groups to complete one or more of the following assignments.

1. Create a diagram that illustrates in detail how a turbine-generator works. Be prepared to explain how the electromagnetic shaft operates to generate electricity.
2. Research how much of the energy supply in the U.S. comes from fossil fuels. Include in your research information related to the world energy supply.
3. Develop a Follow the Path media presentation on how electricity is generated or how electricity gets to homes.

Edison and the Pearl Street Station
Thomas Edison in 1882 helped develop the first U.S. power plant in New York City. This plant brought electric light only to small parts of the city. Fifty years later most homes in the U.S. were still lit with gaslights and candles.
Crude oil is extracted from underground and sent to a refinery for purification. From the refinery, the oil is transported by ship, train, truck, or pipeline to a power plant. Inside the power plant, the oil is burned in large boilers to create steam.

The steam inside a generator makes a large turbine spin. The spinning turbine drives an electromagnetic shaft and generates electricity. The voltage of the electric current (electricity) is increased in transformers.
From a power plant, electricity travels in a circuit. The journey starts on high-voltage transmission lines on tall towers.

The next stop is at a substation, where the voltage is lowered and sent over smaller power lines. These power lines can be overhead or buried underground.

The electricity connects to homes and other buildings through service wires. The electricity passes through a meter that measures how much electricity is used.

The electric current travels to areas like your own neighborhood, where smaller transformers again reduce the voltage.

The electricity goes into a service panel, where fuses protect the wires inside a home from being overloaded.

The electricity needed to power lights, electronic equipment, and the rest of a home or building travels through wires inside the walls. At the flip of a switch, the electricity is at work.
Follow the Path: From Power Plant to Your Home

When you plug a computer cord or cell phone charger into an outlet, it might seem like electricity is coming right from the walls. However, if you follow the journey of electricity, you discover that it has traveled in a circular path (circuit) that began at a power plant.

Over the Miles
From a power plant, the path of electricity begins on high-voltage transmission lines on very tall towers. These transmission lines can carry high-voltage electricity over many, many miles. Along the journey the pressure under which the electricity flows must be reduced to a lower voltage. A first stop is at a large substation. These are located in various neighborhoods. From these substations, the electricity travels at a reduced voltage over smaller power lines. In some areas these power lines are not seen overhead because they are buried underground.

In the Neighborhood
Transformers reduce the voltage again as electricity reaches the homes, schools, and other buildings where it will be used. The electricity goes through wires called service lines (or drops) into our homes and other buildings. At our homes, for example, electricity flows through wires inside walls to all the switches and outlets. If a toaster is plugged in and ready to use, we might imagine how we get our toast. Electricity flows from the wires in the wall to the metal prongs of the toaster plug and through the cord to heat this appliance to make toast. The electricity then flows back through the toaster cord to the outlet, through the inside wires, and back to the power grid. Although it might seem like electricity is just waiting at the outlet or switch for our use, it has traveled a very long journey to be there when we need this power.

Directions:
Work in small groups and select one of these projects.
1. Research more about the life of Alessandro Volta.
   Describe his many contributions to science.
2. Create a bulletin board that illustrates the path that electricity takes from source to generation to the place where it is used.
3. Create a Word Wall with ten or more words related to the path of electricity.

Bonus: Research the smart grid. What makes this grid different from the existing power grid?

Volt, Voltage, and Volta
A volt is a unit of measurement of an electric current. Voltage is the amount of power there is in an electric current. Alessandro Volta (1745–1827) was an Italian physicist who studied about electricity. The electric unit, volt, was named in his honor.
Natural Gas: Follow the Path

The natural gas your home or school might use to cook or heat a room has traveled a long distance. After natural gas deposits are discovered, they are captured via a well. (See Diagram 1—Natural Gas Wells.)

From the natural gas well, the gas goes through a number of steps before it is ready to use in a home, school, or business.

Follow the diagram to learn about these steps and the travels of natural gas after it leaves the well.

Power Point!

Natural Gas – Two Paths to Our Homes
Natural gas, a nonrenewable energy source, is used in power plants to produce electricity to power our lives. In a more direct way, natural gas is piped right into homes and used primarily for space heating. Natural gas is also used in homes to power clothes dryers, water heaters, stoves, and other appliances.

Directions: Review the diagram on page 8 and answer the following questions.

1. What happens to natural gas at the processing plant?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What does it mean to “odorize” natural gas?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. How would you explain what happens to natural gas at compressor stations?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. How does the natural gas get to the centers where it is distributed?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. What are reasons that demand for natural gas and electricity is higher at certain times?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Is It Powered by Electricity or Natural Gas?

Walk through your home or school and determine what powers all the appliances and electronic equipment. Be prepared to discuss your findings in class. Ask an adult family member to help you do the search in your home. Write down the name of an appliance and check the box for the type of power it uses.

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<th>Appliance or Equipment</th>
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Petroleum [oil], natural gas, and coal are found in deposits deep under the Earth. The main deposits of these fossil fuels were formed from prehistoric plants and animals during what scientists call the Carboniferous Period. This was hundreds of millions of years before the time of the dinosaurs. However, some thin deposits of coal are from the late Cretaceous Period. This was about 65 million years ago, when many dinosaurs and some early mammals were alive. During the Carboniferous Period, the Earth was covered with swamps, huge trees, and leafy plants. After the trees and plants died, they became buried under layers of mud, rock, and sand. Over time, hundreds and even thousands of feet of earth covered them.

Time, Temperature, and Pressure
At the same time, the ancient seas and oceans were filled with millions of very tiny plants called algae. As the years passed, the dead material slowly decomposed into organic materials and formed fossil fuels. Different types of fuels were formed depending on the type of debris present, how long it was buried, and the conditions of temperature and pressure that existed while they decomposed. Petroleum and natural gas are formed from the organic remains of marine organisms buried on the ocean floor for millions of year. It is believed that the heat and pressure of the Earth changed what was organic (living material) into petroleum and natural gas.

Coal
There was a time some 300 million years ago when swampy forests partly covered the Earth. Over millions of years these dead plants in these vast primeval forests were covered by layers and layers of dirt and water. The pressure and heat from the top layers turned the dead plants from those swampy forests into coal.

The Fossil Fuels
Petroleum, natural gas, and coal have taken millions and millions of years to form. Fossil fuels cannot be replenished in a short period of time. Fossil fuels are nonrenewable energy sources.

Directions:
1. Read the text and analyze the diagrams on these pages.
2. Be prepared to give reasons why fossil fuels are classified as a nonrenewable energy source.

Bonus: Create a classroom mural showing how petroleum, natural gas, and coal were formed.

Power Point!
Nonrenewable Sources
Oil, coal, natural gas, and propane are all fossil fuels and nonrenewable energy sources. But not all nonrenewable sources are fossil fuels. Uranium ore used as a fuel in nuclear power plants is nonrenewable but is not a fossil fuel. To learn more about energy sources, visit www.eia.gov/kids/.
Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand.

Over millions of years, the remains were buried deeper. The enormous heat and pressure turned them into oil and natural gas.

Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and natural gas deposits.

Before the dinosaurs, many giant plants died in swamps.

Over millions of years, the plants were buried under water and dirt.

Heat and pressure turned the dead plants into coal.
Greenhouse Gas Emissions: Environmental Impacts

There are impacts on the environment when fossil fuels are extracted from the ground, processed, stored, delivered, and burned in power plants to generate electricity. Air pollution and greenhouse gas emissions that contribute to global climate change are some of the environmental impacts.

What Are Greenhouse Gases?
Gases that trap heat in the atmosphere are called greenhouse gases (GHGs). They include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). These gases trap heat, like a greenhouse or a parked car with its windows all closed on a sunny day. These heat-trapping gases are increasing in the atmosphere and are warming the planet. This heating of the Earth is contributing to global climate change.

Climate changes include such things as droughts, the warming of the oceans, the melting of glaciers, and the rising of sea levels.

Where Do They Come From?
Power plants burning fossil fuels, airplanes, and factories all release greenhouse gases (GHGs) into the atmosphere. Almost all vehicles that transport people and products also create and emit these gases into the atmosphere.

Greenhouse gas emissions also come from many of our everyday activities. When we watch TV, play a video game, charge a cell phone, light a room, take a shower, or cook a meal, we are sending GHGs into the atmosphere.

Energy-Saving Actions
Reducing our own use and waste of electricity can help reduce the environmental impacts on our planet. Simple energy-saving habits can reduce the emissions that are contributing to global climate change.

To learn more about greenhouse gases and global climate change, visit www.epa.gov/climatechange/kids/index.html.

Power Point!
Whenever we use energy generated from fossil fuels, greenhouse gases are generated. Powering a computer, lighting or heating a classroom, or fueling a school bus all generate greenhouse gases that contribute to global climate change.
Interpreting a Pie Chart

Directions:
Review this pie chart that provides data on the percentage of greenhouse gas (GHG) emissions from various sources. Use this data to complete the sentences.

1. The chart is organized by ___________________ sectors.

2. The second-largest contributor to greenhouse gas emissions is ________________. This sector contributes _______________ % of all GHG emissions.

3. The production of electricity accounts for _________% of all the greenhouse gas emissions in the United States.

4. Explain why electricity production creates this amount of greenhouse gas emissions.

Bonuses: Prepare a report and illustration on the greenhouse effect. Be prepared to explain to the class why current life on Earth would not be possible without the greenhouse effect.
A Renewable Source
If you were ever warmed by wood burning in a fireplace or from a camp stove, you felt the heat of a biomass resource. The use of wood for heating is probably the most familiar and oldest use of biomass. Although wood is our largest biomass energy resource, it is just one form of a biomass material. Yard clippings, corn, soybeans, sawdust, manure (animal waste), forest residues, almond shells, industrial waste, switch grass, and household garbage are all biomass.

For Heat and Electricity
Biomass energy is any organic material that can be used as a source of fuel. The Earth’s biomass is a huge source of energy which is always being renewed by the sun through a process called photosynthesis. When wood or similar biomass material is burned, the stored chemical energy is released as heat. This heat can be used at power plants to produce steam that turns the generators for making electricity.

Biomass fuels provide an estimated 4 percent of the energy used in the United States. Burning biomass uses waste materials, but also creates carbon dioxide (CO₂) a greenhouse gas that contributes to global climate change.

Look to the Landfills
Imagine all that waste coming from homes, businesses, and factories. All this waste can be an important source of bioenergy. A gas containing methane is given off as materials rot and decompose in landfill sites. At the landfills, this gas, called biogas, can be collected by gas wells. This gas, like natural gas, can be burned in power plants to create the steam to turn the turbines that rotate the generators to make electricity. One advantage of turning landfill waste into electricity is that the amount of waste buried at these sites is reduced.

Cow Power
The manure (waste) produced by cows and other farm animals can also be captured to produce electricity. Biogas, also called methane gas, is produced in large tanks where the animal manure is collected. These tanks are called anaerobic digesters or just digesters. The bacteria in these digesters decompose the manure and methane is released and captured. This methane is used to produce electricity.
Biomass Energy

Talking Garbage
Municipal solid waste (MSW) is commonly called garbage or trash. MSW consists of everyday things we use and then throw away. This garbage can be used as a source of energy to generate electricity.

To learn more, search biomass basics at: www.eia.gov/KIDS/index.cfm.

More Than Garbage

Directions: Review what you have learned in class and have read about biomass energy. Match the sentences or phrases below with the correct word or words. Write the correct letter on the lines to make a match.

a  Any organic material that can be used as a source of fuel
b  The largest biomass energy resource
c  A word describing animal waste
d  A large tank where biogas is captured
e  A root word meaning life
f  Another word for municipal solid waste
g  A place where household and other garbage is taken
h  Something that is easily replaced or made again by nature after it is used

_____ bio  _____ manure  _____ garbage
_____ renewable  _____ wood  _____ digester
_____ landfill  _____ biomass

Bonus: Work with a partner and select one of the following activities to complete.
1. Prepare a diagram to show how methane (biogas) is extracted from landfills.
2. List in chart form the advantages and disadvantages of biomass energy.
3. Think globally and research the use of biomass energy in three different countries.

Power Point!
Coal, Oil, and Natural Gas
Coal, oil (petroleum), and natural gas are at the present time the primary energy sources used in the United States and around the world. These three energy sources are finite resources that cannot be easily regenerated. Oil, coal, and natural gas are known as fossil fuels. They were formed from plants and animals that lived many millions of years ago. (See page 11 for diagrams on the formation of these sources.)

The Burning of Fossil Fuels
Coal is the fossil fuel that is used to generate about 37 percent of the electricity used in the U.S. Only about 1 percent of our electricity comes from petroleum (oil). Most of the oil used in our country is for transportation purposes and not as fuel for power plants.

Natural Gas
Natural gas is used to generate electricity in power plants. About 30 percent of our electricity uses natural gas as an energy source. This energy source is also used directly in homes and other buildings for heating and cooking. This gas is pumped through underground pipes directly to where it is being used. (See Natural Gas: Follow the Path diagram on page 8.)

Environmental Impacts
There are impacts on the environment when fossil fuels are extracted, processed, stored, delivered, and burned in power plants or in the engines of vehicles. Air pollution and greenhouse gas (GHG) emissions that contribute to global climate change are some of the impacts.

Power Point!
When fossil fuels are burned to produce electricity, greenhouse gas (GHG) emissions are released into the atmosphere. In the U.S. about 33 percent of GHG emissions come from the production of electricity. These GHG emissions contribute to global climate change. Visit: www.epa.gov/climatechange/kids/
1. What are the five states in the U.S. that use the largest amount of coal to fuel their power plants?

2. In California, how much of the energy supply is from each of the three fossil fuels?

3. What are projections about the time when the supply of fossil fuels will be exhausted?

4. A Global View: What are some reasons there is a continually increasing demand for energy around the world? (Note: At present time, it is the fossil fuels that supply most of the world’s energy needs.)
For thousands of years, humans have enjoyed the many benefits of hot springs—hot water which “springs” from the ground. In history we learn that ancient Romans bathed in water from hot springs and many people still do today. Springs are places where hot water comes to the surface from a source inside the Earth. Hot water coming out of springs has been warmed by the natural heat of molten rocks deep under the surface of the Earth. Very, very deep in the ground, when water and these molten rocks touch, the water becomes hot and gushes to the surface along with hot steam. Old Faithful, shown in the photo, is a geyser in Yellowstone Park, Wyoming, where hot steam gushes out every 60 to 110 minutes. Geyser is a word that comes from Iceland, where the word geyser means gush.

**Energy from beneath the Earth**

Miners digging for coal know that the deeper you dig down into the Earth, the hotter it gets. It is hotter because of the heat that radiates from the Earth’s molten core. This is the heat used by geothermal energy plants to generate electricity. It is the energy in hot steam that is used to turn turbines and generators to make electricity. This renewable energy source from the Earth is called geothermal. The word geothermal comes from two Greek words, geo for Earth and therme for heat.

**How Do These Plants Work?**

In some areas, the heated underground water rises naturally to the surface. Where this does not occur naturally, bore holes are drilled and cold water is pumped underground and heated by the hot rocks. The hot water is returned to the surface to turn the turbines and generators to generate electricity. The earliest type of geothermal plant, called the dry steam power plant, takes steam directly from the Earth and sends it up to large turbines and generators to produce electricity.

The most common type of plant in use today, the flash steam plant, pumps hot water under high pressure to power generation equipment at the surface, where it becomes steam. The steam [vapor] drives a turbine which, in turn, drives a generator to produce electricity.

**Power for California and the West**

Most geothermal resources and power plants in the U.S. are located in the Western states. California is the largest generator of electricity from geothermal energy in the U.S. In 2012 California received nearly 4.5 percent of its electrical energy from geothermal resources.

The Geysers comprise 45 square miles between the borders of Lake and Sonoma counties. They are the largest complex of geothermal plants in the world.
The first U.S. geothermal plant was built in 1960 at The Geysers in Northern California. Geothermal energy is most often found in areas of existing or historic volcanic activity. Almost all of the geysers in the world are found in only three countries. They are Iceland, New Zealand, and the United States.

**Make a Match**

**Directions:** Review what you have read about geothermal energy. Match the phrases or sentences below with the correct word or words. Write the correct letter on the lines to make a match.

a. Geothermal energy is most often found in places where this existed in the past or is present
b. Largest complex of geothermal power plants in the world
c. Energy from heat generated deep inside the Earth
d. A geyser in Wyoming
e. An early type of geothermal plant
f. A Greek word meaning Earth
g. Something that can be replaced or made again by nature after it is used
h. A unit of electrical measurement
i. The word geyser comes from this Icelandic word
j. One of three countries where the most geysers are found
k. Magma, which can be found under the Earth’s surface

_____ renewable  _____ New Zealand  _____ molten rock
_____ geo  _____ gush  _____ volcanic activity
_____ geothermal  _____ The Geysers  _____ megawatt
_____ dry steam  _____ Old Faithful
Hydropower Energy

Hydropower is electricity that is generated by the flow of water. We can witness the incredible power of moving water by watching a river rushing by after heavy rains. Waterfalls cascading down cliffs can also illustrate the tremendous power of water. This power of water has been used for many hundreds of years to do things like grind wheat into flour and even to cut wood. However, it was not until about 1880 in the U.S. that the power of water was used to generate electricity.

How Does Hydropower Work?
It is the kinetic energy of this moving water that is used to generate electricity. The process usually begins with dams that capture and store river water in large reservoirs. These hydroelectric dams trap the flowing water and then release it again under great pressure. This pressure of the water flow turns a turbine (a large revolving wheel) that then turns a generator. The generator is a machine that contains coils of wire and powerful magnets. When the wire coils are spinning quickly inside the magnets, electricity is produced.

In order for the electricity to be generated, the water has to move with enough speed and volume to turn the generator. The difference in height between the upstream and downstream water levels and the strength of the water flow will both affect the amount of electricity that is generated.

A Renewable Resource
Hydropower, or hydroelectricity, is a renewable energy source because water is a natural resource that is replenishable. Hydropower produces more electricity in the U.S. than any of the other renewable energy sources.

Power Point!
Power from Water: A Global View
Hydropower provides about 20 percent of the world’s electricity supply. Around the world, over 90 percent of all the electricity generated from renewable energy sources comes from hydropower.
Water Works Research
Your teacher will organize the class into small learning groups to research the following five hydropower topics.

Directions:
1. Develop a plan for how your group will work together to research one of the hydropower topics.
2. Identify websites and print resources your group will use for your research.
3. Prepare an interesting and visual way to present your research to the entire class.

Hydropower in California
Our state has about 400 hydroelectric power plants.
What can your group tell the class about the hydropower plants in California? Your group should report on the locations of the largest of these power plants.

The Pros and Cons of Hydroelectricity
There are advantages and disadvantages to any energy source. What can your group identify as the pros and cons of hydropower? Be ready to explain these pros and cons to the class.

Hoover Dam – The Largest Hydro Plant in the U.S.
Hoover Dam is a National Historic Landmark and each year over a million people visit this dam.
What can your group tell the class about Hoover Dam to entice them to learn more about this “Landmark”?

The Hydroelectric Dam – Let’s Diagram It!
Reading text on how a hydroelectric dam works is one way to learn about hydropower.
Your group should provide diagrams, models, or displays to help the class visualize how moving water can generate electricity.

Pumped Storage Plants
There are hydroelectric plants that produce electricity from water in a unique and different way than most hydro plants.
Your group should research the benefits of these pumped storage plants. Be able to explain how these plants operate between an upper and a lower reservoir.
Explain how these pumped storage plants help meet times of peak demand for electricity.
A Nonrenewable Source
Nuclear energy is a form of stored energy that comes from the tiny protons and neutrons in the nucleus of an atom. Stored energy is energy that is latent and not active until certain conditions exist. At nuclear power plants, this stored energy becomes active and released through the splitting of uranium atoms. Nuclear energy creates heat through the splitting of atoms.

Heat into Electricity
To review from an earlier activity on page 5, power plants produce electricity by first converting water into steam using heat. In power plants using fossil fuels, it is oil, natural gas, or coal that is burned to heat the water to make steam. This steam turns turbines to spin the shafts of the generators that convert energy into electricity. Unlike a power plant using oil, for example, at a nuclear power plant the heat to make the steam is created when uranium atoms split apart. Uranium is the “fuel” that generates the heat in a process called fission.

Diablo Canyon
The first commercial nuclear power plant in the U.S. began producing electricity in 1957 in Shippingport, Pennsylvania. At present, nuclear power provides about 19 percent of all the electricity used in our country today. Only coal, natural gas, and petroleum (oil) produce a greater amount of electric power used in our homes, schools, and businesses. California has one operating nuclear power plant, Diablo Canyon, which is located near San Luis Obispo. At Diablo Canyon, pressurized water reactors are the type of reactors used to produce its nuclear energy.
Nuclear Research

Work in small groups to complete one or more of these projects and report to the whole class.

Directions:
1. Use this diagram or create your own to explain the various sections of a nuclear power plant.
2. Research how much electricity in California comes from nuclear energy. How does this compare with the whole of the U.S.? What countries in Europe and in Asia use the most nuclear energy?
3. Research and be able to explain why nuclear energy is considered a nonrenewable energy source.
4. Research how radioactive waste from nuclear plants is stored. Include issues related to long-term storage of radioactive waste.

Bonus: Identify and preview videos and websites that can help explain nuclear energy to students of your age.

Diagram:
- a – cool water source
- b – cooling tower with basin
- c – condenser
- d – steam generator
- e – reactor vessel with control rods
- f – turbine
- g – generator
- h – transformer
- i – power lines
The oceans can produce mechanical energy from the waves and tides and thermal energy from the heat of the sun. Energy from the heat of the sun is called ocean thermal energy conversion, or OTEC.

**Wave Energy**

If you have ever watched surfers riding the waves on a “rough” day, you have seen the energy in waves. These same powerful waves can be used to produce electricity. Technologies have been designed and developed to capture the power in these waves. Presently, there are two main types of wave energy generators. One type of these generators is a fixed device that is installed in the seabed or along the seashore. The other type is that which is floating off shore as barrages (dams) that are constructed across an estuary or inlet.

Other wave energy technologies are in various stages of research and development. Engineers and scientists are not always in agreement on the best type of generators needed to capture the power of the waves or exactly where they should be located. The depth of the ocean, the intensity of the waves, and the amount of local sea travel are all considered when finding ideal locations.

**Energy from the Tides**

Writers often use the words ebb and flow to describe how the ocean tides rise and fall. Most places in the ocean experience two high tides and two low tides every 24 hours. The gravitational force of the sun and moon and the rotation of the Earth cause the oceans to rise and fall.

If you have ever spent a day at the seashore, you witnessed this ebb and flow (or rise and fall) of the tides. While sitting and watching this natural change you might not have imagined that electricity can be produced from the changing of the tides. Tidal energy can be harnessed to create electricity using technologies like offshore turbines and tidal barrages (dams). A dam constructed across an estuary or coastal inlet allows the water to flow in at high tide. This water is trapped and at low tide the water flows back from the dam. The seawater, as it flows in and out, turns a turbine and generator to produce electricity.

**Where to Find Tidal Energy**

There are no tidal energy power plants in the United States and there are only a few locations where they could be constructed. France has the oldest and largest operating tidal energy plant located at La Rance. This plant began operating during the 1960s.

**Ocean Thermal Energy Conversion (OTEC)**

The oceans capture a great amount of the sun’s energy that radiates to Earth each day. This heat from the sun causes the ocean water to circulate, but the warmest water remains on the surface. Swimmers and scuba divers all know how ocean water is colder the deeper they go.

OTEC is a process that uses the temperature differences in the sea to spin a turbine to generate electricity. There are many challenges with OTEC. They include finding oceans with large temperature differences between the surface and various depths. This limits this process to the more tropical regions on the Earth. At present there is an OTEC plant operating off the Kona coast of Hawaii. Others are in planning or development stages in a number of countries.
Diving Deeper into Ocean Energy

**Directions:**
Your teacher will organize the class into groups to study more about one of the three ocean energy technologies.

1. **K** Write what you already know about ocean energy technology.
2. **W** Develop a list of what more you want to know.
3. **L** What have you learned from your research? Be ready to report to the rest of the class.

<table>
<thead>
<tr>
<th>K</th>
<th>What I KNOW</th>
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<table>
<thead>
<tr>
<th>W</th>
<th>What I WANT to Know</th>
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<thead>
<tr>
<th>L</th>
<th>What I Have LEARNED</th>
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</table>
In California, most homes use natural gas or electricity to provide their heat. However, in rural areas, beyond the reach of natural gas pipelines, people often use propane as a source of heat. People living in mobile homes are more likely to use propane than those living in other types of housing. Recreational vehicles use propane as well for their cooking, washing, and heating needs. Your own family might use propane in an outdoor barbecue grill or even on a camping trip. Propane also fuels those colorful hot-air balloons that provide “basket” rides for tourists.

A Nonrenewable Energy Source
Propane is a colorless and odorless gas that is a nonrenewable energy source. Propane is also known as liquefied petroleum gas (LPG). LPG is produced as a by-product of petroleum refining and natural gas processing. Propane may also contain an amount of ethane and butane, other by-products of petroleum refining. During the processing of propane, it is turned into a liquid and stored in huge tanks.

A Smell for Safety
Since propane is an odorless gas, an artificial odor is added so people can easily detect this gas if it leaks. Some call the odor foul-smelling, but it is added for the safety of people using propane or working around propane tanks.

Distributing Propane
When propane is intended for home use, the fuel is delivered by truck to individual users. It is delivered as a liquid when it is pumped into smaller tanks outside the home. Before it is used as a fuel for uses such as space heating, water heating, and cooking, the liquid propane changes back into a gas.

Multiple Uses
Propane has many important uses in agriculture—as a fuel for irrigation pumps, grain dryers, and standby generators. Propane is also used for crop drying and weed control. Besides home and agricultural uses, propane is used to fuel some motor vehicles. The U.S. Department of Energy reports that there are more than 270,000 propane-fueled vehicles on the road. Many are used in fleets, including light- and heavy-duty trucks, buses, taxicabs, police cars, and rental and delivery vehicles.

Only about 2 percent of all the energy used in the U.S. comes from propane. Propane is a fossil fuel.

Power Point!

Call It Propane or Liquefied Petroleum Gas (LPG)
Propane occurs naturally as a gas. When propane is stored and transported it is a liquid. When propane is released from pressurized storage tanks it becomes a gas again.
Review and Recall

Directions:
Read about propane energy and answer the following questions.

1. What five factual things can you recall about propane?

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2. Why is propane used more in rural areas than in cities or suburbs?

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3. What was the safety practice described in the reading?

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4. What types of vehicles are most likely to be fueled by propane (LPG)? Why?

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5. Why is propane classified as a nonrenewable energy source?

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Solar Energy

Each day the sun provides the Earth with enormous amounts of energy. The energy from the sun is what makes life possible on our planet. The sun, either directly or indirectly gives us all the energy we use. The sun provides the energy in the foods we eat. Wind, energy, and tidal energy can power homes using the heat from the sun to generate electricity. The fossil fuels that at present supply most of our electricity are from the sun’s energy that was captured by trees and plants many millions of years ago.

How Does Solar Energy Work?
Solar energy can be captured and used in a variety of ways. The two main technologies for generating electricity from solar energy are photovoltaic (PV) and solar thermal. Photovoltaic (PV) cells turn the energy in sunlight directly into electricity. The most common type of PV cell is made from silicon. Silicon is the main ingredient that is found in sand. PV cells can be arranged in panels on rooftops of homes and other buildings to provide the electricity that is needed by the occupants. PV cells are used to power and light roadway signs and can even be found in small calculators and in battery chargers that power cell phones. PV cells convert sunlight into electricity without the use of turbines.

Solar Thermal Energy
The two types of solar thermal systems are passive or active. No equipment is needed with a passive system. The heat that is created in a parked car on a sunny day can demonstrate a passive system. This type of system could also be illustrated by homes built in ways that take advantage of sunlight to both heat and/or cool the home. An active solar thermal system requires a way to absorb and collect the radiation from the sun and then to store it.

Direct or Indirect
Solar thermal energy works differently from the PV or solar cells that turn sunlight directly into electricity. Solar thermal energy captures the sun’s light to produce heat. Indirectly, this heat is used to produce electricity. Solar collectors in homes are used to heat the water for bathing and cleaning. Some homes, parks, and hotels also use this technology to heat swimming pools.

Solar Thermal Farms
Today most power plants in the U.S. use fossil fuels to generate electricity. However, there are power plants now that use the sun as a heat source to run generators that produce electricity. In the Mojave Desert of California, a very large solar thermal farm is providing power to an estimated 140,000 homes in California.

According to scientists, the sun—that huge star around which the Earth and the other planets in the solar system revolve—has been around for about 4.6 billion years. Since the beginning of time, the sun has provided warmth and light to the creatures of the Earth. Recognizing its importance, many ancient societies actively worshiped the sun as a source of life or energy.
Directions:
1. Read the article The World’s Largest Solar Thermal Farm and analyze the photo.
2. Write a summary of how this solar thermal power plant functions.
3. Explain how using the sun rather than fossil fuels to create electricity reduces carbon dioxide (CO₂) and other greenhouse gas emissions.
4. Locate on a map the Ivanpah Valley area of the Mojave Desert where this plant is located. What are the four closest big California cities to this plant?

Bonus: Do an Internet search to see what magazines and newspapers have written about this plant. In your search include any impacts on birds.

World’s Largest Solar Thermal Plant in California

Out in the middle of the Mojave Desert there is a huge solar thermal plant stretching over more than 3,000 acres. This plant does not use photovoltaic cells, but mirrors to convert sunlight into electricity.

There are some 300,000 mirrors each measuring 70 square feet that collect the energy from the sun. The sunlight collected by the mirrors is directed toward three towers filled with water. Inside the towers the water heats and, as temperatures rise, steam is produced that spins turbines to generate electricity.

Sun All Year
This desert region of California receives sunlight about 340 days a year. The electricity collected at this desert plant services an estimated 140,000 homes.
The Power of the Wind
Humans have used the power of the wind for a very, very long time. The ancient Egyptians traveled upstream 5,000 years ago on the Nile River in wind-propelled boats with sails. European explorers in the 15th century traveled across the world to unknown destinations in ships powered only by the winds in their canvas sails. For many hundreds of years, windmills have harnessed the power of the wind mainly for the pumping of water and the grinding of grains. Today’s wind turbines are no longer called windmills because they do not mill (grind) grain or pump water. These wind turbines use the power of the wind to generate electricity.

Wind Turbines
Just like windmills, the wind turbines are mounted on a tall tower in order to capture the most wind. At a height of 100 feet or more above ground, they are able to capture the faster and less turbulent winds. Each wind turbine usually has two or three giant propeller-like blades to collect kinetic energy—the energy from the motion of the winds. The energy from the wind turns the blades around the rotor. The rotor is connected to a main shaft, which is connected to a generator—a machine with coils of powerful magnets and wires. When spun quickly, electricity is produced. Wind turbines can be used to produce electricity for individual homes, small farms, or other buildings. Wind power that serves a number of people is generated on wind farms. Wind energy is a renewable energy source.

More Wind Information Ahead
Your teacher will assign you to a wind group and suggest websites and other materials to assist with your projects.

Directions:
1. Meet with your group and develop a written plan for how you will divide up tasks. Also create a timeline to meet the “report back” schedule.
2. Meet to review the findings of group members.
3. Create an interesting, visual, and hands-on approach in presenting your project to the entire class.

Call It a Wind Farm
A wind farm is a single location where a large number of wind turbines are grouped together to produce electric power. Some wind farms are located offshore (at sea).
Wind Projects

The Design of Future Wind Turbines
Today, scientists and engineers are designing and testing bigger and bigger wind turbines.
What can your group tell the class about the various designs of existing wind turbines and some future wind turbines now in the design stage? Do not limit your research to wind turbines in the United States.

Environmental Impacts of Wind Turbines
Wind energy is a renewable energy source and, unlike fossil fuels, it does not create greenhouse gases (GHGs) that contribute to climate change.

What are some of the environmental impacts of wind turbines that you can report to the class? Think in terms of impacts on people as well as on animals.

Wind Energy in the Energy Mix
California is moving toward 2020 when, under a state law, 33 percent of electricity must be generated from renewable energy. Wind is part of this mix.

Your project should be presented with diagrams or other visuals on the amount of wind power that is now used to generate electricity in California. Beyond California, how much wind energy is used to generate electricity in the United States? Name the three countries in the world that are using wind power the most.

Offshore Wind Power
You might find it hard to think about a wind farm at sea, but wind power is coming from offshore locations in the U.S. and other countries.

Your project should focus on the types of offshore wind farms in the U.S. and where they are located. What are some of the issues and problems related to developing offshore wind farms? Why is it normally windier at sea than on land?

Turning Blowing Wind into Electricity
We have learned that the power of the wind can create electricity. There are, however, a number of steps before that wind-generated electricity is sent onto the electric grid.

Your project should result in diagrams or other visuals that will illustrate very clearly how the energy of the wind becomes electricity.

Scouting for Wind Farm Sites
Daily, we all experience (feel) that the wind is present. Although the wind is ever present, there are only some locations that are suitable for a wind farm.

Your project should focus on all the geographic issues that are considered before a site for a wind farm is selected. What can you tell the class about some of the wind farm sites in California that have made them ideal? How do scientists and engineers measure wind speed? How important is this speed in selecting an ideal location for a wind farm?
Weighing the Pros and Cons of Energy Sources

If you have been researching and looking for the absolutely perfect energy source, you will not find it! There are both advantages and disadvantages to every known energy source. Your studies about both renewable and nonrenewable sources have shown you many of the benefits and challenges in producing energy. You have also learned of environmental impacts that result from the production of energy. This pro and con chart will help you and your classmates analyze and summarize the advantages and disadvantages of eleven energy sources.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Biomass</td>
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<tr>
<td>Coal</td>
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<tr>
<td>Geothermal</td>
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<tr>
<td>Energy Source</td>
<td>Pros</td>
<td>Cons</td>
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<tr>
<td>Hydropower</td>
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<td>Natural Gas</td>
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<td>Nuclear (Uranium)</td>
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<tr>
<td>Ocean</td>
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<tr>
<td>Energy Source</td>
<td>Pros</td>
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<tr>
<td>Petroleum (Oil)</td>
<td><img src="image" alt="Pumpjack" /></td>
<td><img src="image" alt="Drilling Rig" /></td>
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<tr>
<td>Propane</td>
<td><img src="image" alt="Propane Tank" /></td>
<td><img src="image" alt="Fire Extinguisher" /></td>
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<tr>
<td>Solar</td>
<td><img src="image" alt="Solar Panel" /></td>
<td><img src="image" alt="Solar Panel" /></td>
</tr>
<tr>
<td>Wind</td>
<td><img src="image" alt="Wind Turbine" /></td>
<td><img src="image" alt="Wind Turbine" /></td>
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</table>
What a Source of Power!

More than eighty years ago, Thomas Alva Edison, an American inventor, wrote in the year of his death about the energy future he envisioned. Edison wrote about the inexhaustible (renewable) sources of the sun, wind, and tides. However, Edison said, “I’d put my money on the sun and solar energy.”

Beyond Possibility

During his lifetime Edison obtained over 1,000 patents, created numerous new products, and improved on the telephone created by Alexander Graham Bell. Edison, like many other inventors, scientists, and writers, often imagined things that were beyond possibility at the time. Sometimes the imagination is far ahead of the technology available to make things happen.

Imagineering

If we combine the two words imagination and engineering, we get the blended word imagineering. One way to approach your own energy future is to imagine how your own energy needs could be met in the future. You might begin by thinking of an energy future with cleaner air, less pollution, and fewer greenhouse gas emissions.

Directions:

1. Select an imagineering team to work with on this project.

2. Do your imagineering.

3. Prepare to present (with imagination) your energy future to the entire class.

“We are like tenant farmers chopping down the fences around our houses for fuel when we should be using nature’s inexhaustible sources of energy—sun, wind, and tide. I’d put my money on the sun and solar energy. What a source of power! I hope we don’t have to wait until oil and coal run out before we tackle that.”

Thomas Alva Edison (1847–1931)
Paying for Power: Measuring Natural Gas and Electricity

The energy that powers our daily lives comes from many sources. Gasoline, for example, begins as liquid petroleum, deep inside the Earth. This petroleum must be extracted, processed, and converted into vehicle fuel and then carried by pipelines and trucks to where it will be transferred to a service station. The cost of gasoline depends on many factors, but it is always charged per gallon.

Follow the Steps
Electricity must be generated, transmitted, and distributed over power lines before reaching its destination. Natural gas requires drilling wells, processing to remove contaminants, and delivery by pipelines and service lines to our homes and other places where it will be used. The cost of natural gas and electric power is based on the amount used and is sometimes based on the time of use.

Energy Use in the Home
The pie chart illustrates the yearly energy bill for a typical home in the United States. Heating and cooling are the two items that use the most energy and therefore are the largest share of any utility bill. The heating of water is another major cost.

An average California family pays approximately $48 for natural gas and $87 for electricity each month, or an annual amount of $1,620. In the 50 states, due to climate and weather patterns, an annual utility bill could be far higher or lower than the average in California. Think how the geography of California and the various climate zones in our state would affect the amount of electricity and natural gas that is used by a family.

Check the Utility Bill
Did you ever wonder how to read a utility bill? The bill for Hunter Hayes in this activity will help you discover how people pay for the electricity and natural gas they use each month. Begin by looking at the “prior meter reading” which shows the amount of kilowatt-hours of electricity recorded on the customer’s electric meter at the beginning of the 30-day billing period. The “current meter reading” [this month’s reading] shows the meter reading at the end of the billing period. The difference between the two readings indicates the amount of kilowatt-hours used by the customer over the 30-day billing period.

WORD POWER!
watt – A measure of power.
kilowatt – A unit of electric power that equals 1,000 watts. [Imagine a flat-screen TV. It uses approximately 120 watts per hour.]
kilowatt-hour (kWh) – A measure of electric power used over time. It is equivalent to 1,000 watt-hours.
therm – A measurement of usage of natural gas. A therm is the energy equivalent of burning 100 cubic feet of natural gas.
The number of kilowatt-hours multiplied by the rate—$0.10 per kWh, for example—determines the amount owed.

**Billing for Natural Gas**

Billing for the use of natural gas is calculated in the same way as billing for the use of electricity. Natural gas usage is computed in units of therms and not watts. The “prior meter reading” shows the amount of natural gas on the customer’s meter at the beginning of the 30-day billing period. The “current meter reading” shows the meter reading at the end of the billing period. The difference between the two readings indicates the number of therms used during the billing period. The number of therms multiplied by the rate—$1.20 per therm, for example—determines the amount owed for the month. The actual cost per therm of natural gas is based on two different rates. There is a baseline usage rate of $1.20 per therm plus the higher “over baseline rate” of $1.50.

**Meters do the Measuring**

The devices that track and measure energy use are called meters. Today, most meters in place or being installed are called “smart meters.” These digital meters allow users to see in “real time” how much power their homes are using and what it costs.

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**Let’s Explore More**

**Directions:**

1. What would you estimate Hunter Hayes would pay for electricity and natural gas during a year?
2. What are some factors that could change the amount of his annual utility bill?
3. What are five or more ways that Hunter Hayes might use less electricity and natural gas and reduce his bill?

**Bonus:** Learn more about utility bills by visiting www.pge.com and search for Bills Explained.
Career Exploration: Green Jobs and Careers

What do you want to be when you grow up? This question seems to be the one inquiry that children and youth have all been asked more than once. Adults asking this question usually expect answers that indicate an awareness of jobs, careers, or even an entrepreneurial idea about owning a business. At the present time, answers to this question might actually focus on some of the green jobs and careers to be found in the U.S. and the global economy. Not long ago, probably no one would have imagined a job installing “charging stations” for electric vehicles or working in the ocean installing platforms for an offshore wind farm.

In the future, students attending school today will enter a world with green jobs that will be found in every part of the economy. Some of these jobs are yet unknown and are still to be developed as new clean technologies are developed and put to use.

Define It!

Young children learn that to be green means being “friendly” to the environment by doing things like recycling, turning off lights, and by not wasting. As for green jobs, older students learn that they are ones that contribute directly to preserving or enhancing the quality of our environment. A geothermal technician, a solar installer, a designer of eco-packaging, an environmental attorney, a biomass plant operator, a school district energy manager, and so many more workers are all contributing to a cleaner environment by the jobs they do.

Greening of Existing Jobs

When women and men in existing occupations gain new energy-saving skills and more sustainable ways of working, their jobs can become “green.” The builder who installs energy-saving appliances, light sensors, and double-paned windows is building green. In agriculture, the farmers who use sustainable practices are going green. There are electricians being retrained to wire solar panels and roofers with retraining who help install...
these panels on homes and office buildings. Or imagine the auto mechanic who was retrained to service only electric or hybrid vehicles instead of petroleum-fueled vehicles.

Challenges and Opportunities
In California, around the U.S., and in other countries, goals have been set to increase the amount of energy coming from renewable energy sources. In California, the goal is that by 2020 33 percent of all the energy that is produced must come from renewable sources. In meeting this goal there are both challenges and opportunities. As the state moves from fossil fuels to renewable energy, there are increasing numbers of green careers and jobs becoming available. There could be a future in renewable energy for you!

Let’s Explore More
Directions:
As a whole group, select one or more of the following career awareness and exploration projects for your class.

1. Invite to class a person working in a renewable energy field to discuss their work and the training they had for this position. Consider a video conference if an in-person visit isn’t possible.

2. Take a field trip (virtual or real) to a site where renewable energy is being produced.


4. Create a green job and career bulletin board. Watch it grow with articles and photos throughout the semester.

A Working Definition of Green Jobs
Any activity or service that performs at least one of the following:

- Generation and storing of renewable energy.
- Recycling existing materials.
- Energy-efficient products, manufacturing, distribution, construction, installation, and maintenance.
- Education, compliance, and awareness.
- Natural and sustainable product manufacturing.

Source: California Employment Development Department [www.edd.ca.gov](http://www.edd.ca.gov/)
Crossword Puzzle

ACROSS
3.  A gas collected on farms that can be used to produce electricity.
6.  Birds and bats are considered when selecting a location for a ___________ farm.
8.  An element used in photovoltaic cells.
9.  A machine with blades used in the production of electricity.
10.  A renewable energy source.
12.  A word used to describe products, services, and jobs that are “friendly” to the environment.
16.  All energy sources should be analyzed by looking at the pros and ___________.
17.  The renewable energy source that is most in use around the world.
18.  Another word for molten rock.
20.  Peak period is the time of day when __________ for electricity is the highest.
22.  In a power plant, it is the ___________ that turns the generators.
25.  An American inventor who said in 1931, “I’d put my money on the sun and solar energy.”
27.  A secondary energy source converted from a primary energy source.
28.  A measurement for the use of electricity.
1. The ebb and flow of the ocean can help describe _______ ________. (2 words)
2. A nonrenewable energy source.
4. A fossil fuel that can be used directly in homes for heating or in power plants to produce electricity. (2 words)
5. The process of splitting apart the nucleus of a heavy atom.
7. Oil, coal, and natural gas are called _______ ________. (2 words)
11. CO₂ is the symbol for __________ __________. (2 words)
13. The energy contained within the nucleus of an atom.
14. Wood chips, animal manure, and switch grass are all _________________.
15. A large solar thermal energy farm in California is located in the ___________ ___________. (2 words)
19. Energy from deep inside the Earth.
21. Energy ___________ means using less energy to do the same amount of work.
23. An element used in nuclear plants.
26. One way to describe electricity generated from animal manure is __________ power.
Actions for the Environment

Let's Green the School
Not every school was built or was retrofitted to be green and energy efficient. Nor can every school install solar panels or power its energy needs with a wind turbine. But every school and each student can take actions to be energy efficient, conserve natural resources, and protect the environment. Students all around the United States and in many other countries are taking on environmental projects and green actions in their own classrooms.

Going Green
Students in some schools are “going green” by walking or biking safely to school instead of traveling in a fueled vehicle. Other students have implemented and monitored non-idling zones around their schools. These zones mean that school buses and private vehicles are not polluting the atmosphere when picking up and dropping off students.

Recycling campaigns, energy patrols, water monitoring, paperless days, edible gardens, tree planting, waste-reduction plans, environmental clubs, green service projects, and student-led energy audits are only some of the ways to green the school.

Uniquely Green
Each school setting is different, but every school can take green actions for the environment. No matter the location of a school, there are green projects a class can identify and implement.

Directions:
1. Brainstorm ideas for green projects your class could implement.
2. Present your ideas to the principal, teachers, and parent organizations at your school. Get everyone involved!
3. Select one or more of the green projects to accomplish this semester or school year.

The Green Squad
Visit the Natural Resources Defense Council Green Squad website to get started on activities to green your classroom and school. An animation will open your eyes to small and big greening actions to make a difference for the environment.

www.nrdc.org/greensquad
Energy-Saving Actions at Home

A Global Energy flyer is going home with you at the end of this study. All the renewable and nonrenewable energy sources you have learned about are described on this flyer.

A good discussion of these sources should include how each impacts the environment.

**Wise Use of Energy**

Eight energy-saving tips are listed to help you and your family conserve natural resources and protect the environment. Information on how your parents or guardians can learn more about saving energy is at the My Energy section of www.pge.com. This website includes a survey which can help your family reduce energy consumption and identify opportunities for saving money on your utility bill.

**Directions:**

1. Review the eight energy-saving tips on the flyer. Write how practicing these tips will conserve natural resources and reduce greenhouse gas (GHG) emissions.
2. What are other energy-saving tips that you would add to this list?

**Bonus: Energy-Saving Posters**

Create colorful posters for your classroom and school with energy-saving messages or slogans.

Use recycled materials for your posters.
alternative energy – See renewable energy.

anemometer – A device for measuring wind speed and wind direction.

appliance – A type of equipment, usually powered by electricity, used to perform a function. Common appliances include dishwashers, refrigerators, microwave ovens, and televisions.

atmosphere – The whole mass of air surrounding the Earth.

atom – The smallest unit of matter.

barrage – A type of dam that can be opened or closed to control the amount of water moving in or out.

battery – A device that stores energy and produces an electric current.

biofuel – A fuel produced from plants or other forms of biomass.

biogas – A type of biofuel that contains methane (CH₄) from animal waste and other decomposing waste materials.

biomass – Organic materials such as agricultural crops, plants, garbage, or wood that can be used for the production of energy.

carbon dioxide (CO₂) – See greenhouse gas.

chemical energy – Energy that is stored in a substance that is released during a chemical reaction. Chemical energy, for example, stored in batteries, can be changed into electrical energy.

circuit – A circular path that an electric current travels.

climate – The average weather in a place over a long period of time.
climate change – Refers to any significant change in measures of climate (such as temperature, precipitation, wind) lasting for an extended period of time (decades or more). [www.epa.gov/climatechange/basics/]

clean coal – A fossil fuel and a nonrenewable energy source. Coal comes from the remains of plant life that lived millions of years ago.

conservation – The management, protection, and wise use of natural resources.

current – The flow, or movement, of electricity.

decomposition – The process by which a substance is broken down into basic elements. Plant and animal matter decompose under the right conditions of air, light, and moisture.

demand response – Programs and ways that energy companies (utilities) and consumers can better manage when and how they use energy. Using less energy during peak demand hours is an example of demand response.

distributed energy generation – The generation of electricity near to the place where it is being used. On-site distributed energy generation examples include a school powered by solar panels, a farm powered by its wind turbines, and an office building powered by fuel cells.

electric grid – All the networks that carry electricity from power plants to where it is used. The grid includes power lines, substations, transformers, distribution wires, and more.

electrical energy – The movement of electrons.

electricity – A secondary form of energy that is used for lighting, heating, and powering forms of transportation.

electron – The basic particle that orbits the nucleus of an atom. Electricity is this flow of electrons.

electromagnetic – Having to do with magnetism produced by an electric current.

emission – A discharge, or release, of pollutants into the air, such as from a power plant, smokestack, or automobile engine.

energy efficiency – The use of energy without waste. Energy efficiency refers to work done using the smallest amount of energy needed.

environment – Something that surrounds: surroundings. The natural environment includes land, air, water, and other features of nature.

estuary – A body of water where fresh and ocean waters meet.
finite – Something with a fixed or limited amount such as a “finite” resource.

fossil fuels – Fuels formed from the remains of plants and animals that lived over 70 million years ago. Coal, oil, and natural gas are fossil fuels.

generator – A device used to convert mechanical energy into electrical energy.

geyser – A place where hot water and steam rises out of the Earth.

global warming – Global warming is an average increase in the temperature of the atmosphere near the Earth’s surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, “global warming” often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. [www.epa.gov/climatechange/basics/](http://www.epa.gov/climatechange/basics/)

green – A color. Green can also be used to mean a person or process that helps protect or is “friendly” to the environment.

greenhouse effect – The effect produced when greenhouse gases trap solar radiation in the Earth’s atmosphere and warm the planet. This process occurs naturally and has kept the Earth’s temperature about 60 degrees Fahrenheit warmer than it would be without it. Current life on Earth could not continue without the greenhouse effect. [www.energystar.gov/index.cfm?c=kids.kids_index](http://www.energystar.gov/index.cfm?c=kids.kids_index)

greenhouse gas (GHG) – A gas, such as carbon dioxide (CO₂) or methane (CH₄), that traps the heat of the sun in the Earth’s atmosphere.

greenhouse gas emission – A discharge of greenhouse gas (GHG) into the atmosphere.

green jobs – Careers or jobs that focus on protecting the environment and conserving natural resources.

grid – The overall layout of a distribution system for electricity. See electric grid.

Integrated Demand Side Management (IDSM) – A term used by energy utilities to describe actions that people can take to reduce the demand for energy. See definitions for energy efficiency, demand response, and distributed generation.

kilowatt – A unit of measurement of electric power that equals 1,000 watts.

kilowatt-hour (kWh) – A unit of measurement of electricity used which translates to one kilowatt used for one hour.
landfill – An area of land where waste materials and trash are dumped.

liquefied petroleum gas (LPG) – See propane.

magma – Hot liquefied, or molten rock located deep below the Earth’s surface.

megawatt – A unit of measurement of electrical power equal to one million watts or 1,000 kilowatts.

municipal solid waste (MSW) – Everyday items that are used and discarded. This waste is more commonly called trash or garbage.

natural gas – An air-like substance found in the Earth that can be burned for heat or fuel.

natural resource – A material in nature used by people. Water, air, plants, and soil are examples of natural resources.

nonrenewable energy – A resource such as coal or oil that cannot easily be replenished. They were formed millions of years ago.

nuclear energy – Energy that comes from the splitting of atoms of radioactive materials, such as uranium. Nuclear energy is classified as a nonrenewable energy source because the metal uranium is nonrenewable.

nuclear fission – This process occurs when atoms are split apart to form smaller atoms that release energy. Fission takes place in reactors inside nuclear power plants. See also nuclear energy.

nucleus – The center of an atom. In the nucleus are tiny particles called neutrons and protons. Orbiting around the nucleus are electrons.

oil – See petroleum.

organic waste – Waste material of either plant or animal origin.

OTEC – The abbreviation for ocean thermal energy conversion. See page 24 for a description of this type of ocean energy.

outage – A period of time when a power supply is not available.

parabolic trough – A solar collector that has a linear parabolic shaped reflector that focuses the radiation from the sun on a receiver. See photo on page 29.

peak demand – The times during the day when the demand for electricity is the highest. This period of the day is between noon and 7:00 pm.
**petroleum** – A natural, thick, flammable liquid made of the remains of plants and animals that lived over 70 million years ago.

**photosynthesis** – The process trees and other green plants use to make their food by using water, carbon dioxide (CO₂), and sunlight to make simple sugars.

**photovoltaic cell** – A device which converts some of the energy from the sun (radiant energy) into electrical energy. These cells are usually made from silicon. Also known as solar cells.

**pollution** – Impurities in air, water, and land that create an unclean environment.

**power plant** – A place where energy is generated.

**propane** – A nonrenewable energy source that is produced as a by-product of natural gas processing and oil refining.

**pumped storage plant** – A type of hydroelectric plant where the method of storing and producing electricity can meet high peak demands by moving water between reservoirs at different elevations.

**renewable energy** – An energy source such as solar or wind that can be restored by nature after it is used.

**reservoir** – A natural or artificial lake where a water supply is stored.

**retrofit** – To install new parts or equipment onto or in a building to make it function more efficiently.

**smart grid** – A modernized electric grid. Includes technologies for two-way interaction between consumers and utility companies. Also allows for distributed generation and an increased use of renewable energy sources.

**solar energy** – Energy which comes directly from the sun.

**spring** – A place on the surface of the Earth where water comes from beneath the ground.

**steam** – Water in vapor form. Steam is used in power plants to move the turbine-generators to produce electricity.

**substation** – A facility where the voltage of electricity flowing through a transmission line is reduced.

**therm** – A measurement of the amount of natural gas that is used.

**transformer** – A device to change the voltage of an electric current.

**transmission line** – Wires used to carry electricity from a power plant to a substation, where the voltage is reduced.
**turbine** – A machine with blades used in the production of electricity. Turbines can drive a generator by the forces of steam, moving water, or wind. (See generator.)

**uranium** – An element found in the crust of the Earth. The fuel for nuclear power plants comes from uranium ore.

**utility** – An agency or company that supplies electricity, natural gas, water, or phone service.

**volt (V)** – A unit of measurement of an electric current.

**voltage** – A measure of how hard electricity is being pushed through a conductor such as a transmission line.

**weather** – What is happening in the atmosphere right now in a given place.

**wind** – The word used to describe any natural movement of air in the atmosphere.

**wind power** – Electricity created from the wind. Wind turbines use the wind to produce electricity.
Connecting to the Internet

At the following websites, you will find more about renewable and nonrenewable energy sources, diagrams on how energy is produced, animations on global climate change, and even ways to measure your own use of energy. There are also puzzles, games, ideas for science fair projects, virtual field trips to power plants, and much more to discover.

www.eia.doe.gov/kids
Energy Ant hosts this U.S. Department of Energy website. This site provides extensive information and diagrams for each renewable and nonrenewable energy source. A section on virtual field trips includes a hydropower plant at Hoover Dam, a waste-to-energy plant, a solar rooftop, and wind turbines off the coast of Massachusetts. This site is easy to navigate by putting in keywords in the upper-right corner.

www.energyquest.ca.gov
This website features diagrams, photos, and illustrations along with its content about all the renewable and nonrenewable energy sources. A section of the site helps explain how energy is produced. There are interactive games that teach about energy conservation, puzzles, energy surveys, science projects, and even biographies of scientists. Energyquest has an extensive glossary and a special section on how things work, where students can ask a scientist their own questions. This site is sponsored by the California Energy Commission. (www.energy.ca.gov)

www.epa.gov/climatechange/kids/
This website features interactive games, links, and animations to help explain the greenhouse effect and global climate change. The site also provides information on ways children and youth can save energy, conserve natural resources, and protect the environment.

www.energystar.gov/kids
Your planet needs you. Find out why! This interactive site leads with these two short sentences. At this site you can discover more about energy sources, global climate change, and actions to take to save energy.

www.eere.energy.gov/kids
A variety of interactive games and activities are found on this Department of Energy website. The site includes information on a solar house, a scavenger hunt, and a range of resources for science fair projects.
Organize a Green Team
See these sites for more information:

- Allianceto Save Energy
  http://ase.org/index.php?q=topics/education

- Center for Green Schools
  www.centerforgreenschools.org

- Go Green Initiative
  www.gogreeninitiative.org

- Green Education Foundation
  www.greeneducationfoundation.org

- Green Schools Initiative
  www.greenschools.net

- Green Your School
  www1.eere.energy.gov/education/school_buildings.html

- Natural Resources Defense Council (NRDC), The Green Squad
  www.nrdc.org/greensquad

Remember: Websites are continually updated and redesigned. Some addresses listed here may have changed. If you find that an address no longer works, try this:

Go to the site’s home page. You may find a link there to the resource you are looking for, or the page may include a search box. You can also search for the material you want by entering its name into a search engine such as Google (www.google.com) or Yahoo! (www.yahoo.com).
A Commitment to Environmental Excellence

Pacific Gas & Electric Company (PG&E) delivers safe, reliable, and environmentally responsible electricity and natural gas to approximately 40 percent of Californians. At PG&E, we are committed to being an environmental leader and demonstrating this through our actions. We pledge to think creatively, work cooperatively, and be results-oriented in our environmental stewardship efforts. To learn more about PG&E’s environmental commitment, visit www.pge.com/environment.

Reflecting PG&E’s environmental commitment, these materials provide students with information about energy efficiency and environmental actions they can take to keep the air cleaner and reduce greenhouse gas emissions that contribute to global climate change.