Environmental Volunteers

Energy & Natural Resources Subject Guide

ENVIRONMENTAL VOLUNTEERS ©
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Through this generous support, the Environmental Volunteers was able to develop this curriculum and its hands-on learning stations that will educate thousands of students to become stewards of the environment.

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EV Mission

The Environmental Volunteers believes all children deserve to learn about the natural world through personal exploration, so they can become responsible stewards of the earth. It is the philosophy of the Environmental Volunteers that what children come to know and understand, they are more likely to appreciate and love. And what they love, they will protect.

The Environmental Volunteers mission is to promote understanding of, and responsibility for, the environment through hands-on science education.

We Do This By

- Providing hands-on science education
- Encouraging awareness of the interrelationships between people and nature
- Fostering an attitude of stewardship for the environment
- Providing knowledge and skills to children so they can make informed decisions about the environment

We Value

- Our love of nature, children, and teaching
- Moving society to a sustainable relationship with nature
- Teamwork, volunteering, and friendship
- Lifelong learning, personal growth, and creativity
- The diversity of the students and teachers we serve

Support for California Educational Requirements

California currently requires all teachers in public schools to teach the state educational standards. These standards provide teachers an outline of what their students should know in each subject area by the end of the school year. The EV learning programs strongly align with many of the science standards and often reach standards in other subject areas such as social studies or mathematics.

California State Legislature also passed a pair of bills in 2003 and 2005 to create the Education and the Environment Initiative to bring more environmental education into California classrooms. The Environmental Principles and Concepts (EP&C) learning objectives developed out of this initiative were designed to align with the state standards allowing teachers to bring environmental concepts into all aspects of classroom teaching. The EV can support teacher efforts to incorporate the EP&C learning objectives into their curriculum as our programs strongly connect to the EP&C learning objectives.

Principles of Sustainability

Sustainability is the ability of our society to meet our needs today without compromising the ability of future generations to meet their needs. It is a key concept for fostering strong stewardship in our students and our community. Our students must understand that the resources of our planet are not unlimited and that when we throw things away, they do not just disappear. We must take responsibility for the environment to protect it so it will last for every generation that comes after us. The following principles of sustainability define how we relate sustainability to the learning objectives of the EV subject areas.

<u>Sustainability is:</u>

- Preserving our environment, from our backyards and schoolyards to native habitats such as forests and grasslands.
  We teach our students to show respect for the land. We stay on hiking trails, pick up litter, and appreciate open spaces.

- Restoring our environment, wherever possible, from human impact, and assisting with the recovery of the species that live there.
  We teach our students to respect habitats and the wildlife they support, understanding the benefit of restoration projects and nature's ability to restore itself.

- Practicing responsible use of our planet's resources, to "walk lightly" upon the Earth, leaving it in good shape for future generations.
  We teach our students about the full cost of the choices we make in our lives, what resources we use to build our homes, grow our food, and support our daily lifestyles. We then provide techniques for using those resources more efficiently.

- Understanding the beauty of our planet, the elegance of natural systems, and the interconnectedness of all its parts.
  We teach our students the structure and function of the world around them, which creates the foundation for understanding the complexities of sustainable living.

- Possible! If we empower ourselves to make change, our efforts <u>will</u> make a difference.
  We teach our students that California is a leader in sustainability reforms like energy conservation and extensive recycling programs. As Californians, we are role models to our friends, our neighbors, our countrymen, and our planet.

Energy & Natural Resources Overview

The Environmental Volunteers' Energy & Natural Resource Program has two sets of learning stations. The first, **Electricity—Its Uses and Sources**, introduces fourth grade students to the importance of electricity in our lives and where it comes from, looks at renewable and nonrenewable sources of electricity, examines the impact of those sources on the environment, and provides ideas for reducing those impacts.

The second set of kits, **Global Climate Change—Its All About Carbon,** introduces fifth graders to global climate change, including the carbon cycle, the greenhouse effect, and human impacts on these processes, and offers practical suggestions about how people can reduce their impacts that contribute to climate change.

The Energy and Natural Resources Subject Guide is intended to further understanding of the Environmental Volunteers *Energy and Natural Resources Program* and corresponding learning station activities. Through the use of this guide, volunteers will be able to understand and generate in others an appreciation for how energy and natural resource use provides a foundation for most human activities and our quality of life. The guide also looks at human interaction with the environment and highlights what can be done to reduce our impacts.

State Standards and Environmental Principles and Concepts

The Energy and Natural Resources Program was designed to address specific statewide requirements of the "Science Content Standards for California Public Schools."

The **fourth grade program, Electricity—Its Uses and Sources**, aligns directly to the following state standard:

Physical Sciences:
1g. Students know that electrical energy can be converted to heat, light, and motion.

The program also relates to all parts of standard 1 – electricity and magnetism are related effects that have many useful applications in everyday life.

The **fifth grade program, Global Climate Change: It's All About Carbon**, aligns directly to the following state standards:

Physical Sciences:
1a. Students know that during chemical reactions the atoms in the reactants rearrange to form products with different properties.

1g. Students know properties of solid, liquid, and gaseous substances, such as sugar, water, helium, oxygen, nitrogen, and carbon dioxide.

The program also relates to all parts of standard 1 – elements and their combinations account for all the varied types of matter in the world; and 2f – students know plants use carbon dioxide (CO_2) and energy from sunlight to build molecules of sugar and release oxygen.

In addition, both fourth and fifth grade programs align with a wide variety of the Environmental Principles and Concepts Learning Objectives developed through California's Education and the Environment Initiative.

Introduction

In June 2005, California governor Arnold Schwarzenegger signed an Executive Order establishing aggressive goals for the state of California to address global climate change, and declared, "*...the debate is over. We know the science. We see the threat. And we know the time for action is now.*"

The issues of global climate change and human impact on our environment have become key concerns of our society. City, state, and federal governments are taking action to regulate greenhouse gas emissions and invest in renewable energy infrastructure. Companies are marketing their green business practices. Consumers are looking for environmentally friendly products, such as hybrid cars, energy star appliances, and recycled goods.

As society pays more attention to these environmental issues, schools are looking to educate their students about them. The EV developed the Energy and Natural Resources subject area to support teachers in these efforts. Our interactive, hands-on activities give students the scientific principles and facts about the issues that correlate with state standards for their grade level. In addition, real-life situations, policies, technologies, and day-to-day activities are presented that can empower them to make their community a cleaner and safer environment.

> **Did You Know?**
>
> Governor Schwarzenegger issued an executive order setting goals for the state of California to reduce greenhouse gas emissions. By 2010 levels should be equal to the levels in 2000, by 2020 they should be equal to 1990 levels, and by 2050 they should be 80 percent below 1990 levels.

Electricity: Its Uses and Sources

Electricity Background

This section is intended purely as background information to increase a volunteer's comfort level with the subject. The specific content of this section is not directly represented in the learning objectives of any learning station, and therefore do not require the volunteer's mastery.

<u>Electricity as a Form of Energy</u>

Energy is the ability to do work (in physics this essentially means to make things move), or generate heat. Energy exists in different forms, such as thermal (heat), radiant (light), mechanical, chemical, nuclear, and electrical energy. If the energy is not doing work or generating heat right now, it is **potential energy**. For example, gasoline in your car is potential chemical energy until you start driving. Then it is transformed into thermal energy (heat of combustion) and mechanical energy (moving the car).

There are three primary laws regarding energy, two of which are important in the Energy and Natural Resources subject area. The **First Law of Thermodynamics** is also called the **Law of Conservation of Energy**. It states that energy can neither be created nor destroyed; it can only be converted from one form of energy to another. To continue the car example, the energy of the moving car is not destroyed when you stop; it is transformed into heat through the friction on the break pads and the road. Hybrid cars take some of that energy and transform it back into chemical energy by recharging the battery.

The **Second Law of Thermodynamics** says that each time energy is converted from one form to another, some of the energy is degraded to a less useful form; usually heat. This means that no system can convert energy from one form into another useful form with 100 percent efficiency. For example, a light bulb cannot completely convert all of the incoming electrical energy into light. In fact, a regular incandescent light bulb only converts 5 percent of the incoming electrical energy into light, while the other 95 percent is converted into heat.

Electricity is different from other energy sources, such as natural gas, because it is a **secondary source of energy**. This means we must transform another energy source into electrical energy. In the United States, coal is the number one energy source used for generating electricity. However, in California, natural gas is the number one energy source. We can also generate electricity by converting energy from the sun, from wind, from water, as well as from other sources.

<u>Circuits</u>

Electrons are tiny particles in an atom with a negative charge. Applying a force can make some of the electrons move. An atom that loses electrons becomes positively charged, while an atom that gains electrons becomes negatively charged. Materials made of atoms that easily release or collect electrons are called **conductors**. Those that hang on to their electrons are **insulators**.

Electricity is the movement of electrons along a conducting material. They can only move through a continuous path of conducting material, called a **circuit**. If you have an open circuit, the conducting path for the electricity is not continuous and therefore no electricity can flow. The circuit must be closed (made continuous) in order for electricity to flow along a conducting material. A switch (like a light switch on the wall) connects (closes) and disconnects (opens) two parts of the circuit.

Flowing electrons are called **current**. Electrons always flow away from negative and toward positive charge. A battery has a positive terminal and a negative terminal. Because of the difference in the charge there is potential energy which can eventually do work to move electrons. The size of the difference is measured in **volts**. For example, an AA battery has an electrical potential difference of 1.5 volts.

You can attach a **load** (something to be powered) such as a light bulb, a computer, or a heater into a circuit. Electrons move from the voltage source, in this case the battery, through the load and back to the source. The flowing electrons will power the load, and the load will do its work creating light, heat, or motion.

Measuring Electricity Use

The three most basic units in electricity are voltage, current, and **resistance**. Voltage is measured in volts, current is measured in amps, and resistance is measured in ohms.

If we compare electricity to water flowing through a hose, then voltage is equivalent to the water pressure, the current is equivalent to how much water is flowing, and the resistance is like the size of the hose through which the current has to flow.

A **watt** is a measure of the amount of work done by a certain amount of electric current (amps) at a certain pressure (volts). So volts x amps = watts. Watts are a measure of total electrical power.

In the United States, the power outlets in the wall of your home are supplied with 120 volts. If you plugged a space heater into a wall outlet, and measured the amount of current flowing from the wall outlet to the heater, you could calculate the wattage of the heater. Let's say it uses 10 amps of current. That means that it is a 1,200-watt heater. How do we know that? Because:

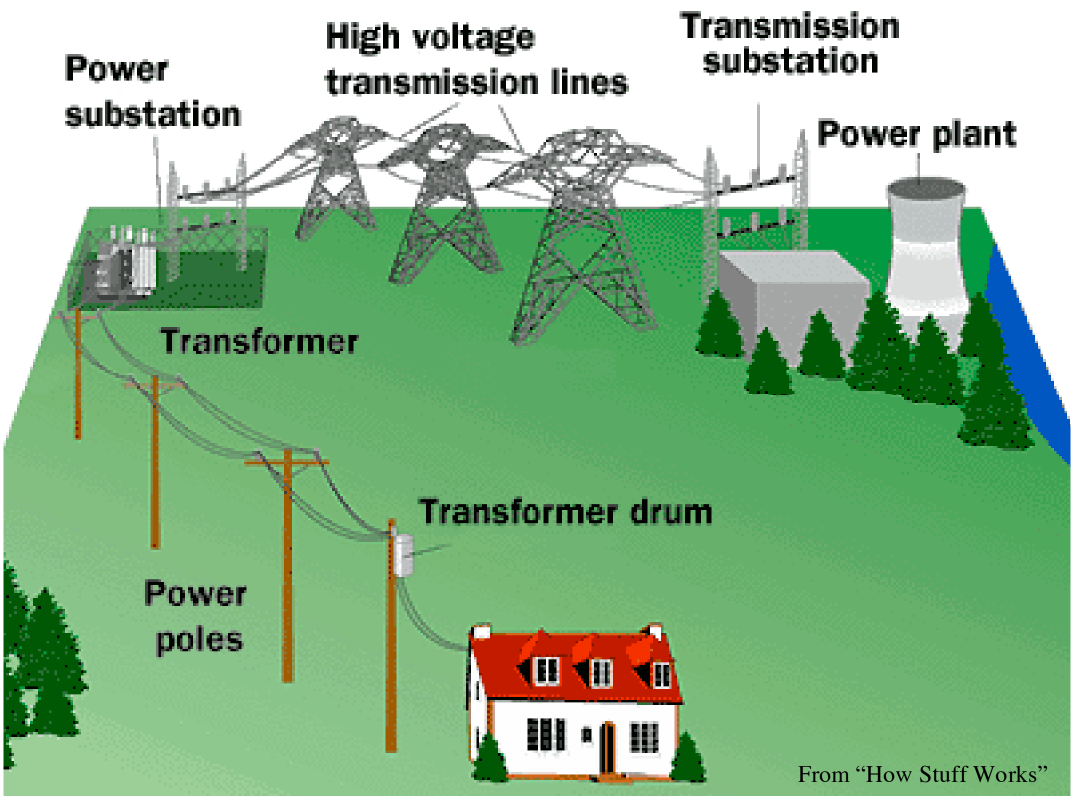
Volts x Amps = Watts (120 volts x 10 amps = 1,200 watts)

Since a watt is a measure of energy per unit of time, to know how much total energy you're using you have to find out the watts of your appliances, lights, electronic devices, etc. and how long you run each one. When you run a 1-watt appliance for one hour, that's a **watt-hour** (Wh). If you leave a 100-watt light on for 10 hours, the light will consume 1 kilowatt-hour of electricity (100 watts x 10 hours = 1 kilowatt-hour). A kilowatt-hour (kWh) is 1,000 watt-hours and that's how the power company measures how much electricity we use.

When electricity is used for light, another important unit is lumens. A **lumen** is the measure of light output. A 60-watt incandescent light bulb gives 800 lumens of light. Because higher wattage incandescent bulbs produce more lumens of light, it is a common misconception that watt equals light output. However, this is a result of the way the bulbs work, not their wattage. A compact fluorescent bulb that gives 800 lumens of light only uses 13-watts of power.

How Electricity is Generated

Electricity is generated primarily in power plants or stations. Power travels from the power plant to your house through the power distribution grid. In almost all cases (solar cells being a notable exception) the heart of a power plant is a generator. A **turbine**, similar to a windmill, is attached to the generator and rotates when a liquid or gas is forced through it. **Generators** convert mechanical energy into electrical energy.



The generator in a power plant produces alternating current (AC) electricity at high voltage, which is delivered to your house through power lines. This electricity is then put through a device called a **transformer** that changes the voltage level but not the power level. If you put 100 Watts into a transformer, then 100 Watts come out the other end. (Actually, there are minor losses in the transformer, since they are only about 95% efficient.) This step is necessary because efficient transmission of electricity over long distances requires high voltages, but using electricity safely requires much lower voltages.

The electricity enters your house through a watt-hour meter, which measures the amount of electricity you use so that you can pay the power company for it. You plug in your computer, lights, TV, refrigerator, and other useful items and you get the electricity that helps transform your life!

Sources and Consequences of Electrical Energy

Many sources are used for generating electricity, and they can be classified into two types: **renewable and non-renewable energy resources**. Non-renewable sources, such as oil, cannot be replaced once they are used up. Renewable means the opposite – the source either cannot be used up, such as the sun's energy, or is capable of renewal, such as forests (biomass).

Wind turbines capture wind energy and hydroelectric plants use moving water to run generators. Nuclear power, geothermal energy, and burning fossil fuels or biomass are all used to boil water to make steam, which turns the turbine in a steam generator.

Every form of electrical generation has advantages and disadvantages. Coal is cheap and efficient but releases carbon dioxide (CO_2) and harmful particulates into the air. Solar generation releases no emissions and has almost no impact on the surrounding environment when installed on rooftops, but is expensive, inefficient, and not always available. Conventional steam plants require large amounts of water for steam and cooling, and can negatively impact local water resources and aquatic habitats.

There is no perfect solution to generating the world's electricity. The challenge is to reduce our demand, increase the efficiency of the devices we use, and reduce the environmental impact of the generation of the electricity wherever possible.

Did You Know?

California has adopted a goal of generating at least 20% of the state's electricity from renewable sources by 2010. This is known as the Renewable Energy Portfolio Standard.

Renewable Energy Sources

The next few sections will describe a variety of energy sources used to produce electricity. There are additional forms of renewable energy such as hydrogen, waves, and tidal power. As innovation in the technologies happen, these may become a part of the electricity generation in this country.

Solar Power

Enough sunlight falls on the Earth's surface each minute to meet the world's energy demands for a whole year, so solar energy is an important renewable energy opportunity. Today, solar power is considered the most abundant, most reliable, and cleanest of all energy sources, and we've only just begun to tap its potential.

California is a leader in the U.S. in producing solar power, but it still costs more than electricity produced from sources such as coal, so that is why it is not yet used more widely.

The most common form of solar generator is a **photovoltaic** (PV) cell made up of special materials that can convert the energy of the sun to electricity. Light is made up of **photons** (packets of energy). When sunlight photons hit a PV cell, many of them are absorbed and create pairs of negatively charged free electrons and positively charged 'holes' (regions short on electrons). A special coating on the surface of the cell attracts the electrons, while the holes move to the back of the cell. This creates a voltage between the front and back of the cell, similar to the positive and negative terminals of a battery. The PV cells can be connected to an external circuit just as a battery would be.

One PV cell produces at most a few watts of electricity. This is a very small amount; so many cells are grouped together into the familiar solar panel to produce more electricity. A device called an inverter converts the direct current (DC) from the solar panels to alternating current (AC) for use throughout your home. Typical solar panels are between 10 and 20 percent efficient at converting sunlight into electricity. However, scientists are striving to develop more efficient materials and panels so that sunlight can be turned into electricity more efficiently.

Photovoltaic systems can be either stand-alone or grid-connected. In a grid-connected system, the PV cells are interconnected with the electrical utility (your local power company), so you can have power on cloudy days. The connection is through a standard utility meter that tracks your total power use while taking into account the electricity production from your solar panels. If your solar panels generate more power than your home needs, your electric meter actually reverses direction as you send energy back to the utility grid. This process is called net metering.

Some advantages of solar energy are:

- No emissions
- Renewable
- Solar panels on buildings do not impact the surrounding environment

Some disadvantages of solar energy are:

- More expensive than other forms of electricity generation
- Does not work at night and has reduced efficiency in cloudy conditions
- Current technologies have limited useful lives

Wind Power

Wind power is another excellent renewable source of electricity. According to the California Energy Commission in 2004, wind energy in California produced 4,258 million kilowatt-hours of electricity, or about 1.5 percent of the state's total electricity. That's more than enough electricity to light a city the size of San Francisco. If every bit of potential wind energy in the U.S. was harnessed, it could power the entire country.

Wind, created by the sun's uneven heating of the earth's surface, produces energy that is captured with wind turbines. Note the distinction between windmills and wind turbines: windmills **transfer** mechanical energy from wind to a machine to do things such as pump water and grind grain into flour; wind turbines **transform** the mechanical energy from the wind into electrical energy.

Wind turbines are generally located in areas with high average annual wind speeds, usually above 13 miles per hour. Wind power is more available during certain seasons because climatic conditions affect wind speed. In California, wind speeds are highest in the hot summer months, and approximately three-fourths of all annual wind power output is produced during the spring and summer. More than 13,000 of California's wind turbines, or 95 percent of all of California's wind generating capacity and output, are located in three primary regions: Altamont Pass (east of San Francisco), Tehachapi (south east of Bakersfield), and San Gorgonio (near Palm Springs, east of Los Angeles).

Wind power plants are made up of hundreds of individual wind turbines with huge blades mounted on 100-foot towers to capture as much wind as possible. The components of a utility-scale "wind farm" include wind turbines, an underground power transmission system, control and maintenance facilities, and a substation that connects the farm with the utility power grid.

Farms, homes, and businesses in windy locations, such as along the coast, can use smaller wind turbines, which can also be used (like solar cells) in areas where it is not feasible to run power lines because of the cost.

The cost of producing wind energy has decreased substantially. In 1993 it was about 7.5 cents per kilowatt/hour. Newer technologies may reduce the cost of wind energy to 3.5 cents per kilowatt-hour. This would make wind power much more affordable as an energy source.

Some advantages of wind power are:

- No emissions
- Renewable
- Easy and relatively quick to add capacity as needed
- New wind turbines produce electricity less expensively

Some disadvantages of wind power are:

- Use of large tracts of land disturb wildlife habitat
- Changes the view for neighboring communities
- Avian mortality due to collisions with wind turbines and associated wires
- Turbines are noisy (newer ones are quieter)

Hydropower

Hydro or waterpower is one of the largest producers of electricity in the United States, supplying about 10 percent of our electricity needs. In states with high mountains and lots of rivers, even more electricity comes from hydropower. In California, for example, about 15 percent of all the electricity comes from hydropower. It is considered a renewable energy source because the water is not consumed, but rather renewed through the natural water cycle.

Did You Know?

California was an early leader in the development of renewable energy for electricity generation in the U.S. and had 16 percent of the country's renewable electric capacity in 2006.

Hydroelectric power captures the kinetic energy of moving water to make electricity. Typically water is collected in a reservoir behind a dam, building up a pressure **head**. The water then flows through an intake system and is fed into a pipe called a penstock, leading to a hydraulic turbine. The water spins the turbine, which spins a generator to produce electricity.

On larger rivers, there is enough kinetic energy in the river current, so the water is sent directly to the powerhouse and the hydraulic turbine.

California's 386 hydropower plants are mostly located in mountain ranges like the Sierras and have a total dependable capacity of about 14,116 megawatts (MW) of capacity. California also imports hydro-generated electricity from the Pacific Northwest.

Although water is a renewable resource, large scale hydroelectric power is not included in the sources of electricity that meet California's goals to increase the renewable content of electricity generation. This is because of the negative environmental impacts of large-scale hydropower, some of which are listed below.

Some of the advantages of hydropower are:

- Hydroelectric dams produce electricity at a constant rate
- Electricity generation can be stopped and started to meet demand
- Reservoirs can be used for water sports and leisure activities
- Reservoir water can be used for irrigation purposes
- No emissions

Some of the disadvantages of hydropower are:

- Dams are extremely expensive to build
- Reservoirs permanently alter the environment, flooding habitat and changing water tables
- Dams prevent fish from reaching upstream spawning areas
- People living in the valley to be flooded must move out, losing their farms and businesses

Geothermal Power

Deep underground, the Earth's core is producing a significant amount of heat, which melts the rock and creates **magma**. As a result, the temperature of the Earth just a few feet below ground is between 50-60°F year round. People as far back as the Romans have taken advantage of this for things like preserving food. In places with a significant amount of seismic or volcanic activity, that magma is relatively close to the surface. The surrounding rocks or groundwater are so hot that they can be used for generating electricity.

There are three types of geothermal power plants, but they all use steam powered generators. Wells are drilled down to the hot rocks or water. Depending on the type of plant, either steam or hot water is brought to the surface. Steam is used directly in the generator. Hot water is either turned into steam or used to heat another liquid to make vapor (steam for a non-water liquid). Water is pumped back down into these reservoirs to maintain their pressure. The Geysers is a geothermal power plant located just north of the Bay Area. It produces a quarter of the green power in California.

Geothermal energy can also help reduce our demand for electricity. Because of the constant temperature below ground, any building can be heated and cooled with geothermal heat pumps. Pipes circulate water between the building and a few feet underground. In the summer, the heat in the building is transferred to the water, which is pumped underground where it cools. In the winter, the water coming back up from underground is warmer than the building and provides basic heating. This reduces our electricity needs because heating and air conditioning units usually require a lot of electricity.

Some advantages of geothermal energy are:

- Minimal emissions, which are easily captured and returned underground
- Renewable
- Available all day, year round
- Heat pumps can be used anywhere

Some disadvantages of geothermal energy are:

- Limited available locations for power plants
- Some plants make small amounts of solid waste
- Steam reservoirs can "dry up" for several years if not managed well

Biomass Power

Biomass energy comes from the organic matter that makes up plants and trees. People have used biomass energy such as burning wood for cooking and heat for thousands of years. Now we use it to generate electricity in two primary ways, waste-to-energy and biogas.

Waste-to-energy power plants burn the biomass fuel directly in boilers that supply steam for the same kind of steam-electric generators used in power plants burning fossil fuels. With **biogas**, bacteria digest biomass, which turns it into methane (the primary component of natural gas). Methane can then fuel a variety of power plant configurations, including steam generators and combustion turbines. This flexibility is the primary benefit of biomass gasification.

Biomass fueled power plants currently generate about 11,000 megawatts (MW), which is about 3 percent of the energy used in the United States, and the second largest source of renewable electrical energy in the nation.

Sources of biomass include food crops, grassy and woody plants, residues from agriculture and forestry, organic waste from household garbage, sewage sludge, and animal manure.

Sustained biomass energy production is carbon neutral (carbon is added and removed from the atmosphere in equal quantities). Biomass energy plants release CO_2, the primary greenhouse gas. However, the cycle of growing, processing, and burning biomass recycles CO_2 through the atmosphere with little or no net gain in CO_2.

Advantages of biomass energy:

- Diverts organic waste from landfills
- Can generate electricity at any time
- Captures energy from agricultural and forest waste previously burned solely for disposal

Disadvantages of biomass energy:

- Generates air pollution that varies depending upon the fuel and technology used
- Energy is required to collect, transport, process, and store biofuels

Nonrenewable Energy Sources

About 81% of the commercial energy consumed in the world comes from nonrenewable energy resources (75% from fossil fuels and 6% from nuclear power). And about 91% of the commercial energy used in the United States comes from nonrenewable energy resources (84% from fossil fuels and 7% from nuclear).

About 345 to 280 million years ago, the world was mostly covered with plants and vegetation, which grew in swamps. This vegetation died off and became submerged under water, where it gradually decomposed, lost oxygen and hydrogen atoms, and left carbon-rich deposits. Peat (partially decayed vegetable matter) formed first. Then over time, the deposits were buried deeply, where heat and pressure changed them to **fossil fuels**. Some deposits turned into coal, some into oil, and some into natural gas.

How Much is Left

By definition, a non-renewable resource can be depleted. How long the resource will last is a difficult question to answer. You need to know more than how much is left, and how fast it is being used. First of all, consumption rates will change as prices and technologies change. There is the possibility of reserves we haven't found or of new technologies that will allow us to reach previously unreachable reserves. Estimates from the most reputable groups on how long fossil fuels will last do not agree. Numbers range from 3-4 decades (usually natural gas or oil) to 3-4 centuries (usually coal). If the lower range is correct, the students we teach will see these resources run out in their lifetimes.

Coal

Nine out of every ten tons of coal mined in the United States today are used to generate electricity, and more than half of the electricity used in this country is coal-generated. In the United States coal is relatively abundant and easy to get to, so it is very cheap. It is also easy to transport and store compared to other fuels.

Because of land disturbance, air pollution, CO_2 emissions, and water pollution, coal has the highest environmental impact of any fossil fuel. In the U.S., electrical power generation (mostly from coal) is the second largest producer of toxic emissions. According to an EPA study, the most threatening material released by coal burning power plants is mercury, which can be harmful to human and animal health.

> **Did You Know?**
>
> Electricity production is generally cleaner in California than elsewhere in the United States, due to large amounts of natural gas, hydro- and nuclear power and small amounts of coal-generated power, as well as the state's history of investments in renewable resources.

Advantages of Coal

- Produces a high amount of energy relative to the energy used to mine and process it
- Low cost
- Easy to transport and store

Disadvantages of Coal

- Severe land disturbance, especially from surface mining
- Releases radioactive particles and mercury into the air
- High air and water pollution
- High CO_2 emissions

Natural Gas

Approximately 22 percent of the energy consumed in the U.S. comes from natural gas. More than 62 percent of the homes in the U.S. use natural gas as their main heating fuel. Natural gas burns cleaner than other fossil fuels emitting less sulfur, carbon, and nitrogen oxides than coal or oil, as well as leaving almost no ash particles. Being a cleaner fuel is one reason that the use of natural gas, especially for electricity generation, has grown so much and is expected to grow even more in the future.

Using sophisticated methods, geologists locate potential oil and gas deposits underground, and then drill a well down to them. If gas is found, it flows up through the well and into large pipelines. The main ingredient in natural gas is **methane**. Some of the other components, such as butane and propane, are separated as byproducts, and are used in a number of ways. For example, propane can be used for cooking on gas grills.

Because natural gas is colorless, odorless and tasteless, mercaptans (chemicals that have a 'rotten egg' odor) are added before distribution. This is a safety measure, because a leak is easily detected by the odor.

Advantages of natural gas

- Produces a high amount of energy relative to the energy used to collect it and process it
- Low cost
- Less air pollution than other fossil fuels
- Easily transported by pipeline

Disadvantages of Natural Gas

- Releases CO_2 when burned
- Unburned natural gas released into the atmosphere from pipeline leaks is a powerful greenhouse gas
- Highly explosive

Oil

Oil is the largest source of energy in the United States, providing close to 40 percent of the nation's power needs. Though most oil is used for transportation or home heating, a small percentage is still used as a fuel for plants generating electricity. Petroleum or crude oil is a thick liquid consisting of hundreds of combustible hydrocarbons, along with small amounts of sulfur, oxygen, and nitrogen.

Burning oil to generate electricity produces significant air pollution. Nitrogen oxides, sulfur dioxide, particulates, CO_2, methane and other greenhouse gases, heavy metals such as mercury, and volatile organic compounds all can come out of the smoke stack of an oil-burning power plant. Sludge and oil residues that are not consumed during combustion are a solid waste burden that contains toxic and hazardous wastes.

Drilling and refining oil produces a long list of air pollutants, toxic and hazardous materials, and emissions of hydrogen sulfide, a highly flammable and toxic gas. All of these emissions can impact the health and safety of workers and wildlife.

Drilling for oil causes only moderate damage to the Earth because the wells don't take up much land. However, oil companies have begun to extract oil from fragile environments like the Arctic tundra in Alaska and the ocean floor. Accidents have happened where large amounts of oil were released into the ocean, killing marine and bird life and disrupting marine ecosystems.

Advantages of Oil

- Produces a high amount of energy relative to the energy used to collect and process it
- Historically, one of the least expensive forms of energy
- Easily transported within and between countries
- Low land use

Disadvantages of Oil

- Creates air pollution when burned
- Releases CO_2 when burned
- Accidental spills have major environmental impact

Nuclear Power

Nuclear energy is energy in the **nucleus** (core) of an **atom**. Atoms are tiny particles that make up every object in the universe. There is enormous energy in the bonds that hold atoms together. Nuclear energy can be used to make electricity, but first the energy must be released either by nuclear fusion or nuclear fission.

In **nuclear fusion**, energy is released when the nuclei of two atoms combine or fuse together to form a larger atom. This is how the sun produces energy. As yet, no one has developed a means of using nuclear fusion for energy generation.

In **nuclear fission**, the nucleus of an atom is split apart to form smaller atoms, releasing energy in the form of heat. In a nuclear fission reactor, neutrons split the nuclei of atoms such as uranium-235 and plutonium-239 and release a great amount of energy mostly as heat that is used to make steam.

The U.S. nuclear power industry, while currently generating about 20% of the nation's electricity, faces an uncertain long-term future. No nuclear plants have been ordered since 1978. High construction and operating costs are part of the problem, but the radioactive waste is the biggest problem with nuclear energy.

We do not know what to do with the radioactive waste that is dangerous for hundreds or thousands of years. Low-level nuclear waste (such as equipment, tools, and protective clothing) has been put it into steel drums and dumped into the ocean or into a few landfills. Unfortunately, the ocean environment has begun to erode a lot of these drums and radioactive waste has leaked out. We do not have a good idea at this point what the extent of damage from this will be.

High-level radioactive wastes are extremely dangerous if not handled properly. This waste must be safely stored for at least 10,000 years and up to 240,000 years. Some proposed disposal methods have been to bury it deep underground, shoot it into space, bury it under the Antarctic ice sheet, or bury it in thick mud deposits in the ocean floor. Yet, after 50 years of research, scientists still do not know if any of those methods would work or be safe.

Advantages of nuclear power:

- Emits 1/6 as much CO_2 as coal (mostly from mining and processing the uranium)
- Power plants themselves have low environmental impact (without accidents)
- Moderate land disruption and water pollution
- Low risk of accidents when multiple safety systems are in place.

Disadvantages of nuclear power:

- High cost
- Accidents have high environmental impacts
- No acceptable solution for long-term storage of radioactive wastes
- Spreads knowledge and technology for building nuclear weapons

Improving our Energy Efficiency

Improving energy efficiency is one of the most important ways that we can reduce the amount of electricity we need to produce. **Energy efficiency** is defined as the percentage of total energy put into a device or system that does useful work; the rest is lost, as it becomes a form of energy the system doesn't use. For example, an incandescent light bulb creates light (useful work) and heat (unused energy). Compact fluorescent lights create less heat and therefore are more efficient.

Did You Know?

The City of San Jose plans to create 50 million square feet of "green" municipal buildings that will be considerably more energy efficient.

You may be surprised to learn that 43% of all commercial energy used in the U.S. is wasted unnecessarily. This is mostly from inefficient motor vehicles, furnaces, appliances and other devices, and from poorly insulated and poorly designed buildings that allow the heated or air-conditioned air to escape, making it necessary to heat or cool new air.

Windows are usually the primary source of energy loss. Well caulked, double-pane windows cut down on this loss. Well-insulated walls, attics, and basements or crawlspaces will also make a big difference in the energy loss. Most utility companies will come out to your house for little or no charge and perform an infrared scan of your house and see where the heat is escaping and to show you where you need to improve your insulation.

Everything we do each day to save energy or use it more efficiently makes a difference. In our own homes some ways to improve our energy efficiency are quite simple. An internet search will give you a number of websites with suggestions. Some of these sites are listed in the resource section at the end of this guide.

Global Climate Change – It's All about Carbon

The Carbon Cycle

Carbon is an element on which all life on Earth is based. Carbon compounds are the major chemical components of organic matter, plants and animals, both living and dead. It is abundant on the earth's surface, although it is usually found combined with other elements. The most common is CO_2, made of one carbon and two oxygen atoms.

Large occurrences of stored carbon are called **sinks**. Some of these sinks include (1) the biosphere, as organic molecules in living and dead organisms; (2) atmospheric CO_2; (3) organic matter in soils; (4) the lithosphere (rocks) as fossil fuels and certain rock deposits; and (5) the oceans as dissolved CO_2 and as calcium carbonate shells in marine organisms.

> Did You Know?
>
> The city of Palo Alto adopted a Climate Protection Plan that, among other things, provides incentives for companies to support telecommuting (working from home), and installs solar heating on all city pools.

Carbon easily moves from sink to sink. This movement results in what we call the **carbon cycle**. The basic cycle has two parts. The short-term cycle works over a period of days, months, or years. The long-term cycle works over a period of thousands, or millions of years.

In the short-term cycle, plants take CO_2 from the air and through **photosynthesis** produce sugars that contain the carbon atoms. Carbon moves from plants to animals through food webs. The carbon that is in plants moves to the animals that eat them (herbivores). Animals that eat other animals (carnivores) get the carbon from the herbivores they eat. Carbon moves from living things to the atmosphere. Animals and plants give off CO_2 gas through **respiration**. Each time you exhale or breathe out, you are releasing CO_2 into the atmosphere. We often don't think of plants "breathing out", but as they use the sugars made during photosynthesis, they create CO_2 just like animals and must get rid of it through their pores.

In the long-term cycle, carbon moves from plants and animals to the ground when plants and animals die and decay. Organisms that decay in the open release their carbon as CO_2

into the air. If they are buried, the carbon goes into the soil, where some of it becomes buried thousands of feet underground and then becomes fossil fuels after millions of years. This carbon can return to the atmosphere naturally through volcanic eruptions. However, this happens at such a slow rate, the carbon in fossil fuel deposits is considered **sequestered** as it is removed from the everyday carbon cycle.

There are a number of additional paths in the carbon cycle. Two important ones involve the CO_2 in the oceans and in soil. Carbon moves between the atmosphere and the oceans through **diffusion**. Diffusion means the CO_2 is moving from an area of high concentration to low concentration. In theory the concentrations between the ocean and the atmosphere would become balanced and CO_2 would stop moving between the two. In the environment however, the winds blow, the ocean currents flow, and temperatures change. These and many other factors result in changing concentrations at a given point and thus, CO_2 is constantly moving between the ocean and the atmosphere.

Similarly, carbon in soil and rocks can move to the atmosphere or the oceans, although by different processes. Soil is a dynamic environment filled with plant roots, insects, worms, and bacteria. All of these things are going through their own biological processes releasing CO_2 (**soil respiration**). In addition, the soil itself is going through chemical and physical processes, such as oxidation, which releases CO_2. New rocks and soil are exposed to the atmosphere through earthquakes, mudslides, weathering, and other forms of erosion.

Human Contributions to the Carbon Cycle

About 7.2 million people currently live in the San Francisco Bay Area. In 2006, the nine counties that comprise the Bay Area emitted 74,554,512 tons of CO_2 through their use of fuels and electricity —the equivalent of about 10.5 tons per resident. Adding this much CO_2 to the atmosphere has a significant impact on the natural carbon cycle.

When we burn fossil fuels like coal, oil, and natural gas to power factories, power plants, and cars and trucks, we release the sequestered carbon drastically more rapidly. Each year, 5.5 billion tons of carbon are released by burning fossil fuels. Of this huge amount, 3.3 billion tons remain in the atmosphere and most of the rest dissolves in the ocean water. We currently have no way to return this carbon to the fossil fuel sinks where it is fully sequestered.

> Did You Know?
>
> California's population is forecast to increase 11% by 2020.

In addition to burning more fossil fuels for industry, transportation, electricity and other uses, we have greatly changed our natural vegetation and forest ecosystems. Remember that plants, including trees, absorb CO_2. About 35% of the extra CO_2 now found in the atmosphere is from deforestation and the conversion of prairie, woodland, and forested ecosystems to agricultural and urban uses. Research shows natural ecosystems can hold 20 to 100 times more CO_2 per unit area than agricultural lands.

The Greenhouse Effect

The **greenhouse effect** is the process through which certain gases in the atmosphere (water vapor, CO_2, nitrous oxide, and methane, for example) trap energy from the sun in the form of heat. Without these gases, heat from sunlight would immediately escape back into space and Earth's average temperature would be about 60ºF colder. The heat these gases trap helps to warm the Earth's surface and actually makes life on Earth possible, so why are we so concerned about the greenhouse effect?

When energy from the sun reaches Earth's atmosphere, some of it is reflected back into space, and clouds and other particles in the atmosphere absorb some of it. About half of the energy from the sun reaches the surface. As the surface warms, the heat is radiated back into the atmosphere. Some of that heat escapes back into space, but a portion of it is trapped in the atmosphere. The amount that remains in the atmosphere is controlled in part by cloud cover, but more importantly by the concentration of greenhouse gases in the Earth's atmosphere. A small amount of greenhouse gases keep the planet's temperature livable. However, as the concentration increases, so does the amount of heat that is retained.

Scientists predict that as greenhouse gases accumulate, the Earth's climate will become warmer. Computer models suggest that doubling of the concentration of the most worrisome greenhouse gas, CO_2, may raise the average global temperature between 2 and 11.5 degrees Fahrenheit, which could lead to an uncontrollable, or runaway greenhouse effect, causing massive global ecosystem disruptions.

We know all of the major greenhouse gases have increased in concentration for about the past 250 years, and all of those increases appear to be driven by human activities. We know the most about the increase in CO_2. Burning more and more fossil fuels has resulted in an estimated 30% increase in CO_2 in the air today than there was 150 years ago. Dr. Charles Keeling began measuring the CO_2 levels at Mauna Loa observatory in Hawaii in 1958. These measurements show a seasonal fluctuation in CO_2 levels (high in the spring, low in the fall), but a dramatic increase in CO_2 levels year over year. The resulting graph is known as the Keeling Curve. This research was combined with CO_2 measurements from ice cores to get a picture of levels for the past 400,000 years. CO_2 levels fluctuate over a period of 100,000 years, but current CO_2 concentrations are about 30% above previous peak levels during the past 400,000 years.

Other greenhouse gases have also increased, but the specific causes are less understood. Methane for example, is given off from swamp-like rice paddies, which have greatly increased, but it is also given off in swamps, which have greatly decreased. Scientists continue to study the issue because greater understanding will help us reduce greenhouse gases in the atmosphere and prevent a runaway greenhouse effect.

Why Do We Care?

Scientists observed changes in the climate as temperatures slowly rose during the 20^{th} century. Some changes they have documented include an increase in global average surface temperature of about 1°F, a decrease of snow cover and sea ice, the retreat of mountain glaciers, a rise in global average sea level, an increase in ocean water temperatures, and an increase in the frequency of extreme precipitation events in some regions of the world (flooding, much greater snowfall, more severe hurricanes, etc.)

These climatic changes have lead to a variety of physical and ecological changes such as a longer growing season in middle and high latitudes, adaptation by certain plant and animal species such as earlier reproduction (producing flowers, laying eggs, etc.) or moving to higher altitude or latitudes, and a decline of some plant and animal species that are unable to adapt.

In the Bay Area, a significant part of our water supplies are held in the Sierra Mountains as snow pack. Warmer temperatures would reduce the amount of snow pack that forms in the winter months. Assuming the amount of precipitation remained constant more would fall as rain and flow immediately down the rivers overflowing reservoirs and flooding neighborhoods. Then as the summer progressed, the snow pack would melt away before the fall leaving the last couple of months with no source of water.

If global climate change continues at the present rate, reduced snow pack won't be our only concern. Over the next 100 years we may see a rise in sea level between 3.5 and 34.6 inches, leading to more coastal erosion, flooding during storms, and permanent inundation in low-lying areas such as Bangladesh or the Mississippi River delta. Warming will also likely cause severe stress on many forests, wetlands, alpine regions, and other natural ecosystems; greater threats to human health as mosquitoes and other disease-carrying species spread warm climate diseases farther north and south; and disruption of agriculture in some parts of the world due to increased temperature and decreased water supplies.

Carbon Footprint and Reducing Our Impact

One of the ways that we can measure how much impact we are having on the environment is to calculate our "**carbon footprint**." A carbon footprint can be found by taking our activities and measuring how much greenhouse gases we produce (specifically units of CO_2), and then comparing that amount to what we think the Earth can sustain. Some say that a typical citizen of industrialized countries uses as much energy in six months as a typical citizen in a developing country consumes during their entire life.

> **Did You Know?**
>
> The Happy Hollow Zoo just south of downtown San Jose installed water dispensers for staff and volunteers, so they are no longer buying bottled water.

There are several websites that have carbon footprint "calculators" to help you measure the amount of CO_2 you may be generating. You are asked questions about the size and type of home you live in, the number of vehicles you or your family owns, how many miles you drive each week, what type of fuel you use to heat your home, and so on. Based on your answers, it calculates the amount of CO_2 you and your family produce in a year and compares it to the average amount produced by others in your country and those in other countries. It then provides you with suggestions on how you can begin to reduce your carbon footprint.

The major contributor to our carbon footprints, and thus to climatic change, is the use of fossil fuels for energy. Advances in the technology of renewable energy sources can reduce our reliance on fossil fuels and would reduce global emissions of CO_2 significantly. There are also many things being done or considered on a global and industrial scale to reduce climate changing activities and consequences, such as replanting significant tracts of forests to withdraw carbon from the atmosphere.

The appendix contains a list of things that fourth and fifth graders can do themselves. An internet search will give you a variety of sources with ideas for things we can all do. Some of these sources are listed in the resources section.

Appendix

Resources

Education
The NEED Project: Putting Energy into Education:
http://www.need.org/EnergyInfobooks.php

The U.S. Environmental Protection Agency's Energy Star Program for Kids:
http://www.energystar.gov/index.cfm?c=kids.kids_index

Pacific Gas and Electric Company's Energenius Educational Series:
http://www.pge.com/energenius/

The California Energy Commission's Bright Schools program:
http://www.energy.ca.gov/efficiency/brightschools/

The U.S. Department of Energy's Energy Kids Page:
http://www.eia.doe.gov/kids/energyfacts/science/formsofenergy.html

Project Learning Tree Energy & Society Program:
http://www.plt.org/cms/pages/21_44_19.html

The California Environmental Protection Agency (Cal/EPA) and the California Integrated Waste Management Board (CIWMB) Education and the Environment Initiative at:
http://www.calepa.ca.gov/education/eei/

Energy Savings
Carbon Footprint:
http://www.carbonfootprint.com

Cool It – collaboration of Acterra, Sierra Club, and 3Degrees
http://www.cool-it.us

We Energies:
http://www.we-energies.com/residential/energyeff/101tips.htm

The U.S. Environmental Protection Agency (EPA):
http://www.epa.gov/climatechange/emissions/ind_calculator.html

WikiHow – How to Reduce your Greenhouse Gas Emissions:
http://www.wikihow.com/Reduce-Your-Greenhouse-Gas-Emissions

Science Background
Role of the ocean in the carbon cycle:
http://www.waterencyclopedia.com/Bi-Ca/Carbon-Dioxide-in-the-Ocean-and-Atmosphere.html

Role of soil in carbon cycle
http://www.vaisala.com/instruments/products/carbondioxide/gmp343/product documentation/vaisalanews/diffusion-based soil respiration measurements.pdf

Keeling Curve – trends in atmospheric CO_2
http://scrippsco2.ucsd.edu/program_history/keeling_curve_lessons.html

Overview of environmental cycles, including the carbon cycle.
http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/earth_system/biogeochemical_cycles.html

In depth description of carbon cycle
http://earthobservatory.nasa.gov/Features/CarbonCycle/carbon_cycle2.php

What Can Kids Do?

Here is a list of things kids can do to reduce their electricity use and their carbon footprint.

Lighting

- Change your light bulbs from incandescent ones to compact fluorescent light bulbs.
- Turn off lights when you leave the room.
- Use natural lighting from windows whenever possible.

Appliances

- Unplug your cell phone charger, TV, and other electronics from the wall when you are not using them, because they use energy when plugged in and on standby. The process can be made easier if you have everything plugged into a surge protector with its own switch.
- Check your thermostat. Chances are you don't need the heating on at all in the summer, and in the winter you can turn it down a little and wear extra layers of clothes.
- Set the refrigerator temperature between 36 and 42 degrees F. Set the freezer control between –5 and +6 degrees F.
- If you're leaving your computer for a while, put it on stand-by. You'll be able to restart it quickly, and it'll take less energy than shutting it down and then restarting it.

Water

- Don’t leave the water running when you brush your teeth or wash your face.
- Take shorter showers or use less water in the bathtub.
- Use a low-flow showerhead.
- Make sure all faucets are turned off and are not dripping.
- Instead of running the faucet until the water gets cold, fill up a pitcher and keep it in the refrigerator for when you need a drink.
- Do not use water that comes in plastic bottles. It takes a lot of energy to make that plastic and more energy to recycle it. Use tap water and a refillable water bottle.

Food

- Eat locally. Fruit and vegetables in supermarkets and most markets are often shipped or flown from distant countries, even if they can easily be grown locally. This requires the burning of fossil fuels for transportation, so buying locally grown produce can save a lot of oil.
- Grow your own food. Planting things like berry bushes, garden vegetables, and herbs will help you eat locally so you won't have to worry about food miles.

Travel

- Buy a bike and use it. With gas prices so high, it will pay for itself. Ride it to work, to run errands, or to have fun.
- Walk short distances rather than drive. It may be convenient to drive, but let's face it, it probably takes longer than walking would, and emits pollutants to boot.

Recycling

- Learn what can go into your family’s recycling bin and what needs to be cleaned or otherwise prepared for the recyclers-then do it!
- If you are away from home and can’t find a recycling bin for your cans or bottles, put them in a bag and carry them home to your recycling bin.

Glossary

Atoms – tiny particles that make up every object in the universe.
Biogas – bacteria digest biomass, which turns it into methane (the primary component of natural gas).
Carbon – an element on which all life on Earth is based, including organic matter, plants and animals, both living and dead. It is usually found combined with other elements.
Carbon cycle – The movement of carbon through the environment from sink to sink.
"**Carbon footprint**" – looking at our daily activities and measuring how much greenhouse gases we produce (specifically units of CO_2), and then comparing that amount to what we think the Earth can sustain.
Circuit – a continuous path of conducting material through which electricity can flow.
Conductor – material made of atoms that easily release or collect electrons, helping the flow of electricity.
Current – flowing electrons of electrical energy. Electrons always flow away from negative and toward positive charge.
Diffusion – the process by which a molecule (like CO_2) moves from an area of high concentration to one of low concentration.
Electricity – movement of electrons along a conducting material.
Electrons – tiny negatively charged particles in an atom.
Energy – the ability to generate heat or do work. (In physics work essentially means to make things move).
Energy efficiency – the percentage of total energy put into a device or system that does useful work; the rest is lost as it becomes a form of energy the system doesn't use.
First Law of Thermodynamics – also called the **Law of Conservation of Energy**, states that energy can neither be created nor destroyed; it can only be converted from one form of energy to another.
Fossil fuels – carbon-rich deposits made over the course of millions of years from dead plants and vegetation. Deposits may be coal, oil, or natural gas.
Generator – a device that converts mechanical energy into electrical energy.
Greenhouse effect – the process through which certain gases in the atmosphere (water vapor, CO_2, nitrous oxide, and methane, for example) trap energy from the sun in the form of heat.
Head pressure – the force created by the weight of water in a reservoir at a hydroelectric dam.
Insulator – material that has no mobile electrons, thus preventing the flow of electricity.
Load – something to be powered, such as a light bulb, a computer, or a heater, inserted into the path of a circuit.
Lumen – the measure of light output.
Magma – rock melted by the heat of the Earth's interior. Usually found deep underground but occasionally comes near or to the surface in fault zones or volcanic eruptions.
Methane – the main ingredient in natural gas.
Non-renewable energy resources – an energy source that cannot be replaced once it is used up, such as fossil fuels.
Nucleus – the center of an atom, which holds a great deal of energy.

Nuclear fusion – the nuclei of two atoms combine or fuse together to form a larger atom, releasing a great deal of energy.
Nuclear fission – the nucleus of an atom is split apart to form smaller atoms, releasing energy in the form of heat.
Photons – packets of energy that make up light or heat.
Photosynthesis – process through which plants take CO_2 from the air and with water and sunlight produce sugars.
Photovoltaic – any technology that converts solar energy into electricity.
Potential energy – energy that is not doing work or generating heat right now.
Renewable energy resources – an energy source that cannot be used up, such as the sun's energy.
Resistance – the degree to which a material opposes electrical current.
Respiration – process through which animals and plants metabolize sugars (from food or made during photosynthesis) and give off CO_2 gas.
Second Law of Thermodynamics – states that each time energy is converted from one form to another, some of the energy is degraded to a less useful form; usually heat.
Secondary source of energy –another energy source must be transformed to get this kind of energy, e.g. electrical energy.
Sequestered – carbon stored in sinks such as fossil fuel deposits where it stays long enough to be ignored when looking at the everyday carbon cycle.
Sinks – large occurrences of stored carbon.
Soil respiration – plant roots, insects, worms, and other living things in soil go through their own biological processes releasing CO_2.
Sustainability – the ability of our society to meet our needs today without compromising the ability of future generations to meet their needs.
Transfer (of energy) – moving energy from one object to another without changing the kind of energy.
Transform (energy) – the change of energy from one form to another (e.g. mechanical to electrical).
Transformer – a device that changes the voltage level but not the power level of electricity.
Turbine – a fan-like device attached to a generator that rotates when a liquid or gas is forced through it.
Voltage –the difference in the charge in two places (such as the two terminals of a battery) creating potential energy difference that can eventually do work to move electrons. The size of the difference is measured in volts.
Waste-to-energy – power generated in plants that burn waste materials (biomass) in boilers that supply steam for generating electricity.
Watt – the amount of work done by a certain amount of electric current
Watt-hour – the amount of energy in watts used over a period of one hour. A 60-watt light bulb turned on for one hour, uses 60 watt-hours. It can also be measured in different factors of watts or time (kilowatt-seconds, megawatt-days, etc.)

ENERGY AND NATURAL RESOURCES LEARNING STATION MATRIX

Title	Grades	Kit Includes	Early Prep	Possible Intro?	Short?	Lending Library?	Description	Learning Objectives
ENR-01: Electricity Name Game	4	1 binder	None	Yes	No	No	Students choose a new last name using electricity words and devices as inspiration, and learn that many electronic devices continue to use power when turned off.	We use electricity in a variety of ways. Some things use electricity even when we turn them off.
ENR-02 Energy Efficiency	4	1 bag, 1 box	None	No	No	No	Students learn that producing unwanted heat, light, or motion makes a device less efficient. They see that energy efficient light bulbs produce less heat than regular light bulbs.	For the same light output, more 'hand-cranking' energy and more electrical energy is needed to light an incandescent bulb than is needed to light a compact fluorescent bulb. An incandescent bulb converts the extra energy into heat.
ENR-03: Electricity Generation	4	2 bags	None	No	No	No	Students explore how to generate electricity from wind, water, and solar sources.	There are many ways to generate electricity, most of which involve spinning a turbine. Solar panels are made of individual cells, which absorb energy from the sun to produce electricity. Wind turbines capture the energy of the wind to spin a turbine to produce electricity. Hydropower dams use the pressure from the water in the resevoir to spin a turbine to produce electricity.
ENR-04: Electrical Supply and Demand Game	4	1 bag	None	No	No	No	Students, acting as a town council, make decisions to develop the town balancing the power requirements with power production.	The balance of electrical supply and demand is an important part of city planning. We must be thoughtful about how we use electricity. There are a variety of ways we can use electricity more efficiently.

ENERGY AND NATURAL RESOURCES LEARNING STATION MATRIX

Title	Grades	Kit Includes	Early Prep	Possible Intro?	Short?	Lending Library?	Description	Learning Objectives
ENR-05: Electricity Generation: Advantages and Disadvantages	4	1 bag, 1 visual	None	No	No	No	Students discuss the advantage and disadvantages of different sources of electrical power.	Considering tradeoffs involves looking at both the advantages and disadvantages before deciding which choice is best.
ENR-06: Introduction to the Carbon Cycle	5	1 visual, 1 binder	None	Yes	No	No	Students build a display that illustrates the basic carbon cycle.	Carbon moves from the atmosphere, to plants, then to animals and back to the atmosphere in the short term carbon cycle. Carbon moves from dead plants and animals deep underground where it becomes fossil fuels. It is returned naturally to the atmosphere through volcanic eruptions, erosion, etc. as part of the long term carbon cycle.
ENR-07: Human Influence on the Carbon Cycle	5	1 box	None	No	Yes	No	Students play a game that demonstrates the impact of human activity (cars, industry, etc.) on the carbon cycle.	Human activities such as driving cars, manufacturing, and generating electricity releases CO2 into the atmosphere faster than our planet can return it underground.
ENR-08: Greenhouse Effect	5	2 boxes, 1 visual	Fill CO2 bottles	No	No	No	Students play a game that demonstrates the greenhouse effect and how greenhouse gases contribute to global climate change.	Greenhouse gases, particularly Carbon Dioxide, absorb heat better than air. Increased greenhouse gases (especially Carbon Dioxide) return more heat toward earth, increasing the surface temperature.

ENERGY AND NATURAL RESOURCES LEARNING STATION MATRIX

Title	Grades	Kit Includes	Early Prep	Possible Intro?	Short?	Lending Library?	Description	Learning Objectives
ENR-09: Carbon Footprint Game	5	1 bag	None	No	No	No	Student discover how the choices we make in how we live changes the impact we have on our environment.	Choices consumers make affect their carbon footprint. These choices include driving and flying habits, food choices, gas, water and electricity use, purchases, recycling and composting. As children mature and make more decisions, their ability to change their carbon footprint increases.
ENR-10: Climate Change Impacts – Snow Pack	5	1 box	None	No	No	No	Students learn how global climate change will impact our lives, specifically how a reduction in snow pack in the Sierras changes the availability of water for the Bay Area.	Global climate change will have local impacts. Warmer weather will reduce the amount of snow in the CA Sierras, which helps store water for the Bay Area throughout the year.
ENR-11: Making a Differnce for Climate Change Brainstorm	5	None (same binder as ENR-06)	None	Conclusion	Yes	No	Students will use what they learn to brainstorm a list of things they can do to make a difference and help curb global climate change.	