Your Renewable Energy World

Discover...
All the different forms of energy.

Explore...
Energy from ocean waves and tides.

Investigate...
Pinwheel physics and energy from the wind.

The way we use energy is Changing

Most of the energy we use today comes from nuclear energy and from fossil fuels: coal, oil, and natural gas. These energy resources are nonrenewable, which means that once we use them up, they are gone forever. Before that happens we need to learn to use more renewable energy from resources that will not run out, such as the sun, wind, and moving water.

Many scientists believe that our climate is changing because of the carbon dioxide (CO_2) that is released as a result of human activities, including the burning of fossil fuels. Renewable energy is sometimes called "green power" because it does not create as much CO_2 as energy made from fossil fuels, and is therefore better for the environment. (While nuclear energy is not considered a renewable energy resource, it also does not produce CO_2.)

Advantages of Renewable Energy Resources

- They can be replenished.
- They produce significantly fewer CO_2 emissions than fossil fuels.
- They are cleaner and do less damage to the environment than fossil fuels.
- They help build a sustainable energy future.

Challenges of Renewable Energy Resources

- Harnessing and distributing renewable energy resources can be more expensive than using fossil fuels.
- Many renewable energy resources are limited by weather, the time of day, or geography.

BRAIN BLAST!

Renewables Brainstorm

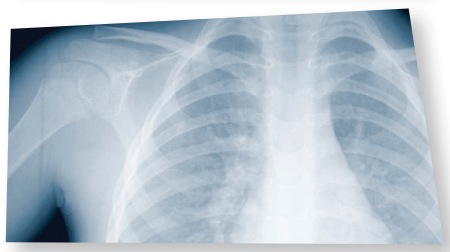
Set a timer for three minutes. With a partner, see how many types of renewable energy resources you can think of without looking inside this booklet. Make a list and share it with your class.

What is Energy?

Energy is the ability to do work. We use different forms of energy for different types of work:

Mechanical energy moves objects from one place to another. You use mechanical energy when you throw a ball.

Electrical energy comes from the movement of ***electrons*** through a conductor, such as a copper wire. (Electrons are parts of ***atoms***, the tiny particles that make up every object on Earth.) Lightning is a natural form of electrical energy.



Radiant energy moves in waves through space. Light, X rays, and radio waves are forms of radiant energy.

Chemical energy is stored in the chemical bonds that hold together atoms and ***molecules***. A molecule is a particle formed from two or more atoms bonded together. Digestion releases chemical energy stored in food. The burning of fuels like wood, coal, and natural gas is a chemical reaction that releases heat.

Thermal energy is created by the movement of atoms and molecules, and is released as heat.

Nuclear energy is stored in the ***nucleus***, or the center, of an atom. It is released when the nucleus splits into many pieces in a process called ***fission***, or when two ***nuclei*** are forced together to form a larger nucleus in a process called ***fusion***.

Word Find

Energy-related words and phrases are in **green** in this booklet. Find them and list them on a sheet of paper.

Choose 10 words that are new to you, and use this booklet or a dictionary to find and write their definitions. **Bonus:** Create your own crossword puzzle or word search with your 10 words and share it with a classmate.

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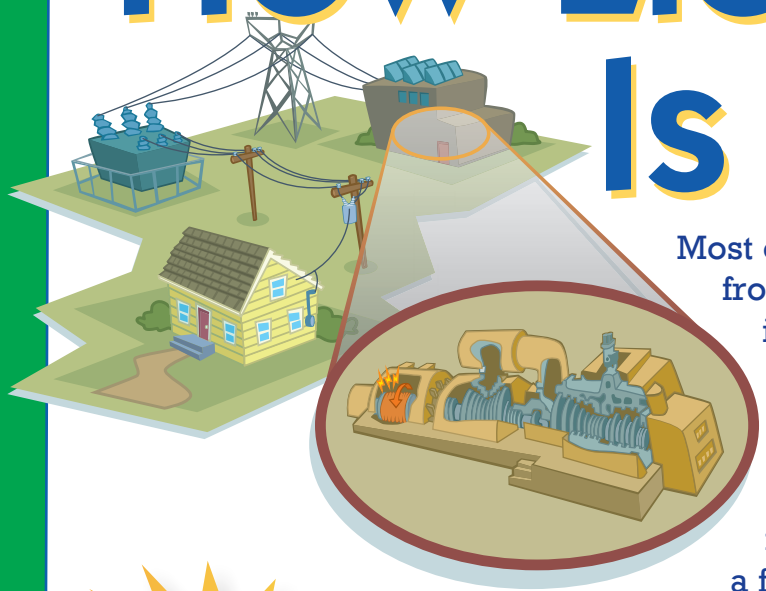
The generation situation:

How Electricity Is Made



Most of the electricity people use comes from power plants. Inside a power plant is a device called a ***generator***. An energy source turns the blades of a ***turbine*** inside the generator, which spins a magnet near a coil of wire. The spinning magnet causes the electrons in the coil of wire to flow. This generates a flow of electricity, which is sent through power lines to where it is needed.

Unscramble the letters and fill in the name of each energy resource that is described in the sentences below. (If you need some clues, look at the pages shown.)

How renewable energy resources generate electricity:

1. The force of moving air turns the blades of small turbines on tall towers.
   __ __ __ __ __ __ __ __ __ (p. 12)
   N I W D R E P W O

2. Water is released from dams to turn large turbines.
   __ __ __ __ __ __ __ __ __ __ (pp. 10-11)
   Y H R D P O E W R O

3. Steam or hot water is piped up from deep inside the earth, pressurized, and then used to turn turbines. __ __ __ __ __ __ __ __ __ __ (p. 13)
   L A T E H R G O E M

4. Farm and lumber waste, energy crops, or methane gas from rotting garbage is burned to heat water into steam that turns turbines.
   __ __ __ __ __ __ __ (p. 14)
   S S I O M A B

5. Special panels of solar cells capture sunlight and convert it directly to electricity that can be used or stored. The sun's energy can also be used to heat water into steam to turn turbines. __ __ __ __ __ __ __ __ __ __ (p. 8)
   O S A L R O P W R E

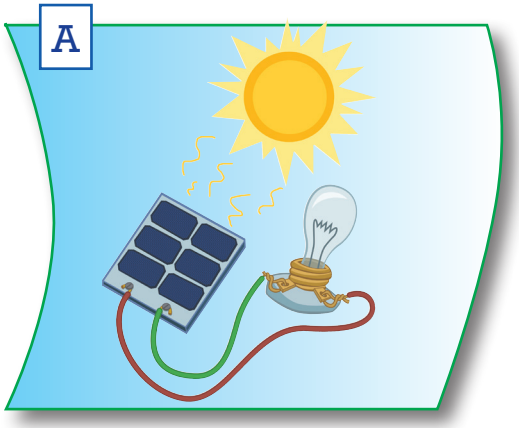
Which circuits WILL WORK?

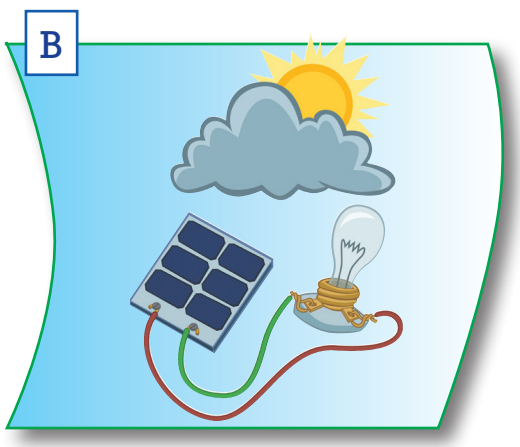
No matter what types of resources are used to generate electricity, it will only flow along a looped pathway called an ***electrical circuit***. A circuit begins and ends at an energy source, such as a power plant, a battery, or a solar cell like the one shown below.

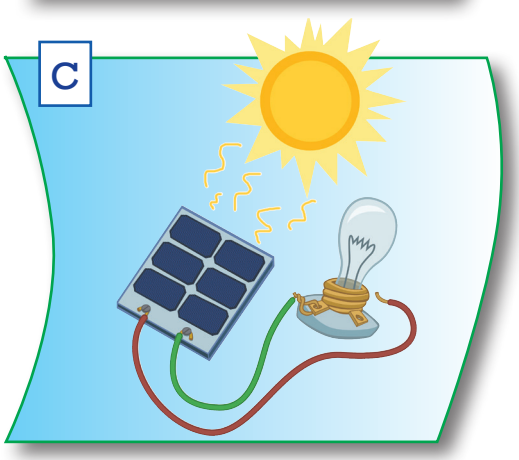
When an electrical circuit is closed, current can flow all the way around it without stopping, and the electricity is on. When a circuit is open, a gap or obstacle keeps the current from going all the way around, and the electricity is off.

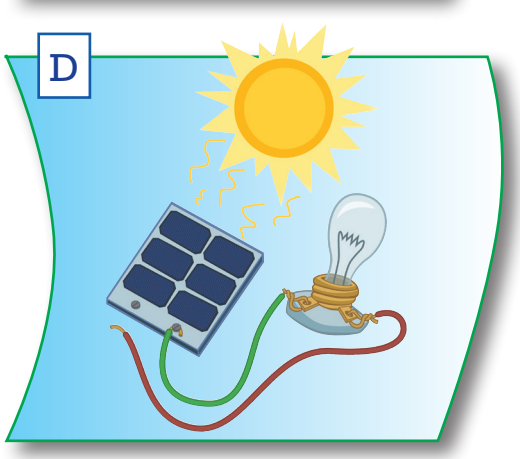
For each circuit shown, do the following:

1. **Predict.** If this were a real-life circuit, would the light bulb turn on? Why or why not?
2. **Investigate.** Build the circuit using a miniature light bulb base (also called an E-10 light bulb base), a 1.2-volt flashlight bulb, a solar cell, and two pieces of insulated wire with one inch stripped off each end. These materials can usually be found at local or online electronics retailers. If you cannot find a solar cell, you may substitute a D battery.
3. **Observe and Conclude.** Cup your hands around the bulb so you can see if it lights up. Record what you see. Was your prediction correct?









Why do we need Renewable Energy?

Fossil fuels and nuclear power supply most of the energy used in the world. These fuels have great advantages and have provided us with low-cost energy for centuries. However, we can no longer rely on them to meet all of our energy needs. Here's why:

Fossil Fuels. Coal, oil, and natural gas were formed underground from the decayed organisms that lived and died hundreds of millions of years ago. We must dig mines and drill deep wells to find these fuels and bring them to the surface. Mining and using fossil fuels can cause air and water pollution.

The earth has only a limited amount of these fuels and humans are using them up very fast. As supplies of fossil fuels get smaller, the cost of finding and mining them rises. Someday there will be no more usable fossil fuels.

Nuclear Power. The atoms of a mineral called ***uranium*** are used to produce most nuclear energy using the process of fission. After the uranium is used it becomes radioactive waste. The waste must be stored safely because otherwise it can cause harm to living things.

Nuclear power plants produce no CO_2 emissions. However, they are very expensive to build, and finding safe storage sites for the used uranium can be difficult.

Did You Know?

We can make our fossil fuel and nuclear energy supplies last longer by conserving energy and not wasting it, and by increasing the use of renewable energy sources. See the back cover for tips on conserving energy.

Mix It Up

Some forms of renewable energy are best for certain climates, geographic areas, or times of day. This is why many utilities rely on a mix of renewable energy, along with fossil fuels and/or nuclear power. When one renewable energy resource is not available or is too expensive, another can be used to meet people's electricity needs.

For example, if your area gets a lot of wind, then ***wind power*** might be a big part of the energy mix your utility uses to generate electricity. If you have many dry and sunny days, ***solar energy*** might be a good option in your area. However, if you live in an area with a lot of rain or high humidity, solar energy might play a smaller part in your utility's energy mix.

Other forms of renewable energy do not depend on weather, but only exist in specific areas. ***Geothermal energy***, for example, is only available in places with underground heat and steam deposits. ***Hydropower*** requires rivers and streams. ***Ocean energy*** requires coastlines.

Did You Know?

By the year 2030, renewables could provide about one-third of all our country's electricity needs. Utilities are working to improve the power line network to carry electricity from renewable power plants to where it is most needed.

BRAIN BLAST!

What's Your Energy Mix?

Think about the area where you live. Predict what types of energy resources, renewable and nonrenewable, generate the electricity you use. Then ask an adult, look on your electric utility's website, or do some library research to find out if your prediction was correct. **Bonus:** Do some research to learn the reasons for the energy mix in your area.

Solar Power

Most solar power is generated by absorbing light energy from the sun and converting it into electricity. Here's how it works:

Solar cells are thin layers of silicon covered with special glass or plastic. They can be connected together to make solar panels. Several panels can be grouped into solar arrays, and large numbers of arrays can be assembled to create a solar power plant.

Solar thin films are light-absorbing materials that are rolled, sprayed, or painted onto rooftops and other surfaces. Thin films are cheaper to make than traditional solar cells, but they are not yet as efficient at producing electricity.

Solar Touchdown

A typical modest-size house in the U.S. requires approximately 20 square yards of solar panels for all its electricity needs. How many similar houses could get all their electricity needs from one football field full of solar panels? (A football field measures about 6,400 square yards including the end zones.)

_____	**divided by**	_____	=	_____
Size of field in square yards		**Size of panels for one house, in square yards**		**number of houses that could be powered by one football field full of solar panels.**

Bonus: How many football fields full of solar panels would it take to supply all the electricity needs for 320,000 houses? For 3,200,000 houses?

Shine On

Some solar power is generated using the sun's heat, rather than its light. For example:

Thermal solar uses mirrors or panels containing tiny tubes filled with water that absorb heat from the sun. On rooftops, they can supply hot water for individual buildings. Concentrated solar can also be used to create steam that spins turbines at electric power plants.

Passive solar technology is when the heat of the sun is used directly. One simple example is letting the sun shine through a window to warm a room.

Advantages

- Solar power generation creates electricity without releasing CO_2.
- Solar power can be generated for individual homes and businesses on rooftops without taking up much space.
- Rooftop solar panels can send extra electricity into the power grid for others to use.

Challenges

- The amount of electricity or hot water that can be produced from solar power depends on weather, location, and time of day.
- Although the cost of solar panels is falling, this is still an expensive energy source.
- Large solar power plants use many acres of land and may require costly new transmission lines to carry the electricity to where it is needed.

Did You Know?

Devices that change light to electricity are called PV, which stands for photovoltaic (FOH toh vohl TAY ihk). Photo means "light" and voltaic means "something that produces an electric current." The word "voltaic" comes from Alessandro Volta, the inventor of the first electric battery.

Let it flow Hydropower

Water constantly moves through a cycle. It evaporates from lakes and oceans, condenses to form clouds, falls as rain or snow, then flows in rivers and streams back to the ocean. Flowing water is a form of mechanical energy that can be harnessed to produce electricity. Here's how it works:

Traditional Hydropower. A body of water is changed so that the water's flow can be used to generate electricity. For example, a dam may be built on a river to trap the water so it can be released through a turbine to generate electricity. Or, water can be pumped from a lower reservoir to a higher reservoir, and stored there. When it is needed, it flows down through a turbine for electricity generation.

New Hydropower. Energy from the natural movement of water is used to produce electricity without changing the water flow. For example, the constant flow of water in a river can spin the blades of underwater turbines to produce electricity.

Advantages

- Hydropower produces no CO_2 emissions and no air pollution.
- Dams create reservoirs that store water. They also make good locations for camping, swimming, and fishing.
- Dams control the flow of water and can prevent flooding.

Challenges

- Hydropower depends on rainfall and snowmelt.
- Droughts can reduce power production.
- Dams can affect water quality and river flows.
- Dams can prevent fish from swimming up rivers to spawn or back to the ocean after breeding. This can reduce fish populations.

Did You Know?

Humans have been harnessing the energy of flowing water for thousands of years. The ancient Greeks used water wheels for grinding wheat into flour and for sawing wood. Today, hydropower is the world's largest and least expensive renewable source of electricity.

Ocean Energy
SURF'S UP!

Waves and tides have energy we can use to generate electricity. Here's how it works:

Tidal Energy. The gravitational pull of the moon and sun, plus the rotation of the earth, causes tides—the rising and falling of ocean levels. Water from high tides can be trapped in reservoirs behind dams like the one below. When the tide drops, the water can be let out through a turbine to generate electricity.

Wave Energy. Buoys or other devices that contain turbines generate electricity as they bob up and down with the movement of waves.

Advantages

- Ocean tides and waves produce clean energy and no CO_2 emissions.
- Ocean tides and waves are constant and predictable.

Challenges

- The equipment for harnessing ocean energy is expensive to build and maintain.
- Underwater turbines could be dangerous to ocean creatures.
- Ocean tides and waves cannot yet meet significant electricity needs.

BRAIN BLAST!

Megawatt Math

The electricity we use in our homes is measured in units called watts. "For example, a hair dryer uses abut 1,500 watts and an LED light bulb uses about 10 watts. Because power plants generate so much electricity, the electricity they make is measured in much larger units called megawatts. One megawatt equals one million watts.

- The world's first tidal dam was built in La Rance, France in 1966. It can produce up to 240 megawatts of electricity. How many watts does this tidal dam produce? _____
- Hoover Dam in the Colorado River can produce up to 2,080 megawatts of electricity. How many watts is this? _____
- How many more megawatts can Hoover Dam produce than the La Rance tidal dam? _____

Wind Power Let it blow

Wind power is one of the world's fastest-growing sources of renewable energy. Here's how it works:

Wind is actually a result of solar energy. When the sun heats air close to the ground, the warm air rises. Wind is created when cooler air rushes into the empty space left by the rising warm air. The blades of a wind turbine capture that energy and use it to power an electric generator.

Advantages

- Wind power does not produce CO_2 emissions.
- Wind is one of the cheapest renewable resources.

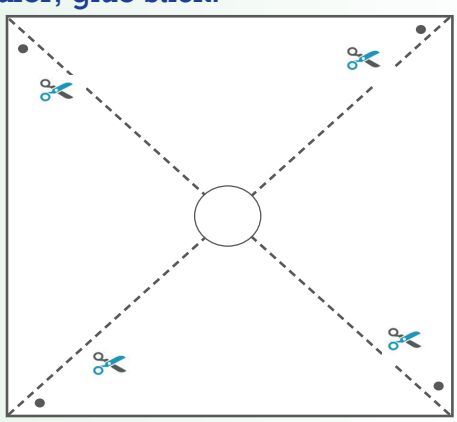
Challenges

- In some places the wind is not strong or does not blow enough of the time.
- Some types of turbines can be noisy or can harm flying birds.
- Wind turbines can be costly. They can also be large and may block scenic views.

BRAIN BLAST!

Build a Pinwheel

Materials: Pencil with eraser, straight pin, paper, scissors, ruler, glue stick.



Directions: Cut out a 4" x 4" square from the paper and use it to make a pinwheel, following the steps below. Then cut out a 6" x 6" square and make another pinwheel in the same way.

Step 1: Copy the pattern shown at right. (Draw an X from the corners with the ruler. Make 4 dots near the corners as shown. Draw a circle the size of a nickel in the center.)

Step 2: Cut along each side of the X, stopping at the center circle. (Don't cut in the circle!)

Step 3: Without creasing the paper, bring each corner dot into the center of the circle so they overlap. Hold them in place with your finger. (A little glue can help.)

Step 4: Carefully insert the pin through the dots and the center of your pinwheel, and part way into the eraser. If you glued the corners down, unstick them so the pinwheel blades slide freely.

Think About It: Blow on each pinwheel from the same direction and with the same amount of force. Which pinwheel spins faster? If you were going to design a wind turbine to generate electricity, would you make the blades long or short?

Under pressure Geothermal

Have you ever seen steam spouting high into the air from a geyser? Geysers are powered by geothermal energy. (The word geo = earth and the word thermal = heat, so geothermal = earth's heat.) This heat energy can be used to make electricity. Here's how it works:

The earth has many layers. The center (core) is extremely hot. Heat transfers from the core to a nearby layer of rock called the mantle. When temperatures and pressures become high enough, some of the mantle rock melts and becomes a fluid called magma. In some places, magma rises into cracks in the earth's outer layer, or crust. Geysers form when the hot, flowing magma heats underground water.

Geothermal power plants drill wells into areas where water is heated by nearby magma. The wells capture the hot water and steam, and use it to run turbine generators.

Advantages

- Geothermal energy does not produce CO_2 emissions.
- Geothermal energy generation is less expensive to build and operate than fossil fuel power plants.

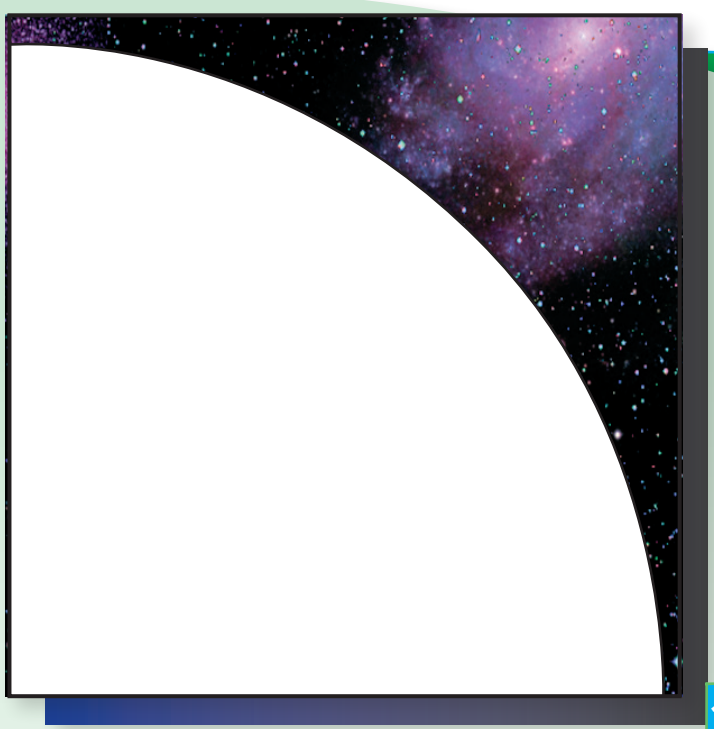
Challenges

- Finding good geothermal sites can be difficult.
- Drilling geothermal wells can be costly, although new drilling methods could bring these costs down considerably.

Layer It On

In the illustration of the earth at the right, use four different colors to draw and label the layers of the earth: the core, the mantle, the magma, and the crust. If you want, include a geothermal geyser!

Bonus: Use the Internet or your school library to find out where geothermal activity is found in the world. Where is it harnessed to produce electricity?



Growing Energy Biomass

Biomass is plant matter and animal waste that can be harvested to create energy in the form of electricity, heat, steam, and fuels. There are three main types of biomass:

Farm and lumber wastes can be collected and burned to heat water to produce the steam needed to turn electric turbines.

Garbage in landfills decomposes and releases ***methane gas***, known as "landfill gas." We can capture methane and burn it to make steam for electricity generation.

Energy farms raise crops such as beets, grains, and kelp. These crops can be burned as fuels for transportation (biofuels) and to generate electricity.

Advantages

- Leftover plant matter and wood waste are readily available from farms and lumber mills.
- Capturing landfill gas for electricity production keeps methane out of the air.
- Many types of biomass can generate electricity at any time, unlike wind and solar.

Challenges

- Biomass does produce some air pollution, but less than fossil fuels.
- Storing biomass and building landfill gas-burning power plants can be costly.
- Growing crops for electricity production and transportation may reduce crops used for food.

BRAIN BLAST!

Landfill in a Bag

Fill a plastic sandwich baggie with a few cooked pinto beans and seal it.

1. **Predict.** On a sheet of paper, predict what will happen if you do not open the bag for a week.
2. **Investigate.** Put the bag in a warm spot where it can be left for seven days.
3. **Observe and Conclude.** Observe the sealed bag at the end of the week. Record any changes in its size or shape. Were your predictions accurate? Why or why not? What do you think happened inside the bag? How does this relate to biomass energy?

Inventing Our Energy Future

Back in 1879, Thomas Edison invented the first incandescent light bulb. He also invented the first wiring system that made electric lighting practical, safe, and economical. In our time, new renewable energy sources and systems are being invented to help power our planet.

Step on it!

Two train stations in Tokyo, Japan, harness energy from the footsteps of millions of commuters who pass through each day. Special floor tiles trigger a small vibration that can be stored as energy. The energy can then power the stations' electronic signs, the lighting system, and ticket gates.

Feel the burn!

A few gym businesses around the country are putting people power to work. One gym in Portland, Oregon, uses the electricity generated from spin bike machines to power the gym's television and stereo systems.

BRAIN BLAST!

Inventor's Challenge

All inventions start with someone's idea. We're going to need a lot of clever ideas in the decades ahead to keep our energy supplies steady. Today's wacky brainstorm could wind up being tomorrow's fuel source!

What's YOUR wild idea for a renewable energy source that can run lights, heat buildings, or power cars? Write a paragraph to describe it, or draw a picture of it, or both. (Remember, the energy must come from a source that won't run out.)

Be an Energy Saver!

No matter what types of resources your energy comes from, saving energy is the best and least expensive way to reduce CO_2 emissions and help our planet stay healthy. Plus, saving energy can help your family save money!

Take the Quiz:

For each statement, write an "A" for Always, an "S" for Sometimes, or an "N" for Never to describe your family's habits.

1. We turn off lights when no one is using them. _____
2. We close the refrigerator and freezer door right away. _____
3. We keep our heater at 68° or lower during the winter and our air conditioning at 78° or higher during the summer. _____
4. We turn off and unplug the TV and DVD player when we finish watching. _____
5. We keep all outside doors and windows closed when our heat or AC is running. _____
6. We turn off the faucet all the way so it does not drip, and I let an adult know if it still does. _____
7. We take half-full baths or short showers (around 5 minutes). _____
8. We walk, bike, or take buses to get places whenever possible. _____
9. We switch out incandescent light bulbs with energy efficient LEDs. _____
10. We turn the water off when brushing teeth. _____

Your Saver Score

Give yourself 2 points for each A, 1 for each S, and 0 for each N.

16-20—You rock! Your family is already saving a lot of energy and helping our planet.

8-15—Pretty good. You do a lot but have some room for improvement.

0-7—Your family could be doing a lot more to save energy.

Take the Saver Pledge

I promise to save energy in my home by following the 10 tips on this page.

Signed,

_____

Your name

_____

Other family members can sign, too!

Your Utility Can Help You Do More

Your local utility is a great resource for information and programs on renewable energy and home energy efficiency. Ask an adult to visit your local utility's website, or call them to find out how your family can support renewable energy and save even more energy at home.