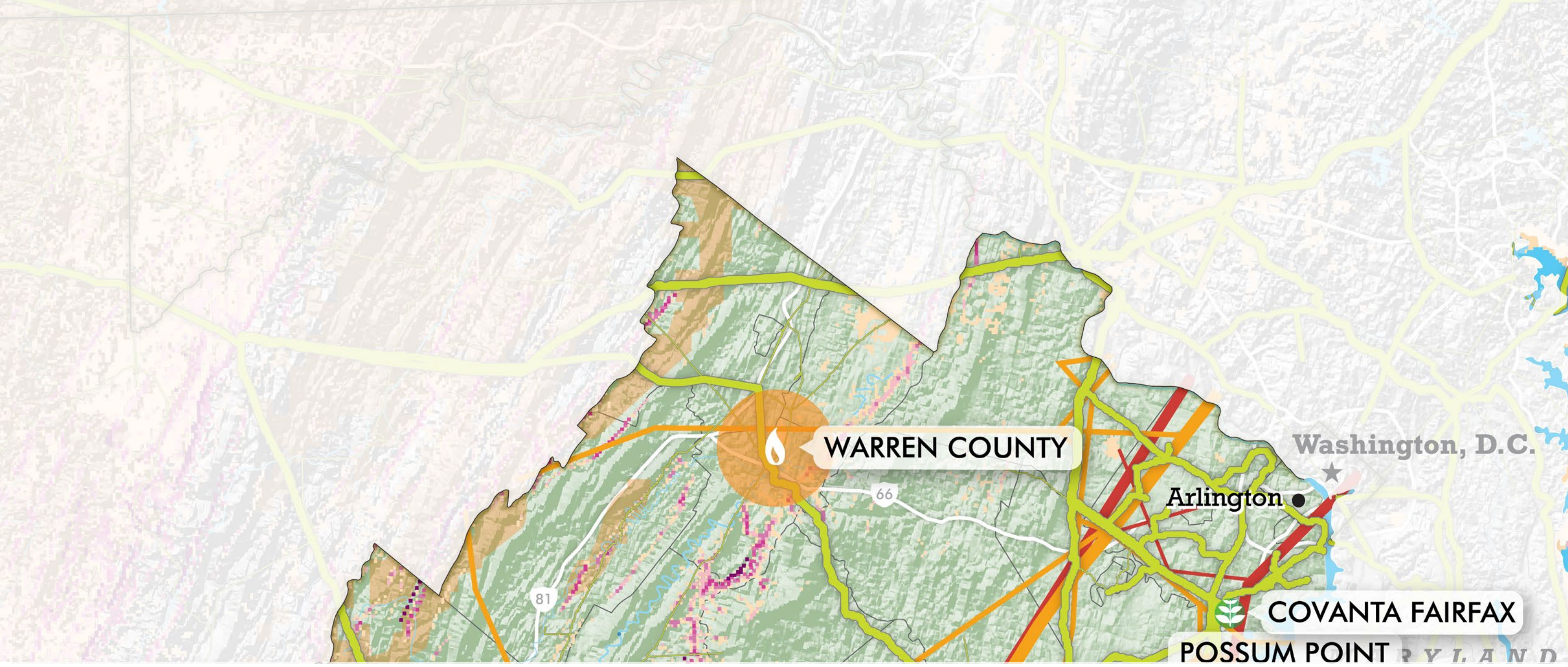
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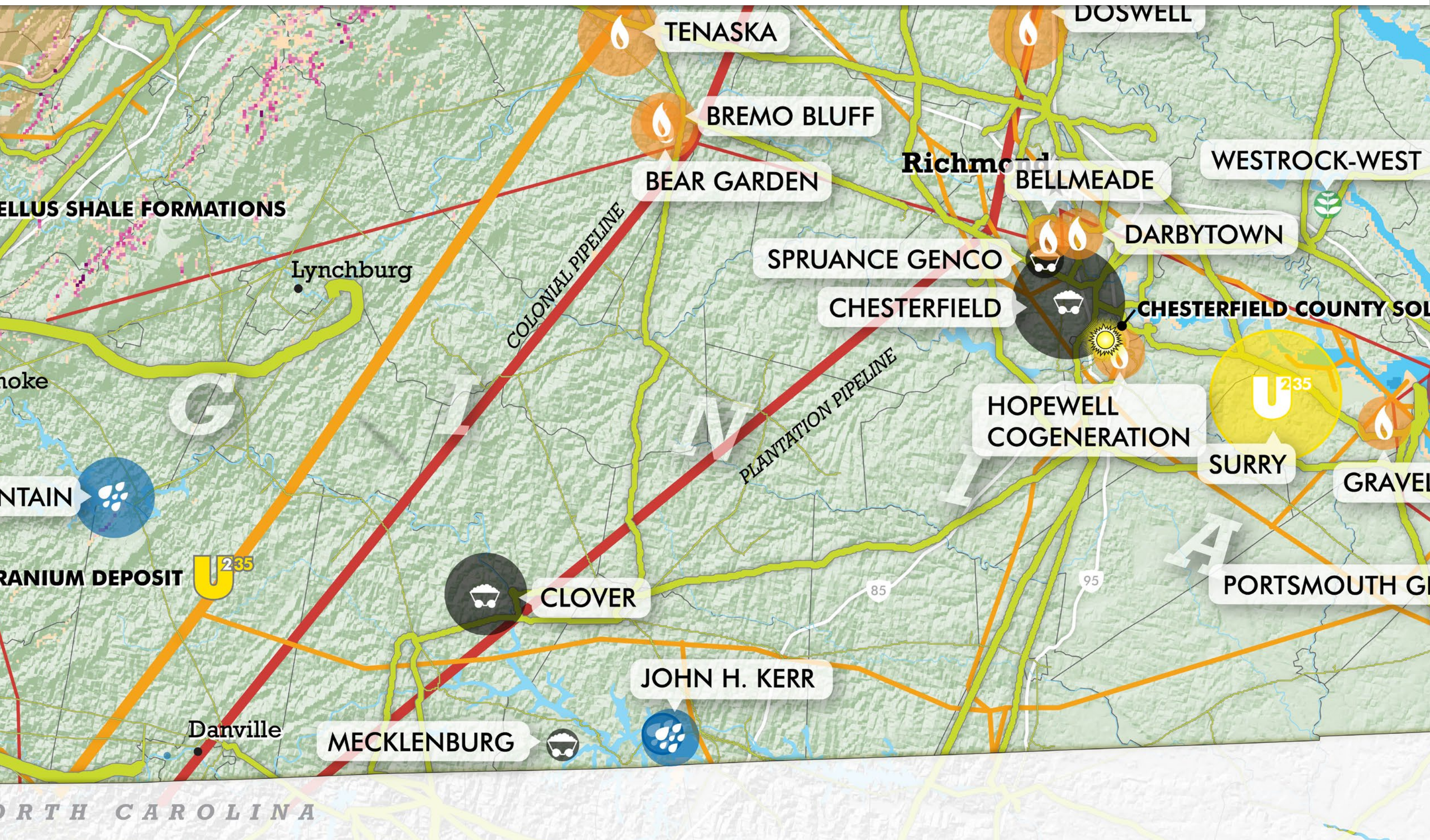
POSSUM POINT


ENERGY IN
VIRGINIA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CHESTERFIELD COUNTY SOL
HOPEWELL COGENERATION
SURRY
GRAVE
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MECKLENBURG
ORTH CAROLINA

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Letter To Teachers

Dear Educator:

Welcome to the Dominion Virginia Energy Program family! This program, sponsored by Dominion and the Virginia Department of Education, provides energy-related classroom materials that support Virginia Standards of Learning while engaging students in discovery related to energy in the Commonwealth. NEED's materials and programs have been reviewed by teachers for effectiveness, and are currently in use in schools across the country. NEED is so pleased to partner with Dominion and the Department of Education to bring this material to your sixth grade classroom, right here in NEED's home state of Virginia.

The curriculum for this program includes the curriculum guide Virginia is for Energy Lovers, a Virginia Energy Program Kit with classroom materials, and a Virginia Energy Map. These materials together will help sixth graders to understand the relevant science concepts related to energy and how it is used here in Virginia. Activities will cover the basic science of energy, energy sources, electricity generation, energy in Virginia – past and present, and energy efficiency and conservation, while allowing students to hone their science process skills and engage in STEM learning. This unit can be used solely in the science classroom, but includes many opportunities to incorporate classroom teachers of other disciplines, such as social studies, technology, and even language arts!

NEED, Dominion, and VDOE are so excited that you are taking part in this effort to bring energy into your classrooms. We encourage you to share your students' learning and successes with us as you work through the lessons and we welcome your feedback. Thank you for being energy lovers and sharing your love with your students!

Virginia Energy Program Kit Contents

2 Superballs	2 Sets of wire & nails	1 Compact fluorescent light bulb
2 Solar panel kits	1 Box of straight pins	1 Light emitting diode bulb
2 Metal thermometers	36 binder clips	1 halogen incandescent light bulb
2 Vinegar bottles	30 long straws	6 Probe thermometers
2 Baking soda containers	30 small straws	6 Beakers
2 Plastic measuring cups	1 Science of Electricity Model set	3 Erlenmeyer flasks
8 Plastic bags	1 Light meter	3 Rubber stoppers
2 DC microammeters	1 9-volt battery	5 Feet of tubing
2 Alligator clip sets	2 Kill A Watt meters	1 VA Round Up Poster Set

VIRGINIA DEPARTMENT OF EDUCATION

Dominion®

NEED National Energy Education Development

The NEED Project
8408 Kao Circle, Manassas, VA 20110
www.NEED.org

Materials

ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
Energy in Motion	Superballs	Meter sticks
Apple Battery	Small zinc nail Large zinc nail Thin copper wires Thick copper wires Tin wire DC microammeter Alligator clips	Apple Metric ruler Black permanent marker Safety glasses
Solar Cells	PV module kit with motor and fan	Paper Protractor Light source
Chemical Reaction	Student thermometers 15 mL Plastic measuring cups Resealable bags	Baking soda Vinegar Safety glasses
Map Hunt	Virginia Energy Map Poster board (optional)	
Virginia Energy Roundup		Construction paper or poster board Plain paper Tape
Energy Stories		Props (optional) Art supplies
Nuclear Power Plant Simulation		Poker or bingo chips Poster board Blue plastic table cloth Index cards String or yarn Hole punch Red construction paper Blue construction paper Rope Flashlight Masking tape Swivel stool (optional)
Mining Challenge		Wooden toothpicks Plastic toothpicks Large paper clips Napkins or paper towels Play money Chocolate chip cookies Timer

ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
Science of Electricity	Small bottle Rubber stoppers with holes Wooden dowel Foam tube 4 Rectangle magnets 2 Nails Small spool of magnet wire Multimeter Alligator clips	Push pin Hand operated pencil sharpener Ruler Permanent marker Sharp scissors Masking tape Fine sandpaper Safety glasses Utility knife (optional)
Wind Can Do Work	Extra-long straws Small straws Binder clips Straight pins	Masking tape Large foam cups approximately 14 cm tall Rulers Hole punches Markers String or thread Paper clips Fan(s) Scissors
Greenhouse in a Beaker	400 or 600 mL Beakers 250 mL Flasks Rubber stoppers with holes 3/16” Vinyl tubing, 60 cm lengths Digital thermometers (cooking or probewear)	Clip light with 75 watt bulb Ruler Masking tape Alka-Seltzer® tablets Safety glasses Water
Light Bulb Investigation	1 Kill A Watt™ meter 1 incandescent halogen light bulb, approximately 850 lumens 1 CFL bulb, approximately 850 lumens 1 LED bulb, approximately 850 lumens	1 Lamp or plug-in light fixture
The Cost of Using Electrical Devices	Kill A Watt™ Meters	Pluggable devices Calculators

Activity 1 – Energy in Motion

Teacher Background

This activity introduces a basic energy transformation. Students will be dropping a familiar object – a superball – and describing the energy transformation taking place as it falls. Gravitational potential energy is stored in objects based on their position as they are held up against the force of gravity. In the activity, students are holding the superball up over the table or floor, opposing gravity pulling it downward. When the ball is released, the potential energy stored in the position of the sphere transforms into kinetic energy, or motion, as the sphere falls. As the superball gets closer to the ground, more of the potential energy is transformed into motion. At the very instant before the ball hits the floor all of the potential energy is changed into motion.

The ball is made of a polymer. A polymer is an organic substance made by combining smaller molecules in a regular pattern to make a large molecule or chain of molecules. When the ball hits the floor, the ball's polymer makeup allows it to absorb energy as the ball flattens a bit. The motion energy the ball had while falling is transforming into elastic energy, stored in the polymer of the superball. As the polymer snaps back into shape, the ball bounces and rises off the floor.

The ball does not bounce to the same height from which it was dropped because some of the potential energy stored initially was transformed to thermal energy (heat) as the ball moved against the air. Some of the gravitational potential energy was also transformed into a bit of sound when the ball hit the floor. Although energy cannot be created or destroyed, no energy transformation is 100 percent efficient; in every energy transformation, some energy is always changed into thermal energy and sound, even if it is hard to see or detect.

Objectives

- Students will be able to explain potential and kinetic energy transformations in a falling sphere, and apply the concept to other moving objects.
- Students will be able to identify the form(s) of energy along a falling object's path.

Materials *FOR EACH GROUP*

- Meter stick
- Super ball
- Bouncing Ball Master, page 26
- Forms of Energy Master, page 27
- Bouncing Ball worksheet, page 64

Time

30-45 minutes, depending on discussion time

Preparation

- Gather materials.*****
- Make copies of the worksheet for students.
- Prepare a copy of the master for projection.

***NOTE:** Activities 1-4 can be set up as stations or centers for students to rotate through.

Procedure

1. Introduce the activity. Have students read about energy transformations in the Student Informational Text.
2. Review the forms of energy with students and ask them for examples of each of the forms of energy.
3. Read and discuss the procedure with students. Make sure students keep close eyes on their superballs.
4. Once students have finished their work, discuss their results.
5. Display the master. Ask students what form(s) of energy is (are) present at each stage of the falling ball displayed. Students will probably not identify thermal energy and sound at the place where the ball hits the floor. Decide if you wish to introduce these forms of energy to the discussion, based on the class' understanding. Ask students how the different surfaces contributed to the energy transformations they observed.
6. Ask students for other examples of gravitational potential energy being transformed into motion. Ask them how this transformation might be useful in daily life.

Activity 2 – Apple Battery

Teacher Background

In this investigation students will be creating a weak battery with an apple and various pieces of metal. The acid in the apple and the differing potential of each metal to release its electrons are what generate the electric current. All metals will give up, or donate, their electrons differently. Some have greater potential to do so, and others are less likely. In this activity, students will see evidence of the electric current flowing from one metal to the other by way of the meter, which measures microamperes (millionths of an ampere). Using two of the same metals on both sides of the meter results in zero current flow, because both metals have the same potential to transfer electrons. It is only when two metals with differing electron donating potentials are used that electric current can flow.

When students push the wires or nails farther into the battery, they should see the needle move farther to the right. This is because there is more surface available to react with the acid in the apple, which generates more current. When students use thicker wires (as opposed to thinner wires of the same metal) they will also see more current generated, because more metal (mass) is available to react.

When students cause the wires to touch, the reaction is still taking place, but because the metals are in direct contact, the electrons flow directly from one piece to the other rather than through the meter. This is a short circuit because the electrons are taking a "shorter", or less resistive, pathway.

Batteries like this are DC power sources; DC stands for direct current. Our homes are wired using AC power, or alternating current. Most electronics use DC power, which is why there is a large transformer within their charging cords. The transformer changes the AC power from the outlet to DC power to recharge the battery in the device. The electrons are forced "backwards", recharging the battery. When the device is switched on, the usual direction of electron flow begins again. Rechargeable batteries are limited in the number of times they can be recharged.

During the activity it is possible that as the wires are left in the battery, the current generated will start to decrease. This is because some oxidation will likely build up on the surface of the apple where it contacts the wires. Simply have students reinsert the wires into new holes and they should start seeing the same results as before.

Objectives

- Students will be able to describe generally how a battery generates electric current.
- Students will be able to identify the forms of energy being transformed in a simple battery.

Materials *FOR EACH GROUP*

- Small zinc nail
- Large zinc nail
- Tin wire
- Thick copper wire
- Thin copper wire
- DC microammeter
- Ruler
- Apple
- 2 Alligator clips
- Permanent marker
- Safety glasses
- Apple Battery worksheet, pages 65-66

Time

30 minutes

Preparation

- Gather the materials.*****
- Make copies of the worksheets for each student.

***NOTE:** Activities 1-4 can be set up as stations or centers for students to rotate through.

Procedure

1. Have students read the section of the Student Informational Text about electricity and batteries.
2. Read through the procedure with students and explain that they will make their own battery.
3. Allow students sufficient time to complete the activity.
4. Upon completion of the activity, discuss the students' results.
5. Ask students why they think the results are as indicated.

Extensions

- Students can test other metals beside other than those directed to see how well they generate current.
- Students could use other fruits or vegetables, or cups of acidic beverages like juice or soda, to see how well they generate current.
- Students could design and test a procedure that links several apple batteries together to operate a device such as a small LED or speaker.

Activity 3 – Solar Cells

Teacher Background

Electricity is simply moving electrons. Light can make electrons move. The photoelectric effect, first mentioned by Albert Einstein, describes light's ability to energize electrons in certain substances. Plants use this effect to create sugar from sunlight, carbon dioxide, and water in photosynthesis. The photoelectric effect can also cause electrons in a substance to become energized, move through a circuit, and do work.

One such substance is the silicon used to create photovoltaic cells in solar panels. This silicon has been treated on one side with another element that provides an extra amount of free, negatively charged electrons. It is treated on the other side with an element that provides extra spaces in which to accept those free electrons. When the PV cells are placed in the light, the photoelectric effect allows the light to energize the free electrons and send them moving to the open spaces. The PV cells are connected in a circuit, so the electrons move through a wire to do work, like light a bulb, before they find the open spaces. So long as the light strikes the PV cell, extra electrons will continue to be energized looking for a new spot, generating electricity along the way.

Several PV cells are connected together to make a solar panel. This solar panel will allow radiant energy to be transformed into electrical energy. Solar panels produce the same amount of electricity on the ground as the do on the roof of a building, because the distance from the sun is so great (roughly 93 million miles). However, the tilt of the solar panel can have a great impact on the electricity it produces. Based on our location on Earth and the season, we receive light at different angles in the sky during the day. Solar panels are often mounted at an angle, facing directly towards the sun as often as possible to allow for maximum capture of radiant energy. Solar panels can even be motorized to track the sun throughout the day! Solar panels should also be mounted so that as often as possible they are unobstructed by shadows and other objects. Cloud cover cannot be controlled, but weather can also be a great factor in the effectiveness of a solar panel.

Solar energy is a clean, renewable natural resource, but PV cells are not currently very efficient. They convert only about 20 percent of the radiant energy that strikes them into electricity. The remainder is changed into thermal energy or reflected back off of the surface.

In this activity, students will be able to observe very quickly how radiant energy can be transformed into electrical energy and beyond with the motor and fan in the kit. Students will also experiment with the variables involved with maximizing the energy transfer in a solar panel.

Objectives

- Students will be able to explain how radiant energy can be converted into electricity and other forms of energy.
- Students will be able to describe the best conditions for using solar panels.

Materials *FOR EACH GROUP*

- PV module kit with motor and fan
- Paper
- Protractor
- Light source
- Photovoltaic Cell master, page 28
- Photovoltaic Cell Fun worksheet, page 67

Time

30-40 minutes

Preparation

- Gather the materials.***** Assemble the PV module if needed.
- Make a copy of the worksheet for each student. Prepare a copy of the master for projection.

***NOTE:** Activities 1-4 can be set up as stations or centers for students to rotate through.

Procedure

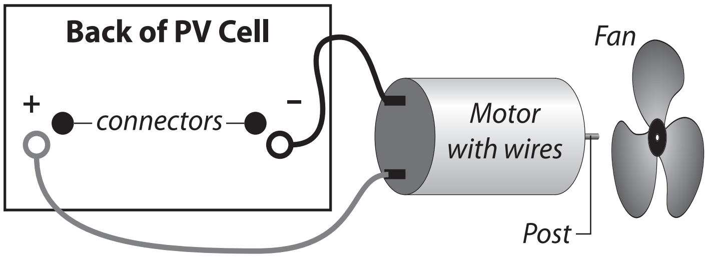
1. Have students read the section of the Student Informational Text about solar energy.
2. Display the master and demonstrate to students how a PV cell works.
3. Read through the procedure with students and explain that they will use the PV cell to generate electricity, and they will also explore the variables that might affect its ability to generate electricity.
4. Allow students time to complete the activity, and discuss their results upon completion.
5. Ask students to explain the energy transformations that occurred. Discuss as a class what variables affected the solar panel most and what might be the best conditions for a solar panel. Ask the class to discuss what they might see as advantages and challenges to using solar panels for electricity.

Solar Panel Assembly and Connection Instructions

1. Attach the wires from the motor to the connectors on the back of the PV cell by removing the nuts from the connectors, sliding the motor wires onto the posts and replacing and tightening the nuts as shown in Diagram 1.
2. Attach the fan to the post on the opposite end of the motor.
3. If nothing happens, remove the motor leads from the solar panel and touch them to the ends of a C battery to "jumpstart" the motor, then try again.*****

***NOTE:** You may need to hold the panel very close to the lamp if working with a halogen incandescent bulb. Use caution and check to be sure the plastic is not melting.

Diagram 1



Activity 4 – Chemical Reaction

Teacher Background

Chemical energy is the most commonly used form of energy. Burning coal or natural gas is a combustion reaction. Combustion is a chemical reaction in which the reactants are a compound with hydrogen, carbon, and oxygen, and the products are carbon dioxide and water. Because energy is released, it is an exothermic reaction. *Exo-* means out and *therm* means heat. Thus an exothermic reaction moves thermal energy outward, and it feels warm (or in the case of a flame, really hot!).There are many other exothermic reactions and your students should be able to name a few.

Endothermic reactions pull thermal energy inward (*endo-* means inward) and feel cool to the touch. A common use of endothermic reactions is an instant cold pack. Students might have a more difficult time coming up with examples of endothermic reactions because they are not very common. Note that freezing water is not an endothermic reaction – it is merely a change in state, which is not a chemical change.

Vinegar is dilute acetic acid, and its chemical formula is H_3COOH. Baking soda's chemical name is sodium bicarbonate, and its chemical formula is $NaHCO_3$. When these are mixed, the basic baking soda neutralizes the acidic vinegar. The products are carbon dioxide, CO_2, in gaseous form, sodium acetate, CH_3COONa, and water, H_2O. Students are observing an endothermic reaction.

Objectives

- Students will be able to recognize the signs of a chemical reaction taking place.
- Students will be able to explain how energy is involved in an endothermic reaction.
- Students will be able to identify the reactants and products of a simple chemical reaction.

Materials *FOR EACH GROUP*

- 1 Thermometer
- 1 Resealable bag
- 2 Small measuring cups
- White vinegar
- Baking soda
- Chemical Reactions worksheet, page 68

Time

30 minutes

Preparation

- Gather the materials.*****
- Make a copy of the worksheet for each student.

***NOTE:** Activities 1-4 can be set up as stations or centers for students to rotate through.

Procedure

1. Introduce the activity to students. Review with them the signs of a chemical reaction taking place (color change, temperature change, gas being released, new substance appearing, energy being released such as with light or a flame).
2. Ask students how many of them have mixed vinegar and baking soda before. Ask the class to predict whether the reaction is endothermic, which pulls energy in and feels cold, or exothermic, which releases energy and feels warm.
3. Have students complete the activity. The amounts of reactants listed in the activity will not exceed the capacity of a sandwich bag, but if students mix more baking soda or vinegar than is listed, they will make a mess. It's a good idea to have paper towels nearby for this reason.
4. When students have completed the activity, they can throw the sandwich bags in the trash can without worries about hazardous material disposal.
5. Ask students about their predictions at the beginning of the activity and how many of them had predicted incorrectly. They will probably be surprised by their findings.
6. Discuss the chemical reaction with them. Write the equation on the board, and point out that the reactants are on the left side and products are on the right side of the equation. Show that the equation is balanced, meaning there are the same number of each type of atom (sodium, hydrogen, oxygen, carbon) on both sides of the arrow. Put a box around the reactants and a circle around the products.

   $$CH_3COOH + NaHCO_3 \Rightarrow H_2O + CO_2 + CH_3COONa$$

7. Ask them which indicator of a chemical reaction was most obvious. Review the list again in step one if they need a reminder.

8. Ask students what energy transformations were occurring in the reaction. Even though the temperature went down, they should still identify chemical energy changing to thermal energy, and they might identify the motion of the carbon dioxide gas.

9. Explain to students that endothermic reactions are much less common in nature than exothermic reactions. Most of our energy use relies on exothermic reactions in power plants and in our vehicles. Ask students to identify others.

Extensions

- Ask students what other common substances might be able to be substituted for the vinegar. Allow them to test their ideas.
- Ask students if they can think of anything else that might substitute for the baking powder to make a reaction. They should not, however, substitute these for the baking soda without close adult supervision as some substances can be harmful when mixed.

Activity 5 – Map Hunt

Teacher Background

The Virginia Energy Map is a great resource for introducing and reinforcing energy content learned throughout the lessons to come. Students can use the information on the map to relate energy to their local region. Reading and analyzing the map are great skills for use in the multidisciplinary classroom, as well.

Objectives

- Students will be able to identify important energy sources to the Commonwealth of Virginia.
- Students will be able to locate important electricity generation facilities in their state
- Students will be able to identify challenges and advantages of transporting energy from plants to people.

Materials

- Virginia Energy Map
- Computer or Internet access (optional)
- Poster board (optional)

Time

30-45 minutes

Preparation

- Hang the map in a prominent place in the classroom. Download a version to project, if you prefer. Using a document camera may also be helpful.

Procedure

1. Show the map to the class and explain that the lessons ahead will be an exploration of energy sources. In these lessons they will learn about how energy is harnessed and used in the world, and in their state, the Commonwealth of Virginia.

2. Discuss the symbols on the key and make sure students know what each symbol represents. Introduce each of the sources using the information on the bottom of the poster if needed.

3. Ask students to find their location on the map. What is the closest energy facility to their town? What type of facility is it (mine power plant, pipeline, etc.)? What other energy infrastructure exists in their area?

4. Ask students to compare their town to another town. Perhaps a town where a family member lives. Ask the class to discuss why they think certain types of facilities are in certain areas.

5. Divide the class into groups of 2-4 students and give each group a topic from the list on page 12. Assign each group to use the map, the Student Informational Text, and additional resources to "hunt" for their information. They will need to then work as a group to create a poster, slide, or display sharing their findings and 1-2 important facts that relate to their findings. (For example, if assigned to "wind" students might explain how winds are created and why certain areas are better for turbines than others).

6. Students will present their findings to the classroom using the map and their poster or display as aides.

TOPIC GROUPS

TOP PRODUCER

- What is the location of the power station with the highest output in Virginia?
- What source of energy does it use to generate electricity?

VA ENERGY USE

- What is the percentage of total energy in Virginia that is consumed by the residential sector?
- What sector of the economy uses the most energy in Virginia?
- Which source of energy provides the most energy to the top sector?

HYDROPOWER

- What is the name and location of the largest hydropower facility in the state?
- What is the difference between conventional and pumped storage hydropower?
- How many conventional facilities exist in the state?

NUCLEAR

- What is the megawatt output of the North Anna Power Station?
- If uranium was mined in Virginia, where would it be found? Is this close or far away from the facilities?
- How much electricity does nuclear energy provide for Virginia?

SOLAR

- Find the large scale solar facility in Virginia.
- Why might it be located where it is?
- Would there be better or worse places for a solar facility in Virginia?

COAL

- Find the cleanest coal plant in Virginia.
- Why might coal be an easy source to use in Virginia?
- Why might coal exports be important to Virginia?

WIND

- Find the locations of proposed wind projects.
- What locations might be good for additional wind turbines?

BIOMASS

- Find the biomass energy facility closest to you.
- How can biomass be turned into energy?
- Why is it renewable?

PETROLEUM/NATURAL GAS

- Find the Possum Point facility.
- Find the pipelines for oil and natural gas. Are they close to the facility?
- How much electricity in VA comes from natural gas?

Activity 6 – Virginia Energy Roundup

Teacher Background

Activities 1-4 explore energy transformations and the forms of energy. Energy transforms constantly in our daily lives. Energy transformations like those observed in the previous activities occur when we use burn fuel in our vehicles, generate power at a generation facility, and switch on lights in our home.
We use ten sources of energy in the United States to power our lives. Each of the 10 energy sources has energy transformations that enable us to use the source for energy. This activity introduces the ten energy sources to students, while exploring how the Commonwealth of Virginia uses each one to provide power each day. This is a great activity to be used in conjuction with Activity 5.

Objectives

- Students will be able to describe both advantages and challenges for each energy source.
- Students will be able to explain how the ten major sources of energy fit into Virginia’s energy portfolio.

Materials

- Plain white paper
- Poster board or large pieces of construction paper
- Markers or computer and printer
- Tape
- Virginia Energy Roundup Clues, page 29
- Energy Source Cards, page 30

Time

30 minutes, plus preparation time

Preparation

- Read through both Part I and Part II of the activity. Decide if you will do both parts, or if you will have students repeat Part I several times, each with a new Energy Source Card.
- On sheets of plain paper, write down six energy facts for each energy source, found on the Virginia Energy Roundup Clues. Do NOT write the names of the energy sources on these plain sheets of paper. Alternatively, you can print them in a large font with a printer.
- Number ten pieces of dark colored paper, one through ten, in large numbers.
- Prepare poster boards for the energy sources, as follows. Mount one fact sheet to the lower half of each poster board. Mount the top edge of the number sheets near the top of the posters. Do not secure the bottom edge of the number sheets to the posters; the number sheets will be used as flaps.
- Write the names of the energy sources on the posters, underneath the number sheet flaps. Lightly secure the bottom or side edge of the number sheets with tape.
- Mount the posters around the walls of the room. Space the posters equally apart and set up chairs for each station, if desired.
- Copy the Energy Source Cards. Make enough copies so there are several for each source. Cut into individual cards.

Procedure

1. Assign players to groups using the Energy Source Cards. Let the players draw these out of a hat or pass them out randomly so that there is an equal number of students per source. Fewer than 10 groups may be used, if needed, but keep all 10 posters on the wall.
2. Instruct the players NOT to tell anyone which group they've picked.

PART I

1. Tell students they each have been assigned to an energy source group.
2. Students are not to speak or communicate with each other at all during this part of the activity.
3. At your signal, students will walk to the poster that is closest and read the clues. If the clues match the energy source card they are holding, they should stay by that poster. If not, they should move on until they find the poster for their energy source.
4. Allow students three minutes to find their correct source posters.
5. At the end of three minutes, instruct the person closest to each poster to slightly lift the flap so that only that group can see what is written beneath it.
6. Any students at the wrong poster should repeat step 3. Students at the correct poster should remain in place. Students should need less time to find their correct places.

PART II

1. During this part of the activity students are allowed to talk to the members of their energy source group.
2. Groups should discuss all six clues, deciding which three are least revealing of their energy source. Limit the amount of time groups have to just a few minutes.
3. Start with one group, and have them read their three selected clues. Students in other groups should raise their hands to guess the identity of that energy source.
4. The next group to read their clues will be the first group to correctly guess the identity of the previous energy source, and the game will continue in this fashion until all energy sources have been read and identified.

Activity 7 – Energy Stories

Teacher Background

In this activity students will be able to better visualize the energy transformations that occur when using two of our major energy sources – coal and natural gas. Students will act out a story for each, that describes how energy flows from formation to use, in order to demonstrate the transformations. As a culminating assessment, students can be asked to apply what they have learned to another energy source.

Objective

- Students will be able to explain how energy is transformed from production to use in natural gas and/or coal.

Materials

- Art supplies or props
- A Cool Coal Story, page 69
- A Cool Coal Story Role Sheet, page 70
- A Nifty Natural Gas Story, page 71
- A Nifty Natural Gas Story Role Sheet, page 72

Time

40-50 minutes

Preparation

- Make a copy of the role sheets for each student.
- Provide art supplies for students to assemble props, or gather suggested items as shown on each role sheet.
- Prepare copies of the stories to project, and/or as handouts.

Procedure

1. Decide which story you will tackle first. Assign students to roles for the story based on the role sheet.
2. Discuss how coal and natural gas are created, produced from the ground, processed, transported, and used. Review any necessary vocabulary, and direct students to the Student Informational Text for more background on these topics.
3. Have each student assemble his/her props, or provide each student with a suggested prop.
4. Project the first story. Act out the story from beginning to end. Students without roles may help to read the story aloud.
5. Assign new roles or move on to the second story. Create new props or redistribute necessary props for the second story. It might be helpful to make sure everyone has an acting part in at least one story.
6. Ask students to compare the two stories for the two sources. How are natural gas and coal similar and how are they different?
7. Ask students to write a paragraph explaining the energy flow involved in the source of your choice (natural gas or coal).

Extensions

- Act out your energy flows for another class or for a parents night at school.
- Ask students to write a new story for another source of energy used in Virginia. Ask them to create parts and roles for their classmates.

Activity 8 – Nuclear Power Plant Simulation

Teacher Background

The operation of a nuclear power plant can be complicated, with its many systems, gauges, valves, backup systems, and alarms. However, the basic process is quite simple, and this simulation allows students to walk through that process.

In the simulation, students will represent the critical parts of a nuclear power plant system: control rods, fuel rods, circulating water, and generation and transmission lines. Energy is represented using "energy chips" and the simulation demonstrates how that energy is passed and distributed throughout the entire system.

Part 1 of the simulation is meant to show the very basic operation, and how the energy is transferred from one loop to another within the power plant operation. Part 2 shows a more realistic distribution of energy within the system, showing that the energy transformed to useful electricity is only about 1/3 of the energy released in the reactor, which is the accepted efficiency of thermal power plants in general.

Materials

- Large supply of poker chips, small candies, marbles, or anything that can be used to represent energy–60-100 pieces are needed
- Three large pieces of poster board
- Blue plastic table cloth
- Index cards
- String or yarn
- Hole punch
- Red construction paper
- Blue construction paper
- Rope
- Flashlight, light fixture, or lamp
- Masking tape
- Swivel stool (optional)

Time

40-50 minutes

Preparation

- Cut two "turbine blades" from one piece of poster board.
- Using the index cards, make 3-4 hang tags that say "steam" on one side and "water" on the other.
  Laminate if you wish. Punch a hole in the two top corners and thread yarn or string through the holes to make a loop big enough for a necklace.
- Make 6-7 two-sided hang tags from red and blue construction paper, so red is on one side and blue is on the other. Laminate if you wish. Punch holes and construct necklaces as before.
- If you would like, trim the plastic table cloth into a pond shape.

Procedure

Assign roles and mark the areas on the floor using the diagram on page 17 for assistance.

1. Mark out three areas on the floor with masking tape. One will be the primary loop, one will be the secondary loop with generator and transmission, and one will be the cooling system. Indicate "exchange zones" where energy chips will be handed from one loop to another as the activity progresses.
2. People are to NEVER cross over from one section to another during the simulation.
3. Each "fuel rod" has five people in line. Form two fuel rods, for a total of 10 people.
4. One person acts as a control rod, with two pieces of poster board.
5. Primary Loop: 3-4 people to act as pressurized water, and circulate with energy chips as described in the simulation and shown on the diagram.
6. Secondary Loop: 3-4 people to act as water/steam, circulating with hang tags that say "water" on one side and "steam" on the other.
7. Turbine: One person with "blades" made from poster board sitting on a swivel stool or standing.
8. Transmission lines: 2-3 people holding rope to represent the transmission lines and electricity grid.
9. Light: One person holding the light to demonstrate energy use in our homes and schools.
10. Cooling system: 2-3 people with hang tags that are red on one side and blue on the other. They will circulate through a "pond" of a blue plastic table cloth on the floor. They will carry the energy chips to the pond (red) and leave the pond without most of them (blue).

Simulation Part 1

1. Begin with the control rod standing between the two fuel rods, blocking the way for the pressurized water people in the primary loop.
2. To start the process, the control rod will come out of the space between fuel rods.
3. The primary loop will circulate, walking between the fuel rods, each picking up two energy chips and turning their hang tags to red. When the primary loop reaches the exchange zone with the secondary loop, those two energy chips are handed to the secondary loop and the hang tags are turned back to blue.
4. The secondary loop will turn their hang tags to “steam” when holding energy chips. In the appropriate exchange zones, one chip will be handed to the transmission line, and the other will be handed off to the cooling loop. At that point the hang tags will be turned back to “water”.
5. Along the transmission line, the energy chip will be passed first through the turbine, who will spin, and the transmission line will continue passing the energy chip to the person holding the light or device, which will be switched on when the energy chip reaches him or her.
6. In the cooling loop, hang tags will be turned to red while holding an energy chip. The loop will circulate through the pond, where the chips will be dropped off, and the hang tags turned back to blue.
7. All of the people in all of the three loops will continue to circulate until you are satisfied that students understand what is happening.

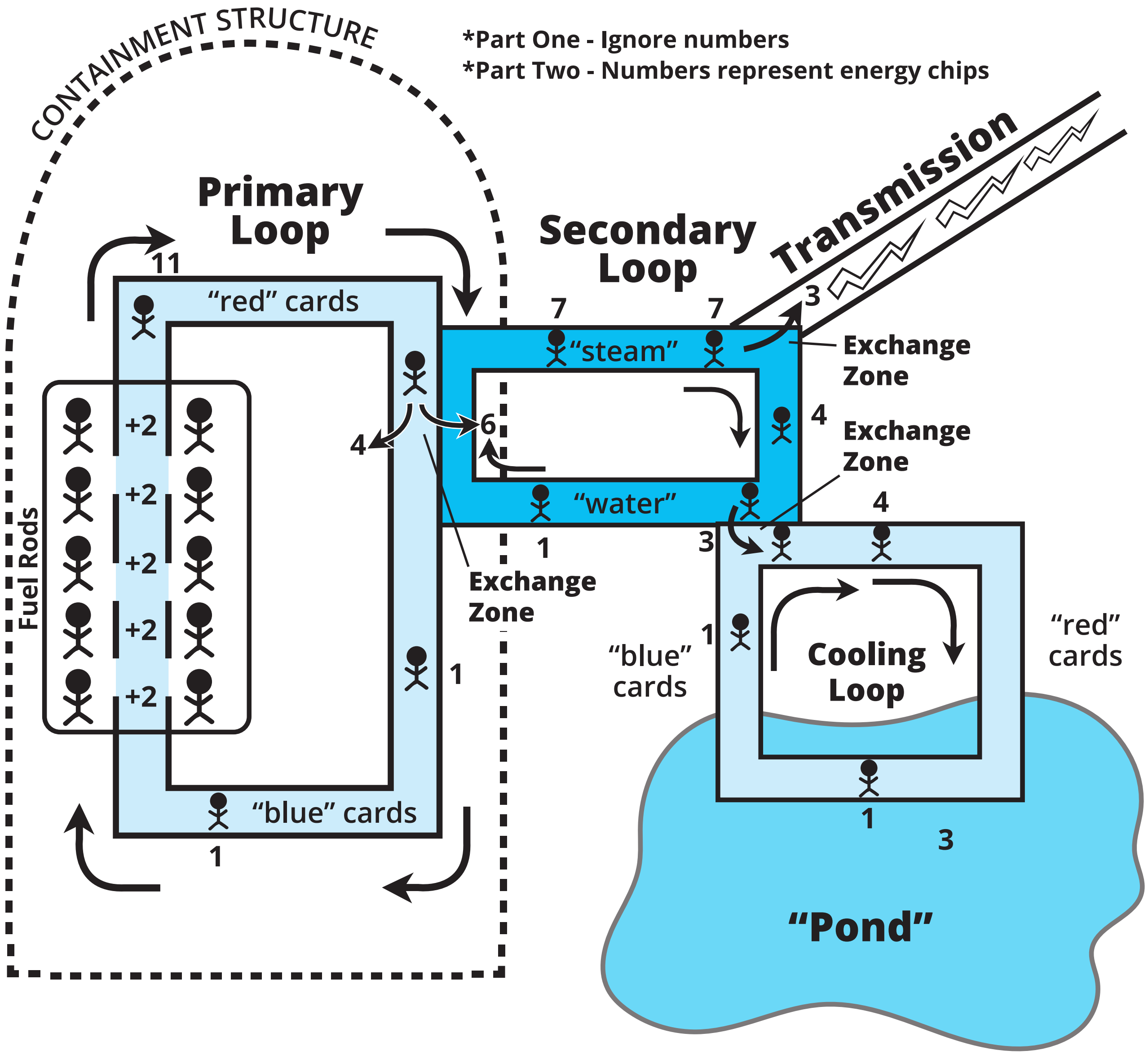
Simulation Part 2

1. Every person representing water in the primary, secondary, and cooling loop should start with one energy chip.
2. The fuel rod people will have desks or tables between them, with an ample supply of “energy chips” on the desks. As the pressurized water people (hang tags blue) move between them, the fuel rods will pass a total of 10 additional energy chips (one from each person in the fuel rods) to the primary loop as shown on the diagram. The hang tag of the pressurized water people should be switched to red at this point.
3. The people in the primary loop will take the 10 energy chips and circulate to the secondary loop. They will “lose” four chips to the environment by dropping them on the floor in the exchange zone and pass on six chips to a secondary loop person. They should still be left with one energy chip.
4. At this point the primary loop should turn their hang tags to blue again and continue through the loop back toward the reactor.
5. As the secondary loop people approach the primary loop, their hang tags say “water.” As they take 6 energy chips from the pressurized water in the exchange zone, they turn their hang tags to say “steam.”
6. The secondary loop “steam” people walk past the turbine and give it a gentle push to turn it, and hand 3 energy chips to the turbine.
7. The turbine hands 3 energy chips to the transmission line.
8. As the energy chips are passed down the transmission line, the electrical device is turned on and off when electrical energy arrives.
9. When the steam gets to the cooling system, they hand three energy chips to the cooling loop and turn their hang tags back to “water.” They should keep one energy chip at all times.
10. The cooling loop people take the three energy chips from the secondary loop and turn their hang tags to the red side. As they walk through the “pond” they drop the three chips into the pond and turn the hang tag to blue, and holding onto one chip. They continue to circulate in this manner.
11. At the conclusion of the activity, the control rod person will walk back into the space between the fuel rods to begin the shutdown process.

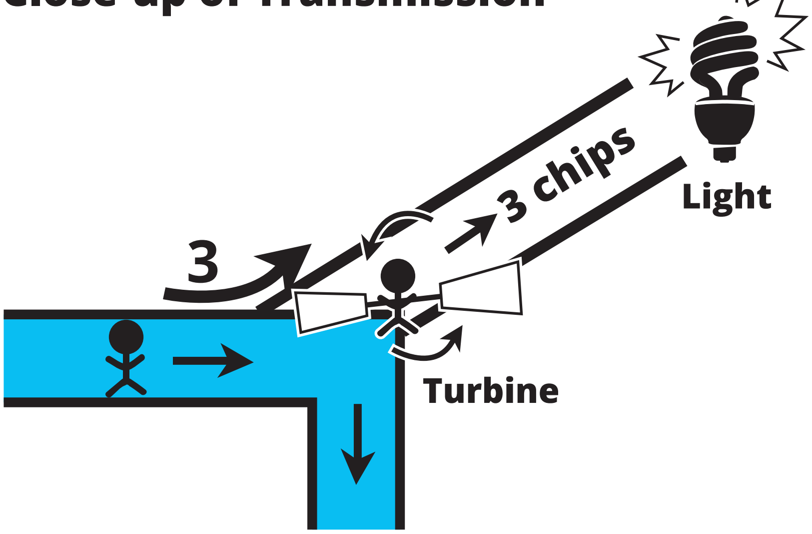
Extensions

- Once you have gone through parts 1 and 2 of the simulation, students may be ready to simulate what happens if one of the systems fails. At this point, limit the secondary loop to holding 20 energy chips as the maximum. Simulate a cooling loop failure by stopping the cooling loop. Students continue as before, but the cooling loop does not circulate. Have students explain what will happen in the secondary loop and the primary loop. Instruct the control rod to intervene, shutting the system down to prevent overheating.
- Simulate a failure in the secondary loop by having them stop. If the primary loop can only hold 20 chips each, what happens to the reactor? Again have the control rod intervene.

DIAGRAM



Close-up of Transmission



Role List/Supplies

10 students	Fuel Rods - Give each student a few energy chips
1 acts as control rod	Give this student 2 pieces of poster board
3-4 students	Primary Loop - Give each student a red and blue tag
3-4 students	Secondary Loop - Give each student a water/steam tag
1 student	Turbine - Give two blades
1 student	Light - Give a light
2-3 students	Transmission Lines - Hold the rope
2-3 students	Cooling System - Give each student a red/blue tag

Activity 9 – Mining Challenge

Teacher Background

Coal provides a lot of the electricity we use in the United States. It is the third highest source for electricity generation in Virginia. Coal must be mined for use. Virginia contains several coal mines that mine for coal at the surface and underground.

In this activity, students will demonstrate the surface mining method of coal recovery using cookies. Students will explore the challenges of running a successful mining operation while protecting the environment and reclaiming their land.

Objective

- Students will be able to describe the process and challenges of mining.

Materials

- 1 Box of wooden toothpicks
- 1 Box of plastic toothpicks
- 20-30 Large paper clips
- Timer
- Napkins or paper towels
- Play money*
- Chocolate chip cookies**
- Mining Challenge worksheets, pages 73-75

NOTES:

*Each team of students will need $105 in play money in varied increments. Extra cash will be needed for the banker.

**A variety of textures of chocolate chip cookies helps to make this activity more authentic. Using a mixture of soft/chewy, hard, large chunk, etc., cookies is suggested. It is also suggested to have enough cookies on hand to complete the activity and extra on-hand for eating, if desired. Be sure the cookies used will be safe for students with allergies. If food is absolutely not allowed in classrooms, consider using clay as an alternative.

Preparation

- Make copies of the worksheets for students.
- Split up students into teams of 3-5 students.
- Separate the play money for each team so that each group has varied denominations adding up to $105.
- Select 3 students or helpers to serve as the banker, equipment salesman, and realtor.
- Set up work stations or areas where teams can purchase materials and do their mining.

Procedure

1. Pass out the student worksheets for the activity.
2. Preview the rules of the activity and the steps each group will need to follow. For younger students, you may choose to have a sample page completed ahead of time to project so students can work through the process and see the calculations they will make.
3. Help teams pick their jobs or roles and determine how many mine sites and tools they want to purchase. For younger students, it is recommended that each team only purchase one mine site. Older students may purchase more, but they will also need extra grid space. If allowing teams to purchase more than one mine (cookie), you may consider giving teams more than the prescribed amount of play money.
4. Hand out cookies as students visit the realtor to purchase their mines. Instruct the teams that these cookies are just for mining and that they should not be eaten until AFTER the activity. Make sure each team maps out their mine on their grid.
5. Direct the teams to begin mining. Keep time for the 1-minute shifts and moderate as teams are determining their earnings and/or buying supplies. Give the signal for when teams should start each shift. Make sure teams are mining only the number of shifts they have selected to mine. You may choose to pre-determine the number of shifts each team will have to do their mining.
6. As teams finish their shifts, remind them to begin the reclamation process. Assist mineral engineers in assessesing fines to their teams.

7. Direct the teams to help their accountant tally up their final balances.

8. Discuss the profits and losses each team faced. Ask students why they might have had losses despite mining plenty of coal. What challenges did they face during mining? What challenges did they face during reclamation?

9. Allow students to eat cookies, if appropriate.

General Rules of the Challenge

1. Each team tries to mine the most coal (chocolate chips) from their mine (cookie).

2. Each team member has a job and must keep that job throughout the game.

3. Cookies must be mined with the tools purchased only – NO hands!

4. Teams must mine in 1-minute shifts. No mining should take place between the timed shifts.

5. After each team finishes their shift allotment, they must reclaim the land using their original outline map and the tools provided.

6. Teams should tally up their total costs and earnings to determine net profit/loss.

Jobs

Banker: Handles all money, gives each team their initial investment. Makes change, collects payroll, and pays out after each shift.

Equipment Salesman: Sells teams their tools before mining and during shifts.

Realtor: Sells teams their mine, hands out cookie.

Mineral Engineer: Purchases mine land from realtor. Determines which tools will be used and purchased. Outlines/ maps out their mine land on the grid. Oversees reclamation.

Accountant: Tracks the expenditures and income of the team. Completes the worksheet table and calculates the final balance. Determines how much coal is mined in each shift. Goes to the banker to seek pay.

Miners: Responsible for mining the coal and reclaiming the land.

Finances

- Each team receives $105 as an initial investment.
- Each mine site (cookie) costs $20.
- Tools have varying costs: wooden toothpick $1, plastic toothpick $2, and paper clip $3.
- Each team must pay EACH miner $15 for each minute-long shift they work. Money will be deposited in the bank until "pay day". This can be paid up-front to the bank or after each round.
- For every ton (square) of coal, teams earn $5 (square must be at least half-full).
- After reclamation, any land outside the original outline of the mine will be assessed a $1 fine for each square.

Activity 10 – Science of Electricity

Teacher Background

Electricity powers our lives. Students might know that wind, hydropower, coal, uranium, or natural gas may be used to generate electricity. But they may not know what electricity is. Very simply, electricity is moving electrons. These electrons are the electrons loosely held in a metal, like copper. When a magnet and a metal like this are near each other, those electrons can be put into motion. A generator makes this process happen by allowing coils of wire to be moved in relation to magnets (or vice versa). In this activity, students will explore how a generator works by viewing a model you have created. They will use their science writing skills to describe how electricity is generated, and how they would enhance the model to optimize its design for greater output.

Objective

- Students will be able to describe how electricity is generated.
- Students will be able to design a model and optimize its performance.

Materials

- Small bottle
- Rubber stoppers with holes
- Wooden dowel
- Foam tube
- 4 Rectangle magnets
- 2 Nails
- Small spool of magnet wire
- Push pin
- Hand operated pencil sharpener
- Ruler
- Permanent marker
- Sharp scissors
- Masking tape
- Fine sandpaper
- Utility knife (optional)
- Multimeter
- Alligator clips
- Safety glasses
- Science of Electricity Model instructions, page 76-78
- Science of Electricity Worksheet, page 79

Time

10-30 minutes, with additional time for assembly and extension

Preparation

- If you have not assembled the model, follow the directions on page 76-78.
- Make a copy of the worksheet for each student.
- Prepare a copy of the instructions for projection or make copies for each student.
- Gather additional supplies if you wish for students to have an opportunity to build their designs.

Procedure

1. Demonstrate the operation of the science of electricity model. Hook it up to a multimeter to demonstrate electricity is being generated.
2. Allow students an opportunity to explore and operate the model.
3. Display the instructions for students to see how the model was created. Ask students to complete the worksheet, by writing about how electricity is generated.
4. Ask the class to brainstorm and create a list of things they might want to alter on the model to generate more electricity.
5. Place the students into groups, or have them work individually to create a procedure that redesigns the model to be a better generator. If time and materials allow, students can assemble, test, and re-test their models.

Activity 11 – Wind Can Do Work

Teacher Background

Wind is the fastest growing source of energy used to generate electric power. Using wind to generate electricity is cost-effective, clean, and can be installed almost anywhere wind speeds are sufficient to make it economically feasible. However, because wind speeds are not 100 percent consistent, and because the size of wind turbines prohibits them from being installed in urban areas, wind energy cannot completely replace other more reliable sources of electricity like uranium and coal. Virginia has several mountainous areas and coastal areas that could make good locations for wind turbines. An offshore wind project has been proposed off the coast of Virginia Beach, but each location requires extensive research before beginning. This activity does not generate electricity, but students will create their own wind turbine to demonstrate how the movement of air can be put to use.

Objective

- Students will be able to explain and diagram how wind can do work.

Materials *FOR EACH STUDENT OR PAIR*

- 1 Large foam cup (approximately 14 cm tall)
- 1 Extra-long straw*
- 1 Small straw
- 1 Binder clip
- 1 Straight pin
- Ruler
- Hole punch
- Marker
- 50 cm String or thread
- Paper clips
- Masking tape
- Scissors
- 4-Blade Windmill Template, Teacher Guide page 31
- Wind Can Do Work worksheet, Student Guide page 80

***Note:** The extra-long straw is long enough for two windmills when cut in half.

Materials *FOR THE CLASS*

- Fan(s)

Procedure

1. Have students read about wind energy in the Student Informational Text.
2. Using directions from the Wind Can Do Work worksheet, students should build windmills.
3. Students should diagram their windmill assembly and trace the energy transformations that occur in this system.
4. Encourage students to investigate the question, "What is the maximum amount of paper clips that can be lifted all of the way to the top of the windmill shaft?" Students should record data and observations in their science notebooks.

Extension

- Students can redesign the windmill to see if they can produce more work from the system.
- Ask students to redesign the windmill so that it could generate electricity

Activity 12 – Greenhouse in a Beaker

Teacher Background

In this activity, students will model the conditions that occur in a greenhouse, or in our atmosphere during the greenhouse effect. Students will simulate what happens in the atmosphere when carbon dioxide is added. CO_2 is added to the atmosphere naturally by processes like photosynthesis. However, by burning fossil fuels for transportation, industry, and electric power, CO_2 is added at a rate that is too high to be absorbed and cycled through the environment naturally. Excess CO_2 in the atmosphere acts like the walls of a greenhouse, trapping thermal energy.

Objective

- Students will be able to describe that carbon dioxide speeds up the transfer of thermal energy.

Materials *FOR EACH GROUP*

- 2 400 or 600 mL Beakers
- 1 250 mL Flask
- 1 Rubber stopper with hole
- 1 Vinyl tubing, 3/16" diameter, 60 cm long
- 1 Clip light
- 1 Ruler
- 2 Digital thermometers (cooking or probewear)
- 1 Small piece of masking tape
- 4 Alka-Seltzer® tablets
- Safety glasses
- Water (room temperature)
- Bright, incandescent work or heat lamp bulb
- Greenhouse in a Beaker worksheets, pages 81-82

Time

40 minutes

Preparation

- Make copies of the worksheets for students.
- Gather materials for the activity and be sure enough outlet space for lamps is available.
- Divide students into groups.

Note

During the experiment the temperature in the CO_2 rich beaker will rise for several minutes. Once a temperature peak is reached, the temperature will start to drop again rapidly. This is because the supply of CO_2 in the small bottle has exhausted itself and because the natural convection currents in the beaker, driven by the heat from the light bulb, will disperse the CO_2.

Procedure

1. Introduce the investigation to students by asking, "If we add carbon dioxide to the air, what effect will this added CO_2 have on the air temperature?"
2. Explain that students will be creating two models of our atmosphere. The beakers will represent our atmosphere and the lamp will represent the sun. One beaker will contain a "normal" atmosphere. Carbon dioxide (CO_2) will be added to the second beaker, creating a CO_2 rich atmosphere. The CO_2 will be produced through a chemical reaction that occurs when Alka-Seltzer® is added to water. The active ingredients in Alka-Seltzer® are aspirin, citric acid, and sodium bicarbonate (NaHCO3). When the tablet is placed in water, an acid-base reaction involving sodium bicarbonate and the citric acid takes place yielding sodium citrate, water, and carbon dioxide. Write the equation on the board and ask students to identify the reactants and products of the equation. Put a box around the reactants and a circle around the products.

$$3NaHCO_3 + C_6H_8O_7 \longrightarrow Na_3C_6H_5O_7 + 3H_20 + 3CO_2(g)$$

3. Divide students into small groups. Pass out the Greenhouse in a Beaker worksheets.
4. Circulate around the room assisting groups as needed.
5. Discuss the results and ask students to brainstorm major CO_2 producers, and ways to reduce its production.

Extension

- Ask students what variables they can change in the investigation. Let students design new investigations, and in their conclusions, have them correlate their changes to actual conditions that may change in Earth's climate system.

Activity 13 – Comparing Light Bulbs

Teacher Background

This activity is designed to teach students about the entire life cycle cost of different lighting choices. It reinforces that there is more to choosing a light bulb than purchase price.

Objective

- Students will be able to explain the true cost of various lighting types and make the best decision for their families based on life cycle cost.

Materials

- Comparing Light Bulbs Answer key, page 32
- Comparing Light Bulbs worksheet, page 84

Time

30-45 minutes

Preparation

- If desired, consult your own utility bill or your utility's website for the kilowatt-hour rate in your area.
- Make a copy of the worksheet for each student.
- Prepare a copy of the answer key to project.

Note

Comparing Light Bulbs and Light Bulb Investigation have been excerpted from Monitoring and Mentoring, which provides extended opportunities for your students to learn about energy efficiency and conservation. The activities make a great Youth Awards Project (www.NEED.org/youth-awards). You can access full pdf copies of these curriculum guides by visiting www.need.org/energyefficiency.

Procedure

1. Explain to students that the cost of a light bulb and its operating cost combine to give the life cycle cost. The life cycle cost, very simply, is the cost to buy and use the bulb. Ask them to predict which type of bulb has the lowest life cycle cost.
2. Explain to students that because the minimum number of bulbs that can be compared is one, all the types of bulbs must be standardized to 25,000 hours of light for a fair comparison because LED bulbs last 25,000 hours on average.
3. Lead students through the calculations. If you know your local electrical energy cost per kilowatt-hour, substitute that number instead of the national average listed.
4. At the conclusion of the activity, have students describe, or write a paragraph about, the light bulb they would choose for their families, using data from the activity to support their choices.

Extensions

- Provide packages of light bulbs for a different brightness for students to pull the information and re-run the calculations.
- Have students take a blank copy of the activity home to work with their parents and discuss their results the next day.

Activity 14 – Light Bulb Investigation

Background

Even though students can calculate the cost of different light bulbs and read the data on the packaging, sometimes seeing is believing. Using a Kill A Watt™ meter they can measure the power being drawn by different styles of light bulbs and compare the light color and quality to help decide which efficient lighting options suit them most.

If you have three identical light fixtures and three meters, we recommend that you conduct side-by-side-by-side tests simultaneously. However, some classrooms may only have access to one of each, thus you can have students compare one bulb at a time. Make sure they use the incandescent halogen bulb last because it does get quite warm very quickly. It can be left off to cool before removing it from the fixture.

This activity can be done as a demonstration, or if you have three lights you can set all three up in a corner of the room for students to compare and make notes.

Objective

- Students will be able to quantitatively and qualitatively describe the different attributes of three different types of light bulbs with similar brightness.

Materials

- One electric lamp or light fixture (three are optional)
- One Kill A Watt™ meter (three are optional)
- One halogen incandescent bulb, approximately 850 lumens
- One CFL bulb, approximately 850 lumens
- One LED bulb, approximately 850 lumens
- Kill A Watt™ Meter Instructions master, page 33
- Light Bulb Investigation, page 84

Time

30 minutes

Preparation

- Decide if you will have students work independently or if you will set this up as a demonstration.
- When acquiring light bulbs, it is not necessary that they all produce exactly the same number of lumens. A difference of fifty or fewer lumens is difficult for the human eye to discern.
- Make a copy of the worksheet for each student.

Procedure

1. Introduce the activity to the students. Explain to them that they are going to be measuring the power used by light bulbs and comparing it to the stated wattage on the packaging.
2. Demonstrate the use of the Kill A Watt™ meter.
3. Instruct students that as they take their measurements, they should also make notes about the color, brightness, and overall quality of the light each bulb produces. Explain that quality is a subjective term and thus they may not all agree that one light is more appealing than another.
4. At the conclusion of the activity, have students decide which bulb they would choose, and why. Have them write a few sentences explaining their choices.

Activity 15 – The Cost of Using Electrical Devices

Background

We plug things in every day. Some things are used so frequently we never even unplug them. More than 40 percent of the energy we use in the U.S. and VA is electricity to provide power to our computers, cell phones, refrigerators, televisions, and gaming systems – just to name a few. This activity allows students to measure and calculate the approximate cost of using each of their favorite pluggable devices. Please remind students to ask permission before unplugging a device that does not belong to them, and review safety procedures for unplugging and plugging devices into outlets.

Objectives

- Students will be able to quantify their energy consumption by measuring the load of common devices.
- Students will be able to calculate or estimate an energy bill using appropriate rates, and converting units as needed.

Materials

- Pluggable devices
- Kill A Watt™ Meters
- Calculators
- Kill A Watt™ Meter Instructions, page 33
- The Cost of Using Electrical Devices worksheet, page 85

Time

One class period

Preparation

- Gather pluggable devices that students may use and make sure outlet space is accessible.
- Divide students into groups for exploration.
- Make a copy of the worksheet for each student.
- Prepare a copy of the meter instructions for projection.

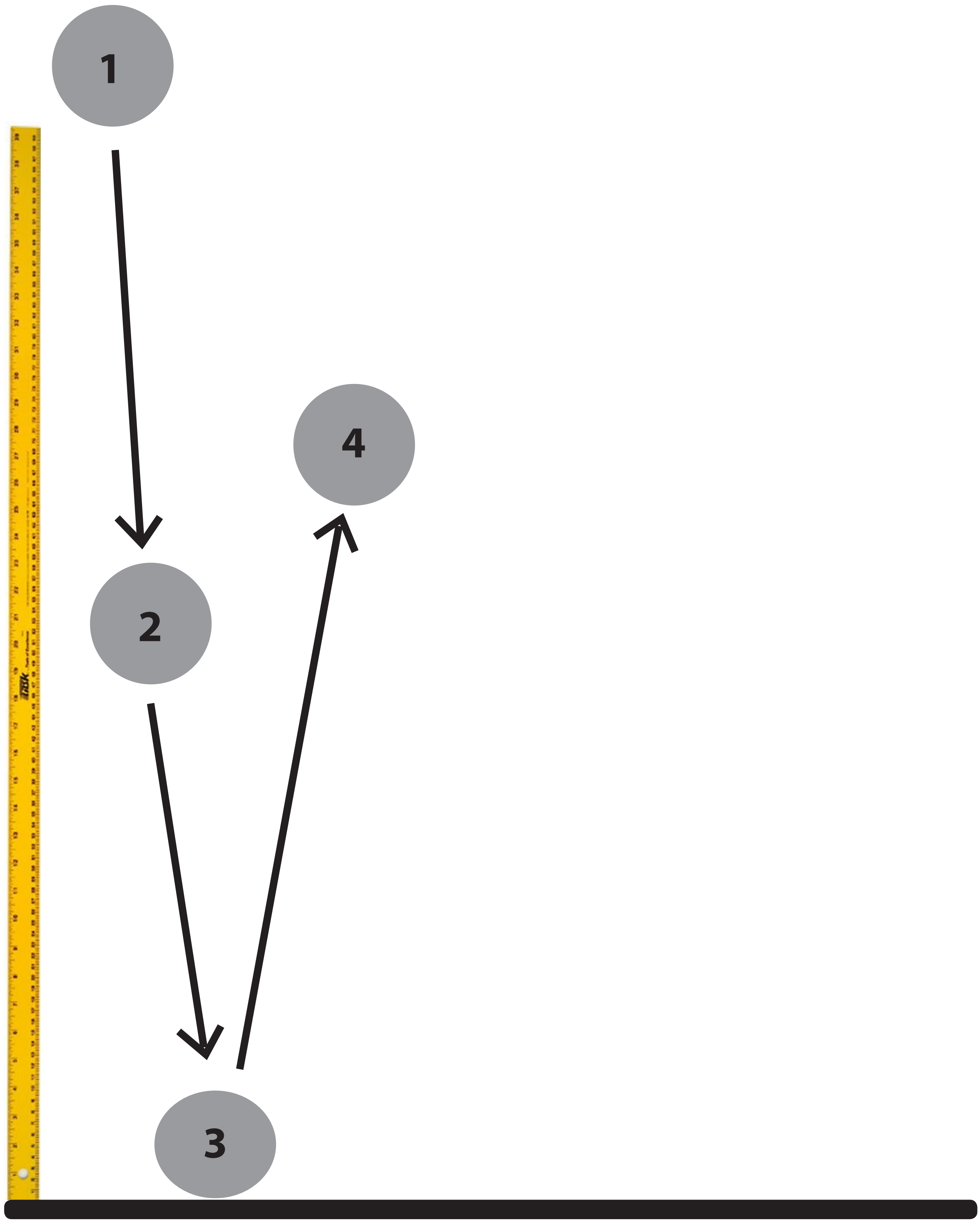
Procedure

1. Have students read the Student Informational Text sections on electricity measurement, and energy efficiency and conservation.
2. Explain to students that many of the devices in your school use electricity. Ask the class to brainstorm a list of devices they use at home and in school that must be plugged in.
3. Display the Kill A Watt™ Meter Instructions, and describe to students how to use the tool to measure the electrical load of their devices.
4. Split students up into groups and ask them to measure several devices and then complete the calculations for each device. If you prefer, you may also substitute the local rate for kilowatt-hour consumption to complete the calculations, rather than using the national residential or commercial averages.
5. Discuss the results as a class. Is it expensive to use these devices? How many of each can be found in the school or in their homes? What would their "bill" look like if they had accounted for the whole building?

Extensions

- Have students complete a class spreadsheet to log different devices and compare results.
- Have students borrow the meters or sign them out to test devices at home to add to the class discussion.

Bouncing Ball



Forms of Energy

All forms of energy fall under two categories:

POTENTIAL

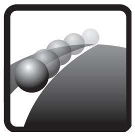
Stored energy and the energy of position (gravitational).

CHEMICAL ENERGY is the energy stored in the bonds between atoms in molecules. Gasoline and a piece of pizza are examples.

NUCLEAR ENERGY is the energy stored in the nucleus or center of an atom – the energy that holds the nucleus together. The energy in the nucleus of a plutonium atom is an example.

ELASTIC ENERGY is energy stored in objects by the application of force. Compressed springs and stretched rubber bands are examples.

GRAVITATIONAL POTENTIAL ENERGY is the energy of place or position. A child at the top of a slide is an example.



KINETIC

The motion of waves, electrons, atoms, molecules, and substances.

RADIANT ENERGY is electromagnetic energy that travels in transverse waves. Light and x-rays are examples.

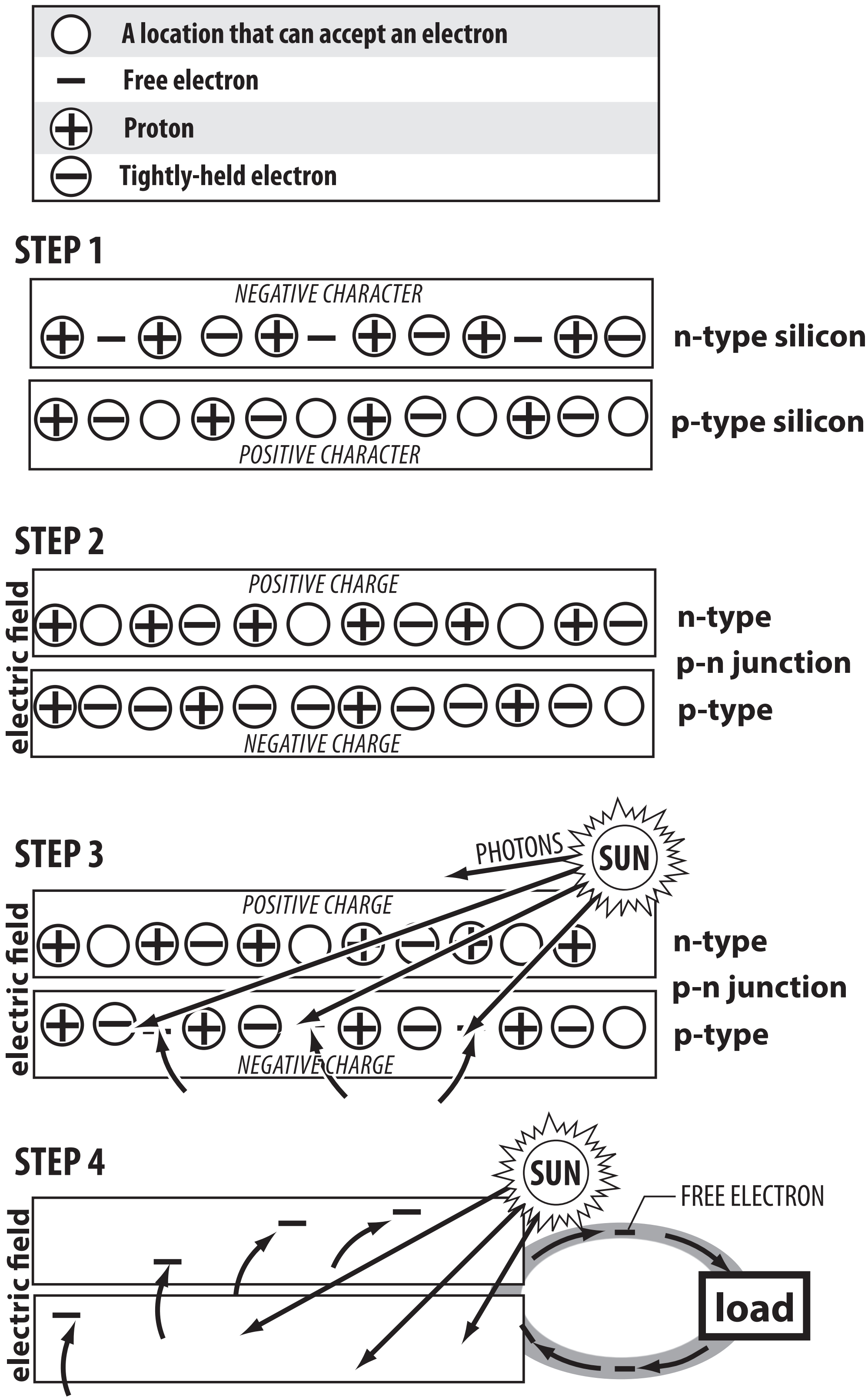
THERMAL ENERGY or heat is the internal energy in substances – the vibration or movement of atoms and molecules in substances. The heat from a fire is an example.

MOTION ENERGY is the energy of the movement of a substance from one place to another. Wind and moving water are examples.

SOUND ENERGY is the movement of energy through substances in longitudinal waves. Echoes and music are examples.

ELECTRICAL ENERGY is the movement of electrons. Lightning and electricity are examples.

Photovoltaic Cell



Virginia Energy Roundup Clues

Nonrenewable Sources

Coal

- I generate 38.6% of the nation's electricity.
- I'm transported mostly by trains.
- Virginia's ports are a major export location for me.
- I'm America's most abundant fossil fuel.
- I am the third leading source for electricity in Virginia.
- Efforts are made to remove sulfur from me.

Natural Gas

- I heat roughly half the nation's homes.
- A chemical is added to me to make it detectable.
- I'm transported mostly by pipeline.
- I am the source used for almost half of Virginia's electricity.
- I am a fossil fuel but I produce almost no air pollution.
- In Virginia, I am found most often along with coal.

Petroleum

- About 48 percent of the nation's supply of me is imported.
- My major use is for transportation fuel.
- My products are shipped to locations in Virginia by pipeline.
- I am the leading source used for all energy in the US.
- Texas, North Dakota, and California produce the most of me.
- The United States is the world's top producer of me.

Propane

- I am a fossil fuel.
- I am obtained by processing two other fossil fuels.
- I can be compressed to a liquid for easy transport.
- I'm colorless and odorless.
- I am often used in rural areas.
- I'm normally stored under pressure.

Uranium

- I'm the nation's third leading energy source for electricity.
- I was first used in 1957 to make electricity.
- My power plants store my spent fuel waste products on site.
- I provide about 31 percent of Virginia's electricity.
- I am used in two locations in Virginia.
- Nation-wide, I'm used in 99 locations total.

Renewable Sources

Biomass

- I can be used to produce methane.
- My energy comes from the sun.
- I am used to generate electricity primarily by burning trash.
- Paper mills use me in combined heat and power (CHP) facilities in Virginia.
- I can be used to make renewable transportation fuels.
- Burning me can produce air pollution.

Geothermal

- I produce less than one percent of US energy.
- I'm used mainly in western states.
- I produce very little of the energy used in Virginia.
- My energy comes from the earth's core.
- My major use is the production of electricity.
- Some homes use me as a heat exchanger for heating and cooling.

Hydropower

- I supply 5-10 percent of the nation's electricity, depending on rainfall.
- There are 26 sites that use me in Virginia.
- I produce a little less than two percent of Virginia's electricity.
- Some countries use me to a great extent to produce electricity.
- My facilities can disrupt wildlife and fish populations.
- One of the largest pumped storage facilities using me is in Bath County, Virginia.

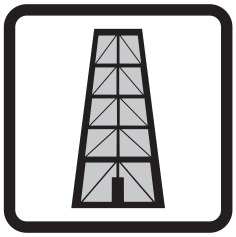
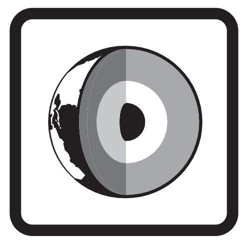
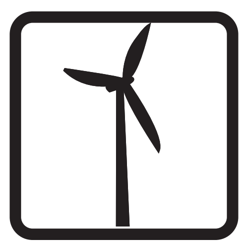
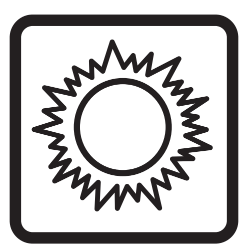
Solar

- I'm not available during all hours of the day.
- I can be converted directly into electricity using photovoltaic cells.
- I'm great for water and home heating.
- I work better in some parts of the country.
- My energy is stored in fossil fuels.
- I'm free to use, but my equipment can be costly.

Wind

- A major research facility to study me is being built off the coast of Virginia.
- I produce no air pollution.
- I'm caused by uneven heating of the Earth's surface.
- Most of my resource in Virginia is offshore.
- I produce 4.4 percent of the nation's electricity.
- Very little of Virginia's electricity is generated using me.

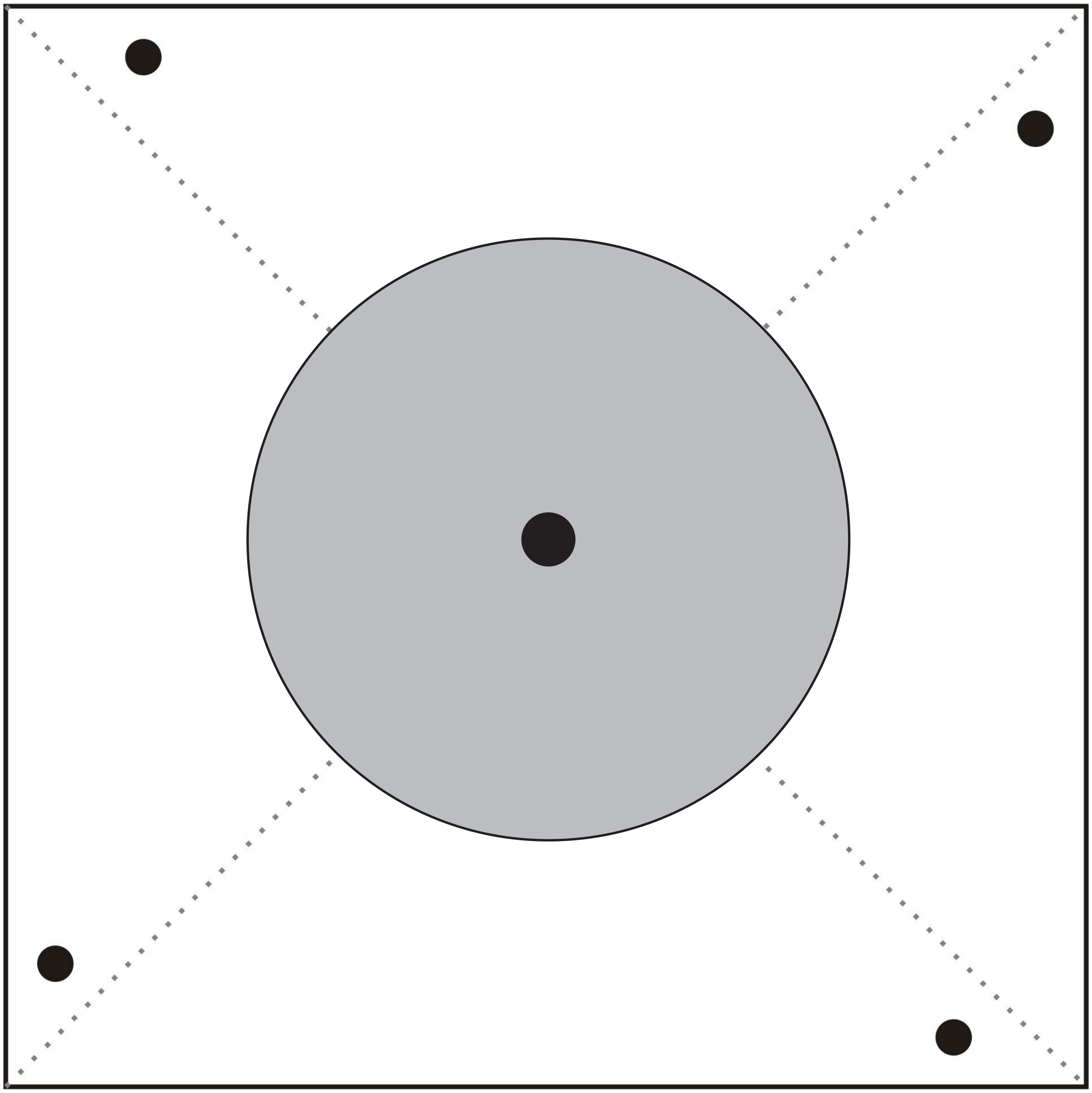
Energy Source Cards

 PETROLEUM	 HYDROPOWER
 COAL	 BIOMASS
 NATURAL GAS	 GEOTHERMAL
 URANIUM	 WIND
 PROPANE	 SOLAR

4-Blade Windmill Template

Procedure

1. Cut out the square.
2. Cut on the dotted, diagonal lines.
3. Punch out the four black holes along the side (being careful to not rip the edges) and the black hole in the center.
4. Follow the directions on the Wind Can Do Work worksheet to complete the windmill.



Comparing Light Bulbs Answer Key




All bulbs provide about 850 lumens of light.

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours	25 bulbs	8.3 bulbs	2.5 bulbs	1 bulb
x	Price per bulb	$0.50	$3.00	$3.00	$8.00
=	**Cost of bulbs for 25,000 hours of light**	**$12.50**	**$24.90**	**$7.50**	**$8.00**
	COST OF ELECTRICITY	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total Hours	25,000 hours	25,000 hours	25,000 hours	25,000 hours
x	Wattage	60 watts = 0.060 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
=	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Price of electricity per kWh	$0.125	$0.125	$0.125	$0.125
=	**Cost of Electricity**	**$187.50**	**$134.38**	**$40.63**	**$37.50**
	LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Cost of bulbs	$12.50	$24.90	$7.50	$8.00
+	Cost of electricity	$187.50	$134.38	$40.63	$37.50
=	**Life cycle cost**	**$200.00**	**$159.28**	**$48.13**	**$45.50**
	ENVIRONMENTAL IMPACT	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Pounds (lbs) of carbon dioxide per kWh	1.23 lb/kWh	1.23 lb/kWh	1.23 lb/kWh	1.23 lb/kWh
=	**Pounds of carbon dioxide produced**	**1,845.0 lbs carbon dioxide**	**1,322.3 lbs carbon dioxide**	**399.8 lbs carbon dioxide**	**369.0 lbs carbon dioxide**

Kill A Watt™ Meter Instructions

Kill A Watt™ Meter

The Kill A Watt™ meter allows users to measure and monitor the power consumption of any standard electrical device. You can obtain instantaneous readings of voltage (volts), current (amps), line frequency (Hz), and electric power being used (watts). You can also obtain the actual amount of power consumed in kilowatt-hours (kWh) by any electrical device over a period of time from 1 minute to 9,999 hours. One kilowatt equals 1,000 watts.

Operating Instructions

1. Plug the Kill A Watt™ meter into any standard grounded outlet or extension cord.
2. Plug the electrical device or appliance to be tested into the AC Power Outlet Receptacle of the Kill A Watt™ meter.
3. The LCD displays all meter readings. The unit will begin to accumulate data and powered duration time as soon as the power is applied.
4. Press the Volt button to display the voltage (volts) reading.
5. Press the Amp button to display the current (amps) reading.
6. The Watt and VA button is a toggle function key. Press the button once to display the Watt reading; press the button again to display the VA (volts x amps) reading. The Watt reading, not the VA reading, is the value used to calculate kWh consumption.
7. The Hz and PF button is a toggle function key. Press the button once to display the Frequency (Hz) reading; press the button again to display the power factor (PF) reading.
8. The KWH and Hour button is a toggle function key. Press the button once to display the cumulative energy consumption; press the button again to display the cumulative time elapsed since power was applied.

What is Power Factor (PF)?

We often use the formula **Volts x Amps = Watts** to find the energy consumption of a device. Many AC devices, however, such as motors and magnetic ballasts, do not use all of the power provided to them. The power factor (PF) has a value equal to or less than one, and is used to account for this phenomenon. To determine the actual power consumed by a device, the following formula is used:

Volts x Amps x PF = Watts Consumed

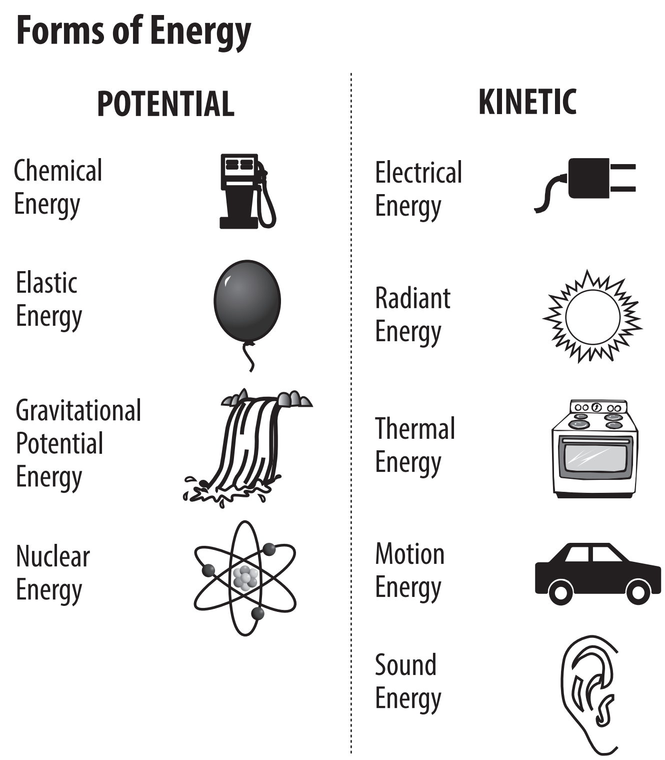
Student Informational Text

What Is Energy?

Energy makes change; it does things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes. Energy makes our bodies grow and allows our minds to think. Scientists define energy as the ability to do work.

Forms of Energy

Energy is found in different forms, such as light, heat, sound, and motion. There are many forms of energy, but they can all be put into two categories: potential and kinetic.



Potential Energy

Potential energy is stored energy and the energy of position, or gravitational potential energy. There are several forms of potential energy.

- **Chemical energy** is energy stored in the bonds of atoms and molecules. It is the energy that holds these particles together. Biomass, petroleum, natural gas, propane, and the foods we eat are examples of stored chemical energy.
- **Elastic energy** is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of elastic energy.
- **Nuclear energy** is energy stored in the nucleus of an atom; it is the energy that holds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called fission. The sun combines the nuclei of hydrogen atoms in a process called fusion.
- **Gravitational potential energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy because of its position. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

Kinetic Energy

Kinetic energy is motion; it is the motion of waves, **electrons**, atoms, molecules, substances, and objects.

- **Electrical energy** is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make electrons move. Electrons moving through a wire are called **electricity**. Lightning is another example of electrical energy.
- **Radiant energy** is **electromagnetic** energy that travels in vertical (transverse) waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Solar energy is an example of radiant energy.
- **Thermal energy**, or heat, is the internal energy in substances; it is the vibration and movement of the atoms and molecules within a substance. The more thermal energy in a substance, the faster the atoms and molecules vibrate and move. Geothermal energy is an example of thermal energy.
- **Motion energy** is the movement of objects and substances from one place to another. Objects and substances move when an unbalanced force is applied according to **Newton's Laws of Motion**. Wind is an example of motion energy.
- **Sound energy** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate; the energy is transferred through the substance in a longitudinal wave.

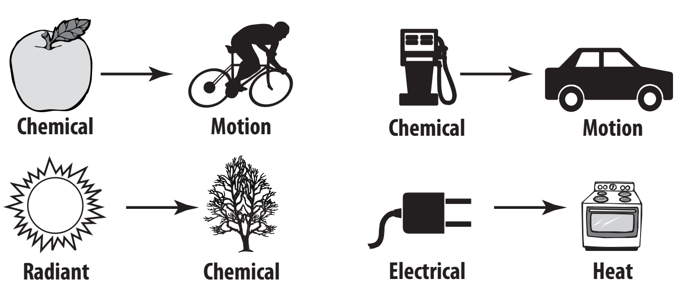
Energy Transformations

Energy cannot be created or destroyed – this is the **Law of Conservation of Energy**. If you are using energy, it is coming from something, somewhere. The electricity used to power your computer doesn't magically appear, it is generated at a power plant, which must bring in some kind of fuel to generate the electricity. Every day we change energy from one form to another. A radio changes electrical energy into sound. Your muscles change chemical energy from your food into motion. The Earth changes the radiant energy from the sun into thermal energy, and as the air gets warmer, thermal energy is again changed into the motion of the wind. Changing one form of energy into another is called a **transformation**.

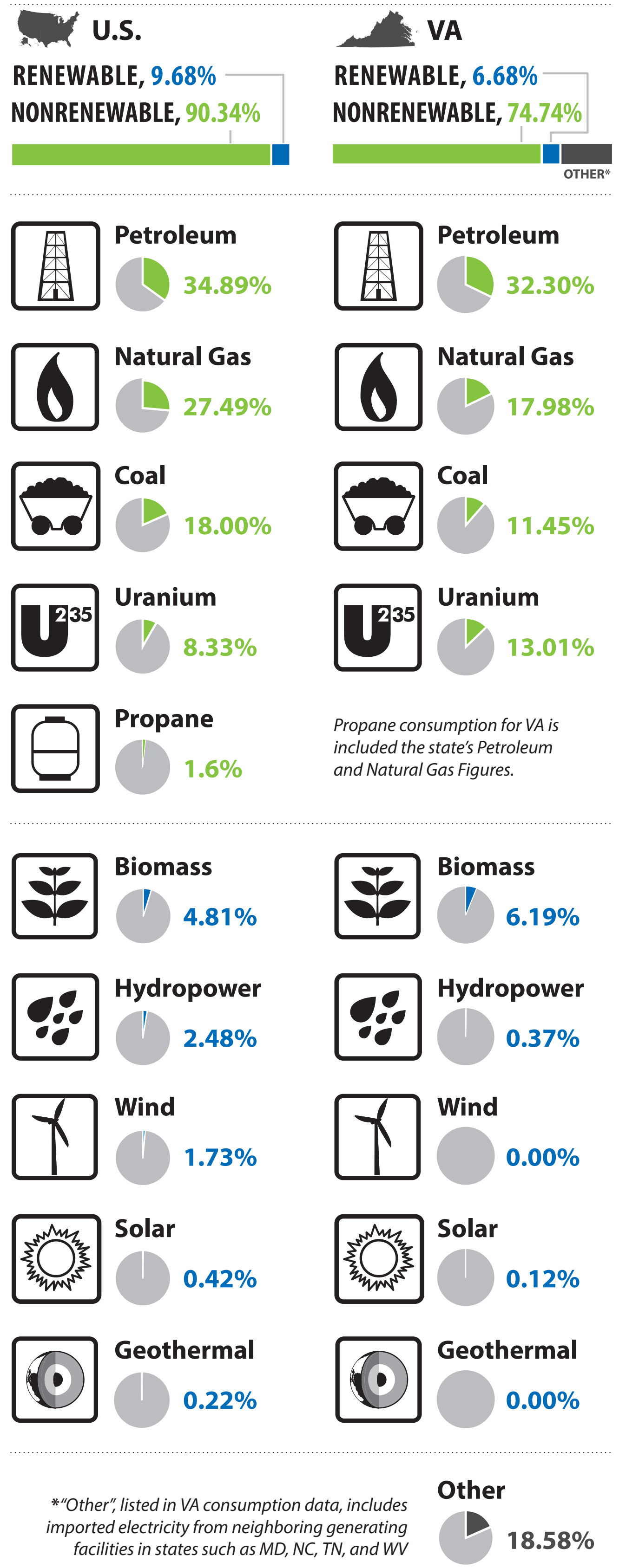
All transformations of energy will also result in some energy being changed into thermal energy, and often some sound, too. When you move your arm up and down, over and over, the muscles in your arm transform the energy from your food into the motion of your arm. But what also happens? When your computer is left on and running a long time, it gets warm. This is because the computer is using a lot of electrical energy, and some of that energy is being changed into heat. When you ride your bike, your muscles are providing the energy to move the bike, but some of the energy is also transformed into sound – you can hear it in the movement of the parts of your bike.

How well we use energy – called **energy efficiency** – is determined by how much useable energy we get from an energy transformation. Even the most efficient machines do not change all of the incoming energy into useful work. Your body functions very well, but overall only about 25 percent of the energy you take in (food you eat) is actually used to do work. That means for every 100 units of energy you eat, 25 units are used in a useful way. The other 75 are changed to heat and a very small amount of sound. Electric power plants that use coal or natural gas are about 35 percent efficient. Other machines, like car engines and old-fashioned light bulbs, are very inefficient, using only about one-tenth of the energy they take in to do the work for which they are made! Using energy sources wisely is very important.

Energy Transformations



U.S. & VA Energy Consumption by Source, 2014



Data: Energy Information Administration
*Total does not equal 100% due to independent rounding.

Sources of Energy

We use many different energy sources to get the energy we need to do work for us. These sources are classified into two groups—renewable and nonrenewable.

Nonrenewable Energy Sources

In the United States, most of our energy comes from **nonrenewable** energy sources. Coal, natural gas, petroleum, propane, and uranium are nonrenewable energy sources. They are used to make electricity, heat our homes, move our cars, and manufacture all kinds of products. These energy sources are called nonrenewable because their supplies are limited. Petroleum, a **fossil fuel**, for example, was formed hundreds of millions of years ago from the remains of ancient sea plants and animals. We can't make more crude oil deposits in a short time.

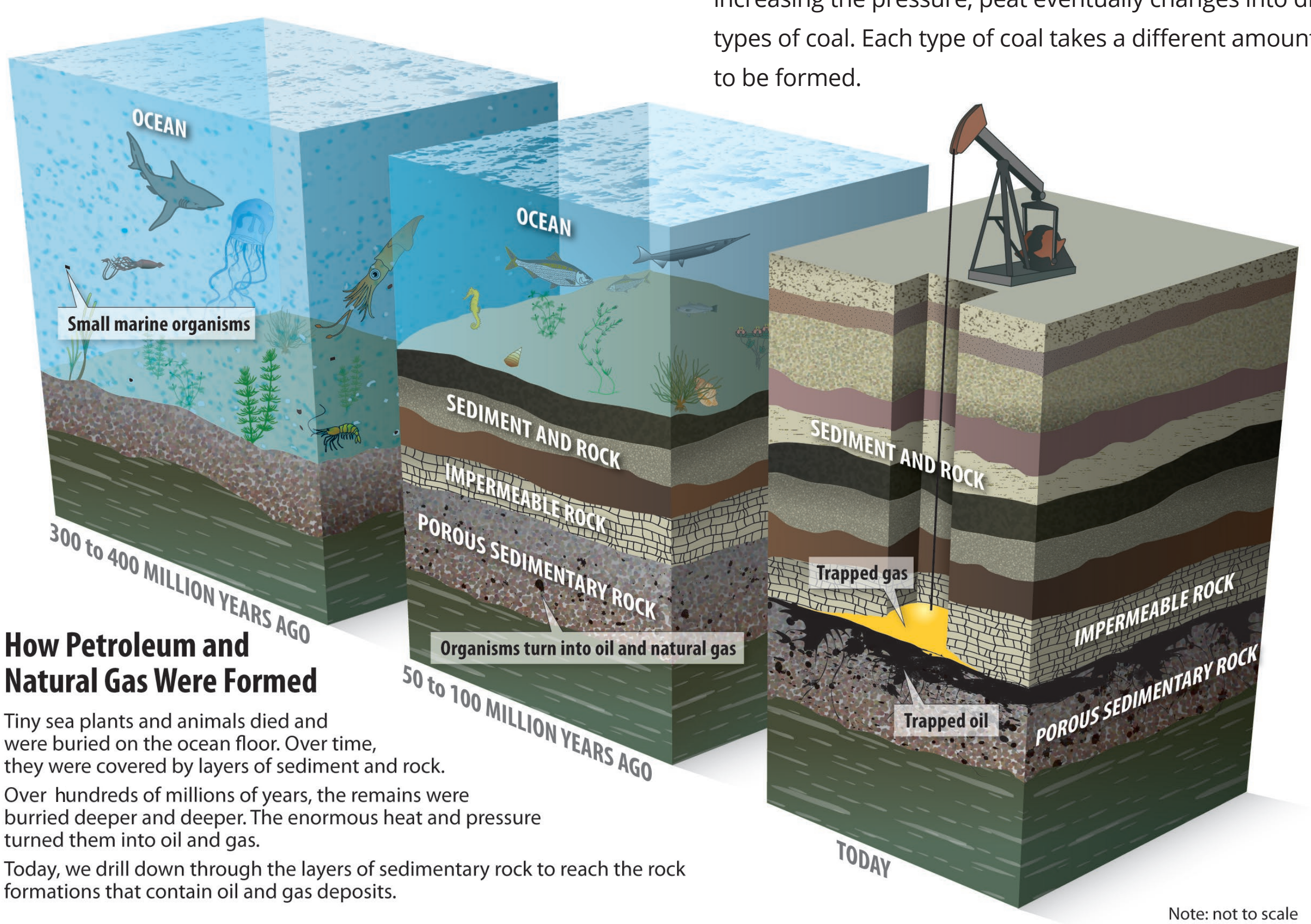
Fossil Fuels

Coal, natural gas, petroleum, and propane are called fossil fuels because they were formed from the remains of plants or animals that lived millions of years ago. Coal was formed primarily from plants in swampy areas that were buried before they could decay completely. Natural gas, petroleum, and propane were formed from tiny sea plants and animals that died and were buried at the bottom of the ocean. In all cases, fossil fuels required a lot of time and a lot of pressure beneath layers and layers of **sedimentary** rock to change them into what we see today.

Coal

Coal is a solid energy source that often looks like a shiny, black rock. Some coal, however, can be dull and lighter in color. The energy we get from coal today came from the energy that plants absorbed from the sun millions to hundreds of millions of years ago. All living plants store energy from the sun. After the plants die, this energy is usually released as the plants decay. Under certain conditions, however, the decay is interrupted, preventing the release of the stored solar energy.

The formation of coal is a simple but lengthy process. Plants that eventually became coal died and were buried under sediment in a swampy area. Over time as layers of sediment were added, the water was squeezed out of the organic matter. At first a substance called **peat** was formed. In some areas, peat is mined and used as an energy source. It is soft, crumbly, and looks like soil with a lot of sticks or dead leaves in it. As more time passes and more layers of rock are added, increasing the pressure, peat eventually changes into different types of coal. Each type of coal takes a different amount of time to be formed.



How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock.

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

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

First peat forms **lignite**, then after more time, **sub-bituminous**, then **bituminous**, and finally **anthracite** coal. Anthracite is very shiny, very dark, and has the greatest amount of energy in it because it took the longest to form and was exposed to the most pressure. Lignite is dark brown, crumbly, and has the least amount of energy in it. Most coal mined in the United States is bituminous or sub-bituminous.

Coal has been used for centuries as a source of heat and was especially important during the **Industrial Revolution** to power the steam engine and make steel. Today, coal is still used to make steel but most of it is used to generate electricity. In fact, the number one energy source used to generate electricity in the U.S. is coal.

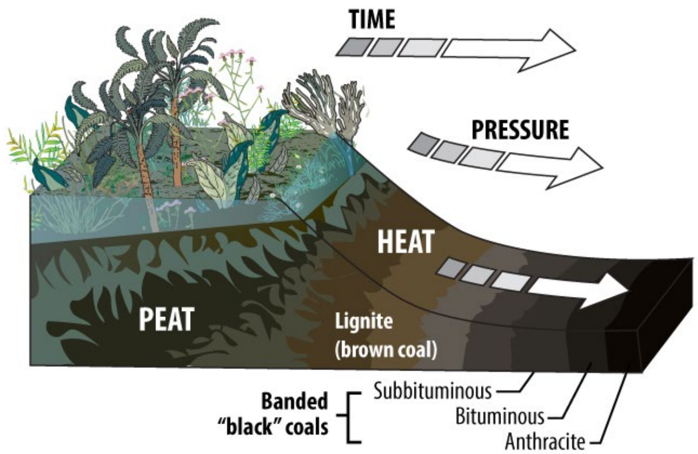
Because coal is buried underground, we must dig it out by **mining**. There are two kinds of coal mines – **underground** and **surface** mines. Underground mining is used when the coal deposit is very deep below ground. A long, deep tunnel is dug to reach the coal, and it is broken into chunks and carted out of the mine. Surface mining is used when the coal is closer to the surface. This style of mining uses enormous machines to scrape back the layers of dirt and rock covering the coal. The coal is removed, and the dirt and rock are pushed back when all of the coal is removed. Both kinds of mining can be dangerous, and workers must follow strict safety guidelines to keep themselves and the other miners safe. When as much coal as possible can be removed, the mine is closed and goes through a process called **reclamation**. This involves putting the area around the mine back into as close to its original form as possible.

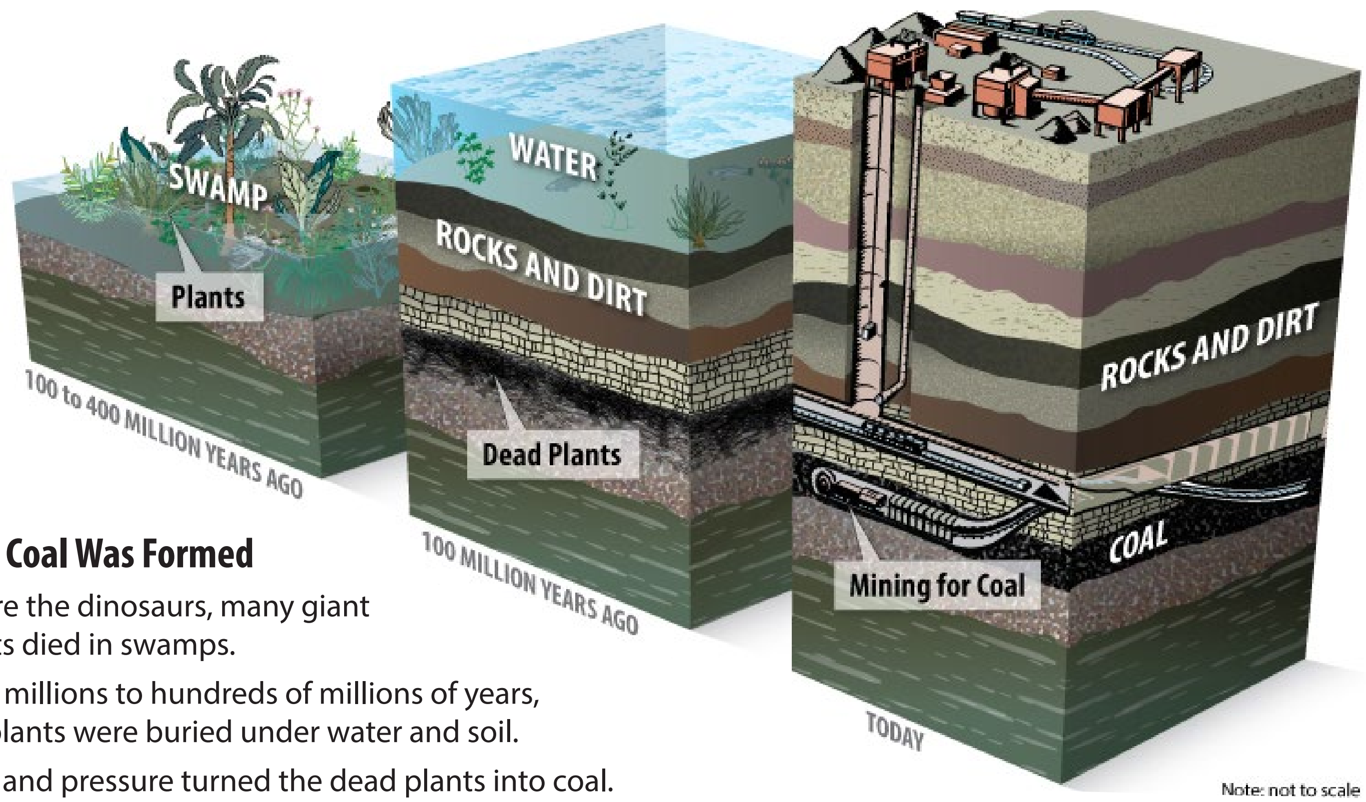
Virginia Energy Fun Fact

The 69 coal mines in far western Virginia produce about 1.5% of the nation's coal. Coal is one of Virginia's primary natural resources used for energy production.

SOURCE: EIA

Coal Formation





How Coal Was Formed

Before the dinosaurs, many giant plants died in swamps.

Over millions to hundreds of millions of years, the plants were buried under water and soil.

Heat and pressure turned the dead plants into coal.

Natural Gas

Natural gas is trapped in underground rocks much like a sponge traps water in its pockets or **pores**. Natural gas is really a mixture of gases. The main ingredient is **methane**. Methane has no color, odor, or taste. As a safety measure, natural gas companies add an odorant, **mercaptan**, to the gas so that leaking gas can be detected (it smells like rotten eggs). Natural gas should not be confused with gasoline, which is made from petroleum.

Natural gas is almost always considered nonrenewable, which means we cannot make more in a short time. However, there are some renewable sources of methane, such as landfills. Natural gas can be found all by itself, or it can be found along with coal and petroleum.

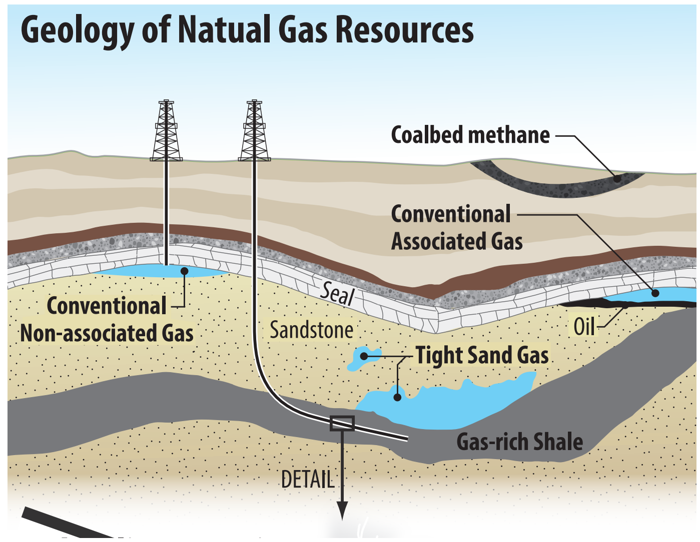
People use natural gas mostly for heating and cooking, but it is also used as a fuel in many electric power plants. Compared to coal, natural gas does not produce as much air pollution because it burns more cleanly. Also, natural gas burners can be turned on and off quite easily to provide more or less electric power as it is needed.

Finding natural gas deposits can be complicated. Geologists use a wide variety of equipment to locate the right sedimentary rocks, and a **core sample** is taken to locate the natural gas. When it is found, a deep hole, called a well, is drilled down to reach the natural gas. Sometimes the underground pressure is strong enough to push the natural gas through a well to the surface. However, there are some kinds of rocks that are not **permeable** enough to allow the gas to flow freely into the well, and a technique called **hydraulic fracturing** is used. This process uses high-pressure water to crack channels into the rock and sand to hold the channels open so that the natural gas can flow through the channels, or fractures, to the surface. From a well, natural gas is pressurized and transported through underground pipes in a system called a **pipeline**.

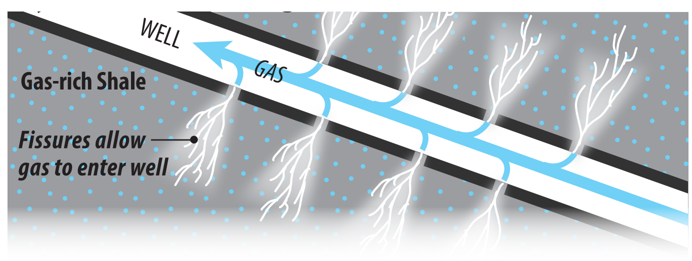
Virginia Energy Fun Fact

Natural gas produces the second highest amount of electricity in Virginia, 27 percent in 2014.

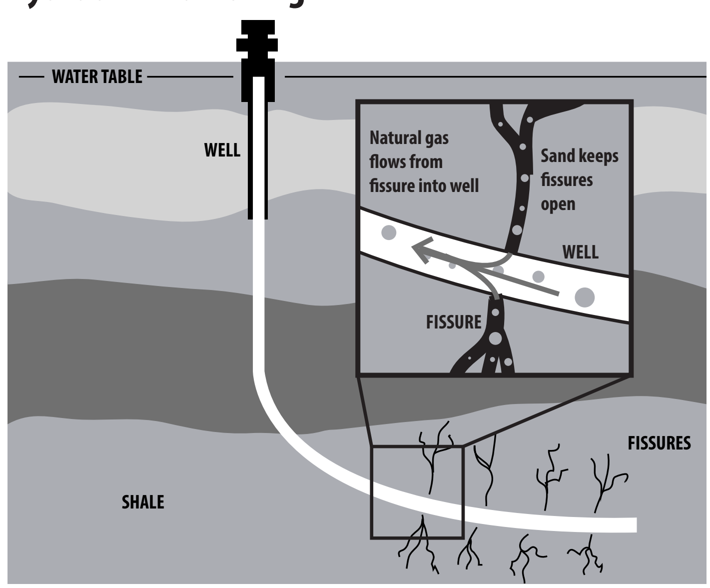
SOURCE: EIA



Hydraulic Fracturing (Close-up)



Hydraulic Fracturing



Petroleum

Petroleum is often called **crude oil**, or oil. It is locked in the pores of rocks almost like water is trapped in a wet sponge. When crude oil comes out of the ground, it can be as thin as water or as thick as tar. Because it takes hundreds of millions of years to form, we cannot make new petroleum reserves as quickly as we use them.

For centuries, petroleum has been used where it would bubble up out of the ground. The ancient Chinese and Egyptians burned crude oil in lamps for light. Before the 1850s Americans used whale oil for lamp light. When overfishing made whale oil more difficult to get, crude oil became the fuel of choice.

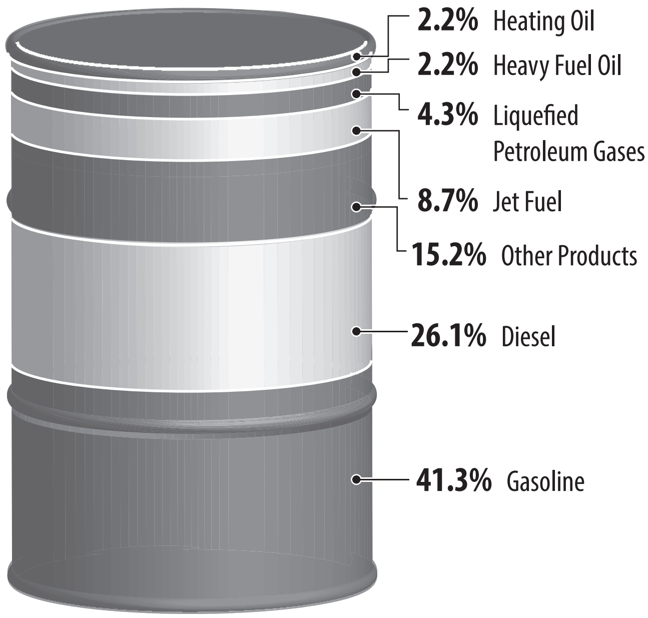
Petroleum is a mixture of compounds called **hydrocarbons**, molecules with only hydrogen and carbon. There can be many different combinations of hydrogen and carbon that have different properties. Some are solids, some are liquids, and some are gases, and often, these compounds are all mixed together and pulled up from the ground at the same time. To separate these compounds from each other, the crude oil must be sent to a **refinery**. That is where petroleum is separated into its useful products like propane, gasoline, diesel fuel, and other materials.

When petroleum refining first began, the only part of crude oil that was desired was kerosene, which was used in lamps and street lights. The rest of the products were thrown away, often into a river! When the automobile was developed and mass produced, a low-cost, widely available fuel was needed. The answer was gasoline, which was also found in crude oil. Today, petroleum provides the most energy in the United States. Almost all transportation fuels are made from petroleum. Thousands of products like toys, car parts, and makeup are made from materials that are made from petroleum.

Propane

Propane is an energy-rich gas that is found mixed with deposits of natural gas and petroleum underground. Propane is one of the many fuels that are included in the **liquefied petroleum gas** (or **LPG**) family. In the United States, propane and LPG often mean the same thing, because propane is the most common type of LPG used. Just as water can be a liquid or a gas (steam), so can propane. Under normal conditions, propane is a gas. Under pressure, propane becomes a liquid.

Products Produced From a Barrel of Oil, 2014



Data: Energy Information Administration

Virginia Energy Fun Fact

About one Virginian household out of ten uses fuel oil, kerosene, or propane for home heating.

SOURCE: EIA

Propane is stored as a liquid fuel in pressurized tanks because it takes up much less space in that form. Gaseous propane takes up 270 times more space than liquid propane. A thousand-gallon tank holding gaseous propane would provide a family enough cooking fuel for one week. The same tank holding liquid propane would provide enough cooking fuel for over five years! Propane becomes a gas when it is released to fuel gas appliances.

Propane is very similar to natural gas. Like natural gas, propane is colorless and odorless. An odorant, called mercaptan, is added to propane so escaping gas can be detected. However, unlike natural gas, propane is moved from place to place in large tanker trucks. People living in rural areas who do not have natural gas pipelines available to them will often use propane to heat their homes or fuel their stoves. Propane is also used in most backyard barbecue grills. Some vehicles, especially forklifts and specialty vehicles at airports, use propane as fuel.

Nuclear Energy

Atoms are extremely tiny, invisible particles that make everything. Atoms have two major parts. The center, called a **nucleus**, is made of particles called **protons** and **neutrons** and is where most of the atom's mass is. Around the nucleus are **electrons**, which are so tiny they have almost no mass at all. The electrons move around at nearly the speed of light. They interact to hold atoms together in compounds like water, petroleum, and even your lunch.

The nucleus of the atom has an enormous amount of potential energy that we can use to make electricity, but first the energy must be released. It can be released from atoms in two ways: nuclear **fusion** and **fission**.

In nuclear fusion, energy is released when atoms are combined or fused together to form a larger atom. This is how the sun produces energy. In nuclear fission, atoms are split apart to form smaller atoms, releasing energy. Nuclear power plants use nuclear fission to produce electricity.

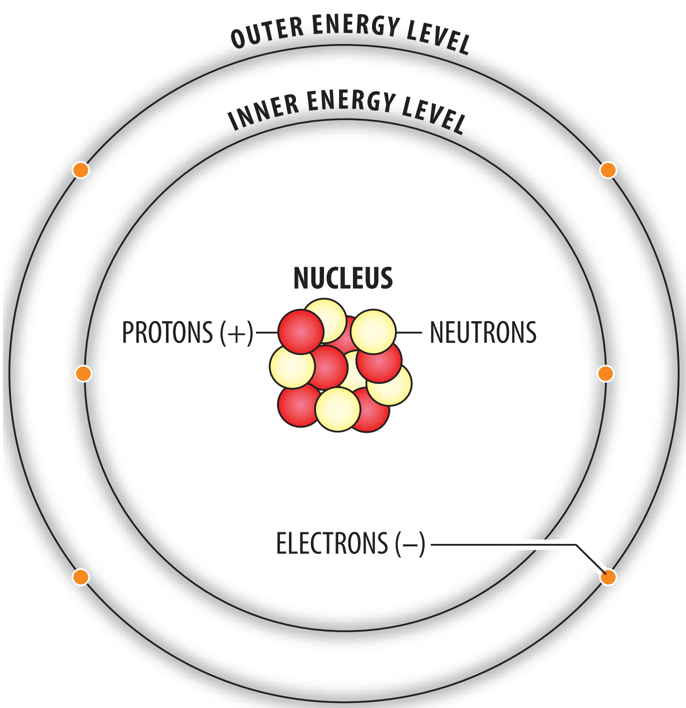
The fuel most widely used by nuclear plants for nuclear fission is **uranium**. Uranium is nonrenewable, though it is a common metal found in rocks all over the world. Nuclear plants use uranium as fuel because its atoms are easily split apart. During nuclear fission, a small particle called a neutron hits the uranium atom and the atom splits, releasing a great amount of energy as heat and radiation. More neutrons are also released. These neutrons go on to bombard other uranium atoms, and the process repeats itself over and over again. This is called a **chain reaction**. Nuclear power plants use the energy released by nuclear fission to heat water into steam to turn a **turbine**.

Uranium has a very high **energy density**, meaning that a small amount of uranium contains a large amount of energy. This is what makes it a good fuel for generating large amounts of electricity all the time. However, uranium is **radioactive**, which can be harmful, and must be handled with extreme care. When uranium fuel is no longer efficient for producing electricity, it is still radioactive, and the waste products must be stored safely, away from people, for thousands of years. This is one of the reasons some people do not want more nuclear power plants built. Uranium is only useful as a fuel for electric power generation. Because the radiation produced by uranium can be harmful, it would not be safe to have small nuclear power plants in cars and trucks! But because uranium is so abundant, it can continue to be used for a long time to generate electricity.

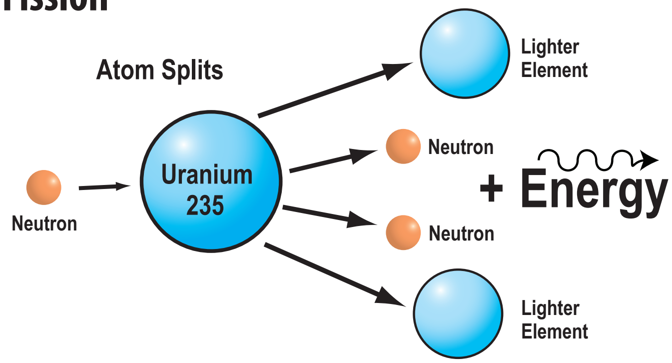
Virginia Energy Fun Fact

Two nuclear power stations – North Anna and Surry – provide Virginia with almost forty percent of its electricity.

SOURCE: EIA



Fission



Renewable Energy Sources

Renewable energy sources include biomass, geothermal energy, hydropower, solar energy, and wind energy. They are called renewable because they are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

Biomass

Biomass is any **organic** matter that can be used as an energy source. Wood, crops, and yard and animal waste are examples of biomass. People have used biomass longer than any other energy source. For thousands of years, people have burned wood to heat their homes and cook their food.

Like fossil fuels, biomass gets its energy from the sun in a process called **photosynthesis**. Plants use sunlight, air, water, and nutrients from the soil to make **carbohydrates**. When we burn wood or yard wastes for heat, we are burning the carbohydrates. Foods that are rich in carbohydrates (like spaghetti) are good sources of energy for the human body. Animal wastes used for energy are taking advantage of the unused energy from food. Biomass is called a renewable energy source because we can grow or create more in a short period of time.

Some forms of biomass are not used directly from the living things that made them. One example is **ethanol**, which is a type of alcohol made by yeast from carbohydrates. In the United States, the most common carbohydrate source of ethanol is corn, but other countries like Brazil use sugar cane or grass too. Ethanol is used to mix into gasoline as a transportation fuel. Personal cars, work trucks, and even race cars run on ethanol mixtures.

Another **biofuel** is **biodiesel**, which is made through a series of chemical reactions with vegetable oil, animal fat, or fryer grease as the starting material. Diesel fuel made from petroleum and biodiesel are both specially made for use in diesel engines in large semi-tractor trucks, farm equipment, and other heavy use vehicles. Unlike petroleum diesel, biodiesel is **biodegradable**, meaning it can be broken down naturally and is non-toxic. Biodiesel can be made from new vegetable oil, or it can be made from the waste oil produced by restaurants. Biodiesel vehicle exhaust can actually smell like french fries!

Even though it's not produced directly from an organic source, another form of biomass is trash. We can use trash for energy by sending it to a waste-to-energy plant, which burns the trash, controls pollution, and uses the heat to generate steam and turn a turbine. Cities that burn trash for energy solve two problems at once – they don't use as much landfill space and they are using a renewable energy source for electricity.

Virginia Energy Fun Fact

Almost five percent of Virginia's electricity is fueled by biomass. Virginia has four waste-to-energy power plants.

SOURCE: EIA

Geothermal Energy

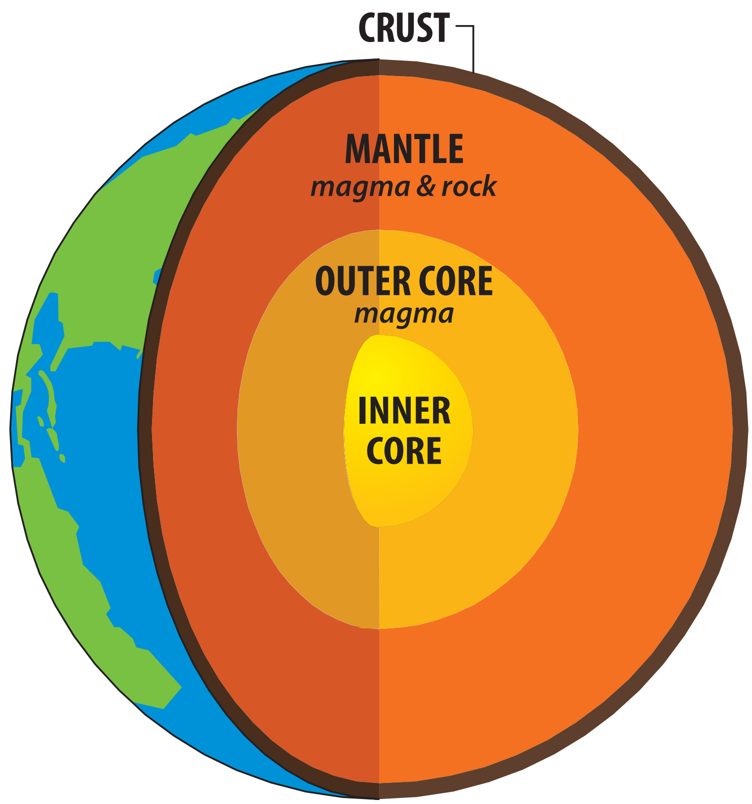
The word **geothermal** comes from the Greek words geo (earth) and therme (heat). Geothermal energy is heat from within the Earth. Geothermal energy is generated in the Earth's **core**, almost 4,000 miles (6,400 km) beneath the Earth's surface. The double-layered core is made up of very hot **magma** surrounding a solid iron center.

Surrounding the outer core is the **mantle**, which is about 1,800 miles (2,900 km) thick and made of magma and rock. The outermost layer of the Earth, the land that forms the continents and ocean floors, is called the **crust**. The crust is three to five miles (5-8 km) thick under the oceans and 15 to 35 miles (24-56 km) thick on the continents.

Very high temperatures are continuously produced inside the Earth because of the great pressure in the core and mantle. Rocks in the crust are warmed by the continuous, slow **radioactive decay** of rock particles, which is natural in all rocks.

The crust is not one solid piece of rock, like the shell of an egg, but is broken into pieces called **plates**. Magma comes close to the Earth's surface near the edges of these plates. This is where volcanoes occur. The lava that erupts from volcanoes is magma that has reached the Earth's surface. Deep underground, the rocks and water in the crust absorb the heat from this magma.

We can dig wells and pump the heated, underground water to the surface. Geothermal energy is called a renewable energy source because the water is replenished by rainfall and the heat is continuously produced deep within the Earth. We won't run out of geothermal energy.



Geothermal energy can be used by homes for heating and air conditioning. Because the ground stays at a constant temperature just a few feet below the surface, it can be used to heat or cool air at different times of the year. A geothermal system uses pipes underground filled with a fluid that is circulated with a pump. In the summer time, the fluid cools air in a **heat exchanger**. In the winter, the same system of fluid-filled pipes warms air in the same heat exchanger.

In certain areas, geothermal energy can be used to generate electricity. In these locations, magma can get closer to the surface because of openings or thinner areas in the crust. In these areas, underground water can get very hot, and even be turned into steam. These high temperatures are used in geothermal power plants to generate steam to turn a turbine and generate electricity. Geothermal energy generates a very small amount of U.S. electricity.

Hydropower

Hydropower (the prefix *hydro* means water) is energy that comes from moving water. The movement of water between the Earth and the atmosphere is part of a continuous cycle called the water cycle. The sun warms water on Earth's surface and evaporates it. As it cools, this moisture condenses into clouds. The moisture is released from the clouds as rain or snow. The oceans and rivers are replenished with moisture, and the cycle starts again.

Gravity causes the water on the Earth to move from places of high ground to places of low ground. The force of moving water can be very powerful. Hydropower is called a renewable energy source because it is replenished by snow and rainfall. As long as the sun shines and the rain falls, we won't run out of this energy source.

Hydropower was used several hundred years ago as a source of energy to grind grain and later to run sawmills. The water of a flowing river or stream was diverted into channels that turned a water wheel, which was connected to a gristmill to grind grain or a saw blade to cut lumber.

In 1882, a hydropower plant was built in Appleton, Wisconsin, that was the first to use the energy in flowing water to turn a turbine and generate electricity. Today over 2,000 sites in the United States produce between five and ten percent of the nation's electricity. The amount of electricity produced changes as the amount of rainfall in an area changes. During times of drought, less electricity is generated. Many other countries rely much more heavily on hydropower for their electricity needs.

Virginia Energy Fun Fact

The Bath County Pumped Storage Station is one of the largest pumped storage hydroelectric facilities in the world, with a generating capacity of more than 3 megawatts of power.

SOURCE: DOMINION

Hydropower is a good source of electricity generation because it is clean and very efficient. As much as 95 percent of the energy in moving water can be transformed into useful electricity. Compared to the 35 percent efficiency of a typical **thermal power plant**, like one that burns coal or natural gas, hydropower is the rock star of electric power generation! So why don't we build more hydropower plants? One reason is that most rivers in the U.S. with water flowing fast enough already have hydropower plants on them. Another reason is that building a dam floods vast amounts of valley land and can force families and whole towns to relocate. Even so, many locations with dams already built for flood control can be upgraded to be electric power generating locations, too.

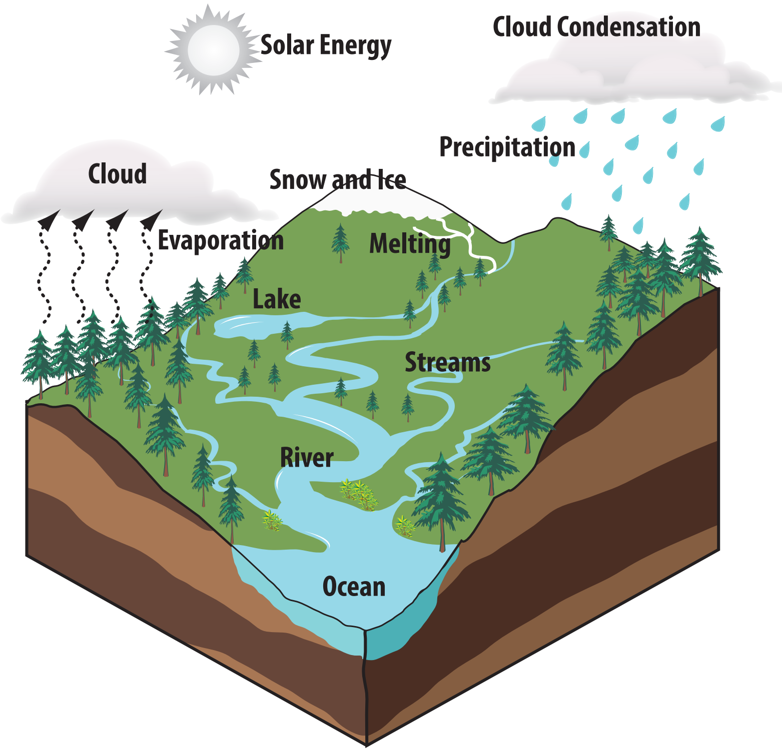
Solar Energy

The sun **radiates**, or sends out, enormous amounts of energy all day, every day, all year, every year. We call this energy **solar energy** and it's the most important energy source on Earth. According to NASA, The sun produces about 500,000,000,000,000,000,000,000 ($5x10^{23}$) horsepower. That is enough energy to melt a block of ice 2 miles wide and 1 mile thick, that extends the entire way from the Earth to the sun, in one second! The sun, like most stars, is made mostly of hydrogen and helium. The sun's energy comes from nuclear fusion in its core.

The energy radiated by the sun takes about eight minutes to travel to Earth. Solar energy, which includes sunlight, travels at the speed of light, 186,000 miles per second, or $3.0x10^8$ meters per second. Only a small part of the radiant energy (including visible light) that the sun sends into space ever reaches the Earth, but that is enough to sustain life on our planet. For millions of years plants have been storing its energy through photosynthesis. Solar energy is considered renewable because the sun will continue to shine as long as life on Earth is possible.

Solar energy has been used by people since history began. Besides light and warmth, sunlight became important when humans began cultivating crops. Ancient people used solar energy for drying crops and animal meat and skins. Today, we still use solar energy for lighting and drying crops like hay. But as technology has changed so has our approach to how we use solar energy.

The Water Cycle



Virginia Energy Fun Fact

According to the Solar Energy Industries Association, Virginia's installed solar capacity is about 22 MW, enough to power more than two thousand homes. This number moves each year as more solar facilities are installed.

SOURCE: SEIA

Using solar energy can be grouped into two general categories: passive and active. When you open the blinds on a cold, winter day to allow the sunlight to warm your room, you're using solar energy in a passive way. Active solar energy use involves using specialized equipment. One way that people all over the world use solar energy actively is with a solar water heater. A dark surface absorbs sunlight and gets hot, and water circulates through pipes near the heated surface, causing the water to get hot, too.

Another way of using solar energy is to generate electricity. There are two types of technology used to generate electricity with sunlight: Concentrated solar power and **photovoltaics** (solar panels). Concentrated solar power, or CSP, involves using reflective surfaces to capture, focus, and reflect the light

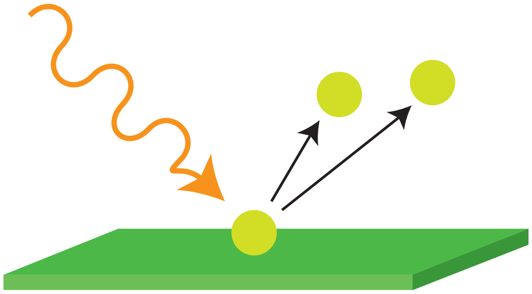
CSP POWER TOWER SYSTEM

onto a fluid or salt that is heated by the light. This extremely hot fluid or salt is then run through a heat exchanger where it boils water to generate steam and turn a turbine – just like a coal, natural gas, or nuclear power plant would.

Photovoltaic systems are the more common of the two solar energy technology groups. They're easy to use, can be adapted for very small or very large uses, and have no moving parts to maintain. You probably know photovoltaics as "solar cells" or "solar panels." The word photovoltaic has the prefix photo, which means "light", and the root word volt, which means "electricity." Photovoltaics use light to generate electricity. How does it work? The **photoelectric effect**.

Without getting too bogged down in details, imagine that light acts like a baseball. If you throw a baseball at a bottle, the bottle will topple over. The photoelectric effect works in a similar way but on a much smaller scale. Light can "knock over" electrons in atoms of certain substances, and make them move. This is called the photoelectric effect. The light has to be just the right color, and the substance has to be just the right material, too, for it to work. Photovoltaics use this particle-like behavior of light to "knock" electrons through an electric circuit. The electrons are the only things that move, and the rest of the photovoltaic cell remains in place. PV cells typically last 20-30 years, because they have no moving parts to repair.

PV cells can be expensive to purchase, but once they are installed and running there is no cost to operate them. If the sun is shining on the panel, it is generating electricity. The smallest PV systems are used for things like road signs that need to move from place to place or in remote or rural areas. Homes and businesses can use PV systems to help generate some of their electricity using solar energy. Electric utilities use large photovoltaic systems to generate electricity when the sun is high and bright in the sky.



THE PHOTOELECTRIC EFFECT

Light of the correct color reaches a special material and energizes an electron. The electron then can move even more than before. In a photovoltaic cell, an electron moves through an electric circuit and does work.

Wind Energy

Wind is simply air in motion. It is caused by the uneven heating of the Earth's surface by radiant energy from the sun. Since the Earth's surface is made of very different types of land and water, it absorbs the sun's energy at different rates. Water usually does not heat or cool as quickly as land because of its physical properties. When air is hotter in one area than in another, it becomes less dense and rises. Cooler, denser air will move in to replace it and create wind. It's really easy for wind to form where land and water meet. During the day, the air above the land heats up more quickly than the air above water. The warm air over the land expands, becomes less dense and rises. The denser, cool air over the water flows in to take its place, creating wind.

Wind has been used for centuries to propel ships through the water and turn gristmills to grind grain. In the last 150 years, ranchers have used wind energy to power pumps to pull water from underground for their horses and cattle. More recently, though, wind energy has been used to generate electricity. It is the fastest growing renewable energy technology in the country.

Wind energy is used to make electricity with a wind turbine. Unlike the steam turbines in a power plant, this turbine is turned directly by the energy source, similar to hydropower. Modern wind turbines are really tall; most are 80 meters high (200-300 feet) and wide enough for a person to climb up and down inside it. At the top of the tower is the **nacelle**, which houses the turbine that generates the electricity. The blades are attached to the turbine by a **rotor hub**. All of these parts work together to capture wind energy to generate electricity.

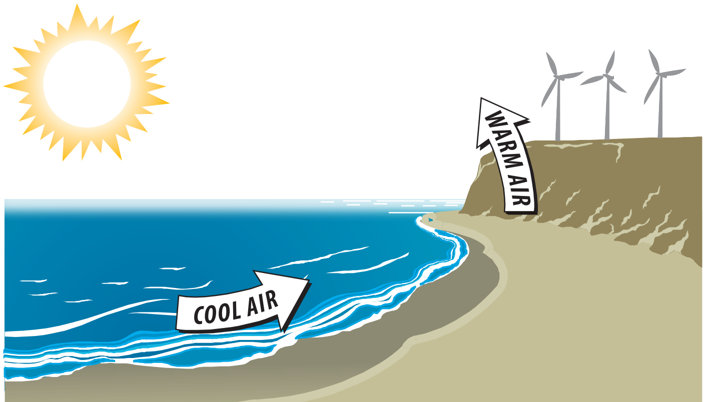
Wind turbines are usually built in large groups called wind farms. No one is actually growing wind, but it is a large area of land where utilities are trying to harvest wind energy. Wind has been growing really fast in the last fifteen years. In 2001, wind turbines generated just 0.18 percent of all electricity generated in the United States. In 2015, that number had increased to 4.7 percent. No other energy source has grown that much in the same time period.

Virginia Energy Fun Fact

The Virginia Department of Mines, Minerals, and Energy plans to permit a 12 megawatt offshore wind test facility off the coast of Virginia. The project is expected to be commissioned in 2017 or 2018.

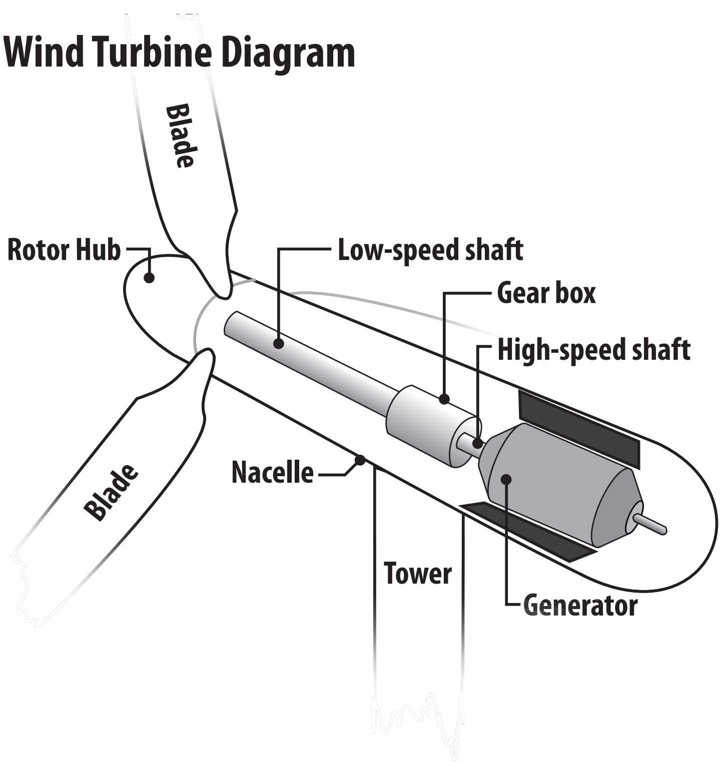
SOURCE: VA DMME

How Wind is Formed



1. The sun shines on land and water.
2. Land heats up faster than water.
3. Warm air over the land rises.
4. Cool air over the water moves in.

Wind Turbine Diagram



Virginia is for Energy Lovers

Each state uses energy in different ways and in different amounts. A state's climate, population, and style of living will all influence how the people in that state use energy. States with large farms and ranches, like Nebraska or Wyoming, use energy differently than smaller states with many cities and towns, like Maryland or Connecticut. Warm states like Florida and Hawaii use energy differently than cooler states like Minnesota and Michigan. How does Virginia compare to the rest of the country?

Virginians use about the same amount of energy as the average American uses. However, homes in Virginia often use more electricity than the average American family, probably because Virginians use their air conditioners more often. Although Virginians often use more energy in the form of electricity, they often pay less, because the cost of electricity is, on average, 1.4 cents less per kilowatt-hour than the national average most Americans pay.

Most of Virginia's total energy use comes from gasoline for automobiles and natural gas and generating electricity. When it comes to electricity, though, the big three energy sources are coal, natural gas, and nuclear energy.

Virginia's coal is mined in the far southwestern corner of the state. Virginia has 69 actively producing coal mines, which produce a little less than two percent of all the coal produced in the United States. Virginia coal is bituminous, the second-highest grade of coal. About 40 percent of coal from Virginian mines is sent to other states. Most of the coal that stays in Virginia is used to generate electricity. Before 2009, most electricity was produced by coal power plants. Today, coal ranks third in Virginia for electricity generation. About half of the coal mined in Virginia is exported to other countries. The seaports on Virginia's Atlantic coast are where more than a third of all the nation's coal exports head out to sea. Virginia plays an important role in the coal market in the United States.

Natural gas production in Virginia has increased dramatically in the last thirty years. Most of the natural gas produced in the state comes from seven southwestern Virginia counties. About 70 percent of the natural gas produced in Virginia comes from methane found where coal is mined. Two of the coalbed methane fields are listed in the nation's top 100 methane deposits. However, it only amounts to about a third of the demand for natural gas in the state. Several natural gas pipelines bring in the rest from other states and the Gulf of Mexico. Natural gas is used by a third of all homes in Virginia for heating and cooking. Electric utilities use natural gas to generate electricity. In 2012 natural gas produced more electricity than coal for the first time. These are the two leading uses of natural gas in Virginia.

The largest source of electricity in Virginia is nuclear power. The two nuclear power plants, Surry and North Anna, each have two reactors. North Anna can produce almost 2 gigawatts (GW) of power, and the reactors at Surry can produce about 1.7 GW. In other words, North Anna can provide enough power by itself for 400,000 homes, and Surry can power 340,000 homes. That's about 25 percent of all the households in the entire state! Nuclear power plants are able to produce large amounts of electricity. They need to be built alongside a major body of water, like a lake or large river, to provide the cooling needed to keep the power plant working. Surry was built on the James River across and downriver a bit from historic Jamestown. North Anna, though, is situated where no large bodies of water exist naturally. To provide the cooling needed for a power plant as big as North Anna, the North Anna River was dammed, forming Lake Anna. The dam also has a hydroelectric power facility built within it, which can produce one megawatt of power (a gigawatt, or GW, is one thousand megawatts, MW).

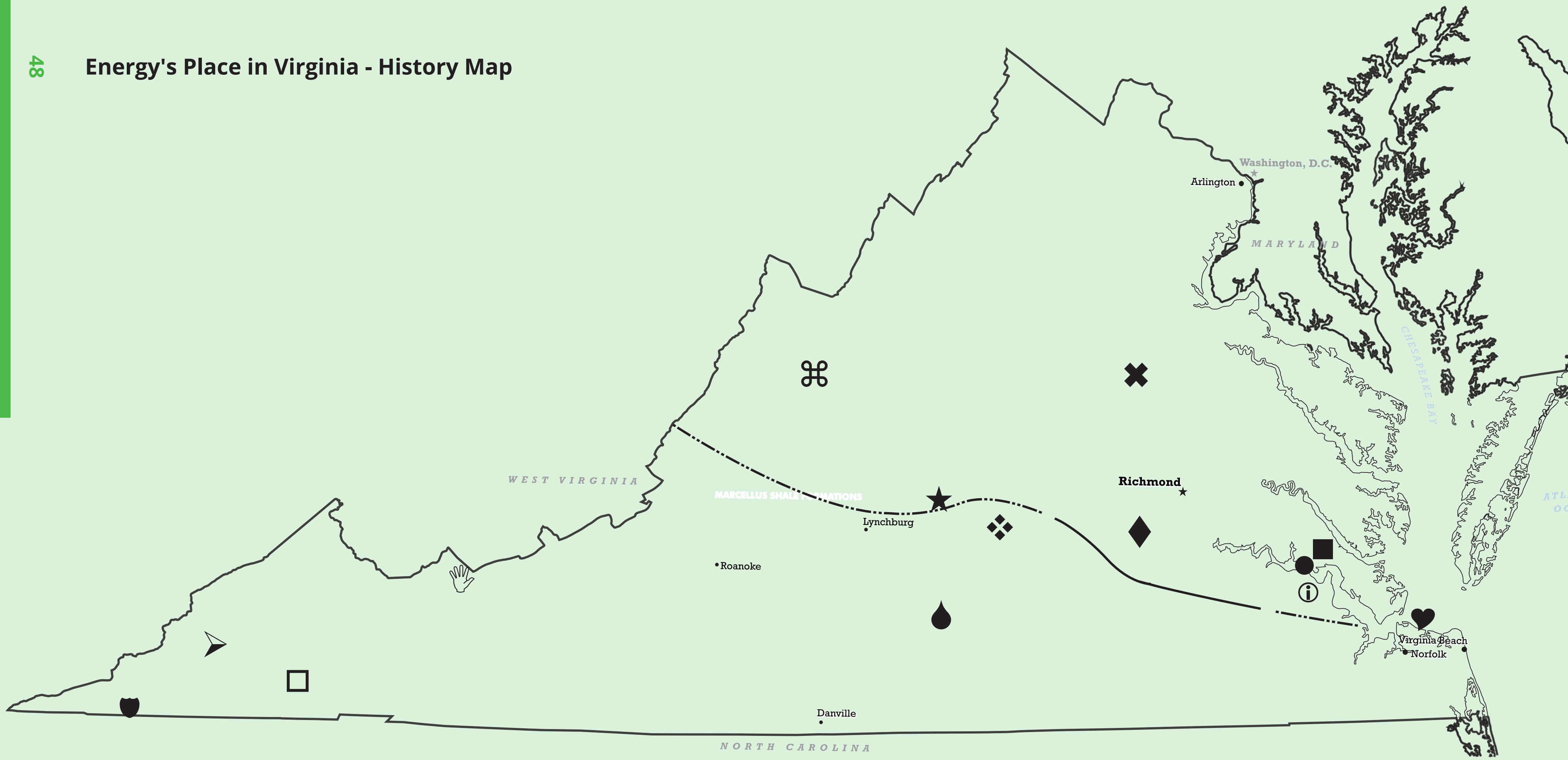
Energy's Place in Virginia History

1600s	Wood is the primary energy source for Virginians
1607	Jamestown established ●
1624	Virginia established as a royal colony
1693	Charter for the College of William and Mary is granted ■
1701	Coal is discovered outside Richmond, Virginia ♦
1748	First commercial coal production is begun near Richmond, Virginia
1776	Virginian Thomas Jefferson writes most of the Declaration of Independence
1776	Virginia declares its independence and becomes an American State
1788	Virginia is the 10th state to ratify the U.S. Constitution
1821	First natural gas well is dug in Fredonia, NY
1837	Cyrus McCormick patents a horse-powered reaper near Walnut Grove ⌘
1840s	Coal Mined in the Briery Creek Basin 💧
1840s	Natural Gas from the Burning Springs on the Kanawha River (now in WV) used to boil saline for salt production, marking the first commercial use of natural gas in the country
1860	Piedmont Coal Company Mine opened in Farmville Basin ❖
1861	Virginia secedes from the Union and joins the Confederate States of America
1863	West Virginia is formed from counties in northwestern Virginia
1865	The Confederate Army is defeated and Virginia is restored to the United States of America
1868	Chesapeake and Ohio Railroad is established ★
1882	First Hydroelectric Power Plant is opened in Appleton, Wisconsin
1885	Coal surpasses wood as the country's main energy source
1890s	Exploratory gas wells drilled in Wise County, Virginia ➢
1893	First dam for hydroelectricity production constructed near Austin, Texas
1899	Ernest Rutherford discovers radiation and names alpha and beta rays
1900s	Pocahontas Mine opened and supplied coal to Naval Yards during World War I ✋
1906-1970	U.S. Demand for natural gas increased by a factor of fifty

1914-1918	World War I
1920	Wood drops to third in energy supplied to the United States, behind Coal and Petroleum
1930s	Early Grove gas field developed ☐
1933	Grand Coulee dam is constructed in Washington
1937	Mercaptan is first added to natural gas, giving it a distinctive, rotten-egg smell, so it can be easily detected
1938	The first uranium atom is split in Germany
1940s	Oil wells drilled in Rose Hill field 🛡
1941-1945	World War II
1942	Research group led by Enrico Fermi demonstrated a sustained chain reaction in uranium in Chicago, Illinois
1945	Trinity test at Alamogordo, New Mexico, demonstrates the first nuclear weapon
1949	Almost one-third of the nation's electricity comes from hydroelectricity
1953	USS Nautilus, the first nuclear-powered submarine, is launched
1955	Petroleum becomes the top energy source in the United States
1957	Electricity is first produced from nuclear power in Santa Susana, California
1964	Chesapeake Bay Bridge-Tunnel is opened ♥
1971	New Virginia State Constitution goes into effect
1972	Surry Nuclear Power Plant opens ⓘ
1973	Organization of Arab Petroleum Exporting Countries declares embargo, leading to shortages of petroleum products nation-wide
1977	President Jimmy Carter proposes an energy policy to reduce energy consumption, focusing on energy conservation
1978	North Anna Nuclear Power Plant opens ✖
1979	Valve malfunction leads to only nuclear power plant accident in the United States at Three Mile Island in Pennsylvania
1983	Natural gas reached its highest historical price at a little over $10 per thousand cubic feet
1984	Nuclear power surpassed hydropower in electric power production
2007	Browns Ferry nuclear power plant in Tennessee is brought back online after being shut down in 1985

SOURCE: Virginia Places, EIA, Dominion

Energy's Place in Virginia - History Map



The following important events are shown on th emap above using the symbols shown:

1607	Jamestown established ●
1693	Charter for the College of William and Mary is granted ■
1701	Coal is discovered near Richmond, Virginia ♦
1837	Cyrus McCormick patents a horse-powered reaper near Walnut Grove ⌘
1840s	Coal Mined in the Briery Creek Basin 💧
1860	Piedmont Coal Company Mine opened in Farmville Basin ❖
1868	Chesapeake and Ohio Railroad is established ★
1890s	Exploratory gas wells drilled in Wise County, Virginia ➢
1900s	Pocahontas Mine opened and supplied coal to Naval Yards during World War I ✋
1930s	Early Grove gas field developed □
1940s	Oil wells drilled in Rose Hill field 🛡
1964	Chesapeake Bay Bridge-Tunnel is opened ♥
1972	Surry Nuclear Power Plant opens ⓘ
1978	North Anna Nuclear Power Plant opens ✖

The Nature of Electricity

Your entire life, you've flipped a switch or pushed a power button and automatically, even magically, you've lit a room or can start working on the computer. We don't really give it any thought, but electric power generation uses more energy than any other part of our economy. What is this thing with which Benjamin Franklin experimented, and that we have become so dependent upon?

Electrical Charges

Studying **electricity** goes back to ancient Greece and beyond. Amber, which is petrified tree resin, can be rubbed with a cloth and then used to pick up tiny things such as pieces of paper. The word electricity comes from the Greek electron, which means amber. What we now call **static electricity** was first called the amber effect, and describes an object which has been charged by rubbing.

Benjamin Franklin observed several objects being charged with static electricity, and noticed that sometimes they **attract**, or pull together, and sometimes they **repel**, or push apart. Franklin named the charges "positive" and "negative." He saw that positive and negative charges appeared in equal amounts, and if one of the objects became positive, the other became negative. There were never only positive charges or only negative charges, but always positive and negative.

Atomic Structure

To understand electric charge you need to think of the structure of the **atom**. Atoms are the smallest pieces of matter, and are made of three particles. The **nucleus** of the atom, found at the atom's center, contains nearly all of the atom's mass and is made of positively charged particles, called **protons**, and **neutrons**, which have no charge. Moving around outside the nucleus are tiny particles called **electrons**. Electrons have almost no mass and move at nearly the speed of light in their energy levels. When two objects are rubbed together and charge is transferred, electrons move from one object to the other. The object which lost the electrons becomes positively charged, and the object which gained the electrons becomes negatively charged.

Conductors and Insulators

Electrons can be transferred quickly and almost immediately through a **conductor**. A conductor is a substance through which electrons can easily move. If you have a material that will not easily allow electrons to move, it is called an **insulator**. This doesn't mean that insulators absolutely will not allow electrons to move, because they will, it just won't happen easily.

Magnets

All atoms have electrons, and all electrons move around the nucleus of the atom. Electrons are also spinning. Spinning electrons create small **magnetic fields** and act like microscopic magnets or micro-magnets. This is because electrons have an electric charge, and if they move they make a magnetic field. Magnetism and electricity are related. Magnets can create electricity and electricity can produce magnetic fields. Every time a magnetic field changes, an electric field is created. Every time an electric field changes, a magnetic field is created. Magnetism and electricity are always linked together; you can't have one without the other. This phenomenon is called **electromagnetism**. It's hard to explain electromagnetism simply. Like gravity, we don't know why electromagnetism works, but we know it works all the time and we can measure, predict, and use it to our advantage.

In most objects, the electrons located around the nucleus of the atoms spin in random directions throughout the object. This means the micro-magnets all point in random directions, cancelling out their tiny, individual magnetic fields. Objects that we call **magnets** are different—they have atoms with micro-magnets that do not cancel each other out and work together to create an overall magnetic field. A small number of magnetic atoms in an object won't turn it into a magnet. To make a magnet you need a lot of magnetic atoms. The tiny, individual magnetic fields of those magnetic atoms work together so that the object overall has its own magnetic field.

In a magnet, the micro-magnets of magnetic atoms all line up, forming larger regions with magnetic fields. Those fields all line up in a magnet, which means the north- and south-seeking poles of the micro-magnets created by the atoms are aligned. All of the micro-magnets work together to give the magnet itself an overall north- and south-seeking pole. A magnet is often labeled with north (N) and south (S) poles. The magnetic force in a magnet flows from the north pole to the south pole.

Have you ever held two magnets close to each other? They don't act like most objects. If you try to push the south poles together, they repel each other. The two north poles also repel each other. If you turn one magnet around, the north and the south poles are attracted to each other. The magnets come together with a strong force. Just like protons and electrons, opposites attract.

Magnets Can Produce Electricity

We can use magnets to make electricity because of electromagnetism. A magnetic field can move electrons. Some metals, like copper, have electrons that are loosely held; they are easily pushed from their levels.

Power plants use huge turbine generators to make the electricity that we use in our homes and businesses. Power plants use many fuels to spin **turbines**. They can burn coal, oil, or natural gas to make steam to spin turbines. Or they can split uranium atoms to heat water into steam. They can also use the power of rushing water from a dam or the energy in the wind to spin the turbine.

The turbine is attached to a shaft in the generator. Inside the **generator** are magnets and coils of copper wire. The magnets and coils can be designed in two ways—the turbine can spin the magnets inside the coils or can spin coils inside the magnets. Either way, the electrons are pushed from one copper atom to another by the moving magnetic field.

Coils of copper wire are attached to the turbine shaft. The shaft spins the coils of wire inside two huge magnets. The magnet on one side has its north pole to the front. The magnet on the other side has its south pole to the front. The magnetic fields around these magnets push and pull the electrons in the copper wire as the wire spins.

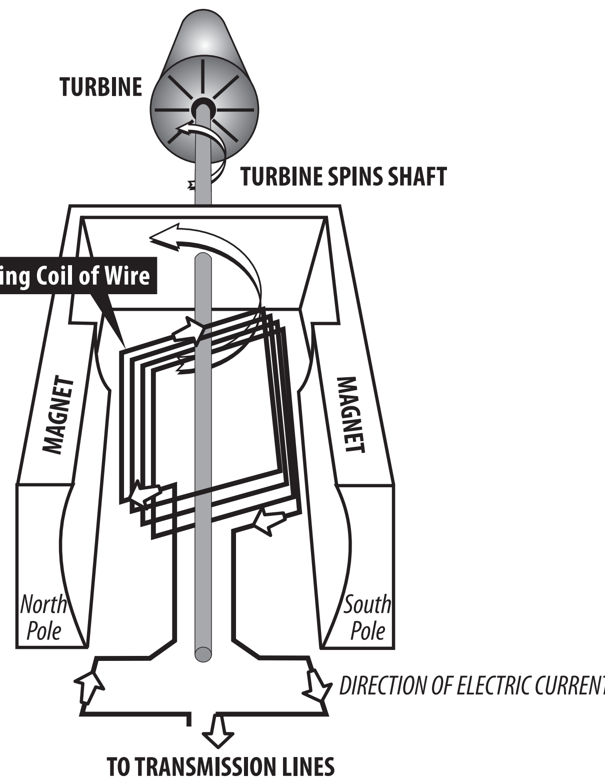
The electrons in the coil flow into transmission lines. These moving electrons are the electricity that flows to our houses. Electricity moves through the wire very quickly.

The north pole vs. the North Pole

Earth has a magnetic field made by the iron in the core. So in one sense, our planet is an extraordinarily huge magnet. The Earth's magnetic field flows from the South Pole to the North Pole. These are capitalized because they describe a specific location. However, when talking about magnets in general, they all have a north pole and a south pole, which are not specific places. Therefore, we do not capitalize north and south when talking about ordinary magnets.

SOURCE: EIA

Turbine Generator



Batteries Can Also Produce Electricity

A **battery** produces electricity using two different metals in a chemical solution. A **chemical reaction** between the metals and the chemicals frees more electrons in one metal than in the other.

One end of the battery is attached to one of the metals; the other end is attached to the other metal. The end that frees more electrons develops a positive charge, and the other end develops a negative charge because it attracts the free, negatively charged electrons. If a wire is attached from one end of the battery to the other, electrons flow through the wire to balance the electrical charge.

A **load** is a device that does work or performs a job. If a load—such as a light bulb—is placed along the wire, the electricity can do work as it flows through the wire. In the Electrical Circuits diagram on the next page, electrons flow from the negative end of the battery through the wire to the light bulb. The electricity flows through the wire in the light bulb and back to the battery.

Electricity Travels in Circuits

Electricity travels in closed loops, or **circuits**. It must have a complete path before the electrons can move. If a circuit is open, the electrons cannot flow. When we flip on a light switch, we close a circuit. The electricity flows from the electric wire through the light and back into the wire. When we flip the switch off, we open the circuit. No electricity flows to the light.

When we turn on the TV, electricity flows through wires inside the set, producing pictures and sound. Sometimes electricity runs motors—in washers or mixers. Electricity does a lot of work for us. We use it many times each day.

In the United States, we use electricity to light our homes, schools, and businesses. We use it to warm and cool our homes and help us clean them. Electricity runs our TVs, DVD players, video games, and computers. It cooks our food and washes the dishes. It mows our lawns and blows the leaves away. It can even run our cars.

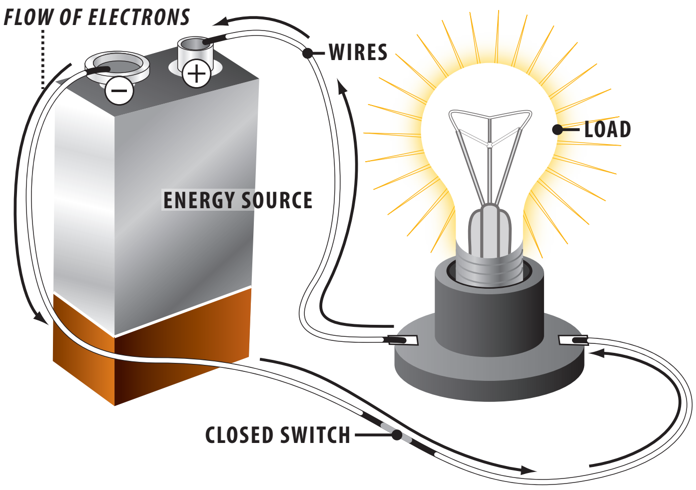
Electricity Measurement

Electricity makes our lives easier, but it can be confusing because we cannot see it. We are familiar with terms such as watt, volt, and amp, but we may not have a clear understanding of these terms. We buy a "60-watt equivalent" light bulb, a tool that needs 120 volts, or a vacuum cleaner that uses 8.8 amps, and we don't think about what those units mean.

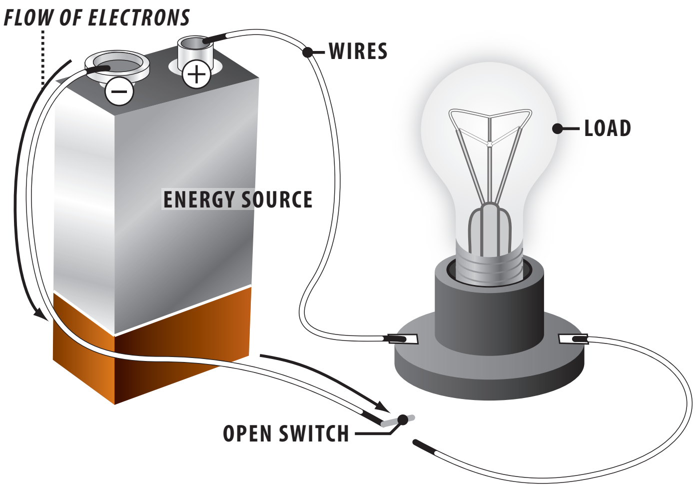
Using the flow of water as an analogy can make electricity easier to understand. The flow of electrons in a circuit is similar to water flowing through a hose. If you could look into a hose at a given point, you would see a certain amount of water passing that point each second.

The amount of water depends on how much pressure is being applied—how hard the water is being pushed. It also depends on the diameter of the hose. The harder the pressure and the larger the diameter of the hose, the more water passes each second. The flow of electrons through a wire depends on the electrical pressure pushing the electrons and on the cross-sectional area of the wire.

Electrical Circuits



A closed circuit is a complete path allowing electricity to flow from the energy source to the load.



An open circuit has a break in the path. There is no flow of electricity because the electrons cannot complete the circuit.

Voltage

The pressure that pushes electrons in a circuit is called **voltage (V)**. Using the water analogy, if a tank of water were suspended one meter above the ground with a 1-cm diameter pipe coming out of the bottom, the water pressure would be similar to the force of a shower. If the same water tank were suspended 10 meters above the ground, the force of the water would be much greater, possibly enough to hurt you.

Voltage is a measure of the **electric potential**, or pressure, applied to electrons to make them move. It is a measure of the strength of the current in a circuit and is measured in **volts (V)**. Just as the 10-meter high tank applies greater pressure than the 1-meter high tank, a 10-volt power supply (such as a battery) would apply greater potential than a 1-volt power supply. Higher voltages mean harder work can be done because the electrons have more potential.

AA batteries are 1.5 volts; they apply a small amount of voltage or pressure for lighting small flashlight bulbs or remote controls. A car usually has a 12-volt battery—it applies more voltage to push current through circuits to operate the radio or defroster. The standard voltage of wall outlets is 120 volts—a dangerous amount of voltage. An electric clothes dryer is usually wired at 240 volts—a very dangerous voltage.

Current

The flow of electrons can be compared to the flow of water. The water current is the number of molecules flowing past a fixed point; **electric current (I)** is the number of electrons flowing past a fixed point in a second. Electric current is defined as electrons flowing between two points having a difference in voltage. Current is measured in **amperes** or **amps (A)**. One ampere is 6,250,000,000,000,000,000 (6.25×10^{18}) electrons moving through a circuit each second. Most electronic devices, like cell phones and laptop computers, use milliamps (mA), which are thousandths of an ampere. Vacuum cleaners and other objects with strong motors use 5-10 amps.

With water, as the diameter of the pipe increases, so does the amount of water that can flow through it. With electricity, conducting wires take the place of the pipe. As the thickness of the wire increases, so does the amount of electric current (number of electrons) that can flow through it.

Power

Power (P) is a measurement of how fast work gets done. Think about moving a pile of 50 bricks from your front yard to your back yard. If you carry all of them at once, but move slowly, you use power. If you move ten times faster but only carry five bricks at a time, you use the same amount of power. Power tells us how fast a task can be accomplished.

Electric power tells us how quickly electricity is being used. Mathematically, power in watts is calculated by multiplying the voltage times the current. Going back to our brick example, carrying all the bricks slowly would be similar to high current but low voltage. Carrying a few bricks at a time and moving faster would be like a low current with a high voltage. Both situations can use the same amount of power, though the work is being done differently.

A few years ago, people commonly bought light bulbs based on their **wattage**, or the number of watts used to light the bulb. Common light bulbs used in homes were 60W and 75W. A night light would use a 25W bulb. Today, people use light bulbs that are much more efficient, such as compact fluorescent (CFL) or light-emitting diode (LED) bulbs. However, people still often buy light bulbs based on their "equivalent wattage" because that tells them about how bright the light bulb should be.

Microwave ovens are frequently purchased based on the power they use. A higher wattage microwave will heat more food faster than a lower wattage oven. However, the high-powered microwave will cost more to operate because it uses more power. As we discussed earlier, homes are wired to deliver a consistent voltage throughout the house – most outlets deliver 120 volts. The difference in power is how much current the microwave will use. Higher powered microwaves will draw more current.

Electrical Energy

Electrical energy introduces the concept of time to electric power. In the water analogy, it would be the amount of water falling through the pipe over a period of time, such as an hour. When we talk about using power over time, we are talking about using energy. Using our water example, we could look at how much work could be done by the water in the time that it takes for the tank to empty.

The electrical energy that an appliance or device consumes can be determined only if you know how long (time) it consumes electric power at a specific rate (power). To find the amount of energy consumed, you multiply the rate of energy consumption (measured in watts) by the amount of time (measured in hours) that it is being consumed. Electrical energy is measured in watt-hours (Wh).

Energy (E) = Power (P) x Time (t)

E = P x t or E = W x h = Wh

Another way to think about power and energy is with an analogy to traveling. If a person travels in a car at a rate of 40 miles per hour (mph), to find the total distance traveled, you would multiply the rate of travel by the amount of time you traveled at that rate. If a car travels for 1 hour at 40 miles per hour, it would travel 40 miles.

Distance = 40 mph x 1 hour = 40 miles

If a car travels for 3 hours at 40 miles per hour, it would travel 120 miles.

Distance = 40 mph x 3 hours = 120 miles

The distance traveled represents the work done by the car. When we look at power, we are talking about the rate that electrical energy is being produced or consumed. Energy is analogous to the distance traveled or the work done by the car.

A person wouldn't say he took a 40-mile per hour trip because that is the rate. The person would say he took a 40-mile trip or a 120-mile trip. We would describe the trip in terms of distance traveled, not rate traveled. The distance represents the amount of work done.

The same applies with electric power. You would not say you used 100 watts of light energy to read your book, because a watt represents the rate you use energy, not the total energy used. The amount of energy used would be calculated by multiplying the rate by the amount of time you read. If you read for five hours with a 100- W bulb, for example, you would use the following formula:

Energy = Power x Time

E = P x t

Energy = 100 W x 5 hours = 500 Wh

One watt-hour is a very small amount of electrical energy. Usually, we measure electric power in larger units called **kilowatt-hours (kWh)** or 1,000 watt-hours (kilo = thousand). A kilowatt-hour is the unit that utilities use when billing most customers. The average cost of a kilowatt-hour of electricity for residential customers is about 12.5 cents.

To calculate the cost of reading with a 100-W bulb for 5 hours, you would change the watt-hours into kilowatt-hours, then multiply the kilowatt-hours used by the cost per kilowatt-hour, as shown below:

500 Wh x = 0.5 kWh

0.5 kWh x $0.125/kWh = $0.0625 or $0.06

It would cost about six cents to read for five hours using a 100-W bulb.

Secondary Energy Source

Electricity is different from most sources of energy. Unlike coal, petroleum, or solar energy, electricity is a **secondary source of energy**. That means we must use other energy sources to make electricity. It also means we can't classify electricity as renewable or nonrenewable.

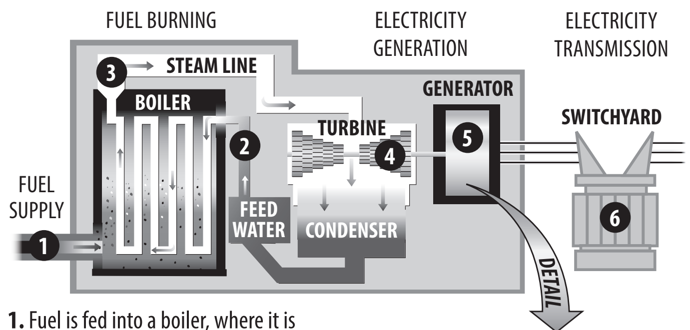
Coal, which is nonrenewable, can be used to make electricity. So can hydropower, a renewable energy source. The energy source we use can be renewable or nonrenewable, but electricity is neither.

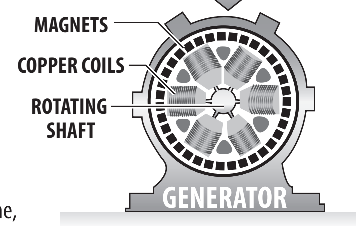
Generating Electricity

Most of the electricity we use in the United States is generated by large power plants. These plants use many fuels to produce electricity. Thermal power plants use coal, biomass, petroleum, or natural gas to superheat water into steam, which powers a generator to produce electricity. Nuclear power plants use nuclear fission to produce the heat. Geothermal power plants use heat from inside the Earth.

Wind farms use the kinetic energy in the wind to generate electricity, while hydropower plants use the energy in moving water. Solar farms use sunlight to generate electricity directly in solar cells. Solar energy can also be used to heat a fluid to generate steam, turn a turbine, and generate electricity like all other thermal power plants do.

Thermal Power Plant





1. Fuel is fed into a boiler, where it is burned to release thermal energy.
2. Water is piped into the boiler and heated, turning it into steam.
3. The steam travels at high pressure through a steam line.
4. The high pressure steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

Fuels that Make Electricity

Four kinds of power plants produce most of the electricity in the United States: coal, natural gas, nuclear, and hydropower. Coal plants generate about 39 percent of the electricity we use in the U.S. There are also wind, geothermal, waste-to-energy, and solar power plants, which together generate less than ten percent of the electricity produced in the United States. Virginia uses coal, uranium, natural gas, hydropower, solar, and waste-to-energy plants.

Fossil Fuel Power Plants

Fossil fuel plants burn coal, natural gas, or oil to produce electricity. These energy sources are called fossil fuels because they were formed from the remains of ancient sea plants and animals. Most of our electricity comes from fossil fuel plants. Power plants burn the fossil fuels and use the heat to boil water into steam. The steam is channeled through a pipe at high pressure to spin a turbine generator to make electricity. Fossil fuel power plants produce emissions that can pollute the air and contribute to global climate change.

Fossil fuel plants are also called thermal power plants because they use heat energy to make electricity. Coal is used by most power plants because it is cheap and abundant in the United States. There are many other uses for petroleum and natural gas, but the main use of coal is to produce electricity.

Nuclear Power Plants

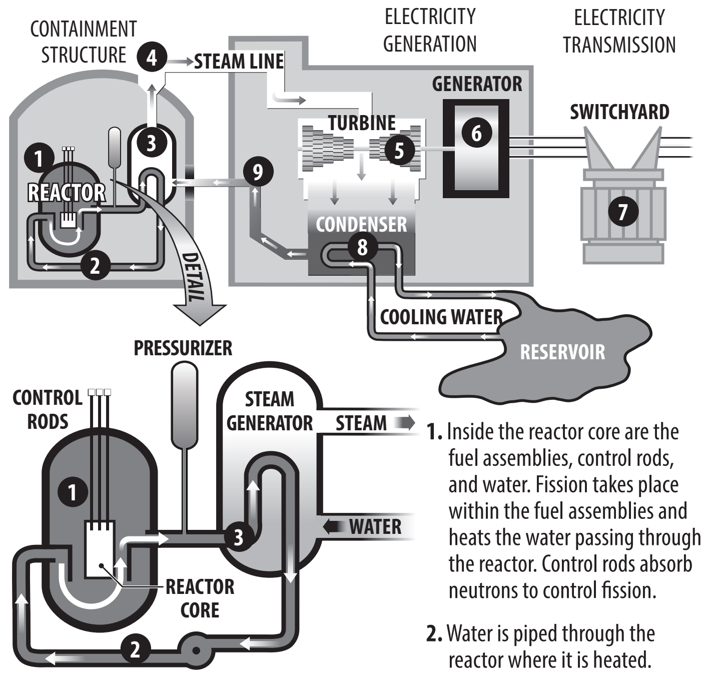
Nuclear power plants are called thermal power plants, too. They produce electricity in much the same way as fossil fuel plants, except that the fuel they use is uranium, which isn't burned.

Uranium is a mineral found in rocks underground. The uranium is processed into small pellets the size of a pencil eraser or the end of your pinky finger. The pellets are stacked in an assembly of fuel rods and control rods. Operators control the reactor by raising or lowering the control rods, which can absorb neutrons and slow down the chain reaction. The fission of the uranium atoms releases thermal energy, which is used to turn water into steam. As in any other thermal power plant, the steam then drives a turbine generator.

Nuclear power plants don't produce carbon dioxide emissions, but their waste is radioactive. Nuclear waste must be stored carefully to prevent contamination of people and the environment.

Nuclear Power Plant

Pressurized Water Reactor



1. Inside the reactor core are the fuel assemblies, control rods, and water. Fission takes place within the fuel assemblies and heats the water passing through the reactor. Control rods absorb neutrons to control fission.
2. Water is piped through the reactor where it is heated.
3. It then travels to the steam generator where it heats a secondary system of water.
4. The steam generator keeps the steam at a high pressure. The steam travels through a steam line to the turbine.
5. The high pressure steam turns the turbine as it passes through, which spins a shaft. The steam then travels through the condenser where it is condensed by cooling water and is pumped back into the steam generator to repeat its cycle.
6. The turbine spins a shaft that travels into the generator. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This generates electricity.
7. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.
8. The unused steam continues into the condenser where cool water from the environment (river, ocean, lake, reservoir) is used to condense it back into water. The cooling water never comes in direct contact with the steam, so it is safe to return to the environment.
9. The resulting water is pumped out of the condenser with a series of pumps, reheated and pumped back to the reactor vessel.

Hydropower Plants

Hydropower plants use the energy in moving water to generate electricity. If the water in a river is not flowing fast enough, a dam may be built. The dam holds the water back, and raises the level of the water. This stores gravitational potential energy in the water that can be used to generate electricity. Fast-moving water is used to spin the blades of a turbine generator directly. Steam does not need to be generated, so almost all of the energy of the flowing water can be transformed into electric power. Hydropower is called a renewable energy source because it is renewed by rainfall.

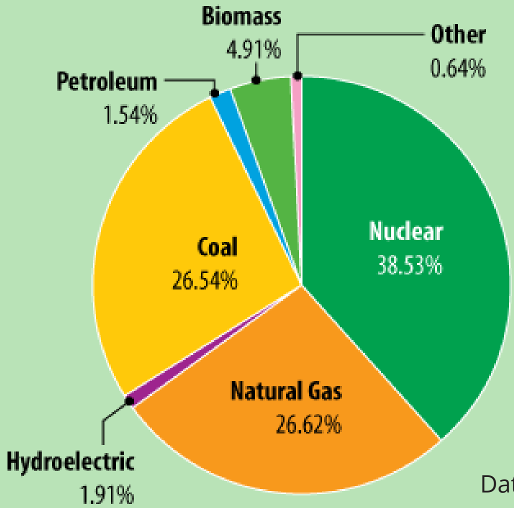
Generating Electricity in Virginia

In Virginia, 129 different locations generate electricity using coal, natural gas, hydropower, biomass, petroleum, solar power, or uranium as energy sources. However, the majority of these are smaller scale generating facilities where the electricity generated is used directly on site. For example, paper mills will burn wood wastes in a process called Combined Heat and Power (CHP), which provides the total energy needs for that facility. Landfills use biogas from them in CHP applications to provide the heat and electricity needed to run the landfill. A large proportion of electrical generating facilities in Virginia are of this type, where the power produced is used on-site by the facility running the generator.

Even though hydroelectric facilities are one of the more numerous types of facilities, with 26 in Virginia, hydropower represents only five percent of the electric power generating capacity in the state. And even though there are only two, nuclear power plants represent seventeen percent of the total generating capacity. In electric power generation, the size of the plant is more important than how many are present. You may live in an area where there are several hydroelectric facilities, such as southern and southwestern Virginia, but your electricity more likely is generated by a larger natural gas power plant a little farther away. Your family's electric bill contains information about the fuel used by your utility company to generate your electricity.

Before 2009, coal was king of electricity in Virginia. Then in 2009, nuclear power from Surry and North Anna nuclear power stations surpassed the electricity generated from coal. Currently natural gas and nuclear power are used to generate most of the electricity in the Commonwealth of Virginia. Virginian power plants generate just about two percent of all the electricity generated in the United States. Because Virginians use a little more electricity than the average American, much of the power used in the state is produced outside of Virginia. So even though nuclear power is only 17 percent of the generating capacity in Virginia, other nuclear power plants outside the state provide additional electricity, which is why nuclear power represents nearly 40 percent of the power used on an annual basis.

Virginia Net Electricity Generation, 2014



Data: EIA

Energy Efficiency and Conservation

The way we use energy is influenced by many factors. The availability of certain energy sources, the weather, environmental factors, and our household income all determine how willing we are to use energy.

The U.S. Department of Energy divides energy users into different categories: **electric power generating, residential, commercial, industrial**, and **transportation**. These are called the sectors of the economy. Of these five sectors, electric power uses the most energy; almost 40% of our total energy. However, it is more useful to talk about the other four sectors and include the electricity they use in that discussion. We've already talked about how electricity is generated. When we talk about the types of energy users in the United States, keep in mind that they all use electricity to some degree.

Any place where people live is considered a residential building. Commercial buildings include offices, stores, hospitals, restaurants, and schools. Residential and commercial buildings are often grouped together because they use energy in the same ways—for heating and cooling, lighting, heating water, and operating appliances. Together, homes and buildings consume over 11 percent of the energy used in the United States today. About 70 percent of the energy used by residential and commercial buildings is in the form of electric power. In the last 30 years, Americans have reduced the amount of energy used in their homes and commercial buildings. We still heat and cool rooms, and heat hot water. We have more home and office machines than ever. Most of the energy savings have come from improvements in technology and in the ways the equipment is manufactured.

The industrial sector includes the facilities that manufacture products, such as clothing, cars, building materials, even the paper used to print these words. The United States is a highly industrialized country. We use a lot of energy for industry. Today, the industrial sector uses 21.7 percent of the nation's energy. Every industry uses energy, but some industries use much more energy than others. We call these energy-intensive industries. However, advanced technologies allow all industries to do more with less energy.

The United States is a big country, and today people move around more than ever before. One hundred years ago, people would be born, grow up, live, and die all in the same community, or very nearby. Now people move from city to city, and even state to state, several times in their lives. The transportation sector doesn't move just people, it also moves materials used by industry to manufacture products, and then it moves those products to the people who want to buy them. The transportation sector uses about twenty-seven percent of the energy supply to move people and goods from one place to another.

So what's the big deal about using all this energy? Well, for one, nine-tenths of the nation's energy comes from nonrenewable resources. That means if we don't change the way we get and use energy, at some point we won't have the energy sources we need. The problem isn't just about how you're going to access the Internet for new music or videos. Things that we use to survive, like refrigerators and medical equipment, also use energy. Not having resources to power them can really create problems for us.

Beyond that, burning fossil fuels like gasoline, coal, and natural gas releases carbon dioxide into the atmosphere. Carbon dioxide is a **greenhouse gas**, meaning it absorbs and holds heat rather than allowing it to radiate out into space. The **greenhouse effect** overall is a good thing when it's kept under control. It's what keeps us warm at night when the sun is shining on the other side of the planet. Without the greenhouse effect, the dark places during the night would get too cold for people and animals to survive. Plants use carbon dioxide to make sugar and release oxygen, but the problem is that we are putting more carbon dioxide into the air than the plants can take out, and its **concentration** – how much is mixed into the atmosphere on average – is increasing faster than the plants can keep up. When we put more carbon into the atmosphere than is being taken out, the average temperature of the air goes up. You've probably heard of **global climate change**. This means that the climate – average weather patterns from year to year – is changing all over the world, and scientists agree it's because of the carbon dioxide that goes into the atmosphere when we burn a lot of fossil fuels. How do we get this under control?

Are You Management Material?

One of the best things we can do is to manage the amount of energy we use. This means we are looking at everything we do that uses energy, and evaluating whether it's a wise use or if we can do without it. There are some things we just need to use energy for, like lights in school, and keeping our food cold so it doesn't spoil. But there's always room for improvement. The two best ways to manage our energy use are through efficiency and conservation.

Energy Efficiency

Energy efficiency means we use equipment, objects, or technology that use the least amount of energy to get the task done. Let's look at a ridiculous example. How wise would it be for a principal to drive a large school bus to work, by herself? Should one man be the only person riding in a 200-seat passenger jet? What if your neighbor were to buy the most enormous refrigerator available, only to keep one jug of milk cold? Each of these crazy scenarios shows a very, very unwise way to use energy. A person who is the only one in the car going to work can buy a smaller vehicle that uses less fuel or pick up some coworkers along the way. Airlines put as many people on planes as possible to move them from one city to the next because it's the best use of jet fuel. And a single person without a lot of food to keep cold can get by with a smaller refrigerator that won't run as often. Each of these examples demonstrates efficiency.

Lighting: A Bright Idea for Efficiency

One of the most energy-expensive items in homes used to be lighting. When Thomas Edison perfected the light bulb in 1879, it was a marvelous invention that changed the way people lived. 100 years later, in 1979, the light bulbs that people were buying weren't that different! The old incandescent bulbs produced light by getting very, very hot – so hot the filament inside glowed. As much as 90 percent of the electricity that went into the bulb came out as heat, not light, meaning 100 units of electricity only produced 10 units of light.

In 2007 Congress passed the Energy Independence and Security Act, which changed the way light bulbs would be manufactured in the United States. Today all general-use light bulbs must meet minimum energy efficiency requirements. People can still buy incandescent bulbs for specialty items like appliances and special construction work lamps. But for everyday lighting, **halogen-incandescent**, **compact fluorescent** (CFL), and **light emitting diode** (LED) lights are our choices.

Other Opportunities for Efficiency

We use many appliances and electronic devices that contribute to a typical household's energy use. The biggest energy users include refrigerators, clothes washers, and dryers. However, televisions left on all the time, and game systems left running when not in play also use large amounts of electricity. When shopping for new appliances and electronics, you should think of two price tags. The first one is the purchase price. The second price tag is the cost of operating the machine during its lifetime.

You'll be paying that second price tag on your utility bill every month for the next 5 to 20 years, depending on the device. Many energy efficient devices cost more to buy, but save money with lower energy costs. Over the life of an appliance, an energy efficient model is always a better deal.

	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
Brightness	850 lumens	850 lumens	850 lumens	850 lumens
Life of Bulb	1,000 hours	3,000 hours	10,000 hours	25,000 hours
Energy Used	60 watts = 0.06 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
Price per Bulb	$0.50	$3.00	$3.00	$8.00

You can compare appliances by using **EnergyGuide labels**. The government requires appliances like refrigerators and hot water heaters to display yellow and black EnergyGuide labels. These labels do not tell you which appliances are the most efficient, but they will tell you the annual energy usage and average operating cost of each appliance so that you can compare them.

When you shop for new appliances and electronics, consider only those with the **ENERGY STAR®** label, which means they have been rated by the U.S. Environmental Protection Agency and Department of Energy as the most energy efficient devices in their classes.

If every clothes washer purchased in the U.S. this year earned the ENERGY STAR® label, we would save 540 million kilowatt-hours of electricity, 20 billion gallons of water, and 1.4 trillion **Btus** of natural gas, resulting in energy bill savings of about $250 million every year.

Energy Conservation

Energy conservation is the other half of the energy management story. While energy efficiency deals strictly with the equipment or technology we use to do work, energy conservation describes behaviors that lead to using less energy. It would be nice if we could go to our local appliance and electronics store and buy all new ENERGY STAR® rated devices, but most people can't do that. Even if you're using the same television that your parents watched when they were in school, you can manage your energy use when watching television.

To help you understand what energy conservation is all about, take a look at two different people. Tom and Eddie are both sixth graders living in the same neighborhood. They live in similar houses, and they go to the same school. Tom and Eddie's parents all work at jobs outside the home, so Tom and Eddie are both needed to help out with chores around the house.

Tom wakes up when his first alarm goes off. He turns it off, then rolls over and goes back to sleep. Ten minutes later, his second alarm goes off. He turns that alarm off, and lies still in bed again. Ten minutes later, Tom's third alarm goes off, and Tom's dad turns on the light. Reluctantly, Tom rolls out of bed onto the floor. He picks up his game controller and remote control, and turns his TV on. His video game is in the same place where he left it last night, and he can manage to squeeze in ten minutes more of playing the game before he has to get ready for school.

When Tom can no longer afford to waste another second without the risk of being late for school, Tom hits "pause" on his controller and goes into the bathroom. He turns on the light, squeezes some toothpaste on his tooth brush, turns on the water, and brushes his teeth. Tom then washes up and combs his hair. Tom leaves the bathroom, goes back into his bedroom where the light and TV are still on and the game is still in paused mode. Tom gets dressed, gathers his books and homework, ties his shoes, and sleepily shuffles off to the kitchen for breakfast.

Opening the refrigerator, Tom takes a look to see what's available. There's some juice, so Tom reaches across the refrigerator to get a glass out of the dishwasher. Turning with the juice, and the refrigerator door open, Tom pours a glass of juice and puts it back in the fridge. Tom isn't very fond of traditional breakfast foods, so he takes a slice of pizza from last night's dinner and places it on a pan in the oven. Tom turns on the oven to warm his pizza and takes a sip of juice.

Yuck! Tom suddenly remembers how awful juice tastes immediately after toothpaste! After a few minutes, Tom opens the oven door and checks his pizza. Seeing that it's warm, Tom leaves the oven turned on and the oven door open while he gets a plate. He carefully takes the pan out of the oven, puts the pizza on his plate, and sits down to eat. Tom's dad comes into the kitchen and asks why the oven is on. Around a mouthful of pizza, Tom says, "I heated up my pizza."

Once Tom has finished his pizza, he goes to the sink to rinse his dishes and put them in the dishwasher. He turns the water on hot and waits for it to get hot. While waiting, he scrolls through his phone to see what his friends have posted online. Tom forgets for a minute what he's doing and then realizes that the water is running. Tom now rinses the dishes under the very hot water and gets some on his hand. OUCH! Leaving the water running, Tom reaches for a towel to dry his hands off, then places the dishes in the dishwasher. Tom is the last one to eat breakfast, so he puts soap in the dishwasher and turns it on even though there are only three other plates, two forks, and two coffee mugs in with his own dishes. Then Tom turns the hot water off.

On another street in the same neighborhood, Eddie's alarm goes off, waking him up. Because Eddie is a heavy sleeper, he has put his alarm on the other side of the room. To turn the annoying thing off, he has to get out of bed. Eddie turns on the light and picks up his phone to see what his friends have posted online before it's time to get ready for school. He would rather play some more of that great game he got over the weekend, but it takes too much time for his game system to start up.

Eddie leaves his room and turns off the light. Entering the bathroom, Eddie turns on the light and the water and gets his toothbrush wet. He turns off the water, applies the toothpaste, and brushes his teeth. Then Eddie turns the water back on to rinse, and leaves it on to wash his face. Completing these tasks, Eddie turns the water off, combs his hair, turns the light off, and goes back to his room.

The sun is rising now, and Eddie opens the blinds on his window to let in some light. He gets dressed, gathers his books and homework, and ties his shoes. Eddie sleepily shuffles into the kitchen thinking about what he'd like for breakfast. Eddie, like Tom, would rather eat leftover pizza than regular breakfast food, so he takes the juice and pizza out of the refrigerator and closes the door. Eddie pours himself a glass of juice and puts the pizza on a plate. Placing the plate in the microwave, Eddie sets the timer and pushes start. Then Eddie puts the juice and the rest of the pizza back in the refrigerator. The pizza is warm at this point, so Eddie takes his breakfast to the kitchen table. Taking a sip of juice, Eddie makes a terrible face just as his father walks in, and Eddie's dad starts to laugh. "Never drink juice after brushing your teeth, Eddie!"

After breakfast, Eddie returns to the sink to rinse his dishes. He turns on the cold water, rinses the plate and glass quickly, turns off the water, and puts the dishes in the dishwasher. It's not very full, so he closes it and decides he will run it later when there are more dishes to wash.

Who is the better energy manager, Tom or Eddie? If you said Eddie, you're right. Tom missed multiple opportunities to conserve energy in his house. Apparently, he left his game system running all night instead of saving his game and turning it off. He left the light, TV, and game system running while he was in the bathroom washing up. And, when he left the bathroom, there isn't any indication that he turned off the water, let alone the lights. Tom stood with the refrigerator door open while pouring his juice. He used the oven to heat up just one slice of pizza, and left the oven on and the oven door open. He used the hottest water available to simply rinse crumbs off his plate when he was finished eating, he let the water run and run, and the hot water is turned up so high that the hot water burned Tom's hands. Finally, Tom didn't wait until the dishwasher was full to run it. Tom used a lot more energy than he needed to, and that was just his morning – imagine how the rest of his day went!

Conservation is more than just turning off the lights and water when they're not needed. Conservation includes walking or riding your bike when you can, combining errands into a single trip, and planning the route that travels the least distance when running those errands. Conservation also means the thermostat is set high enough to keep the house warm, but not so warm you can sit around in shorts in winter. Instead of running the air conditioner all summer, turn it off when the temperature and humidity get low enough to allow it. If you and your friends are going to a movie, carpool. All of these little behaviors add up to big energy savings.

Efficiency and conservation combine to help us use less energy. Using less energy means we will have more of those nonrenewable energy sources farther into the future, and will have less air pollutants and greenhouse gases released now.

ENERGY SAFETY AT HOME

This section is designed for you to pull it out and take it home to share with your family.

How our family uses energy:

Check off all the energy users listed below that you have in your home right now, or that your family plans to buy in the next month or two. Inspect each of them with an adult from your family to make sure they are being used safely. Read the safety tips on the next pages and sign the pledge below with your family members.

- ☐ Blender
- ☐ Boiler
- ☐ Box or stand-mounted fan
- ☐ Ceiling fan
- ☐ Ceiling-mounted light fixture
- ☐ Central air conditioner
- ☐ Coffee maker
- ☐ Cooktop – electric
- ☐ Cooktop – gas
- ☐ Crock pot
- ☐ Dehumidifier
- ☐ Desktop computer
- ☐ Dishwasher
- ☐ DVD / Blu-ray player
- ☐ Electric dryer
- ☐ Electric griddle or skillet
- ☐ Electric water heater
- ☐ Floor lamps
- ☐ Forced air furnace – electric
- ☐ Forced air furnace – gas
- ☐ Forced air furnace – other fuel
- ☐ Freezer – chest-style
- ☐ Freezer – upright
- ☐ Gaming system
- ☐ Garage door opener
- ☐ Gas dryer
- ☐ Gas water heater
- ☐ Heat pump heating system
- ☐ Home network router (wifi)
- ☐ Humidifier
- ☐ Laptop computer
- ☐ Lawn mower – push style
- ☐ Lawn mower – riding style
- ☐ Microwave oven
- ☐ Mixer
- ☐ Modem or other Internet device
- ☐ Nightlights
- ☐ Oven/range – electric
- ☐ Oven/range – gas
- ☐ Passenger vehicle (any type) – diesel
- ☐ Passenger vehicle (any type) – gasoline
- ☐ Passenger vehicle (any type) – other fuel
- ☐ Personal fan (small, desktop)
- ☐ Popcorn maker
- ☐ Power tools (any)
- ☐ Printer
- ☐ Refrigerator
- ☐ Small electronic chargers (such as cell phone)
- ☐ Space heater
- ☐ Stereo or sound system
- ☐ Table lamps
- ☐ Tankless gas water heater
- ☐ Television – LED
- ☐ Television – liquid crystal display
- ☐ Television – other or unknown type
- ☐ Television – plasma
- ☐ Television – tube-style
- ☐ Toaster
- ☐ Toaster oven
- ☐ Waffle maker
- ☐ Wall-mounted air conditioner
- ☐ Wall-mounted lamps
- ☐ Wall-mounted room heater
- ☐ Washing machine
- ☐ Water softener or conditioner
- ☐ Window air conditioner

I have read the safety information and will use energy safely in the home

_______________ _______________ _______________

_______________ _______________ _______________

SAFETY AROUND LARGE APPLIANCES

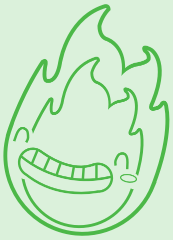
- Do not play inside large appliances like dryers and unplugged freezers.
- Be careful when opening oven doors to avoid burns.
- Avoid touching parts of the water heater or furnace when they are running.
- Keep the areas around dryers, ovens, water heaters, and furnaces clear of dust, fabric, and other flammable materials.
- To avoid burns, keep the water heater set below 120°F.
- Never remove safety covers from large appliances.
- Do not tamper with electrical panels, fuse boxes, breaker boxes, or utility meters in any way.

SAFETY WITH SMALL APPLIANCES AND ELECTRONICS

- Never plug more than one appliance into an outlet at a time.
- If using a power strip or surge protector for electronics, make sure the total amount of power used by all the devices does not exceed what the power strip is made to support. Use the UL rating on each charger and compare it to the UL stamp on the power strip.
- Do not remove safety covers from appliances.
- Keep hair, clothes, and other loose items from hanging into motorized appliances like mixers and fans.
- Check power cords regularly for cracks and other wear. Do not use an electrical device with a power cord with cracks, worn places, or that have become loose.
- Always unplug a device using the plug and do not pull on the cord.
- Keep appliances like toaster ovens and electric griddles away from flammable materials.
- Allow plenty of air flow around computers, TVs, and other electronics that might overheat.
- Do not use devices that are making strange noises, smell like smoke, or are emitting sparks.
- When in doubt, throw it out! Do not use worn, broken, or otherwise damaged electrical devices.
- Keep anything that uses electricity well away from all sources of water.
- Don't use anything electric, including battery-powered devices, while bathing.

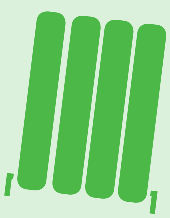
NATURAL GAS SAFETY

- If you smell gas, leave the area first, then call 911. Never turn on the light or operate a cell phone in a room when you smell gas!
- When lighting a gas stove, if the burner does not light quickly turn off the gas, wait five minutes, and try again.
- Never tamper with a gas line or gas meter outdoors.
- A few days before you dig in your yard, call 811 to locate gas lines and other utilities.
- Do not allow objects that burn to come near a gas burner, oven, furnace, or space heater.
- If a gas appliance such as the oven, furnace, or dryer is operating and you begin to feel sick or dizzy, open a window and leave the room. Then call 911.



SPACE HEATER SAFETY

- If an extension cord is needed, use a heavy-duty cord and do not plug anything else into it.
- Keep space heaters several feet away from furniture, curtains, and other flammable objects.
- Do not allow small children near space heaters.
- Immediately unplug any electric space heater that is smoking and leave the room. Get an adult to look at the heater. Call 911 if it keeps smoking.
- Kerosene space heaters should only be used in large rooms with good air flow.
- If you are using a kerosene space heater and begin to feel sick or dizzy, open a window, leave the room, and call 911.
- Never use a space heater while sleeping.
- Never leave a space heater unattended.
- If the space heater looks worn, charred, or otherwise damaged, do not use it.



SAFETY WITH POWER TOOLS AND YARD MAINTENANCE TOOLS

- Make sure you know how to use any power tool or yard equipment before turning it on.
- When filling gas tanks, make sure the engine is cool. If the engine was running when it ran out of gas, wait until the engine cools before refilling it.
- Do not fill gas tanks in an enclosed area, like a closed garage or indoors.
- Do not use power cords for power tools if they are worn or frayed.
- Do not plug more than one tool into a power cord.
- Do not plug more than one tool or power cord into an outlet.
- Do not remove any safety guards or covers from mowers, saws, and other power tools.
- Always wear shoes when working with yard tools like string trimmers and lawn mowers.
- Do not use power cutting tools in a way other than the manufacturer intends. For example, don't use saws on limbs above your head.
- Do not use gas-powered devices, like generators or leaf blowers, in an enclosed space.
- Do not leave the car running inside the garage with the door closed.
- If a machine with a gasoline engine is running and you feel sick or dizzy, leave the area immediately and call 911.
- Keep fingers and hands away from blades. Even hand-operated hedge shears and pruning shears are very sharp.
- Never *under any circumstances* place your hand or foot under a lawn mower while the engine is running, even if the blade is not turning.

Bouncing Ball

Questions

- What happens to the energy in an object when you raise it above a surface?
- What happens to the energy in a raised object when you drop it?
- What variables might affect the energy of a dropped object?

Hypothesis

Write a sentence in the form of "If... then..." that addresses each of the questions.

Materials

- Superball
- Meterstick

Procedure

1. On a hard surface, such as a tile floor, raise the ball to a height of 50 cm and drop it.
2. Use a partner to observe and record the height of the ball's bounce. Repeat 4 more times.
3. Raise the ball to a height of 1 meter and repeat Steps 1 and 2.
4. Repeat Steps 1–3 on a carpeted surface.
5. Compare your results with your partner's.

Data

	HEIGHT OF BOUNCE				
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Hard Surface—50 cm height					
Hard Surface—1 meter height					
Carpet Surface—50 cm height					
Carpet Surface—1 meter height					

Conclusions

- Did the ball bounce twice as high when dropped from 1 meter compared to 50 cm?
- Did the ball bounce higher on the hard or carpeted surface? Explain why this might have happened?
- What happened to the ball's energy during the collisions? Why didn't it bounce all the way back up?
- Into what other forms of energy was the ball's energy converted when it collided with the surface?
- Did your results match your partner's? If not, why do you think they were different?
- Explain which collision would cause more damage: A car colliding with a parked car or a car colliding with a truck moving toward the car?

Apple Battery

Questions

- How do the diameter of the metal pieces, depth of the metal pieces, and metal combination affect the electric current produced by an apple battery?
- What energy transformation(s) occur?

Hypothesis

Write a sentence in the form of "If... then..." that addresses each of the questions.

Materials

- Small zinc nail
- Large zinc nail
- Tin wire
- Thick copper wire
- Thin copper wire
- DC microammeter
- Ruler
- Apple
- 2 Alligator clips
- Permanent marker
- Safety glasses

Procedure

1. Use the ruler and permanent marker to make marks at 1 cm, 2 cm, 3 cm, and 4 cm on each nail and wire.
2. Insert the large zinc nail and thick copper wire into the apple 1 cm. Make sure the ends do not touch each other.
3. Attach the end of one alligator clip to the positive (red) terminal of the microammeter, and the other end of the clip to the thick copper wire.
4. Attach one end of the second alligator clip to the negative (black) terminal of the microammeter, and the other end of the clip to the zinc nail.
5. Reverse the arrangement of the alligator clips, observe what happens on the microammeter.
6. Draw a diagram of the apple battery and record your observations.
7. Push the nail and wire into the apple in one-centimeter increments, up to four centimeters. Record the microammeter readings in Data Table 1.
8. Push the nail and wire into the apple so that the ends are touching. Record the microammeter reading in Data Table 1.
9. Remove the thick copper wire and replace it with the thin copper wire, inserting it into the apple. Reattach the alligator clips and repeat steps 7 and 8.
10. Remove the large zinc nail and replace it with the small zinc nail, inserting it into the apple. Reattach the alligator clips and repeat steps 7 and 8.
11. Push the two copper wires into the apple and attach the wires to the microammeter. Record the microammeter reading in Data Table 2.
12. Experiment with other combinations of metals and record your readings in Data Table 2.

Data

DATA TABLE 1

	LARGE ZINC NAIL AND THICK COPPER WIRE	LARGE ZINC NAIL AND THIN COPPER WIRE	SMALL ZINC NAIL AND THIN COPPER WIRE
1 cm			
2 cm			
3 cm			
4 cm			
METALS TOUCHING			

DATA TABLE 2

COMBINATION OF METALS	MICROAMMETER READING
2 COPPER WIRES	

Conclusion

- Explain how the depth, diameter, and combinations of wires affected the electrical output of the apple battery. Use data to support your answer. Describe the energy transformation(s) that occurred.

Photovoltaic Cell Fun

Questions

- What energy transformations occur in a PV cell (solar panel)?
- How does changing the amount of radiant energy reaching the solar panel affect the panel's electrical output?
- How does the angle of the light affect the amount of electricity produced by a solar panel?

Hypothesis

Write a sentence in the form of "If... then..." that addresses each of the questions.

Materials

- PV Cell kit
- Light source
- Protractor
- Paper

Procedure

1. Attach the motor to the PV module by removing the screws on the posts of the PV module, sliding one connector from the motor onto each post, then reconnecting the screws.
2. Attach the fan to the stem of the motor so that you can see the motion of the motor.
3. Place the module under a bright light source. Record your observations in your science notebook.
4. Cover ¼, then ½, then ¾ of the module using a piece of paper and observe what happens to the spinning of the fan. Record your observations in your science notebook.
5. Using the protractor, hold the PV module at different angles to the sun. Change the angle by 5 degrees and repeat several times. Record the angles you use. Observe and record your observations. What is the best angle?
6. Cover part of the PV module with paper and change its angle. Observe and record your observations.
7. Observe and note the direction of the spin of the fan. Remove the wires from the PV module posts and connect them to the opposite posts. Observe and record your observations.

Conclusions

- What have you learned about PV cells and their ability to convert radiant energy into electricity?
- How does changing the area of sunlight exposure on the PV module affect the amount of electricity produced?
- How does changing the angle of the PV module to the sunlight affect the amount of electricity produced?
- Which angle and exposure of the PV module produced the most electricity?
- Explain the results of reversing the wires on the PV module posts.

Chemical Reactions

Question

- Does the chemical reaction between vinegar and baking soda produce or absorb heat?

Materials

- 1 Thermometer
- 15 mL of Vinegar
- 15 cc Baking soda
- 1 Ziplock bag
- 2 Measuring cups

Measurement

cc = mL
cc = cubic centimeters are used to measure the volume of solids
mL = milliliters are used to measure the volume of liquids

Procedure

1. Pour 15 mL of vinegar into a clean, empty ziplock bag. Feel the vinegar through the bag to observe its temperature.

OBSERVATION: ____

2. Carefully place the thermometer in the bag with the bulb in the vinegar and record the temperature of the vinegar. Leave the thermometer in the bag.

VINEGAR: ______________ ºF ______________ ºC

3. Carefully pour 15 cc of baking soda into the ziplock bag. BE CAREFUL! The chemical reaction will foam and fill the bag.
4. Wait 30 seconds and record the temperature of the mixture. Remove the thermometer from the bag and zip the bag closed.

VINEGAR & BAKING SODA MIXTURE: _________ ºF _________ ºC

5. Feel the mixture through the bag and observe its temperature.

OBSERVATION: ____

Conclusion

- Is the chemical reaction between vinegar and baking soda exothermic or endothermic? How do you know?

A Cool Coal Story

A long, long time ago before even the dinosaurs roamed the Earth, the sun shone in the sky and giant plants grew in swampy forests. Like all living things, these plants died.

And more plants grew and died. This happened over and over for millions of years—plants grew and died and fell into the swamp.

The plants on the bottom got squished—really, really squished. After millions of years of being really squished those plants turned into COAL.

Now the coal is buried in the ground. Big machines—giant bulldozers and steam shovels— dig it up.

The machines load the coal onto trains and barges to take it to the power plant.

Inside the power plant there is a giant tub of water with a big oven in the middle. The coal is put into the big oven and burned.

The smoke from the fire is cleaned with big scrub brushes before it goes up the smokestack and into the air.

Inside the oven it gets really hot. So hot, the water in the tub boils and turns into steam. The oven is called a boiler because it boils the water and turns it into steam.

That steam comes roaring through a big pipe and turns a giant pinwheel, called a turbine.

The middle of the pinwheel has coils of wire wrapped around it. On the blades of the pinwheel are big magnets. When the magnets spin around the wire, it makes electricity. That is amazing!

Now, we can't go down to the power plant to buy a bag of electricity. So, the electricity comes to us.

A wire from the turbine runs out of the power plant and up a tall, tall pole. The electricity flows up the wire to the top of the pole. It flows through high-power lines from pole to pole until it gets to our town.

Then it flows into lots of small wires to our houses. Inside our houses—hidden in the walls—are lots of wires. They go to all the switches and all the outlets all over our house and the electricity flows through them.

When we flip on a light switch, the electricity flows into the light bulb and makes light.

When we plug a radio into an outlet, we get music. The electricity flows through the cord to make it work. Electricity runs our washers and dryers, TVs, and video games.

Lots of the electricity in our country is made by burning coal. The energy in the coal came from the sun.

A Cool Coal Story Role Sheet

Students will demonstrate the flow of energy to produce electricity using props. Depending on the audience, signs with the different forms of energy can be used by the students to identify the energy transformations. This activity can also be used to demonstrate other energy flows, like biodiesel, ethanol, natural gas, etc.

Sun		Nuclear fusion—produces energy
	Prop & Action	Yellow ball
Radiant Energy		Nuclear energy in the sun is transformed to radiant energy and travels through space to Earth. Radiant energy travels in WAVES.
	Prop & Action	Long pieces of yellow ribbon, several students wave in the air
Chemical Energy		Radiant energy is absorbed by green plans and through photosynthesis converts radiant energy to chemical energy.
	Prop & Action	Green plants or silk plants, students bring up from floor
Stored Chemical Energy		Green plants die and are compressed under extreme pressure over a LONG period of time and become COAL. Chemical energy is stored in the coal.
	Prop & Action	Green plants or silk plants, students step on leaves
Coal		Coal is mined and taken to a power plant. (Additional details may be added if desired.)
	Prop & Action	Pieces of coal OR wads of black construction paper, students pick up coal from ground
Thermal Energy		Coal is burned in the furnace. Stored chemical energy produces thermal energy.
	Prop & Action	Empty box, coal is put into "furnace" box
Thermal Energy		The thermal energy heats the water. Water becomes steam.
	Prop & Action	Hot pot or bottled water, student lifts up hot pot
Steam		Steam travels down pipes (plastic tubing) to the turbine.
	Prop & Action	Plastic hose or tubing, connect tube to hot pot used above
Motion/Mechanical Energy		Steam causes the turbine blades to spin.
	Prop & Action	Student arms, student stands with arms outstretched and bent upwards at the elbow, student spins as steam touches them
Electrical Energy		The turbine is connected to the generator causing the magnets to spin around the copper coils producing electrical energy.
	Prop & Action	Bar magnets, copper ribbons, three students hold bar magnets, one student is 'wrapped' in copper colored ribbon or wire, students with magnets 'spin' around copper wire
Electrical Energy		Electrical energy travels down the power lines to our homes.
	Prop & Action	Twisted rope, start with twisted rope then pull away the smaller pieces to designate the low voltage lines that come into our homes
Electrical Energy		Electrical energy powers our homes.
	Prop & Action	Light bulb and extension cord, student pulls chain on light bulb or switches it on
Variations		*Other energy flows can be demonstrated, substituting other sources for the coal (corn to ethanol; soybeans to biodiesel; decomposing garbage to methane, etc.)*

A Nifty Natural Gas Story

Hundreds of millions of years ago, long before the dinosaurs roamed, most of the Earth was covered with vast, deep oceans. Tiny plants and animals lived in these oceans.

The sun's radiant energy was changed into chemical energy by the plants, which helped them grow. The animals ate the plants, and both the plants and animals stored the sun's energy in their bodies as chemical energy.

When they died, they sank to the ocean floor. As more and more plants and animals died, they sank and made a thick layer deep under the water.

Over time, more layers of rock, sand, and other dead plants and animals built up. As the layers built up, they pressed down hard on the layers beneath.

As the layers of rock built up, the deepest layers got hot. They were under very high pressure with all that weight on top of them.

Eventually, those dead plants and animals under all those layers of rock changed. Now they weren't plants or animals. Now they were special molecules called hydrocarbons, with only hydrogen and carbon in them.

The hydrocarbons became trapped in tiny holes in the rocks. Then they waited.

And waited.

And waited some more - millions of years!

Many years ago, people began to notice bubbles coming out of the ground beneath ponds and lakes. They discovered that the bubbles were flammable – they could fuel a fire. The people used bamboo and other hollow plant stems to carry the bubbling gas to their villages.

Today, geologists search for the layers of rock that contain the hydrocarbons. They use a lot of special equipment and computers to find natural gas. Then they drill an exploratory well. Six times out of ten, they are successful!

The natural gas is pumped out of the ground at the well. It is separated from any liquids and water that might be mixed with it, and compressed into high pressure gas pipelines. The gas moves to the processing facility.

Natural gas has no odor, so at the final processing facility, a chemical called mercaptan is added. Mercaptan smells like rotten eggs! That is what you smell if natural gas is leaking.

After processing, electrical power plants might use natural gas to generate electricity for homes, businesses, and schools. Most homes also use natural gas to heat water and stay warm in cold weather.

Natural gas produces almost no air pollution when it is burned. Because it is flammable, it is important to use it safely. If you ever smell natural gas, leave the area immediately and then call 911.

All of those tiny plants and animals millions of years ago are now providing us a clean energy source that is easy to use. Do you think they would be happy to know so many people rely on them?

A Nifty Natural Gas Story Role Sheet

Students will demonstrate the flow of energy to heat homes using props. Depending on the audience, signs with the different forms of energy can be used by the students to identify the energy transformations. This activity with different props can also be used to demonstrate other energy flows, like coal to electricity, biodiesel, ethanol, etc.

Sun – Nuclear Energy		Nuclear fusion in the sun produces vast amounts of energy
	Prop & Action	Yellow ball
Radiant Energy		The sun's radiant energy is transferred to Earth by electromagnetic waves.
	Prop & Action	Long pieces of yellow ribbon; students wave the ribbon in the air
Chemical Energy		Radiant energy is absorbed by tiny green plants in the ocean and changed to chemical energy by photosynthesis.
	Prop & Action	Artificial plants or paper "seaweed"; students move up from the floor and "float" around
Storing Chemical Energy		Tiny animals in the ocean ate the plants and stored their chemical energy.
	Prop & Action	Sock puppets; sock puppet animals "eat" the plants
Natural Gas Formation		The tiny plants and animals died. Over millions and millions of years, they were covered by many layers of dirt and rock. The high pressure changed them into natural gas.
	Prop & Action	Large pieces of brown and black paper and cardboard (several different types and colors); plants and sock puppets are dropped to the floor and the layers of "sediment" are stacked on top of them.
Natural Gas Exploration and Production		A well is drilled into the ground to locate natural gas. The gas is brought out of the ground through the well.
	Prop & Action	Long, hollow cardboard tube, or a rolled-up piece of paper; hold the tube vertically with hands over the head, and push the tube downward to the floor. Use one hand to wave fingers over the top of the tube in a wiggling motion to indicate the flowing of natural gas.
Separation, Dehydration, and Compression		The raw natural gas from the ground is separated from impurities and water, and compressed to high pressure.
	Prop & Action	Plastic mixing bowl or bottle; student uses hand to simulate separating the gas from the impurities, and another student pushes both hands together in a compressing motion to load the "gas" into the "pipeline"
Processing		At the processing facility, a chemical called mercaptan is added to the gas to make it smell like rotten eggs.
	Prop & Action	One long piece of garden hose or other tubing, and one eye dropper; one student holds the tubing from the separator to the processing facility, and one student holds the end of the tubing in one hand and the dropper in the other. The dropper is used to simulate adding mercaptan to the gas
Distribution		The processed gas is transported by pipeline to businesses and homes.
	Prop & Action	Another long piece of garden hose or other tubing; student holds it between the processing facility and the end use location
End Use – Thermal Energy		In our homes, natural gas is burned to heat water and keep us warm in cold weather.
	Prop & Action	Small lighter; student (or adult) lights the lighter and other students hold their hands up to the flame to indicate they are being warmed by the fire.

Mining Challenge

Objective

- You will work in teams of 3 to 5. Each team will become a mining company. Your company wants to mine as much coal (chocolate chips) from your mine (cookie) as possible. Each team will be given a starting investment of $105.00 to purchase land, equipment, and pay their miners. There will be a class banker, equipment salesman, and realtor who sells the land to be mined. A list of costs includes:

    Each mine will cost $20.00 to purchase

    Wooden tools will cost $1.00 each to purchase

    Plastic tools will cost $2.00 each to purchase

    Metal tools will cost $3.00 each to purchase

    Each miner must be paid $15.00 for each shift

    Each ton (square) of coal mined is worth $5.00

    Land outside the original mine after reclamation will cost $1.00 (per square)

Procedure

1. Each team member will assume a role in the company. Read the job descriptions below and write each team member's name on the line next to the job he/she has picked.

The mineral engineer (1 team member) is responsible for purchasing the land to be mined and determining which tools the team will purchase. He/she will also survey the boundaries of the mine, outlining the land boundaries on the grid. When the mining shift ends, he/she will oversee reclamation of the land.

Mineral Engineer ____

The accountant (1 team member) is responsible for tracking the expenses and income of the company.

Accountant ____

The miners (1-3 team members) are responsible for 'mining' the coal and reclaiming the land.

Miner 1 ____

Miner 2 ____

Miner 3 ____

2. Decide how many mines ($20.00 each) your company wants to purchase and what mining supplies you wish to purchase.

3. Determine how many 1-minute shifts your team will use to complete the mining.

4. Mine your land (cookie) during the timed shifts. Remember, you may ONLY use the tools purchased to do your mining – NO HANDS! Try to recover as much coal (chocolate chips) as possible during each shift. At the end of each minute shift, place your coal in the grid to be counted. Each ton will earn you a payout. A square must be at least half-full to count as a ton. Tally up labor costs to pay the miners and take this money to the bank for safe keeping. Your accountant will keep track of your funds earned and paid.

5. Once your team has mined for the number of shifts you selected, you must reclaim your land. Try to piece your cookie together so that the land is as good as, or better than, it was before.

6. The mineral engineer will determine if any land is outside the original mine and fine your team $1.00 for any land leftover outside of the original mine outline.

7. Help your accountant total up your expenses and earnings and complete the final balance.

Data

Name of your company:____________________ Beginning Balance: $_______________

EXPENSES	QUANTITY	UNIT PRICE	TOTAL
Mine Site		$20.00	
Wooden Toothpick		$1.00	
Plastic Toothpick		$2.00	
Paper Clip		$3.00	
Labor Costs		$15.00 per shift	
Reclamation		$1.00 per square	
TOTAL EXPENSES			**$**

Area of Mine Site

Outline your mine (cookie) on the grid below.

Put mined coal (chips) here.

Income from coal: _______________

$5 per ton (square must be at least half-full to be counted as a ton)

Final Balance

Step 1

Beginning balance	$______________	Current balance	$______________
Minus expenses	$______________	Plus income from coal	$______________
Current balance	$______________	Ending balance	$______________

Step 2

Did your company make a profit or suffer a loss? (+ or -) ____________________

What was your profit/loss amount? $____________________

Science of Electricity

Objective

To demonstrate how electricity is generated.

Caution

- The magnets used in this model are very strong. Use caution when handling.
- Use caution with nails and scissors when puncturing the bottle.

Materials

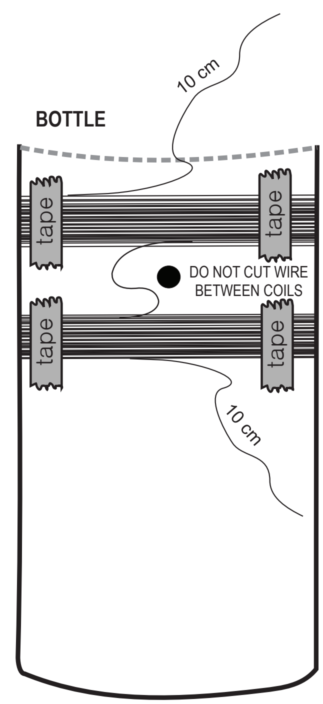
- 1 Small bottle
- 1 Rubber stopper with ¼" hole
- 1 Wooden dowel (12" x ¼")
- 4 Strong rectangle magnets
- 1 Foam tube
- 1 Small nail
- 1 Large nail
- Magnet wire
- Permanent marker
- 1 Pair sharp scissors
- Masking tape
- Fine sandpaper
- 1 Push pin
- 1 Multimeter with alligator clips
- Hand operated pencil sharpener
- Ruler
- Utility knife (optional)

Preparing the Bottle

1. If needed, cut the top off of the bottle so you have a smooth edge and your hand can fit inside. This step may not be necessary. If necessary, a utility knife may be of assistance.
2. Pick a spot at the base of the bottle. (HINT: If the bottle you are using has visible seams, measure along these lines so your holes will be on the opposite sides of the bottle.) Measure 10 centimeters (cm) up from the base and mark this location with a permanent marker.
3. On the exact opposite side of the bottle, measure 10 cm up and mark this location with a permanent marker.
4. Over each mark, poke a hole with a push pin. Do not distort the shape of the bottle as you do this. **CAUTION:** Hold a rubber stopper inside the bottle behind where the hole will be so the push pin, and later the nails, will hit the rubber stopper and not your hand, once it pokes through the bottle.
5. Widen each hole by pushing a nail through it. Continue making the hole bigger by circling the edge of the hole with the side of the nail. (A 9/32 drill bit twisted slowly also works, using a rubber stopper on the end of the bit as a handle.)
6. Sharpen one end of the dowel using a hand operated pencil sharpener (the dowel does not have to sharpen into a fine point). Push the sharpened end of the dowel rod through the first hole. Circle the edge of the hole with the dowel so that the hole is a little bigger than the dowel.
7. Remove the dowel and insert it into the opposite hole. Circle the edge of the hole with the dowel so that the hole is a little bigger than the dowel. An ink pen will also work to enlarge the hole. Be careful not to make the hole too large, however.
8. Insert the dowel through both holes. Hold each end of the dowel and swing the bottle around the dowel. You should have a smooth rotation. Make adjustments as needed. Take the dowel out of the bottle and set aside.
9. With a permanent marker, label one hole "A" and the other hole "B."

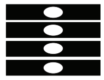
Generator Assembly: Part 1

1. Tear 6 pieces of tape approximately 6 cm long each and set aside.
2. Take the bottle and the magnet wire. Leave a 10 cm tail, and tape the wire to the bottle about 2 cm below hole A. Wrap the wire clockwise 200 times, stacking each wire wrap on top of each other. Keep the wire wrap below the holes, but be careful not to cover the holes, or get too far away from the holes.
3. DO NOT cut the wire. Use two pieces of tape to hold the coil of wire in place; do not cover the holes in the bottle with tape (see diagram).
4. Without cutting the wire, move the wire about 2 cm above the hole to begin the second coil of wraps in a clockwise direction. Tape the wire to secure it in place.
5. Wrap the wire 200 times clockwise, again stacking each wrap on top of each other. Hold the coil in place with tape (see diagram).



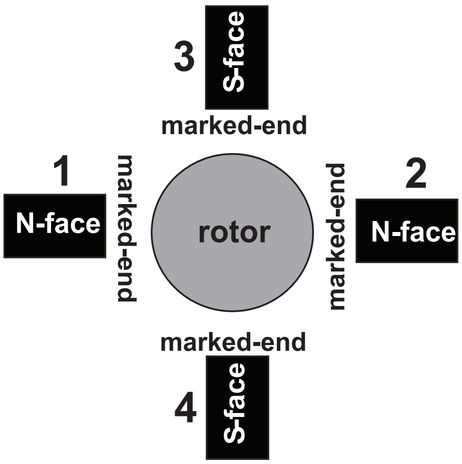
6. Unwind 10 cm of wire (for a tail) from the spool and cut the wire.
7. Check your coil wraps. Using your fingers, pinch the individual wire wraps to make sure the wire is close together and close to the holes. Re-tape the coils in place as needed.
8. Using fine sandpaper, remove the enamel coating from 4 cm of the end of each wire tail, leaving bare copper wires. (This step may need to be repeated again when testing the model, or saved for the very end).

Diagram 1



Stacked Magnets End View

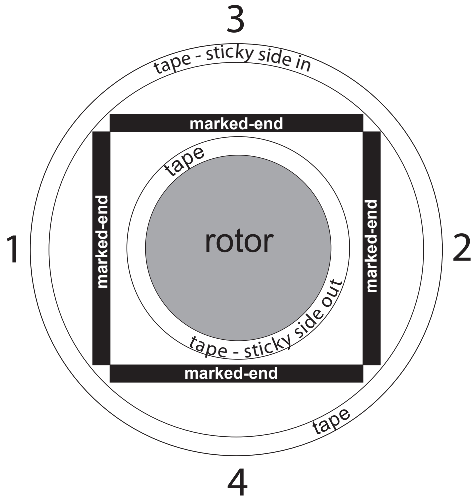
Diagram 2



Rotor Assembly

1. Measure 4 cm from the end of the foam tube. Using scissors, carefully score a circle around the tube. Snap the piece from the tube. This piece is now your rotor.
2. On the flat ends of the rotor, measure to find the center point. Mark this location with a permanent marker.
3. Insert the small nail directly through the rotor's center using your mark as a guide.
4. Remove the small nail and insert the bigger nail.
5. Remove the nail and push the dowel through, then remove the dowel and set aside. Do NOT enlarge this hole.
6. Stack the four magnets together. While stacked, mark one end (it does not matter which end) of each of the stacked magnets with a permanent marker as shown in Diagram 1.
7. Place the magnets around the foam piece as shown in Diagram 2. Make sure you place the magnets at a distance so they do not snap back together.
8. Wrap a piece of masking tape around the curved surface of the rotor, sticky side out. Tape it down at one spot, if helpful.
9. Lift the marked end of Magnet 1 to a vertical position and attach it to the rotor. Repeat for Magnets 2, 3, and 4.
10. Secure the magnets in place by wrapping another piece of masking tape over the magnets, sticky side in (Diagram 3).

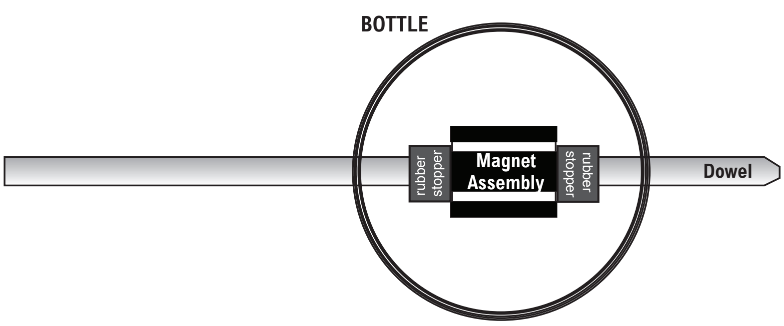
Diagram 3



*WARNING: These magnets are **very** strong. Use caution when handling.*

Generator Assembly: Part 2

1. Slide the sharp end of the dowel through Hole A of the bottle.
2. Inside the bottle, put on a stopper, the rotor, and another stopper. The stoppers should hold the foam rotor in place. If the rotor spins freely on the axis, push the two stoppers closer against the rotor. This is a pressure fit and no glue is needed.
3. Slide the sharp end of the dowel through Hole B until it sticks out about 4 cm from the bottle.
4. Make sure your dowel can spin freely. Adjust the rotor so it is in the middle of the bottle.



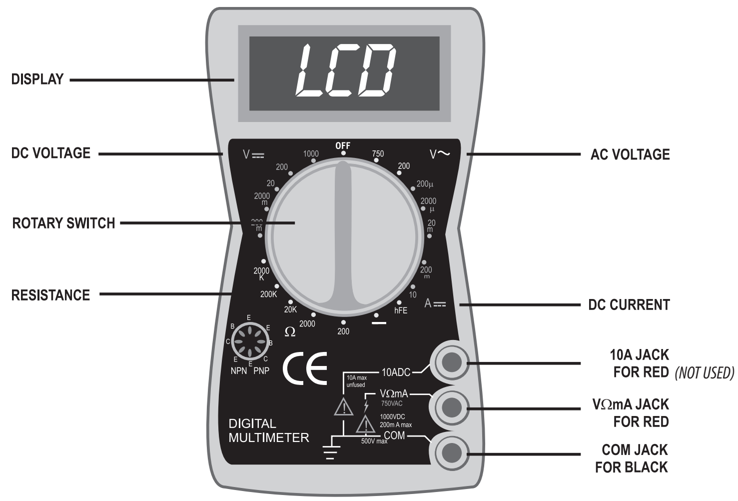
Assembly Notes

- The stoppers can be cut in half so that one stopper is made into two, to allow for more materials. These often slide more easily on the dowel. This must be done using sharp scissors or a utility knife, and can often be dangerous. As this step is not required (the kit supplies you with two stoppers to use), exercise extreme caution.
- If the foam rotor fits snugly on the dowel, put the stoppers on the outside of the bottle to help center the rotor in the bottle. Leave enough space to allow free rotation of the rotor.
- The dowel may be lubricated with lip balm or oil for ease of sliding the stoppers, if necessary.
- If a glue gun is available, magnets can be attached to the rotor on edge or on end to get them closer to the coils of wire. Use the magnet to make an indentation into the foam. Lay down a bead of glue, and attach the magnets. If placing the magnets on end, however, make sure they clear the sides of the bottle for rotation.

Testing the Science of Electricity Model

1. Connect the leads to the multimeter to obtain a DC Voltage reading.
2. Connect one alligator clip to each end of the magnet wire. Connect the other end of the alligator clips to the multimeter probes.
3. Set your multimeter to DC Voltage 200 mV (millivolts). Voltage measures the pressure that pushes electrons through a circuit. You will be measuring millivolts, or thousandths of a volt.

Demonstrate to the class, or allow students to test how spinning the dowel rod with the rotor will generate electricity as evidenced by a voltage reading. As appropriate for your class, you may switch the dial between 200 mV and 20 volts. Discuss the difference in readings and the decimal placement. Speed of rotation will impact meter readings.



Note: Your multimeter may look different than the one shown. Read the instruction manual included in the multimeter box for safety information and complete operating instructions.

Troubleshooting

If you are unable to get a voltage or current reading, double check the following:

- Did you remove the enamel coating from the ends of the magnet wire?
- Are the magnets oriented correctly?
- The magnet wire should not have been cut as you wrapped 200 wraps below the bottle holes and 200 wraps above the bottle holes. It should be one continuous wire.
- Are you able to spin the dowel freely? Is there too much friction between the dowel and the bottle?
- Is the rotor spinning freely on the dowel? Adjust the rubber stoppers so there is a tight fit, and the rotor does not spin independently.

Notes

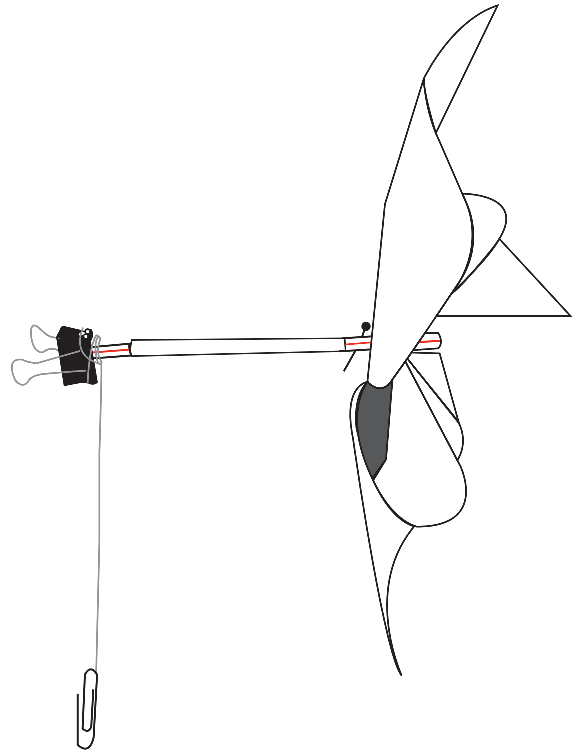
- The Science of Electricity Model was designed to give students a more tangible understanding of electricity and the components required to generate electricity. The amount of electricity that this model is able to generate is very small.
- The Science of Electricity Model has many variables that will affect the output you are able to achieve. When measuring millivolts, you can expect to achieve anywhere from 1 mV to over 35 mV.
- More information about measuring electricity can be found in NEED's Intermediate Energy Infobook. You may download this guide from www.NEED.org.

Optional: Redesign the generator to test different variables including the number of wire wraps, different magnet strengths, and number of magnets.

Science of Electricity Model

Observe the science of electricity model. Draw and label the parts of this model. On the lines below, explain how electricity is generated.

Wind Can Do Work



Question

- What is the maximum load that can be lifted all of the way to the top of the windmill shaft?

Materials

- 4-Blade Windmill Template
- 1 Extra-long straw
- 1 Small straw
- Masking tape
- 50 cm String or thread
- Paper clips
- Large foam cup
- 2 Straight pins
- Binder clip
- Fan
- Ruler
- Hole punch
- Marker
- Scissors

Procedure

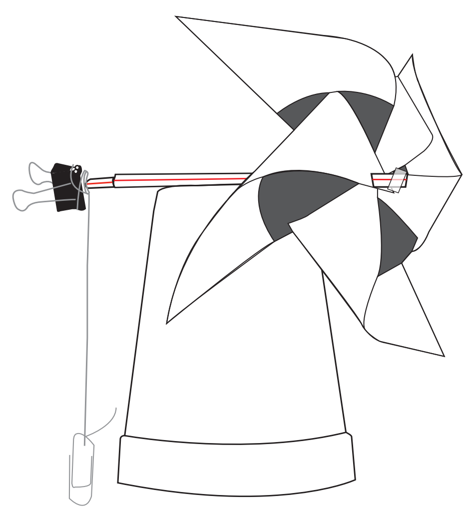
1. Turn the cup upside down.
2. Cut the longer straw so that you have an 8 cm length. Share the other portion with another student or group, or discard it. Tape this straw horizontally to the bottom of the cup (which is now the top) so that there is an equal amount of straw on both ends. Set this aside.
3. Prepare the windmill blades using the 4-Blade Windmill Template.
4. Measure 1.0 cm from the end of the small straw and make a mark. Insert a pin through the small straw at this mark. This is the front of the straw.
5. Slide the small straw through the windmill blades until the back of the blades rest against the pin. Gently slide each blade over the end of the straw. Secure the blades to the straw using tape.
6. Insert the small straw into the larger straw on the cup.
7. Tape the string to the end of the small straw. Tie the other end of the string to a paper clip. Make sure you have 30 cm of string from the straw to the top of the paper clip.
8. On the very end of the small straw near where the string is attached, fasten a binder clip in place for balance and to keep the string winding around the straw.
9. Slide the small straw forward to bring the binder clip next to the larger straw. Place a second straight pin through the small straw at the other end of the larger straw. This will keep the blades away from the cup while still allowing them to move and spin.
10. Place your windmill in front of the fan and observe. Record observations in your science notebooks.
11. Investigate: Keep adding paper clips one at a time to determine the maximum load that can be lifted all of the way to the top. Record your data.

Conclusion

- Draw a diagram of the system. Label the energy transformations that occurred in order for work to take place.

Extensions

- How could you change the design of your windmill to produce more work from the system?
- What variables can you change in this investigation? Create a new investigation changing one variable at a time.



Greenhouse in a Beaker

Question

- What affect does adding carbon dioxide to the air have on the air's temperature during the day and during the night?

Hypothesis

Write a sentence in the form of "If... then..." that addresses the question.

Materials

- 2 400 or 600 mL Beakers
- 1 250 mL Flask
- 1 Rubber stopper with hole
- 1 Vinyl tubing, 3/16" diameter, 60 cm long
- 1 Clip light
- 1 1000-1100 lumen Bulb (equivalent to 75-watt incandescent)
- 1 Ruler
- 2 Probe thermometers
- Small piece of masking tape
- 4 Alka-Seltzer® tablets
- Safety glasses
- 240 mL Water (room temperature)

Procedure

Part 1—Day

1. Set up the light source 15 cm in front of the two beakers. The beakers should be receiving equal light.
2. Insert the tubing through the hole in the 250 mL flask. Place the other end of the tubing near the bottom of one of the beakers. Secure the tubing inside this beaker with a small piece of masking tape.
3. Add 120 mL of water to the flask.
4. Turn on the clip light. Wait for the temperature in each beaker to stabilize. The temperatures in the beakers should be similar, but they do not have to be exactly the same.
5. Record the stable temperature of each beaker in the data table.
6. Break two Alka-Seltzer® tablets in half and drop the pieces into the flask. Secure the rubber stopper into the flask and make sure the tubing still leads from the flask to the beaker.
7. Record the temperature of each beaker every 30 seconds for three minutes.

Part 2—Night

1. After you have data to model temperatures during the day, empty out your beakers and flask. Refill the flask with 120 mL water. Resecure the tubing inside one of the beakers.
2. Turn on the clip light. Wait for the temperature to stabilize. The temperatures in the beakers should be similar, but they do not have to be exactly the same.
3. Record the stable temperature of each beaker in the data table.
4. Break two more Alka-Seltzer® tablets in half and drop the pieces into the flask. Secure the rubber stopper as done before.
5. Turn off the light.
6. Record the temperature of each beaker every 30 seconds for three minutes.

Data

Record your data in these tables or copy the tables into your science notebook.

Simulated Day Data

	BEAKER 1 (WITHOUT CO_2)	BEAKER 2 (WITH CO_2)
Beginning Temperature		
30 seconds		
1 minute		
1 minute, 30 seconds		
2 minutes		
2 minutes, 30 seconds		
3 minutes		

Simulated Night Data

	BEAKER 1 (WITHOUT CO_2)	BEAKER 2 (WITH CO_2)
Beginning Temperature		
30 seconds		
1 minute		
1 minute, 30 seconds		
2 minutes		
2 minutes, 30 seconds		
3 minutes		

Create a graph displaying both the day and night temperatures for both beakers.

Conclusions

- Do you accept or reject your hypothesis? What were the results of your investigation? Use data to explain what happened.
- Why do you think this happened?
- How does this demonstration relate to climate change?

Comparing Light Bulbs

The graphic below shows four light bulbs that produce the same amount of light. You might use bulbs like these as a bright overhead light. One bulb is an incandescent light bulb (IL), one is a halogen, one is a compact fluorescent light (CFL), and another is a light emitting diode (LED). Which one is the better bargain? Let's do the math and compare the four light bulbs using the residential cost of electricity at $0.125/kWh.

1. Determine how many bulbs you will need to produce 25,000 hours of light by dividing 25,000 by the number of hours each bulb produces light.
2. Multiply the number of bulbs you will need to produce 25,000 hours of light by the price of each bulb. The cost of each bulb has been given to you in the chart below.
3. Multiply the wattage of the bulbs (using the kW number given) by 25,000 hours to determine kilowatt-hours (kWh) consumed.
4. Multiply the number of kilowatt-hours by the cost per kilowatt-hour to determine the cost of electricity to produce 25,000 hours of light.
5. Add the cost of the bulbs plus the cost of electricity to determine the life cycle cost for each bulb. Which one is the better bargain?
6. Compare the environmental impact of using each type of bulb. Multiply the total kWh consumption by the average amount of carbon dioxide produced by a power plant. This will give you the pounds of carbon dioxide produced over the life of each bulb. Which one has the least environmental impact?




All bulbs provide about 850 lumens of light.

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours				
x	Price per bulb	$0.50	$3.00	$3.00	$8.00
=	**Cost of bulbs for 25,000 hours of light**				

	COST OF ELECTRICITY	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Total Hours	25,000 hours	25,000 hours	25,000 hours	25,000 hours
x	Wattage	60 watts = 0.060 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
=	Total kWh consumption				
x	Price of electricity per kWh	$0.125	$0.125	$0.125	$0.125
=	**Cost of Electricity**				

	LIFE CYCLE COST	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Cost of bulbs				
+	Cost of electricity				
=	**Life cycle cost**				

	ENVIRONMENTAL IMPACT	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Total kWh consumption				
x	Pounds (lbs) of carbon dioxide per kWh	1.23 lb/kWh	1.23 lb/kWh	1.23 lb/kWh	1.23 lb/kWh
=	**Pounds of carbon dioxide produced**				

Light Bulb Investigation

Question

- How does the wattage vary for different types of bulbs?

Hypothesis

Write a sentence in the form of "If... then..." that addresses the question.

Materials

- 3 Lamps
- 1 Incandescent light bulb
- 1 Compact fluorescent light bulb (CFL)
- 1 Light emitting diode bulb (LED)
- 1 Kill A Watt™ monitor

Procedure

1. Place the incandescent bulb in one lamp, the CFL in another lamp, and the LED bulb in the third lamp. (If you do not have three lamps, conduct three trials, one for each bulb.)
2. Place the lamps on a table.
3. Plug the Kill A Watt™ monitor into an outlet and plug the lamp with the incandescent bulb into the monitor.
4. Turn on the lamp. Record the wattage using the Kill A Watt™ monitor. Turn off the lamp and unplug it from the monitor.
5. Plug the lamp with the CFL bulb into the monitor. Turn on the lamp and record the wattage. Turn off the lamp.
6. Plug the lamp with the LED bulb into the monitor. Turn the lamp on and record the wattage. Turn off the lamp.
7. Compare the wattage measured by the monitor to the stated wattage of the bulbs found on their packaging, or printed on the bulbs themselves.

Data

BULBS	WATTAGE FROM MONITOR	STATED WATTAGE
Incandescent		
CFL		
LED		

Conclusion

- What did you learn about the wattage of the three bulbs? Use data to support your answer.
- Compare and contrast the light produced by each bulb. Did you notice a big difference from one to another? Which bulb would you install in your home? Why?

The Cost of Using Electrical Devices

Background

Electricity consumption is measured in killowatt-hours (kWh). A killowatt is equal to 1,000 watts. A Kill A Watt™ monitor can measure the electrical consumption of machines and electrical appliances. The average cost of a kWh of electricity for schools is $0.10 per kWh. The average cost of a kWh of electricity for homes is $0.125 per kWh.

Question

Which items are the largest energy consumers in your school?

Materials

- Kill A Watt™ meter

Hypothesis

Write a sentence in the form of "If... then..." that addresses the question.

Procedure

Calculate how much it costs to operate the machines in your classroom or at home. You need to know the wattage, the cost of electricity, and the number of hours a week each machine is used.

You can estimate the number of hours the machine is used each week, then multiply by 40 to get the yearly use. We are using 40 weeks for schools, because school buildings aren't used every week of the year. Using the copier as an example, if it is used for ten hours each week, we can find the yearly use like this:

Yearly use = 10 hours/week x 40 weeks/year = 400 hours/year

Remember that electricity is measured in kilowatt-hours. You will need to change the watts to kilowatts. One kilowatt is equal to 1,000 watts. To get kilowatts, you must divide the watts by 1,000. Using the copier as an example, divide like this:

kW = W/1,000
kW = 1,265/1,000 = 1.265

The average **cost of electricity for homes in the U.S. is about twelve and a half cents ($0.125)** a kilowatt-hour or about ten cents ($0.10) in schools. You can use this rate or find out the actual rate from your home or school's electric bill. Using the average cost of electricity, we can figure out how much it costs to run the copier for a year at school by using this formula:

Yearly cost	**=**	**Hours used**	**x**	**Kilowatts**	**x**	**Cost of electricity (kWh)**		
Yearly cost	**=**	**400 hours/year**	**x**	**1.265 kW**	**x**	**$0.10/kWh**		
Yearly cost	**=**	**400**	**x**	**1.265**	**x**	**$0.10/kWh**	**=**	**$50.60**

MACHINE OR APPLIANCE	HOURS PER WEEK	HOURS PER YEAR	WATTS (W)	KILOWATTS (kW)	RATE ($/kWh)	ANNUAL COST
Copier	*10*	*400 hours*	*1,265 W*	*1.265 kW*	*$0.10*	*$50.60*

Virginia Energy Bingo - Teacher Instructions

Time

- 45 minutes

Get Ready

Duplicate as many *Virginia Energy Bingo* sheets (found on page 88) as needed for each person in your group. In addition, decide now if you want to give the winner of your game a prize and what the prize will be.

Get Set

Pass out one *Virginia Energy Bingo* sheet to each member of the group.

Go

Part One: Filling in the BINGO sheets

Give the group the following instructions to create bingo cards:

- This bingo activity is very similar to regular bingo. However, there are a few things you'll need to know to play this game. First, please take a minute to look at your bingo sheet and read the 16 statements at the top of the page. Shortly, you'll be going around the room trying to find 16 people about whom the statements are true so you can write their names in one of the 16 boxes.
- When I give you the signal, you'll get up and ask a person if a statement at the top of your bingo sheet is true for them. If the person gives what you believe is a correct response, write the person's name in the corresponding box on the lower part of the page. For example, if you ask a person question "D" and he or she gives you what you think is a correct response, then go ahead and write the person's name in box D. A correct response is important because later on, if you get bingo, that person will be asked to answer the question correctly in front of the group. If he or she can't answer the question correctly, then you lose bingo. So, if someone gives you an incorrect answer, ask someone else! Don't use your name for one of the boxes or use the same person's name twice.
- Try to fill all 16 boxes in the next 20 minutes. This will increase your chances of winning. After the 20 minutes are up, please sit down and I will begin asking players to stand up and give their names. Are there any questions? You'll now have 20 minutes. Go!
- During the next 20 minutes, move around the room to assist the players. Every five minutes or so tell the players how many minutes are remaining in the game. Give the players a warning when just a minute or two remains. When the 20 minutes are up, stop the players and ask them to be seated.

Part Two: PLAYING BINGO

Give the class the following instructions to play the game:

- When I point to you, please stand up and in a LOUD and CLEAR voice give us your name. Now, if anyone has the name of the person I call on, put a big "X" in the box with that person's name. When you get four names in a row—across, down, or diagonally—shout "Bingo!" Then I'll ask you to come up front to verify your results.
- Let's start off with you (point to a player in the group). Please stand and give us your name. (Player gives name. Let's say the player's name was "Joe.") Okay, players, if any of you have Joe's name in one of your boxes, go ahead and put an "X" through that box.
- When the first player shouts "Bingo," ask him (or her) to come to the front of the room. Ask him to give his name. Then ask him to tell the group how his bingo run was made, e.g., down from A to M, across from E to H, and so on.
- Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on his bingo run. That player then stands and the bingo winner asks him the question which he previously answered during the 20-minute session. For example, if the statement was "can name two renewable sources of energy," the player must now name two sources. If he can answer the question correctly, the bingo winner calls out the next person's name on his bingo run. However, if he does not answer the question correctly, the bingo winner does not have bingo after all and must sit down with the rest of the players. You should continue to point to players until another person yells "Bingo."

Looking for additional energy bingo? Check out NEED's *Games and Icebreakers* guide for additional bingo suggestions and other fun energy games to play in your classroom. Download the guide by visiting www.NEED.org.

Virginia Energy Bingo - Answer Key

A. Has visited a power plant in Virginia

B. Knows the #1 source for electricity in Virginia

C. Knows the importance of Bath County, Virginia, in terms of energy

D. Uses a solar clothes dryer

E. Knows where a wind energy research facility could be built in Virginia

F. Can name both nuclear power plants in Virginia

G. Can name two fossil fuels

H. Can describe two ways to save energy at home

I. Knows the average cost of a kilowatt-hour of electricity in Virginia

J. Knows which light bulbs are least expensive when considering life cycle cost (purchase + electricity used)

K. Has seen geothermal energy

L. Knows how uranium atoms give off energy

M. Can name two ways to improve a car's fuel efficiency

N. Knows how natural gas is usually transported

O. Knows the type of biomass used to provide utility-scale electricity most often in Virginia

P. Can name two renewable energy sources

A Share location / describe	**B** 1. Uranium / nuclear 2. Natural Gas 3. Coal	**C** Contains one of the largest pumped storage hydroelectric facilities	**D** Should describe a clothesline
E Offshore along the continental shelf	**F** North Anna, Surry	**G** Coal, natural gas, petroleum, propane	**H** Turn off lights, insulation, saving water, etc.
I 11.19 cents for residential customers in 2014	**J** LED bulbs	**K** Describe type and location	**L** Nuclear fission
M Maintain tire pressure, change air filter, remove excess weight, easy starts and stops, etc.	**N** Pipeline	**O** Waste-to-energy power plant	**P** Biomass, Geothermal, Hydropower, Solar, Wind

Virginia Energy Bingo

A. Has visited a power plant in Virginia

B. Knows the #1 source for electricity in Virginia

C. Knows the importance of Bath County, Virginia, in terms of energy

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N. Knows how natural gas is usually transported

O. Knows the type of biomass used to provide utility-scale electricity most often in Virginia

P. Can name two renewable energy sources

A NAME	B NAME	C NAME	D NAME
E NAME	F NAME	G NAME	H NAME
I NAME	J NAME	K NAME	L NAME
M NAME	N NAME	O NAME	P NAME

Virginia Energy SOL Strands and Concepts by Lesson

Activity	SOL Strands and Concepts
Energy in Motion	Force, Motion, and Energy Interrelationships in Earth/Space Science Scientific Investigation, Reasoning, and Logic
Apple Battery	Force, Motion, and Energy Scientific Investigation, Reasoning, and Logic
Solar Cells	Force, Motion, and Energy Earth Resources Scientific Investigation, Reasoning, and Logic
Chemical Reaction	Force, Motion, and Energy Matter Scientific Investigation, Reasoning, and Logic
Map Hunt	Earth Resources Force, Motion, and Energy
Virginia Energy Roundup	Earth Resources Force, Motion, and Energy
Energy Stories	Earth Resources Force, Motion, and Energy
Nuclear Power Plant Simulation	Earth Resources Force, Motion, and Energy
Mining Challenge	Earth Resources Force, Motion, and Energy Scientific Investigation, Reasoning, and Logic
Science of Electricity	Force, Motion, and Energy Scientific Investigation, Reasoning, and Logic
Wind Can Do Work	Earth Resources Force, Motion, and Energy Scientific Investigation, Reasoning, and Logic
Greenhouse in a Beaker	Force, Motion, and Energy Matter Scientific Investigation, Reasoning, and Logic
Light Bulb Investigation	Earth Resources Scientific Investigation, Reasoning, and Logic
The Cost of Using Electrical Devices	Earth Resources Scientific Investigation, Reasoning, and Logic

Glossary

ampere / amp	the units used to measure electric current
anthracite	highest rank of coal with a very high carbon content, hard and shiny
atom	the smallest particle of matter; the smallest piece of an element that still has the properties of that element
attract	to pull toward
battery	a device that uses chemical reactions to generate electric current
biodegradable	able to be broken down by living organisms
biodiesel	fuel made from vegetable oil to be used in a diesel engine
biofuel	fuel made from biomass
biomass	energy source from recently living things, such as plants and animal waste, or garbage
bituminous	second highest ranking coal, high carbon content, hard and satiny
Btu	British thermal unit; measures the energy content of a substance; one Btu is the energy needed to raise the temperature of one pound of water by one degree Fahrenheit
carbohydrate	a molecule made of carbon, hydrogen, and oxygen, with a ratio of one carbon to two hydrogen to one oxygen
chain reaction	a nuclear reaction that sustains itself; the neutrons from one fission bombard other nuclei, which release more neutrons, which bombard more nuclei, and so on
chemical energy	the energy stored in the bonds between atoms, such as fossil fuels and food
chemical reaction	an interaction between substances that results in new substances being formed
circuit	a pathway for electrons to follow
commercial sector	the portion of our economy that includes businesses, offices, churches, and schools
compact fluorescent light bulb	a small, twisted tube of glass that contains mercury vapor that absorbs electrical energy and releases light energy
concentration	the amount of a substance dissolved in a certain volume of another substance; for example, the amount of sugar dissolved in a bottle of water is its concentration
conductor	a substance that will allow electrons to move about easily
core	the center of a sphere; the center of the Earth
core sample	a long, cylinder-shaped sample of earth removed from a drilling site that shows the rock layers beneath
crude oil	petroleum as it comes out of the ground before it's been processed
crust	outermost layer of the Earth
elastic energy	energy stored by applying a force, such as in stretching a rubber band or winding a spring
electric current	electrons flowing past a point in a second
electric potential	the push behind an electron that determines its ability to move and do work
electric power generating sector	the portion of our economy responsible for generating electric power
electrical energy	energy delivered by the utility company; the amount of electric power used combined with the amount of time in which it was used; measured in kilowatt-hours
electricity	movement of electrons; the energy of moving electrons
electromagnetic	having both an electrical part and a magnetic part

electromagnetism	the phenomenon where a moving electric field creates a magnetic field, and a moving magnetic field creates an electric field
electron	exceptionally tiny particle found moving around the nucleus of an atom at nearly the speed of light
energy	the ability to do work or cause a change
energy density	the amount of energy contained in a certain volume of a substance
energy efficiency	the amount of useable energy obtained from a single transformation or series of them
ENERGY STAR®	program with the Environmental Protection Agency and Department of Energy that applies efficiency criteria to identify the most efficient appliances and electronics available
EnergyGuide label	large, black and yellow sticker on appliances that provides energy costs of the appliance and compares it to others in its class
ethanol	alcohol produced by fermenting sugar
fission	splitting the atom of a large nucleus into smaller nuclei
fossil fuel	fuel made from the remains of ancient organisms
fusion	combining the nuclei of two small atoms to make one larger nucleus
generator	device that changes motion energy into electrical energy
geothermal	the thermal energy within the Earth
global climate change	the scientific consensus that climate warming patterns are likely caused by human activities
gravitational potential energy	energy stored as a result of the position of an object or substance
greenhouse effect	insulating effect that some gases in the atmosphere have to keep thermal energy in
greenhouse gas	gas that is able to hold thermal energy like a “blanket” over the Earth
halogen incandescent bulb	incandescent bulb with a glass capsule around the filament; the capsule is filled with an inert, halogen gas
heat exchanger	a device that transfers thermal energy to or away from a flowing fluid, such as in a forced air furnace
hydraulic fracturing	using high-pressure water to make tiny fractures in shale and allow natural gas to flow through it
hydrocarbon	a molecule made of only hydrogen and carbon
hydropower	the energy found in flowing water
Industrial Revolution	period of time starting in the mid-19th century where machines began to be widely used to manufacture goods
industrial sector	portion of the economy responsible for manufacturing products
insulator	substance that does not allow electrons to move about easily
kilowatt-hour	unit used to measure the electrical energy as provided by electrical utilities
kinetic energy	energy of a moving object or substance
Law of Conservation of Energy/Matter	energy matter can neither be created nor destroyed, they can only change form
lignite	lowest ranking coal that is soft, brown, and high in moisture content
light emitting diode bulb	light bulb that uses light emitting diodes to produce light
liquefied petroleum gas (LPG)	gas that has been separated from petroleum and compressed to liquid form; usually propane but can include butane

load	any device in a circuit that uses electricity, like a light or a motor
magma	molten rock beneath the Earth's crust
magnet	object that will respond to a magnetic field
magnetic field	area around a magnet that exerts a force on other magnets
mantle	layer of the Earth beneath the crust
mercaptan	compound containing sulfur that smells like rotten eggs and is added to natural gas and propane so it can be detected
methane	simplest hydrocarbon, containing just one carbon atom and four hydrogen atoms
mining	digging into the Earth to obtain minerals like iron ore and coal
motion energy	energy of a moving object, like a kid on a bike or the wind
neutron	largest particle in an atom, found in the nucleus; has no electric charge
Newton's Laws of Motion	laws defined by Sir Isaac Newton that describe the way objects move
nonrenewable	not able to be regenerated in a short amount of time
nuclear energy	the energy stored in the nuclei of atoms
nucleus	structure at the center of the atom that contains the atom's mass
organic	living, or containing carbon
parabola	u-shaped figure, like a bowl or a satellite dish
peat	decayed or decomposed plant material created in an area of high moisture and low oxygen
permeable	allows a substance to move through it
petroleum	mixture of hydrocarbons formed from the remains of ancient ocean plants and animals
photoelectric effect	light of a certain color can make electrons move when it strikes the right substance
photosynthesis	the process plants use to take the energy of sunlight and store it in sugar
photovoltaic	using light to generate electricity
pipeline	long series of very large pipes, usually underground, that carry natural gas or petroleum products from one place to another
plates	in geology, parts of the Earth's crust that are moving around on top of the mantle
polymer	a large organic molecule formed by combining many smaller molecules (monomers) in a regular pattern
porous	a substance with holes that can hold a fluid, like a sponge holds water
potential energy	stored energy
power	the rate at which energy is used or work is done
propane	hydrocarbon with formula C_3H_8 that can be compressed into a liquid and transported
proton	particle found in the nucleus of an atom that is positively charged; the number of protons determines the identity of the element
radiant energy	energy that travels in electromagnetic waves, like light or radio waves
radiate	send outward in all directions
radioactive	substance that emits high-energy particles or waves
radioactive decay	the breakdown of radioactive elements as they emit particles or waves
reclamation	returning land to as near its original condition as possible
refinery	facility that separates the mixture of hydrocarbons in crude oil into their useful products

renewable	able to be regenerated in a short period of time
repel	push apart
residential sector	portion of the economy where people live
rotor hub	structure connecting the blades of the turbine to the generator shaft
secondary source of energy	energy that must be obtained from another source, such as gasoline or electricity
sedimentary	made from sediment, or layers of dirt, silt, and other debris
solar energy	energy from the sun
sound energy	vibrations in substances that produce sound
static electricity	electrons moving all at once in a sudden discharge
sub-bituminous	rank of coal between bituminous and lignite, dark gray in color, and lower in carbon than bituminous coal but less containing moisture than lignite
surface mine	area where minerals are obtained by scraping layers of ground away to reach the deposits
thermal energy	internal energy of substances that causes the atoms or molecules to move
thermal power plant	electric power plant that uses thermal energy to generate steam and turn a turbine
transformation	changing one form of energy into another
transportation sector	portion of the economy responsible for moving people and goods from place to place
turbine	device that spins, turning magnets or coils of wire to produce electricity
underground mine	area dug beneath the surface of the Earth to obtain minerals from deep within the Earth’s crust
uranium	element with 92 protons in its nucleus; substance used in a nuclear power plant to produce electricity
Volt	measure of the electric potential in a circuit
voltage	another way of describing electric potential
wattage	another way of describing electric power
wind	movement of air currents in the atmosphere

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