

Teacher Guide



Appalachian Power

School Energy Efficiency Kits Program



An AEP Company

TAKE CHARGE™



National
Energy
Foundation

Dear teacher,

The Appalachian Power School Energy Efficiency Kits Program is providing students with TakeCharge Kits. The goal of this program is to help students and families learn ways to use energy and water more efficiently.

This guide contains additional, supplementary energy education. Use the activities you choose to meet the needs of your students. Share lessons and activities throughout the school year to review energy concepts.

The lessons in this guide are multidisciplinary and are correlated to the Virginia and West Virginia Learning Standards, STEM and Next Generation Science Standards. Each lesson contains an objective, materials needed and detailed learning standard correlations. Some lessons contain student sheets; others are to be done as class discussions or demonstrations.

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Virginia Correlations

Fifth Grade

Lesson Name	Science and Engineering Practices	Force, Motion and Energy	Earth Resources	English Standards	Math Standards
Energy: What is It?		5.2 5.3 5.4		5.DSR.A 5.C.1	
Shine a Light on History			5.9	5.DSR.A 5.W.1 5.C.1 5.C.2	
Energy for Electricity		5.2 5.4	5.9	5.DSR.A 5.C.1	
Rollar Coaster Energy	5.1	5.2 5.3		5.DSR.A 5.W.1.B 5.C.1	5.CE.1 5.CE.3 5.MG.1
It's Electric		5.4		5.DSR.A 5.W.1.B 5.C.1	
The Art of Circuits		5.2 5.4		5.DSR.A 5.C.1	
How Do You Rate?			5.9	5.DSR.A 5.C.1	
The Cost of Looking Your Best			5.9	5.DSR.A 5.C.1	5.CE.1 5.CE.3
Energy in Math			5.9	5.DSR.A 5.C.1	5.CE.1
Water Energy Connection		5.2	5.9	5.DSR.A 5.C.1	

West Virginia Correlations

Fifth Grade

Lesson Name	Physical Science	Earth and Space	Engineering, Technology and Applications of Science	English Standards	Math Standards
Energy: What is It?				ELA.5.19 ELA.5.30	
Shine a Light on History		S.5.9		ELA.5.19 ELA.5.20 ELA.5.30	
Energy for Electricity		S.5.9 S.5.11	S.5.16	ELA.5.19 ELA.5.30	
Rollar Coaster Energy			S.5.17	ELA.5.19 ELA.5.30	M.5.8 M.5.10
It's Electric	S.5.1			ELA.5.19 ELA.5.30	
The Art of Circuits				ELA.5.19 ELA.5.30	
How Do You Rate?		S.5.9 S.5.11		ELA.5.19 ELA.5.30	
The Cost of Looking Your Best		S.5.11	S.5.16	ELA.5.19 ELA.5.30	M.5.10
Energy in Math				ELA.5.19 ELA.5.30	M.5.8
Water Energy Connection		S.5.11		ELA.5.19 ELA.5.30	

Energy: What Is It?

Objective:

The students will be able to define energy.

Materials and Curriculum
Correlations ▼

► Introduction

Energy is a term that is often misunderstood. In this lesson, students explore the various forms of energy and the conversion of energy from one form to another.

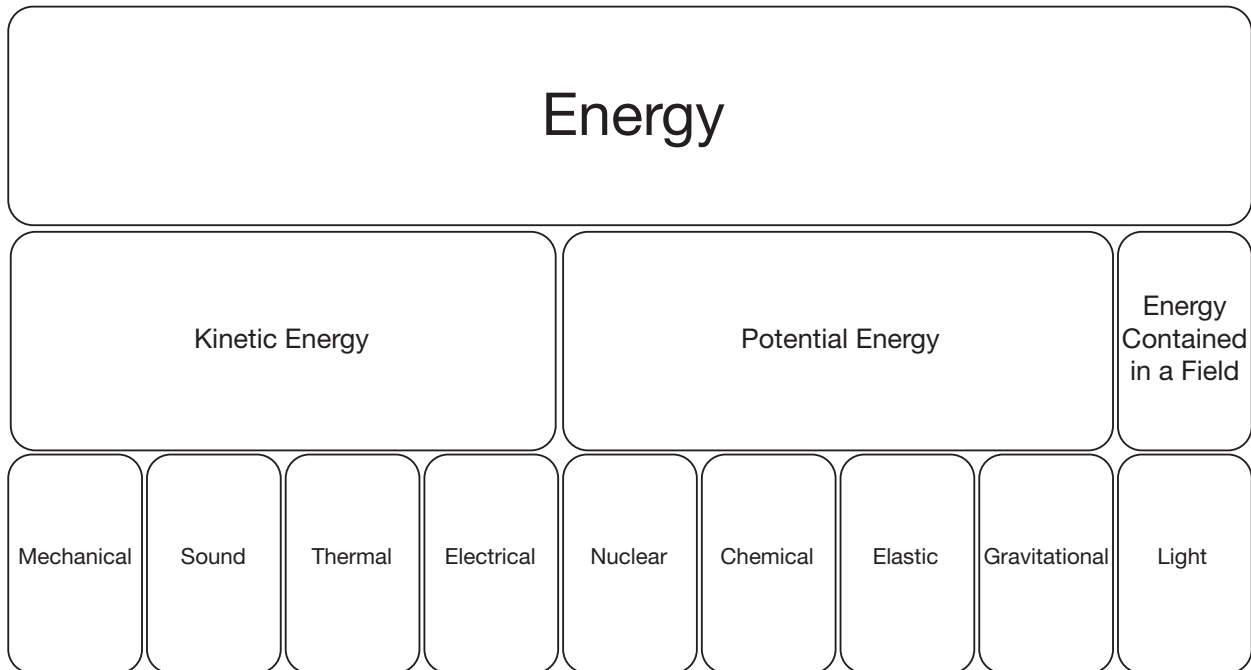
Procedure

1. Introduce the question of “What is energy?” by demonstrating situations where energy changes are clearly apparent. You may choose activities from the following list and carry them out either as teacher demonstrations or student activities.
 - a. Connect a battery to a light or bell.
 - b. Burn magnesium ribbon (students should not look directly at burning ribbon).
 - c. Produce sound through a speaker (e.g., radio).
 - d. Connect a solar cell and motor to illustrate the conversion of light energy to electrical and mechanical energy.
 - e. Wind a spring-driven windup toy or clock.
 - f. Burn a candle.
 - g. Mix sodium bicarbonate and dilute acid.
 - h. Blow up a balloon and release it.
 - i. Boil a small beaker of water.
2. For each demonstration or experiment, students (perhaps in small groups) should answer the following questions:
 - What do you observe?
 - Has energy been used? Where did it go?
 - Has energy been produced? Where did it come from?
3. Students should discuss and write down a definition of energy in their own words.
4. Discuss answers students have written. You may want to introduce students to the forms of energy in the graphic organizer below as you discuss student answers. This discussion should allow the following points to be made:
 - a. Energy is defined as the ability to do work. Kinetic energy is energy of motion, doing work NOW. Potential energy is stored based on the position and composition of an object, which could be changed to release the energy.
 - b. Energy can be detected only when some kind of change occurs. It cannot be seen.
 - c. Energy exists in many forms. Some energy forms are more useful than others.
 - d. Energy can be changed from one form to another.

- e. Temperature is a measure of the average translational kinetic energy of the atoms or molecules in an object. In practical terms, this means that the atoms or molecules move faster in a sample of matter as the temperature of the sample increases.
- f. The law of conservation of energy states that energy cannot be created or destroyed, but only changed from one form to another. This law suggests that the universe contains all the energy that ever existed, the energy just changes forms.

- g. Objects or materials that can produce a change are a source of energy. Fuels such as coal, oil and natural gas are sources of chemical potential energy. Wind energy is a source of mechanical kinetic energy.

Explain that energy is an idea or concept that people use to help explain their surroundings and changes in their environment. One definition commonly used to describe energy is the ability to do work or to cause change. This definition can be discussed and compared to the students' definitions.



Materials Needed:

The materials used will vary depending on the demonstration or experiments chosen

- Battery and lights (optional)
- Vinegar and baking soda (optional)
- Windup toy (optional)

- Candle and match (optional)
- Solar cell (optional)
- Balloon (optional)
- Drum (optional)

Curriculum Correlations

K-ETS1 - 1

1-ETS1 - 1

2-ETS1 - 1

3-ETS1 - 1

4-PS3 - 1

4-PS3 - 2

4-PS3.D

4-ETS1 - 1

4-ETS1 - 2

5-ETS1 - 1

5-ETS1 - 2

MS-PS3 - 2

MS-PS3 - 4

MS-PS3.A

MS-ETS1 - 1

HS-PS3 - 2

HS-PS3.A

HS-PS3.B

HS-PS3.D

HS-ETS1 - 2

HS-ETS1 - 3

Shine a Light on History

Objective:

Students will gather details and make inferences from text to explain historical events related to electricity. They will use their knowledge to write information text to support an opinion.

Materials and Curriculum Correlations ▼

► Introduction

Thomas Edison and Nick Holonyak are two famous lighting inventors. They both made major contributions that changed the way people lived. Thomas Edison patented the incandescent bulb in 1880. Since that time, people have enjoyed the convenience of using electricity for light. Nick Holonyak created the first practical, visible spectrum LED which revamped lighting as we know it.

In this activity, students will study the contributions of these two inventors. They will gather details to form an opinion about which man was more influential in history.

Procedure

1. Pass out copies of the student sheet and have students read about each inventor. If time allows, they can use the internet, or other sources, to find additional information.
2. Have students fill out research cards for each inventor. Using that information, they should decide which inventor was more influential in history and write a persuasive paragraph, with details from their research, to support their opinion.
3. Challenge students to practice reciting their paragraph and then present it to another student(s) in an attempt to change a differing opinion.

Discussion

- What kinds of light bulbs are used in your home? How do they affect the way you live and work?
- What do you think the next great electric invention will be?
- Thomas Edison said, "Genius is one percent inspiration and ninety-nine percent perspiration." What did he mean? How does his quote apply to you?

To Know and Do More

A light bulb package has a lighting facts label that contains different numbers.

- The light output is in lumens.
- The power used by the bulbs is measured in Watts. The higher the wattage, the more energy the bulb uses.
- A measure of how warm or cool the light from that bulbs looks is measured in Kelvin (K). Low numbers are warmer light hues (orange or yellow). High numbers are cooler hues (blue or green).

When buying new bulbs, we should shop by lumens, not wattage. We save energy by finding bulbs with the lumens we need, then choosing the lowest wattage possible for that number of lumens.

Lighting Facts		per bulb
Brightness	800 lumens	
Estimated Yearly Energy Cost \$1.08		
Based on 3 hrs/day, 11¢/kWh Cost depends on rates and use		
Life	Based on 3 hrs/day	23 years
Light Appearance		
Warm	▲ 2700 K	Cool
Energy Used	9 Watts	

Materials Needed:

- Copies of student sheet

Curriculum Correlations

4-PS3 - 2

MS-PS3 - 3

HS-ESS3 - 1

K.RI.3

K.SL.1

1.RI.3

1.W.3

1.SL.1

2.RI.3

2.W.3

2.SL.1

3.RI.6

3.RF.4

3.W.2

3.SL.1

4.RI.6

4.RF.4

4.W.2

4.SL.1

5.RI.6

5.RF.4

5.W.2

5.SL.1

MS-W.2

MS-SL.1

HS-W.2

HS-SL.1

Edison vs Holonyak



Early light bulbs could not be sold because they did not last long enough, were too expensive and used too much energy. In 1879 Thomas Edison improved the light bulb so that it lasted longer, 14.5 hours. He continued to test thousands of materials for the filament (the part of the bulb that produces light when heated by an electric current) until his bulb could last 1,200 hours! Edison made other improvements to the early light bulb that made it good enough to be used in homes, schools and businesses.

Edison's work with electricity didn't stop at light bulbs. He improved the way electricity was generated and transported to places where it was needed. Edison also developed the first electric meter, a device which measures the amount of electricity used by a location or device. Edison was a hard worker who patented 1,093 of his inventions. His famous quote is, "Genius is one percent inspiration and ninety-nine percent perspiration." Thomas Edison's improvements to the way people used electricity and lighting changed the way they lived. Electricity helped get work done more quickly and easily. Electric light made it possible to do activities at night and to extend the time people could work or play.

What were two of Thomas Edison's accomplishments that made electric lighting possible?

What do you think was Thomas Edison's greatest strength as an inventor?



Nick Holonyak was an engineering professor from the University of Illinois who later went to work for General Electric. In 1962, when he was 33, he created the first practical, visible light-emitting diode (LED). Holonyak was trying to create a semiconductor laser, but instead, he accidentally created something even more important, a light that would replace incandescent bulb. His coworkers called the red LED he created “the magic one.”

LEDs started as indicator lights on electrical equipment. Then, they were put in digital watches and later were used in traffic lights. Now LEDs are replacing less efficient light bulbs everywhere. Their price has dropped dramatically and continues to fall. LEDs help us save the natural resources that are used to generate electricity. This is because they use approximately 90% less energy and last up to 25 times longer than an incandescent bulb. By 2035, it is predicted that most lighting installations will use LED technology, significantly impacting energy savings in the U.S.

What was interesting to you about Nick Holonyak’s discovery of the red LED?

How did Nick Holonyak’s discovery of the red LED help people today?

Compare the facts that you have learned about Edison and Holonyak. Which inventor do you think was more influential in history? Write a paragraph that states your opinion and gives two or more facts to support your opinion. Practice reciting the paragraph and read it to a classmate(s) with a different opinion. Did you change their mind?

Energy for Electricity

Objective:

Students will describe energy transformations required to produce electric energy for homes.

Materials and Curriculum
Correlations ▼

► Introduction

Electric generation requires many energy transformations. In this activity, students will complete the Electric Generation Student Sheet, which is like a puzzle showing the steps in the generation process. Students will learn how electricity is generated and delivered to their homes.

Procedure

1. Ask students if they believe that energy is important to their lives. How would their lives be different without electricity?
2. Ask students where electricity comes from and how it is made. Tell them that the process of generating and delivering electricity requires many energy transformations.
3. Pass out pieces of the “Electric Generation Puzzle” and give students a few minutes to put the pieces in order. (boiler, turbine, generator, power line, transformer, consumer)
4. Go through each step of the puzzle, asking students to give the type and form of energy going in and coming out of each step. Point out that burning the fuel in the boiler is a chemical change that breaks the bonds of the hydrocarbons in the fuel to release thermal energy (and waste products such as carbon dioxide and sulfur dioxide). Compare the turbine to a pinwheel, demonstrating how steam can turn the turbine to create mechanical energy. The transformer’s job is to change the voltage, either up or down. Step-up transformers are needed to replace voltage lost as electricity is converted to thermal energy by electric resistance in the power lines. Many household electronic devices have step-down transformers, which are a miniature version of those on electric poles. These small transformers also commonly contain components to convert the alternating current (AC) from an outlet into direct current (DC).
5. Have students name some further energy transformations that occur once electricity is used in their homes.
6. Ask students how other energy sources would produce electricity differently. When using nuclear power, wind power, hydropower or solar power, which pieces would change or be removed? Distribute the energy source cards and have students work the original puzzle with the new energy sources.
7. Have students discuss the environmental effects of using renewable versus nonrenewable fuels.
8. List advantages and disadvantages of each method of producing electricity. Each energy source has benefits and drawbacks that must be considered and balanced.
9. Help students identify some of the economic and social impacts involved in changing our fuel mix.

Description of Electric Generation Process

1. Boilers at a power plant convert chemical potential energy from fuel (fossil fuels, biomass, hydrogen) to thermal kinetic energy, changing water to steam. Light and chemical energy (new chemicals in the gases produced) are also formed but the energy does not contribute to the process of electric generation.
2. Turbines are turned by steam, converting thermal kinetic energy to mechanical kinetic energy. Thermal energy from friction within the mechanism is produced as well but does not contribute to the electric generation process.
3. Generators, turned by a turbine, rotate a coil of wire in a magnetic field converting mechanical kinetic energy to electric kinetic energy. Thermal energy from friction within the mechanism is produced as well but does not contribute to the electric generation process.
4. Power lines transmit electric energy at several thousand Volts. Resistance heating in wires converts electric energy back to thermal energy, resulting in a voltage drop and a loss of usable energy. High voltage lines from a power plant are called transmission lines. The transmission lines run to a substation which contains transformers and switches.
5. Transformers and substations may be step-up or step-down. Step-up transformers along the power lines increase voltage periodically; step-down transformers, on poles or in yards, reduce the voltage to a safe level for home use.
6. Consumers convert electric energy into many forms to run lighting and home appliances.

To Know and Do More

1. Investigate how transformers work. The websites below are useful guides to show how transformers step voltage up and down and how household transformers also convert alternating current (AC) to direct current (DC).
2. Check out explainthatstuff.com/transformers.html and science.howstuffworks.com for detailed information on how power grids work.
3. If you have access to a voltmeter, have students design and build transformers. Test the voltage in and out of transformers and compare to the number of turns of wire on each core. Have students see if they discover a pattern.

Materials Needed:

- Copies of “Electric Generation student sheet,” cut apart
- Copies of “Energy Source Cards Electric,” cut apart
- Pinwheel (optional)
- Hand generator (optional)
- Transformer from a household item, such as a cell phone charger (optional)

Curriculum Correlations

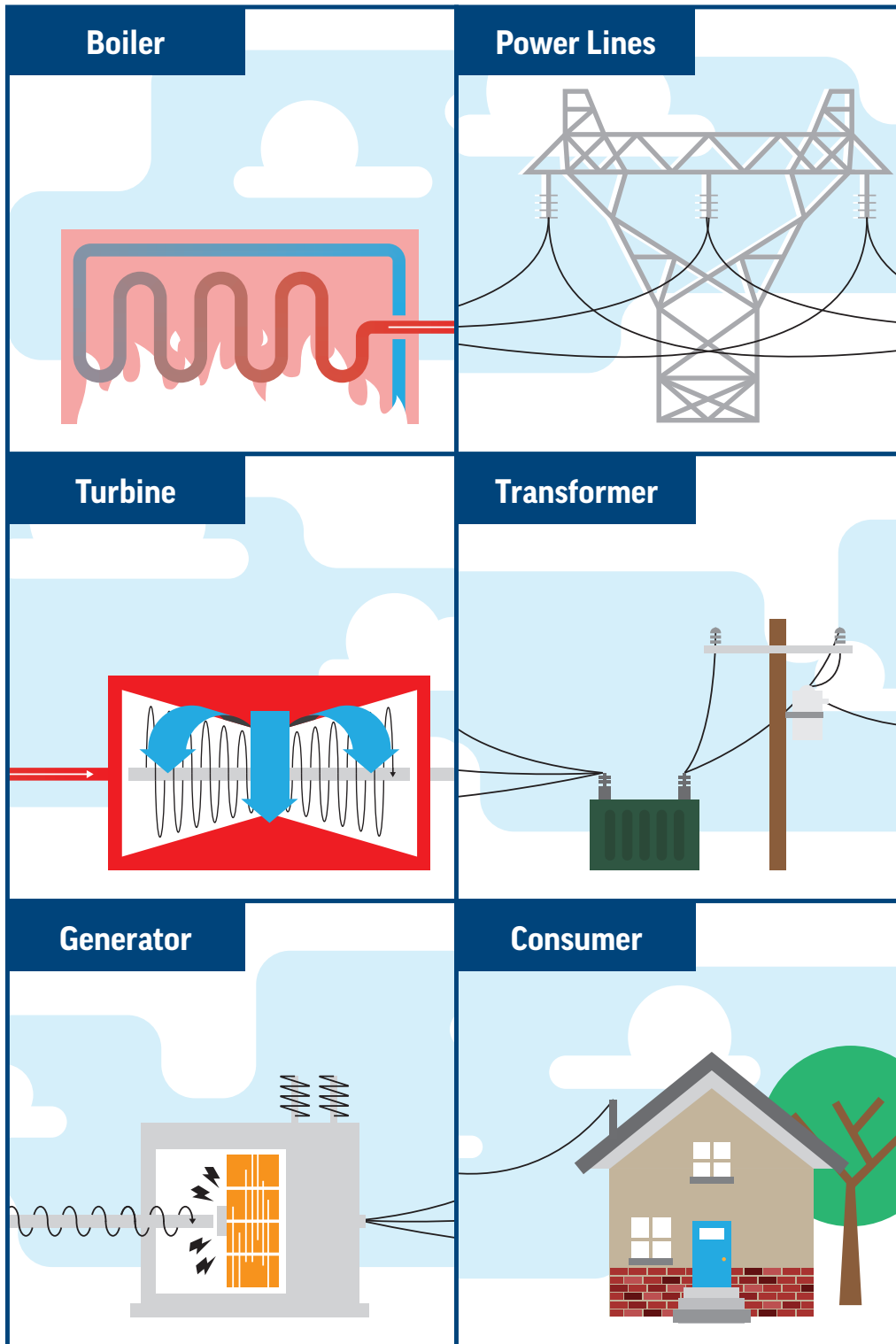
K-ESS2 - 2
4-PS3 - 2
4-PS3 - 4
5-ESS3 - 1

MS-PS1 - 2
MS-PS2 - 3
MS-PS2 - 5
MS-PS3.A

MS-PS3.B
HS-PS1 - 4
HS-PS3 - 1
HS-PS3 - 2

HS-PS3.A
HS-PS3.B
HS-PS3.D

Electric Generation



Energy Source Cards Electric

<p>Geothermal Created with heat from inside the earth</p> 	<p>Biomass Organic material with stored energy</p> 
<p>Hydroelectric Dam Produces electricity from falling water</p> 	<p>Wind Generator Produces electricity from wind</p> 
<p>Photovoltaic Panel Produces electricity from sunlight</p> 	<p>Power Tower Produces heat from reflecting sunlight</p> 
<p>Nuclear Reactor Produces heat from uranium</p> 	<p>Hydrogen Fuel Cell Produces electricity from hydrogen and oxygen in a chemical reaction</p> 

Roller Coaster Energy

Objective:

Students will design and build a roller coaster.

Materials and Curriculum Correlations ▼

► Introduction

There are two main types of energy, kinetic and potential. In this lesson, students explore the conversions from potential energy (PE) to kinetic energy (KE) in a roller coaster and calculate the amount of each. Students then relate this to the law of conservation of energy and the efficiency of the energy conversion.

Procedure

1. Before class, very carefully slice the pipe insulation lengthwise to form two semicircular tubes. Then join the two halves with tape to make a track approximately 4.5 yards long.
2. If possible, introduce this activity by showing a video clip of roller coasters in action.
3. Ask students why roller coasters always start out with a large hill. Ask what has to be put into the system to get the car to the top of the hill. (energy from motors or generators)
4. Show students the materials, bending the pipe insulation to form loops, curves and hills. Encourage them to start with a simple, straight track and add elements such as loops after they figure out an appropriate slant.
5. Pass out copies of the student sheet.
6. Tell students it is imperative that they measure the height, time and mass of the marble as explained on their worksheets. Without these numbers, they will be unable to calculate the PE and KE of their marbles.
7. Monitor student work, prodding them to record measurements for at least one track that works before time runs out. Students tend to get carried away in building complicated tracks that do not work.
8. Discuss the answers to the worksheet questions. Where on the track was the point of maximum PE? Maximum KE? Where did the “missing” potential energy go? (It was converted to thermal energy and sound.) What caused this energy “loss?” (friction) How could students improve the efficiency of their coasters?

Answers to Questions on “Roller Coaster Energy”

1. Potential energy decreases.
2. Height is decreasing.
3. Answers vary with student’s hypothesis, but potential energy will be greater than kinetic energy as calculated.
4. Yes, kinetic energy measured is only the mechanical energy of the marble. Thermal and sound energy produced by friction with the track are not measured.
5. Forces are gravity (F_w), friction and the force of the track pushing up on the marble (the normal force, F_n).
6. Forces are the same as in number 5, but the normal force changes direction. It is always perpendicular to the track, while gravity is always downward. The frictional force is always opposite the direction of movement.
7. Answers may vary, but students should realize that they need enough kinetic energy to reach the critical velocity needed to complete loops and that there is a need to control g-forces so people are not injured.

To Know and Do More

1. As an extension, ask students to think of real roller coasters. What other energy systems are involved to create the total roller coaster experience? (i.e., lights, sound systems, brakes) Discuss how roller coasters have changed since they were first invented. Why are most modern coasters built from steel rather than wood?
2. Relate this activity to the study of force and motion. How do roller coaster designers make sure that you will not fly off the track or get too sick? (Use of a three-wheel system, computer modeling of g-forces, etc.) How do different types of tracks and weather conditions affect the ride? How does where you sit on the train affect the ride?
3. Allow students to use game software such as 3D Roller Coaster Designer, Roller Coaster Tycoon or Ultimate Ride to design roller coasters. Google SketchUp has also been recommended by teachers. It is available at no charge at sketchup.com.

Materials Needed:

- Marbles
- Foam pipe insulation (available from home improvement and hardware stores; get the largest diameter available)
- Stopwatches
- Meter sticks or measuring tape
- Masking tape
- Balances
- Other materials may be brought by students
- Student sheet

Curriculum Correlations

K-PS2 - 1
K-PS2 - 2

4-ETS1 - 1
4-ETS1 - 2

HS-PS2 - 2
HS-PS2 - 3

K-ETS1 - 1
2-PS1 - 3
2-ETS1 - 1
2-ETS1 - 2
2-ETS1 - 3
3-PS2 - 1
3-PS2 - 2
3-PS2 - 3
3-ETS1 - 1
3-ETS1 - 2
4-PS3 - 1
4-PS3 - 3
4-PS3 - 4

5-PS2 - 1
5-ETS1 - 1
5-ETS1 - 2
5-ETS1 - 3
MS-PS3 - 1
MS-PS3 - 2
MS-PS3 - 3
MS-PS3 - 4
MS-PS3 - 5
MS-ETS1 - 1
MS-ETS1 - 2
MS-ETS1 - 3
HS-PS2 - 1

HS-PS2 - 4
HS-PS2.A
HS-PS3 - 1
HS-PS3 - 2
HS-PS3 - 3
HS-PS3 - 4
HS-PS3 - 5
HS-PS3.A
HS-PS3.B
HS-PS3.C
HS-PS3.D
HS-ETS1 - 2
HS-ETS1 - 3

Roller Coaster Energy

Objectives

After completing this project, you should be able to:

- Construct a roller coaster that will accelerate a marble to speeds of at least 2 m/s.
- Calculate weight (the force of gravity on a mass), speed and kinetic energy (KE) and potential energy (PE) for your marble.
- Explain how the law of conservation of energy relates to your roller coaster.

Materials

- Stopwatch
- Meter stick
- Paper and pencil
- Pipe insulation
- Masking tape
- Marble
- Balance
- Calculator

Hypothesis

Which will be larger, the PE at the beginning of the track or the KE at the end of the track?

Procedure

1. Title a piece of notebook paper “Log Sheet.” Record the mass of your marble at the top of the sheet. Divide the rest of the paper into three sections labeled Trial 1, Trial 2, Trial 3. Leave plenty of room! You may use more than one piece of paper.
2. On the log, draw a simple straight track roller coaster design, and then build it with the pipe insulation. The end of the coaster must touch the ground.
3. When you design a track that works, be sure to measure each part of the coaster (starting height, height and width of loops, track length, etc.) so you can replicate your results and record the measurements on the drawing in your log.
4. Measure 2 m (about six and a half feet) on the ground from the end of your roller coaster track and mark it with a piece of tape. This will be the 2 m distance you use to find your marble’s speed.
5. Roll the marble down the track, timing the marble from the bottom of the track until it hits the piece of tape. Record the time in your log. This is Trial 1.
6. Use the time from step 5 to determine the speed of your marble ($v = d/t$), and record the speed in your log under Trial 1.

7. Repeat steps 2 through 6 above for Trials 2 and 3, trying different designs. Be sure to measure, sketch and record everything in your log.
 8. After the three trials, decide which design will get you the most points using the criteria on the bottom of this page. Build this coaster to show your teacher. Test it several times before you are graded by the teacher.
 9. Convert the efficiencies to decimals before multiplying.
 10. Record the starting height, time and marble mass at the bottom of this sheet.
 11. After you have been graded, calculate weight (F_w), PE of your marble at its starting point, KE of the marble at the end of the track and efficiency (eff).
- $F_w = mg$ $PE = F_w h$ $KE = 1/2mv^2$ $Eff = (KE\ out / PE\ in) \times 100\%$
12. Compare the PE and KE, noting in the log any differences between the numbers. Also note any other forms of energy you witnessed during your trials.
 13. Complete the questions on the next page, staple this paper to your log and hand it in.

Final Trial to Be Graded:

Starting height (m): Time (s): Mass of marble (kg):

Calculate values for

Weight (N): Speed (m/s): PE (J): KE (J):

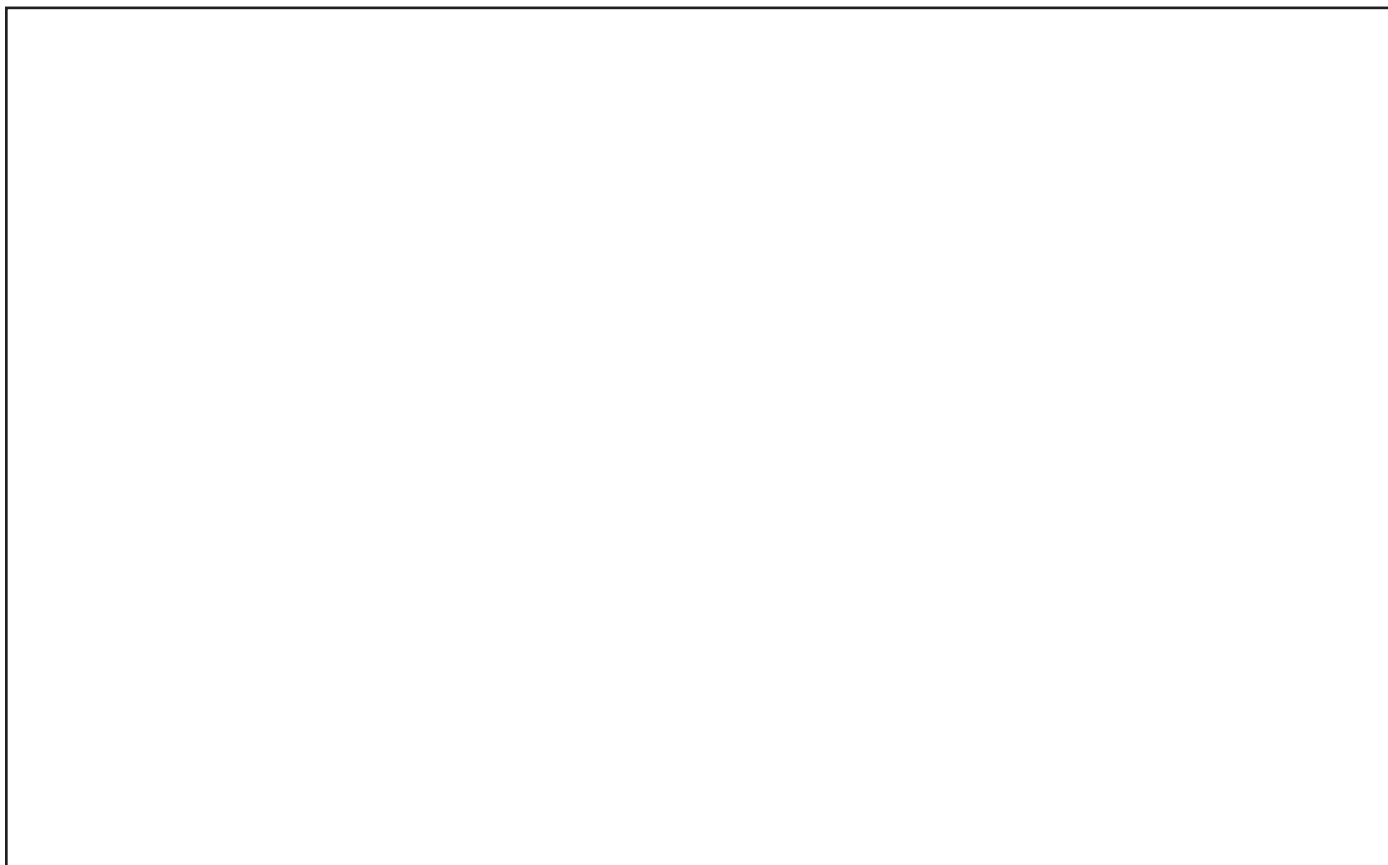
Efficiency of energy conversion from the start of the run (%):

Grading:

<p>complete log = 30 points marble completes track = 20 points each hill = +10 points each curve = +10 points each loop = +20 points</p>		<p>speed < 2 m/s = +0 points speed 2-3 m/s = +5 points speed 3-4 m/s = +10 points speed > 4 m/s = + 15 points conclusions = 10 points</p>
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TOTAL POINTS EARNED _____

Drawing of graded coaster with measurements:



Questions

1. What happened to the potential energy of the marble as it traveled through the track?
2. Why did this happen?
3. Was your hypothesis supported by this experiment? Why or why not?
4. Does your roller coaster obey the law of conservation of energy? Explain why or why not.

It's Electric

Objective:

Students will understand the concepts of conductors and insulators.

Materials and Curriculum
Correlations ▼

► Introduction

The following experiment illustrates the concepts of conductors and insulators. Students will discover which fruits and vegetables conduct the most electricity and learn about the properties of conductors and insulators.

Procedure*

*Please ensure no one in your classroom has an allergy to any food items you may use.

1. Explain to students that a conductor is a material that allows electricity to pass through easily. Examples include aluminum foil, wire and people. An insulator does not let electricity flow through easily. Examples are paper, plastic and rubber.
2. Divide the class into groups of students to work through the experiment.
3. Hand out the materials listed to each team.
4. Allow the students time to do the activity and answer the questions.
5. Discuss the students' findings as a class and what conclusions can be made from this information.

Conclusions

- The fruits and vegetables in this activity can conduct electricity.
- The electrodes react with the juice inside the fruits and vegetables to conduct electricity.
- The best electrodes are zinc and copper.
- The best fruit as a conductor is an apple.
- The best vegetable as a conductor is a carrot.
- The farther apart the electrodes, the more efficiently electricity is conducted.
- Zinc and copper on opposite sides of an apple yielded the best results.

Materials Needed:

- Student sheet
- Voltage meter
- 2 Steel nails for electrodes
- 2 Pieces of copper wire with plastic removed for electrodes
- Ruler
- Sandpaper
- 2 Zinc nails for electrodes
- Fruits and vegetables: banana, apple, lemon, lime, orange, cucumber, carrot, potato and tomato

Curriculum Correlations

K-ETS1 - 1
1-ETS1 - 1
2-PS1 - 4
2-ETS1 - 1
3-ETS1 - 1
3-ETS1 - 2
4-PS3 - 2
4-PS3 - 4

4-ETS1 - 1
4-ETS1 - 2
5-ETS1 - 1
5-ETS1 - 2
MS-PS1 - 6
MS-PS2 - 3
MS-PS2 - 5
MS-PS3 - 3

MS-ETS1 - 1
HS-PS2 - 5
HS-PS3 - 1
HS-PS3 - 3
HS-PS3 - 5
HS-ETS1 - 3

It's Electric

Discover which fruits and vegetables conduct the most electricity and learn about the properties of conductors and insulators.

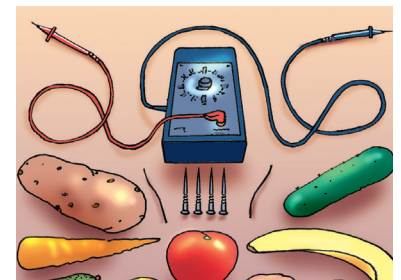
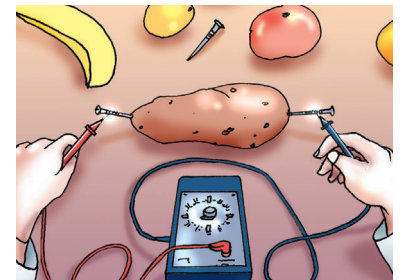
Materials

Ruler, voltage meter, sandpaper, two steel nails, two zinc nails, two pieces of copper wire, fruits and vegetables

Procedure

1. Use sandpaper to file the tip of each nail and copper wire before the experiment begins.
2. Place one copper and one zinc electrode into a banana one inch apart.
3. Using the voltage meter, touch each electrode to measure the electricity and record the data in the table below.
4. Next use the copper/steel combination.
5. Repeat with the zinc/steel combination.
6. Repeat steps 2 to 5 with each fruit and vegetable.
7. Record all the data in the chart below.

		Electrodes		
		Copper/Zinc	Copper/Steel	Zinc/Steel
Fruits and Vegetables	Apple			
	Orange			
	Carrot			
	Banana			
	Lime			
	Tomato			
	Lemon			
	Potato			
	Cucumber			



Questions

1. Which fruit was the best conductor?
2. Which vegetable was the best conductor?
3. Why do you think certain items were better conductors than others?
4. What did you learn from the electrodes?

The Art of Circuits

Objective:

Students will learn about conservation of energy and energy transfer by experimenting with electric circuits.

Materials and Curriculum Correlations ▼

► Introduction

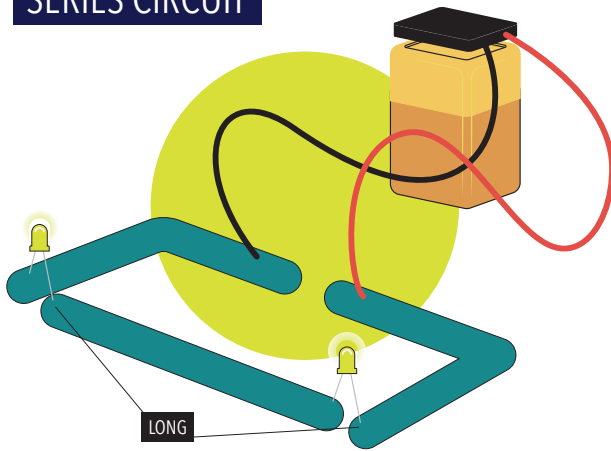
Materials that allow a flow of electric current to pass through them more easily are called conductors. Aluminum, silver and copper are examples. Insulators block the flow of electricity. Nonmetallic materials, such as rubber, plastic, wood, cloth and dry air are insulators. An electric circuit is a path of conductors through which electric current flows. Energy can be transferred from place to place by electric current.

In this activity, students will use salt dough, which is a conductor, to design circuits which will transfer electric energy. If they are successful, the electricity will be transformed to light and heat energy in a miniature LED bulb.

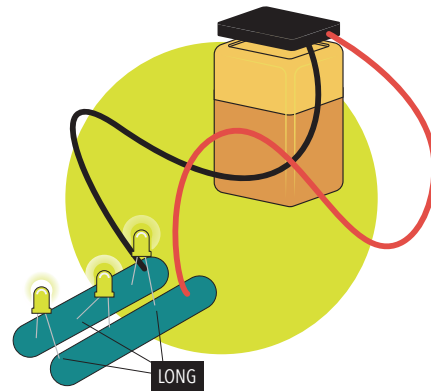
Procedure

1. Introduce students to their materials:
 - a. Attach the battery to a battery clip with red and black cables. The red lead is the positive terminal and the black lead is the negative terminal.
 - b. Examine the LED bulb. Two wires (or legs) extend from the bulb. The longer wire is the positive side of the LED and the short wire is the negative side. The LED should only be connected to dough, never directly to the battery terminals, which will cause the bulb to burn out.
2. Tell students that electricity can only go through the circuits they will create in one way. The positive terminal of the battery (red lead on battery clip) must be nearest a positive (long) leg of the LED. A battery pushes electricity around the circuit through the positive leg and out the negative (short) leg, then repeating through the next positive leg (if there is more than one LED in the circuit).
3. Explain that electricity will take the path of least resistance. It is easier for electricity to travel through the dough than through the LED, so if two pieces of dough are touching, the LED will not light.
4. Challenge students to design a simple circuit like the ones on the next page.

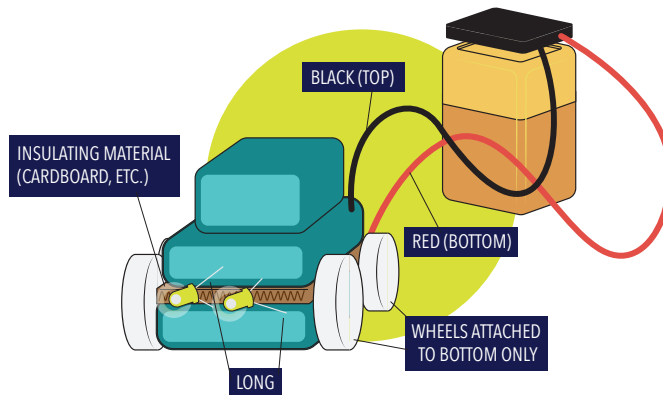
SERIES CIRCUIT



PARALLEL CIRCUIT



If time allows, have students create a circuit work of art like the one below. Since the conductive dough cannot touch, use insulating material between layers.

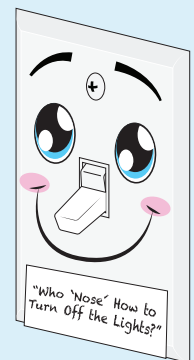


Discussion

- How does your dough circuit light the LED compared to the circuits at your home?
- In a series circuit with multiple LEDs, what happens to the brightness of the LEDs that are further from the battery? Why?

To Know and Do More

When a light switch is off, the electric pathway to a bulb is not complete and electricity cannot flow to light that bulb. When you flip the switch on, you close the circuit and the light turns on. If light is not needed, it is important not to waste the natural resources used to generate the electric power that is being transformed to light. Have students create characters without noses to put over light switches at school or home. The art should help remind them to turn lights off!



Materials Needed:

- Playdough® or homemade salt dough
- 9V batteries
- 9V battery clips with red and black cables
- 2V LED miniature light bulbs
- Insulating material: cardboard, packaging plastic or dough made from sugar, not salt (optional)

Curriculum Correlations

4-PS3 - 2	4-ETS1.A	MS-PS3.A-B
4-PS3 - 4	5-ETS1 - 1	MS-ETS1 - 1
4-PS3.A-B, D	5-ETS1.A	MS-ETS1.A
4-ETS1 - 1	MS-PS3 - 3	

How Do You Rate?

Objective:

Students will conduct a home survey to determine how they can use energy more efficiently by changing their habits and improving conditions.

Materials and Curriculum Correlations ▼

► Introduction

We use natural resources every day. Sometimes we use them just as they come from earth or the atmosphere. At other times we alter their makeup to fit our needs. For instance, we use the sun just as it is to dry clothes, but we use photovoltaic cells to capture the sun's energy and convert it to electricity, a secondary energy source. We use coal just as it comes to us from the earth to make electricity or we use it to provide coke for steel manufacturing. Many natural resources we use every day are nonrenewable, once we use them they are gone. Others are renewable, they can be replaced through natural and/or human processes.

It is responsible to use all resources efficiently and wisely. When we do, we reduce energy use, save money and preserve the environment. Making wise decisions today will have a positive impact on our future.

Imagine the difference we could make if we all used energy more efficiently. We would conserve natural resources for the future and enjoy better air quality and a better life. Each one of us can truly make a difference. All it takes is knowledge and action.

Procedure

Using energy efficiently and conserving our natural resources are responsible and easy actions that students can take today to show they respect the environment and have a desire to protect and preserve it.

1. Pass out the student sheet. Discuss the actions that may apply to the school (e.g., windows and doors have weather-stripping; drapes or blinds are open on cold, sunny days and closed on hot days; thermostats are adjusted at night; lawns are only watered early or late in the day). As you discuss each action, write a T for true or F for false on the board to see how the school rates. What can the students do to improve energy use at school?
2. Decide on several actions the students can take at school to help save energy and protect the environment. One action might be to use both sides of their paper and then recycle. If a room is empty during lunch or at other times, they can be sure lights are turned off and computers are on sleep mode.
3. Have the students take the survey home and complete it with their parent's or guardian's help. Explain to students that it is important to record their true energy use and not mark what they think they should be doing.
4. How did the students' homes rate? Discuss the results of the home survey. Help students to become enthusiastic about conserving natural resources and using energy more efficiently.
5. Prepare a graph to show the results of the energy efficiency survey. Which efficiency tips are already practiced by most students? Which were least used? Graph the number of students marking "yes" for each item.
6. Find the mean, median, mode and range of the data on the home survey.

Discussion

Discuss the benefits of energy conservation. How will our energy use impact our future? Compare the benefits and possible inconveniences and their correlation to our quality of life.

To Know and Do More

1. Why do you think people do not practice all of the energy efficiency tips on the survey? Are there false assumptions that affect people's behavior? (Believing that turning things on and off uses more energy than leaving them on, for example.)
2. Discuss how people in other geographic areas and cultures would rate. Does everyone have a car, dishwasher or an air conditioner?

Career Awareness Activity

Have the students think of some careers that could have a big impact on their community's energy usage. Some areas to consider: Teachers impact energy usage through education and by example; utility workers impact energy usage through installation and maintenance; government regulators have an influence through restrictions and rewards, such as financial benefits or tax breaks.

Materials Needed:

- Student sheet

Curriculum Correlations

K-ESS2 - 2
K-ESS3 - 3
3-PS2 - 3
4-ESS3 - 1

5-ESS3 - 1
5-ESS3.C
MS-LS2 - 1
MS-ESS3 - 3

MS-ESS3.A
HS-ESS3 - 3

How Do You Rate?

How energy efficient is the building you live in? Together with your parents or guardians, answer the following questions to rate your home or apartment.

Circle T if the statement is true, F if the statement is false or NA if the statement does not apply to your living situation.

Heating and Cooling

Windows and doors have good weather-stripping.	T	F	NA	Garage is insulated.	T	F	NA
Window coverings are open on cold, sunny days and closed on hot days.	T	F	NA	Air filters on furnace and air conditioner are cleaned and changed regularly.	T	F	NA
Window coverings are closed at night when heat is on.	T	F	NA	An energy audit has been conducted by your local utility in the last 3 years.	T	F	NA
Thermostat is set at 68 F or lower in winter.	T	F	NA	Thermostat is adjusted at night.	T	F	NA
Air-conditioning is set as high as is comfortable in summer.	T	F	NA	Fireplace damper is closed when fireplace is not in use.	T	F	NA
Ducts are insulated in unheated/uncooled areas.	T	F	NA				

Water

A pitcher of water is kept in the refrigerator for drinking.	T	F	NA	Hot water heater is set at 120 F.	T	F	NA
Faucets and toilets do not leak.	T	F	NA	• If someone in your household has a compromised immune system, consult your physician.	T	F	NA
Showers and faucets are fitted with energy-efficient shower heads and aerators.	T	F	NA	Hot water pipes from water heater are insulated.	T	F	NA
Showers last no longer than 5 minutes.	T	F	NA	Broom, not hose, is used to clean driveways and sidewalks.	T	F	NA
Toilets are low flow or tanks use water displacement devices.	T	F	NA	Faucet is shut off while brushing teeth and shaving.	T	F	NA

Appliances

Dishwasher is usually run with a full load.	T	F	NA	Clothes are often hung up to dry.	T	F	NA
Automatic air-dry is used with the dishwasher.	T	F	NA	Refrigerator is set between 35 F and 38 F.	T	F	NA
Washing machine is usually run with a full load.	T	F	NA	Lids are usually put on pots when boiling water.	T	F	NA
Cold water is used in washing machine most of the time and is always used for rinses.	T	F	NA	Oven preheating time is reduced or not preheated at all.	T	F	NA
Clothes dryer is usually run with a full load.	T	F	NA				

Lighting

Lights are turned off when not in use.	T	F	NA	Light bulbs are kept dusted and clean.	T	F	NA
LED bulbs are used.	T	F	NA	Sunlight is used whenever possible.	T	F	NA
Security and decorative lighting is powered by solar energy.	T	F	NA				

Trash

Glass, cans and newspapers are recycled.	T	F	NA	Reusable bags are used for groceries, or bags are recycled.	T	F	NA
Plastic is separated and recycled.	T	F	NA	Rechargeable batteries are used when possible.	T	F	NA
Old clothes are often given to charities, secondhand clothing stores, etc.	T	F	NA	Food is often bought in bulk.	T	F	NA
Food scraps and organic waste are composted.	T	F	NA	Products made of recycled materials are favored.	T	F	NA
Overpackaged products are usually avoided.	T	F	NA				

Transportation

Car is properly tuned and tires inflated.	T	F	NA	Family members often walk or ride a bike for short trips.	T	F	NA
Family drivers obey speed limit on the highway.	T	F	NA	Families carpool when possible.	T	F	NA
Public transportation is used when possible.	T	F	NA				

Environment

Trees and bushes are maintained for wildlife shelter and food.	T	F	NA	Native plants are used to decrease water use.	T	F	NA
Bird feeders or bird houses are maintained.	T	F	NA				

Yard and Workshop

Lawns are watered early or late in the day.	T	F	NA	Cutting edges on tools are kept sharp.	T	F	NA
Grass is mowed to a height of 2 to 4 inches.	T	F	NA	Electrical tools are maintained and gas equipment is kept tuned and serviced.	T	F	NA
Hand tools, like pruners and clippers (rather than power tools) are used whenever possible.	T	F	NA				

Score 1 point for True, 0 points for False and 0 points for Not Applicable (NA).

Total Points:

Discuss the results of this survey with your family.

What can you and your family do to raise your score?

The Cost of Looking Your Best

Objective:

Students will investigate the amount of energy used at home in a day, determine how much is wasted and discover ways they can save and use energy more efficiently.

Materials and Curriculum
Correlations ▼

► Introduction

Without even thinking about it we use energy every day to clean our clothes, cook our food and look our best. We do not consider where this energy comes from while blow-drying our hair; it is just always there. However, we do not have an endless supply. Our energy, natural resources, environment and lifestyle are tightly interconnected.

Every time we use energy we use natural resources and we affect our environment. As we become more aware of this, it helps us make better choices, reduce our energy waste and be good stewards of our resources. As we learn to be more environmentally responsible, we can influence others to be wise energy users too.

Procedure

1. Discuss with students how much energy they use in the morning to get ready for school. Make a list on the board of items they use that require energy. Do not forget the alarm clock, toothbrush, lights, air conditioner, furnace and so on.
2. Pass out the student sheet. Have students take the activity home and complete it with their families. Allow time in a few days to discuss their findings. What factors made the differences in each student's use? Have students come up with simple tips to conserve while still looking their best.

Discussion

Discuss energy use in students' great-great-grandparents' day. What energy did it take for them to look their best? Did it take them longer to get ready?

To Know and Do More

Using a beach ball, label alternating sections with “Expert Energy Saver” and “Energy Saving Skills.” Divide students into two teams; toss the ball back and forth, giving each student an opportunity to catch it. When a student catches the ball, if their left thumb lands on “Expert Energy Saver,” their team gets a point; if it lands on “Energy Saving Skills,” they can earn two points for giving an energy saving tip.

Career Awareness Activity

Brainstorm with the students to think of all the careers that help us look our best: hair stylists, dry cleaners, dentists, plastic surgeons, etc. Discuss the energy usage and energy needs of these different careers.

Materials Needed:

- Student sheet

Curriculum Correlations

4-ESS3 - 2

5-LS2.A

5-ESS3 - 1

5-ESS3.C

MS-LS2 - 1

MS-ESS3 - 3

MS-ESS3.A

HS-ESS3 - 3

The Cost of Looking Your Best

It takes energy to look your best. Energy is needed to shower, blow-dry your hair, brush your teeth and wash and dry your clothes. Use the chart below to estimate the energy costs for looking your best.

Here Is How:

- In the column labeled “Times/Year,” record how often you perform that activity in a year.
- In each row, multiply the number in the “Units” column by the amount in the “Cost/Activity” column and then by the number you recorded in the “Times/Year” column to determine a subtotal cost for that activity.
- Add together each subtotal for your total annual energy cost for these activities.
- Multiply this number by the number of family members in your home for a grand total.

Activity	Units	Cost/Activity	Times/Year	Annual Subtotals
Shower 8 minutes	17 gallons	x \$0.01/gallon	x	\$
Bath	36 gallons	x \$0.01/gallon	x	\$
Hand/Face Wash	1 gallon	x \$0.01/gallon	x (Estimate washes/day x 365)	\$
Hair Dryer, 5 minutes (1500 W)	0.125 kWh	x \$0.1512/kWh	x	\$
Washing Clothes in Hot Water	25 gallons	x \$0.01/gallon	x (Estimate loads/week x 52 weeks)	\$
Drying Clothes	1 load	x \$0.42/load	x (Estimate loads/week x 52 weeks)	\$
Total Annual Cost for You				\$
(x ___ Number of Family Members) = Total Annual Energy Cost for Your Family				\$

Hair dryer and clothes dryer costs based on the use of electricity at a rate of \$0.1512/kWh.

Energy in Math

Objective:

Students will interpret and evaluate numerical expressions as they solve word problems.

Materials and Curriculum Correlations ▼

► Introduction

In this activity, students will complete the problem set found on the next page within an allotted time (10 minutes). Students will solve the mathematical problems making connections to real-world situations.

Procedure

1. Instruct students on the importance of learning to solve real world problems using their math skills. You may want to review some steps to solving word problems before beginning the first problem. The following questions might be useful to review:
 - Can you draw something to help you?
 - What can you draw?
 - What conclusions can you make from your drawing?
 2. Distribute copies of the student sheet.
 3. Model the problem.
 4. Consider having a pair of students work at the board while the others work independently or in pairs at their seats.
- As students work, circulate. Reiterate the questions above. After several minutes, have the demonstrating students receive and respond to feedback and questions from their peers if necessary.
5. Calculate to solve and write a statement.
Give everyone 2 minutes to finish work on that question, sharing their work and thinking with a peer. All should write their equations and statements of the answer.
 6. Assess the solution for reasonableness.
Give students 1 to 2 minutes to assess and explain the reasonableness of their solution.

Discussion

The student discussion is intended to invite reflection and active processing of the total lesson experience. Invite students to review their solutions for the problem set. They should check work by comparing answers with a partner before going over answers as a class. Look for misconceptions or misunderstandings that can be addressed. Then guide students in a conversation to debrief the problem set and process the lesson.

Any combination of the questions below may be used to lead the discussion.

- What did you notice about this word problem?
- What is different in the problem?
- What are we trying to find out?
- How can we represent this part of the story? (draw, write a number, use manipulatives)
- What would help us organize our thinking and our work? (answers may vary: draw it out, act it out, write an equation, etc.)
- What strategies can we use to solve this problem?

Answers to Student Sheet Questions:

1. Maggie, Michael, Jessie, Karen
2. \$284
3. 720 Watts
4. 9%

Materials Needed:

- Student sheet
- Individual white boards (optional)

Curriculum Correlations

3-PS2 - 3
3.OA.3
3.OA.4
3.OA.7
3.OA.8
3.NBT.2
4-ESS3 - 1
4.OA.3
4.NBT.4

4.NBT.5
4.MD.2
5-LS2.A
5-ESS3 - 1
5-ESS3.C
5.OA.2
5.NBT.5
5.NBT.7
6.RP.3c

6.SP.5
6.SP.5b
6.SP.5c
MS-LS2 - 1
MS-ESS3 - 3
MS-ESS3.A
HS-ESS3 - 3

Energy in Math

Show your work as you solve each problem.

1. Jessie saved more energy than Michael. Michael saved more energy than Maggie. Maggie saved less energy than Jessie. Karen saved more energy than Jessie. List the kids' names in order of how much energy they saved, least to most:
 - Jessie, Karen, Maggie, Michael
 - Maggie, Michael, Jessie, Karen
 - Michael, Jessie, Maggie, Karen
 - Maggie, Karen, Michael, Jessie

2. The Maher family used 57,000 gallons of water a year, costing them \$525 to heat it. Estimate how much money they would save in a year if they cut their hot water use by 30,820 gallons.
 - \$100
 - \$240
 - \$284
 - \$525

3. If each person in a house uses a 60 Watt bulb in their own bedroom 4 hours a day, and there are three people living there, how many Watts will be used a day to light the bedrooms?
 - 20 Watts
 - 240 Watts
 - 650 Watts
 - 720 Watts

4. For every 10 degrees the water heater setting is turned down, you can save 6% of the energy used. If Charles turns his water heater down by 15 degrees, about what percent savings in energy will he save?
 - 6%
 - 9%
 - 12%
 - 15%

Water Energy Connection

Objective:

Students will understand the concept of the water-energy nexus and its importance through a historical discussion of inventions. Students will create their own inventions that address water and energy conservation and present their inventions and discuss how their inventions could potentially positively impact their environmental impacts to the class.

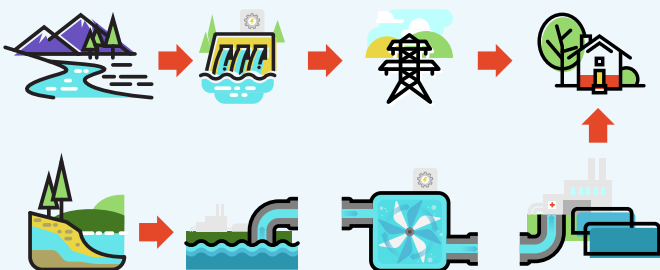
Materials and Curriculum Correlations ▼

► Introduction

The water-energy nexus is the connection between water availability and energy production and likewise the use of energy to prepare water to be available for use by humans. Ancient inventions like the waterwheel used the energy from water to create necessities of life, while likewise using its mechanical energy to push water to humans for different means of use. The same relationship exists today between water and hydroelectric power and water treatment systems which require water to generate electricity, while using that same energy to make water available in our homes.

Procedure

1. Ask the students, “Do you know that the water you use at home is connected to the energy you use?” Allow for student responses and encourage creativity. Explain energy is used to pump, transport, clean and heat water. Water is used to extract and produce energy sources that we use. This connection between water and energy is known as the water-energy nexus. Explain how the choices we make impact both resources.
2. Write “Water-Energy Nexus” on the whiteboard and define it as the interdependence between water and energy systems. Illustrate the nexus on the board similar to the diagram below. This will help visual learners to better see how the water-energy relationship works.
3. Hold a class discussion about how water and energy are related. Prompt questions:
 - How do we use water at home?
 - How do we use energy at home?
 - Can you think of any examples of how using water affects our energy use and vice versa? (If you didn't get the chance earlier, you could discuss how energy is used to pump, transport, clean and heat water.)Write key points on the whiteboard to help students understand the connection.



To Know and Do More

1. Optional activity: Show a video on waterwheels. Talk about the invention of the waterwheel and the problems it solved for people. Talk about how it needed water to work but that it also created the energy needed to pump water to higher ground for use, as well as pushed water through canals to farmers for irrigation.
2. Divide the class into small groups or pairs. Explain that throughout history, inventions have helped us save water and energy. An example would be an efficient shower head that mixes air with the stream of water, so less water is used.
3. Next, explain that students will be inventing something that helps conserve both water and energy. Give each group a large sheet of paper and markers. Instruct students to brainstorm their ideas for inventions. Encourage creativity and practicality. They should consider how their inventions can make daily life more efficient by saving water and energy.
4. Each group should choose one invention idea from their brainstorming session. Provide materials like colored pencils, crayons and markers for students to draw and label their inventions on the large sheets of paper. Students should also write a brief description of how their inventions work and how they conserve water and energy.
5. Have each group present their invention to the class. They should explain how their invention works and how it illustrates the water-energy nexus. For example, they could explain how energy (gravitational) moves the water, water produces mechanical energy in the wheel which grinds the corn, etc.
6. After each presentation, allow the class to ask questions and provide feedback. Explain to the students that, just like they came up with ideas for saving water, adults are constantly looking for ways to conserve water and to create energy saving devices. Depending on the age level, teachers could discuss how this student invention project is what mechanical engineers, materials scientists and other energy workers do for a living.



Optional activity: Build a waterwheel in class to show how water is needed to make it spin.

Materials needed:

- 2 Plastic plates
- 6 to 8 Plastic cups or small containers
- Electrical or hard sticking tape
- A dowel the length of or longer than a pencil
- A water pitcher or watering can
- Optional: Storage tray (If used, dowel must be as long as storage tray is wide)

To Know and Do More

1. If students found the invention activity fun or exciting, inform them that they could get paid to come up with new ideas to save water and energy. Introduce students to jobs like water technology inventor, environmental engineer, water resource manager, hydrologist, sustainable building designer, environmental scientist, water efficiency consultant, agricultural water efficiency specialist, desalination engineer, research scientist, wastewater treatment engineer, aquatic ecosystem restoration specialist, environmental educator, water quality scientist or green technology entrepreneur.
2. If students are concerned about water and energy but don't think their interests match with any of these careers, make a grid like the one below and post or project it in the classroom. Put common interests across the top and careers from the list down the side.

Assign students to research particular careers and then place check marks in the boxes to the right of individual careers as they align with the interests above.

	Art	Math	Science	History	Writing
Water Technology	X	X	X	X	X
Inventor					
Environmental Scientist					
Desalination Engineer					
Hydrologist					

Materials Needed:

- Whiteboard and markers
- Poster paper or large sheets of paper
- Markers, colored pencils and crayons
- Index cards
- Laptops or tablets (optional, for research)
- Access to online resources (optional)

Curriculum Correlations

K-LS1 - 1
 K-ESS3 - 3
 K-ETS1 - 1
 1-ETS1 - 1
 2-LS2 - 1
 2-ESS2 - 3
 2-ETS1 - 1
 3-PS2 - 2

4-ESS3 - 1
 4-ESS3 - 2
 4-ETS1 - 1
 4-ETS1 - 2
 4-ETS1 - 3
 5-ESS2 - 1
 5-ESS2 - 2
 5-ESS3 - 1

MS-PS3 - 5
 MS-LS2 - 1
 MS-ESS2 - 4
 MS-ESS3 - 3
 MS-ETS1 - 1
 MS-ETS1 - 2
 HS-PS3 - 3
 HS-LS2 - 7

3-ETS1 - 1

3-ETS1 - 2

3-ETS1 - 3

4-PS3 - 2

4-PS3 - 4

5-ETS1 - 1

5-ETS1 - 2

5-ETS1 - 3

MS-PS1 - 6

MS-PS3 - 1

HS-ESS2 - 6

HS-ESS3 - 1

HS-ESS3 - 4

HS-ETS1 - 1

HS-ETS1 - 2