GOING OFF-GRID

ELEMENTARY GUIDE

ComEd®

NEED

Putting Energy into Education

Teacher Advisory Board

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

1.800.875.5029
www.NEED.org

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NEED
Putting Energy into Education

Welcome & Kit List

Energy is a very widely used term. But, it's not just a description of how much sugar our students have had today – it's much more! Energy gives us the ability to do work or make change. It moves planes, trains, and automobiles. It bakes cupcakes and freezes ice cream. It plays our favorite songs, powers our computers, and even lights our parking lots! This ComEd-sponsored curriculum and accompanying kit will help introduce your students to basic energy concepts, and help them to develop an understanding of electricity and the sources of energy that power the off-grid Aris lighting systems on your school grounds.

Get Ready

- Read through the book and identify activities you will demonstrate for or complete with students.
- Familiarize yourself with the teacher instructions for the activity or activities you have selected. Teacher instructions for each activity will appear first in the book, and any student worksheets will follow, where applicable.
- Make copies of any student worksheets that might be necessary for completing the activity.

Get set

- Gather the materials needed for the activity as listed in the teacher instructions. A list of materials provided is found below. Some additional materials may be needed and will be listed on the teacher instruction sheet.
- Prepare a space to complete the activity or demonstration for the class. Activities may also be set up as stations, if you desire.

GO!

- Have students work through the steps in the experiment with your direction or independently.
- Encourage students to use the student worksheet or student notebooks, where applicable, to record their ideas and data, and answer questions.
- Discuss any analysis and conclusions as a class.

Materials Supplied by ComEd

- 1 Elementary Energy Infobook
- 1 Set of Nifty Natural Gas Prop Cards
- 4 Double pan bucket balances
- 4 1-g Mass sets
- 4 DC microammeters
- 4 Pair of nails (large and small)
- 4 Pair of copper wires (thick and thin)
- 4 Sets of alligator clips
- 4 Sets of radiation cans
- 8 Lab thermometers
- 4 Plastic beakers
- 4 PV cell kits
- 4 Solar house kits
- 1 Package clay
- 1 Roll plastic wrap
- 1 Pack black paper
- 1 Pack white paper
- 100 Clear straws
- 30 Stirrer straws
- 1 Box straight pins
- 30 Binder Clips
- 30 Foam Cups
- 1 Spool thread
- 4 Hole punches
- 1 Box paper clips
- 1 CFL bulb
- 1 LED bulb
- 1 Incandescent bulb

Aris Wind Off-Grid Remote Power Unit (RPU)

A RENEWABLE LIGHTING SYSTEM

Getting Your School "LIT"

As part of the Community of the Future Initiative, ComEd partnered with Aris Renewable Energy, Chicago Housing Authority, and Chicago Public Schools to install off-grid, remote powered lighting units in the Bronzeville Community to provide safety in underlit/underserved areas, and to educate the community on renewable generation, energy storage, and grid resiliency.

These off-grid, hybrid LED street lights, or RPUs, consist of five key components: a steel pole, an LED lamp, a wind turbine, a solar panel, and an energy storage unit. The wind turbine and solar panels generate electricity to charge the energy storage unit. The LED draws the stored energy to illuminate your school grounds.

These RPUs also collect data in real-time to showcase how much energy is generated, stored, and/or discharged at a certain moment. Your classroom can use this data to make observations and inferences based on a given day.

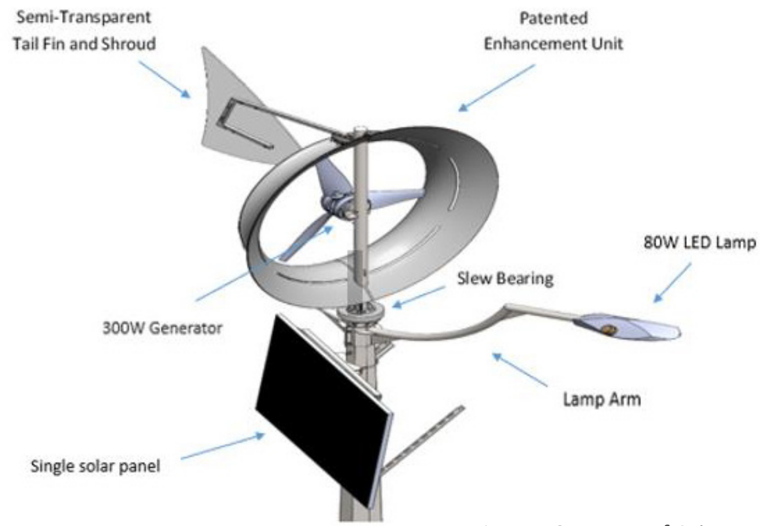


Image Courtesy of Aris.

Specifications

- The lamp is an LED that requires 80 W of power for maximum brightness, but only 45 W when less light is required.
- The wind turbine incorporates a tail fin to orient the turbine based on wind direction. The wind turbine can generate up to 300 W in peak wind conditions.
- The solar panel is equipped with an optimizer that minimizes shading effects and protects the battery. The solar panel can generate up to 320 W.
- The battery can store up to 5 kWh and will avoid total discharge to maintain battery life. The battery is programmable to operate until different depths of discharge are met.

But really, how does it work?

- The battery is charged during the day by solar and wind energy generation (if available).
- If the battery is fully charged, additional energy generation is automatically slowed or stopped.
- The battery is discharged at night, sending its energy to the lamp for lighting the area. The lamp brightness can be reprogrammed. The brighter light desired, the more energy is required to power the lamp.
- If wind is available at night, the turbine will continue to generate electricity to charge the battery.
- For more information, specifics, and diagrams, head to www.ariswind.com, and check out "RPU Streetlight."

The Energy I Used Today

TEACHER INSTRUCTIONS

Background

This activity will help students begin to think about all the ways in which they might use energy in their day, in hopes that they will begin thinking about how they can save energy through their behaviors (conservation), and use technologies to help save energy during necessary tasks (efficiency). Students will think about their day-to-day activities at home in the structure of the activity. To further the learning and discussion, have students consider how their energy use at school might stack up.

Objectives

- Students will be able to describe different ways in which we use energy in society.
- Students will be able to describe efficiency and conservation, and categorize an energy saving measure as either efficiency or conservation.

Materials

- Calculators (optional)

Time

- 15-20 minutes

✔ Procedure

1. Prepare a copy of the master to project and share with the students at the close of the activity.
2. Review the student worksheet with the class. Explain to students that they will circle all the items they used this morning and used when they got home after school yesterday
3. Project the master on page 6 and have students tally up their total energy use in energy bucks. A total score of 45 or below is considered very good in terms of energy savings. Discuss as a class what students might have to do to cut down their score.
4. Ask students what part of their day is missing from the list (school time). Ask students to come up with a list of ways in which they use energy in school or see energy being used at school.
5. Introduce the terms "energy efficiency" and "energy conservation" (see below). Explain that the activities you will be exploring within this unit will help them to think about how energy is used, and how energy and money can be saved through simple, daily actions (conservation), and using energy-saving technologies like the ARIS light systems (efficiency). Efficiency and conservation work together!
    - **energy efficiency** - doing the same task but using less energy with a special tool or appliance. Example: upgrading to LED light bulbs and fixtures.
    - **energy conservation** – changing a behavior or action when using energy. Example: riding a bike instead of driving a car a short distance.

The Energy I Used Today

TEACHER MASTER

ENERGY BUCK VALUES

Waking Up

Alarm Clock or Radio 2

Breakfast

Microwave.. 2
Stove/Oven.. 5
Toaster Oven/Toaster 3
Refrigerator 3

Ready for School

Air Conditioning/Heating 10
Radio/CD Player/MP3 Player/iPod 2
TV/DVD Player 3
Gaming System... 3
Shower/Bath 3
Hair Dryer 3
Curling Iron/Curlers/Flat Iron 3
Telephone/Cell Phone 2
Computer 3
iPad/Tablet 2

Room Lighting

Bedroom.. 2
Bathroom 2
Kitchen 2
Family Room.. 2
Other 2

Getting to School

Walk.. 0
Bicycle 0
School Bus 1
Carpool 2
Family Vehicle... 5

After School

Air Conditioning/Heating 10
Travel in Vehicle... 5
Lights 2
Computer 3
iPad/Tablet 2
Gaming System.. 3
Radio/CD Player/MP3 Player/iPod 2
TV/DVD Player 3
Telephone/Cell Phone 2
Snack Preparation...................................... 2

Last Night

Air Conditioning/Heating 10
Microwave... 2
Stove/Oven.. 5
Toaster Oven/Toaster 3
Refrigerator 3
Grill 2
Lights 2
TV/DVD Player 3
Gaming System.. 3
Shower/Bath 3
Hair Dryer 3
Telephone/Cell Phone 2
Computer 3
iPad/Tablet 2
Radio/CD Player/MP3 Player/iPod 2

The Energy I Used Today

STUDENT WORKSHEET

Circle the things you used or did in the left column. When you have completed the list, your teacher will show you how many Energy Bucks each activity or device uses. Write those numbers in the right column, then add them together to find your Total Energy Bucks Used.

What device woke me up this morning?	ENERGY BUCKS
Alarm Clock or Radio	______________

What devices were used to make my breakfast?

Microwave	______________
Stove/Oven	______________
Toaster Oven/Toaster	______________
Refrigerator	______________

What devices did I use as I got ready for school this morning?

Air Conditioning/Heating	______________
Radio/CD Player/MP3 Player/iPod	______________
Gaming System	______________
TV/DVD Player	______________
Shower/Bath	______________
Hair Dryer	______________
Curling Iron/Curlers/Flat Iron	______________
Telephone/Cell Phone	______________
Computer	______________
iPad/Tablet	______________

What rooms had lights turned on this morning?

Bedroom	______________
Bathroom	______________
Kitchen	______________
Family Room	______________
Other	______________

How did I get to school today?	ENERGY BUCKS
Walk	________________
Bicycle	________________
School Bus	________________
Carpool	________________
Family Vehicle	________________

What devices did I use after school yesterday?	
Air Conditioning/Heating	________________
Travel in Vehicle	________________
Lights	________________
Computer	________________
iPad/Tablet	________________
Gaming System	________________
Radio/CD Player/MP3 Player/iPod	________________
TV/DVD Player	________________
Telephone/Cell phone	________________
Snack Preparation	________________

What devices were used at home last night?	
Air Conditioning/Heating	________________
Microwave	________________
Stove/Oven	________________
Toaster Oven/Toaster	________________
Refrigerator	________________
Grill	________________
Lights	________________
TV/DVD Player	________________
Gaming System	________________
Shower/Bath	________________
Hair Dryer	________________
Telephone/Cell Phone	________________
Computer	________________
iPad/Tablet	________________
Radio/CD Player/MP3 Player/iPod	________________

Total Energy Bucks Used ________________

Energy Source Matching

TEACHER INSTRUCTIONS

Background

This activity will introduce or reinforce the energy sources for your students. For a brief introduction, complete the matching activity alone. For a more in-depth exploration, have your students refer to the *Elementary Energy Infobook* in your kits for more background information and complete a jigsaw.

Objectives

- Students will be able to describe different ways in which we use energy in society.
- Students will be able to list the sources of energy.

Materials

- *Energy Sources Matching* cards
- *Elementary Energy Infobook* (optional)
- Art supplies and poster board (optional)

Time

- 15-20 minutes, or more depending on activites completed

✔ Procedure

1. Make copies of the student worksheet for each student. Prepare a copy of the answer key to project if necessary.
2. Make one set of matching cards for each student group. Cut and clip together. Alternatively, you can have the students cut out their pieces before playing.
3. Explain to students that there are 10 sources of energy that we use to power our lives. Have students complete the matching worksheet to introduce the sources to the class.
4. Project the answer sheet and/or discuss answers. See the optional extension below to increase student knowledge and understanding. Complete the extension, if desired before or after the matching below.
5. Divide the class into groups. Provide each group their matching sets. Ask the students to complete the matching activity, matching ALL three items together to make a set – symbol, energy source, and description. The person that gathers the most sets is the winner.
6. Have groups shuffle and create a tournament for fun, or reintroduce as a formative assessment throughout the unit.

Extension (*Optional)*

- Assign students to 10 teams. Each team will be assigned an energy source. Each group should read the *Elementary Energy Infobook* pages on their source, record at least 6 important facts about their source and make a poster to display around the classroom.

Energy Source Matching

ANSWER KEY

Write the number of the energy source on the line next to its definition.

1. Petroleum (oil)	9	**Black rock burned to make electricity.**
2. Wind	7	**Energy from heat inside the Earth.**
3. Biomass	8	**Energy from flowing water.**
4. Uranium	3	**Energy from wood, waste, and garbage.**
5. Propane	2	**Energy from moving air.**
6. Solar	4	**Energy from splitting atoms.**
7. Geothermal	5	**Portable fossil fuel gas often used in grills.**
8. Hydropower	1	**Fossil fuel for cars, trucks, and jets.**
9. Coal	10	**Fossil fuel gas moved by pipeline.**
10. Natural Gas	6	**Energy in rays from the sun.**

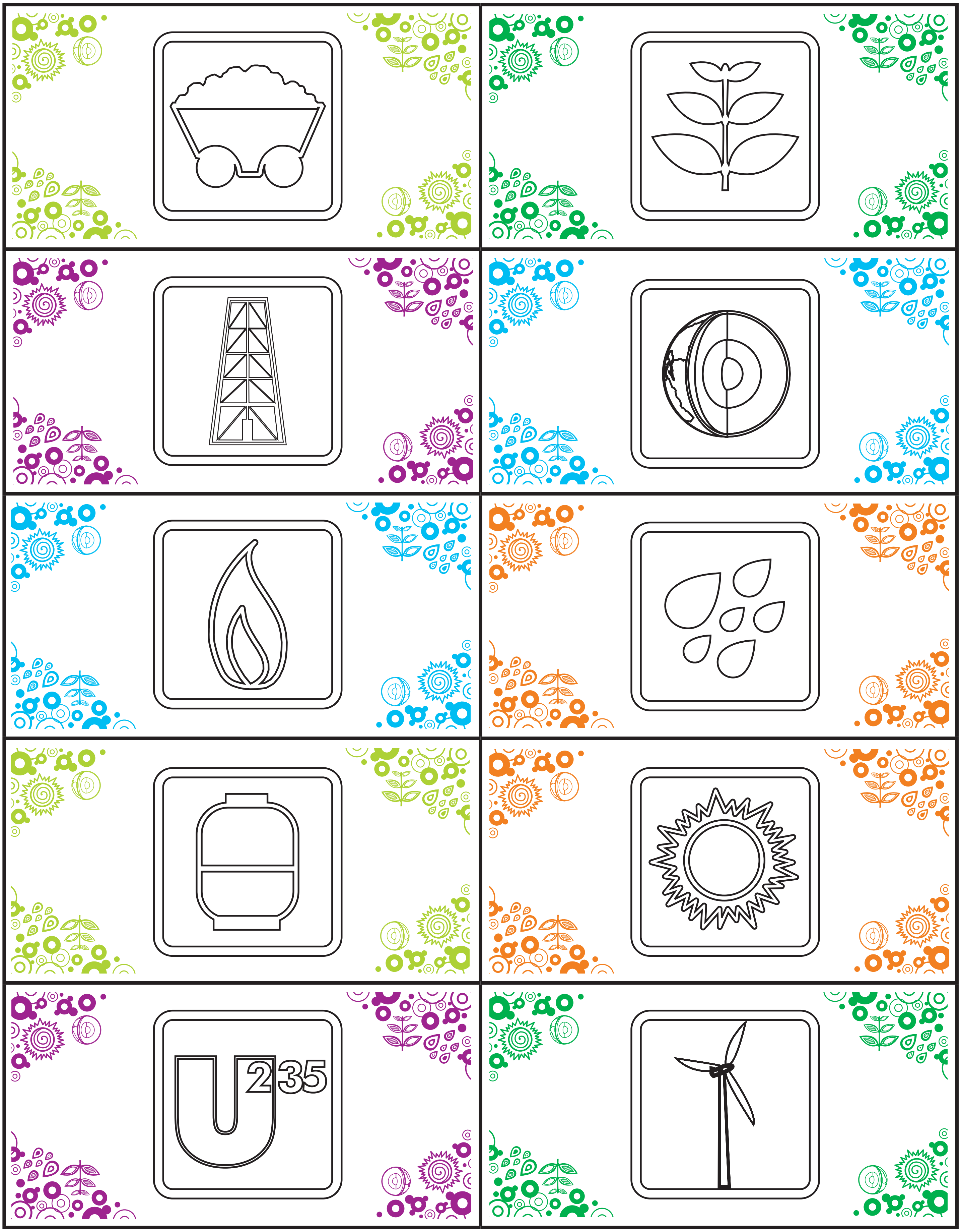
Energy Source Matching

STUDENT WORKSHEET

Write the number of the energy source on the line next to its definition.

1. Petroleum (oil)	________	**Black rock burned to make electricity.**
2. Wind	________	**Energy from heat inside the Earth.**
3. Biomass	________	**Energy from flowing water.**
4. Uranium	________	**Energy from wood, waste, and garbage.**
5. Propane	________	**Energy from moving air.**
6. Solar	________	**Energy from splitting atoms.**
7. Geothermal	________	**Portable fossil fuel gas often used in grills.**
8. Hydropower	________	**Fossil fuel for cars, trucks, and jets.**
9. Coal	________	**Fossil fuel gas moved by pipeline.**
10. Natural Gas	________	**Energy in rays from the sun.**

Coal	Biomass
Petroleum	Geothermal
Natural Gas	Hydropower
Propane	Solar
Uranium	Wind


U235

Black rock that is burned to make electricity.	**Energy from wood, waste, and garbage.**
Fuel that provides energy for cars, trucks, and jets.	**Energy from heat inside the Earth.**
The fossil fuel that heats most homes.	**Energy from flowing water.**
The portable fuel - under pressure, it's a liquid.	**There is a lot of energy in its rays.**
Energy from splitting the atoms of this element.	**Energy from moving air.**

Nifty Natural Gas

TEACHER INSTRUCTIONS

Background

When students think of energy, they most often are thinking of electricity; however, a significant proportion of our total energy is supplied by natural gas, and as more natural gas is unlocked from shale deposits, that proportion will continue to increase. The purpose of this activity is to help students understand how natural gas is used in the energy industry and how we can use it as consumers. Students will also identify the energy transformations of natural gas from formation to end use.

Objective

- Students will be able to explain the energy transformations or flows involved with natural gas, from production to use.

Time

- 40-60 minutes

Materials

- Art supplies or prop cards

Procedure

1. Make a copy of *A Nifty Natural Gas Story Pantomime* for each student.
2. Provide art supplies for students to assemble their props, or gather the suggested items or reasonable substitutes as shown on the handout. A sample set of prop cards is included in your kit.
3. Prepare copies of the masters to project.
4. Review the forms of energy with the class. Project the master to add to class discussion.
5. Explain and/or review energy transformations using the master as a visual. Discuss the forms of energy in each part of the transformation.
6. Explain to the class that energy transformations allow us to use our energy sources for electricity, to power vehicles, and to heat/cool our homes.
7. Assign students to a specific role on the pantomime sheet.
8. Discuss how natural gas is produced, processed, transported, and used.
9. Have each student assemble his/her props, or provide each student with a suggested prop.
10. Review or introduce any new vocabulary as needed. Project the story. Act out the story from beginning to end. Extra students may help read the story aloud.
11. Substitute in different students or props as necessary.
12. Ask students to write an essay explaining the energy flow involved to produce electricity from natural gas.

Extension

- Have students substitute different energy sources into the energy flow, creating a new story, props, and outcome for each.

Forms of Energy

TEACHER MASTER

All forms of energy fall under two categories:

POTENTIAL

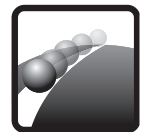
Stored energy and the energy of position (gravitational).

CHEMICAL ENERGY is the energy stored in the bonds of atoms and molecules. Biomass, petroleum, natural gas, propane, and coal are examples.

NUCLEAR ENERGY is the energy stored in the nucleus of an atom – the energy that holds the nucleus together. The energy in the nucleus of a uranium 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. Water in a reservoir behind a hydropower dam is an example.



KINETIC

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

RADIANT ENERGY is electromagnetic energy that travels in transverse waves. Solar energy is an example.

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

MOTION is the movement of a substance from one place to another. Wind and hydropower are examples.

SOUND 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.

A Nifty Natural Gas Pantomime

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.

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, electric 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 less air pollution than other fossil fuels 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?

Understanding an Electricity Bill

TEACHER INSTRUCTIONS

Background

This quick activity aims to help students become familiar with how utilities are measured and billed. Students will analyze the bill like it is a chart or graph, looking for important items that may relate to how much energy they use in a billing cycle.

Objective

- Students will be able to read and interpret the information on an electricity bill.

Materials

- Calculators (optional)
- Additional examples of utility bills (optional)

Time

- 15-20 minutes

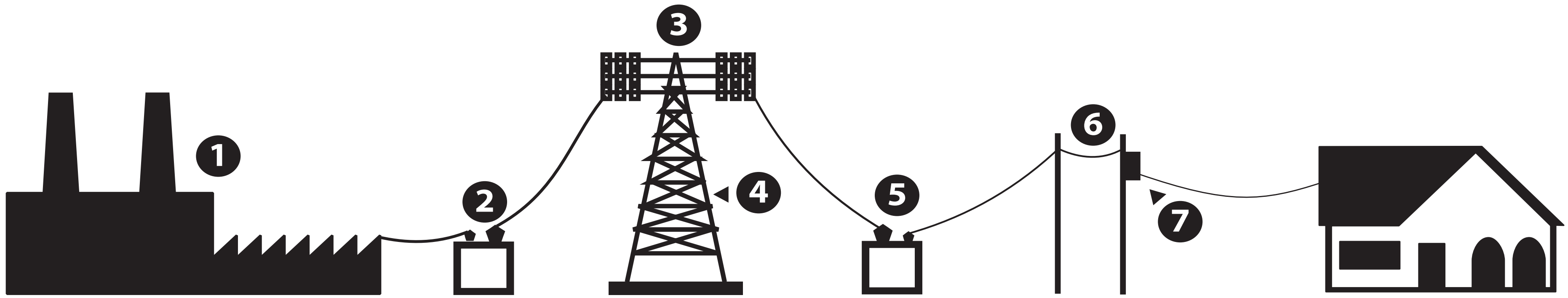
✔ Procedure

1. Prepare a copy of the master to project.
2. Make copies of the sample bill and explanation for each student or make a digital copy for projection and discussion.
3. Explain how electricity is transported. Direct students to the *Elementary Energy Infobook* section on electricity and/or project the master and explain what is happening at each step. Remind students that power is generated to meet the customer's needs. It is then transported to them and they are billed based on how much they actually use.
4. Explain the sample school electric utility bill. If available, distribute or project a copy of your school's actual utility bill for comparison.

Transporting Electricity

TEACHER MASTER

Explain what each of the components numbered below does to get electricity from the generator to the consumer.



Sample School Electric Bill

Nov 27, 2018 1

Customer Bill

ABC Elementary School
Anytown, USA

Your Electric Company

Billing and Payment Summary

Account # 000-1234 2 **Due Date: Jan 02, 2019** 3

Total Amount Due: $ 7,462.61 4

To avoid a Late Payment Charge of 1.5% please pay by Jan 02, 2019

Previous Amount Due:	$ 8,152.93
Payments as of Nov 27:	$ 8,152.93

Meter and Usage **Usage History**

Current Billing Days: 34

Billable Usage

Schedule 130	*10/23 - 11/26* 12
Total kWh	12192
Dist Demand	61.0 10
Demand	57.0
Schedule 130	*10/23 - 11/26*
Total kWh	69888
Dist Demand	272.0 10
Demand	259.0

Measured Usage 5

Meter: 000-1234	*10/23 - 11/26*
Current Reading	4147
Previous Reading	4020
Total kWh	12192 6
Current Reading	.60
Demand	57.60 11
Multiplier: 96	
Meter: 111-4567	*10/23 - 11/26*
Current Reading	51746
Previous Reading	51382
Total kWh	69888 6
Current Reading	1.35
Demand	259.20 11
Multiplier: 192	

Explanation of Bill Detail

Your Electric Company		**1-800-123-4567**
Previous Balance	**8,152.93**	
Payment Received	**8,152.93**	
BALANCE FORWARD		**0**
Non-Residential Service (Schedule 130)	***10/23 - 11/26***	
Distribution Service		
Basic Customer Charge		**86.52**
Distribution Demand		**206.29**
13 **Electricity Supply Service (ESS)**		
ESS Adjustment Charge		**83.93 CR**
Electricity Supply kWh		**214.94**
ESS Demand Charge		**558.85** 7
Fuel Charge		**353.81**
Sales and Use Surcharge		**2.68** 8
Non-Residential Service (Schedule 130)	***10/23 - 11/26***	
14 **Distribution Service**		
Basic Customer Charge		**86.52**
Distribution Demand		**919.87**
Electricity Supply Service (ESS)		
ESS Adjustment Charge		**374.243 CR**
Electricity Supply kWh		**909.41**
ESS Demand Charge		**2,539.36** 7
Fuel Charge		**2,058.15**
Sales and Use Surcharge		**13.38** 8
TOTAL CURRENT CHARGES		**7,463.61** 9
TOTAL ACCOUNT BALANCE		**7,463.61** 4

For service emergencies and power outages, call 1-800-123-4567.

Mailed on Nov 28, 2018

Please detach and return this payment coupon with your check made payable to Your Electric Company.

Payment Coupon

Bill Date Nov 27, 2018 1

Please Pay by 01/02/2019 3
$ 7,463.54 4

Amount Enclosed

Account # 000-1234 2

Send payment to:

ABC Elementary School
123 Main Street
Anytown, USA 98765

Your Electric Company
PO BOX 123456
Anytown, USA 98765

01166005000 000000009368 6868686 0001234 11272007

Sample School Electric Bill

EXPLANATION AND DISCUSSION

Explanation

1. Bill mailing date
2. Customer account number
3. Payment due date
4. Total amount due
5. Meter readings by date in kilowatt-hours (note that there are two meters on this bill)
6. Actual kilowatt-hours consumed
7. Cost of the electricity consumed
8. Sales and use surcharge
9. Total current charges
10. Demand. This is a measurement of the rate at which electricity is used. The monthly demand is based on the 15 minutes during a billing period with the highest average kilowatt use. Demand charges are designed to collect some of the generation and transmission-related costs necessary to serve a particular group or class of customers.
11. Actual demand for the meter
12. Schedule 130. A rate class that determines how much is paid per kWh of usage and kW demand
13. Electricity supply service. Customers are billed for the electricity supply and the delivery of the electricity. The supply charge reflects the cost of generating the electricity at the power plant.
14. Distribution service. The delivery charge reflects the cost of delivering the electricity from the power plant to the customer.

Discussion

The appearance of utility bills will be different from one utility to the next, but they typically contain the same information. The rate that a school or other commercial building pays for electricity is determined by measuring two items: the electrical energy usage, in kilowatt-hours, and the electrical energy demand, measured in kilowatts.

The demand is the maximum amount of power that the building needed within a time frame. The higher the total amount of kilowatts being used at any given time by a building, the higher this charge is. Demand can be reduced by rescheduling when high energy devices are running, or scheduling them such that their use is spread out evenly throughout the day. For example, vacuum cleaners or other appliances with high energy motors can be run after school is over, when other devices are turned off. Professional energy managers can make recommendations about this scheduling, or some other changes that can help a building's occupants reduce the demand portion of their electric bill.

The energy use portion is how much electrical energy, in kilowatt-hours, is used in total during the billing period. The more devices turned on and running, the higher the energy use charge is. This portion of the utility bill can be reduced by turning off unnecessary items or installing more efficient equipment. For example, computer monitors in a school computer lab can be turned off at the end of the school day, or ENERGY STAR®appliances can be used in place of older, less efficient models.

Ask your teacher, principal, or building manager for a copy of the school's electric bill, and identify as many of the above items on it as you can. If you have more than one building in your school district, see if you can get bills for other buildings to compare. Talk about ways you as students can help reduce both the demand as well as the energy use portions of your school's utility costs.

Elementary Baseload Balance

Background

Most students don't give electric power much thought until the power goes out. Electricity plays a giant role in our day-to-day lives. This activity demonstrates how electricity supply is adjusted to meet the demands of consumers. It also encourages students to explore the differences between baseload and peak demand power, and how energy source cost and availability factor into the decisions made in power generation.

You will lead your students through a hypothetical day, consisting of morning, all day, evening, and night. As the time of the day changes, students are encouraged to think about how their energy use changes. Brass or plastic weight sets or plastic building bricks are used to represent power demand or power generation, and you can adjust the activity according to the age and abilities of your students. Some groups may be able to self-direct in this activity and determine the mass in grams or the number of plastic bricks to use, and others will need your guidance and direction. A simple, double-pan balance is used to show how demand for electricity is balanced with generation by electric power producers.

NOTE: If you do not have access to a double-pan balance, you can download an alternative procedure at:
www.NEED.org/wp-content/uploads/2020/01/Elementary_Baseload_Balance.pdf

✪Objectives

- Students will be able to explain how demand for electricity changes throughout the day.
- Students will be able to list energy sources used for baseload generation and those that can be used for peak demand.

Suggested Materials

- Double-pan balance
- Gram weight set OR plastic building blocks
- Clock

Time

- 30-45 minutes

Preparation

- In this activity, a five gram weight will represent 5 MW of load or generation. If your weight set has enough pieces to accommodate this activity, use it. If not, collect enough plastic building bricks, using a scale of one brick is equal to 5 MW of load or generation (two bricks of the same size equal 10 MW). Consult the *Cheat Sheet* to see how many you will need. If you use building bricks, you may want to designate one color for generation and one color for demand. If you teach younger students and decide to use bricks, you might assemble brick sets representing the different amounts of load or generation as written in the Procedure. Use a dry-erase marker to label them.
- Copy the *Balance Placards.* Cut them apart and fold them on the dotted line to make tent-style labels that stand up.
- Copy and cut apart the *Peak Demand and Generation Cards*.
- Designate one student to be the time keeper. That student will be responsible for indicating the time on the demonstration clock as you move through the activity.

CONTINUED ON NEXT PAGE

✔ Procedure

1. Start by explaining what demand, load, generation, baseload, and peak mean in this activity. Demand is our desire for electricity exactly when we want it. Load is the amount of electricity we pull from the grid. Generation is the amount of electricity that power plants produce. Baseload or base generation refer to electricity use or production at all times of the day or night, all year long. Peak demand or generation refer to electricity use or production that vary at different times of the day or night, and different times during the year. For example, hospitals use power all day and all night, and coal-fired power plants generate power all day and night. However, we may only use air conditioning during the warmer months and usually more in the afternoon and evening than in the morning. Some energy sources, like solar and wind, are only able to produce power at certain times of the day. Some energy sources, like hydropower and natural gas, can be used as base generation, and can increase their generation to meet peak demand.
2. Distribute the peak load or generation cards to students. Hand them as many weights or bricks as they need, or have them calculate what they need, depending on age and ability.
3. Place the balance on the table in front of you. Place the "Demand" card on one side of the balance such that students can read the word. Place the "Generation" card on the other side of the balance in a similar fashion.
4. Say, "All day and all night, we use electricity. Our refrigerators run, hospitals take care of people, and factories produce goods." Place 115 MW worth of bricks or weights in the Demand pan. The balance will tip to the Demand side.
5. Say, "All day and all night, power plants produce electricity. Coal, natural gas, hydropower, and nuclear power plants run all day and all night, generating electricity." Place 115 MW worth of bricks or weights in the Generation pan. The pans should now be balanced.
6. Say, "See how the two pans are balanced? Electric utility companies are careful to make only as much electricity as we will use. If they produce more electricity than needed, the energy is wasted and cannot be stored. If they don't produce enough, some things we need will not be able to work correctly."
7. Instruct the time keeper to set the clock to read 7:00. Say, "It is now 7:00 in the morning, and people are getting up to start their day. Who has the morning peak demand?" As this student comes to the table with the balance, ask students to think of things they use in the morning that need electricity. Answers may include things like a coffee maker, toaster, the lights in the bathroom, or an electric toothbrush. When the Morning Peak Demand student places the weights or bricks in the pan, the balance should tip toward Demand.
8. Say, "What will the power company do now?" Allow students a moment to think about what should be done. Allow them to see the card the Morning Peak Demand student had, and know how much demand was placed on the system. Ask students to come to a consensus about what peak power source(s) should be utilized to balance the scale.
9. The student(s) with the power source(s) to meet morning demand should place their weights or bricks in the Generation pan. The pans should now be balanced.
10. Say, "Utilities try to make sure they spend as little as possible while meeting demand. This way they don't have to bill customers even more in the future. How much money did it cost to meet the morning demand? Do you wish to change the sources you used?" Allow students some time to discuss this and come to a consensus, adjusting the Generation pan as appropriate.
11. Say, "Some things are turned on and run all day long, like lights at a school or computers at a business. Who has all day demand?" As this student comes to the front, ask students to think of things that we use during the day that use electricity. Answers may include things like television, computers, and any machines at school. The All Day Demand student should place the correct number of weights or bricks in the Demand pan.
12. Say, "What will the power company do now?" Allow students a moment to think about and come to a consensus about what should be done. Remind them to consider the cost of their choice. Students should add generation weights or bricks to balance the pans.

CONTINUED ON NEXT PAGE

13. Instruct the time keeper to move the clock to 5:00. Say, “It’s now 5:00 and the end of the day. School is over, offices are closing, and people are going home for the day. What do we need to do to the Demand pan?” Allow students to think about what should be done, and come to a consensus.
14. As students remove the morning demand and perhaps the all day demand weights or bricks from the Demand side of the balance, the balance will tip toward the Generation pan.
15. Use your hand to equilibrate the balance so it’s even on both sides. Say, “Are there any other adjustments we need to make? Does someone have a card that says, ‘Evening Peak Demand’?” As that student comes forward, ask students to think of things that might be used in the evening, but not during the day. Ask students to guess whether evening demand would be less than, the same as, or greater than demand during the day. As the Evening Peak Demand student lays the appropriate weights or bricks in the Demand pan, hold the balance steady until students decide how demand will shift in the evening. Then remove your hand, allowing the balance to equilibrate.
16. Say, “What about generation? What will happen to the source(s) you have chosen to use to generate power during the day?” If students have chosen solar power, they will need to remove that from the generation side of the balance and replace it with something else. They may or may not need to add or subtract generation depending on what they did with the all day long demand.
17. Instruct the time keeper to move the clock to read 11:00. Finally, say, “It is now 11:00 pm, and everyone is in bed or will be in bed very soon. We are back to baseload and base generation.” Remove all of the peak demand weights or bricks, and remove excess generation weights or bricks, returning to the same amount you started with at steps 4-5.
18. Discuss with students how demand and generation changed throughout the day. Ask them how they think it changes from one month to the next, or how different seasons affect the demand and generation of electricity.

Cheat Sheet

Demand and Generation Equivalents

MW Equivalent	Total mass of weights	Bricks needed (examples)
5	5 grams	1 2x2
10	10 grams	1 2x4 or 2 2x2
15	15 grams	1 2x2, 1 2x4
20	20 grams	2 2x4
25	25 grams	1 2x2, 2 2x4
30	30 grams	3 2x4
35	35 grams	1 2x2, 3 2x4
40	40 grams	4 2x4
45	45 grams	1 2x2, 4 2x4
50	50 grams	5 2x4
55	55 grams	1 2x2, 5 2x4
60	60 grams	6 2x4
65	65 grams	1 2x2, 6 2x4
70	70 grams	7 2x4
75	75 grams	1 2x2, 7 2x4
80	80 grams	8 2x4
85	85 grams	1 2x2, 8 2x4
90	90 grams	9 2x4
95	95 grams	1 2x2, 9 2x4
100	100 grams	10 2x4
105	105 grams	1 2x2, 10 2x4
110	110 grams	11 2x4
115	115 grams	1 2x2, 11 2x4

Demand and Generation Amounts

Time of Day	Demand	Generation
Baseload (all day, all night)	115 MW	115 MW
Morning	20 MW	20 MW
All day	15 MW	15 MW
Evening	15 MW	15 MW

NOTE: Baseload remains on the balance throughout the activity. Morning, all day, and evening are added and removed according to the time during the activity, and whether students consider the all day activities to be included with evening. **The maximum demand or generation on the balance is 150 MW.**

Demand

Generation

Morning Peak Demand **20 MW**	**Natural Gas Peak Generation** **10 MW** **$150 any time**
All Day Peak Demand **15 MW**	**Wind Generation** **10 MW** **$45 evening only**
Evening Peak Demand **15 MW**	**Solar Generation** **10 MW** **$75 daytime only**
Natural Gas Peak Generation **10 MW** **$90 any time**	**Hydropower Peak Generation** **5 MW** **$50 any time**
Natural Gas Peak Generation **5 MW** **$90 any time**	**Hydropower Peak Generation** **10 MW** **$60 any time**

Building a Battery

TEACHER INSTRUCTIONS

Background

Students will know that batteries power some of their favorite devices — tablets, phones, computers, hand-held gaming systems, even cars. This activity helps students to understand the basic components in a battery, how they can store energy, and how they can turn it into electricity.

✪ Objective

- Students will be able to describe how chemical energy can transform into electrical energy.

Materials

- 1 Microammeter
- 2 Zinc nails (one large/one small)
- 2 Copper wires (one thick/one thin)
- 1 Set of alligator clips
- 1 Apple (or other fruit item)

Time

- 30-40 minutes

✔ Procedure

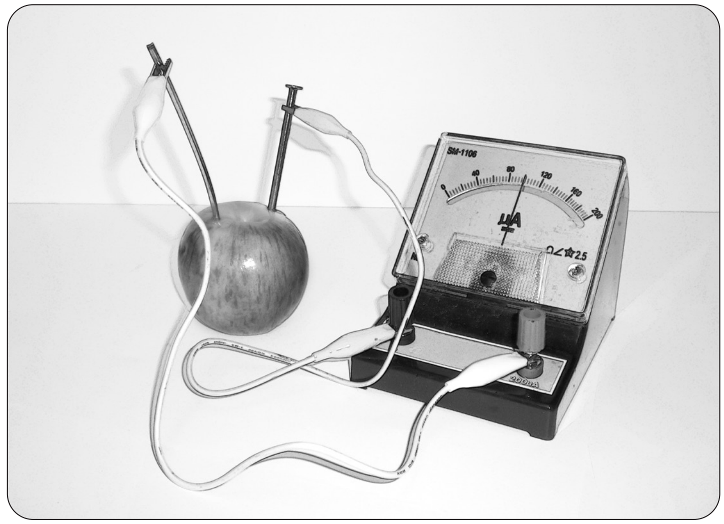
1. Make copies of the student worksheet.
2. Introduce the activity by asking students what they know or have heard about acids. Discuss common acids students might recognize—battery acid, lemon juice, etc. Tell students that acids react with some other materials. Energy is released when they react.
3. Distribute the student worksheet, and instruct the students to complete in larger groups. Alternatively, you could also conduct this as a demonstration.
4. Review and discuss the Conclusion questions and Extensions.

Building a Battery

STUDENT WORKSHEET

Background

Batteries are used to produce electricity. Most batteries contain an acid and one or more metals that react when they come in contact with the acid. This reaction can sometimes make electricity—a form of energy. A meter can measure the flow of electricity.



Question

How can an apple be used to produce electricity?

Hypothesis

Read the procedure. Make a prediction to answer the question on a separate piece of paper.

Materials *PER GROUP*

- 1 Apple
- 1 Ammeter
- 2 Nails (gray)
- 2 Copper wires (orange-brown)
- 1 Set of alligator clips

Procedure

1. Attach the alligator clips to the black and red connectors on the front of the meter.
2. Insert the large nail and thick copper wire into the apple just a bit.
3. Attach the wire from the black connector to the nail and the other connector to the copper wire. Record the meter reading: __________
4. Push the nail and the copper wire further into the apple, but not touching. Record the meter reading: _________
5. Complete Steps 2 - 5 using the small nail and thin copper wire. Record the meter readings: Q#3_________

   Q#4_________

Conclusion

1. What energy transformation occurred in this activity?

Extensions

- Find out what happens if you attach both nails or both copper wires to the clips.
- Experiment with different fruits and metals to determine which ones produce electricity.

Radiation Cans

TEACHER INSTRUCTIONS

Background

The sun's radiant energy can do many things — provide warmth & growth, generate electricity, provide light etc. This activity will show how energy from the sun can be trapped to provide heat.

Objective

- Students will be able to explain that light can be reflected or absorbed and then converted to thermal energy (heat).

Materials

- Radiation can sets
- Thermometers
- 250 mL Beakers
- Water
- Light source
- Timer

Time

- 60 minutes

Procedure

1. Set up centers or stations each with one set of radiation cans, 2 thermometers, a beaker, and water. Make sure the stations are situated in the sunlight or each has a light source.
2. Explain the procedure and have the students complete the activity in groups.
3. Review the activity with the students, discussing the following concepts:
    - radiant energy can be reflected or absorbed when it hits objects;
    - absorbed radiant energy can be converted into heat;
    - black objects tend to absorb radiant energy; and
    - shiny objects tend to reflect radiant energy.
4. Ask students to describe where how we use the sun for thermal energy.

Radiation Cans

STUDENT WORKSHEET

Question

What happens to the sun's radiant energy when it comes in contact with a black can or a shiny can?

Hypothesis

In your science notebook, write your hypothesis in an "If…then…because…" format.

Caution

Do not look directly at the sun or its reflection; doing so can be harmful to your eyesight.

Materials

- 1 Set of radiation cans (one black and one shiny)
- 2 Thermometers
- 1 Beaker
- Room temperature water
- Light source (sunny day or bright artificial light)
- Timer

Procedure

1. Put thermometers into the empty black and shiny cans and replace the lids. Position the thermometers so they are not touching the bottoms of the cans. Record the starting temperature of both cans.
2. Place the cans in a sunny place or under the light source. Record the temperature every minute for fifteen minutes using the data table on the next page.
3. Calculate the change in temperature for each can and record it in the DT column of the data table.
4. Remove the cans from the direct light. Take the lid off of each can and allow the air inside to return to room temperature.
5. Fill both cans with 150 mL of room temperature water and record the temperatures.
6. Place the cans under the same light source. Record the temperature every minute for 15 minutes.
7. Calculate the change in temperature for each can and record it in the DT column of the data table.

Conclusions

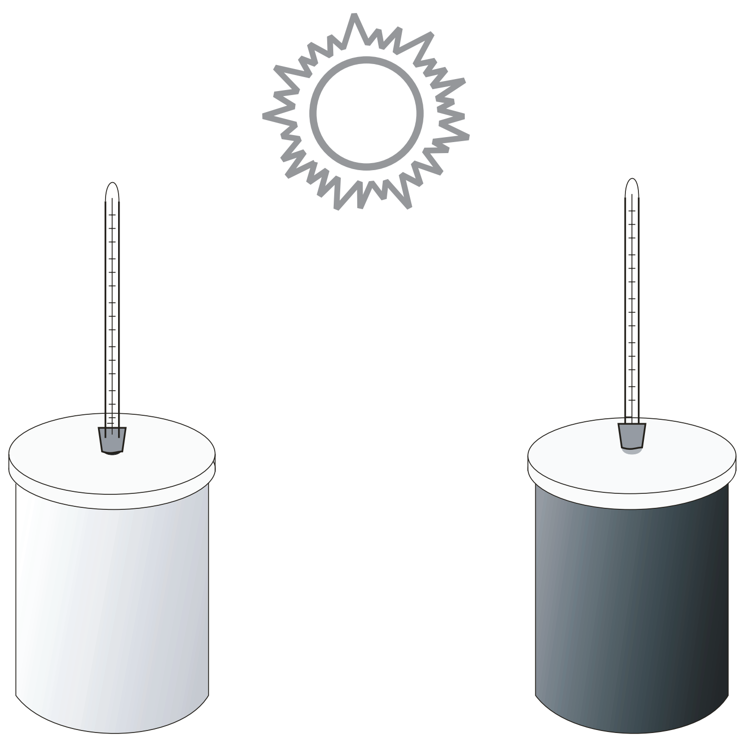
1. What have you learned about converting radiant energy into heat? How does that relate to reflection and absorption of radiant energy in the black and shiny cans?
2. Compare the results of measuring temperature change in cans with air and cans with water. What did you notice? Use data to explain what happened in each trial.
3. What color should a solar water heater be and why? Use data to support your answer.

Data

Use or re-create the tables below in your science notebook for your data.

Air Only																	
	Starting Temperature	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	∆T
Black Can																	
Shiny Can																	

Room Temperature Water																	
	Starting Temperature	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	∆T
Black Can																	
Shiny Can																	



Photovoltaic Cells

TEACHER INSTRUCTIONS

Background

This activity will help demonstrate how solar energy, or radiant energy, generates electricity. These solar panels are a simplified version of what students might see on the ARIS lighting systems on your school grounds. Students can begin to explore variables affecting a cell's output and apply it to the solar-powered lights they see outside.

Objectives

- Students will be able to explain how a PV cell transforms radiant energy directly into electricity.
- Students will be able to explain how a motor transforms electricity into motion.

Materials

- PV module kit with motors and fans
- Paper
- Bright light source

Time

- 60-75 minutes

✔Procedure

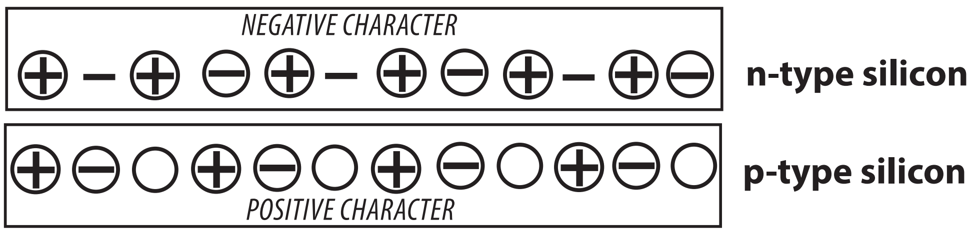
1. Make copies of the student worksheet and distribute as needed.
2. Place students into four groups. Explain the procedure and have the students complete the activity in their groups.
3. Review the activity with the students, using the *Photovoltaic Cell* master to review and discuss the following concepts:
    - PV cells transform radiant energy directly into electricity;
    - motors transform electricity into motion; and
    - sunlight and artificial light are both examples of radiant energy.

Photovoltaic Cells

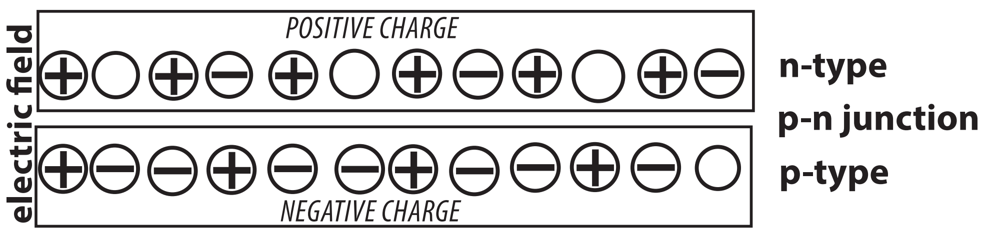
TEACHER MASTER

○	A location that can accept an electron
–	Free electron
⊕	Proton
⊖	Tightly-held electron

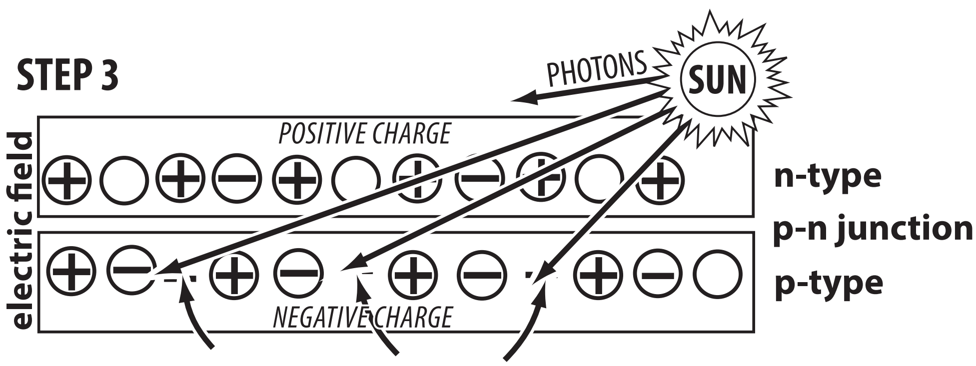
STEP 1



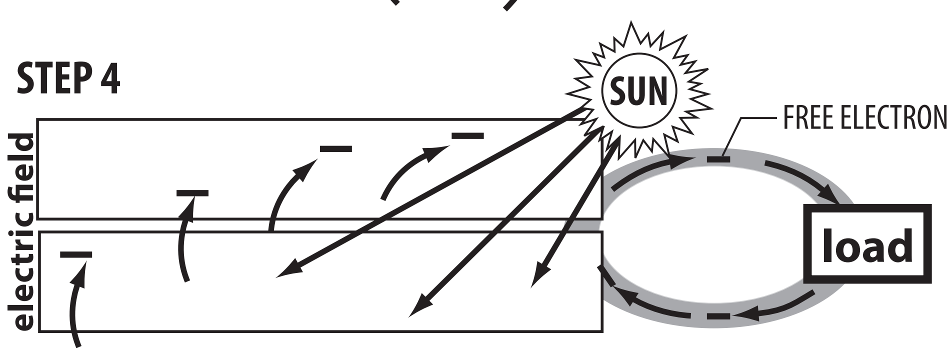
STEP 2



STEP 3



STEP 4



Photovoltaic Cells

STUDENT WORKSHEET

Question

How does changing the amount of radiant energy reaching the solar panel affect the panel's electrical output?

Hypothesis

In your science notebook, write your hypothesis in an "If…then…because…" format.

Materials

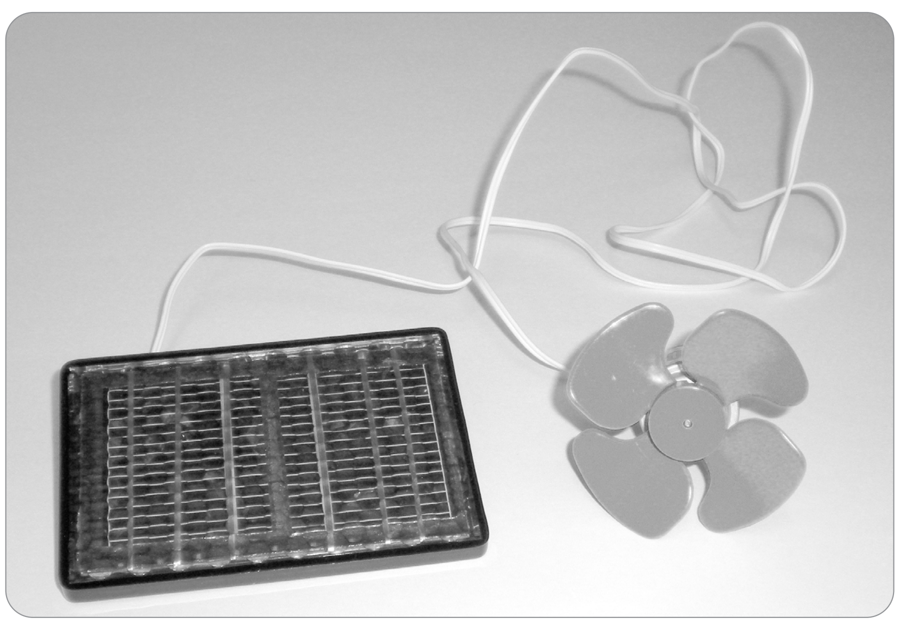
- 1 PV module
- 1 Motor
- 1 Fan
- Paper
- Bright light source

✔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. Hold the PV module at different angles to the sun. Estimate the angles you use. Observe and record your observations.
6. Cover part of the PV module 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

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



Solar House

TEACHER INSTRUCTIONS

Objectives

- Students will be able to explain that photovoltaic (PV) cells turn radiant energy from the sun into electricity.
- Students will be able to describe examples of how electricity can produce light and motion.

Materials

- 4 Solar house kits
- Transparency film or plastic wrap
- Clay
- 4 Cardboard boxes - 12x12x12 or similar
- Black construction paper
- 2 Sheets of white copy paper for each group
- Ruler
- Tape
- Scissors
- Student Guides

Time

- 30-45 minutes

✔ Procedure

1. Set up four centers, each with one solar house kit, a piece of transparency film, a small piece of clay, scissors, and tape. If you desire, art supplies can also be included at each center, allowing for students to decorate the boxes to look like houses.
2. Divide the class into four groups.
3. Instruct students to read the *Elementary Energy Infobook* section on solar energy. Explain that solar energy is renewable and can make electricity. Review the *Photovoltaic Cell* master, as needed.
4. Explain the procedure to the students, emphasizing that all of the students in the groups should have an opportunity to help with the activity. (As an alternative, every student can prepare his/her own box house and take turns installing the PV equipment.) Assign each group of students to a center and have them complete the activity using the Student Guide or their science notebooks. For younger students, it is recommended that adult or older student helpers at each center assist students with this activity.
5. Review the activity with the class, reinforcing the following concepts:
    - a solar collector turns solar (radiant) energy into heat;
    - a PV cell changes solar (radiant) energy into electricity; and
    - electricity can produce light and motion.

Extension

- As a great introduction to PV cells, set up the *PV Ping Pong Simulation* as found in NEED's *Energy From the Sun* Teacher Guide for intermediate students.

Solar House

STUDENT WORKSHEET

Question

How can solar energy be used in your house?

Materials

- Cardboard box
- Scissors
- Clear transparency film or plastic wrap
- Black construction paper
- 2 Sheets of white paper
- Clay
- Tape
- Solar house kit
- Ruler

✔ Procedure

1. Using the scissors, cut large windows and a door on one side of the box.
2. Tape clear transparency film over the windows if you have it. Use plastic wrap as a substitute.
3. Make a round water storage tank from black construction paper. Attach it to the side of the house with tape.
4. Make two holes 1 cm in diameter in the top of the box.
5. Push the shaft of the motor through one of the holes.
6. From the inside of the house, attach the fan blades to the motor. Make sure there is enough room above the blades for the fan to turn without bumping the ceiling. Use a strip of tape to hold the motor in place.
7. Push the LED through the other hole and tape it in place.
8. Attach the PV cells to the fan and LED.
9. Lay the PV cell with tubing on top of the house with the tubing extending down to the black water storage tank. Tape in place, or use clay to hold in palce.
10. Carefully carry the house model into the sun. Observe the speed of the fan and the brightness of the LED. Tilt the PV cells so they are directly facing the sun. How does this affect the speed of the fan? Use a piece of clay under the PV cells to leave them in this position.
11. Simulate a bright, overcast day by placing a single sheet of white paper over the PV cells. Observe the speed of the fan and the bright-ness of the LED.
12. Simulate a very cloudy day by placing two sheets of white paper over the PV cells. Record your observations of the fan speed and LED brightness.
13. Simulate nighttime by placing a piece of cardboard over the PV cells. Record your observations of the fan speed and LED brightness.

Data and Observations

Make a diagram of your solar house below. Label the parts.

Data and Observations Continued

Record your observations in the table below.

Light Conditions	Fan Speed	LED Brightness
Bright sunlight, PV cells laying flat		
Bright sunlight, PV cells tilted toward the sun		
Bright overcast (one sheet of paper)		
Cloudy (two sheets of paper)		
Nighttime (cardboard)		

Conclusions

1. Did the PV cells work differently laying flat or pointed towards the sun? Explain which worked better.

2. How would the change in seasons and different location of the sun in the sky affect how well a PV cell works where you live?

Wind Can Do Work

TEACHER INSTRUCTIONS

Objective

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

Caution

The straight pins are sharp. Review with students how to safely handle sharp objects. After the pin is in place, carefully wrap a small piece of tape around the sharp end.

Materials *FOR EACH PAIR*

- 1 Extra-long straw*
- 1 Small straw
- Masking tape
- 2 Straight pins
- 1 Binder clip
- 50 cm Thread or string
- Paper clips
- Foam cup
- Scissors
- Marker
- Ruler
- Hole punch
- *4-Blade Windmill* template

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

Materials *FOR THE CLASS*

- Fans
- Student Guides

Time

- 60 Minutes

✔Procedure

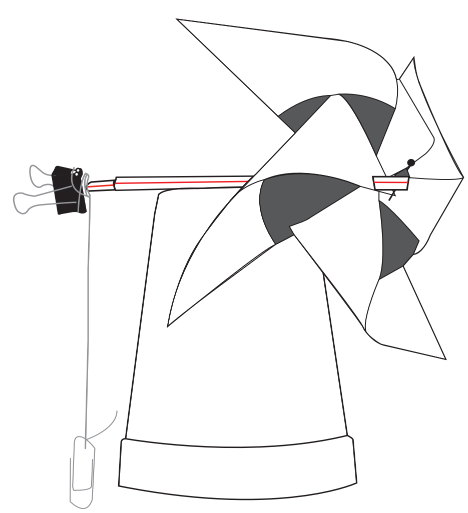
1. Cut thread or string into 50 cm lengths for each pair. Make copies of the *4-Blade Windmill* template for students.
2. Prepare copies of the instructions and student worksheets as needed.
3. Explain that wind is energy and people use wind's energy to do work. Instruct students to read the *Elementary Energy Infobook* text sections on how wind is used.
4. Working with a partner, students should follow the directions on the *Wind Can Do Work* instructions to construct a windmill that can lift paper clips.
5. Students should follow the investigation procedure and record data, observations, and write a conclusion on their worksheets.

Extension

- Let students redesign the windmill changing one of the variables and conduct new tests.

Volunteers

This is a good day for parent volunteers to come into your classroom and help with the investigation.

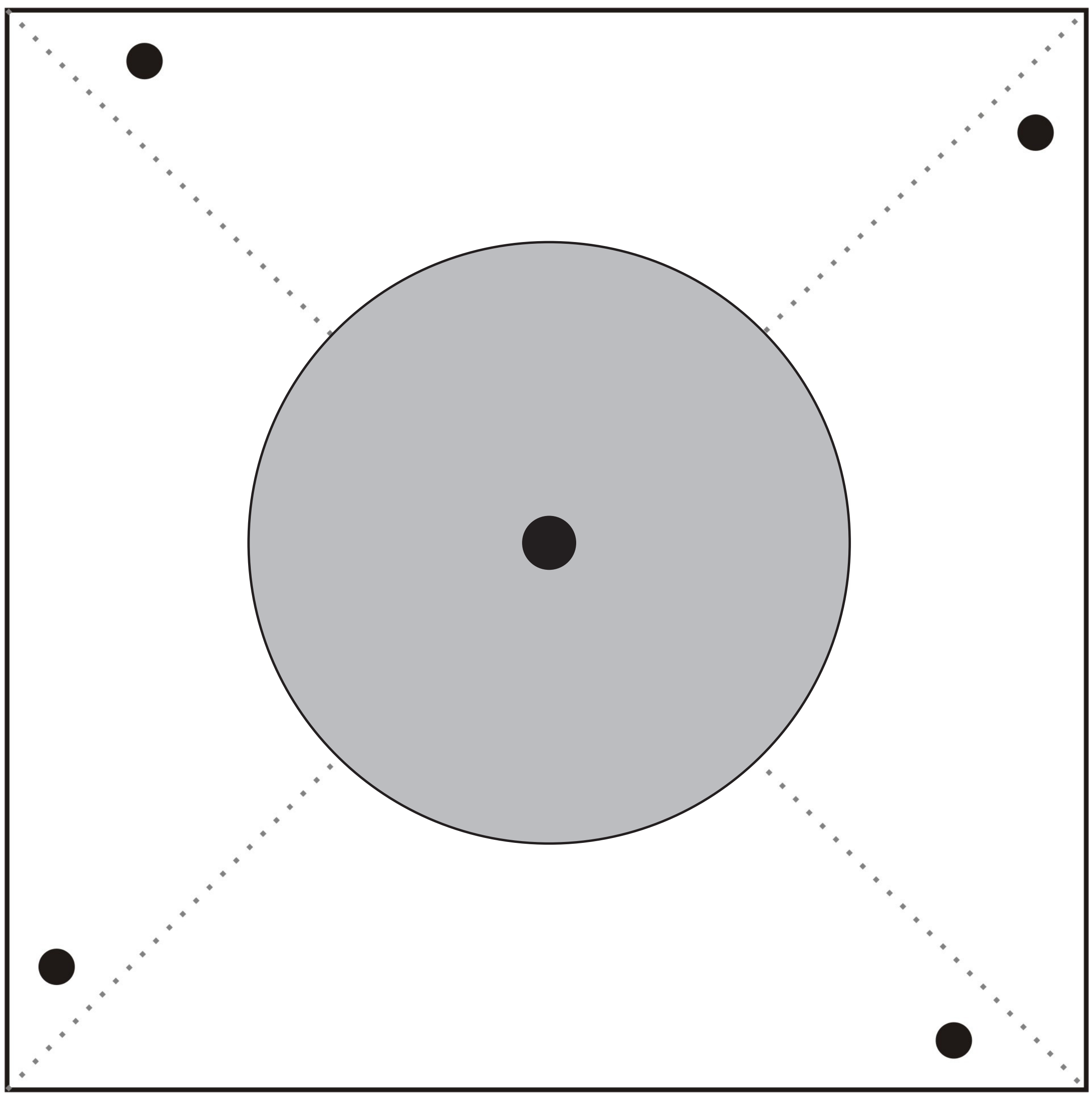


4 Blade Windmill

TEMPLATE

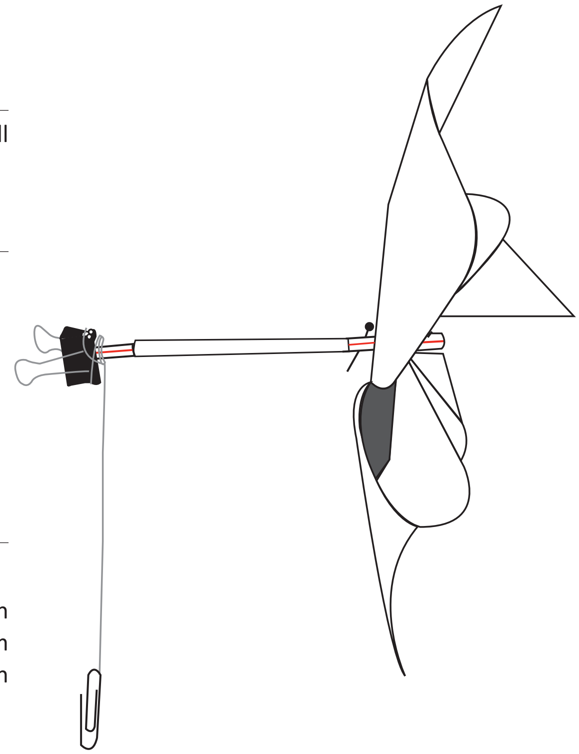
✔Procedure

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.



Wind Can Do Work

INSTRUCTIONS



Question

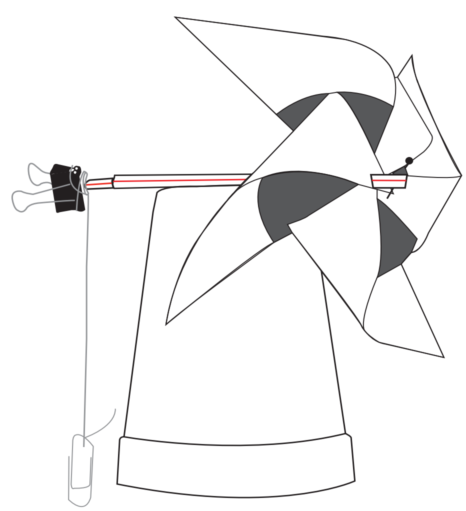
What is the maximum load that can be lifted all of the way to the top of the windmill shaft?

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 or another pin.
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.



⁂ Conclusions

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.

Wind Can Do Work

STUDENT WORKSHEET

Question

How many paper clips can be lifted all of the way to the straw?

Hypothesis

If ____

then ____

because ____

✔ Procedure

1. Build your windmill using the directions and windmill blade template your teacher gives you.
2. Attach a paper clip to the string. Can the wind lift the paper clip all of the way to the straw? Record data in the table below.
3. Continue adding paper clips one at a time until the paper clips fail to reach the straw. Record data below. Add onto the data table, if needed.

IMPORTANT: Use the same wind speed for each test!

Diagram

Draw a picture of your windmill in the box to the right. Use the vocabulary below to label the parts.

- Blades
- Tower
- Shaft
- Load

Data

Fill in the chart below to show how many paper clips can be lifted.

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Number of Paper clips									

⁂ Conclusions

How do windmills work? Use observations and data from your investigation to help explain how the system works.

What changes could you make to the windmill system so you could lift more paper clips? Draw a picture and use words to show your new windmill design.

The Facts of Light

TEACHER INSTRUCTIONS

Background

Lighting used to be simple. We would buy bulbs based on their wattage, and schools and offices used long fluorescent tubes for light. That was that. Then in 2007, The Energy Independence and Security Act was passed, changing lighting for many, and mandating better efficiency in lighting options. Now, we have a variety of lighting choices, which can be confusing. This lesson helps students understand the types of lighting available for purchase, and those that may still be in homes, allowing students to compare how they work, their efficiency, and their cost to use.

✪Objectives

- Students will be able to describe how different light bulb types produce light.
- Students will be able to compare and contrast light bulb types for efficiency and cost.

Materials

- Incandescent bulb
- CFL bulb
- LED bulb
- Calculators (optional)

Time

- 15-20 minutes

✔ Procedure

1. Prepare a copy of the activity and answer keys to project or make copies as needed.
2. Ask the class what kinds of light bulbs they see in their homes. Help them to identify the lighting they might use indoors and outdoors, and use the classroom to serve as a model, where needed. Ask students to predict how many light bulbs they have in their home.
3. Have students read the Energy Infobook about lighting.
4. Preview the activity and ask students to complete individually or complete as a class. Discuss which lighting type works best while saving money.

The Facts of Light

ANSWER KEY

Step		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
1		Number of bulbs to get 25,000 hours	25 bulbs	8.3 bulbs	2.5 bulbs	1 bulb
	x	Price per bulb	$0.50	$1.50	$1.50	$1.33
2	=	Cost of bulbs for 25,000 hours of light	$12.50	$12.45	$3.75	$1.33
		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
3	=	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
	x	Price of electricity per kWh	$0.129	$0.129	$0.129	$0.129
4	=	Cost of Electricity	$193.35	$138.57	$41.89	$38.67
		LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
5		Cost of bulbs	$12.50	$12.45	$3.75	$1.33
6	+	Cost of electricity	$193.35	$138.57	$41.89	$38.67
7	=	Life cycle cost	$205.85	$151.02	$45.64	$40.00

The Facts of Light

STUDENT WORKSHEET

How much does it cost to create 25,000 hours of light from each bulb?



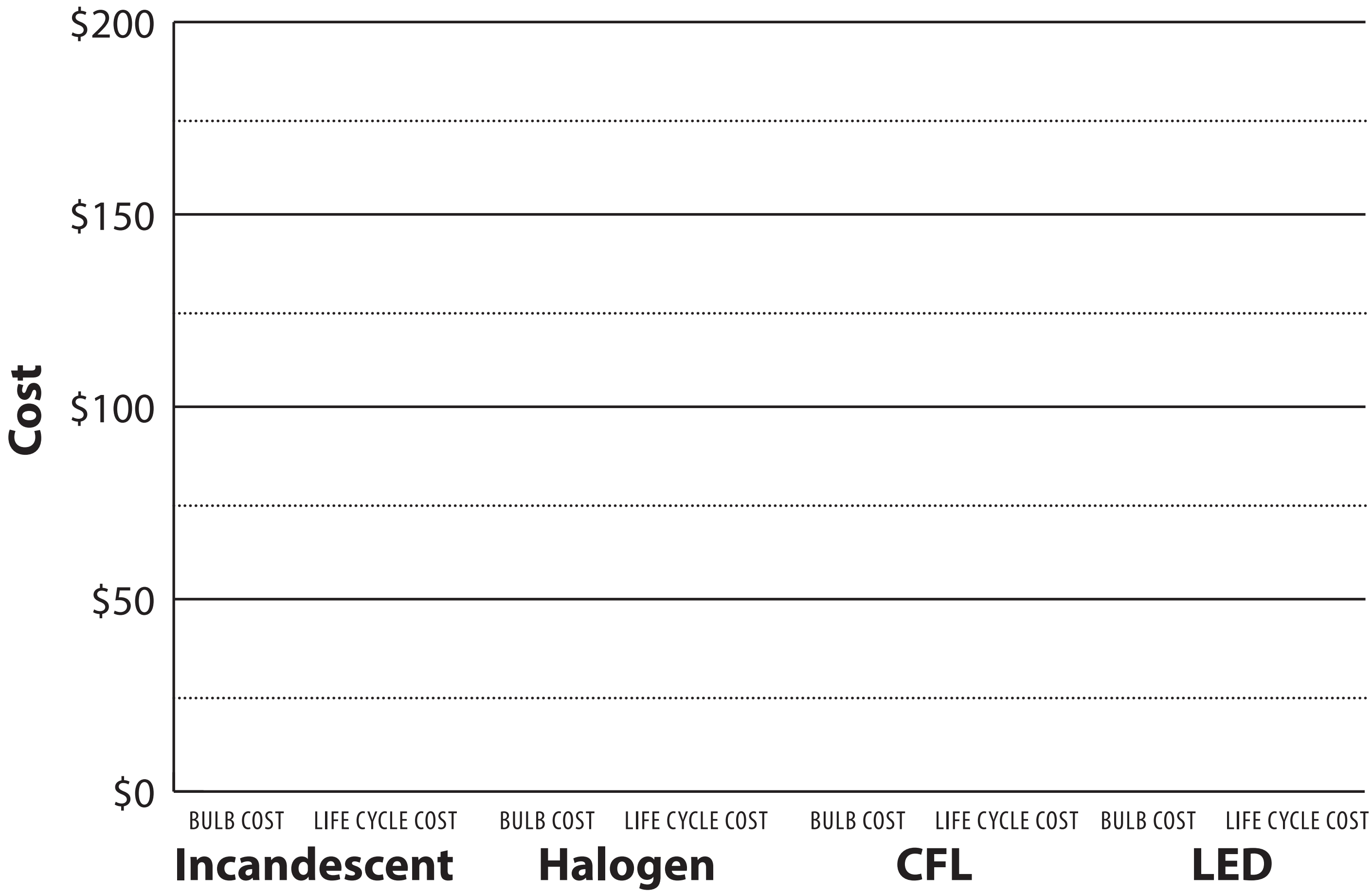

All bulbs provide about 850 lumens of light.

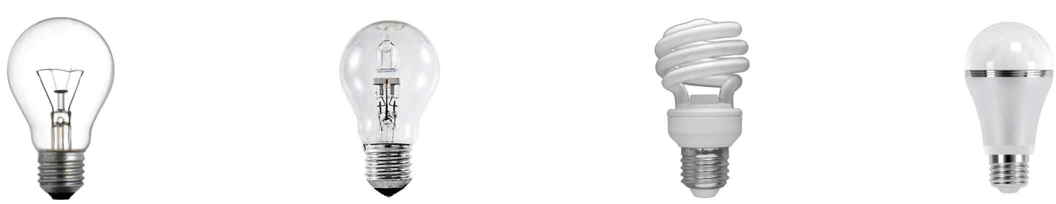
	COST OF BULB		**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
		Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
1		How many bulbs do you need to get 25,000 hours?				
	x	Price per bulb	$0.50	$1.50	$1.50	$1.33
2	=	Cost 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
3	=	Total kWh consumption				
	X	Price of electricity per kWh	$0.129	$0.129	$0.129	$0.129
4	=	Cost of Electricity				
	LIFE CYCLE COST		**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
5		Cost of bulbs				
6	+	Cost of electricity				
7	=	Life cycle cost				

The Facts of Light

STUDENT WORKSHEET

Comparing Light Bulbs





	Incandescent	Halogen Incandescent	CFL	LED
Bulb Cost	$12.50	$12.45	$3.75	$1.33
Electricity Cost				
Life Cycle Cost				

NOTE: Bulb cost reflects the number of bulbs needed to produce 25,000 hours of light, which is the lifespan of one LED bulb. To produce the same amount of light, it would take 25 incandescent bulbs and 2.5 CFL bulbs.

Answer the following questions in your science notebook.

1. Draw the Comparing Light Bulbs graph in your science notebook. Use the data provided to create a bar graph.
2. Looking at the graph and the data table, what conclusions can you draw about the cost of each type of bulb?
3. If you were going to change all of the light bulbs in your home, which bulbs would you use and why?

Analyzing Data

TEACHER INSTRUCTIONS

Background

In this activity, students will begin to explore the data gathered by the Aris lighting RPU to understand how it works to generate electricity and store energy to power the lamp. Students will first become familiar with the user interface screenshots and learn to draw conclusions from the items they see compared to daily weather information, etc. As students become more familiar, you may have them look at the data each week from their school, compare it to the other sites, and identify patterns and variables that might affect each site's lighting.

Objectives

- Students will be able to read, synthesize, and analyze the data and graphics on the Aris RPU data sheets.
- Students will be able to describe basic variables that affect solar panel and wind turbine performance (wind speed, weather patterns, etc.).
- Students will be able to compare and contrast different Aris systems.

Materials

- Internet access
- Calculators (optional)
- Aris shared data file: https://ariswind.sharefile.com/share/getinfo/scab599c491945519

Time

- 30 minutes, plus ongoing time for continued data analysis

✔ Procedure

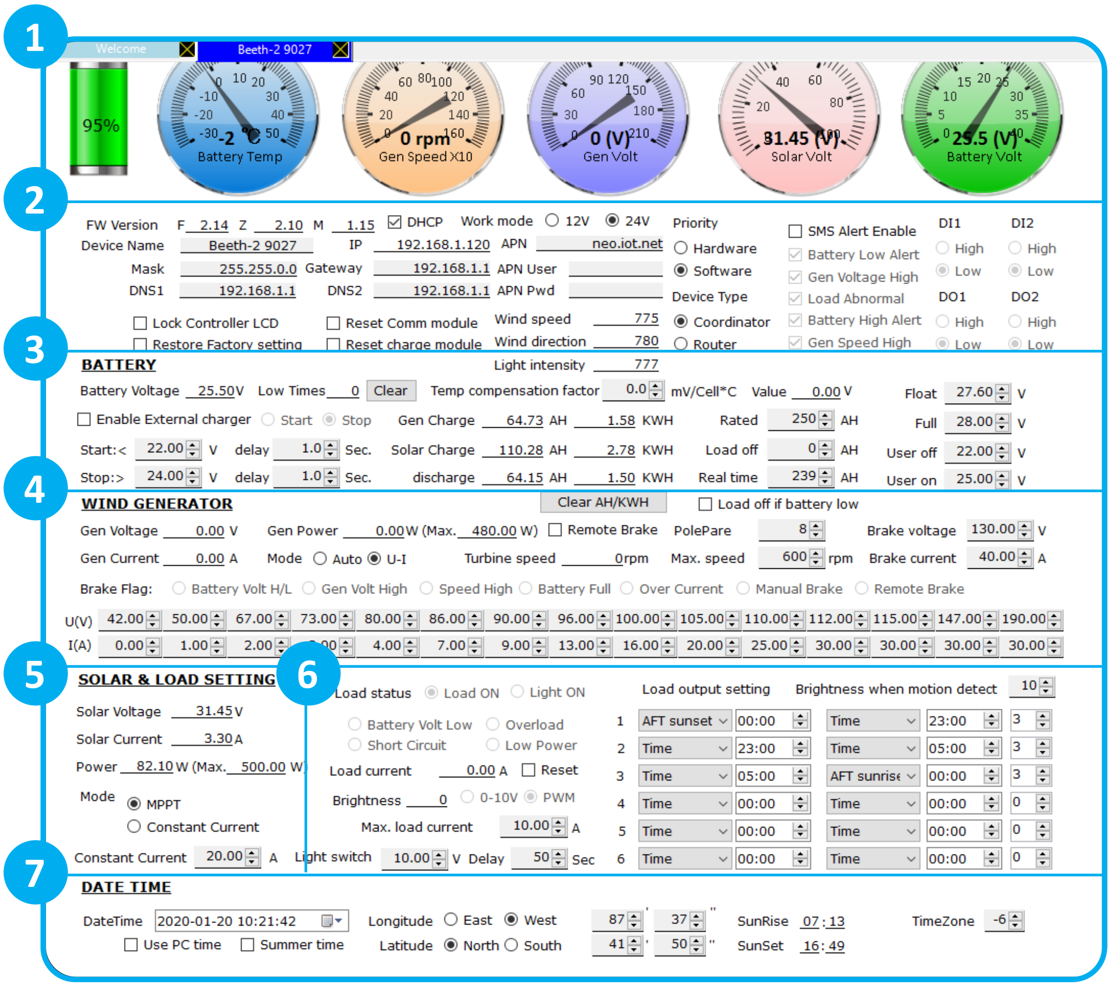
1. Visit the Aris shared file to preview data from each school site as needed. Review the master of the user interface screenshot and identify all the parts listed on the key.
2. Prepare a digital copy of the master to project and/or copies of the student worksheet and master to distribute. Or, visit the link for the shared files and project a more recent version of the data from your school in color. It may also be helpful to prepare a copy of the Aris system overview on page 5 for display.
3. Explain to the class that data is often reported in charts, tables, and graphs.
4. Show or describe the Aris system to your students.
5. Show and explain the data displayed by the Aris user interface. Describe the various dials and sections of the screen, specifically pointing out the time in the bottom (military time), and the presence of solar generation and wind generation on the dials at the top. It may make sense to also pull up a local weather report for that time of day to verify weather conditions (relative sun/clouds, wind speed, etc.). Ask the students to write two sentences summarizing the information in the top line (dials) of the screenshot.
6. Be sure to also point out the battery's instantaneous voltage in comparison to the "full" voltage, and on the battery diagram at the top. Ask students to verify the battery charge calculation if calculating percentages is in their math skills arsenal.
7. Ask students basic questions about the data and the display. For example, why might it be important to know the sunrise and sunset times? Why might the system report on the speed of the generator AND the volts produced? Why might the lamp have different brightness settings? Why might there be volts produced but no current?
8. Show the students the shared data from the other schools. Have the students compare the conditions and associated generation and charging between the various locations and begin to look for similarities and differences over time. What variables might account for the differences between the school sites? Ask students what kind of conditions might need to be in place to drain the battery?

Extension

- Provide your students a screenshot, and focusing simply on the top line (dials), have the students reverse-engineer the day's weather conditions at the time data was pulled.

Analyzing Data

TEACHER MASTER & KEY



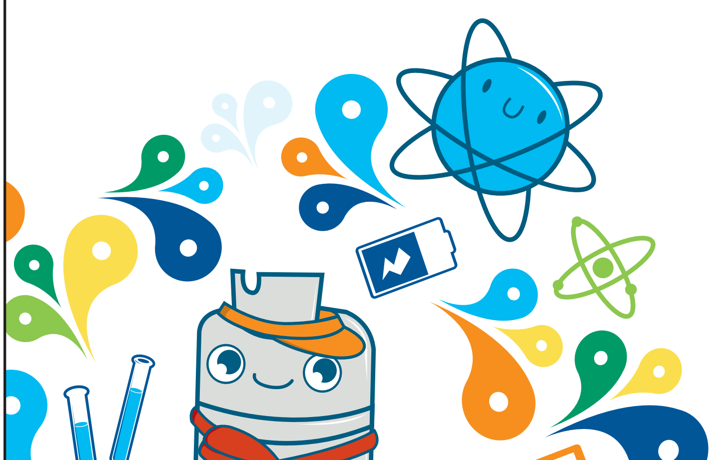
✔ Key

1. **Data Dashboard** – This area shows the most relevant data for students, including current battery charge (%), battery temperature, wind turbine speed, wind turbine generation (V), solar panel generation (V), and battery charge (V).
2. **RPU Information** – This area shows general information for the installers and programmers, including the device's name, current programmed settings, and server information for data collection.
3. **Battery** – This area contains information pertaining to the battery. It will show the battery's current voltage, which should match the reading on the green dial, as well as what full capacity would be when fully charged. It also indicates how many kWh are generated by the wind turbine and solar panel to charge the battery, as well as how much power is discharged.
4. **Wind Generator** – This section showcases how much energy is generated by the wind turbine and its current speed, which should match the purple dial at the top. It also shows the speeds and currents at which a break is applied to slow/stop the generator.
5. **Solar Panel** – This area shows the solar generation from the solar panel.
6. **Load Settings** – This area gives information about the lamp and its settings. It will showcase the times the lamp is set to be on, and at which brightness. The brighter the light, the more power it will consume. It will also show if the battery should be low for any reason.
7. **Date and Time** – This section shows the date and time (military time) at which the reading was pulled. It also shows the latitude and longitude coordinates of the RPU, and at what time sunrise and sunset occurred.

YOUTH ENERGY CONFERENCE AND AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math). The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info:
www.NEED.org/event/youth-energy-conference-and-awards/



YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

All NEED schools have outstanding classroom-based programs in which students learn about energy. Does your school have student leaders who extend these activities into their communities? To recognize outstanding achievement and reward student leadership, The NEED Project conducts the National Youth Awards Program for Energy Achievement.

Share Your Energy Outreach with The NEED Network!
This program combines academic competition with recognition to acknowledge everyone involved in NEED during the year—and to recognize those who achieve excellence in energy education in their schools and communities.

What's involved?

Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

Want more info?

Check out **www.NEED.org/need-students/youth-awards/** for more application and program information, previous winners, and photos of past events.

Awesome Extras!

Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching!

This page is available at www.NEED.org/educators/awesome-extras/.