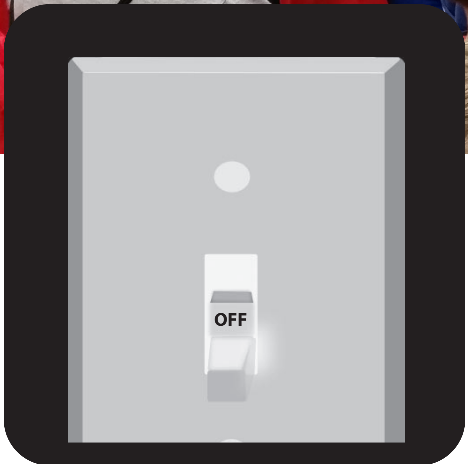
2018-2019

School Energy Experts

Teacher Guide

Hands-on activities that introduce students to the ways in which we use energy in school buildings. The school becomes a living laboratory as students explore thermal energy transfer, electricity, lighting, and even conduct their own building audit.



Grade Level:

Int — Intermediate

Subject Areas:

- Science
- Social Studies
- Language Arts
- Math
- Technology

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National Energy Education Development Project

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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.

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School Energy Experts

School Energy Experts Kit

- 1 Incandescent bulb
- 1 Compact fluorescent light bulb (CFL)
- 1 Light emitting diode bulb (LED)
- 1 Kill A Watt® meter
- 5 Sets of radiation cans (2 per set)
- 10 Lab thermometers
- 3 Bags of insulating materials (cellulose, packing peanuts, fiberglass batting)
- 5 Boxes
- 3 Student thermometers
- 1 Light meter
- 1 Waterproof digital thermometer
- 1 Digital humidity/temperature pen (hygrometer)
- 1 9-volt Battery (for light meter)
- 1 Infrared (IR) thermometer
- 5 Respirator Masks
- 30 Student Guides

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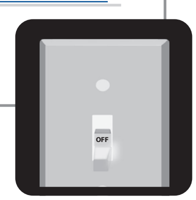


Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

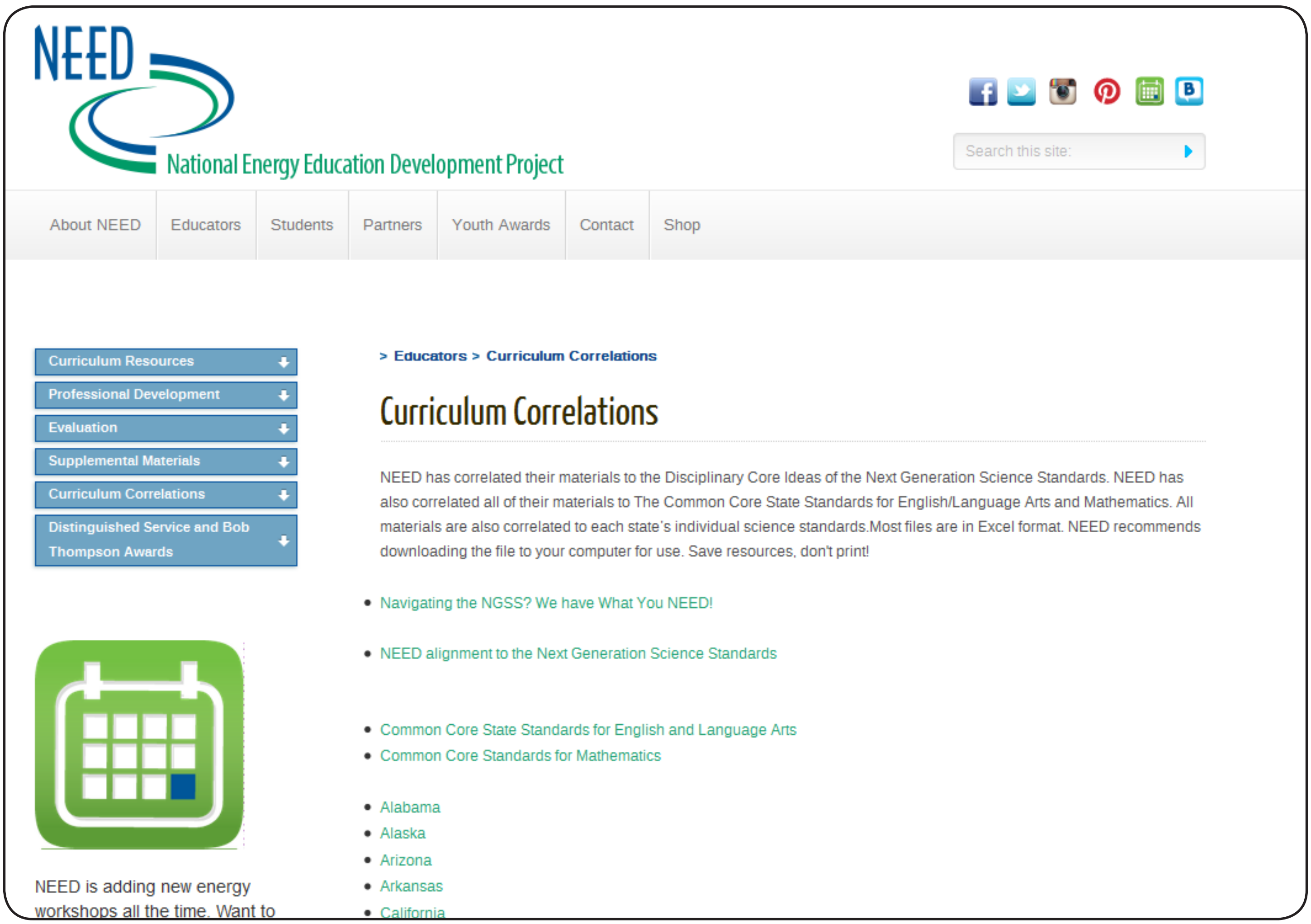
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



School Energy Experts Materials

LESSON	ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
LESSON 2	*Conduction, Convection, Radiation Demonstration*		▪Several sheets of scrap paper ▪Large buckets, bins, or boxes
	Radiation	▪Infrared (IR) thermometer	
	Insulation Investigation	▪Radiation Cans ▪Small boxes ▪Insulation materials (cellulose, packing peanuts, fiberglass batting) ▪Lab thermometers ▪Plastic zip-close bags ▪5 Respirator Masks	▪Rubber bands ▪Spray can expandable foam insulation ▪Hot water ▪Tape ▪Thick rubber or work gloves
	Air Infiltration Investigation		▪Tissue paper ▪Pencils ▪Tape
LESSON 3	*Measuring Electricity Use and its Cost*	▪Kill A Watt® meter	▪Electrical devices for investigation ▪Calculators (optional)
	Understanding Electrical Utility Bills		▪Copies of school electric bills
LESSON 4	*Light Bulb Investigations*	▪Student thermometers ▪CFL Bulb ▪LED Bulb ▪Incandescent bulb ▪Kill A Watt® meter ▪Light meter	▪1-3 Lamps ▪Tape ▪Ruler or meter stick ▪Calculators (optional)
LESSON 6	*Student Audits*	▪Digital thermometer ▪Hygrometer ▪Light meter ▪Kill A Watt® meter	▪Clipboards or folders

***NOTE**: Handle fiberglass insulation with caution. Use masks, gloves, and eye protection to minimize fiber and skin contact.

Teacher Guide

Grade Level

- Intermediate, grades 6-8

Time

10 -14 class periods or less depending on the activities selected and in-class and out-of-class time used.

Introduction

School Energy Experts is designed to be the classroom education component of a total energy management plan for intermediate schools. An energy management plan could also include training of the building manager, administrators, and maintenance staff, and retrofitting the building.

The activities in this unit have been designed in a series of lessons to build on one another, providing all of the information students need to conduct a student energy audit of the building, and understand building operation.

Home Kit

Managing Home Energy Use is an at-home supplement to the energy consumption activities in this guide. *Managing Home Energy Use* follows the same format as this guide and expands on the efficiency and conservation knowledge gained while using the home as the learning laboratory. Additional home kit materials can be purchased as well. For more information, visit www.NEED.org.

Background

School Energy Experts introduces students to the concepts of energy, energy consumption, economic and environmental effects of the energy industry and its consumers, and conservation and efficiency. This series of activities involves hands-on learning, teaching others, monitoring energy use, and changing behaviors.

School Energy Experts is a hands-on unit that explores consumption, efficiency and conservation using the school as a real–world laboratory, ultimately culminating in energy savings in the entire building. The activities encourage the development of cooperative learning, math, science, comparison and contrast, public speaking, and critical thinking skills.

Preparation

- Familiarize yourself with the Teacher Guide, the Student Guide, and the information for each activity. Make sure that you have a working knowledge of the information, definitions, and conversions.
- Familiarize yourself with the equipment in the kit. Procure materials needed that are not included within the kit (see chart on page 5).
- Also included in this guide are two reinforcement activities. *Energy Efficiency Bingo*, and *Conservation in the Round*. These formative assessments are fun additions to the content and can be used as introductory activities or assessments throughout. Familiarize yourself with the instructions on pages 20-22 and make copies of pages 51-54 as needed.
- Make copies or digital masters of the following pages in the Teacher Guide for projection:

MASTER	TEACHER GUIDE PAGE
Forms of Energy	42
U.S. Energy Consumption by Source, 2016	43
Thermometer	44
Transporting Electricity	45
Kill A Watt® Meter	46
The Light Meter	47
Light Bulb Comparison	48
Digital Thermometer	49
Hygrometer	50
Energy Efficiency Bingo	51
Conservation in the Round Cards	52-54

Additional Resources

- The data in this curriculum comes mostly from the U.S. Department of Energy's Energy Saver website at http://energy.gov/energysaver/energy-saver. This website has additional information, maps, and statistics that the students can use. Copies of the Energy Saver Guide may be downloaded from the Energy Saver website.
- NEED's *Blueprint for Student Energy Teams* is an excellent resource to couple with this guide as you begin studying the efficiency of your buildings. The blueprint helps teachers and school staff to utilize their students to create energy teams and affect energy change in their buildings.

Science Notebooks

This unit refers to students using science notebooks to record their questions, hypotheses, data, observations, and conclusions as they work through each activity. If your students are not familiar with science notebooking, they may use the student worksheets in the Student Guides for guidance. Rubrics for assessing student work can be found on page 17.

Lesson 1 – Introduction to Energy Use

Background

In this introductory lesson, students are introduced to energy forms, sources of energy, economic sectors that consume energy, and energy efficiency and conservation. These activities aim to help students summarize information in the student text and provide a foundation for understanding how technology helps us use less energy (energy efficiency) and how our behavior can affect our energy consumption (energy conservation).

Objectives

- Students will be able to describe the forms and sources of energy.
- Students will be able to explain how the different sectors of the economy use energy.
- Students will be able to explain and provide examples of energy efficiency and conservation.

Concepts

- Energy exists in many forms.
- To use energy, it is often transformed from one form to another several times.
- Sectors of the economy use energy differently.
- Energy efficiency relates to how much energy machines use to do work.
- Energy conservation is modifying behavior to save energy.

Time

1-2 class periods

Materials

- *Forms of Energy* master, page 42
- *U.S. Energy Consumption by Source, 2016* master, page 43
- Student Guide pages 2-10

Preparation

- Make copies of the student pages as needed.
- Prepare masters of *Forms of Energy* and *U.S. Energy Consumption by Source, 2016* for projecting.
- Read through the *Energy Definitions and Conversions* master on page 9 of the Student Guide to make sure you are familiar with all of the units and definitions.

✔ Procedure

1. Introduce the unit, explaining that this unit is designed to help students understand how energy is used at school and how students and staff can work together to reduce how much energy is used in the building.
2. Explain that the same concepts in this unit can be incorporated at home, with slight modifications in how they are approached.
3. Display the *Forms of Energy* master and explain the forms. Encourage students to write the definition and examples of each in their science notebooks.
4. Introduce or review the sources of energy if necessary by asking students to complete the matching activity on page 7 of the Student Guide.
5. Introduce the *Forms and Sources of Energy* activity, providing as much guidance for students as is necessary. Display the *U.S. Energy Consumption by Source, 2016* master and discuss the different sources of energy and the forms in each as we use them.

CONTINUED ON NEXT PAGE

6. Discuss the different sectors of the economy, and how they use the same energy resources but to do different things. Discuss specific examples of residential, commercial, transportation, and industrial energy use in your own community.
7. Introduce the concepts of energy efficiency and conservation as they relate to managing energy use in school. Guide students as much as necessary in completing the *Efficiency vs. Conservation* activity on page 10 of the Student Guide.

Lesson 2 – Understanding Thermal Energy

Background

Lesson 2 focuses on thermal energy and how it is transferred. Students are introduced to conduction, convection, radiation, and insulation, and Fahrenheit and Celsius temperature scales are discussed, with the relationship for converting between the two.

Objectives

- Students will be able to explain the three mechanisms of thermal energy transfer, and identify the direction in which it transfers.
- Students will be able to hypothesize how surfaces that absorb or transfer thermal energy might affect temperatures in adjacent spaces.
- Students will be able to identify the best insulator given laboratory data.

Concepts

- Thermal energy is the energy of moving particles. Gases have more thermal energy relative to solids. All substances have some thermal energy.
- Thermal energy always transfers from high temperature to low temperature.
- Thermal energy is transferred via three mechanisms: conduction, convection, and radiation.
- Conduction is transfer of thermal energy via direct contact with a warmer object.
- Convection is transfer of thermal energy via a moving fluid, such as water or air.
- Radiation is transfer of thermal energy via radiating waves, known as infrared radiation.
- Thermal insulators block or slow down the transfer of thermal energy.
- Temperature is measured primarily with two temperature scales. The Fahrenheit scale is used in the United States, and the Celsius scale is used world-wide.

Time

3-4 class periods

Materials

- Several sheets of scrap paper
- 2 Large buckets, bins, or boxes
- 5 Sets of radiation cans
- 5 Small boxes - all the same size
- 3 Insulation materials (cellulose, packing peanuts, fiberglass batting)
- 15 Small zip-close bags
- 10 Lab thermometers
- 1 Can spray foam insulation
- 5 Respirator Masks
- Thick rubber or work gloves
- Hot water
- Rubber bands
- Tissue paper
- Pencils
- Tape
- 1 Infrared (IR) thermometer
- *Thermometer* master, page 44
- Student Guides pages 11-22

Caution

- Students should not handle fiberglass insulation without gloves, eye protection, and a mask, and we recommend that it only be handled under adult supervision. Your kit also contains cellulose insulation, which is often blown into wall cavities and attic spaces, and packing peanuts. The cellulose is a reasonable representation of fiberglass or spray foam.

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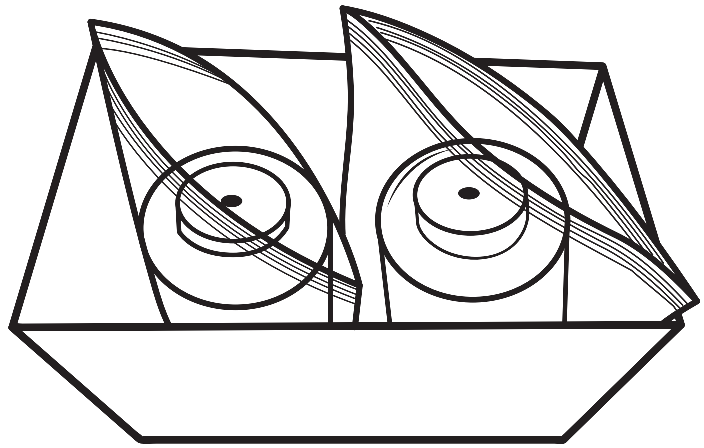
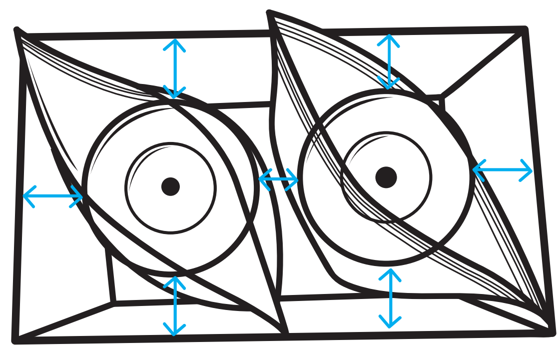
Preparation

- Gather all materials for each of the activities. If you are able, ask your building manager what type of insulation is utilized above the ceiling of your classroom or around the school, and obtain a small amount of that type of insulation for students to investigate in *Insulation Investigation*.
- For the conduction, convection, and radiation demonstration activity, crumple pieces of scrap paper ahead of time, or you may decide to have students do it for you.
- Prepare a copy of the *Thermometer* master to project.
- Make copies of the student pages as needed.
- For the *Insulation Investigation*, prepare ahead of time one box with spray foam insulation. Attach one zip-closed plastic bag to each can in a set of cans, and place the set inside one box. Make sure there is space between the cans and that the space between the cans and between the cans and box is as equal as possible (see diagram at right). Follow the spray foam instructions to dispense a layer of spray foam insulation around the cans, and allow it to cure and harden at least overnight, 24 hours if possible. The plastic bags protect the cans from insulation sticking to them and model a vapor barrier. If the foam expands up and above the level of the can tops, use a serrated knife to trim it so that it is even with the can tops after curing, and the tops of the cans can be accessed.
- On the day you do the *Insulation Investigation*, heat water to at least 100 °F, but not hotter than 140 °F. You will need enough to fill 10 radiation cans, plus an allowance for spills.





✔ Procedure

1. Introduce the concept of thermal energy by discussing how particles are moving in various objects or substances in the classroom. Talk about ice, liquid water, and steam, and have students illustrate in their science notebooks the relative difference in particle motion between them. Encourage students to use words, pictures, or a combination to best understand the concept.
2. Project the *Thermometer* master. Explain that temperature and thermal energy are related, but not interchangeable. Explain the two temperature scales, and how they are related, then show that the mathematical relationship includes the ratio of the number of degrees between water's boiling and freezing temperatures (5:9).
3. Explain that thermal energy always transfers from high temperature to low temperature. Ask students to provide examples of thermal energy transfer and identify the high temperature object or substance, and the low temperature object or substance.
4. Explain to students that as a class you will all model how thermal energy is transferred.
5. To model conduction, have your students stand side-by-side in a line, with one bucket or box at each end of the line. Place all the crumbled paper in one box. Explain to the students that the paper represents thermal energy, and the box with all the paper is hotter because it has more thermal energy than the empty box. Tell students they, standing in a line, are a conductor from one box to another. Students should make sure they can easily pass paper between them, and if not they should adjust their positions. When you say begin, students begin passing paper along the "conductor" (the line of students) until all the "heat" (the crumpled paper) is distributed evenly between the two boxes and the students. It may be helpful to know how many pieces of paper you are using, or you can just visually estimate the distribution of the paper. Tell students that when they have the thermal energy evenly distributed, both boxes and the conductor between them are all the same temperature and energy is no longer being transferred.

CONTINUED ON NEXT PAGE

6. Convection is modeled by having the students move into a long, narrow circle. Place the boxes on opposite sides of the room and indicate a circular pathway the students should move in. Place all the "heat" (cumpled paper) in one box. Explain to students that the full box is hotter than the empty box. To transfer the energy by convection, students will pick up some "heat" from the full box and carry it in the pathway you indicate to the empty box. Students will continue to do this until the "heat" is evenly distributed among the buckets and students. At that point everything is the same temperature and energy transfer stops.
7. Radiation is modeled in the most fun way of all! You will stand at the front of the room holding one box. You can have another student hold the other box if you wish, and you can each have a partner to help you "radiate" if you wish. Students will be given the "heat." They are hotter than you and the buckets, and they should radiate the energy toward you by throwing it to the boxes. You or your partner then radiate some of it back until the energy is evenly distributed. This models radiation in that it is the least efficient way to transfer energy to a specific object, and shows how other objects (the floor, for example) get heated as well.
8. Discuss safety of lasers and tools with lasers, and demonstrate the appropriate use of the infrared (IR) thermometer. Explain that when the button is pressed, the device measures the surface temperature of any object at which it is directed.
9. As a class, use the IR thermometer to complete the *Radiation* activity. Have students record and suggest items in the predicted ranges. Find the actual temperatures and try to find one device or surface that fits in each category on the worksheet. Have students complete the conclusion as individuals or in small groups.
10. Discuss how radiant transfer of thermal energy can be a major factor in the comfort of a room. A cold winter day will make the walls feel colder, thus making the room feel colder than the stated temperature.
11. Return the paper to the recycle bin, and have students make the graphic organizer from the Student Guide, page 16.
12. Introduce the concept of an insulator to students. Explain to them that good thermal insulators do not allow thermal energy transfer by any of the three mechanisms, and keep hot air masses separated from cool air masses.
13. Preview the *Insulation Investigation* activity for students, assigning a control set of cans to one group of students, the empty box to another group, and the three types of insulation to three other groups. Assign roles to students as necessary.
14. Explain to students the importance of experimental controls. In this activity, the spay-foam insulated cans needed to be covered with a plastic bag to keep the foam from sticking to them, and the cans and insulation need to be contained in a box to keep the spray foam from going all over the table. Therefore, to maintain experimental control, each of the cans must be wrapped in a plastic bag, and one set of cans must be placed in an empty box while another plastic-wrapped set of cans is set on the table without a box. The independent variable is the type of insulation; using boxes and bags in the manner described eliminates their presence or absence from being a confounding variable.
15. Have students conduct the investigation, and provide for them a place to record their data for classroom discussion. A chalk board or white board work well, or if you have the ability, allow them to input their data onto a computer spreadsheet from which they can make graphs to compare how quickly the temperature changed for each insulation type.
16. When students have finished the activity, discuss the data as a large group, then encourage students to identify the best insulator and explain why it is best.
17. Distribute materials for the *Air Infiltration Investigation* and assign students to a window or group of windows to test. Have students come back as a large group to discuss their findings. They will come back to this activity when they conduct their student audits.

Lesson 3 – Understanding Electrical Energy

Background

Students will be introduced to the basics of electricity, including current, voltage, power, and how the utilities charge homes and schools for electric power. Efficiency with electrical appliances is introduced, including a discussion of the ENERGY STAR® program. Students measure how much energy electrical devices at school use, and what their monetary and environmental costs are.

Objectives

- Students will able to explain electric power at a basic level.
- Students will be able to determine which devices are most efficient using data gathered from the device itself.
- Students will be able to calculate the cost and environmental impact of operating electrical devices.

Concepts

- Electrical charges and magnetic fields are related.
- Moving a magnetic field will generate electric current. This is how generators at power plants operate.
- Electric power is a combination of the current and voltage, and is measured in watts.
- The electric utility measures electrical consumption in a school two ways: demand, and energy use.
- Electrical demand is the greatest total power used at any point within a given time frame.
- Electrical energy use is the total kilowatt-hours used within a building.
- Not all devices use the same amount of power. Some can be more efficient and earn an ENERGY STAR® rating.
- All plug-in devices use at least a small amount of power, and those devices can add up to big savings when turned off.
- Using electricity affects the environment.

Time

2-3 class periods, plus 1-2 additional periods for *Baseload Balance*, if needed

Materials

- Assorted electrical appliances and electronic devices
- Kill A Watt® Meter
- *Transporting Electricity* master, page 45
- *Kill A Watt® Meter* master, page 46
- Student Guide pages 23-36
- Calculators (optional)

Preparation

- Gather materials needed for the activities. For the *Measuring Electricity Use and Iis Cost* activity, a wide variety of devices typically found in school is best. Printers, computers, charging stations, copy machines, small refrigerators, etc. make good test subjects, as do any science lab equipment students use frequently such as electronic balances, hot plates (with caution), and microscopes.
- Prepare *Transporting Electricity* and *Kill A Watt® Meter* masters to project.
- Familiarize yourself with the Kill A Watt® meter and its controls.

Additional Resources

- If your students need a refresher or basic knowledge of electricity, check out NEED's *ElectroWorks*.
- If you would like to go into more detail about climate change with your students, you can use some of the *Understanding Climate Change* activities at this point to reinforce the importance of reduced energy use.

These guides and more can be downloaded free of charge in PDF format at shop.NEED.org.

CONTINUED ON NEXT PAGE

- Read through the information for *Baseload Balance* and decide if you will use it. The instructions and materials can be found on pages 23-41 of this guide.
- Make copies of the student pages as needed.

✔ Procedure

1. Introduce or review electricity with students. Explain that moving electric charges have magnetic fields, and vice versa. Explain that this phenomenon, called electromagnetism, is what electric power generation is based on.
2. Explain the different aspects of measuring electricity – current, voltage, power, and electrical energy (kilowatt-hours). Show how they are related mathematically, and use the water pressure analogy outlined in the student text to help students understand them. Be sure to emphasize that the water tank analogy is not a perfect model, but it is a reasonably good representation.
3. Explain how electricity is transported. Project the *Transporting Electricity* master and explain what is happening at each step. Allow students time to write these steps and descriptions in their own words in their notebooks or in the Student Guide.
4. Explain that electric utilities must have electricity available to consumers all day, every day, and must have power available that exceeds expected demand. If you choose to do so, this is a good time to incorporate the *Baseload Balance* activity.
5. Briefly explain that using fossil fuels to generate electricity has negative environmental impacts, and that reducing electrical energy use can help mitigate those impacts.
6. Preview the *Measuring Electricity Use and Iis Cost* and *Comparing Appliances* activities for students by explaining what they are intended to demonstrate.
7. Lead students through, and allow students at least one class period to conduct the Kill A Watt® activity. Younger students may need a little help with the calculations.
8. Explain the sample school electric utility bill found in the Student Guide on page 34. If available, distribute or project a copy of your school's utility bill for comparison.

Extensions

- Have your students go out into their neighborhood or community and photograph, from a safe distance, the different parts of electricity transmission that they can find. Using the map found on https://www.eia.gov/state/, locate power plants in your area. Students can print and paste, or digitally insert these photographs and their locations into a master file you create.
- Use your local electric utility bill to determine how much carbon dioxide is emitted based on the energy source breakdown provided by your utility. Utilities are mandated to report this information on the bill or on an enclosure with the bill. Most report it monthly or quarterly. You can use mathematical proportions to get a reasonable estimate of carbon dioxide emissions per kilowatt-hour based on the U.S. average amount and energy source breakdown.

Lesson 4 – Understanding Lighting

Background

From 1879 until 2007, lighting was simple. We bought incandescent light bulbs based on their wattage, and schools and other commercial buildings used four-foot fluorescent tubes for light. In 2007 the Energy Independence and Security Act was passed, mandating better efficiency in lighting. Since then we've been presented with a smorgasboard of lighting choices, which can be confusing. This lesson aims to break down the types of lighting available to consumers, explaining how they work and how they compare in terms efficiency and brightness.

✪ Objectives

- Students will be able to explain in basic terms how each of the available lighting styles produces light.
- Students will be able to compare light bulbs based on efficiency and brightness.
- Students will be able to calculate the life cycle cost of lighting to justify a purchase decision.

CONTINUED ON NEXT PAGE

★Concepts

- Light fixtures and light bulbs transform electrical energy into radiant energy, but they do it different ways.
- Old-style incandescent bulbs using filaments are 90 percent inefficient and have been replaced with more efficient lighting.
- Simply changing a light bulb in a fixture can dramatically reduce the amount of electrical energy used in a building.
- Light bulbs should be compared according to the lumens emitted, found on the Lighting Facts label, and not by the wattage as was done years ago.

Time

1-2 class periods

Materials

- Student thermometers
- CFL bulb
- LED bulb
- Incandescent bulb
- Kill A Watt® meter
- Light meter
- 1-3 Lamps
- Tape
- Ruler or meter stick
- Calculators (optional)
- *Light Bulbs Comparison* master, page 48
- Student Guide pages 37-42

Preparation

- Gather the materials needed to conduct the activities. When students test the bulbs for brightness, it is helpful to have the other lights turned off to get the most accurate measurement possible.
- Prepare a copy of the *Light Bulb Comparison* master to project while leading students through the activity on page 42 of the Student Guide.
- Decide ahead of time if you are going to have students do calculations using precise decimal calculations of number of bulbs needed (8.3 and 2.5) or whole numbers of bulbs needed (9 and 3) in the comparison activity. One is mathematically precise while the other reflects real-world purchases.
- Make copies of the student pages as needed.

✔Procedure

1. Introduce the unit by asking students about the types of lighting they use. Help them identify the lighting in the room. Explain to students that they will be learning about the different kinds of lighting and which are most efficient.
2. Assign reading the student text as an in-class activity or homework.
3. Have students work through the *Light Bulb Investigations* in small groups. In between groups, the thermometers should be allowed to return to room temperature before the next group works.
4. Introduce the *Comparing Light Bulbs* master. Go through the information with students, and guide them as much as necessary through the activity.

Extensions

- This lesson does not delve into light temperature, which is a measure of the color and perception of light. In general, higher temperature light is more blue, while lower temperature light is more red. Your students may find this discussion interesting and relevant because the light quality is a large determining factor when people purchase light bulbs. Navigate to https://energy.gov/energysaver/lighting-principles-and-terms for more information, and discuss as a class. Have students design an experiment to test light temperature and color.

Lesson 5 – Energy Systems Working Together

Background

Very few energy using systems in a building work alone. Heating systems require a fuel for heat – usually natural gas or fuel oil in schools – and an electrical system that distributes that energy to heat the building. Lighting can affect the heating and cooling system if it radiates thermal energy itself. Because no system in a school stands alone, this lesson is designed to help students understand how all the systems in the school use energy while working together.

Objective

- Students will be able to explain how one energy-using system in a building might affect another.

Concepts

- Energy systems use more than one form of energy.
- Buildings require a group of system components that work together to keep its occupants comfortable and working well.
- If one system within a building does not function properly, the others may not operate efficiently.

Time

1 class period

Materials

- Student Guide pages 43-45

Preparation

- Preview the lesson to anticipate student questions. It may be helpful to gather some basic knowledge about the energy consuming systems in your school building to relate the fictitious story in the lesson to students' own experiences.
- Make copies of the student pages as needed.

Procedure

1. Introduce the lesson by asking students to brainstorm energy consuming systems in your school. List their ideas where all students can see them, such as on the white board or projection screen.
2. Have students read the text, making notes about Washington School on the *Spot the Energy Wasters* worksheet.
3. Place students in small groups to continue working on an energy saving action plan for Washington School. Younger students may need some prompting to identify all the areas where energy can be saved.

Extensions

- As an introductory activity before conducting an audit themselves, have students brainstorm areas in your school where they already know energy is not being used efficiently.

Lesson 6 – Evaluating Energy Use in a Building

Background

Students know they are an integral part of the school, but they often feel very powerless inside it. One area where students can take some control and affect positive change is by conducting a student energy audit and developing an energy savings plan.

Lesson 6 provides a framework for students to evaluate the energy being used within your school and to develop a plan for reducing energy use. Additionally, students develop leadership and presentation skills as they collect and evaluate data and make decisions about what to do, then present those ideas to authorities within the school.

✪Objective

- Students will be able to independently audit a classroom or group of rooms with minimal supervision and guidance.

★Concepts

- All buildings use energy.
- Many areas in a school use energy the same ways, such as from one classroom to another, and others use energy very differently, such as in the cafeteria or gymnasium.
- Even the most efficiently equipped schools can reduce the amount of energy used.

Time

2 class periods for introduction and discussion, and several blocks of 15 minutes each for student groups to gather data

Materials

- Digital thermometer
- Hygrometer
- Light meter
- Kill A Watt® meter
- Infrared (IR) thermometer
- Clipboards or folders
- *Kill A Watt® Meter* master, page 46
- *The Light Meter* master, page 47
- *Digital Thermometer master,* page 49
- *Hygrometer* master, page 50
- Student Guide pages 46-55
- Additional copies of *Student Audit Recording Form*, Student Guide pages 53-54, as needed

Preparation

- Familiarize yourself with all the audit tools.
- Prepare masters needed of *Kill A Watt® Meter, The Light Meter, Digital Thermometer*, and *Hygrometer* to project during discussion.
- Well ahead of your audit day(s), communicate with other teachers and staff in your building to inform them about what your students are doing and to seek permission to enter their rooms and work spaces to gather data. Ideally, data is gathered while the room is in use and also when no one is using the room, for comparison.
- Assign students to groups of 3-5 students per group, and assign each group to a work area consisting of one or more classrooms, and at least one other, non-classroom space such as the library, front office, or lunch room.
- Assign one group of students to each section of questions on the *School Building Survey* in the Student Guide on pages 51-52. They will find the answers to those questions for the final recommendation phase.
- Make as many copies of the *Student Audit Recording Form* as your students will need – usually 2 or 3 copies per student per room evaluated. One copy is for data gathering while the room is in use, one when the room is empty, and a third after energy-saving recommendations have been made and implemented, for comparison.
- Gather clipboards or folders and pens for students to use while auditing spaces. It also may be useful to make "Student Auditor" hang tags or name badges for students to wear while auditing.

CONTINUED ON NEXT PAGE

✔ Procedure

1. Project the masters for each of the audit tools, explaining how they work. Decide as a group which temperature scale will be used to record temperatures. Because HVAC professionals in the U.S. work with degrees Fahrenheit, you may find this is the best scale to use for this activity.
2. Discuss the procedures students will follow to audit the school. To practice, have the entire class audit your classroom and its surroundings, with one student reading each audit tool. You can also have several students use each tool to practice with them, if you'd like.
3. Split students into their working groups and have them each assume a role within the group. One student will need to read the thermometer and test hot water temperature; one student will operate the hygrometer and record general data about the room such as occupancy and blinds, etc.; one student will use the light meter and record data about lighting; one student will use the Kill A Watt® meter where appropriate and gather data about plugged-in devices; one student will use the IR thermometer to gather data about the temperatures of surfaces/landscaping, and the temperatures exiting systems in the space; and one student will conduct the tissue paper test and record data about doors, windows, and drafts. Groups with fewer than five students should double up on roles.
4. Have students read the *School Building Survey* questions. Assign each section to one of the working groups. Allow time for the groups to determine who can answer the questions for them. You may need to help younger students with this, and you will probably have to help facilitate this information gathering.
5. After students have audited each space and answered their *School Building Survey* questions, reconvene as a class and discuss the data. Provide a place for recording class-wide observations and a place for brainstorming energy-saving ideas.
6. Decide how you would like students to proceed with their recommendations, whether with a written report or an oral presentation, or both. If students are going to make a presentation, have them select who the main presenter(s) should be. Secure an appointment for students to present their findings and present their energy-saving plan to adminstrators, faculty, or other students.
7. Enlist the help of other teachers and student groups and conduct an energy savings campaign in the school. Students can make posters and flyers, and record video PSAs to encourage students and staff to conserve energy.

Extensions

- Student energy audits lend themselves very nicely to a Youth Awards project, and can provide an avenue for your students to develop leadership and presentation skills. For more information, visit http://www.need.org/youth-awards.

Assessment and Evaluation

☑ Group Work Rubric

- Ask students to help devise a rubric to assess their group work on data collection, and class discussion during the audit process. A sample data and notebooking rubric can be used below.
- Evaluate final group work on final audit reccomendations. Share the rubric with groups ahead of time. A sample is provided below.
- Use Energy Efficiency Bingo and Conservation in the Round as formative assessments throughout the unit.
- Evaluate the unit with your students using the *Evaluation Form* on page 59. Return it to NEED.

Student Reporting Form or Science Notebook Rubric

- This is a sample rubric that can be used with student reporting forms or science notebooks. You may choose to only assess one area at a time, or look at an investigation as a whole. It is suggested that you share this rubric with students and discuss the different components ahead of time.

	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	DATA/OBSERVATIONS	CONCLUSIONS
4	Written explanations illustrate accurate and thorough understanding of scientific concepts.	The student independently conducts investigations and designs and carries out his or her own investigations.	Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used appropriately. Data and observations are presented clearly and neatly with appropriate labels.	The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts.	The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations.	Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly.	The student communicates what was learned and uses some evidence to support reasoning.
2	Written explanations illustrate a limited understanding of scientific concepts.	The student may not conduct an investigation completely, parts of the inquiry process are missing.	Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately or have some missing information.	The student communicates what was learned but is missing evidence to support reasoning.
1	Written explanations illustrate an inaccurate understanding of scientific concepts.	The student needs significant support to conduct an investigation.	Data and/or observations are missing or inaccurate.	The conclusion is missing or inaccurate.

☑ Group Work Rubric

- This is a sample rubric that can be used to assess group recommendation projects for Lesson 6.

	CONTENT	ORGANIZATION	ORIGINALITY	WORKLOAD
4	Project covers the topic in-depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Project shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Project includes essential information about the topic. Subject knowledge is accurate.	Content is organized in a logical sequence.	Project shows some original work. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Project includes essential information about the topic, but there are 1-2 factual errors.	Content is logically organized but may have a few confusing sections.	Project provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing a fair share of the work.
1	Project includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Project provides some essential information, but no original thought.	The workload is not divided, or it is evident that one person is doing a significant amount of the work.

Answer Keys

Energy Source Matching | *STUDENT GUIDE PAGE 7*

9, 7, 8, 3, 2, 4, 5, 1, 10, 6

Forms and Sources of Energy | *STUDENT GUIDE PAGE 8*

Part 1

Nonrenewable	Renewable
Petroleum – chemical	Biomass – chemical
Coal – chemical	Hydropower – motion
Natural Gas – chemical	Wind – motion
Uranium – nuclear	Solar – radiant
Propane – chemical	Geothermal – thermal

Part 2

Chemical – 85.7%

Nuclear – 8.7%

Motion – 4.7%

Radiant – 0.6%

Thermal – 0.2%

Nonrenewable – 89.5%

Renewable – 10.4%

Transporting Electricity | *STUDENT GUIDE PAGE 30*

1. Power Plant: Site of electrical power generation
2. Step-up transformer: Voltage from the power plant is increased dramatically for transmission
3. Transmission line: Carries very high voltage power over large distances
4. Power tower: Supports very high voltage lines
5. Step-down transformer: Reduces voltage of electricity for local distribution
6. Distribution line: Carries power from transmission lines to neighborhoods and businesses
7. Neighborhood transformer: Reduces voltage to safer level for home use

Comparing Appliances | *STUDENT GUIDE PAGE 36*

Water Heater 1	Expenses	Cost to Date	Water Heater 2	Expenses	Cost to Date
Purchase Price	$750	$750	Purchase Price	$650	$650
Year One	$240	$990	Year One	$270	$920
Year Two	$240	$1,230	Year Two	$270	$1,190
Year Three	$240	$1,470	Year Three	$270	$1,460
Year Four	$240	$1,710	Year Four	$270	$1,760
Year Five	$240	$1,950	Year Five	$270	$2,000
Year Six	$240	$2,190	Year Six	$270	$2,270
Year Seven	$240	$2,430	Year Seven	$270	$2,540

How many years will it take before you begin to save money? A little more than three years.

How much money will you have saved after seven years? $110

Comparing Light Bulbs | *STUDENT GUIDE PAGE 42*

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours	25 bulbs	8.3 bulbs	2.5 bulbs	1 bulb
x	Price per bulb	$0.50	$1.50	$1.50	$1.33
=	**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
=	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Price of electricity per kWh	$0.126	$0.126	$0.126	$0.126
=	**Cost of Electricity**	**$188.25**	**$134.91**	**$40.79**	**$37.65**
	LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Cost of bulbs	$12.50	$12.45	$3.75	$1.33
+	Cost of electricity	$188.25	$134.91	$40.79	$37.65
=	**Life cycle cost**	**$200.75**	**$147.36**	**$44.54**	**$38.98**
	ENVIRONMENTAL IMPACT	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Pounds (lbs) of carbon dioxide per kWh	1.6 lb/kWh	1.6 lb/kWh	1.6 lb/kWh	1.6 lb/kWh
=	**Pounds of carbon dioxide produced**	**2,400.0 lbs carbon dioxide**	**1,720.0 lbs carbon dioxide**	**520.0 lbs carbon dioxide**	**480.0 lbs carbon dioxide**

Energy Efficiency BINGO Instructions

***Energy Efficiency Bingo* is a great icebreaker for a NEED workshop or conference. As a classroom activity, it also makes a great introduction to an energy unit.**

Preparation

- 5 minutes

Time

- 45 minutes

Bingos are available on several different topics. Check out these resources for more bingo options!

- Biomass Bingo—*Energy Stories and More*
- Change a Light Bingo—*Energy Conservation Contract*
- Coal Bingo—Coal guides
- Energy Bingo—*Energy Games and Icebreakers*
- Forms of Energy Bingo—*Science of Energy*
- Hydropower Bingo—Hydropower guides
- Hydrogen Bingo—*H_2 Educate*
- Nuclear Energy Bingo—Nuclear guides
- Oil and Natural Gas Bingo—Oil and Natural Gas guides
- Solar Bingo—Solar guides
- Transportation Bingo—Transportation guides
- Wind Energy Bingo—Wind guides

Get Ready

Duplicate as many *Energy Efficiency Bingo* sheets (found on page 51) as needed for each person in your group. In addition, decide now if you want to give the winner of your game a prize and what the prize will be.

Get Set

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

Go

PART ONE: FILLING IN THE BINGO SHEETS

Give the group the following instructions to create bingo cards:

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

PART TWO: PLAYING BINGO

Give the class the following instructions to play the game:

- When I point to you, please stand up and in a LOUD and CLEAR voice give us your name. Now, if anyone has the name of the person I call on, put a big "X" in the box with that person's name. When you get four names in a row—across, down, or diagonally—shout "Bingo!" Then I'll ask you to come up front to verify your results.
- Let's start off with you (point to a player in the group). Please stand and give us your name. (Player gives name. Let's say the player's name was "Joe.") Okay, players, if any of you have Joe's name in one of your boxes, go ahead and put an "X" through that box.
- When the first player shouts "Bingo," ask him (or her) to come to the front of the room. Ask him to give his name. Then ask him to tell the group how his bingo run was made, e.g., down from A to M, across from E to H, and so on.

- Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on his bingo run. That player then stands and the bingo winner asks him the question which he previously answered during the 20-minute session. For example, if the statement was "can name two renewable sources of energy," the player must now name two sources. If he can answer the question correctly, the bingo winner calls out the next person's name on his bingo run. However, if he does not answer the question correctly, the bingo winner does not have bingo after all and must sit down with the rest of the players. You should continue to point to players until another person yells "Bingo."

ENERGY EFFICIENCY BINGO

ANSWERS

A. Can name two ways to increase a car's MPG

B. Can name three ways to save energy at home

C. Can name three ways to save energy at school

D. Has at least one ENERGY STAR® appliance at home

E. Knows the definition of *energy efficiency*

F. Knows the definition of *energy conservation*

G. Knows what an ENERGY STAR® label means

H. Knows what SEER is

I. Knows a type of bulb that uses one-quarter of the energy of incandescents

J. Knows where to find an EnergyGuide label

K. Can name two appliances that should be run only when fully loaded

L. Uses day lighting in the classroom instead of overhead lights

M. Sets this item differently at day and night and for the season

N. Knows the number one use of energy in the home

O. Has an energy conservation team at school

P. Knows whether energy is the first, second, or third highest expenditure in a school district (choose one)

A proper tire inflation, drive the speed limit, slow acceleration	**B** Switch to CFLs or LEDs, use a programmable thermostat, wash clothes in cold water, etc.	**C** Turn off computers/lights/appliances when not in use, close doors and windows, etc.	**D** ask for location/description
E Using technologies to continue activities at the same level while using less energy	**F** Choosing to use less energy through alternative behaviors or actions	**G** The product meets energy efficiency requirements	**H** seasonal energy efficiency ratio of cooling output by power consumption
I CFL or LED	**J** On appliances and products for homes and business	**K** dishwasher and clothes washer	**L** ask for details
M programmable thermostat	**N** heating/cooling	**O** ask for description/details	**P** second, the first is personnel

Conservation in the Round

***Conservation in the Round* is a quick, entertaining game to reinforce information about energy sources, forms of energy, and general energy information from the *Monitoring and Mentoring* student informational text or the *Intermediate Energy Infobook*.**

Grades

- 5–12

Preparation

- 5 minutes

Time

- 20–30 minutes

"In the Rounds" are available on several different topics. Check out these guides for more, fun "In the Round" examples!

- Coal in the Round—Coal guides
- Energy in the Round—*Energy Games and Icebreakers*
- Forms of Energy in the Round—*Science of Energy* guides
- Hydrogen in the Round—*H_2 Educate*
- Oil and Natural Gas Industry in the Round—*Fossil Fuels to Products*, *Exploring Oil and Natural Gas*
- Solar Energy in the Round—*Energy From the Sun*
- Transportation Fuels in the Round—Transportation guides
- Uranium in the Round—Nuclear guides

Get Ready

- Copy the *Conservation in the Round* cards on pages 46-48 onto card stock and cut into individual cards.
- Make an additional copy to use as your answer key. This page does not need to be cut into cards.
- Have the class refer to the informational text in the Student Guides for quick reference, or refer to the *Intermediate Energy Infobook*.

Get Set

- Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
- Have the students look at their bolded words at the top of the cards. Give them five minutes to review the information about their words from their Student Guides.

Go

- Choose a student to begin and give the following instructions:
  - Read the question on your card. The student with the correct answer will stand up and read the bolded answer, "I have ______."
  - That student will then read the question on his/her card, and the round will continue until the first student stands up and answers a question, signaling the end of the round.
- If there is a disagreement about the correct answer, have the students listen to the question carefully looking for key words (forms versus sources, for example) and discuss until a consensus is reached about the correct answer.

Alternative Instructions

- Give each student or pair a set of cards.
- Students will put the cards in order, taping or arranging each card so that the answer is directly under the question.
- Have students connect the cards to fit in a circle or have them arrange them in a column.

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 transmitted on the electric grid to consumers. It also encourages students to explore the differences between baseload and peak demand power, and how power companies maintain supply to ensure customers have power as they need it.

Students will be introduced to the economics of electricity generation and supply and be able to see first-hand the financial challenges utilities must overcome to be able to provide the power demanded by consumers at the lowest cost. Figures, costs, and sources used in this activity are roughly based on current industry uses and costs, but have been made into round figures for ease of implementation. Students will first play a game with a game board and pieces. This activity is then followed by a simulation where students assume roles as "loads" or "generation". You may decide to change the order of the activity or eliminate a part of the activity to meet the needs of your students.

Objectives

- Students will be able to differentiate between baseload and peak demand power.
- Students will be able to explain the purpose of using a variety of sources to meet base and peak load power demand.
- Students will be able to describe the challenges of using certain sources to meet base and peak load power demand.

Materials

- Scissors and tape for each student or small group
- String
- Rope
- Colored paper
- Individual marker boards with erasers and markers
- *Baseload Balance Student Information*, pages 27-28
- Game board for each student or small group, pages 30-31
- Game pieces for each student or small group, pages 32-33
- *Generation Parameters* master, page 34
- Hang tags, pages 35-39
- *Incident Cards*, page 40
- *Cheat Sheet*, page 41

Vocabulary *SPECIFIC TO THE GAME*

- Baseload
- Generation
- Load
- Transmission
- Peak demand
- Megawatt

Preparation

- Familiarize yourself with the activity instructions and student background information before facilitating the game with students. Decide which version of the game you will use, if only using one part of the activity.
- Make a copy of the *Cheat Sheet* for yourself to have handy when going over the game and during game play with students.
- Copy the hang tags and cut them apart. Attach the tags to three colors of paper or color the cards so that the generation, the transmission, and the load cards are each a different color. Laminate, if desired, for future use.
- Make a copy of the *Incident Cards*. Cut the cards apart and fold on the dotted line. Laminate, if desired, for future use.
- Make a copy of the *Game Board* and *Game Pieces* for each student or small group of students. Laminate the board for future use, if desired.
- Make a copy of the background information for each student.
- Prepare a copy of the *Generation Parameters* master to project for discussion.
- Designate an area of the room to be the Regional Transmission Organization (RTO). On one side of this area will be the generation group, and the other side will be the load group. Each side should have its own marker board, eraser, and marker.

- Decide if a student will be the RTO leader, or if the teacher or another adult will assume this role. Having a student assume this position will create a more student-centered activity. Depending on the ability of the students in your group, using a student for this role may require more monitoring and time than if a teacher is in charge.
- Instruct all students to read the *Baseload Balance Student Information* the night before playing as a homework assignment.

✔ Procedure *FOR INDIVIDUAL / SMALL GROUP PLAY*

1. Distribute a game board and game pieces to each student or small group of students.
2. Explain the game board, and what each section represents. Explain that the x-axis shows the 24 hours of a typical day, and the y-axis shows the amount of electric power in demand.
3. Explain the game pieces by describing each energy source, the amount of power being generated, and the difference between base-load and peak load.
4. Instruct the students to cut the game pieces apart.
5. Students are to "meet demand" by laying their game pieces over the game board, starting first with baseload generation, using it to meet baseload demand. They can make small tape rings to hold their pieces in place on the game board, as needed.
6. To meet peak demand, students should trim their game pieces to cover the peak demand shown on the game board, maintaining the information on each piece (trim the blank areas first).
7. At the bottom of the game board, students can calculate the cost of electric power generation by adding the costs of the generating supply for that hour, if desired. Students can then calculate the average cost per megawatt-hour to generate electricity in that 24-hour period.

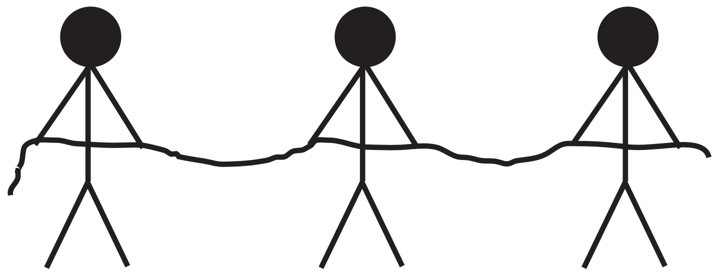
❓ Discussion Questions

1. What is the peak demand time? When is the least amount of power needed?
2. What was the average cost per megawatt-hour during daylight hours?
3. What was the average cost per megawatt-hour over the entire 24-hour period?
4. Everyone needed to use most of the same baseload generation. However, there were options for some of the generation and options to meet peak demand. Why did you choose your particular sources?
5. How would knowledge of historical data and weather forecasts help in making decisions about which sources to use?

✔ Procedure *FOR SIMULATION ACTIVITY*

1. Assign each student a role that corresponds to each hang tag. If your class does not have enough students for each tag, the baseload tags can be tied to the rope because they are always in operation. A list of the roles can also be found on page 25. The Transmission roles are best assigned to students who are able to think quickly on their feet and have good math skills.
2. Allow time for students to research their roles and re-read the background information. Students should be familiar with the vocabulary and information on their hang tag, including generating capacity, energy source, and power demand. Depending on the level of your students, you may choose to have them skip the section of the background information that discusses regional transmission organizations and independent system operators.
3. Project the *Generation Parameters* master for the class. Discuss the relative cost for each source and plant type as well as the suggested reasoning for the cost of each.

4. The activity begins with the transmission organization students gathering in the Regional Transmission Organization area, each holding onto the rope or string. The student on each end should have plenty of available rope or string onto which the generation students and load students will attach. These students will decide which peak load providers (plants) will be brought online to meet increasing demand as the activity progresses. They will also help the RTO by tabulating the current load or generation on their side of the line. They will display it on their marker board and update it as the activity progresses.



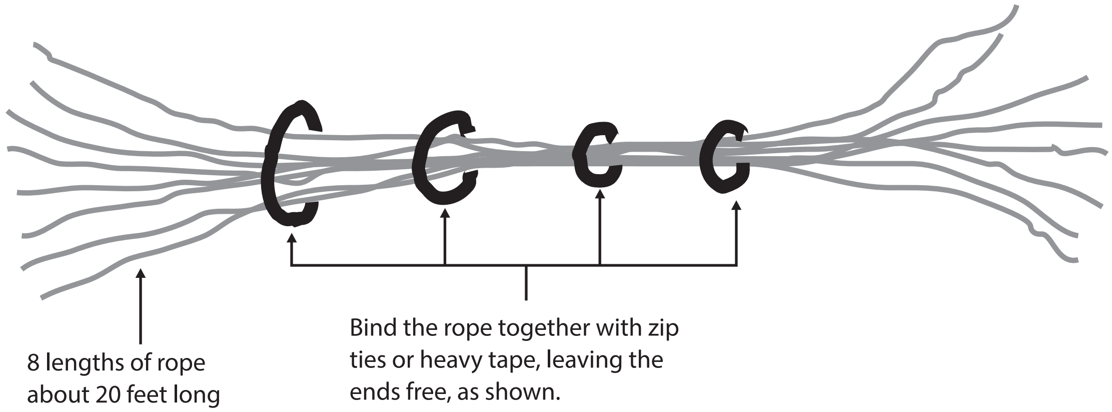
5. In the generation group, the residential baseload, commercial baseload, heavy industry baseload, and all baseload generation students all hold ends of the rope on their respective sides. They will be holding onto the rope during the entire activity because as baseload power or generation, they are providing or using power all the time.
6. At the appropriate time indicated on each hang tag, each load student will join the grid, increasing the load demand. Residential demand comes up (online) at about 7:00 a.m. as people begin to wake. Demand continues to rise as more residential, commercial, and industry come on the grid, pulling electricity or creating another load.
7. The transmission organization students will need to balance the generation against the load while using the cheapest sources available for the longest amount of time. They will choose the best generation students to come online to balance the load students. The RTO can monitor or assist the transmission group by announcing the time and reminding each load or role when to join on.
8. If time allows after going through the activity once (one complete 24-hour period), reset the activity to early morning and run through a second time. Choose one or more of the three *Incident Cards* to introduce to the balance. You may also wish to reassign students to different roles, depending on their command of the activity in the first round.

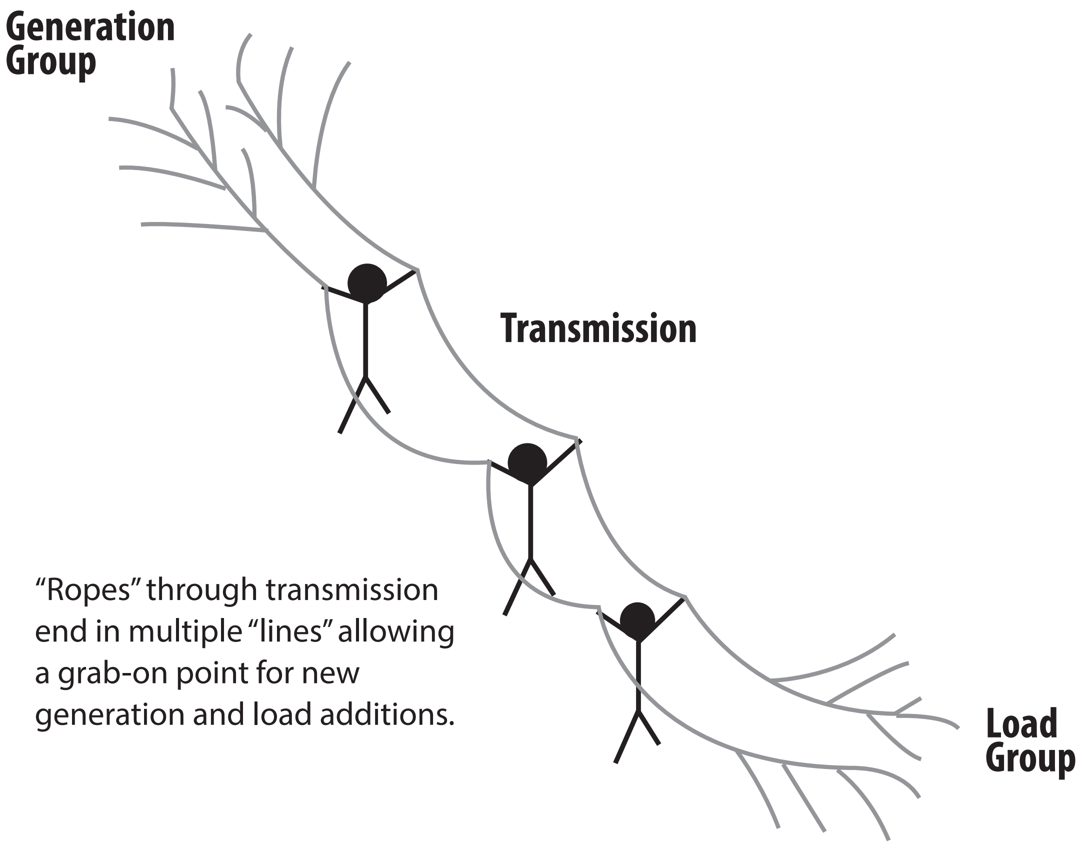
Student Roles for Ending Activity

- Baseload demand – three students
- Peak load demand – eight students
- Baseload generation – six students
- Peak load generation – seven students
- Transmission – three to five students
- RTO – one to three students or a teacher

Extensions

- RTOs usually require generation to be 15 percent above demand. Play the game again accounting for the prescribed demand plus the additional 15 percent. Hold a class discussion about why this extra generation is required.
- Have students brainstorm other scenarios that could fit onto an incident card, and test out those scenarios.
- Students could write a persuasive letter in support of a certain type of power plant after playing the game. Letters should include information gleaned about the plant's advantages and disadvantages, as well as the feasibility for use in generation of electricity at the lowest cost.
- The transmission of power on the grid during this game could also be illustrated with power "lines" made of rope. These ropes would represent the low-voltage and high-voltage lines that carry electricity. Make two bundles of rope, 8 pieces in each. Fasten the bundles of rope together with zip ties or duct tape, leaving several feet of loose rope on each end (see diagram on the next page). As generation and loads are added, each student can hold onto a different end of the rope to more accurately demonstrate the distribution of power (see diagram on next page).


8 lengths of rope
about 20 feet long
Bind the rope together with zip ties or heavy tape, leaving the ends free, as shown.


Generation Group
Transmission
"Ropes" through transmission end in multiple "lines" allowing a grab-on point for new generation and load additions.
Load Group

Baseload Balance Student Information

Introduction

Four kinds of power plants produce most of the electricity in the United States: coal, natural gas, nuclear, and hydropower. Coal plants generate about 33 percent of the electricity we use. There are also wind, geothermal, waste-to-energy, solar, and petroleum power plants, which together generate a little less than ten percent of the electricity produced in the United States. All of this electricity is transmitted to customers, or loads, via the network of transmission lines we call the grid.

Fossil Fuel Power Plants

Fossil fuel plants burn coal, natural gas, or petroleum to produce electricity. These energy sources are called fossil fuels because they were formed from the remains of ancient sea plants and animals. Most of our electricity comes from fossil fuel plants in the form of coal and natural gas.

Power plants burn the fossil fuels and use the heat to boil water into steam. The steam is channeled through a pipe at high pressure to spin a turbine generator to make electricity. Fossil fuel power plants can produce emissions that pollute the air and contribute to global climate change. The amount and type of emissions can vary based upon the type of fossil fuel and technologies used within the plant.

Fossil fuel plants are sometimes called thermal power plants because they use heat energy to make electricity. (*Therme* is the Greek word for heat.) Coal is used by many power plants because it is inexpensive and abundant in the United States.

There are many other uses for petroleum and natural gas, but the main use of coal is to produce electricity. Over 90 percent of the coal mined in the United States is sent to power plants to make electricity.

Nuclear Power Plants

Nuclear power plants are called thermal power plants, too. They produce electricity in much the same way as fossil fuel plants, except that the fuel they use is uranium, which isn't burned. Uranium is a mineral found in rocks underground. Uranium atoms are split to make smaller atoms in a process called fission that produces enormous amounts of thermal energy. The thermal energy is used to turn water into steam, which drives a turbine generator.

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

Hydropower Plants

Hydropower plants use the energy in moving water to generate electricity. Fast-moving water is used to spin the blades of a turbine generator. Hydropower is called a renewable energy source because it is renewed by rainfall.

Cost of Electricity

How much does it cost to make electricity? Cost depends on several factors.

▪ Fuel Cost

The major cost of generating electricity is the cost of the fuel. Many energy sources can be used. There are also other factors that tie into the cost of a fuel, including production cost, manufacturing or refining costs, cost of transporting the fuel, and more. Hydropower is the cheapest energy source while solar cells are typically the most expensive way to generate power.

▪ Building Cost

Another factor is the cost of building the power plant itself. A plant may be very expensive to build, but the low cost of the fuel can make the electricity economical to produce. Nuclear power plants, for example, are very expensive to build, but their fuel—uranium—is inexpensive. Coal-fired plants, on the other hand, are cheaper to build, but the fuel (coal) is more expensive than uranium.

▪ Efficiency

When figuring cost, you must also consider a plant's efficiency. Efficiency is the amount of useful energy you get out of a system. A totally efficient machine would change all the energy put in it into useful work. Changing one form of energy into another always involves a loss of usable energy. Efficiency of a power plant does not take into account the energy lost in production or transportation, only the energy lost in the generation of electricity.

Combined Cycle vs. Simple Cycle

In the most simple of thermal power plants, a fuel is burned, and water is heated to form high-pressure steam. That steam is used to turn a single turbine. Thermal power plants running in this manner are about 35 percent efficient, meaning 35 percent of the energy in the fuel is actually transformed into useable electrical energy. The other 65 percent is "lost" to the surrounding environment as thermal energy.

Combined cycle power plants add a second turbine in the cycle, increasing the efficiency of the power plant to as much as 60 percent. By doing this, some of the energy that was being wasted to the environment is now being used to generate useful electricity.

In general, today's power plants use three units of fuel to produce one unit of electricity. Most of the lost energy is waste heat. You can see this waste heat in the great clouds of steam pouring out of giant cooling towers on some power plants. For example, a typical coal plant burns about 4,500 tons of coal each day. The chemical energy in about two-thirds of the coal (3,000 tons) is lost as it is converted first to thermal energy, and then to motion energy, and finally into electrical energy. This degree of efficiency is mirrored in most types of power plants. Thermal power plants typically have between a 30-40% efficiency rating. Wind is usually around the same range, with solar often falling below the 30% mark. The most efficient plant is a hydropower plant, which can operate with an efficiency of up to 95%.

Meeting Demand

We don't use electricity at the same rate at all times during the day. There is a certain amount of power that we need all the time called baseload power. It is the minimum amount of electricity that is needed 24 hours a day, 7 days a week, and is provided by a power company.

However, during the day at different times, and depending on the weather, the amount of power that we use increases by different amounts. We use more power during the week than on the weekends because it is needed for offices and schools. We use more electricity during the summer than the winter because we need to keep our buildings cool. An increase in demand during specific times of the day or year is called peak demand. This peak demand represents the additional power above baseload power that a power company must be able to produce when needed.

Power plants can be used to meet baseload power or peak demand, or both. Some power plants require a lot of time to be brought online – operating and producing power at full capacity. Others can be brought online and shut down fairly quickly.

Coal and nuclear power plants are slow, requiring 24 hours or more to reach full generating capacity, so they are used for baseload power generation. Natural gas is increasing in use for baseload generation because it is widely available, low in cost, and a clean-burning fuel.

Wind, hydropower, and solar can all be used to meet baseload capacity when the energy source is available. Wind is often best at night and drops down in its production just as the sun is rising. Solar power is not available at night, and is greatly diminished on cloudy days. Hydropower can produce electricity as long as there is enough water flow, which can be decreased in times of drought.

To meet peak demand, energy sources other than coal and uranium must be used. Natural gas is a good nonrenewable source to meet peak demand because it requires only 30 minutes to go from total shutdown to full capacity. Many hydropower stations have additional capacity using pumped storage. Some electricity is used to pump water into a storage tank or reservoir, where it can be released at a later time to generate additional electricity as needed. Pumped storage hydropower can be brought fully online in as little as five minutes.

Some power plants, because of regulations or agreements with utilities, suppliers, etc., do not run at full capacity or year-round. These power plants may produce as little as 50 percent of maximum generating capacity, but can increase their output if demand rises, supply from another source is suddenly reduced, or an emergency occurs.

Making Decisions

Someone needs to decide when, which, and how many additional generating locations need to be brought online when demand for electricity increases. This is the job of the Regional Transmission Organization (RTO) or Independent System Organization (ISO). ISOs and RTOs work together with generation facilities and transmission systems across many locations, matching generation to the load immediately so that supply and demand for electricity are balanced. The grid operators predict load and schedule generation to make sure that enough generation and back-up power are available in case demand rises or a power plant or power line is lost.

Transmission Organizations

Besides making decisions about generation, RTOs and ISOs also manage markets for wholesale electricity. Participants can buy and sell electricity from a day early to immediately as needed. These markets give electricity suppliers more options for meeting consumer needs for power at the lowest possible cost.

Ten RTOs operate bulk electric power systems across much of North America. More than half of the electricity produced is managed by RTOs, with the rest under the jurisdiction of individual utilities or utility holding companies.

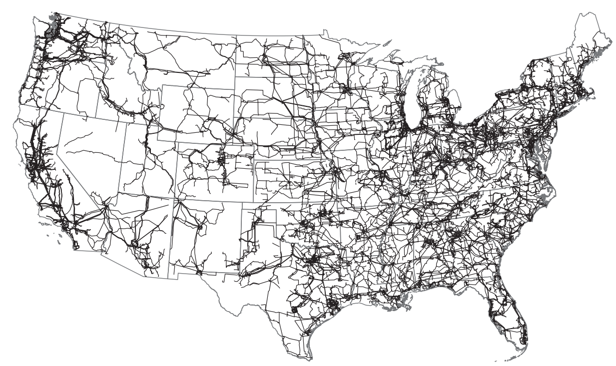
In the 1990s, the Federal Energy Regulatory Commission introduced a policy designed to increase competitive generation by requiring open access to transmission. Northeastern RTOs developed out of coordinated utility operations already in place. RTOs in other locations grew to meet new policies providing for open transmission access.

Members of RTOs include the following:

- Independent power generators
- Transmission companies
- Load-serving entities
- Integrated utilities that combine generation, transmission, and distribution functions
- Other entities such as power marketers and energy traders

RTOs monitor power supply, demand, and other factors such as weather and historical data. This information is input into complex software that optimizes for the best combination of generation and load. They then post large amounts of price data for thousands of locations on the system at time intervals as short as five minutes.

The Continental U.S. Electric Grid



Data: Energy Information Administration

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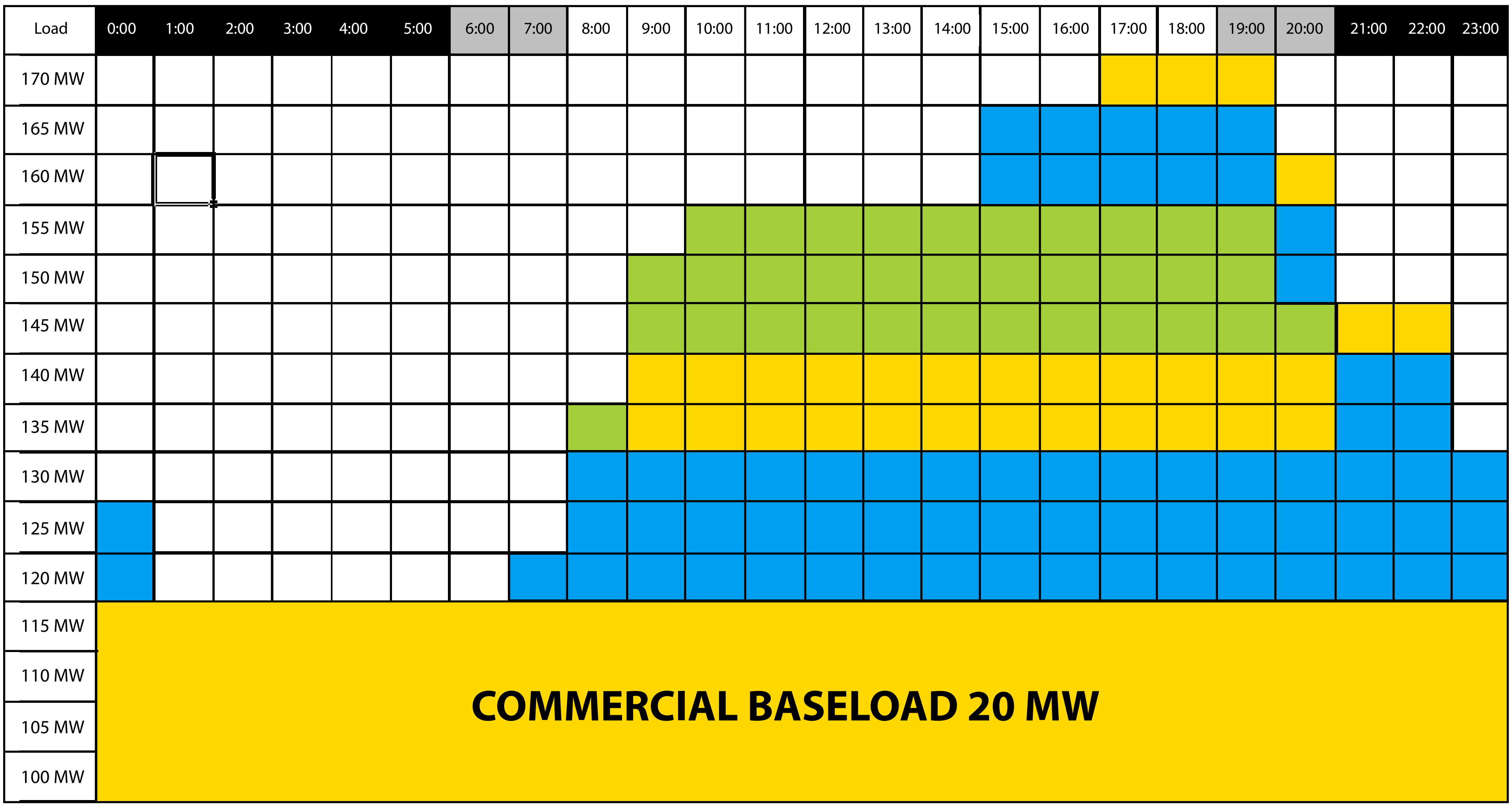
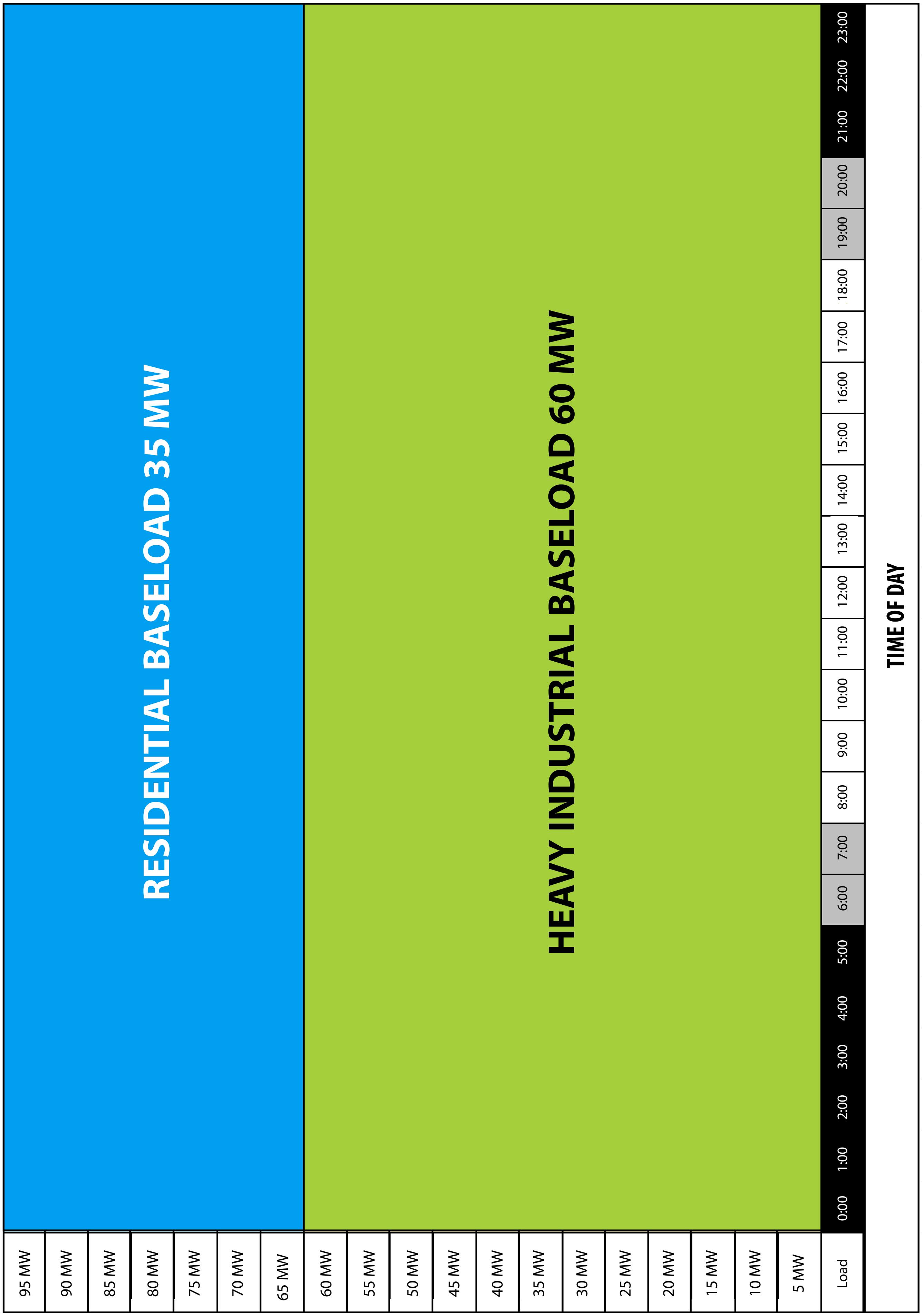
Baseload Balance
GAME BOARD




RESIDENTIAL BASELOAD 35 MW
HEAVY INDUSTRIAL BASELOAD 60 MW
95 MW
90 MW
85 MW
80 MW
75 MW
70 MW
65 MW
60 MW
55 MW
50 MW
45 MW
40 MW
35 MW
30 MW
25 MW
20 MW
15 MW
10 MW
5 MW
Load
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
TIME OF DAY

Baseload Balance
GAME PIECES

Load	0:00	1:00	2:00	3:00	4:00	5:00	6:00	7:00	8:00	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
5 MW	Coal Baseload Generation 40 MW, $40/MWh																							
5 MW																								
5 MW																								
5 MW																								
5 MW																								
5 MW																								
5 MW																								
5 MW																								
5 MW	Natural Gas Combined Cycle Baseload 20 MW, $50/ MWh																							
5 MW																								
5 MW																								
5 MW																								

5 MW	Nuclear Baseload 50 MW, $30/MWh		
5 MW			
5 MW			
5 MW			
5 MW			
5 MW			
5 MW			
5 MW			
5 MW			
5 MW			
5 MW	Hydropower Baseload, 5 MW, $30/MWh		
5 MW	Wind Baseload, 5 MW, $80/MWh	Solar Baseload, 5 MW, $180/MWh	Wind Baseload, 5 MW, $80/MWh
5 MW	Hydropower Pumped Storage Peak Load, 10 MW, $60/MWh, 5 minutes lead-in time required		
5 MW			
5 MW	Natural Gas Simple Cycle Peak Load, 10 MW, $90/MWh, 30 minutes lead-in time required		
5 MW			
5 MW	Natural Gas Simple Cycle Peak Load, 5 MW, $90/MWh, 30 minutes lead-in time required		
5 MW	Natural Gas Simple Cycle Peak Load, 10 MW, $150/MWh, 30 minutes lead-in time required		
5 MW			
5 MW	Natural Gas Simple Cycle Peak Load, 5 MW, $200/MWh, 30 minutes lead-in time required		
5 MW	Natural Gas Simple Cycle Peak Load, 5 MW, $600/MWh, 30 minutes lead-in time required		
5 MW	Hydropower Peak Load, 5 MW, $50/MWh, 5 minutes lead-in time required		

Baseload Balance
GENERATION PARAMETERS

Fuel	Capacity	Type of Generation	Time Required for Full Capacity	Cost per Megawatt-hour
Coal	40 MW	Baseload	24 hours	$40
Nuclear (Uranium)	50 MW	Baseload	24 hours +	$30
Natural Gas Combined Cycle (NGCC)	20 MW	Baseload	30 minutes +	$50
Wind	5 MW	Baseload	Immediate when wind speed is sufficient; primarily at night	$80
Solar	5 MW	Baseload	Immediate when solar intensity is sufficient; only during day	$180
Hydropower	5 MW	Baseload	5 minutes	$30
Hydropower Pumped Storage	10 MW	Peak load	5 minutes	$60
Hydropower	5 MW	Peak load	5 minutes	$50
Natural Gas Simple Cycle (NGSC)	5-10 MW each site	Peak load	5 minutes	$90-$600

Baseload Balance Hang Tag Template

Generation
Baseload
Nuclear
50 MW
$30 / MW-hour

Generation
Baseload
Coal
40 MW
$40 / MW-hour

Generation
Baseload
Natural Gas CC
20 MW
$50 / MW-hour

Generation
Baseload
Hydro
5 MW
$30 / MW-hour

Generation
Baseload
Wind
5 MW
$80 / MW-hour

Generation
Baseload
Solar
5 MW
$180 / MW-hour

Generation

Peak Load

Natural Gas SC

10 MW

$90 / MW-hour

Generation

Peak Load

Natural Gas SC

5 MW

$90 / MW-hour

Generation

Peak Load

Natural Gas SC

10 MW

$150 / MW-hour

Generation

Peak Load

Natural Gas SC

5 MW

$200 / MW-hour

Generation

Peak Load

Natural Gas SC

5 MW

$600 / MW-hour

Generation

Peak Load

Hydro (pumped storage)

10 MW

$60 / MW-hour

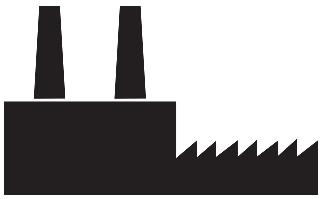
Generation

Peak Load

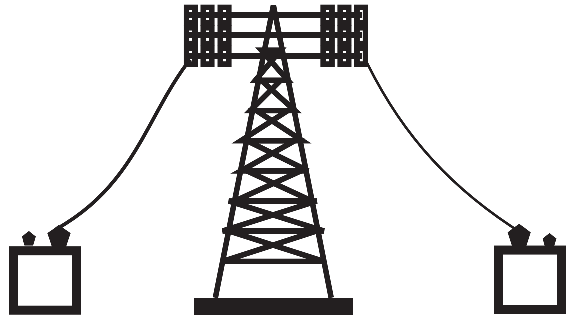
Hydro

5 MW

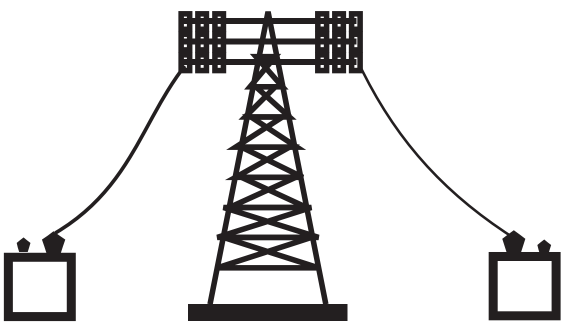
$50 / MW-hour



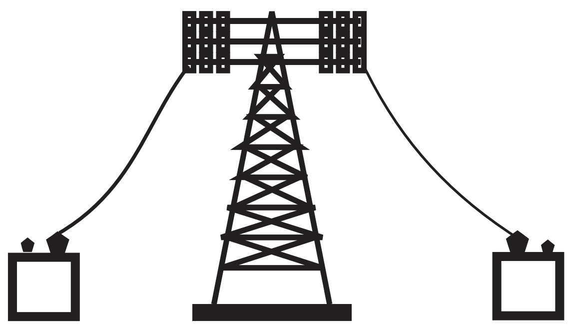
Transmission



Transmission



Transmission



Load

Commercial

20 MW

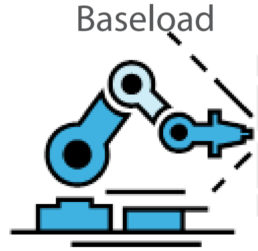
Baseload

Load

Heavy Industry

60 MW

Baseload



Load
Residential
35 MW
Baseload

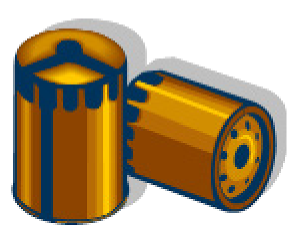
Load
Residential
5 MW
7:00 am – 12:00 am

Load
Residential
10 MW
8:00 am – 11:00 pm

Load
Commercial
10 MW
9:00 am –9:00 pm

Load
Commercial
5 MW
5:00 pm – 11:00 pm

Load
Light Industry
5 MW
8:00 am – 9:00 pm

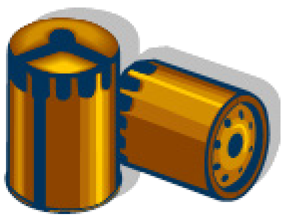


Load

Light Industry

5 MW

9:00 am – 8:00 pm



Load

Residential

10 MW

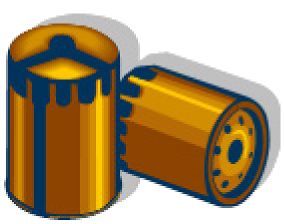
3:00 pm – 1:00 am

Load

Light Industry

5 MW

10:00 am – 8:00 pm



Regional Transmission Organization

Baseload Balance
INCIDENT CARDS

INCIDENT	At 3:00 p.m. heavy cloud cover moves over the region taking out your solar generation. If you can't provide enough power to meet the load, RTO must choose who will lose power and be in blackout. How could a blackout have been avoided?
INCIDENT	At 2:00 p.m. a baseload coal unit trips and you lose 10 MWs of baseload coal. If you can't provide enough power to meet the load, RTO must choose who will lose power and be in blackout. How could a blackout have been avoided?
INCIDENT	At 5:00 p.m. a derecho hits, damaging power lines. You lose half your commercial and residential load. You must balance your load with generation. Could this have been predicted?

Baseload Balance
CHEAT SHEET

	HANG TAGS
3	Baseload Demand
8	Peak Load Demand
6	Baseload Generation
7	Peak Load Generation
3 - 5	Transmission
1 - 3	RTO (Regional Transmission Organization)
28 - 32	**TOTAL**

LOADS

	BASELOAD DEMAND
Residential	35 MW
Heavy Industry	60 MW
Commercial	20 MW
TOTAL	**115 MW**

	PEAK LOAD/DEMAND
7:00 a.m. - 12:00 a.m.	5 MW Residential
8:00 a.m. - 9:00 p.m.	5 MW Light Industry
8:00 a.m. - 11:00 p.m.	10 MW Residential
9:00 a.m. - 8:00 p.m.	5 MW Light Industry
9:00 a.m. - 9:00 p.m.	10 MW Commercial
10:00 a.m. - 8:00 p.m.	5 MW Light Industry
3:00 p.m. - 1:00 a.m.	10 MW Residential
5:00 p.m. - 11:00 p.m.	5 MW Commercial

GENERATORS

AVAILABLE GENERATION

BASELOAD GENERATION		
Coal Baseload	40 MW	$40/MW
Natural Gas Baseload	20 MW	$50/MW
Nuclear Baseload	50 MW	$30/MW
Hydropower Baseload	5 MW	$30/MW
Solar Baseload	5 MW	$180/MW
Wind Baseload	5 MW	$80/MW

PEAK GENERATION			
Hydropower Pumped	10 MW	$60/MW	5 MIN
Natural Gas Simple Cycle	10 MW	$90/MW	30 MIN
Natural Gas Simple Cycle	5 MW	$90/MW	30 MIN
Natural Gas Simple Cycle	10 MW	$150/MW	30 MIN
Natural Gas Simple Cycle	5 MW	$200/MW	30 MIN
Natural Gas Simple Cycle	5 MW	$600/MW	30 MIN
Hydropwer Peak	5 MW	$50/MW	5 MIN

	TOTAL ONLINE
TOTAL BASELOAD DEMAND	115 MW

PEAK LOAD COMING ONLINE

7:00 a.m. - 12:00 a.m.	5 MW	120 MW
8:00 a.m. - 9:00 p.m.	5 MW	125 MW
8:00 a.m. - 11:00 p.m.	10 MW	135 MW
9:00 a.m. - 8:00 p.m.	5 MW	140 MW
9:00 a.m. - 9:00 p.m.	10 MW	150 MW
10:00 a.m. - 8:00 p.m.	5 MW	155 MW
3:00 p.m. - 1:00 a.m.	10 MW	165 MW
5:00 p.m. - 11:00 p.m.	5 MW	170 MW

PEAK LOAD GOING OFFLINE

		TOTAL ONLINE
8:00 p.m.	Lose 10 MW (2 Tags)	160 MW
9:00 p.m.	Lose 15 MW (2 Tags)	145 MW
11:00 p.m.	Lose 15 MW (2 Tags)	130 MW
12:00 a.m.	Lose 5 MW (1 Tags)	125 MW
1:00 a.m.	Lose 10 MW (1 Tags)	115 MW

Forms of Energy

All forms of energy fall under two categories:

POTENTIAL

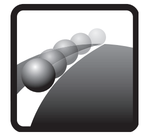
Stored energy and the energy of position (gravitational).

CHEMICAL ENERGY is the energy stored in the bonds 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.

U.S. Energy Consumption by Source, 2016

NONRENEWABLE

PETROLEUM **36.97%** *
Uses: transportation, manufacturing - includes propane

NATURAL GAS **29.20%** *
Uses: heating, manufacturing, electricity - includes propane

COAL **14.60%**
Uses: electricity, manufacturing

URANIUM **8.65%**
Uses: electricity

PROPANE
Uses: heating, manufacturing

*Propane consumption is included in petroleum and natural gas totals.

RENEWABLE

BIOMASS **4.89%**
Uses: heating, electricity, transportation

HYDROPOWER **2.54%**
Uses: electricity

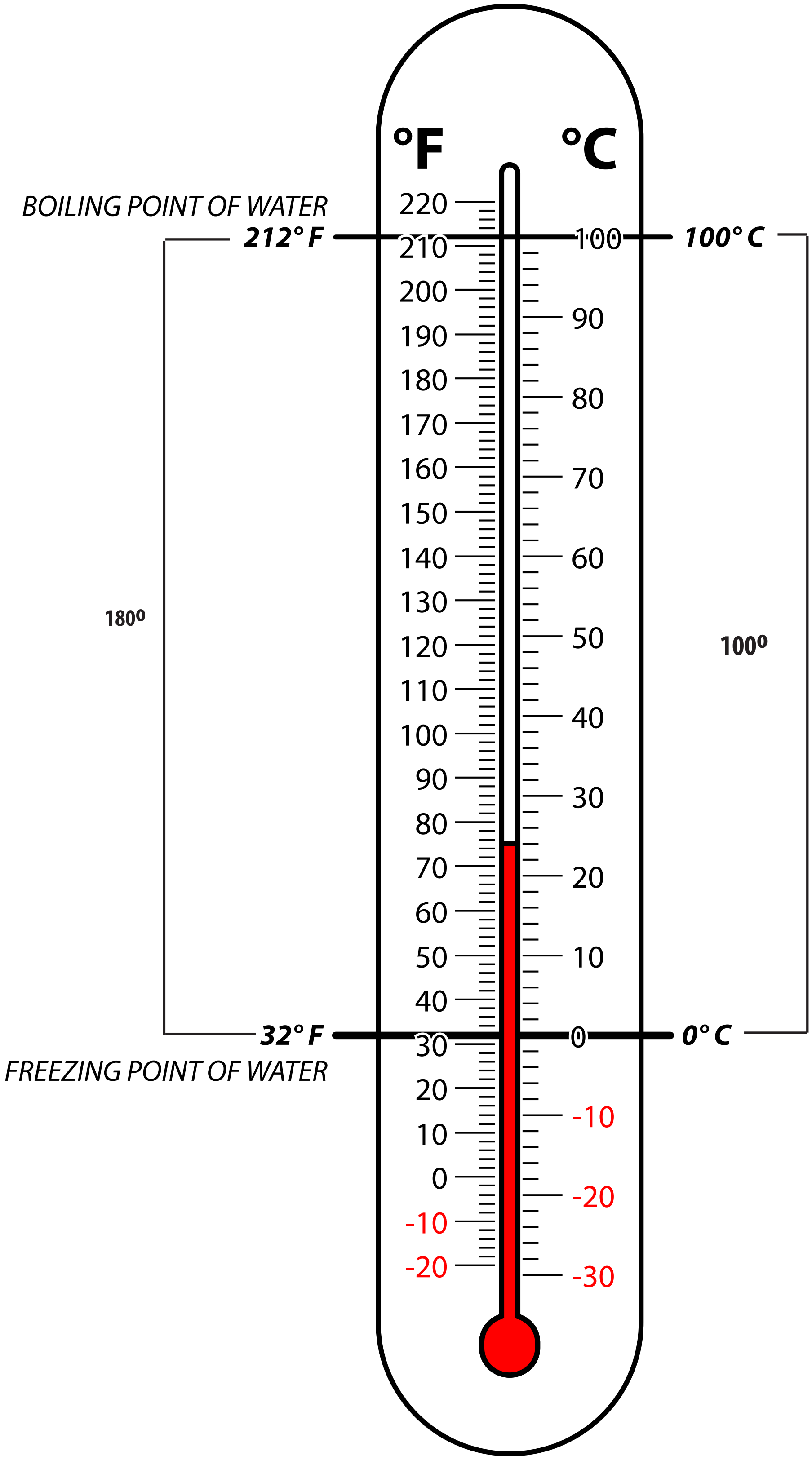
WIND **2.15%**
Uses: electricity

SOLAR **0.59%**
Uses: heating, electricity

GEOTHERMAL **0.22%**
Uses: heating, electricity

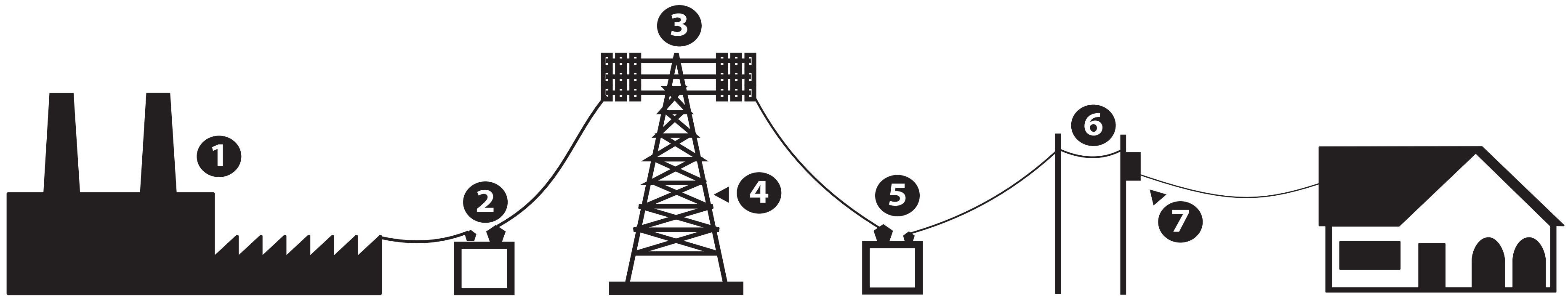
**Total does not add up to 100% due to independent rounding.
Data: Energy Information Administration

Thermometer



Transporting Electricity

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



Kill A Watt® Meter

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

Operating Instructions

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

What is Power Factor?

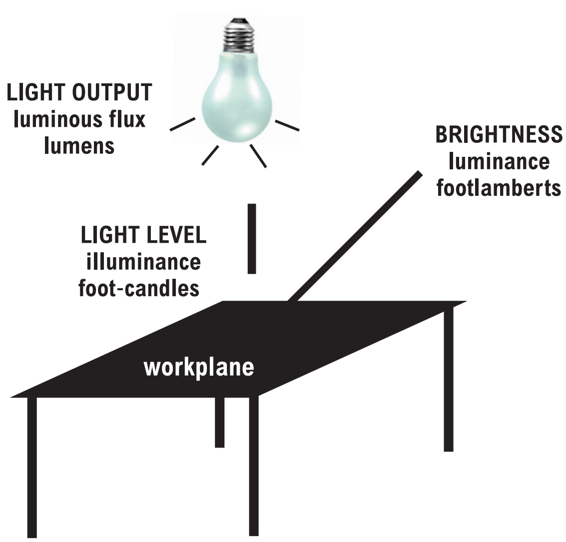
The formula **Volts x Amps = Watts** is used to find the energy consumption of an electrical device. Many AC devices, however, such as motors and magnetic ballasts, do not use all of the power provided to them. The Power Factor (PF) has a value equal to or less than one, and is used to account for this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

Volts x Amps x PF = Watts Consumed

The Light Meter

Operating Instructions

1. Insert the battery into the battery compartment in the back of the meter.
2. Slide the ON/OFF Switch to the ON position.
3. Slide the Range Switch to the B position.
4. On the back of the meter, pull out the meter's tilt stand and place the meter on a flat surface in the area you plan to measure.
5. Hold the Light Sensor so that the white lens faces the light source to be measured or place the Light Sensor on a flat surface facing the direction of the light source.
6. Read the measurement on the LCD Display.
7. If the reading is less than 200 fc, slide the Range Switch to the A position and measure again.



Light Output or Luminous Flux

A lumen (lm) is a measure of the light output (or luminous flux) of a light source (bulb or tube). Light sources are labeled with output ratings in lumens. A T12 40-watt fluorescent tube light, for example, may have a rating of 3050 lumens.

Light Level or Illuminance

A foot-candle (fc) is a measure of the quantity of light (illuminance) that actually reaches the workplane on which the light meter is placed. Foot-candles are workplane lumens per square foot. The light meter can measure the quantity of light from 0 to 1000 fc.

Brightness or Luminance

Another measure of light is its brightness or luminance. Brightness is a measure of the light that is reflected from a surface in a particular direction. Brightness is measured in footlamberts (fL).

Light Bulb Comparison




	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
Brightness	850 lumens	850 lumens	850 lumens	850 lumens
Life of Bulb	1,000 hours	3,000 hours	10,000 hours	25,000 hours
Energy Used	60 watts = 0.06 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
Price per Bulb	$0.50	$1.50	$1.50	$1.33

Digital Thermometer

A digital thermometer measures the temperature of a substance and displays the temperature reading on its face. It has a battery for power. Sometimes they are waterproof for measuring the temperature of a liquid.

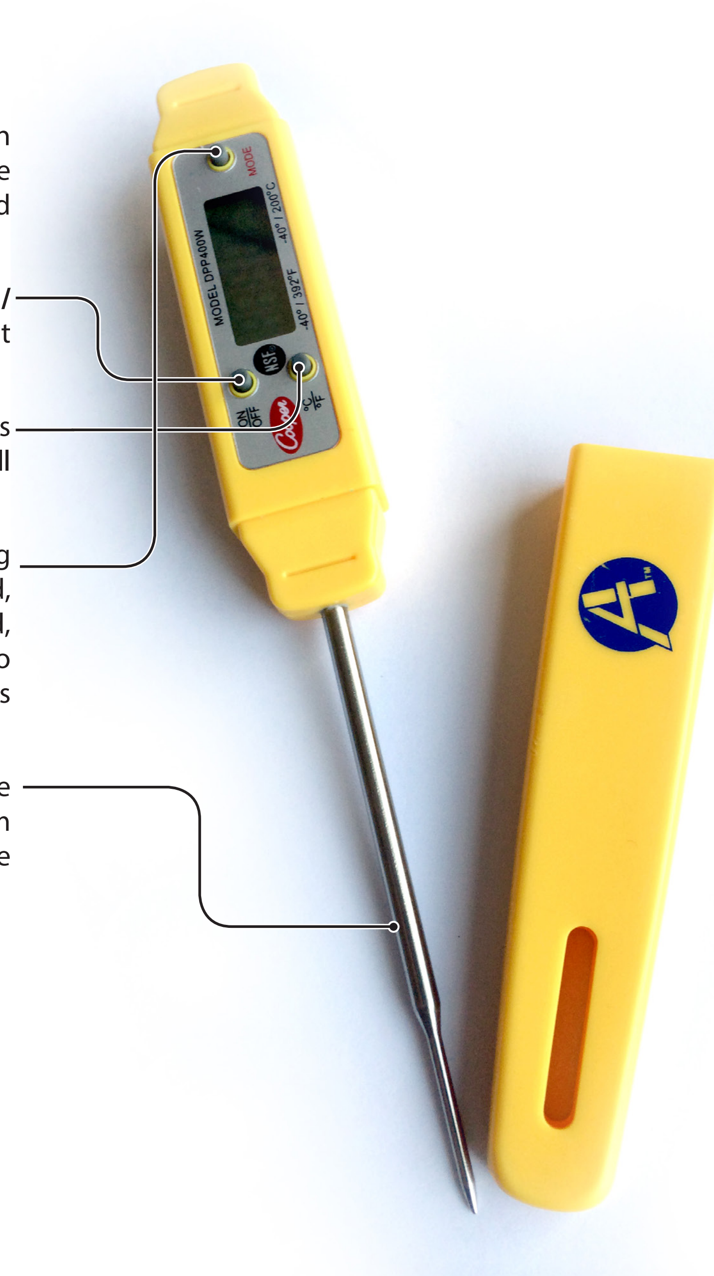
This digital thermometer can measure the temperature in Fahrenheit or Celsius. It shows the temperature range of the thermometer. It can read temperatures from -40° to 392°F and -40° to 200°C.

It has three buttons. The button on the bottom left is the **ON/OFF** switch. If the thermometer is not used for a few minutes, it turns itself off.

The **C/F** button on the bottom right switches from the Celsius scale to the Fahrenheit scale. The face of the thermometer will show a C or an F to indicate which scale is being used.

The **mode** button on the top holds the temperature reading when it is pushed. If you need the exact temperature of a liquid, you push the hold button while the thermometer is in the liquid, then remove the thermometer to read it. This button will also allow you to view the maximum and minimum temperatures measured when pushed two or three times.

The **metal stem** of the thermometer can measure the temperature of the air or the temperature of a liquid. The stem should be placed about halfway into a liquid to measure the temperature.



Hygrometer

HUMIDITY/TEMPERATURE PEN

Scientists measure the amount of water vapor in the air in terms of relative humidity—the amount of water vapor in the air relative to (compared to) the maximum amount it can hold at that temperature. Relative humidity changes as air temperature changes. The warmer the air is, the more water vapor it can hold.

Air acts like a sponge and absorbs water through the process of evaporation. Warm air is less dense and the molecules are further apart, allowing more moisture between them. Cooler air causes the air molecules to draw closer together, limiting the amount of water the air can hold.

It is important to control humidity in occupied spaces. Humidity levels that are too high can contribute to the growth and spread of unhealthy biological pollutants. This can lead to a variety of health effects, from common allergic reactions to asthma attacks and other health problems. Humidity levels that are too low can contribute to irritated mucous membranes, dry eyes, and sinus discomfort.

This digital humidity/temperature pen measures relative humidity and temperature and displays the readings on its face. It has a battery for power. It can display the temperature in Fahrenheit or Celsius. The reading shown on the right is 68.5°F. Devices that measure humidity are also called hygrometers.

The hygrometer displays relative humidity in terms of percentage. The hygrometer shown reads 35%. This means that the air contains 35 percent of the water vapor it can hold at the given air temperature. When the air contains a lot of water vapor, the weather is described as humid. If the air cannot carry any more water vapor, the humidity is 100 percent. At this point, the water vapor condenses into liquid water.

Maintaining relative humidity between 40 and 60 percent helps control mold. Maintaining relative humidity levels within recommended ranges is a way of ensuring that a building's occupants are both comfortable and healthy. High humidity is uncomfortable for many people. It is difficult for the body to cool down in high humidity because sweat cannot evaporate into the air.

Directions

ON/OFF KEY

Press the ON/OFF key to turn the power on or off.

°F/°C

Press the °F/°C key to select the temperature unit you want to use, Fahrenheit or Celsius.

MAX/MIN

Press the MAX/MIN key once to display the stored maximum readings for temperature and humidity.

An up arrow will appear on the left side of the display to indicate the unit is in the maximum recording mode.

Press the MAX/MIN key a second time to display the stored minimum readings for temperature and humidity. A down arrow will appear on the left side of the display to indicate the unit is in the minimum recording mode.

Press the MAX/MIN key a third time to return to normal operation.

CLEAR

If an up or down arrow is displayed, press the CLEAR key until - - - appears on the display. The memory is cleared. New maximum or minimum values will be recorded within 3 seconds.

ENERGY EFFICIENCY BINGO

A. Can name two ways to increase a car's MPG

B. Can name three ways to save energy at home

C. Can name three ways to save energy at school

D. Has at least one ENERGY STAR® appliance at home

E. Knows the definition of *energy efficiency*

F. Knows the definition of *energy conservation*

G. Knows what an ENERGY STAR® label means

H. Knows what SEER is

I. Knows a type of bulb that uses one-quarter of the energy of incandescents

J. Knows where to find an EnergyGuide label

K. Can name two appliances that should be run only when fully loaded

L. Uses day lighting in the classroom instead of overhead lights

M. Sets this item differently at day and night and for the season

N. Knows the number one use of energy in the home

O. Has an energy conservation team at school

P. Knows whether energy is the first, second, or third highest expenditure in a school district (choose one)

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

I have kilowatt-hour. Who has a light bulb that produces more heat than light?	**I have landscaping.** Who has the most effective way for consumers to reduce the amount of energy used by industry?
I have an incandescent. Who has energy is neither created nor destroyed?	**I have reduce, reuse, repair, recycle.** Who has any behavior that results in using less energy?
I have the Law of Conservation of Energy. Who has the number one use of energy in the home?	**I have conservation.** Who has the length of time you use an energy efficient appliance before you begin to save money?
I have heating and cooling. Who has the label designating energy efficient home appliances?	**I have payback period.** Who has the nation's leading recycled product?
I have ENERGY STAR®. Who has a way to reduce energy use by planting trees to block wind and provide shade?	**I have steel.** Who has a material that resists the flow of heat?

I have insulation. Who has a way to use gasoline more efficiently?	**I have energy efficiency.** Who has a digital meter installed in your home that communicates with your utility company to monitor and control energy usage?
I have keep tires properly inflated. Who has solar, hydropower, geothermal, biomass, and wind?	**I have Smart Meter.** Who has a way to learn how a building can use energy more efficiently?
I have renewables. Who has a light bulb that uses less than one-fourth the energy of a traditional incandescent bulb?	**I have energy audit.** Who has the label that shows an appliance's annual energy use and operating cost?
I have a light emitting diode (LED). Who has the leading source of air pollution?	**I have EnergyGuide.** Who has the flow of electrons?
I have vehicle emissions. Who has using technology that needs less energy to perform the same function?	**I have electricity.** Who has caulking, sealing, and weather-stripping cracks around doors and windows?

I have ways to reduce air infiltration. Who has an alternative mode of transportation?	**I have take short showers.** Who has an energy intensive industry?
I have riding a bicycle. Who has the concept that a society should meet its energy needs without compromising the needs of future generations?	**I have petroleum refining.** Who has a device that allows you to control the temperature in your home?
I have energy sustainability. Who has the sector of the economy that uses the most petroleum?	**I have programmable thermostat.** Who has a renewable transportation fuel?
I have transportation. Who has the kitchen appliance that uses the most energy?	**I have ethanol.** Who has the nonrenewable energy source that is used to generate most of the nation’s electricity?
I have refrigerator. Who has a way to reduce the cost of heating water?	**I have coal.** Who has a measure of electricity consumption?

Understanding Energy Use Evaluation Form

State: ____________ **Grade Level:** ____________ **Number of Students:** ____________

1. Did you conduct the entire unit?	❑ Yes	❑ No
2. Were the instructions clear and easy to follow?	❑ Yes	❑ No
3. Did the activities meet your academic objectives?	❑ Yes	❑ No
4. Were the activities age appropriate?	❑ Yes	❑ No
5. Were the allotted times sufficient to conduct the activities?	❑ Yes	❑ No
6. Were the activities easy to use?	❑ Yes	❑ No
7. Was the preparation required acceptable for the activities?	❑ Yes	❑ No
8. Were the students interested and motivated?	❑ Yes	❑ No
9. Was the energy knowledge content age appropriate?	❑ Yes	❑ No
10. Would you teach this unit again?	❑ Yes	❑ No

Please explain any 'no' statement below.

How would you rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the unit more useful to you?

____

____

____

____

Other Comments:

____

____

____

____

Please fax or mail to **The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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National Ocean Industries Association
National Renewable Energy Laboratory
NC Green Power
Nebraskans for Solar
New Mexico Oil Corporation
New Mexico Landman's Association
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