2017-2018

Energy of Moving Water

Teacher Guide

Inquiry–based and critical thinking activities that help intermediate students to develop a comprehensive understanding of energy, electricity, hydropower, and emerging ocean energy technologies.

Grade Level:

Int Intermediate

Subject Areas:

Science

Social Studies

Math

Language Arts

Technology

NEED

National Energy Education Development Project

Teacher Advisory Board

NEED Mission Statement

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

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Teacher Advisory Board

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

Energy Data Used in NEED Materials

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

NEED
National Energy Education Development

1.800.875.5029
www.NEED.org

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Energy of Moving Water
Teacher Guide

Energy of Moving Water Kit

Materials in Kit
- 12 Bar magnets
- 3 Horseshoe magnets
- 3 Ring magnets
- 15 Compasses
- 3 Sewing needles
- 3 Wood disks
- 3 Magnetic field demonstrators
- 6 9 V Batteries
- 3 D Batteries
- 8 AAA Batteries (for voltmeter)
- 6 Pieces of coated copper wire
- 6 Large iron nails
- 6 Small iron nails
- 6 Wallpaper pans
- 6 64 oz. Rectangular jugs
- 6 Motors
- 6 Hubs
- 72 Small dowels
- 1 Roll double-sided tape
- 3 Water reservoirs with dispenser caps and tubing
- 3 Bundles of wooden spoons
- 3 Funnels
- 3 Sets of alligator clips
- 2 Voltmeters
- 30 Student Guides

Science of Electricity Model Materials in Kit
- 1 Small round bottle
- 1 Spool of magnet wire
- 1 12" x ¼" Wooden dowel
- 4 Rectangle magnets
- 2 Rubber stoppers with ¼" hole
- 1 Foam tube
- 1 Set of alligator clips
- 1 Multimeter
- 2 Nails

***Energy of Moving Water* was developed by The NEED Project with funding and technical support from the National Hydropower Association and the Hydro Research Foundation.**

Table of Contents

Hydro Research Foundation

PROUD MEMBER OF IREC Interstate Renewable Energy Council

NHA National Hydropower Association

Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

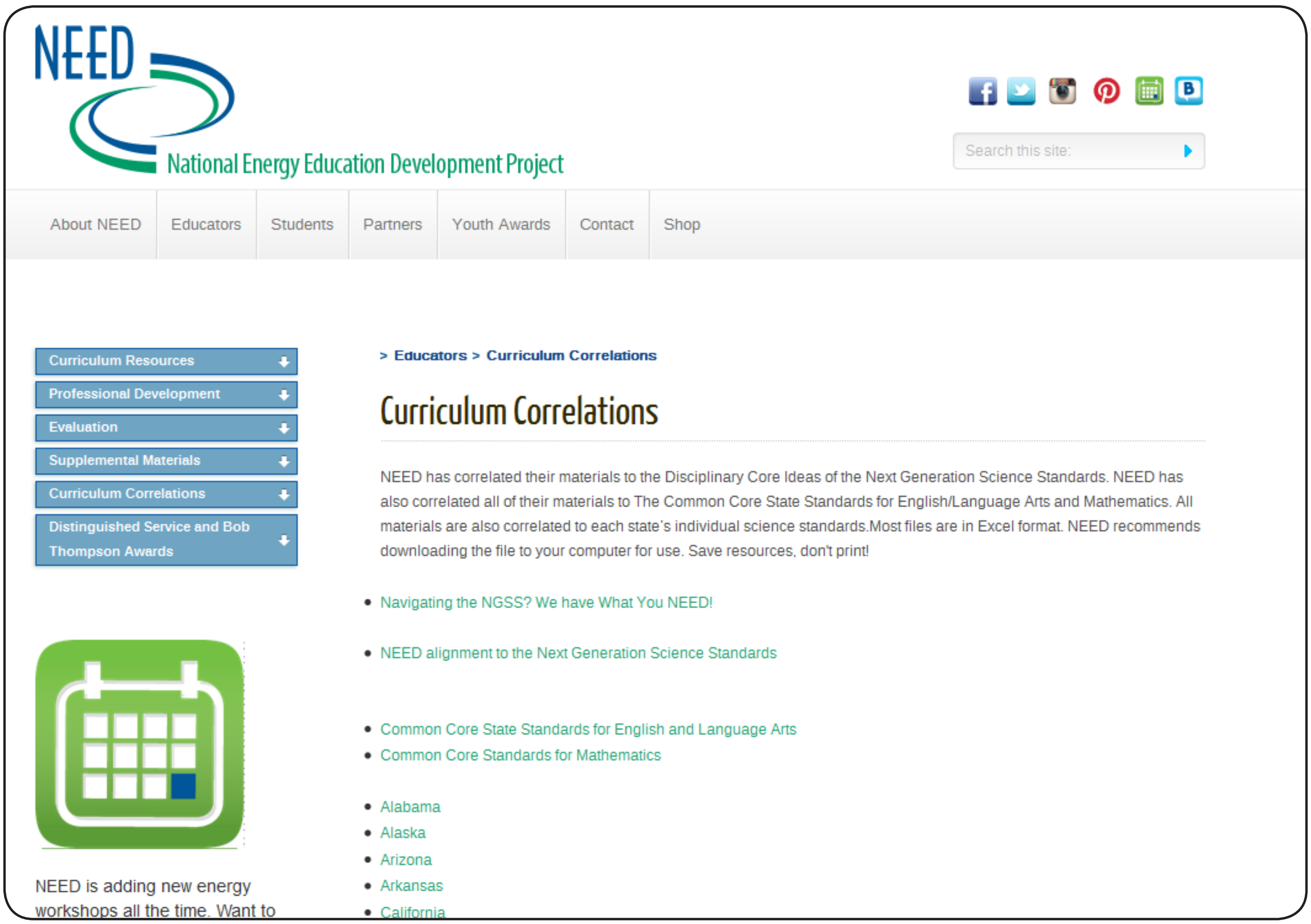
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's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



Energy of Moving Water Materials

ACTIVITY NAME	INCLUDED IN KIT	ADDITIONAL MATERIALS NEEDED
Science of Electricity Model Assembly	▪Small round bottle ▪Rubber stopper with ¼″ hole ▪12″ x ¼″ Wooden dowel ▪Foam tube ▪4 Rectangle magnets ▪Small nail ▪Large nail ▪Spool of magnet wire	▪Push pin ▪Hand operated pencil sharpener ▪Ruler ▪Permanent marker ▪Sharp scissors ▪Masking tape ▪Fine sandpaper
Introduction to the Unit	▪Multimeter ▪Alligator clips	▪Assembled *Science of Electricity Model*
Magnets and Compasses	▪Bar magnets ▪Compasses ▪Sewing needles ▪Wood disks	▪Paper clips ▪Tape ▪Small dishes ▪Water
Magnetic Fields	▪Bar magnets ▪Horseshoe magnets ▪Ring magnets ▪Compasses ▪Magnetic field demonstrator	▪White paper
Electromagnets 1	▪Coated copper wire ▪Large iron nails ▪Compasses ▪9 V Batteries	▪Paper clips
Electromagnets 2	▪Coated copper wire ▪Large iron nails ▪Small iron nails ▪9 V Batteries ▪D Batteries	▪Paper clips
Force of Water Explorations	▪Wallpaper pans	▪2-Liter soda bottles (flat sided) ▪Rulers ▪Push pins ▪Duct tape ▪Towels or paper towels ▪Permanent markers ▪Water ▪Buckets (optional)
Turbine Assembly and Explorations	▪64 oz. Jugs ▪Motors ▪Hubs ▪Wooden dowels ▪Nails ▪Reservoir units ▪Wooden spoons ▪Multimeter or voltmeters ▪Funnels ▪Alligator clips ▪AAA Batteries (voltmeter) ▪Double-sided tape	▪Sharp scissors ▪Safety glasses ▪Fast-drying glue ▪5 Gallon bucket(s) ▪Meter sticks ▪Stopwatch or watch with second hand ▪Glue gun (optional)

Teacher Guide

Grade Level

- Intermediate, grades 6–8

Time

- Approximately 18 45-minute class periods

Magnet Safety

The neodymium magnets contained in your kit are very strong and need to be handled with care. Please follow these safety guidelines.

- Use caution when handling the magnets. Fingers and other body parts can be severely pinched between two attracting magnets.
- Wear safety glasses when handling magnets.
- When separating the magnets, slide them apart as if you were dealing playing cards, do not pull them apart.
- Do not place magnets near electronic equipment, cell phones, appliances, magnetic I.D. cards, or credit cards.
- Do not allow the magnets near a person with a pacemaker or similar medical aid. The magnetic field can affect the operation of these devices.
- Magnets are choking hazards. Do not place magnets in your mouth.

Background

Energy of Moving Water is an inquiry–based unit for intermediate students with teacher and student guides containing comprehensive background information on energy, electricity, hydropower, and emerging ocean energy technologies, with case studies, a history of hydropower timeline, and information on careers in the hydropower industry.

The curriculum includes hands–on, inquiry–based explorations; group presentations; and a cooperative learning activity focusing on ways to use hydropower to increase electricity generation for a local community. Students will also be able to build models that represent dams and generators. The kit contains most of the materials to conduct the activities.

Several activities in the unit are appropriate for language arts and social studies classes and may be used as part of an integrated, multidisciplinary unit.

Concepts

- Energy is found in many forms—potential and kinetic.
- Electrical energy is the energy of moving electrons or electrical charges.
- Electricity and magnetism are related—electric currents produce magnetic fields and magnetic fields produce electric currents in conducting wires.
- Many energy sources are converted into electricity because it is easy to transport and use.
- Water continuously cycles through the Earth's atmosphere and surface in a process called the water cycle.
- The water cycle is driven by solar energy.
- Water is a renewable energy source.
- People have used dams to control the water in rivers and extract its energy for many years.
- The energy of moving water can be harnessed and converted into electricity in many ways, including technologies for harnessing the energy in ocean tides, waves, and currents.
- Hydropower has advantages and disadvantages.

Science Notebooks

Throughout this curriculum, science notebooks are referenced. If you currently use science notebooks or journals, you may have your students continue using these. A rubric to guide assessment of student notebooks can be found on page 16 of the Teacher Guide.

In addition to science notebooks, student worksheets have been included in the Student Guide. Depending on your students' level of independence and familiarity with the scientific process, you may choose to use these worksheets instead of science notebooks. Or, as appropriate, you may want to make copies of worksheets and have your students glue or tape the copies into their notebooks.

Preparation

- Read the Teacher and Student Guides thoroughly and decide how you are going to implement the unit in your classroom. Make sure you are familiar with each activity in both guides.
- Obtain the additional materials needed for the hands–on activities.
- Assemble the *Science of Electricity Model* (Teacher Guide pages 27-29) and become familiar with the operation of the model and all the other equipment in the kit, especially the multimeter and its settings. Directions for using the multimeter are included on page 25 of the Teacher Guide.
- Assign students to groups and topics for the presentation and culminating activity.
- Make copies of the *Hydropower Pre/Post Assessment* on page 40.

Activity 1: Introduction to the Unit

✪ Objective

- Students will be able to list previous knowledge about water, electricity, and energy.

Time

- One class period

Materials

- 1 Multimeter
- Set of alligator clips
- *Science of Electricity Model* instructions, pages 27-29
- *Science of Electricity Model* materials
- Copies of the *Hydropower Pre/Post Assessment,* page 40

✔ Procedure

1. Assemble the *Science of Electricity Model* using the instructions.
2. Have the students take the *Hydropower Pre/Post Assessment* as a pre-test. The answer key is provided on page 15.
3. If students are not receiving their own copy of the Student Guide, copy the KWL organizers (Student Guide pages 29-31), or have students create their own in their science notebooks. They should individually list what they know and would like to know about energy, electricity, and water. Then have each student exchange his/her information with a classmate.
4. Facilitate a class discussion about what they know and want to know. Make note of student misconceptions to address as you work through the unit.
5. As an additional introductory activity, play *Hydropower Bingo* with the class. Instructions begin on page 19. This activity can be used as a formative assessment throughout the unit.
6. Demonstrate the operation of the *Science of Electricity Model* to stimulate interest in the topic. It is not necessary to go into details about its construction or operation at this time, as students will be investigating the model further in an upcoming lesson.
7. Assign students to presentation groups for Activity 2's jigsaw and give them instructions and a timeline for completing the assignment.

Activity 2: The Basics of Energy, Electricity, and Water Jigsaw

✪ Objective

- Students will create a presentation and instruct others on topics related to hydroelectricity.

Time

- Two class periods

✔ Procedure

1. Divide the students into six groups as noted below. Be cognizant of student abilities when assigning them to groups; students who need to be challenged may handle the information on atomic structure and electricity well, while struggling readers may be more comfortable with the water cycle. All background reading and additional information are found in the Student Guide, on the following pages. Listed first are the page numbers of necessary student text. In parentheses are associated worksheets and reinforcement on each topic. Additional topics can be added as needed, but may require independent research.
   - Forms of Energy—pages 3–4 *(Forms and Sources of Energy—page 33)*
   - Sources of Energy—page 5 *(U.S. Energy Flow, 2015—page 34)*
   - Atomic Structure—pages 6–7 *(Atomic Structure—page 36)*
   - Electricity and Electromagnetism—pages 7–8 *(U.S. Electricity Flow, 2015—page 35)*
   - Measuring Electricity—pages 9–11 *(Measuring Electricity—pages 37–38)*
   - Characteristics of Water and The Water Cycle—page 12 *(The Water Cycle—page 39)*
2. If needed, make copies of the worksheets, as indicated in parentheses above, for all students.
3. Assign the groups to each create a five minute presentation to teach the other students their topic. They will use the information on pages 3–12 of the Student Guide and the corresponding worksheets. It is suggested that the students use one or two class periods to create their presentations.
4. Instruct the groups to use the *Presentation Topic Organizer* on page 32 of the Student Guide to plan their presentations. Make sure the groups receive your approval of their design plans before they proceed. You can choose a specific format for the presentations or allow the groups to decide on their own formats.
5. As the groups deliver their presentations, make sure the other students are completing the worksheets and adding information to their KWL organizers.
6. Use the *Group Presentation Rubric* on page 16 to evaluate the presentations.

NOTE: Energy and Electricity Flow diagrams include figures that have been calculated and, in some cases, rounded by the Energy Information Administration and by NEED. Student figures may differ slightly.

Activity 3: Magnets and Compasses Exploration and Magnetic Fields Exploration

✪ Objectives

- Students will be able to describe the properties of magnets.
- Students will be able to identify characterisitics of magnetic fields.

Time

- One class period

Materials AT EACH MAGNETS AND COMPASSES CENTER

- 2 Bar magnets
- 1 Compass
- 1 Sewing needle
- 1 Wood disk
- 20 Small paper clips
- 1 Small dish of water
- Tape
- *Magnets and Compasses* worksheet (Student Guide page 40)

Materials AT EACH MAGNETIC FIELDS CENTER

- 2 Bar magnets
- 1 Horseshoe magnet
- 1 Ring magnet
- 4 Compasses
- 1 Magnetic field demonstrator
- 1 Sheet of white paper
- *Magnetic Fields* worksheet (Student Guide page 41)

✔ Procedure

1. Gather all materials for the activities.
2. Set up six centers, three for each exploration—*Magnets and Compasses* and *Magnetic Fields*.
3. Divide the students into six groups and assign each group to a center.
4. Students should review the procedure for their station, *Magnets and Compasses* or *Magnetic Fields*. Answer any questions and instruct the students to record their hypotheses in their Student Guides or science notebooks.
5. Instruct the groups to go to the centers and complete the exploration, recording their observations and data. They should write a conclusion for their station once they have finished.
6. When students are done with their first station, have them switch so they can complete the second station.
7. Have a class discussion to review learning for the day.

Activity 4: Electromagnets 1 and Electromagnets 2 Explorations

✪ Objectives

- Students will be able to describe how magnets and electricity are related.
- Students will be able to identify variables that affect the force of an electromagnet.

Time

- One class period

Materials *AT EACH ELECTROMAGNETS 1 CENTER*

- 1 Piece of coated copper wire
- 1 Large iron nail
- 1 Compass
- 1 9-volt Battery
- 20 Small paper clips
- *Electromagnets 1* worksheet (Student Guide page 42)

Materials *AT EACH ELECTROMAGNETS 2 CENTER*

- 1 Piece of coated copper wire
- 1 Large iron nail
- 1 Small iron nail
- 1 9-volt Battery
- 1 D Battery
- 20 Small paper clips
- *Electromagnets 2* worksheet (Student Guide page 43)

✔ Procedure

1. Gather all materials for the activities.
2. Set up six centers, three for each exploration—*Electromagnets 1* and *Electromagnets 2*.
3. Divide the students into six groups and assign each group to a center.
4. Students should review the procedure for their station, *Electromagnets 1* or *Electromagnets 2*. Answer any questions and instruct the students to record their hypotheses in their Student Guides or science notebooks.
5. Instruct the groups to go to the centers and complete the exploration, recording their observations and data. They should write a conclusion for their station once they have finished.
6. When students are done with their first station, have them switch so that they can complete the second station.
7. Have a class discussion to review learning for the day.
8. Re-visit the *Science of Electricity Model*. Discuss as a class how they think it is working. As an assessment of the last few activities, have each student complete the *Science of Electricity Model* worksheet on page 44 of the Student Guide.

Activity 5: History of Hydropower

Objective

- Students will be able to identify important events and contributions to the use of hydropower over time.

Time

- One class period

Materials

- *History of Hydropower* worksheets (Student Guide page 45)

✔ Procedure

1. Have the students read *Water as an Energy Source—Hydropower* (page 13) and *History of Hydropower Timeline* (page 26) in the Student Guide.
2. Have the students complete the *History of Hydropower* activity.
3. Facilitate a class discussion of the milestones the students consider the most important and why.
4. Have the students add to their *KWL Organizer for Water*.

Language Arts Extension

Depending on your students' writing abilities, have students turn the *History of Hydropower* activity into a five-paragraph essay, using the steps of the writing process. You may find this to be a good cross-curricular piece to incorporate in English classes.

Activity 6: Dams and Their Uses

Objective

- Students will be able to list the uses for a dam.

Time

- One class period

Materials

- *Dams and Their Uses* worksheet (Student Guide page 46)

✔ Procedure

1. Have the students read the sections on dams (pages 13–18) in the Student Guide.
2. Have the students complete the *Dams and Their Uses* activity.
3. Facilitate a class discussion of the different uses of dams, including flood control, irrigation, management of water supply for downstream areas, and electricity generation.
4. Have the students add to their *KWL Organizer for Water*.

Extension

Students can use page 46 of the Student Guide as an information organizer or outline, and can create a multimedia presentation on hydropower as an independent research project.

Activity 7: Force of Water Explorations

✪ Objective

- Students will be able to identify variables that affect the force of flowing water at a dam.

Time

- One–two class periods

Materials *AT EACH CENTER*

- 1 2–Liter soda bottle*
- 1 Ruler
- 1 Push pin
- 1 Wallpaper pan
- Towel or paper towels
- Permanent marker
- Water supply
- Duct tape
- Buckets (optional)
- *Force of Water* worksheets (Student Guide pages 47-51)

NOTE: Make sure the bottles have flat surfaces without curves or decorative molded features. One-liter bottles can also be an acceptable substitute.

Preparation

- Gather all materials for the activity. You will need one 2-liter soda bottle for each group in every class.
- Each exploration should take 10–15 minutes to complete. If the students cannot complete all of the explorations in one class period, set up a schedule for the students.

Classroom Management Tips

- It will save water if containers or buckets are made available to students to pour their water into between trials (when instructions say to empty the bottle).
- Ask students to help supply your stock of 2-liter bottles by visiting their recycling bins. It may be helpful to offer a reward.

✔ Procedure

1. Divide the students into six groups and assign them to centers.
2. Review the procedures for the *Force of Water* explorations with the students. Answer any questions and explain the schedule for completing the explorations.
3. Instruct the students to formulate hypotheses to answer the questions in the explorations, using their Student Guides or science notebooks.
4. Instruct the groups to complete the explorations according to your schedule.
5. Instruct the groups to answer the conclusion questions. Review observations and conclusions as a class.

Activity 8: Turbine Assembly and Exploration

Objectives

- Students will create a model of a hydropower turbine, and be able to describe its limitations, as well as similarities and differences related to an actual hydropower turbine.
- Students will be able to explain how a hydropower facility generates electricity.

Time

- One class period

Materials AT EACH OF SIX CENTERS

- 1 64-oz. Jug
- 1 Motor
- 1 Hub
- 12 Wooden dowels
- 1 Pair sharp scissors
- 3 Pieces of double-sided tape
- 1 Nail
- 12 Wooden spoons
- Safety glasses
- Fast-drying glue
- *Turbine Assembly Instructions* (Student Guide page 52)
- *Reservoir Unit Instructions* (Student Guide page 53)
- *Electricity Meter Directions* (Student Guide page 54)
- Glue gun (optional)

Materials AT EACH OF THREE TESTING STATIONS

- 1 5-Gallon bucket
- 1 Multimeter or voltmeter (AAA batteries needed for voltmeter)
- 1 Reservoir unit (assembled)
- 1 Meter stick
- 1 Funnel
- 1 Set of alligator clips
- Stopwatch or watch with second hand

Preparation

- Gather all materials for the activity. Set up six centers for construction of the turbine, and three testing stations.
- Make a demonstration turbine ahead of time, to better assist students as they assemble their own turbines.
- The attachment point between the motor and the wires is fragile. It is suggested that a glue gun is used to reinforce the attachment of the wires before the explorations.

Classroom Management Tips

- If you have multiple classrooms using the turbines, you will need to allow enough time each day to have students build and disassemble the turbines for the next class to use.
- Glue guns can be a helpful alternative to double-sided tape when attaching the motors to the jug and the dowels to the spoons. Supervise this process if necessary.

✔ Procedure

1. Review the *Turbine Assembly Instructions*, *Reservoir Unit Instructions,* and *Electricity Meter Directions* with the students. Show the students how to attach the meter leads to the motor wires with the alligator clips.
2. Have students build the turbine models in teams. Students should build a total of 12 blades to be used in the first investigation.
3. If there is time, students may explore how their turbine works and become familiar with using the water reservoir unit as well.

NOTE: *The multimeter is able to measure smaller amounts of electricity than the voltmeter. For measurements less than 0.25 volts, students should use the multimeter.*

Activity 9: Turbine Explorations

Objective

- Students will be able to list variables that affect the amount of electricity generated by a turbine.

Time

- Two class periods

Materials SEE ACTIVITY 8

- Assembled turbines
- Testing stations
- *Exploring Turbine Blades* investigation (Student Guide page 55)
- *Exploring Reservoir Height* investigation (Student Guide page 56)
- *Teaching About Your Turbine* worksheet (Student Guide page 57)

✔Procedure

1. Have students read through the turbine model investigations on pages 55–56 of the Student Guide. Before beginning their investigations, students should write down their hypotheses in their Student Guides or student notebooks.
2. Groups should complete the two investigations. As groups finish, students should individually complete the *Teaching About Your Turbine* worksheet as an assessment.
3. Facilitate a class discussion each day about the groups' observations and conclusions. Students may use their results and assessment responses to power discussion.

Extension

Have groups change a variable on their turbine and see if they can generate more electricity. Make copies of the *Independent Turbine Investigation* on page 35 for students to use to record their procedure and observations.

Activity 10: Advantages and Disadvantages of Conventional Hydropower

Objective

- Students will be able to list and describe the advantages and disadvantages of hydropower.

Time

- One class period

Preparation

- Make copies of the *Advantages and Disadvantages of Hydropower* graphic organizer on page 36 for each student.

✔Procedure

1. Have the students read about the advantages and disadvantages of hydropower and the case studies on pages 19–21 of the Student Guide. Instruct them to add new information to their *KWL Organizer for Water*.
2. Have the students complete the *Advantages and Disadvantages of Hydropower* graphic organizer.
3. Facilitate a class discussion of the advantages and disadvantages of using hydropower to generate electricity.

Activity 11: The Future of Hydropower

Objective

- Students will be able to describe an emerging technology being used or developed in the hydropower industry.

Time

- One class period plus homework

✔ Procedure

1. Have the students review the information on new hydropower initiatives and ocean energy technologies on pages 22–25 of the Student Guide. Students can also research additional technologies under development at www.energy.gov/eere/water/marine-and-hydrokinetic-energy-research-development. Students can also look at the Department of Energy's worldwide database of research and development globally in hydrokinetics by visiting en.openei.org/wiki/Marine_and_Hydrokinetic_Technology_Database. There are also good pictures and descriptions found on the water power wiki space, en.openei.org/wiki/Gateway:Water_Power.
2. Instruct the students to do additional research on the technology they think will generate the most electricity in the future (see page 28 of the Student Guide for additional web resources) and complete *The Future of Hydropower* activity on page 58 of the Student Guide.
3. Have the students share what they have learned with the class.

Activity 12: Careers in the Hydropower Industry

Objective

- Students will be able to list the careers in the hydropower industry.

Time

- One class period

✔ Procedure

1. Have the students read the career information on pages 27–28 of the Student Guide, choose a career that sounds interesting to him/her, and conduct research on that career.
2. Have each student write a résumé to be used to apply for a job in the career he/she has researched using the resumé format on page 59 of the Student Guide.

Technology Extension

- Introduce your students to online professional networking sites, such as LinkedIn. Have students construct sample digital profiles rather than résumés.

Culminating Activity—Hot Topics in Hydropower

✪ Objectives

- Students will be able to list and describe advantages and disadvantages of hydropower.
- Students will be able to list and describe the challenges associated with siting a power generation facility.

Time

- Two–three class periods plus homework

✔ Procedure

1. Choose a scenario from pages 37-38 and make copies for the students. Divide the students into role groups—Scenario 1 has 14 roles, Scenario 2 has 16. Assign each group to one of the specific roles.
2. Explain the activity to the students. Have the students read the activity and review the scenario.
3. Guide the students to the *Issue Organizer* on page 60 of the Student Guide. Explain that each student should complete the organizer individually, then meet in groups to organize the information.
4. Instruct the students to use the information in the Student Guide, as well as outside research, to complete the organizer.
5. After the students have completed the organizers individually, have them meet in their role groups to discuss their findings. Instruct the students to add to their organizers any additional information provided by group members.
6. Have each group develop a presentation to be made to the council. Each group must choose a spokesperson to represent themselves and make the presentation at the meeting. Give the groups a time frame in which to complete their presentations.
7. Conduct the council meeting and have the class decide upon and discuss the actions that should be taken.

☑Evaluation

1. Use the *Rubrics for Assessment* on pages 16–17 to evaluate student performance.
2. As a review activity, play *Hydropower Bingo*. Instructions begin on page 19.
3. Have the students take the *Hydropower Pre/Post Assessment* on page 40 as a post–unit evaluation.
4. Evaluate the unit with the students using the *Evaluation Form* on page 43 and return it to NEED.

☑Hydropower Pre/Post Assessment Answer Key

1. a	4. a	7. d	10. b
2. b	5. d	8. d	
3. c	6. c	9. d	

Rubrics for Assessment

Group Presentation Rubric

GRADE	CONTENT	ORGANIZATION	ORIGINALITY	WORKLOAD
4	Topic is covered in–depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Presentation shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Presentation includes essential information about the topic. Subject knowledge is good.	Content is logically organized.	Presentation shows some original thought. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Presentation includes essential information about the topic, but there are 1–2 factual errors.	Content is logically organized, but with a few confusing sections.	Presentation provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group did not do his/her fair share of the work.
1	Presentation includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Presentation provides some essential information, but no original thought.	The workload is not divided, or several members are not doing their fair share of the work.

Inquiry Explorations and Science Notebook Rubric

GRADE	SCIENTIFIC CONCEPTS	DIAGRAMS	PROCEDURES	CONCLUSIONS
4	Written explanations illustrate accurate and thorough understanding of scientific concepts underlying inquiry.	Comprehensive diagrams are accurately and neatly labeled and make the designs easier to understand.	Procedures are listed in clear steps. Each step is numbered and is written as a complete sentence.	Conclusions describe information and skills learned, as well as some future applications to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts underlying inquiry.	Necessary diagrams are accurately and neatly labeled.	Procedures are listed in a logical order, but steps are not numbered or are not in complete sentences.	Conclusions describe the information learned and a possible application to a real life situation.
2	Written explanations illustrate a limited understanding of scientific concepts underlying inquiry.	Necessary diagrams are labeled.	Procedures are listed but are not in a logical order or are difficult to understand.	Conclusions describe the information learned.
1	Written explanations illustrate an inaccurate understanding of scientific concepts underlying inquiry.	Necessary diagrams or important components of diagrams are missing.	Procedures do not accurately reflect the steps of the design process.	Conclusions are missing or inaccurate.

Culminating Project Rubric

GRADE	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 good.	Content is logically organized.	Project shows some original thought. 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 with 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 did not do his/her 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 several members are not doing their fair share of the work.

Energy Measurements

1 cal = calorie: a measure of heat energy; the amount of heat energy needed to raise the temperature of one gram of water by one degree Celsius

1 cal = 4.187 joules

1 Btu = British thermal unit: a measure of heat energy; the amount of heat energy needed to raise the temperature of one pound of water by one degree Fahrenheit; one Btu is approximately the amount of energy released by the burning of one wooden kitchen match.

1 Btu = 1,055 joules

1 Btu = 252 calories

1 Q = quad: 1 quadrillion Btu; quads are used to measure very large quantities of energy; the U.S. uses one quad of energy about every 3.76 days.

1 therm = 100,000 Btu; approximately the amount of heat energy in one Ccf of natural gas.

1 kWh = kilowatt-hour: one kilowatt of electricity over one hour; one kilowatt-hour of electricity is the amount of energy it takes to burn a 100-watt light bulb for 10 hours; the average cost of one kilowatt-hour of electricity for residential customers in the U.S. is $0.127, or about thirteen cents.

1 kWh = 3.6 million joules (3.6 Megajoules)

1 kWh = 3,412 Btu

1 cf = cubic foot: a measure of volume; one cf of natural gas contains about 1,037 Btu.

1 Ccf = one hundred cubic feet; one Ccf of natural gas contains about 1.037 therms of heat energy.

1 Mcf = one thousand cubic feet; one Mcf of natural gas for residential customers in the U.S. in 2015 cost $10.38.

Energy Flow Diagram Explanation

The left side of the diagram shows energy production (supply) figures for 2015 in the U.S. by source and imports:

- The top four on the list—coal, natural gas, crude oil, and natural gas plant liquids (NGPL)—are fossil fuels that provided 70.60 quads of energy.
- Uranium (nuclear) produced 8.34 quads of energy.
- Renewables (solar, wind, hydropower, geothermal, and biomass) produced 9.69 quads of energy.
- The bottom shows imports, mostly crude oil and petroleum products, that produced 20.24 quads of energy while all other imported energy produced 3.37 quads of energy.
- The diagram shows that most of 2015 U.S. energy supply came from fossil fuels and domestic production, and that the U.S. imported 21.32 percent of its total energy supply.

The right side of the diagram shows energy consumption figures by energy source and sector of the economy. Electricity generation has been included in these consumption figures.

- The U.S. exported 13.11 quads of energy in 2015.
- The residential sector (homes) consumed 20.87 quads of energy or 21.38 percent of total energy consumption.
- The commercial sector (businesses) consumed 18.01 quads of energy or 18.45 percent of total energy consumption.
- The industrial sector (manufacturing) consumed 31.07 quads of energy or 31.82 percent of total energy consumption.
- The transportation sector (vehicles) consumed 27.72 quads of energy or 28.39 percent of total energy consumption.

Electricity Flow Diagram Explanation

The left side of the diagram shows energy sources used to generate electricity in 2015 in the U.S.:

- Coal produced 36.53 percent of electricity in the U.S., followed by natural gas (26.77 percent) and uranium (21.47 percent). Renewables are used to generate 13.75 percent of U.S. electricity.

The right side of the diagram shows electricity consumption figures by sector of the economy:

- Notice that only 13.19 quads of electricity (33.95 percent of total generation) are actually used by consumers—the other 62.08 percent is lost during conversion and distribution, or used by the power plant in operation.

NOTE: Energy and Electricity Flow diagrams include figures that have been calculated and, in some cases, rounded by the Energy Information Administration and NEED. Student figures may differ slightly.

Hydropower BINGO Instructions

Get Ready

Duplicate as many *Hydropower Bingo* sheets (found on page 39 of the Teacher Guide) 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 *Hydropower 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.

***Hydropower 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*
- Energy Bingo—*Energy Games and Icebreakers*
- Energy Efficiency Bingo—*Monitoring and Mentoring* and *Learning and Conserving*
- Hydrogen Bingo—*H_2 Educate*
- Nuclear Energy Bingo—Nuclear guides
- Oil and Natural Gas Bingo—Oil and Natural Gas guides
- Science of Energy Bingo—*Science of Energy* guides
- Solar Bingo—Solar guides
- Transportation Bingo—Transportation guides
- Wind Energy Bingo—Wind Energy Guides

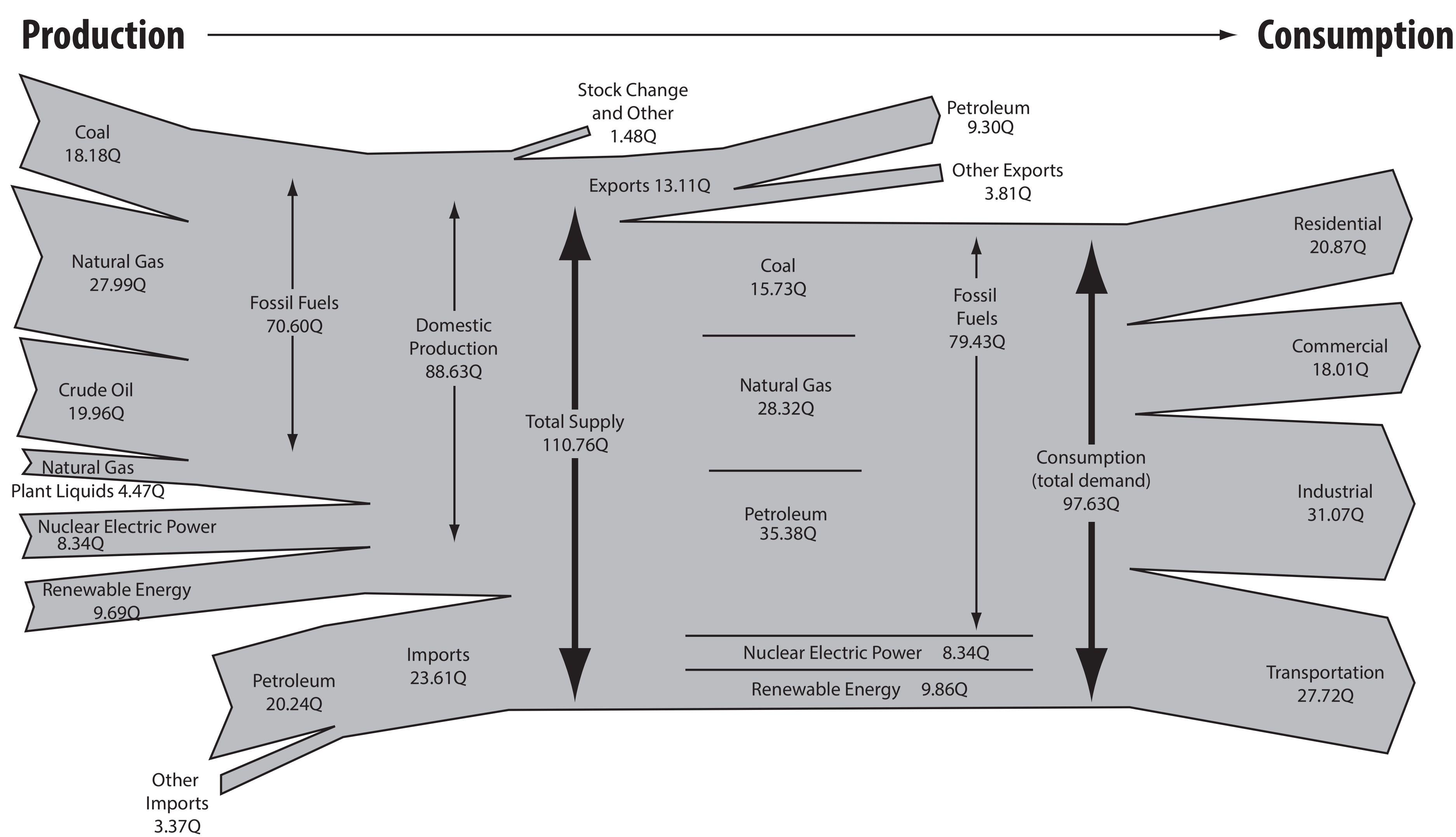
- Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on his bingo run. That player then stands and the bingo winner asks him the question which he previously answered during the 20-minute session. For example, if the statement was "can name two 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."

ANSWERS

A. Knows the percentage of U.S. electricity supplied by hydropower
B. Knows another name for the water cycle
C. Knows the process by which water becomes a gas in the water cycle
D. Knows the form of energy of the water stored in a reservoir
E. Can explain what a generator does
F. Knows the federal agency that regulates public hydropower dams
G. Can name the device in a hydropower plant that captures the energy of flowing water
H. Can name the energy source that supplies most of U.S. electricity
I. Knows the source of energy that drives the water cycle
J. Knows what energy source causes ocean waves
K. Can explain the force that produces tides in the ocean
L. Knows the three main parts of a hydropower plant
M. Knows the process by which water vapor becomes a liquid
N. Knows the state that produces the most hydropower
O. Can explain what a pumped storage facility does
P. Knows how many hydroelectric power plants there are in the U.S.

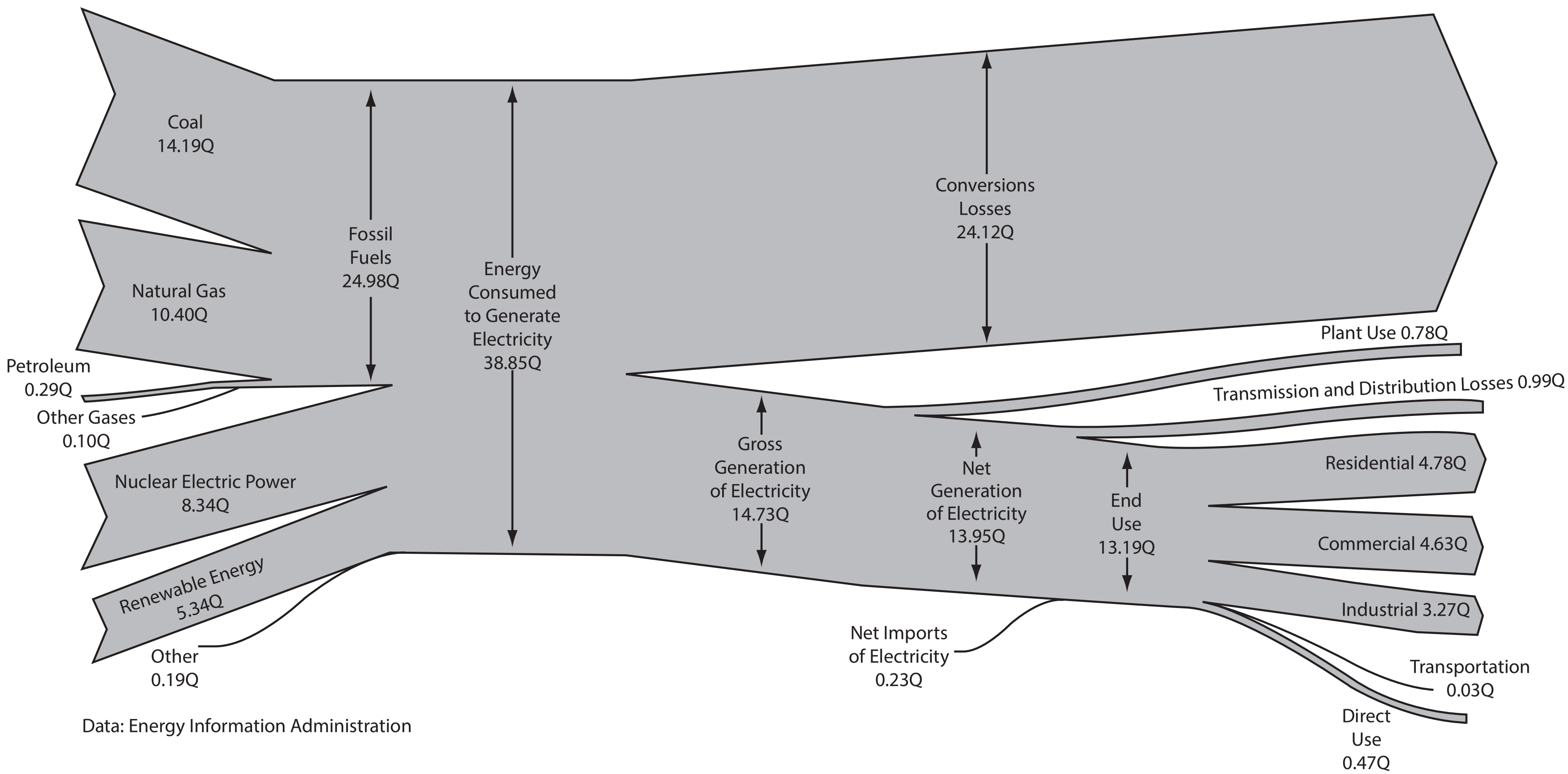
A 5-10% depending on amount of rainfall	**B** hydrologic cycle	**C** water becomes a gas through evaporation	**D** gravitational potential energy
E generator converts kinetic energy into electrical energy	**F** FERC Federal Energy Regulatory Commission	**G** a turbine captures the energy of flowing water	**H** coal produces about 33% of U.S. electricity
I solar energy drives the water cycle	**J** ocean waves are caused primarily by wind	**K** tides are formed by the gravitational pull of the moon	**L** reservoir, dam, and power plant
M condensation	**N** Washington State	**O** it has two reservoirs at different heights and circulates water between them	**P** about 2,200 hydroelectric power plants

U.S. Energy Flow, 2015



Data: U.S. Energy Information Administration

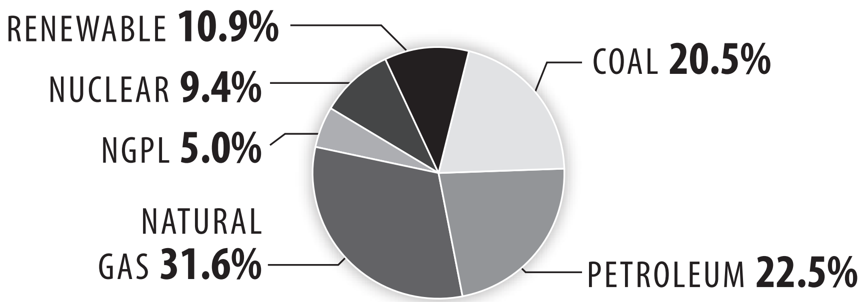
U.S. Electricity Flow, 2015



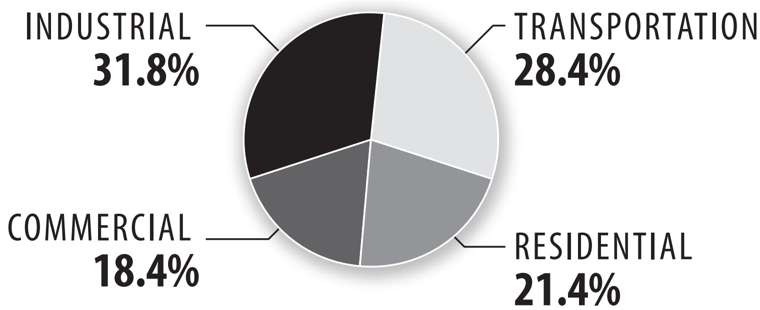
Data: Energy Information Administration

Energy and Electricity Flow Graphing Answer Keys*

Domestic Energy Production By Source, 2015

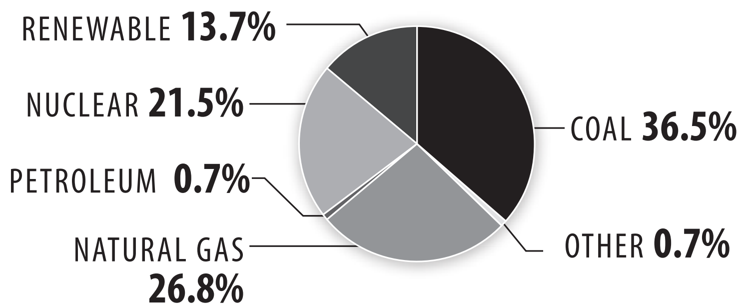


U.S. Energy Consumption By Sector of the Economy, 2015**

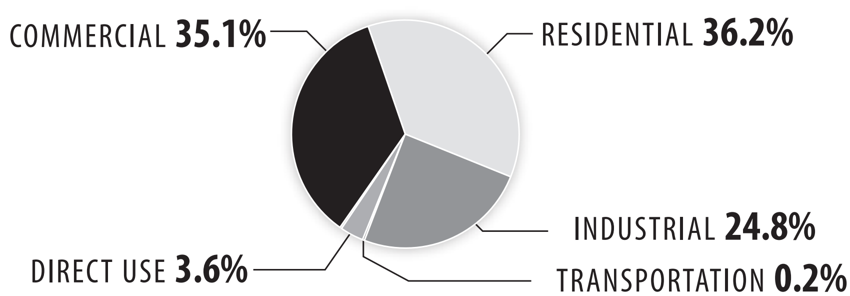


**includes electricity generation

U.S. Electricity Production By Source, 2015

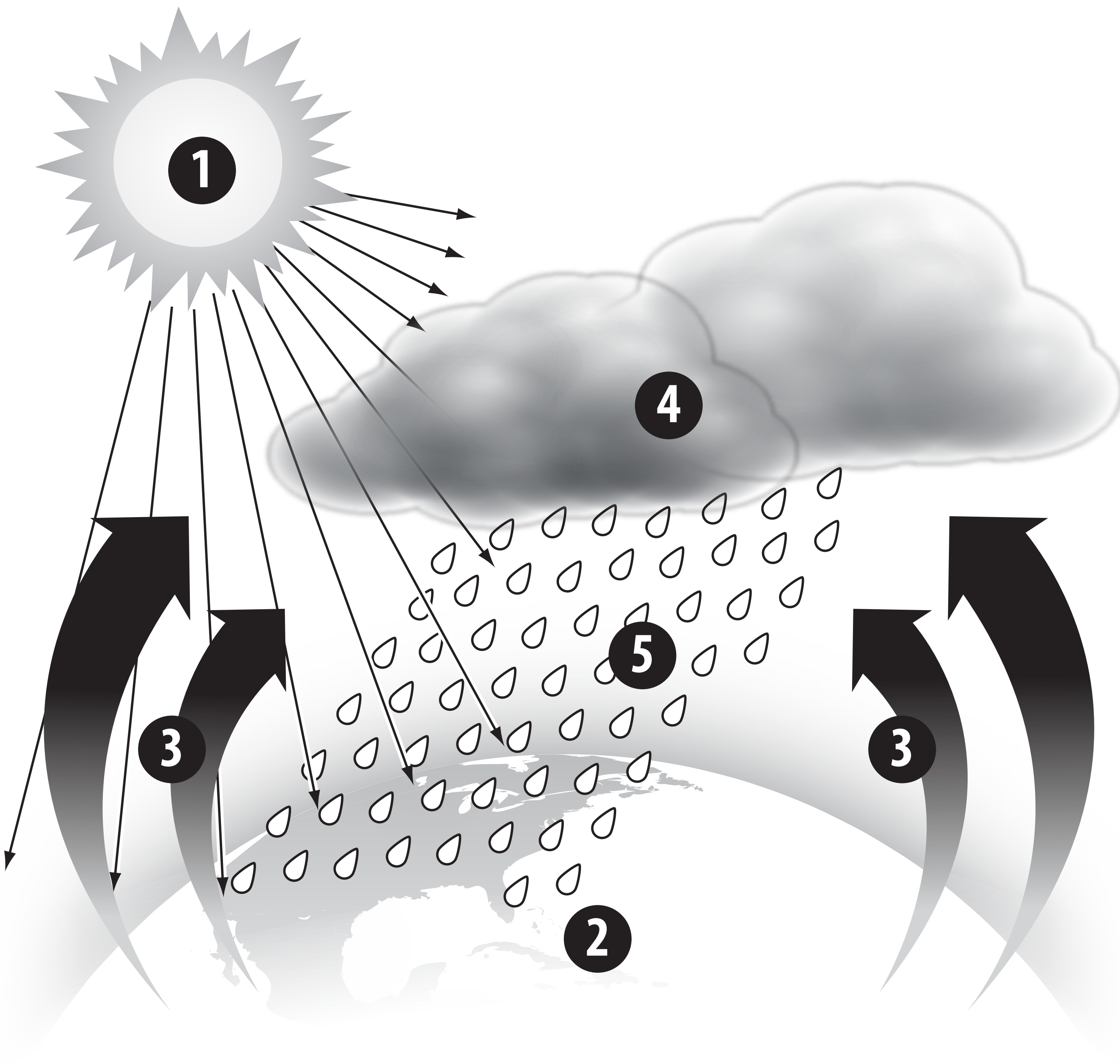


U.S. Electricity Consumption By End Use, 2015



NOTE: Student answers may differ slightly from answer key figures due to independent rounding of data.

The Water Cycle



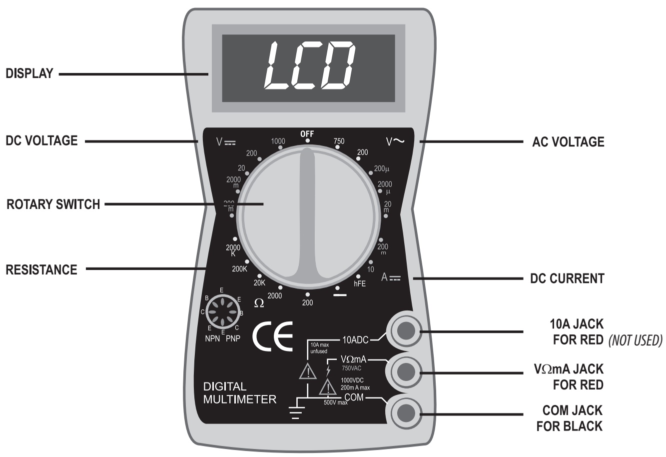
Measuring Electricity

Multimeters and voltmeters are tools used to measure electricity. The multimeter allows you to measure current, resistance, and voltage, and displays the reading numerically. The voltmeter measures voltage only, but displays a visual reading as higher electrical outputs illuminate more lights.

When using either meter it should be noted that some measurements will never "stay still" at a single repeatable value. This is the nature of the variables being monitored in some circumstances. For example, if you were to measure the resistance between your two hands with the ohmmeter setting on the multimeter (megohm range—millions of ohms), you would find that the values would continuously change. How tightly you squeeze the metal probes and how "wet" or "dry" your skin is can have a sizable effect on the reading that you obtain. In this situation you need a protocol or standardized method to allow you to record data.

We recommend that you discuss with your class the variability of measurement and let them come up with a standard for collecting data. They may decide to go with the lowest reading, the highest reading, or the reading that appears most frequently in a certain time period.

Digital Multimeter



Directions:

DC VOLTAGE

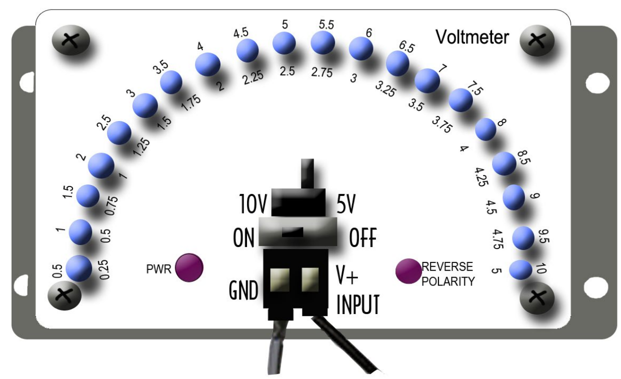
1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to highest setting on DC VOLTAGE scale (1000).
3. Connect leads to the device to be tested using the alligator clips provided.
4. Adjust ROTARY SWITCH to lower settings until a satisfactory reading is obtained.
5. With the hydropower turbine, usually the 20 DCV setting provides the best reading.

DC CURRENT *(must include a load in the circuit) NOT NECESSARY FOR THESE ACTIVITIES*

1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to 10 ADC setting.
3. Connect leads to the device to be tested using the alligator clips provided.
   Note: The reading indicates DC AMPS; a reading of 0.25 amps equals 250 mA (milliamps).

YOUR MULTIMETER MIGHT BE SLIGHTLY DIFFERENT FROM THE ONE SHOWN. BEFORE USING THE MULTIMETER, READ THE OPERATOR'S INSTRUCTION MANUAL INCLUDED IN THE BOX FOR SAFETY INFORMATION AND COMPLETE OPERATING INSTRUCTIONS.

Visual Voltmeter



Directions:

1. Switch the tab over to 5V.
2. Press down on the GND button. Insert one wire from the turbine into the hole on the bottom. Release the button to secure the wire in place.
3. Repeat step two with the other wire on the V+ Input side.
4. Turn on the voltmeter.
5. Place the turbine in a flow of water. The lights on the voltmeter will light indicating how much electricity is being generated.

NOTES

- *If the Reverse Polarity light flashes, switch the wires in the GND and V+ Input locations.*
- *The voltmeter's lowest reading is 0.25 volts. If you do not see any lights, connect the turbine to the multimeter for smaller readings.*

Basic Measurement Values in Electronics

SYMBOL	VALUE	METER	UNIT
V	Voltage (the force)	Voltmeter	Volts
I	Current (the flow)	Ammeter	Amps/Amperes
R	Resistance (the anti-flow)	Ohmmeter	Ohms

1 Ampere = 1 coulomb/second

1 Coulomb = 6.24×10^{18} electrons (about a triple axle dump truck full of sand where one grain of sand is one electron)

Prefixes for Units

- **Smaller**

  (m)illi = x 1/1000 or 0.001 or

  (µ) micro = x 1/1000000 or 0.000001 or 10^{-6}

  (n)ano = x 1/100000000 or 0.000000001 or 10^{-9}

  (p)ico = x 1/1000000000000 or 0.000000000001 or 10^{-12}

- **Bigger**

  (k)ilo = x 1000 or 10^3

  (M)ega = x 1000000 or 10^6

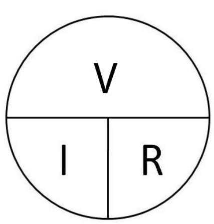
  (G)iga = x 1000000000 or 10^9

Formulas for Measuring Electricity

V = I x R

I = V/R

R = V/I



The formula pie works for any three variable equation. Put your finger on the variable you want to solve for and the operation you need is revealed.

- **Series Resistance (Resistance is additive)**

  $R_T = R_1 + R_2 + R_3 \ldots + R_n$

- **Parallel Resistance (Resistance is reciprocal)**

  $1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \ldots + 1/R_n$

  ***NOTE*:** ALWAYS convert the values you are working with to the BASE unit. For example, don't plug kilohms (kΩ) into the equation—convert the value to ohms (Ω) first.

Science of Electricity Model

✪ Objective

To demonstrate how electricity is generated.

Caution

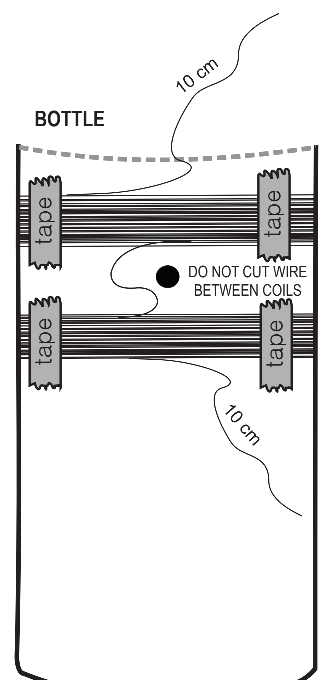
- The magnets used in this model are very strong. Refer to page 6 of this guide for more safety information.
- Use caution with nails and scissors when puncturing the bottle.

Materials

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

Preparing the Bottle

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

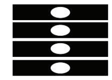


Generator Assembly: Part 1

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

5. Wrap the wire 200 times clockwise, again stacking each wrap on top of each other. Hold the coil in place with tape (see diagram).
6. Unwind 10 cm of wire (for a tail) from the spool and cut the wire.
7. Check your coil wraps. Using your fingers, pinch the individual wire wraps to make sure the wire is close together and close to the holes. Re-tape the coils in place as needed.
8. Using fine sandpaper, remove the enamel coating from 4 cm of the end of each wire tail, leaving bare copper wires. (This step may need to be repeated again when testing the model, or saved for the very end).

Diagram 1



Stacked Magnets End View

Diagram 2

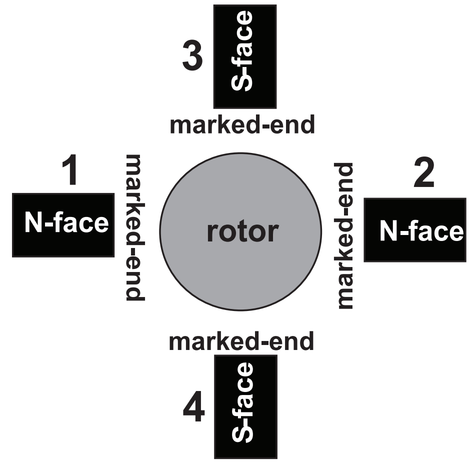
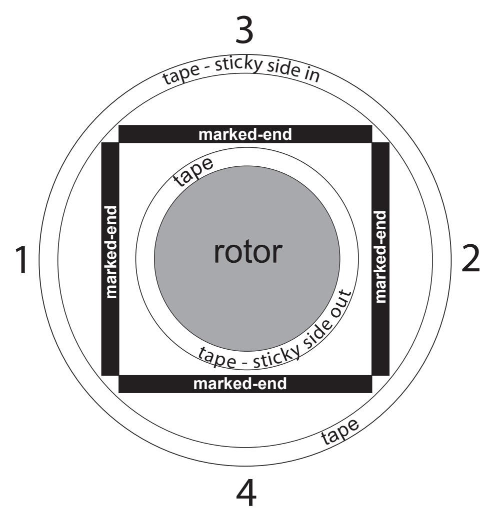


Diagram 3



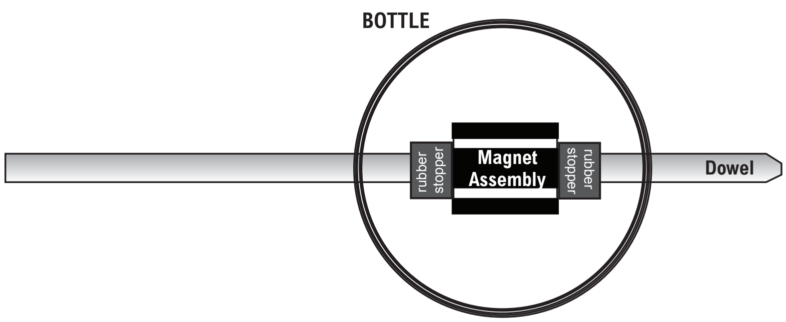
Rotor Assembly

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

WARNING: These magnets are ***very*** *strong. Use caution when handling.* *See page 6 for more information.*

Generator Assembly: Part 2

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



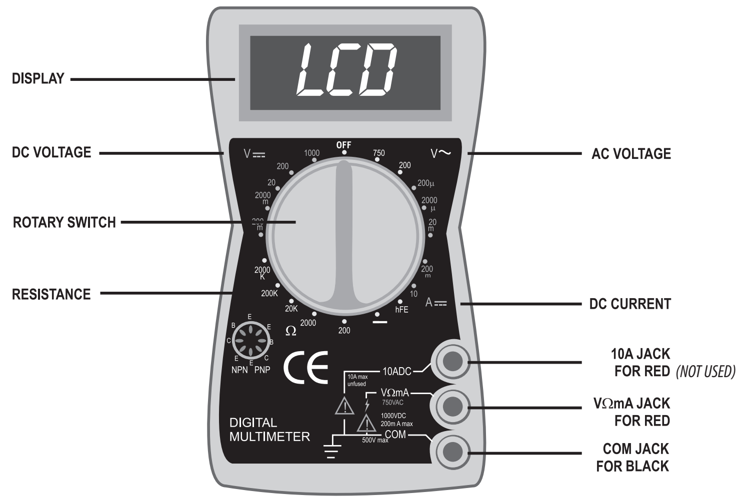
Assembly Notes

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

Testing the Science of Electricity Model

1. Connect the leads to the multimeter to obtain a DC Voltage reading.
2. Connect one alligator clip to each end of the magnet wire. Connect the other end of the alligator clips to the multimeter probes.
3. Set your multimeter to DC Voltage 200 mV (millivolts). Voltage measures the pressure that pushes electrons through a circuit. You will be measuring millivolts, or thousandths of a volt.
4. Demonstrate to the class, or allow students to test how spinning the dowel rod with the rotor will generate electricity as evidenced by a voltage reading. As appropriate for your class, you may switch the dial between 200 mV and 20 volts. Discuss the difference in readings and the decimal placement.*
5. Optional: Redesign the generator to test different variables including the number of wire wraps, different magnet strengths, and number of magnets.

*Speed of rotation will impact meter readings.



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

Troubleshooting

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

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

Notes

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

Reservoir Unit Instructions

1. Examine the water reservoir unit. Place one end of the tubing onto the end of the screwtop dispenser.
2. To fill the unit with water, place the unit with the opening on top and the spout lifted. Fill the unit completely with water. Screw the top securely on and make sure the valve is closed on the dispenser.
3. Lift the hose above the reservoir unit, slightly open the valve and put pressure on the unit to remove any air pockets at the top of the unit. Close the valve.
4. Place the unit on its side with the spout near the bottom when conducting all experiments, as shown in Diagram 1. Make sure there are no air pockets in the unit when you place it on its side to conduct the experiments.
5. Make sure there are no kinks in the hose when conducting experiments.
6. When conducting the experiments, rotate the valve to open and close and to ensure a constant rate of flow. Unscrew the dispenser to refill the unit.
7. Make sure the water from the hose hits the blades of the hub as shown in Diagram 2.
8. After each trial, use the funnel to pour the water from the bucket back into the unit. If necessary, add more water so that the unit is completely full.

Diagram 1

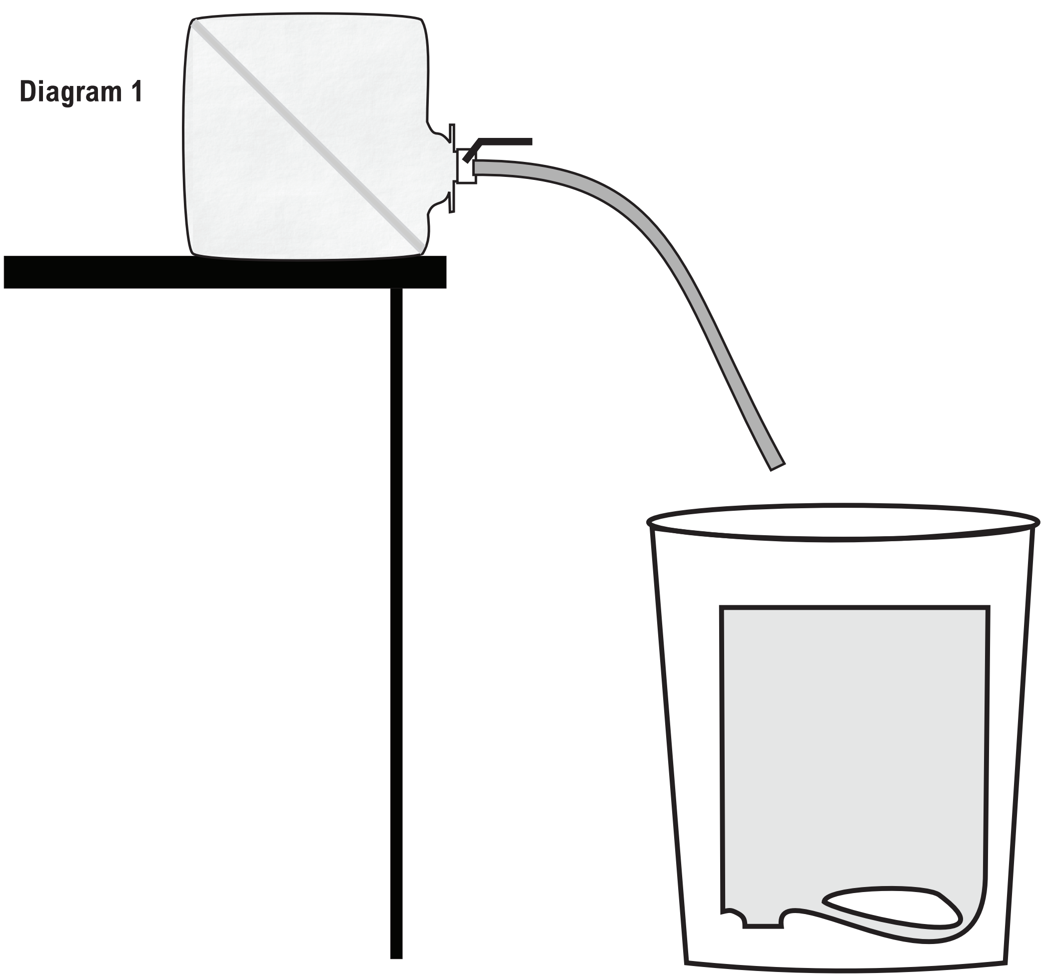
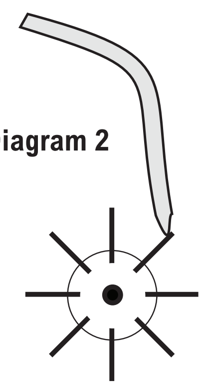


Diagram 2



Forms and Sources of Energy Answer Key

In the United States we use a variety of resources to meet our energy needs.

1 Using the graphic below, determine how energy is stored or delivered in each of the sources of energy. Remember, if the source of energy must be burned, the energy is stored as chemical energy.

NONRENEWABLE		RENEWABLE	
Petroleum	*CHEMICAL*	Biomass	*CHEMICAL*
Natural Gas	*CHEMICAL*	Hydropower	*MOTION*
Coal	*CHEMICAL*	Wind	*MOTION*
Uranium	*NUCLEAR*	Solar	*RADIANT*
Propane	*CHEMICAL*	Geothermal	*THERMAL*

2 Look at the U.S. Energy Consumption by Source graphic below and calculate the percentage of the nation's energy use that each form of energy provides.

What percentage of the nation's energy is provided by each form of energy?

Chemical *86.5%*

Nuclear *8.6%*

Motion *4.2%*

Radiant *0.4%*

Thermal *0.2%*

What percentage of the nation's energy is provided

by nonrenewables? *90.2%*

By renewables? *9.7%*

U.S. Energy Consumption by Source, 2015

NONRENEWABLE

PETROLEUM 36.6% *
Uses: transportation, manufacturing - includes propane

NATURAL GAS 29.0% *
Uses: heating, manufacturing, electricity - includes propane

COAL 16.0%
Uses: electricity, manufacturing

URANIUM 8.6%
Uses: electricity

PROPANE
Uses: heating, manufacturing

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

RENEWABLE

BIOMASS 4.9%
Uses: heating, electricity, transportation

HYDROPOWER 2.4%
Uses: electricity

WIND 1.8%
Uses: electricity

SOLAR 0.4%
Uses: heating, electricity

GEOTHERMAL 0.2%
Uses: heating, electricity

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

Atomic Structure Answer Key

Below is an atom of magnesium (Mg). Magnesium is a silvery white metal that has 12 protons, 12 electrons, and 12 neutrons. Number the words on the left with the correct part of the atom in the diagram.

proton __2__

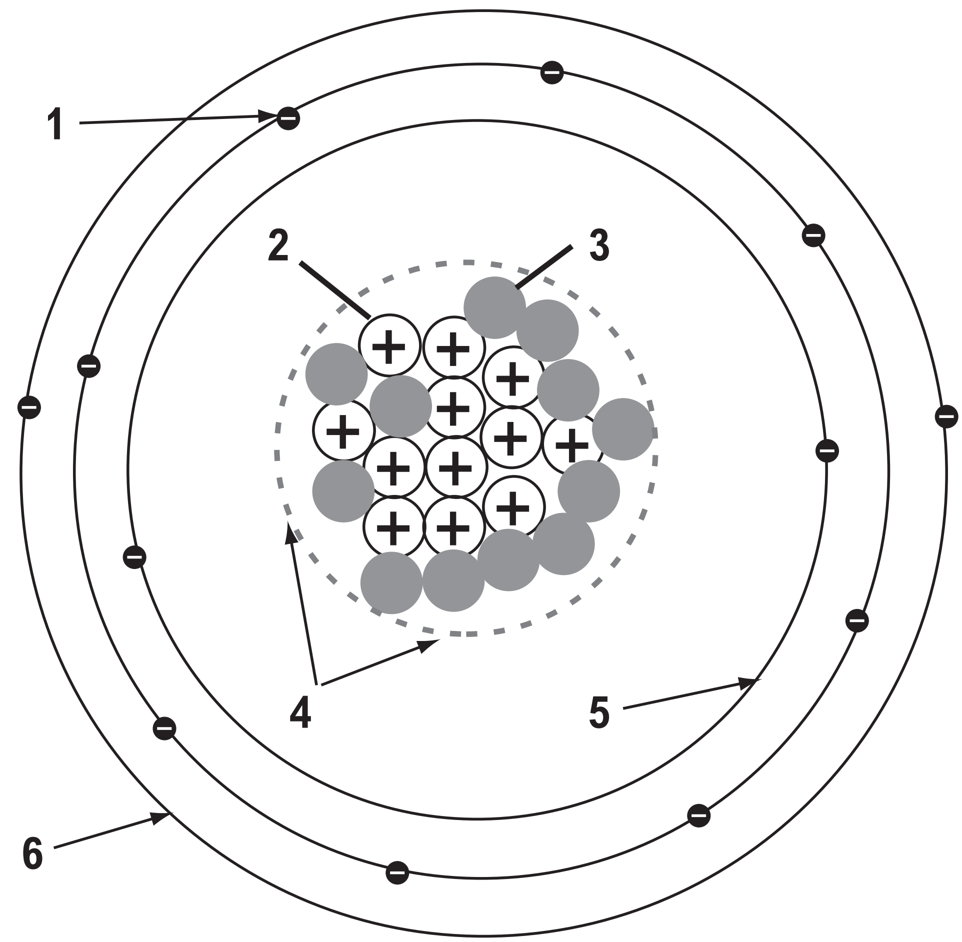
electron __1__

neutron __3__

inside energy level __5__

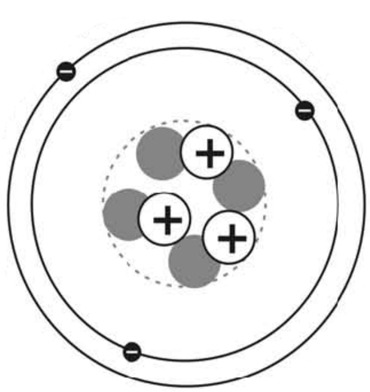
nucleus __4__

outside energy level __6__

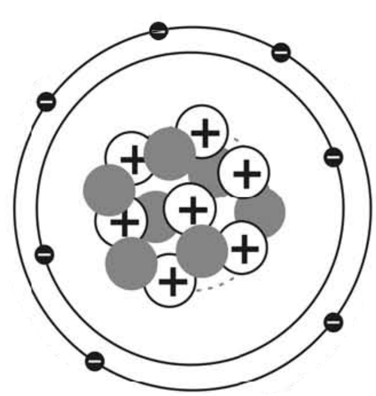


Magnesium-24

Draw the protons, neutrons, and electrons on the atoms below. Be sure to put the electrons in the correct energy levels. Lithium has three protons and four neutrons. Nitrogen has seven protons and seven neutrons.



Lithium-7



Nitrogen-14

Measuring Electricity Answer Key

TABLE 1

VOLTAGE	=	CURRENT	X	RESISTANCE
1.5 V	=	**0.5 A**	x	3 Ω
12 V	=	3 A	x	4 Ω
120 V	=	4 A	x	**30 Ω**
240 V	=	**20 A**	x	12 Ω

TABLE 2

POWER	=	VOLTAGE	X	CURRENT
27 W	=	9 V	x	**3 A**
180 W	=	120 V	x	1.5 A
45 W	=	**15 V**	x	3 A
240 W	=	120 V	x	2 A

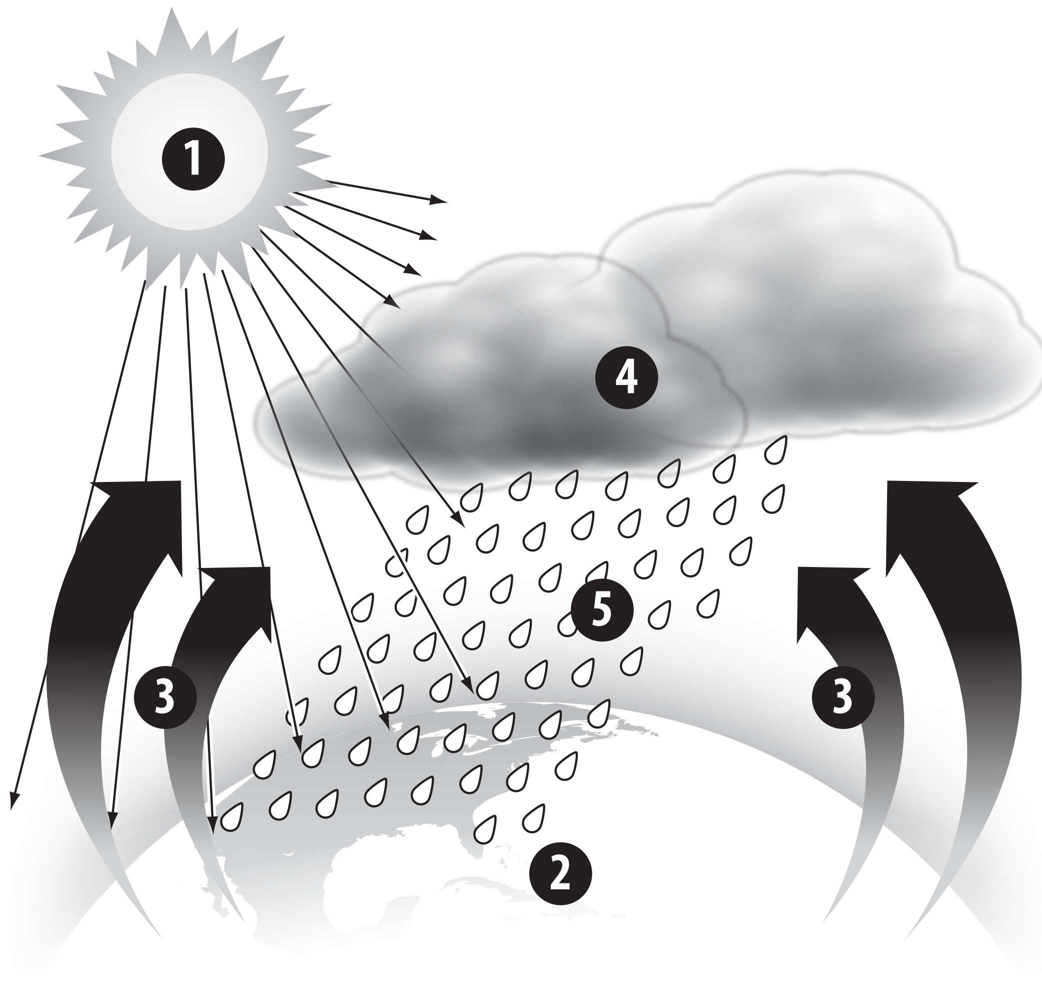
TABLE 3

APPLIANCE	POWER	=	VOLTAGE	X	CURRENT
TV	180 W	=	120 V	x	**1.5 A**
COMPUTER	40 W	=	120 V	x	**0.33 A**
PRINTER	120 W	=	120 V	x	**1 A**
HAIR DRYER	1,000 W	=	120 V	x	**8.33 A**

TABLE 4

POWER	X	TIME	=	ELECTRICAL ENERGY (kWh)	X	PRICE	=	COST
5 kW	x	100 h	=	**500 kWh**	x	$ 0.127	=	**$63.50**
25 kW	x	4 h	=	**100 kWh**	x	$ 0.127	=	**$12.70**
1,000 W	x	1 h	=	**1 kWh**	x	$ 0.127	=	**$0.13**

The Water Cycle Answer Key



1. Solar (radiant) energy provides the energy that fuels the water cycle.
2. Liquid water on the Earth is pulled to the ground by gravitational force and stored mainly in the oceans.
3. The sun's energy evaporates the water from oceans and lakes and turns it into water vapor (gas) that rises into the atmosphere.
4. The water vapor in the atmosphere cools and condenses back into a liquid to form clouds.
5. Precipitation, either liquid (rain) or solid (snow or ice pellets), falls back to the Earth and replenishes bodies of water.

Independent Turbine Investigation

Objective

To determine the optimum___________that will produce the greatest electrical output.

Question

How does___________affect the electrical output of a turbine?

Hypothesis

Make a hypothesis to address the question using the following format: If (manipulated variable) then (responding variable) because …

Variables

Manipulated Variable (independent or the one variable that changes): ____________________

Responding Variable (dependent or the variable you measure): Electrical Output

Controlled Variables (variables that are kept the same): ____________________

Materials

Procedure

1.
2.
3.
4.
5.

Data

Graph your data on graph paper or digitally: The manipulated variable is written on the X-axis (horizontal) and the responding variable is written on the Y-axis (vertical).

Conclusion

Using results from your data, explain if your hypothesis was supported or refuted. Include why you think this is the case.

Advantages and Disadvantages of Hydropower

List and explain several advantages and disadvantages of hydropower.

Advantages	Disadvantages

Culminating Activity: Hot Topics in Hydropower

You have been assigned to represent a stakeholder in the following scenario. Your assignment is to research and write a persuasive essay supporting your position. You will also make a presentation to the Town Council and be expected to defend your position. Use the *Issue Organizer* on page 60 to organize the information for your presentation.

Scenario 1

You reside in a growing coastal town on the ocean. Most of the town's income is from commercial fishermen, sports fishermen, and summer vacationers. A manufacturing company has expressed interest in building a new plant near your town that would offer employment opportunities to local residents. Your electricity is supplied by a municipal conventional hydropower plant, but it cannot produce the electricity the plant needs to operate. Several proposals have been made to generate more electricity by building a tidal or wave plant or by increasing the electricity produced by the hydropower plant. Identify your position in your thesis statement. Give at least three reasons for your position and support each reason with three facts.

- **Municipal Hydropower Plant Manager:** Wants to improve the current dam facility, upgrading it to produce more electricity.
- **Resident:** Wants economical electricity and also new job opportunities.
- **Ocean View Homeowner's Association Member:** Wants to protect scenic views and property values.
- **Local Indian Tribe Representative:** Wants to protect fishing rights in the ocean.
- **Sports Fisherman's Association Member:** Wants to protect the fish population.
- **Commercial Fisherman's Union Representative:** Wants to protect the fish population.
- **Mayor:** Wants to improve the town's business options.
- **Marine Biologist:** Wants to protect the local marine environment.
- **Environmentalist:** Wants the dam torn down (decommissioned) so the river can return to its original state.
- **Marine Mammal Activist:** Wants to ensure the marine ecosystem is protected, specifically marine mammals.
- **Renewable Energy Enthusiast:** Wants to encourage the expansion of renewable energy technologies.
- **Hydro Developer:** Wants to bring new hydropower technologies to the area as demonstration projects.
- **Plant Manufacturer:** Wants to build a new manufacturing plant near the town and needs a reliable supply of electricity.
- **Elderly Resident on Fixed Income:** Wants to make sure electricity rates do not increase.

Culminating Activity: Hot Topics in Hydropower

You have been assigned to represent a stakeholder in the following scenario. Your assignment is to research and write a persuasive essay supporting your position. You will also make a presentation to the City Council and be expected to defend your position. Use the *Issue Organizer* on page 60 to organize the information for your presentation.

Scenario 2

You live in a city where historically there was a large salmon population in the local river. The river was dammed 75 years ago by the local energy company to produce electricity for the city and surrounding area. No fish ladders were built around the dam. Now many people want to decommission (tear down) the dam to restore the river and allow the salmon to return to their native habitat. This would mean developing a new source for electricity.

Based on your assigned role, research the effects of maintaining the dam as it is, upgrading the dam with fish ladders and more efficient turbines, and decommissioning the dam. Identify your position in your thesis statement. Give at least three reasons for your position, and support each reason with three facts.

(See Elwha River Dam: www.nps.gov/olym/learn/nature/elwha–ecosystem–restoration.htm.)

- **Local Energy Company Representative:** Wants to maintain the dam and provide economical electricity.
- **Residential Consumer:** Wants a reliable source of economical electricity.
- **Local Indian Tribe Representative:** Wants to protect tribal fishing rights in the river and reservoir.
- **Sports Fisherman:** Wants fish population to remain high downstream from the dam.
- **Mayor:** Wants to protect city services, improve business opportunities, and maintain way of life.
- **Environmental Biologist:** Wants to protect the river ecosystem.
- **Environmental Activist:** Wants the river returned to its natural state.
- **Renewable Energy Enthusiast:** Wants to make sure renewable energy is used to generate the city's electricity.
- **River Property Owner:** Wants to make sure his property is protected and property values are maintained.
- **Reservoir Property Owner:** Wants to make sure his property is protected and property values are maintained.
- **Recreational Boater:** Wants to be able to continue boating on the reservoir.
- **Hydro Developer:** Wants to install new hydropower technologies at the existing dam.
- **Wind Developer:** Wants to build a wind farm on a nearby mountain to provide electricity.
- **City Waste Treatment Facility Manager:** Wants to maintain its services without change. The facility is located right next to the river, and has been returning treated water into the river. If the dam is decommissioned, it may have to relocate and change its practices.
- **City Water Board Member:** Wants to maintain a reliable source of drinking water. The reservoir is used to supply drinking water to the city.
- **Elderly Resident on Fixed Income:** Wants to make sure electricity rates do not increase.

HYDROPOWER BINGO

A. Knows the percentage of U.S. electricity supplied by hydropower

B. Knows another name for the water cycle

C. Knows the process by which water becomes a gas in the water cycle

D. Knows the form of energy of the water stored in a reservoir

E. Can explain what a generator does

F. Knows the federal agency that regulates public hydropower dams

G. Can name the device in a hydropower plant that captures the energy of flowing water

H. Can name the energy source that supplies most of U.S. electricity

I. Knows the source of energy that drives the water cycle

J. Knows what energy source causes ocean waves

K. Can explain the force that produces tides in the ocean

L. Knows the three main parts of a hydropower plant

M. Knows the process by which water vapor becomes a liquid

N. Knows the state that produces the most hydropower

O. Can explain what a pumped storage facility does

P. Knows how many hydroelectric power plants there are in the U.S.

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

Hydropower Pre/Post Assessment

1. The energy stored in the contained water of a hydropower reservoir is ______________.

a. potential b. radiant c. kinetic d. electrical

2. Renewable energy sources provide what percentage of total U.S. energy consumption?

a. 0–4% b. 5–10% c. 11–20% d. 21–30%

3. The process that draws water from oceans into the atmosphere is ______________.

a. sublimation b. deposition c. evaporation d. precipitation

4. The energy of moving water is fueled by ______________.

a. gravity b. radiant energy c. the water cycle d. precipitation

5. A dam on a river can provide ______________.

a. electricity b. flood control c. irrigation d. all of these

6.The negatively charged particle of an atom is a(n) ______________.

a. neutron b. proton c. electron d. nucleus

7. A device that captures the energy of moving water in a hydropower dam is called a ______________.

a. motor b. generator c. electrometer d. turbine

8. A hydropower generator converts ______________.

a. potential energy to electrical energy
b. kinetic energy to potential energy
c. chemical energy to kinetic energy
d. motion energy to electrical energy

9. Technologies are currently available to harness the energy of ______________.

a. ocean currents
b. ocean tides
c. ocean waves
d. all of the above

10. Hydropower produces what percentage of total electricity generation in the U.S. today?

a. 1–3% b. 5–10% c. 15–17% d. 25–27%

NEED's Online Resources

NEED'S SMUGMUG GALLERY

http://need-media.smugmug.com/

On NEED's SmugMug page, you'll find pictures of NEED students learning and teaching about energy. Would you like to submit images or videos to NEED's gallery? E-mail info@NEED.org for more information.
Also use SmugMug to find these visual resources:

Videos

Need a refresher on how to use Science of Energy with your students? Watch the Science of Energy videos. Also check out our Energy Chants videos! Find videos produced by NEED students teaching their peers and community members about energy.

Online Graphics Library

Would you like to use NEED's graphics in your own classroom presentations, or allow students to use them in their presentations? Download graphics for easy use in your classroom.

AWESOME EXTRAS

Looking for more resources? Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching in your classroom! This page is available under the Educators tab at www.NEED.org.

THE BLOG

We feature new curriculum, teacher news, upcoming programs, and exciting resources regularly. To read the latest from the NEED network, visit www.NEED.org/blog_home.asp.

EVALUATIONS AND ASSESSMENT

Building an assessment? Searching for standards? Check out our Evaluations page for a question bank, NEED's Energy Polls, sample rubrics, links to standards alignment, and more at www.NEED.org/evaluation.

E-PUBLICATIONS

The NEED Project offers e-publication versions of various guides for in-classroom use. Guides that are currently available as an e-publication can be found at www.issuu.com/theneedproject.

SOCIAL MEDIA

Stay up-to-date with NEED. "Like" us on Facebook! Search for The NEED Project, and check out all we've got going on!

Follow us on Twitter. We share the latest energy news from around the country, @NEED_Project.

Follow us on Instagram and check out the photos taken at NEED events, instagram.com/theneedproject.

Follow us on Pinterest and pin ideas to use in your classroom, Pinterest.com/NeedProject.

NEED ENERGY BOOKLIST

Looking for cross-curricular connections, or extra background reading for your students? NEED's booklist provides an extensive list of fiction and nonfiction titles for all grade levels to support energy units in the science, social studies, or language arts setting. Check it out at www.NEED.org/booklist.asp.

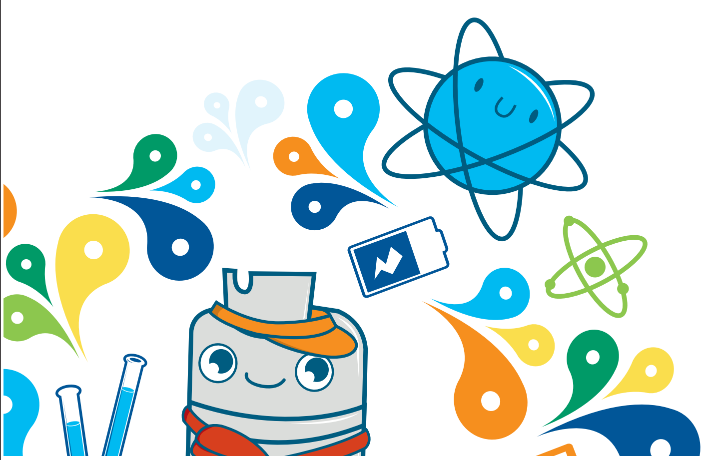
U.S. ENERGY GEOGRAPHY

Maps are a great way for students to visualize the energy picture in the United States. This set of maps will support your energy discussion and multi-disciplinary energy activities. Go to www.NEED.org/maps to see energy production, consumption, and reserves all over the country!

YOUTH ENERGY CONFERENCE AND AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math). The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. A limited number of spaces are available for a special two-day pre-conference event, which allows students access to additional information, time to discuss energy with their peers, and access to industry professionals. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info: http://tinyurl.com/youthenergyconference



YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

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

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

What's involved?

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

Want more info? Check out **www.NEED.org/Youth-Awards** for more application and program information, previous winners, and photos of past events.

Energy of Moving Water 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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Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
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