ENERGY IS ELECTRIFYING!

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Topic Focus:
Energy Systems, Forms, Sources and Flows

Recommended Grade Level:
Grade 4

Subject Areas:
Physical Science, Earth and Space Science

Disciplinary Core Ideas:
PS3 (Physical Sciences) – Energy
ESS3 (Earth and Space Science) – Earth and Human Activity
ETS1 (Engineering, Technology and Applications of Science) – Engineering Design

Time Frame;
This unit is composed of 11 Lessons which incorporate the *Biological Sciences Curriculum Study (BSCS) 5E Instructional Model* - Engage, Explore, Explain, Elaborate and Evaluate.

Unit Objectives: By the end of this unit students will:

- Understand the concept of Energy as a System, with goals, inputs, outputs and processes.
- Understand the different Forms of Energy and Energy Transfer
- Understand how Electricity is Generated, and Transmitted from place to place.
- Understand the different Technologies humans have developed to harness energy for our use.
- Become familiar with different sources of energy, both non-renewable and renewable.
- Be involved in the Energy Design Process by participating in Renewable Energy Investigations.
- Create an Energy Chain, and be able to trace the Energy of the Sun to these lights in our classroom. (NOTE to teachers: Most but not all of our energy comes from the sun, including, nuclear, geothermal and tidal energy.)
- Learn how to be Energy Systems Thinkers, and understand how to make good energy choices in our homes, schools and communities.

TABLE OF CONTENTS:

UNIT SUMMARY

Energy is not a concrete/tangible concept to teach, but the need to establish the foundations in K-12 education is necessary, and expressed in the language of the Next Generation Science Standards. This unit is an introduction to the essential principles necessary to become an energy literate student and citizen. The following concepts will be explored:

- Nature of Energy
- Forms of Energy
- Energy Flow through systems
- Energy Transfer
- Energy Use by Human Societies
- Sources of Energy
- Electricity Generation and Transmissions
- Impact of Energy on the Natural Environment

This broad introduction will lay the groundwork for more in-depth study of energy issues as students' progress through their K-12 education, and prepare them to be energy literate citizens.

Many activities have been adapted from an *Energy Literacy* curriculum developed by the Hitchcock Center for the Environment. Our original version was developed as a 2-day unit that Hitchcock Center educators piloted in local classrooms. This new unit was designed to take approximately 2 weeks to complete, and provides the opportunity for students to explore energy in more depth, and participate in design investigations, and integrate math and literacy skills.

In addition to adapting the unit from our existing curriculum, it also includes resources from various websites that allow material to be accessed for educational purposes. References to these resources are imbedded in each Daily Lesson where appropriate, and also listed in the Resources at the end of the unit.

I hope the users of this energy unit find the activities engaging, and more importantly, contribute to educating the next generation of energy literate citizens. So let us inspire our students with some BRIGHT IDEAS, as we explore Energy Is Electrifying!

Patty O'Donnell
Hitchcock Center for the Environment
September, 2013

UNIT DESIGN AND DEVELOPMENT

The format used in this unit is the Biological Sciences Curriculum Study (BSCS) 5E Instructional Model, which includes the five phases of Engage, Explore, Explain, Elaborate and Evaluate. The National Science Teachers Association (NSTA) also employed this model in a recent publication, Science for the Next Generation.

In addition to developing curriculum that incorporates the language of the Next Generation Science Standards, the need to infuse climate and energy topics into formal education was strongly recommended during a national Climate and Energy Literacy Summit, held in December 2012, at the University of California, Berkeley. The resulting document - "Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education" – does not provide specific curriculum, but serves as a guide to direct and inspire curriculum development. (See link in the resources section at the end of the unit.)

Some lessons in this unit have been adapted from the ENERGY THINKING curriculum developed by Northeast Sustainable Energy Association (NESEA). The Hitchcock Center for the Environment has been offering an Energy Literacy Program for several years based on the NESEA unit.

There is a plethora of additional online educational materials and literature related to energy education. I have referenced those that I found to be most useful for elementary educators, and encourage the reader to explore these for background information and extensions. They are imbedded in each Daily Lesson Plan where necessary, and listed in the Resources section at the end of the unit.

DAILY LESSON PLAN OVERVIEW: *ENERGY IS ELECTRIFYING*

* *NOTE*: At the end of most Daily Lessons are the relevant **Attachments to Daily Lesson.** Many are inserted as informational resources, and can be used as needed. Links to all websites are referenced in the *Resources* section of each day.

EXPLANTATION OF TABLES
Adapted from the Next Generation Science Standards (NGSS)

TABLE 1 - **Disciplinary Core Ideas** DCI's) covered in the *Energy Is Electrifying* unit.

TABLE 2 - **Performance Expectations** or standards based on the **Topic Arrangements** of the, from the Fourth Grade Storyline 'Energy', and Grades 3-5 'Engineering Design'.

TABLE 3 - **Foundations Boxes** - which list (from left to right) the specific science and engineering practices, disciplinary core ideas (DCIs), and crosscutting concepts that were combined to produce the performance expectations (PEs).

TABLE 4 - **Common Core State Standards Connections** – ELA/Literacy and Mathematics

TABLE 1: Disciplinary Core Ideas

Disciplinary Core Ideas covered in *Energy Is Electrifying* Unit (DCI'S from NGSS): **I. Core Idea PS3 (PHYSICAL SCIENCES) - ENERGY** • PS3.A: Definitions of Energy • PS3.B: Conservation of Energy and Energy Transfer • PS3.D: Energy in Chemical Processes and Everyday Life **II. Core Idea ESS3 (EARTH AND SPACE SCIENCE) - EARTH AND HUMAN, ACTIVITY** • ESS3.A: Natural Resources **III. Core Idea ETS1 (ENGINEERING, TECHNOLOGY AND APPLICATIONS OF SCIENCE) - ENGINEERING DESIGN** • ETS1.A: Defining Engineering Problems
*NOTE: The following Earth and Space Science DCI's are not included in 4th grade NGSS standards, but are referenced here because they are relevant to the unit. *** • ESS3.C: Human Impacts on Earth Systems (5TH Grade ESS3) ** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. • ESS3.D: Global Climate Change (In Middle School - MS ESS3) **

NOTE TO TEACHERS: This unit also incorporates NGSS standards from the *Disciplinary Core Idea Engineering Design*, for the 3-5 grade span. Performance Expectations are included in the following table. For a more detailed view of the Engineering Design standards, refer to the website, http://www.nextgenscience.org/3-5ets1-engineering-design

TABLE 2: Performance Expectations by Topic

Performance Expectations by Topic – Grade 4 - Energy *Students who demonstrate understanding can:* **4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.** **4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents** **4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.** **4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** **4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.**
Performance Expectations by Topic - Grade 3-5.Engineering Design Students who demonstrate understanding can: **3-5-ETS1-1.** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. **3-5-ETS1-2.** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. **3-5-ETS1-3.** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*: (See Table below)

TABLE 3: Foundations Boxes (See Appendix for more information on Cross-Cutting Concepts)

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Asking Questions and Defining Problems • Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3) **Planning and Carrying Out Investigations** • Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2) **Constructing Explanations and Designing Solutions** • Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1) • Apply scientific ideas to solve design problems. (4-PS3-4) **Obtaining, Evaluating, and Communicating Information** • Obtaining, **e**valuating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods. • Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)	**PS3.A: Definitions of Energy** • The faster a given object is moving, the more energy it possesses. (4-PS3-1) • Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3) **PS3.B: Conservation of Energy and Energy Transfer** • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2), (4-PS3-3) • Light also transfers energy from place to place. (4-PS3-2) • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4) **PS3.C: Relationship Between Energy and Forces** • When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3- 3) **PS3.D: Energy in Chemical Processes and Everyday Life** • The expression **"**produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4) **ESS3.A: Natural Resources** • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1) **ETS1.A: Defining Engineering Problems** • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (secondary to 4-PS3-4)	**Energy and Matter** • Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4) **Cause and Effect** • Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1) • Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2) - **Connection*s to Engineering, Technology, and Applications of Science*** ***Interd*ependence of Science, Engineering, and Technology** • Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1) **Influence of Engineering, Technology, and Science on Society and the Natural World** • Over time, **p**eople's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1) • Engineers improve existing technologies or develop new ones. (4-PS3-4) -- **Connections to Nat*ure of Science*** ***Science is a Hu*man Endeavor** • Most scientists and engineers work in teams. (4-PS3-4) • Science affects everyday life. (4-PS3-4)

TABLE 4: Common Core State Standards Connections

Common Core State Standards Connections:

ELA/Literacy –

RI.4.1 *Refer to details and examples in a text when explaining what the text says explicitly and when drawing inferences from the text. (4-PS3-1)*
RI.4.3 *Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. (4-PS3-1)*
RI.4.9 *Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably. (4-PS3-1)*
W.4.2 *Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)*
W.4.7 *Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4- PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)*
W.4.8 *Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4),(4-ESS3-1)*
W.4.9 *Draw evidence from literary or informational texts to support analysis, reflection, and research. (4-PS3-1),(4-ESS3-1)*

Mathematics –

MP.2 *Reason abstractly and quantitatively. (4-ESS3-1)*
MP.4 *Model with mathematics. (4-ESS3-1)*
4.OA.A.1 *Interpret a multiplication equation as a comparison, e.g., interpret 35 = 5 × 7 as a statement that 35 is 5 times as many as 7 and 7 times as many as 5. Represent verbal statements of multiplicative comparisons as multiplication equations. (4-ESS3-1)*
4.OA.A.3 *Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding. (4-PS3-4)*

* The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

The section entitled “Disciplinary Core Ideas” is reproduced verbatim from *A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas*. Integrated and reprinted with permission from the National Academy of Sciences.

ENERGY IS ELECTRIFYING – DAILY LESSON PLANS

DAY 1 - BRIGHT IDEAS
(Engage)

- *INTRODUCTORY ACTIVITY - Flick the classroom light switch* on and off to grab your students' attention. This activity will also serve as a great pre-assessment to understand their prior knowledge and misconceptions about Energy and Electricity.

  Ask the Question: What has to happen for the lights to go on in our classroom?

  Class Brainstorm – Write kids ideas on board.
  Clarify there are no right/wrong answers, just your Bright Ideas!
  (Most likely, several students will have said Electricity!)

- *ACTIVITY 2 – Share unit objectives with students*. Tell students we will be studying Energy and Electricity for the next two weeks, and be able to answer our first question.

  Unit Objectives:

  - You will understand that Energy is a System.
  - You will also understand how electricity is generated, and carried from place to place.
  - You will understand different forms of energy, and how energy changes.
  - You will understand the different technologies humans have developed to harness energy for our use.
  - You will become familiar with different sources of energy, both non-renewable and renewable.
  - You will participate in a renewable energy investigation.
  - You will be able to create an Energy Chain, and be able to trace the Energy of the Sun to these lights in our classroom. (NOTE to teachers: Most but not all of our energy comes from the sun, including, nuclear, geothermal and tidal energy.)
  - You will understand why we need to make good energy choices in our homes, schools and communities.

  Note: Unit Objectives can be listed on a poster in the classroom for student referral throughout the unit.

- *ACTIVITY 3 - Introduce Science Notebook/Journal* – Provide students with a science notebook for the unit. Tell them they will use this to write, record data, draw and store worksheets they've collected throughout the unit. If possible, have students spend a few minutes writing reflections in their journals at the end of each day. Provide the following list of suggestions about what they could write about:

  - Something new you learned
  - A question
  - A drawing
  - A poem
  - Something you want to share with your family
  - Something that gave you inspiration for your energy chain drawing

  Suggestion: Post journal bullet points in front of room for students to refer to during their Daily Reflections journal writing. Unless you want to prompt them otherwise, let students choose how they want to reflect.

- *ACTIVITY 4* - Read Children's Book*: My Light,* by Molly Bang, aloud to the class (preferably project book pages with an ELMO Visual Presenter)

  - Read this book slowly, taking time to pause at each page. The text is minimal, but the images are powerful.

  - Follow the yellow dots on every page - these represent the suns energy, flowing from the sun to earth, moving around, and changing form.

  - *Pre-Assessment Journal Writing* – Have students write 3 things they learned from reading My Light in their journals.

  Rationale: Every time I read *My Light* by Molly Bang, I am inspired by the author's ability to make a seemingly overwhelming and complex concept accessible. Ms. Bang brilliantly creates connections, and interconnections, all beginning with the singular source of energy for life on earth – our SUN.

- *ACTIVITY 5* - Watch Video: "NOVA SUN LAB" in the Sun101 section entitled *Anatomy of the Sun* (length 3:22 minutes).
  http://www.pbs.org/wgbh/nova/labs/lab/sun/3/1/

  (NOTE: New users will be prompted to login with a Guest Pass, or sign up for a free PBS Learning media account.)

  The images of the sun as a burning ball of energy 93 million miles away are very powerful. Have kids think about how the sun's energy travels to earth, and flows through systems. Remind them of the images in the book *My Light*.

Rationale: In the process of looking online for a realistic image to capture the immense power of the sun, I discovered NOVA Energy Lab and Sun Lab, an educational online video series designed by PBS online. Each lab consists of short video segments that cover key concepts, including explanations of existing technologies, and research design challenges to engage viewers in solving our energy dilemma. In addition, The Energy Lab standards are closely aligned with the Next Generation Science Standards (NGSS), making them very relevant to the changing landscape of science education.

- *JOURNAL REFLECTIONS*: Inform students they will be doing this at the end of every day.

- *HOMEWORK:* Ask your family members if they know what had to happen to make the lights go on in your home. Write down everyone's answers. Tell your family that you will be educating them about the energy and electricity that they use in your house.

- *EXTENSIONS*:

  * NOTE to teachers about NOVA Labs:

    If you wish to use the NOVA Labs videos individually, outside the context of a particular Lab, all videos can be found on the following link - organized according to the Lab for which they were produced.
    http://www.pbs.org/wgbh/nova/labs/videos/

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-2, 4-ESS3-1
Science and Engineering Practices: Asking Questions and Defining Problems, Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.D, ESS3.A, ESS3.C
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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RESOURCES:

My Light, by Molly Bang, Blue Sky Press; First Edition (March 1, 2004)
Molly Bang also has a website which provides more detailed information about the science of electricity, for those who want more background information:
http://www.mollybang.com/Pages/mylight.html

NOVA LABS: http://www.pbs.org/wgbh/nova/labs/ (Follow THE LABS tab to link to the SUN LAB and ENERGY LAB.)

DAY 2 – WHAT IS ENERGY? INTRODUCTION TO ENERGY SYSTEMS THINKING
(Engage)

- *ACTIVITY 1* – Have Group Discussion about Homework: What were your family members ideas about how we get electricity?

  Record student responses on chart paper to be referred to at the end of the unit to evaluate how their understanding has evolved.

- *ACTIVITY 2* – Introduce Energy Systems Diagram:

  Introduce the class to the **Energy Systems Diagram**. (See Attachments to Daily Lesson). If possible project the image on the board in the front of the room.

  Note to teachers: Before the class, teachers should read about this activity, adapted from the Northeast Sustainable Energy Association (NESEA) *Energy Thinkers* curriculum unit. It is a useful visual tool to help students understand that Energy is a System with many interacting components. (See Resources links at end of daily lesson.) *

  Refer to the *Teacher Background Reading from the NESEA Energy Thinking Unit* on the following pages for an explanation about how to use this diagram with your students, to help them to better understand **Energy As A System**.

  There are two versions of this diagram, one with graphics, and one left blank for students to fill in as they apply this model at various times throughout this unit.

  You will be referring to this diagram throughout the unit, as a way to help kids evaluate our Energy Use, and make Smart Decisions, and formative assessment.

  Example: Use this example with whole class - Roasted Marshmallows:

  Goal: Roasted Marshmallows at a picnic
  Input: Twigs, marshmallows, matches
  Processes: Gather twigs, arrange to make fire, strike the match
  Outputs: Things we want – a toasty marshmallow;
  Things we don't want – smoke from fire, ashes, burnt marshmallow, risk of forest fire
  How to do it better: Use drier wood so not so smoky, Use a solar cooker, etc.

- *ACTIVITY 3* – Have class watch video segment from the *Switch Energy Project*: *Energy Issues: What You Need to Know* (2 minutes long)

  http://www.switchenergyproject.com/topics/energyissues

Rationale: This video is the introduction to the *Switch Energy Project* video series, and provides a short but compelling look of how everything in our lives – cars, internet, phones, appliances, houses, schools, food, clothes, every product we own and use - is powered by energy!

- *ACTIVITY 4* – Small Group Follow-up Activity to video:

1) Have students work in small groups. Provide each group with a copy of the *Energy Systems Diagram* to fill in. Provide prompts/pictures of an object, some which were mentioned in the video, for example:

  - Your blue jeans
  - Your backpack
  - Your sneakers
  - Your T-shirt
  - Chocolate bar
  - Plastic water bottle

2) Refer each group to the *Energy Systems Diagram*, and have them fill in all the parts they can think of about what must happen to get the desired product in their group. What is the Energy Chain?

As an example, what had to happen for the blue jeans you are wearing to get in your closet? Trace it backwards! This can be a very revealing exercise. If you go back to the source, you will end up with *My Light, the SUN!*

Prompt questions could include:

  - What material is your product made of?
  - How was it produced?
  - What kind of energy went in to producing it?
  - Where did those materials come from?
  - Where was your product manufactured?
  - How did it get here?
  - What kind of energy did it take to deliver your product here?
  - What might be some of the unwanted outputs of producing this object?

3) Have each group share their ides with the class. No two groups will be the same because each Goal had different inputs, different outputs, and different processes!

This is a great exercise to help students recognize how everything truly is powered by energy! It profoundly influences how they (and we!) think about everything they do, and everything they use for the rest of their lives. This awareness is fundamental to becoming energy literate.

- *ACTIVITY 5* - Have follow-up discussion: What is energy? The following definition is from the U.S. Energy Information Administration (EIA):

Energy makes change possible. We use it to do things for us. It moves cars along the road and boats over the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs on the radio and lights our homes. Energy is needed for our bodies to grow and it allows our minds to think.

Scientists define energy as the ability to do work. Modern civilization is possible because we have learned how to change energy from one form to another and use it to do work for us and to live more comfortably.

http://www.eia.gov/kids/energy.cfm?page=about_forms_of_energy-basics

- *JOURNAL REFLECTIONS*

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-2, 4-ESS3-1
Science and Engineering Practices: Asking Questions and Defining Problems, Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.D, ESS3.A, ESS3.C
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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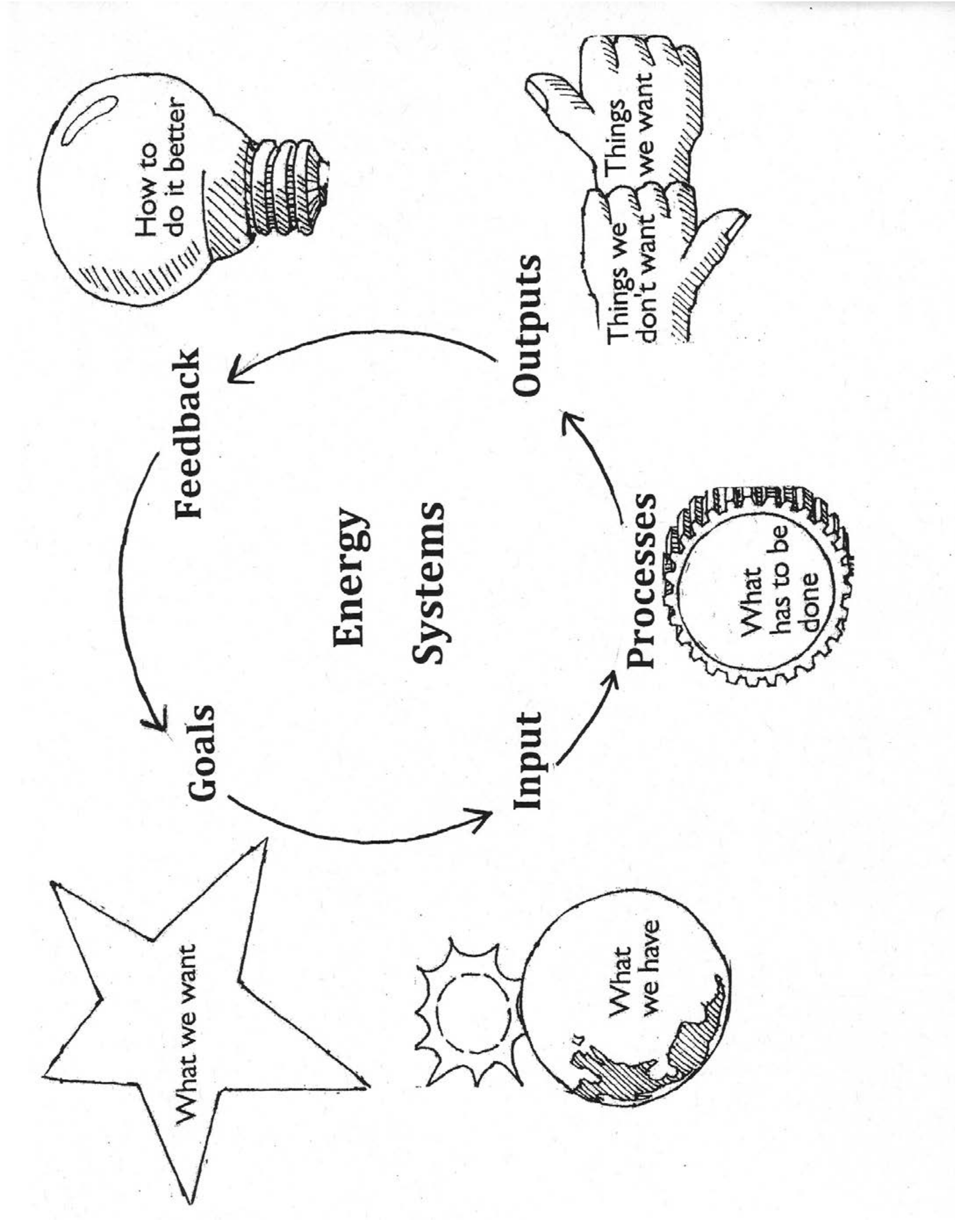
RESOURCES:

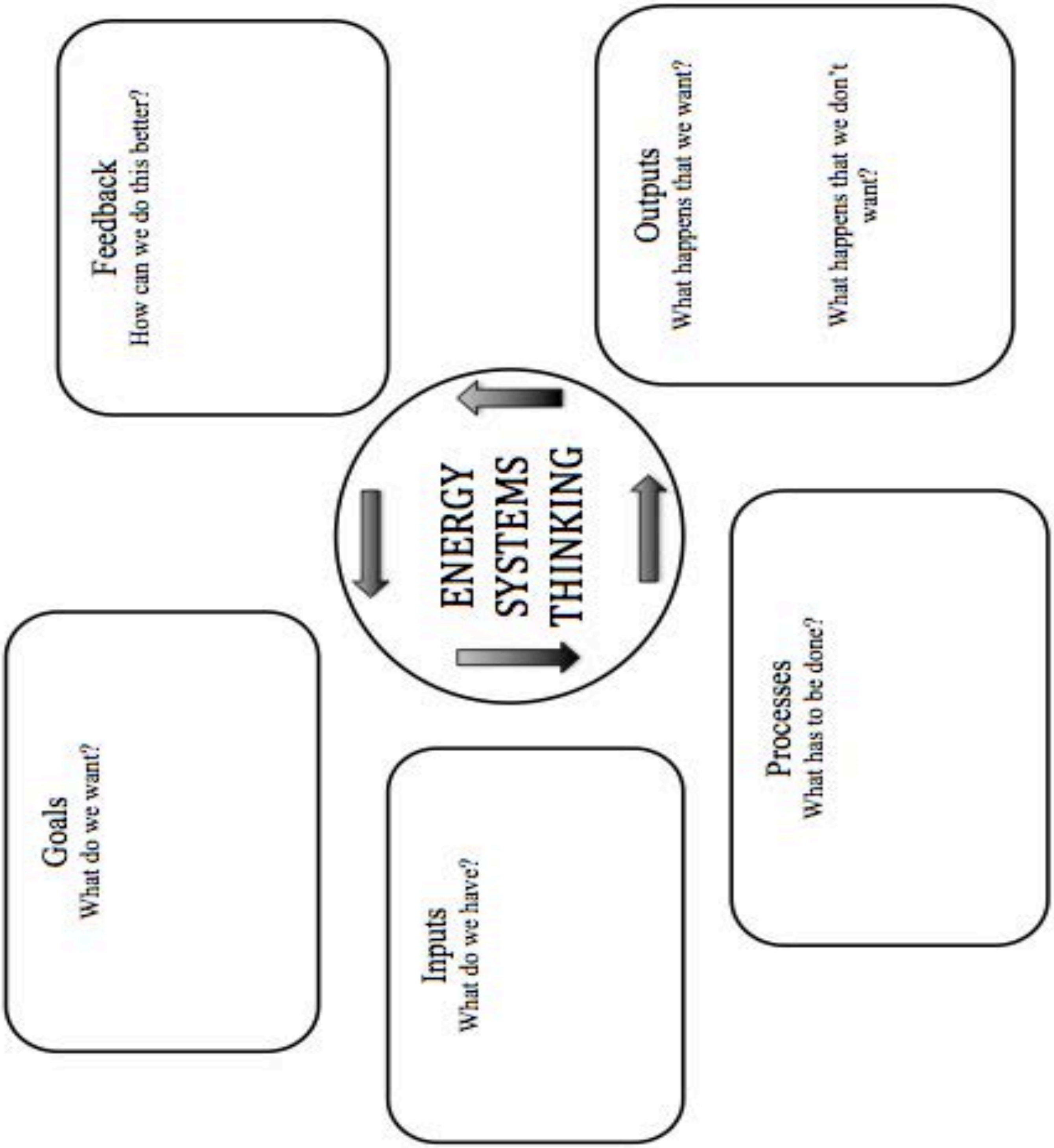
* *NOTE TO TEACHERS:* The *Energy Systems* diagram was adapted from the *Energy Thinkers* curriculum unit developed by the Northeast Sustainable Energy Association (NESEA). www.nesea.org
It is available for **download** from EnergyTeachers.org, a network for educators interested in energy production and use: http://energyteachers.org/home.html
For a direct link to the NESEA Energy Education Document, *Energy Thinking for Massachusetts:* http://energyteachers.org/project_detail.php?project_id=13 - Energy Thinking for Massachusetts (pdf file format)

Switch Energy Project videos: http://www.switchenergyproject.com (Note: Teachers, professors and school libraries can receive a free Education Edition DVD of Switch, plus receive a password for free access to stream and download the film. See the Education link on the website.)

NEED - National Energy Education Development Project. The NEED project provides in-depth curriculum about teaching Energy, and can be downloaded for educational, non-commercial purposes. For Grades 3-4 curriculum refer to the *Elementary Energy Infobook*.
http://www.need.org/ Curriculum-Guides-by-Grade-

ATTACHMENTS TO DAILY LESSON:


Energy
Systems
Goals
Input
Processes
Outputs
Feedback
What we want
What
we have
What
has to be
done
Things we
don't want
Things
we want
How to
do it better


Feedback
How can we do this better?
Outputs
What happens that we want?
What happens that we don't want?
ENERGY
SYSTEMS
THINKING
Goals
What do we want?
Inputs
What do we have?
Processes
What has to be done?

Teacher Background Reading from NESEA Energy Thinking Unit

We use energy and energy systems to provide us with much of what we need in life. Warm houses in the winter, a variety of foods year round, lighting and the work of appliances at the flip of a switch are a few examples. Our lives would not be as comfortable, our food as plentiful, or our ability to get around as convenient without the energy systems that support our lifestyles. Yet every energy system also has negative consequences such as air and water pollution, visual impacts, or destruction of animal habitats.

The activities will introduce students to a system of thinking about the pros and cons of energy use on society and the environment, and the science and technology of converting natural resources into useful energy and using energy efficiently.

In this unit, students will use a universal systems model to analyze;

Where energy comes from
How energy resources are processed into useful energy and transported
Consequences of using energy
How to reduce negative consequences of energy use.

They will do this by viewing energy use as a ***system*** *that is made up of* ***Goals*** *(what they want),* ***Inputs*** *(what resources are used),* ***Processes*** *(what has to be done),* ***Outputs*** *(positive and negative consequences of energy use), and* ***Feedback*** *(ideas for how the system can be improved).*

Goals: *The primary goal of any energy system is to provide for a human need, such as a house at a comfortable temperature, warm water, well-lit rooms, or moving people and things. Less obvious, but just as important goals are that the energy system be safe, low cost, as pollution free as possible, and not contribute to global warming.*

Inputs*: The most basic input to an energy system is some natural resource that provides energy. Petroleum, coal, sunlight, wind, natural gas, moving water, wood, and radioactive materials are all examples. Other inputs include materials and energy needed to build such infrastructure as power plants, transmission lines, roads, furnaces, cars, or light bulbs; in short, everything needed to manufacture and maintain the energy system.*

(Continued on next page)

Processes: Converting a natural energy resource into a usable form of energy and transporting it to where it is needed are the most basic processes of an energy system. Converting crude oil into gasoline and gasoline into motion are two processes used in America's most popular transportation system – getting around in the family car. Transporting crude oil to a refinery and gasoline to a gas station are also processes needed to make this system work.*

Outputs: All energy systems provide people with something they want or we wouldn't build them. But they also cause many things to happen that people don't want. A warm house in the winter, warm water, and well-lit rooms are examples of wanted outputs. Pollution, depletion of resources, impacts on human health, and environmental degradation are examples of unwanted outputs.*

Feedback: Feedback is thinking, "What would improve this energy system?" This type of question can lead to changing the energy system in ways that retain what you like and reduce what you don't like about the system. Nearly all ideas on how to change an energy system affect the Input and Processes categories and fit into the following three groups.*

- *Change the Energy Resource (change of Input)*
- *Use more Efficient Technologies (change of Process)*
- *Change Human Behavior (change of Process) -*
  For instance, you may ask, "How can we light our classroom without causing so much air pollution?" Responses may include (a) buy electricity produced by a clean, renewable energy resource, (b) upgrade the room lights to more efficient fixtures or (c) turn lights off when no one is in the room or when sunlight is available. Each of these would fit into one or more of the above groups

DAY 3 – FORMS OF ENERGY
(Explore)

- *BACKGROUND INFORMATION: Forms of Energy*

  Provide students with copies of the *Forms of Energy* hand-out (see attached).
  If possible project this image on a white board and discuss with the entire class.
  Tell them energy comes in many forms, and can be converted from one form to another.
  All the different forms of energy fall under two main categories, Potential Energy and Kinetic Energy.

- *ACTIVITY 1 (Small Group Activity 1)* – Have students look around room and see how many different forms of energy they can identify. Examples of kinetic energy may include: electrical energy that powers room appliances, radiant energy from lights, thermal or heat energy from school heating system. Examples of potential energy may be chemical energy stored in calculator batteries, gravitational energy in objects stored high on shelves, mechanical energy stored in rubber bands when stretched.

- *ACTIVITY 2 (Small Group Activity 2) -* Provide each table with a collection of small toys and gadgets, or photos of different items. Prompt students to discuss what different forms of energy are needed for that item to function, and how the energy changes forms:
  Examples may include:

  - A flashlight
  - A TV
  - A computer
  - A wind-up toy car
  - A photo of a car
  - A spring
  - A yo-yo

  Have each group present their ideas to the class

- *ACTIVITY 3 (Whole Class Activity)* - *Energy Forms Charades - Acting out Energy Forms*. This is a fun "kinetic" activity for the whole class to engage in, to help reinforce the concept of Forms of Energy. *Procedure:*

  1. Discuss the topic of energy with your students, referring to the background information provided above. This information is also reinforced on the *Leader's Reference Sheet* shown below.

  2. Choose an open area large enough to facilitate moving about. Introduce the activity by telling students, "In order to learn a little bit about how energy works in our lives, we are going to act out the various forms of energy."

  3. Explain that they will be playing charades. The words in *italics* are suggestions of what kids can do. They can also be creative.

ACTING OUT ENERGY FORMS ~ Leader's Reference Sheet:

1. **KINETIC ENERGY** is energy in motion *(pretend to power walk)*.

    - **Radiant Energy** is the energy of electromagnetic waves, or light, traveling from the sun *(splay fingers, pointing slightly down and move your arms in a downward wave motion, mimicking sunrays traveling to Earth)*.

    - **Thermal Energy** is energy that is vibrating due to heat *(jiggle up and down slightly)*. The hotter the matter gets, the faster it moves *(jiggle body up and down faster)*.

    - **Electrical Energy** is energy that is electrons moving through wires *(put hands at sides and shuffle fast a few paces, turn and continue to shuffle, as if you are moving inside a wire)*. Electrical energy is also lightning! *(Pose with your hand raised at a diagonal, finger pointed up to the sky and then point down across your body to the ground. Repeat a few times. Think disco dancing.)*

    - **Motion** is the movement of a substance from one place to another. **Wind Energy** is one example. (*Wave your arms in big slow circles and make a low and constant "whoosh" sound as if you are a windmill.)* **Hydropower** is another example- energy that comes from moving water *(move hands in wave-like motion)* falling down on turbine blades and turning them *(bend over sideways as if falling and spinning your arms)*.

2. **POTENTIAL ENERGY** is energy that is stored or waiting *(tap your foot and look at your wrist)*.

    - **Chemical Energy** is energy stored in food *(pretend to pick up a treat and smack your lips)*, in batteries *(pretend to hold a battery up examining it)*, in fossil fuels *(squat into a ball like a lump of coal)*, and in plants *(feet and legs together, arms out like leaves, head arced to sunlight)*.

    - **Nuclear Energy** is energy that holds the nucleus of an atom together *(pretend to hold something small in your hands)*. Energy is released when nuclei are split apart *(pretend to pull something apart between your hands)* or forced together *(clap your hands once)*.

    - **Stored Mechanical Energy** or **Elastic Energy** is energy stored in an object that is either compressed *(tighten up your body)* or stretched *(stretch your body out like a rubber band)*.

    - **Gravitational Energy** is energy in a position to be acted upon by gravity *(look down and teeter on your feet, as if you are about to fall — be dramatic with hands waving, body bobbing)*.

    - **Magnetic Energy** is energy created by a magnetic field *(pretend your hands are magnets attracting and repelling)*.

Note: This activity was developed by Arianna Alexsandra Grindrod - former Education Director for the **Northeast Sustainable Energy Association (NESEA)**, for their teacher-training series *Energy Thinking*. (See link in resources section *)

- *ACTIVITY 4 - Optional Follow-up Video:* NOVA Energy Lab/Using Energy/Energy Defined: *"Not All Forms Are the Same"* (length 2:41). This video provides additional background information about energy, energy forms, and energy conversion (http://www.pbs.org/wgbh/nova/labs/lab/energy/1/2/)

- *JOURNAL REFLECTIONS*

- *EXTENSIONS - History and Literacy:* An optional extension to this lesson would be to have students research energy discoveries and scientists. Early inventors were very observant of the phenomenon around them, and wanted to understand it better. They took risks and did some pretty amazing experiments. We would not be where we are today if it weren't for these ground-braking discoveries in science! Of course, there's always more to know!
  The following are useful resources:

  Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education
  http://www1.eere.energy.gov/education/energy_literacy.html

  Energy Timelines and Famous People in the History of Science
  http://www.eia.gov/kids/energy.cfm?page=4

  Children's Book: *Flick a Switch: How Energy Gets to Your Home*, by Barbara Seuling and Nancy Tobin. Holiday House. 2003 Grades 4-6

  How Things Work Website. For a broad look at famous inventors and inventions, refer to this link: http://science.howstuffworks.com/innovation
  To research inventors associated with electricity refer to this link:
  http://science.howstuffworks.com/electricity.htm

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1, 4-PS3-2, 4-PS3-3, 4-PS3-4, 4-ESS3-1
Science and Engineering Practices: Asking Questions and Defining Problems, Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.D, ESS3.A, ESS3.C
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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RESOURCES:

NEED (National Energy Education Development Project): Refer to Curriculum-Guides-by-Grade, Elementary 3-5, Energy Flows.pdf; see also Greek Mythology and Forms of Energy http://www.need.org/

* Acting Out Energy Forms can be found on the following link: http://energyteachers.org/project_detail.php?project_id=13

ATTACHMENTS TO DAILY LESSON:

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.

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

GRAVITATIONAL 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.

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

Teacher Information

What is Energy?

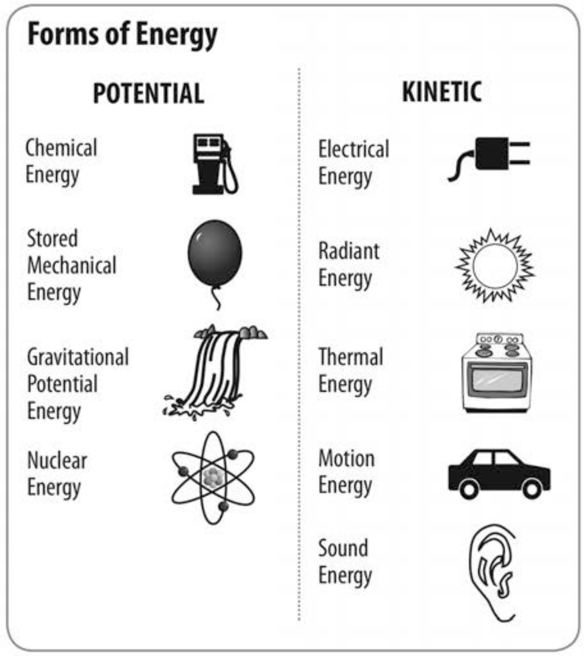
Energy is the ability to do work, the ability to make a change. Everything that happens in the world involves a change of some kind, the exchange of energy in some way. The total amount of energy in the universe remains the same. When we use energy, we do not 'use it up'. Instead, we convert one form of energy into other forms. Usually the conversion of energy produces some heat, which is considered the lowest form of energy, since it dissipates into the surroundings and is difficult to capture and use again. Energy is categorized in many ways—by the forms it takes and by what it does—the changes it makes and the effects we can see or feel or measure.

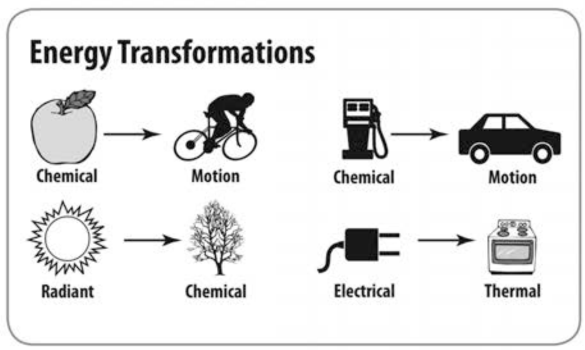
What Energy Does—energy is recognized in many ways.

- Light is energy, and the transformation of energy produces light—the movement of energy in transverse waves or rays is called radiant energy.
- Heat is energy, and the transformation of energy produces heat—the movement of atoms and molecules within substances is called thermal energy.
- Sound is energy, and the transformation of energy produces sound—the back-and-forth vibration of substances in longitudinal waves is called sound energy.
- Motion is energy, and the transformation of energy can produce motion—energy of motion is called kinetic energy.
- Growth requires energy, and the transformation of energy within living things can produce growth—the energy needed for plants to grow comes from radiant energy and the energy needed for everything else to grow is stored in the bonds of substances and is called chemical energy.
- Electricity is energy, and the transformation of energy can produce electricity—when electrons move through a substance it is called electricity.

Forms of Energy—energy is recognized in many forms, all of which are potential or kinetic.

- Radiant Energy (Light, X-rays)
- Thermal Energy (Heat)
- Sound (Echoes, Music)
- Motion Energy (Wind)
- Chemical Energy (Energy in Wood, Fossil Fuels)
- Electrical Energy (Electricity, Lightning)
- Nuclear Energy (Fission, Fusion)
- Gravitational Energy (Hydropower)
- Stored Mechanical Energy (Springs)





For more information and activities about energy transformations, download *Primary Science of Energy* (grades 1-3) or *Science of Energy* (grades 4-5) from www.NEED.org.

DAY 4 and 5 – INTRODUCTION TO ELECTRICITY AND ELECTRO-MAGNETS

(Explore, Explain)

OVERVIEW: For the next 2 days students will be exploring Electricity Generation and Electro-magnets. They will be introduced to the Disciplinary Core Ideas related to Energy. They will also participate in engineering design investigations, constructing and testing mini-models of electro-magnetic generators. This is a foundational exercise that helps kids to expand their thinking about power generation on a larger scale. Topics will include:

- Brief History of Electricity
- Electricity Basics
- Materials
- Electro-magnets Investigation (Activities 1- 3)

NOTE TO EDUCATORS: The next several lessons will include engineering design investigations. There will be components of changing design variables, making observations, gathering data, recording data, and graphing data, which will satisfy the NGSS Science and Engineering Practices, and the Common Core Math Standards.

BACKGROUND INFORMATION:

- *Brief History of Electricity*: Ask Your Students to contemplate the question, What is Electricity? How do we know it's there if we can't see it? This section begins with an introduction to an important discovery by Michael Faraday in 1931 that lead to modern day electrical generation - the Electromagnet.

READ this brief description about Michael Faradays discovery to the class:

> *Michael Faraday was a famous English scientist born in 1791. As a teenager he was very interested in the concept of energy, read many books and performed many experiments.*
>
> *1831 he discovered that passing a magnet through a copper wire could produce an electric current. It was an amazing discovery. Almost all the electricity we use today is made with magnets and coils of copper wire in giant power plants. Both the electric generator and electric motor are based on this principle. A **generator** converts motion energy into electricity. A **motor** converts electrical energy into **motion energy**.*
>
> Note: Other scientists were also involved in important Energy discoveries. For more information, refer to the links in the Resources section at the end of Day 3.

- *ELECTRICITY BASICS* – Refer to the following Electricity handouts for detailed information to review and/or provide to your students. (See Attachments to Daily Lesson)

  - Teacher Background Information – Electricity (Adapted from NESEA *Energy Thinking Curriculum, Chapter 3: Abracadabra, Electricity! p. 90-91*)

  - NEED Elementary Energy Infobook (see Resources)
    - *Electricity*, *Magnets are Special*
    - *Magnets Can Make Electricity*
    - *Electricity Travels Through Wires*
    - *Electricity Travels in Loops*

  - NEED Wonders of Wind Teacher Guide
    - *Measuring Electricity,*
    - *Multimeter* graphic

MATERIALS:

- Strong Bar magnet, about 3 inches long
- Copper wire (Plastic-coated or clear-coated)
- Alligator clips, a pair for each group
- Wire cutter (for the class)
- Wire stripper or sand paper
- Duct or electrical tape
- Multimeter *
- Wooden Shish-kabob skewers

Note about materials: Most materials can be found at hardware or electronics stores, or ordered online from science suppliers. An updated Materials List of where the Hitchcock Center has purchased these materials for our *Energy Literacy Unit* is inserted at the end of the unit.

* *MULTIMETERS* are electronic instruments that combine several functions into one hand-held unit. Most Multimeters can measure voltage, current, and electrical resistance, and are available in Analog or Digital readout formats. Analog Multimeters have a pointer that moves over a scale calibrated for all the different measurements that can be made. Digital Multimeters display the measured value in numerals, and may also display a bar of a length proportional to the quantity being measured.

We have been using the Analog models in our Energy Programs at the Hitchcock Center, and find them more effective in reading small currents, i.e. those generated by the hand-held electric generators designed by students. Both formats will read zero when the magnet is still, and show that a voltage is being generated when the magnet is spinning.

MULTIMETER CONNECTIONS: The BLACK WIRE connects into the Negative (−) jack on the meter. The RED WIRE connects into the Positive (+) jack.

MULTIMETER SETTINGS: Set the Multimeter Dial to read DC Current – which is measured in Amps (A) – at the lowest setting, which is usually .5mA (milliamps). This is the most sensitive setting for students to get a reading of electric current generated from their devices. (See additional instructions in NESEA Energy Thinkers curriculum. There is also a link in wikiHow re: *How to Read a Multimeter.*)

STUDENT USE OF MULTIMETERS: Before introducing students to the materials they will use in their designs, show them how the Multimeter works. Instructions and an enlarged graphic are in the *Attachments*, It may be helpful if you project this on a Smart Board for the whole class to view. Explain how to read the Multimeter. Show students the settings they will be using. Tell them they will use these devices again during investigations of renewable energy sources.

- *ELECTRO-MAGNET INVESTIGATIONS:*

ACTIVITY 1 - INTRODUCTION TO ELECTRO-MAGNETS: Tell students they will be working in teams to build and investigate hand-held electro-magnets generators. Provide this brief overview to explain why we do this:

- We design electro-magnets to generate an electric current
- Passing a magnet through a coil of wire causes electrons in the wire to move, which creates an electric current
- We use devices to measure a change in energy
- We connect our generators to something to observe if it does work.
- If so, electricity is flowing!
- We think about how these designs can be adapted to generate electricity on a large scale
- We use lots of tools, and have fun investigating!

ACTIVITY 2 - DESIGNING THE ELECTRO-MAGNET MODEL:

- *OVERVIEW*:
  - Before engaging in the design process, review the basic information about electricity, and magnets, and how to read a Multimeter in advance.
  - Provide each student group with assembly instructions for the model they will be constructing.
  - Show students materials and a completed version of the design.

- *BAR MAGNETS:* Provide each group of students a pair of bar magnets so they can experiment with the magnetic attraction/repulsion. They could also think of different materials in the classroom that magnets are ‘attracted’ to.

- *MODEL CONSTRUCTION,* adapted from the NESEA *Energy Thinkers* curriculum (See Attachment entitled *Build a Hand Made Electric Generator,* and link to website.)
  This version involves wrapping wire in coils, taping a bar magnet to a wooden skewer, and positioning the skewer and magnet so the magnet passes through the coil.

  * *IMPORTANT DESIGN CONSIDERATIONS*:

  - Make sure the length of wire is adequate for students to wrap several coils around the magnet – we recommend 12 feet per model.

  - If using plastic-coated copper wire, strip the ends with wire-strippers. If using clear-coated copper wire, use sand paper to strip the ends.

  - Use alligator clips to connect the copper wires to the Black and Red Lead Wires attached to the Multimeters. This completes the circuits so the electricity can flow.

- *JOURNAL REFLECTIONS/FOLLOW-UP QUESTIONS*:

  - Ask students what FORMS OF ENERGY they are observing!
  - What kind of energy had to go into spinning the magnet manually!
  - What happened between the magnet and the copper wire?
  - How might you improve your design to generate more electricity? Their answers may be very interesting! They may try really hard to spin the magnet faster; they may suggest increasing the number of copper coils! I have considered connecting the shaft to a hamster wheel!
  - How can electricity be generated on a larger scale? (NOTE: this is the lead-in question to introduce Steam Turbine Generators on the next day!)

- *EXTENSIONS:*

  1) INTRODUCE VARIABLES: Ask students how they might adapt their designs to generate more electric current. For example, they may suggest adding more coils of wire in their circular bundle around the skewer. They may suggest increasing the speed of the magnet rotation.

  2) An alternative electromagnet design option is available from the website *Energy for Keeps* (http://energyforkeeps.org/for-teachers).
     This model describes how to wrap copper wires around an empty toilet paper roll, and a compass to determine if an electric current is generated when students insert a bar magnet in and out of the tube.

     Student teams could construct both versions of the electro-magnet models. This would provide the opportunity to work with their designs, introduce variables, and observe and measure electricity generation. Students can determine which design generates the most current, and propose additional strategies to increase the efficiencies of their designs.

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1***,*** 4-PS3-2, 4-PS3-3, 4PS3-4, 3-5-ETS1.1, 3-5-ETS1.2, 3-5-ETS1.3
Science and Engineering Practices: Asking Questions and Defining Problems, Planning and Carrying Out Investigations, Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ETS1.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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RESOURCES:

Energy for Keeps: Creating Clean Electricity from Renewable Resources
http://energyforkeeps.org/for-teachers (Under the link for teachers, click on the Activity *Steam Turbine and Getting Current: Generating electricity Using a Magnet*)

NESEA Energy Education Document, *Energy Thinking for Massachusetts:*
http://energyteachers.org/project_detail.php?project_id=13 - Energy Thinking for Massachusetts (pdf file format)

NEED (National Energy Education Development Project):
http://www.need.org (Curriculum-Guides-by-Grade- / Refer to Elementary 3-5, Elementary Energy Infobook.pdf)

For additional activities about magnets, refer to NEED (Curriculum-Guides-by-Grade- / Elementary 3-5, Wonders of Magnets.pdf)
http://www.need.org

FOR INFORMATION ON ELECTRIC CIRCUITS, Refer to the NEED website, or see the following links
http://science.howstuffworks.com/electricity5.htm
http://energyquest.ca.gov/story/chapter04.html

MULTIMETER INSTRUCTIONS LINKS:
http://www.wikihow.com/Read-a-Multimeter

ATTACHMENTS TO DAILY LESSON:

TEACHER BACKGROND INFORMATION - ELECTRICITY (Adapted from NESEA Energy Thinking)

Almost all of the electricity used in Massachusetts, whether it is powered by natural gas, nuclear, coal, oil, wood, hydropower, wind, or other biomass (such as waste or landfill gas) is produced with an **electric generator.** Massachusetts is heavily dependent on natural gas for the production of electricity with over one half of the state's electricity produced from this resource. About 5% is produced from renewable energy sources such as hydroelectric power, wind, solar, wood, waste, and landfill gas.

An **electric generator** converts mechanical energy into electrical energy through **electromagnetic** induction. Electromagnetic induction occurs when a coil of wire experiences a changing magnetic field, which causes a voltage to be induced in the coil. This effect was discovered in 1830 by the English physicist **Michael Faraday** and is known as Faraday's Law.

There are many ways a coil can experience a changing magnetic field. Electric generators accomplish this either by moving a magnet within a coil of wire—as **students will do in the Hand Made Generator activity**—or, as in most commercial electric generators, coils of wire are spun within a circle of large permanent magnets. Either way, a voltage is "induced" in the coils.

The coils of wire in a generator are attached to a central shaft that can be turned by an outside force. For electric power generation, the shaft is connected to a set of turbine blades that can be turned by high pressure steam, wind, or moving water. The specific design of the turbine blades depends on the energy source used to turn them. For example, wind turbines use long narrow wing-shaped blades, while hydroelectric turbines use many compact cup-shaped blades.

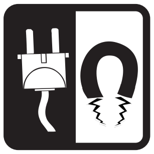
Most of Massachusetts's power plants use high pressure steam to spin turbine blades. Power plants in Massachusetts rely on burning fossil fuels, wood, waste, landfill gas or the heat of a nuclear reaction to produce the steam needed to drive a generator.

Electricity is normally generated at a large power station and distributed to users through a network of wires known as the **power grid**. Producing electricity from small scale solar and wind power sites is changing this pattern by enabling the production of electricity at many different sites, often right where it is required. This pattern of producing electricity is called distributed power generation. When a small power site produces excess power, it can sell it to the utility, which will resell it to other consumers.

Electricity is a highly refined form of energy derived from many different energy sources. How fast it is consumed (or generated) is measured in watts (W). (For instance, a 100watt light bulb consumes electric energy 10 times faster than a 10watt bulb.)

The amount of electrical energy—a product produced by electric utilities—consumed is measured in watt-hours or kilowatt-hours (kWh). (One kilowatt-hour equals 1,000 watt-hours.) A 100watt bulb left on for ten hours uses 1,000 watt-hours of electric energy (100 watts multiplied by 10 hours equals 1,000 watt-hours or 1 kWh). A 10watt bulb left on for the same amount of time uses 100 watt-hours of energy or 0.1 kWh. Utilities charge for how many kilowatt-hours customers consume.

Excerpt from NESEA Energy Thinking, Chapter 3: Abracadabra, Electricity! p. 90-91



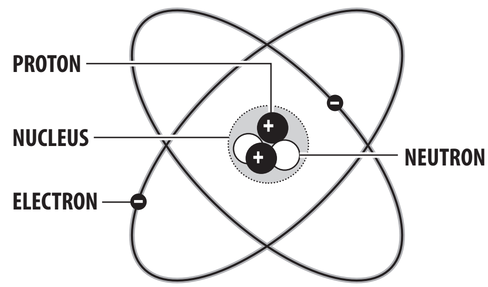
Electricity

Electricity is a mysterious force. We can't see it like we see the sun. We can't hold it like we hold coal. We know when it is working, but it is hard to know exactly what it is. Before we can understand electricity, we need to learn about atoms.

Atoms

Everything is made of **atoms**—every star, every tree, every animal. Even people are made of atoms. The air and water are, too.

Atoms are the building blocks of the universe. They are very, very tiny particles. Millions of atoms would fit on the head of a pin.



Protons, Neutrons, and Electrons

An atom looks like the sun with the planets spinning around it. The center is called the **nucleus**. It is made of tiny **protons** and **neutrons**. **Electrons** move around the nucleus in **energy levels**, or shells, far from the nucleus.

When an atom is in balance, it has the same number of protons and electrons. It can have a different number of neutrons.

Electrons stay in their shells because a special force holds them there. Protons and electrons are attracted to each other. Protons have a **positive charge (+)** and electrons have a **negative charge (–)**. Opposite charges attract each other.

Electricity is Moving Electrons

The electrons near the nucleus are held tight to the atom. Sometimes, the ones farthest away are not. We can push some of these electrons out of their energy levels. We can move them. Moving electrons are called electricity.

Magnets are Special

In most objects, all the atoms are in balance. Half of the electrons spin in one direction; half spin in the other direction. They are spaced randomly in the object. Magnets are different. In **magnets**, the atoms are arranged so that the electrons are not in balance.

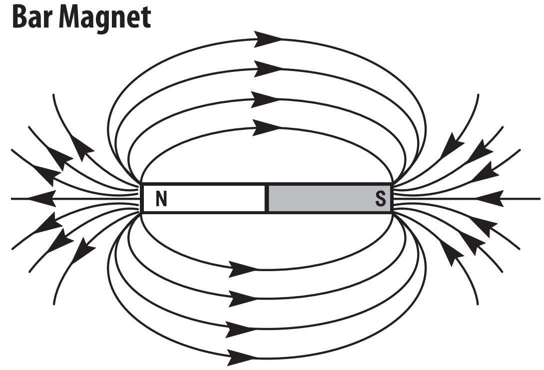
The electrons don't move from one end to the other to find a balance. This creates a force of energy called a **magnetic field** around a magnet.

We call one end of the magnet the **north (N) pole** and the other end the **south (S) pole**. The force of the magnetic field flows from the north pole to the south pole.

Have you ever held two magnets close to each other? They don't act like most objects. If you try to push the two north poles (N) together, they **repel** each other. If you try to push the two south poles (S) together, they repel each other.

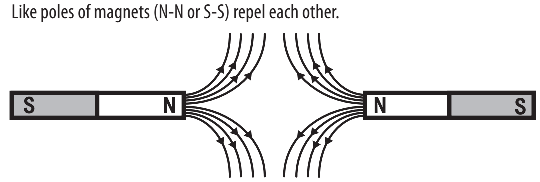
Turn one magnet around and the north (N) and the south (S) poles **attract**. The magnets stick to each other with a strong force. Just like protons and electrons, opposites attract.

Bar Magnet



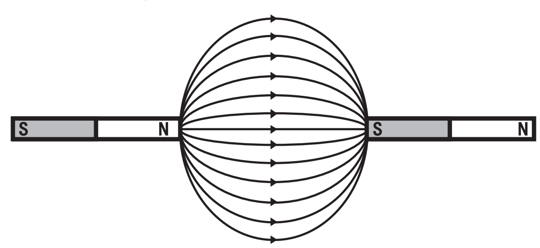
Like Poles

Like poles of magnets (N-N or S-S) repel each other.



Opposite Poles

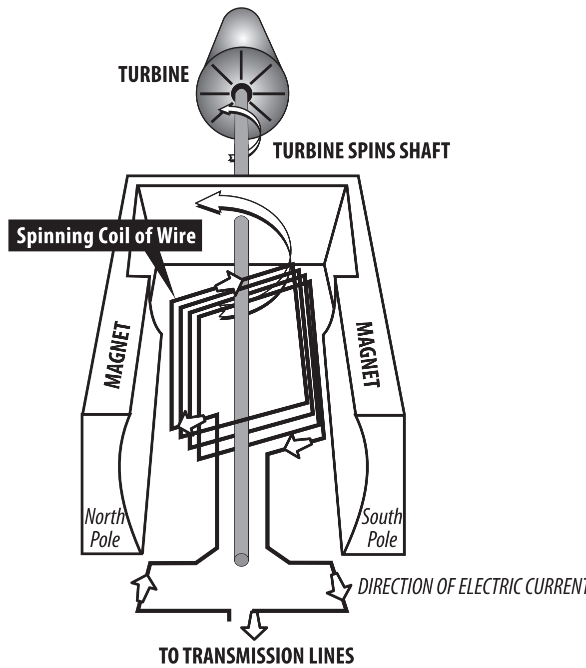
Opposite poles of magnets (N-S) attract each other.



Magnets Can Make Electricity

We can use magnets to make electricity. A magnetic field can pull and push electrons to make them move. Some metals, like copper, have electrons that are loosely held. They are easily pushed from their shells.

Magnetism and electricity are related. Magnets can create electricity and electricity can produce magnetic fields. Every time a magnetic field changes, an electric field is created. Every time an electric field changes, a magnetic field is created. Magnetism and electricity are always linked together; you can't have one without the other. This is called **electromagnetism**.



Power Plants Use Magnets

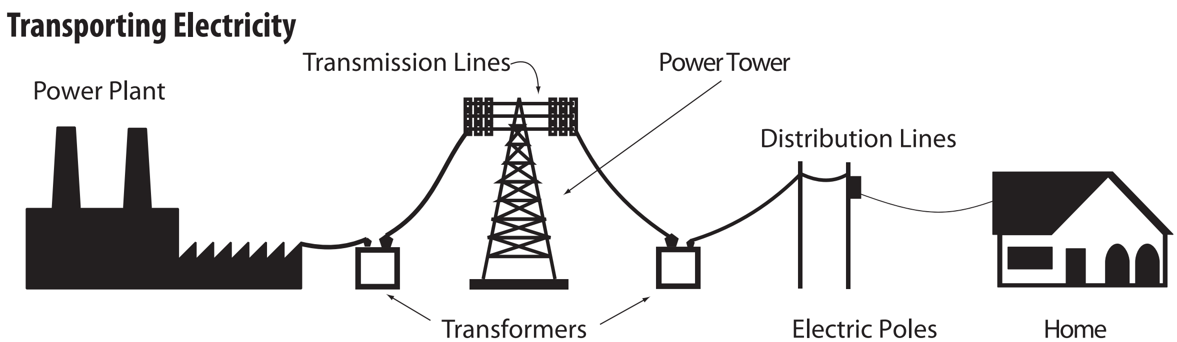
Power plants use huge magnets to make, or generate, electricity. In a **generator**, a big coil of copper wire spins inside the magnets. As it spins, the magnetic fields push and pull electrons in the wire.

The electrons in the copper wire flow into power lines. These moving electrons are the electricity that powers our houses.

Power plants use giant wheels, called **turbines**, to spin the coils of wire in the generators. It takes a lot of energy to spin turbines. Power plants use many fuels to get that energy.

Electricity Travels Through Wires

The spinning turbines make electricity. It flows into **power lines**. The electrons flow through the power lines to our houses. They flow through the wires in our houses and back to the power plant. Then they start their journey again.



There are many different types of power lines. The power plant makes electricity. The electricity flows through **transmission lines** held up by **power towers**. The transmission lines carry large amounts of electricity to electric poles in cities and towns.

Distribution lines carry small amounts of electricity from the **electric poles** to houses and businesses. **Transformers** make sure the electricity is in the proper units (**voltage**) for our use.

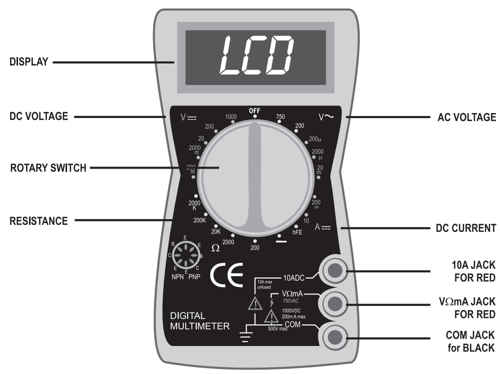
Measuring Electricity

Included in the kit is a tool to measure electricity—a multimeter. The multimeter allows you to measure current, resistance, and voltage, and displays the reading numerically.

When using a multimeter 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 (megaohm 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

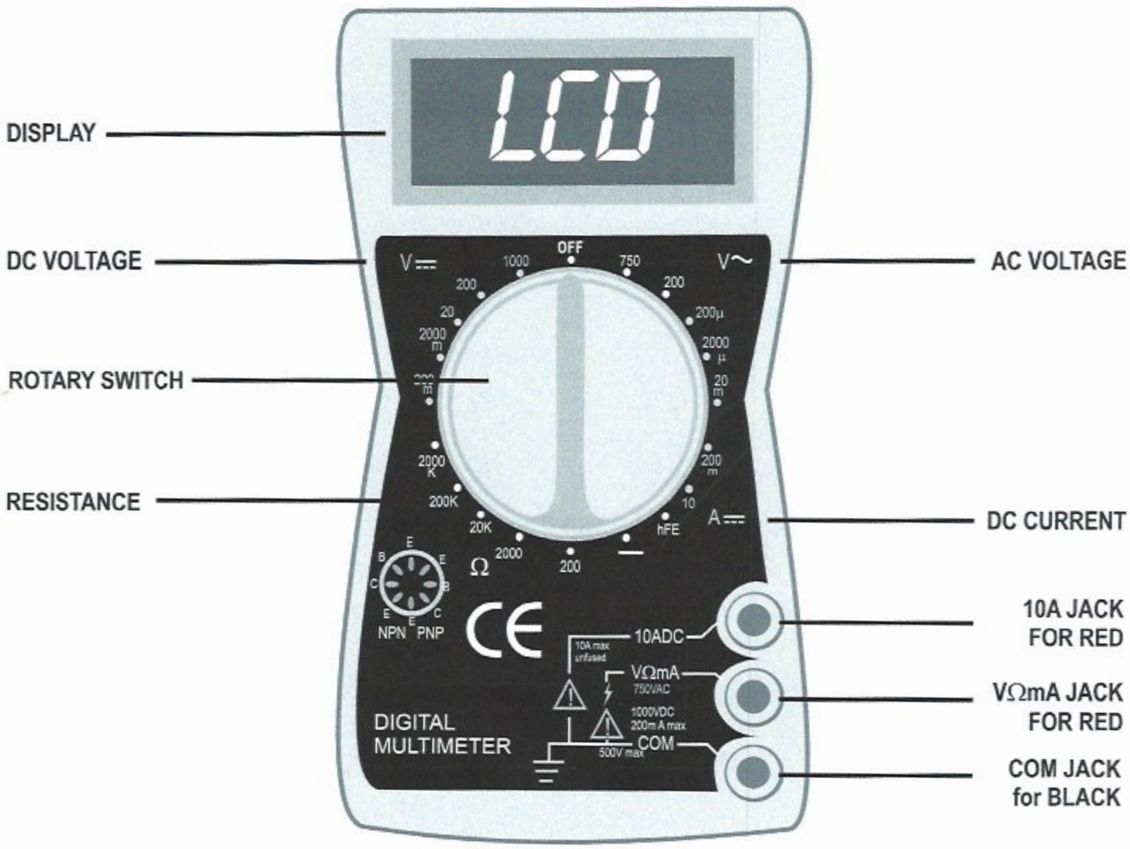
1. Connect RED lead to VΩmA jack and BLACK to COM.
2. Set ROTARY SWITCH to highest setting on DC VOLTAGE scale (1000).
3. Connect leads to the device to be tested using the alligator clips provided.
4. Adjust ROTARY SWITCH to lower settings until a satisfactory reading is obtained.
5. With the wind turbine,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

DC CURRENT (NOT USED IN THIS ACTIVITY)

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.

MULTIMETER



DISPLAY
LCD
DC VOLTAGE
AC VOLTAGE
ROTARY SWITCH
RESISTANCE
DC CURRENT
OFF
10A JACK FOR RED
VΩmA JACK FOR RED
COM JACK for BLACK
10ADC
VΩmA
COM
NPN PNP
DIGITAL MULTIMETER

Build a Hand Made Electric Generator

(Adapted from NESEA Energy Thinking Curriculum)

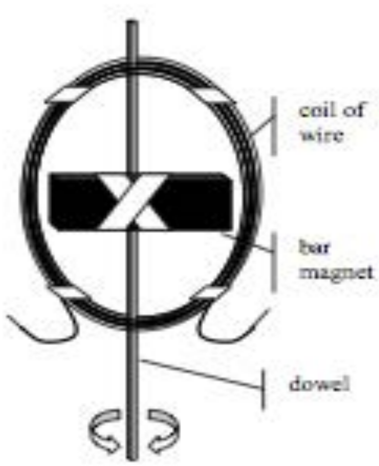


Fig 1: Simple electric generator

Materials

For one hand-made electric generator. You will need one per team - at least three students per team.

- 12 feet of copper wire
- Masking tape
- Sturdy wooden shish-kabob skewers
- Bar magnet, about 3 inches long
- Multimeter

1. Prepare the spinning magnet. Tape a bar magnet firmly to the wooden skewer so that it is perpendicular to the skewer. (See Figure 1.)

2. Create the coil. Wrap the wire into a doughnut where the center hole is slightly larger in diameter then the length of the magnet. The magnet must be able to be spun on the dowel within the coil. Use pieces of tape to hold the coil of wire in shape. Leave the two wire ends protruding from the coil.

3. Insert the magnet into the coil. Insert both ends of the dowel through strands of the coiled wire so that the magnet is held in the center of the coil. Note that in this position, when you spin the dowel, the magnet will pass back and forth through the coil.

4. If using plastic-coated copper wire, strip the ends with wire-strippers. If using clear-coated copper wire, use sand paper to strip the ends.

5. Test the generator. Connect a multimeter to the two wire ends. Set the multimeter to millivolts (the lowest most sensitive voltage setting) and spin the skewer. The multimeter will read zero volts when the magnet is still, and will move slightly when a voltage is being generated.

DAY 6 – GENERATING ELECTRICAL ENERGY
(Explore)

OVERVIEW: The focus of this lesson will be on:
- Electric Power Generation
- Steam Turbine Generators
- Transmission/flow of Electricity through the System

Students will apply their knowledge of electricity and electro-magnets to understand how electricity is produced in large power plants. Emphasis will be on the design of steam turbine generators powered by fossil fuel energy sources. (Subsequent days will introduce students to renewable energy alternatives.)

Students will also be introduced to how energy flows and is transported through the system. This will support their understanding of an Energy Chain, which they will be creating at the end of the unit as a summative assessment of their understanding of these concepts.

- *ACTIVITY 1 – Watch Video:* NOVA Energy Lab - *Putting Energy to Use* (length 2:14 minutes) *Society has been revolutionized by our ability to convert energy into different, more useful forms. As fossil fuels become harder to find, scientists look for new energy sources to power our lives.* http://www.pbs.org/wgbh/nova/labs/videos/#energy-lab

- *ACTIVITY 2* - Have students read the attached page *Steam-Powered Electric Generators (from NESEA Energy Thinkers)* for background information.

  - Project enlarged image on Smartboard and talk students through the steps involved in generating electricity from steam. This particular graphic shows coal as the fuel source in the boiler.

- *ACTIVITY 2* - Project the image *How a Power Plant Works* (from NEED) to provide a different visual to help students understand the process of how electricity is generated. POINT OUT to students that what is lacking in the NEED graphic is the smokestack where Carbon Dioxide and other by-products of combustion are emitted into the atmosphere!

- *ACTIVITY 3* - Provide students with an enlarged copy of the *Steam-Powered Electric Generator* graphic (unlabeled) to follow the arrows, and describe the steps involved in generating electricity from steam.

  Next, have them *color the arrows* to represent different energy transformations. (See attached black and white, and colored-in graphics)

  Last, provide students with the labeled *Steam-Powered Electric Generators* sheet, for them complete. (Note: An answer key version is attached.)

JOURNAL REFLECTIONS: Provide the following writing Prompt: Refer Students back to Molly Bang's book *My Light*, particularly the images about power generation.

Have them write about how much more they understand about electricity, how we generate electricity in power plants, and how energy flows through the system.

Remind them they will each draw an Energy Chain at the end of the unit, and that everything we are studying will add to their knowledge.

EXTENSIONS: If time allows, students can engage in extension activities about hydroelectric power plants, and nuclear power plants. Links to lessons are available on both the NEED and EnergyTeachers.org websites.

Power Source Puzzles: This activity was created by *PowerSleuth.org* an Energy Education Curriculum website, designed for Maine students in grades 4 – 8.
Puzzles include: coal, natural gas, wind, solar and water (hydro) power.
(Lesson Link: http://www.powersleuth.org/docs/EnergyLightsMaine-Lesson6.pdf)

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1, 4-PS3-2, 4-PS3-3, 4PS3-4, 3-5-ETS1.1, 3-5-ETS1.2, 3-5-ETS1.3
Science and Engineering Practices: Asking Questions and Defining Problems, Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ESS3.A, ESS3.C, ESS3.D, ETS1.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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RESOURCES:

The following link to the U.S. Energy Information Administration is a Good primer to Electrical Power Generation)
http://www.eia.gov/kids/energy.cfm?page=electricity_science-basics

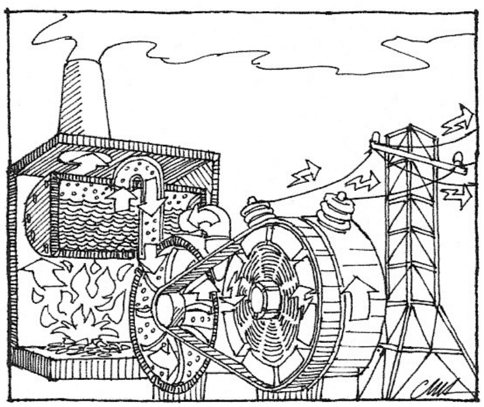
ATTACHMENTS FOR DAILY LESSON:

Steam-Powered Electric Generators

Names:____ Date: ____________________

Almost all electricity used in Massachusetts comes from steam-powered electric generators. Only a very small amount of electricity used in Massachusetts comes from hydropower. Wind and solar-electric panels are used even less and most of the electricity labeled as renewable comes from burning waste, landfill gasses, and wood to create steam for steam-powered electric generators.

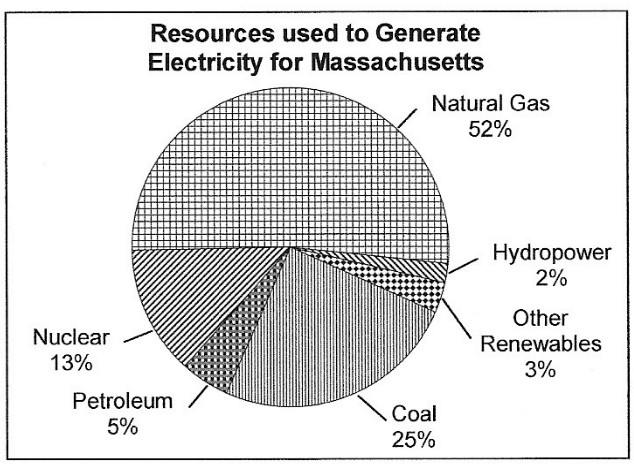
How do steam-powered electric generators work?
Instead of using wind or moving water to turn turbine blades, a steam-powered electric generator uses high-pressure steam to spin the blades.



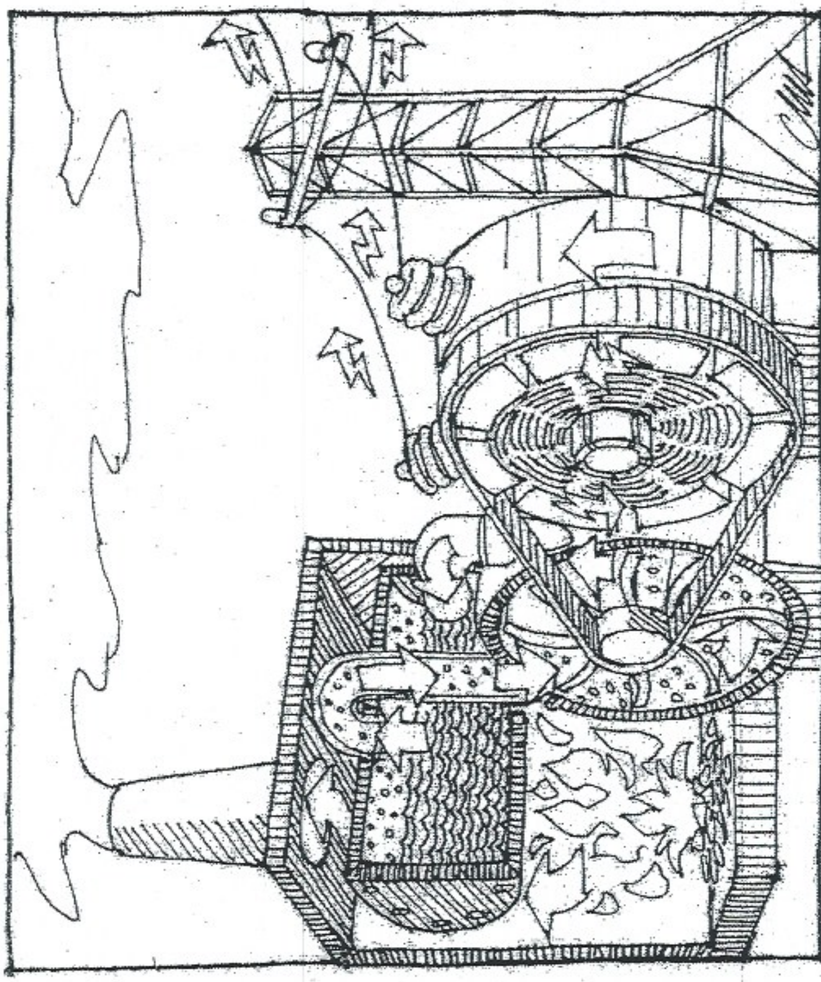
It may help to picture this by looking at a hot whistling teakettle. When the water in the kettle boils it turns to steam. Steam takes up a lot more space then liquid water but the kettle doesn't change size, so the steam creates pressure inside the kettle. The pressure will push steam and air through any holes in the kettle. In your teakettle at home the hole is probably a whistle. If you look closely at a boiling teakettle you can see the steam and air being pushed out the whistle-hole.

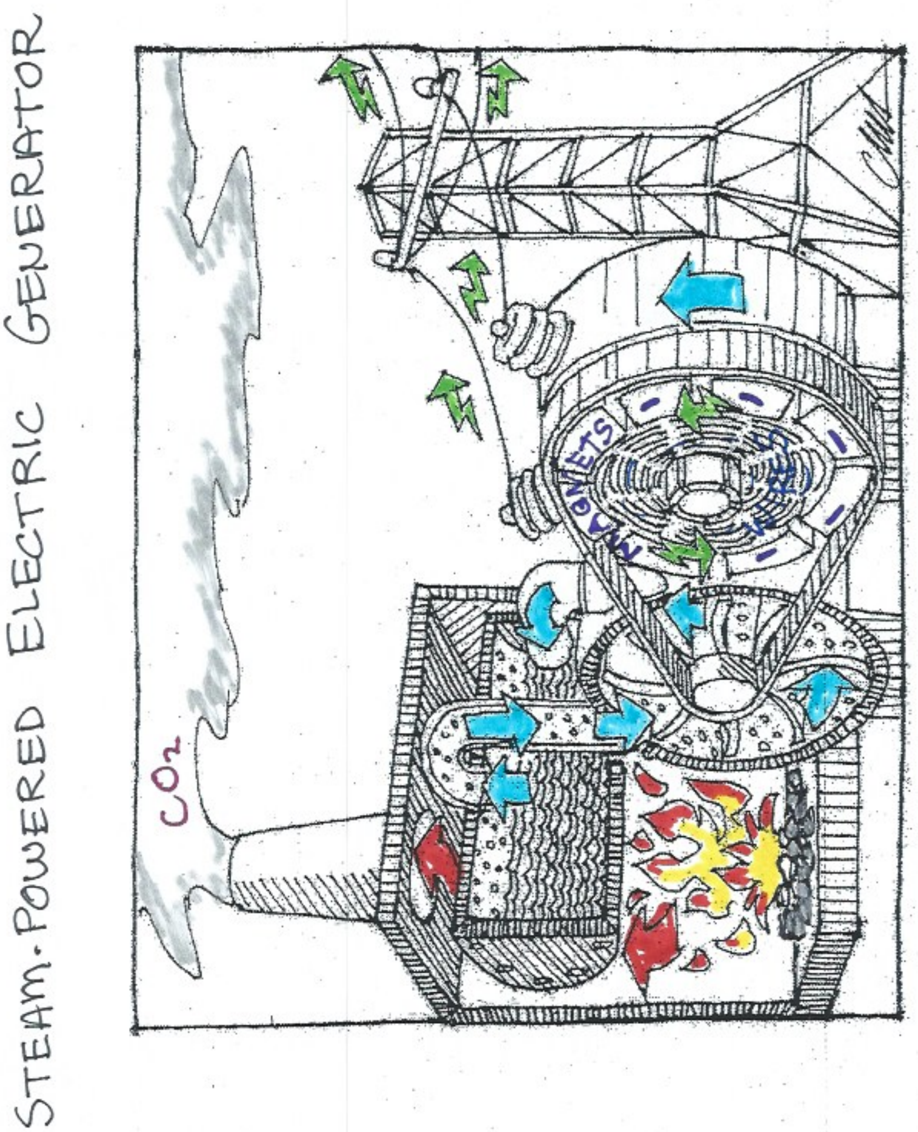
In a steam-powered electric generator, the steam and air are channeled through pipes, which direct the steam and air against turbine blades causing the blades to rotate the shaft of the generator. The rotating shaft causes coils of wire and large magnets to move by each other, producing electricity.

What energy sources are used to make the steam to turn the turbine blades?
About eight-tenths of the electricity used in Massachusetts comes from burning a fossil fuel to make steam for steam-powered electric generators. Burning natural gas is used to make about half of Massachusetts's electricity, one-fourth comes from burning coal, and a small amount (one-twentieth) comes from burning petroleum (oil).



About one-eighth of the electricity made in Massachusetts comes from making steam with nuclear reactors for steam-powered electric generators.



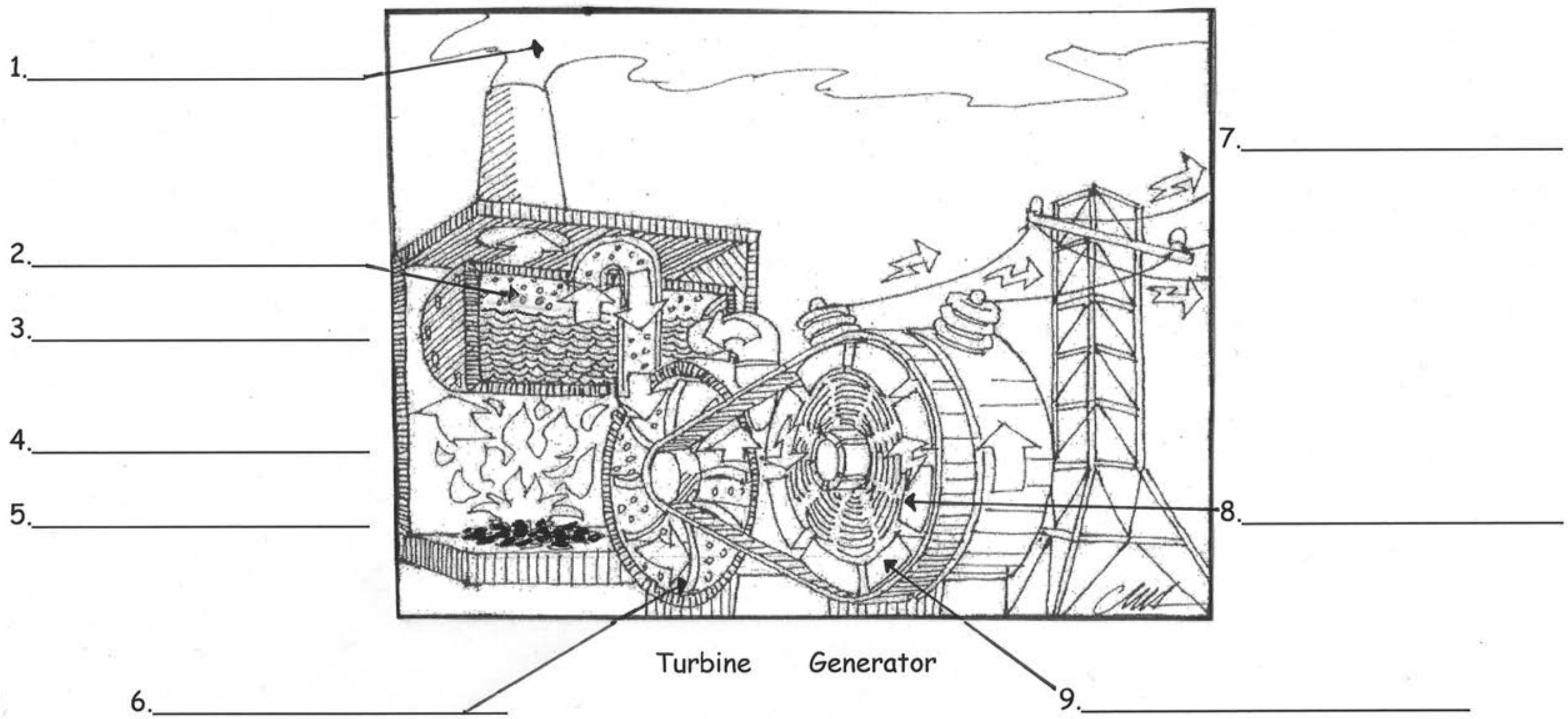

STEAM-POWERED ELECTRIC GENERATOR
CO_2
MAGNETS
WIRES

Steam-Powered Electric Generator

Name______________________________ Date______________

Label the parts of the steam-powered electric generator using the words below:

- Steam
- Electric Power Lines
- Water
- Fire
- Fuel
- Carbon Dioxide (CO_2)
- Coils of Wire
- Magnets
- Turbine Blades

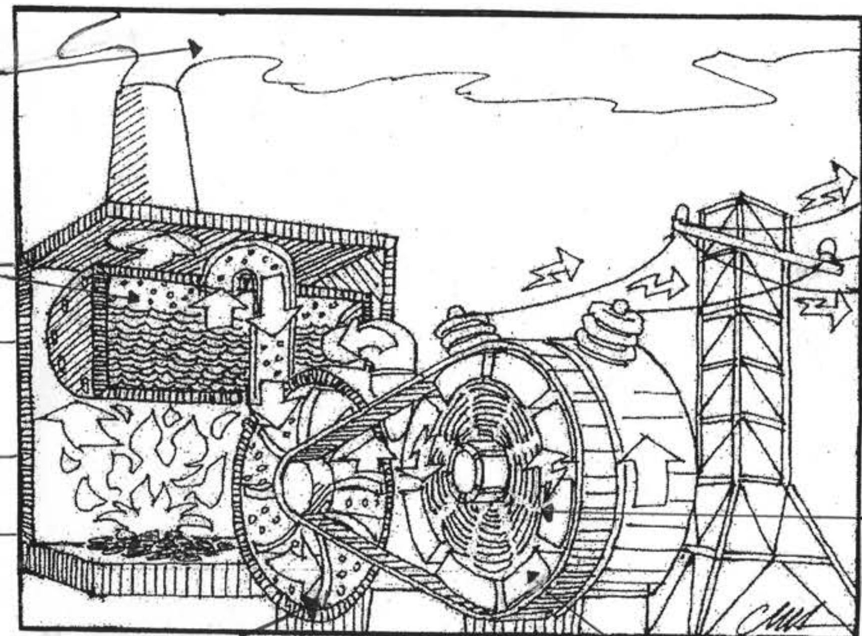


Steam-Powered Electric Generator (Answer Key)

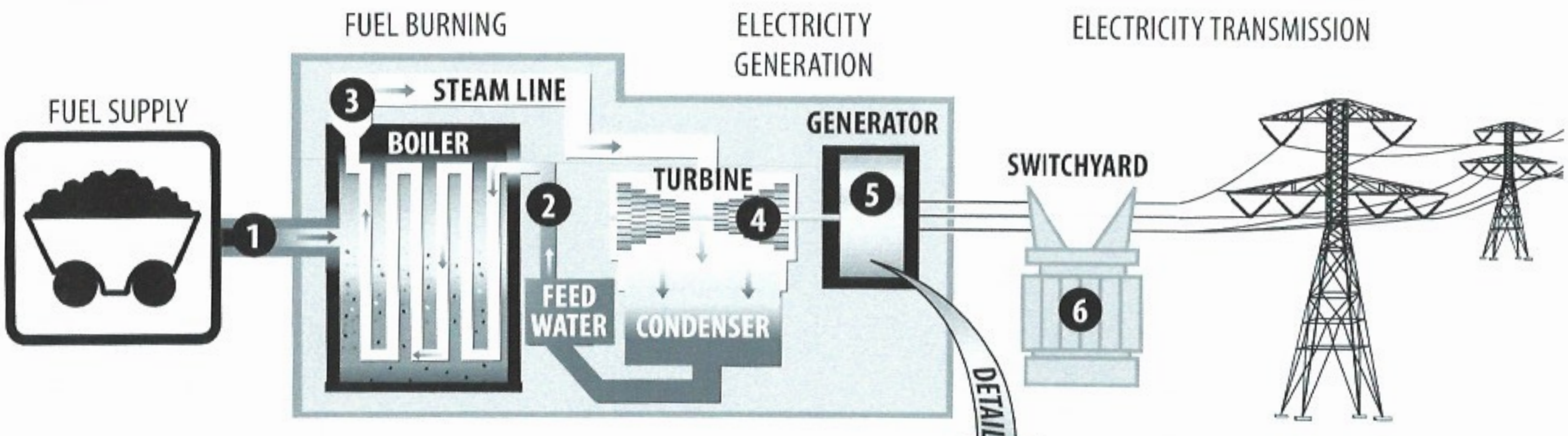
Name________________________ Date______________

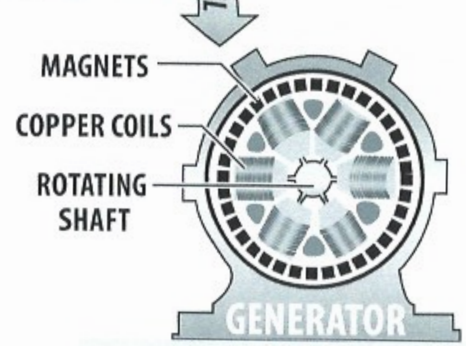
Label the parts of the steam-powered electric generator using the words below:

- Steam
- Electric Power Lines
- Water
- Fire
- Fuel
- Carbon Dioxide (CO_2)
- Coils of Wire
- Magnets
- Turbine Blades



How a Power Plant Works





1. Fuel is burned to make heat.
2. Water is heated, turning it into steam.
3. The steam travels through a steam line.
4. The steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins wires producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

DAY 7 – 9: SOURCES OF ENERGY
(Explore, Explain, Elaborate)

NOTE TO TEACHERS: For the next three lessons students will learn about Sources of Energy:

- Non-renewable Energy Sources - Fossil Fuels, Fossil Fuel Formation (Day 7)
- Renewable Energy Sources, (Day 8 and 9)

DAY 7 – NON-RENEWABLE ENERGY, FOSSIL FUELS

OVERVIEW: This day will introduce students to non-renewable energy sources, specifically fossil fuels. Activities will include:

- Watching an Energy Lab video from NOVA
- Literacy Activity Relating to Coal
- Energy Card Activity adapted from NESEA Energy Thinkers
- Math Extensions

- *ACTIVITY 1* - Watch a short video from NOVA Energy Lab *"Growing Appetite, Limited Resource*. This video is a great introduction to our fossil fuel use, and depicts why we need to change our Energy habits. (http://www.pbs.org/wgbh/nova/labs/lab/energy/1/1/) (Length 2 minutes: 21 seconds)

- *ACTIVITY 2* - Read *The Tale of Fossil Fern* (From NEED. See next attachments at end of Day 6 or refer to web-link.) http://www.need.org/needpdf/EnergyStoriesAndMore.pdf p. 44-46

  Preface: *The Tale of Fossil Fern* is a fun and informative story in the NEED Energy Infobooks, however an essential element is missing that is important in understanding the environmental context of fossil fuel use – THE CARBON ATOM!

  Therefore a new story has been added - *Introducing Carl Carbon* - so students can follow his journey along with Fossil Fern, through Earth systems. This lays the groundwork for understanding the Carbon Cycle, and integrating this knowledge into our Energy Systems Thinking. (See attached)

  JUST FOR FUN, I also adapted the Carl Carbon story to a song - *A Song About Carl Carbon* - to the tune of the Beverly Hillbillies TV show. (See attached)

  Both of these adaptations also introduce Photosynthesis, because this was a key step in plants using the energy of the sun to capture and store atmospheric Carbon. (A graphic about photosynthesis from NEED *Energy Flows*, has been attached.)

- *ACTIVITY 3 –* Share real coal if available (See *Materials List* at end of unit for suppliers.) Provide each group or student with a real piece of coal. Ask the following questions:

    1. How was this lump of coal made?
    2. What had to happen?
    3. What must happen for this coal to generate electricity, so our lights can go on?
    4. What might be some of the Unwanted Outcomes (refer to the Energy Systems diagrams) of using coal for electricity?
    5. How old might this coal be?
    6. Why is it called a Fossil Fuel?
    7. What other fuels are derived from fossils? (Answer: Oil and natural gas.)

    Refer back to Steam-Powered Electric Generator Illustration from previous lesson. Ask students what kind of fuel was being burned to boil the water, to make the steam, to turn the turbine, to generate the electricity, that flowed through the wires, and eventually into our school to light up our room?! (Answer: coal.)

- *ACTIVITY 4 -* ENERGY CARD SORT: This activity was adapted from the NESEA Energy Thinkers curriculum. The Energy Cards are representative of the steps in the Energy Chain from the sun to desired outcomes (i.e. lighting our classroom).

    - The Energy Cards inserted in this unit have been adapted from the Electricity Set. They have been organized by the steps in the fossil fuel energy chains, and the renewable energy chains (wind, hydroelectric, solar-electric).

    - Make sure to copy the Energy Cards back-to-back because each graphic has an accompanying explanation on the reverse side. Cut the cards before giving them to students.

    - Give each group different sources of energy, and different desired goals/outcomes. Many of the in-between 'process' steps will be the same in each set. An additional page of just desired outcomes is included.

    - Instruct students to arrange the cards in an energy chain. All will begin with the sun, end with a goal.

    - Remind students they are thinking of what had to happen for the energy source to provide the desired outcome. This reinforces the concepts presented in the Energy Systems Diagram.

    A FEW NOTES ON THE ENERGY CARDS:

    1) The 3 fossil fuel sets (coal, oil and natural gas), and the one page with Hydropower and Wind Power cards will need to have the following cards added to complete the chain:

    ~ *Solar card*
    ~ *Electric Power Lines* card
    ~ *Goal* card

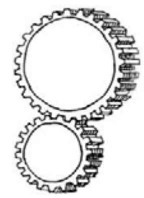
2) The *Solar Electric* chain is short (three cards), so you may want to add that to a group that's doing other renewables.

3) *Energy Transformations*: The bottom of each graphic will list the energy forms associated with that energy source or process. This reinforces the previous lesson on forms of energy, and transformations. Example: the coal-fired power plant card shows that the energy started as chemical energy (coal) and ended up as electrical energy (electricity).

4) *Symbols on Cards*: Each card has one of the following symbols on the upper left corner which correspond to the *Energy Systems Diagram*.

Goal

Input



Process

5) The original sets can also be accessed from the NESEA *Energy Thinkers* link below.)

- *JOURNAL REFLECTIONS*

- *EXTENSIONS:*

Math Extension:

- Using the Attached Worksheets from the NEED Elementary Energy Infobook Activities Guide, have students calculate and compare how much energy use in the U.S. from renewable vs. non-renewable sources. The data shown is from 2011

- Students will calculate basic percentages, make a pie chart, and a bar graph to help them visually represent and interpret energy use data.

- A teacher answer sheet is also attached.

This data could be used as a math extension activity for students, introducing them to interpreting data tables, and constructing line and bar graphs to visually represent data. The EIA report looks at use, cost, and trends for both nonrenewable and renewable energy sources.

Note to Teachers About U.S. Energy Use Data: For up-to-data energy use in the United States, refer to the Monthly Energy Review of the US Energy Information Administration.

This comprehensive source has lots of data tables, graphs, metric conversion tables, and an extensive glossary. The most recent report was published July 2013
http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

Literacy Follow-up Activity: Have students write their own story about the chunk of coal they observed!

Optional Video: If time permits, watch the Video *"Energy Sources",* produced for Teachers' Domain: Digital Media for the Classroom and Professional Development (Note: This video is 6 minutes long. It provides a comprehensive overview of all Energy Sources used to generate electricity, including pros and cons of each. This connects well to the Energy Systems Thinking referred to often in this unit.)
http://mass.pbslearningmedia.org/resource/phy03.sci.phys.energy.energysource/energy-sources/

- *FORMATIVE ASSESSMENT SUGGESTION:* Give students' copies of the Fossil Fuel Energy Flow handout from NEED (see attached) and a copy of the Energy Systems Thinking diagram from Day 2 of this unit.
  Using the Fossil Fuel Energy Flow diagram, have students fill in the Energy Systems Thinking sheet, starting with the GOAL of watching TV, INPUTS of coal, the PROCESSES involved in power production and transportation, and OUTPUTS, both *wanted* (i.e. electricity) and *unwanted* (i.e. greenhouse gas emissions).
  Note: Students will be doing a similar formative assessment after Day 9, where the Inputs will be renewable energy sources.

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1**,** 4-PS3-2, 4-PS3-3, 4PS3-4, 3-5-ETS1.1, 3-5-ETS1.2, 3-5-ETS1.3
Science and Engineering Practices: Asking Questions and Defining Problems, Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ESS3.A, ESS3.C, ESS3.D, ETS1.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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RESOURCES:

NEED (National Energy Education Development Project):
http://www.need.org (Curriculum-Guides-by-Grade- / Primary, Energy Stories and More)

NESEA Energy Education Document, *Energy Thinking for Massachusetts:*
http://energyteachers.org/project_detail.php?project_id=13 - Energy Thinking for Massachusetts (pdf file format)

A great website for energy information for teachers and students is the U.S. Energy Information Administration's website, Energy Kids (http://www.eia.gov/kids)

(Energy Kids features more than 100 pages of fun educational content for kids, parents, and teachers. Kids can learn about energy and challenge their brains with energy Sudoku, crossword puzzles, word searches, and the new "Energy Sliders" game. Teachers` can submit energy lesson plans, share their expertise and get chosen as contributor of the month. The site also features energy-related stories, hands-on activities, and research articles for the classroom.)

For information and graphics about coal formation, transportation, mining, production, uses and environmental impacts, see *Energy Kids Coal Basics*: http://www.eia.gov/kids/energy.cfm?page=coal_home-basics

The U.S Department of Energy (DOE) also has lessons on Energy Education, including fossil energy: http://www.fossil.energy.gov/education/energylessons/index.html

ATTACHMENTS TO DAILY LESSON:

The Tale of Fern Fossil

Once upon a time, a beautiful fern tree grew in a swamp. All day, she soaked up sunlight and stored it in her fronds. The sun's energy helped her grow tall.

The biggest frond was Fern Fossil. Every day she stretched closer to the sun. She was proud to be the tallest frond on the tree.

One day, the sky grew dark and a strong wind blew. The other fronds huddled together. They gave each other strength. But Fern was too high. She was all alone. There were no fronds tall enough to help her.

The wind blew harder and Fern's stem snapped. She fell from the tree into the dark water. Fern sank to the bottom of the swamp. She thought her journey was over. Nature had a different plan for Fern. For a long time, she lay in the swamp. More plants fell into the water. They covered Fern like a blanket.

After many years, the water dried up and the swamp turned into land. Dinosaurs roamed over the Earth. Fern lay under the ground, buried deeper and deeper.

The weight of the dirt and the heat of the Earth changed Fern. She was no longer green. She lost her leafy shape, but she still had the sun's energy stored in her.

Fern Fossil had turned into a shiny black rock full of energy. She was a piece of coal. Fern and many other plants were now a big seam of coal buried under the ground.

One day, a big machine dug into the Earth. It took away the dirt on top of the coal. It lifted Fern from the Earth and put her into a huge truck. She was taken to a building where she was washed, then put on a train. The train chugged through the night to a power plant. Fern was put into a boiler and burned. Her energy produced a lot of heat.

The power plant used Fern's energy to make electricity. It traveled through a power line to a house. A little boy turned on a light so that he could read. The energy that Fern had gotten from the sun millions of years ago was lighting the night. Fern had traveled a long way.

Introducing Carl Carbon

The Tale of Fern Fossil would not be complete without the introduction of Carl Carbon – for without him Fern would not have grown. When Fern was young, Carl Carbon was circulating around in the air above earth, stuck together with Oxygen twins Owen and Olivia (we call this CO2, short for one Carbon, and two oxygen molecules).

As Fern grew, her leaves breathed in the CO2 that Carl was made of, mixed with water (H2O) pulled from her roots, and with the ENERGY of the sun, she made food for herself to keep growing – plant sugar, made of all the Carbon Dioxide, the Water, and the Energy of the sun. That process is called Photosynthesis.

Eventually Fern died, but remember that Carl Carbon was part of Fern Fossil, so when she was buried deep underground, so was he. The energy that was captured by the sun so long ago to help Fern grow, was stored in her cells, and buried with her.

Carl Carbon was stuck underground with Fern Fossil a very long time – hundreds of millions of years – until he and Fern became COAL. (Coal is called a fossil fuel, because it is made of plants and animals that lived a long time ago.)

After eons in the dark, Carl Carbon was brought back to the surface of the earth, transported in trains to power plants to make energy for human use. Burning, or combustion needs an energy source – like Coal – and oxygen from the air. So at the Power Plant, Carl Carbon met up the Oxygen twins again – Olivia and Owen – and was released back into the air as Carbon Dioxide or CO2 (Carbon plus two Oxygens).

We are burning lots of coal and fossil fuels, so the Carbon Dioxide in our atmosphere is increasing. Scientists know it acts as a blanket around the earth, making it warmer like the inside of your car on a sunny day. This is having an effect on Earths climate systems, which is why people are concerned about how much fossil fuel we are burning. All the Carbon, like Carl, once buried deep underground, is being burned and released into our air faster than Earth Systems can soak it back up, so its like a thick blanket, getting thicker with time. This is called the Greenhouse Effect.

We are concerned about the effects of this warming climate on our planet – on the people, the animals, and the other life forms that live here. That is why we study about Energy, and Climate, and all the Systems of the Earth that fit together like a big jigsaw puzzle.

Quick overview: Carl Carbon met the Oxygen twins on a leaf of Fossil Fern, who drank water from her roots, and ZAP, the energy of the sun made SUGAR to help Fern grow. So Carl Carbon, now part of the sugar molecules in Fern, stayed with her for a very long time. Long after Fern died, Carl was still there.

Written by Patty O'Donnell, September 2013

A Song About Carl Carbon

(To the tune of the Beverly Hillbillies TV show)

There once was a story ‘bout a fossil named Fern,
But somethin' was omitted that I think you ought to learn,
It's that Fern was made of carbon,
from photosynthesis,
And something that important is a fact you shouldn't miss!

Carbon that is, black rock, coal from trees…

CO_2 from the air and water from below,
Got zapped by the sun so Fern could grow and grow,
Fern died and was buried,
Deep under the ground
The Carbon slowly cycles, round and round.

As coal that is, buried deep, underground…

The coal was dug out from deep in the ground,
Loaded on to trains, transported all around,
Burned in power plants
To give us ENERGY,
But as we all know
Nothin’ is for free.

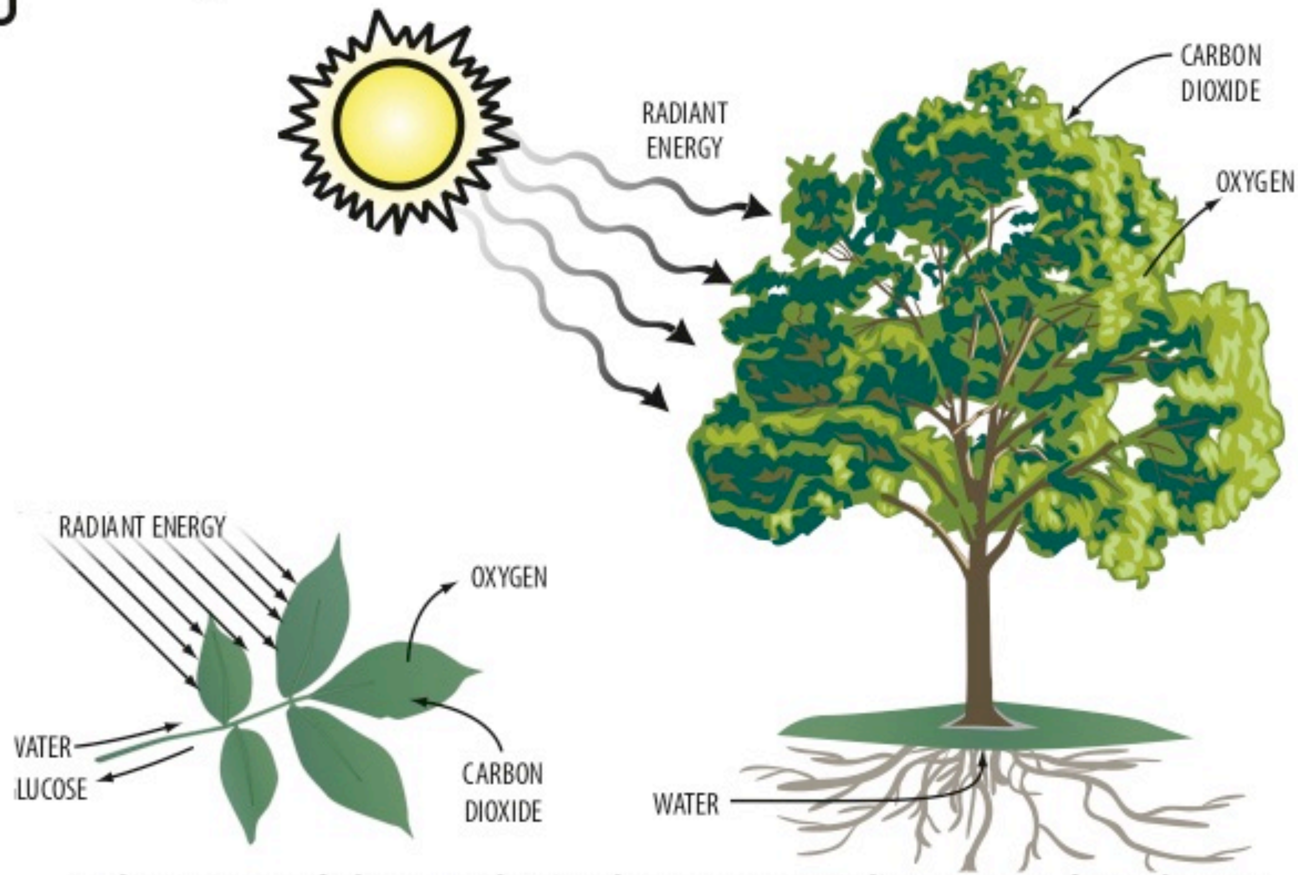
Energy that is, what we need, to fuel our lives…

Let’s name that Carbon Carl, and follow him around
From his time in the air, to deep in the ground
Back up to the surface
And loaded on to trains
Don’t forget this part of the Energy Chain

Carl that is, Carl Carbon…

Written by Patty O’Donnell, September 2013

Photosynthesis



In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose (or sugar).

water + carbon dioxide + sunlight ⟶ glucose + oxygen

$$6\,H_2O + 6\,CO_2 + \text{radiant energy} \longrightarrow C_6H_{12}O_6 + 6\,O_2$$

Coal

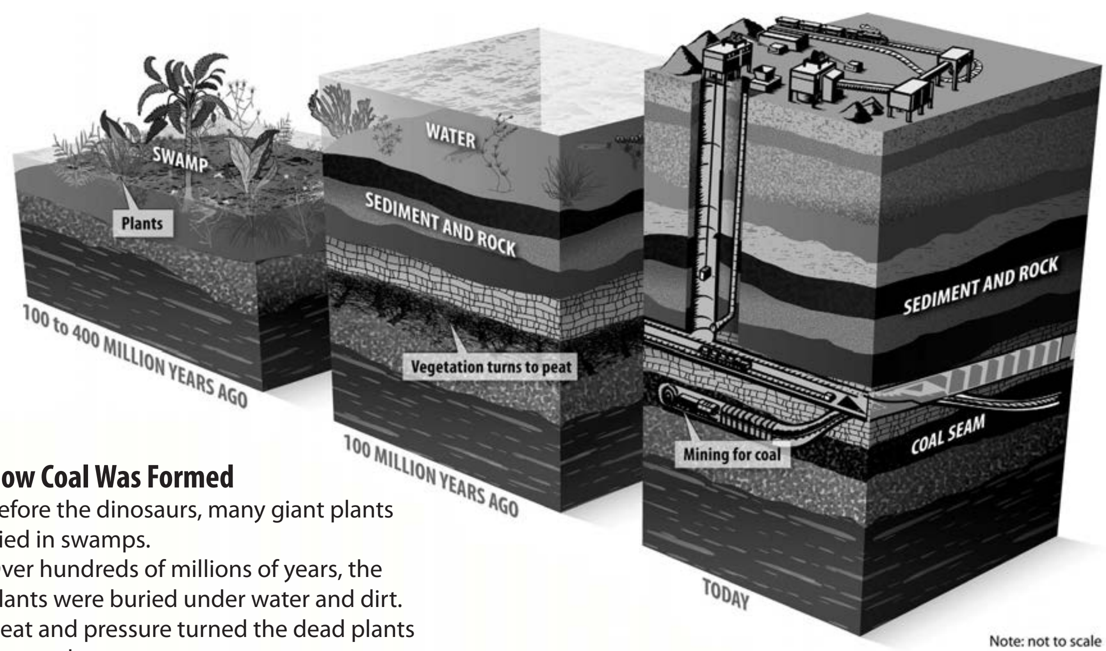
Coal looks like shiny black rock. Coal has lots of energy in it. When it is burned, it makes heat and light energy. Many years ago, Native Americans burned coal to make pots. The early settlers didn't use much coal—they burned wood.

People began using coal in the 1800s to heat their homes. Trains and ships used coal for fuel. Factories used coal to make iron and steel. Today, we burn coal mainly to make electricity.

Coal is a Fossil Fuel

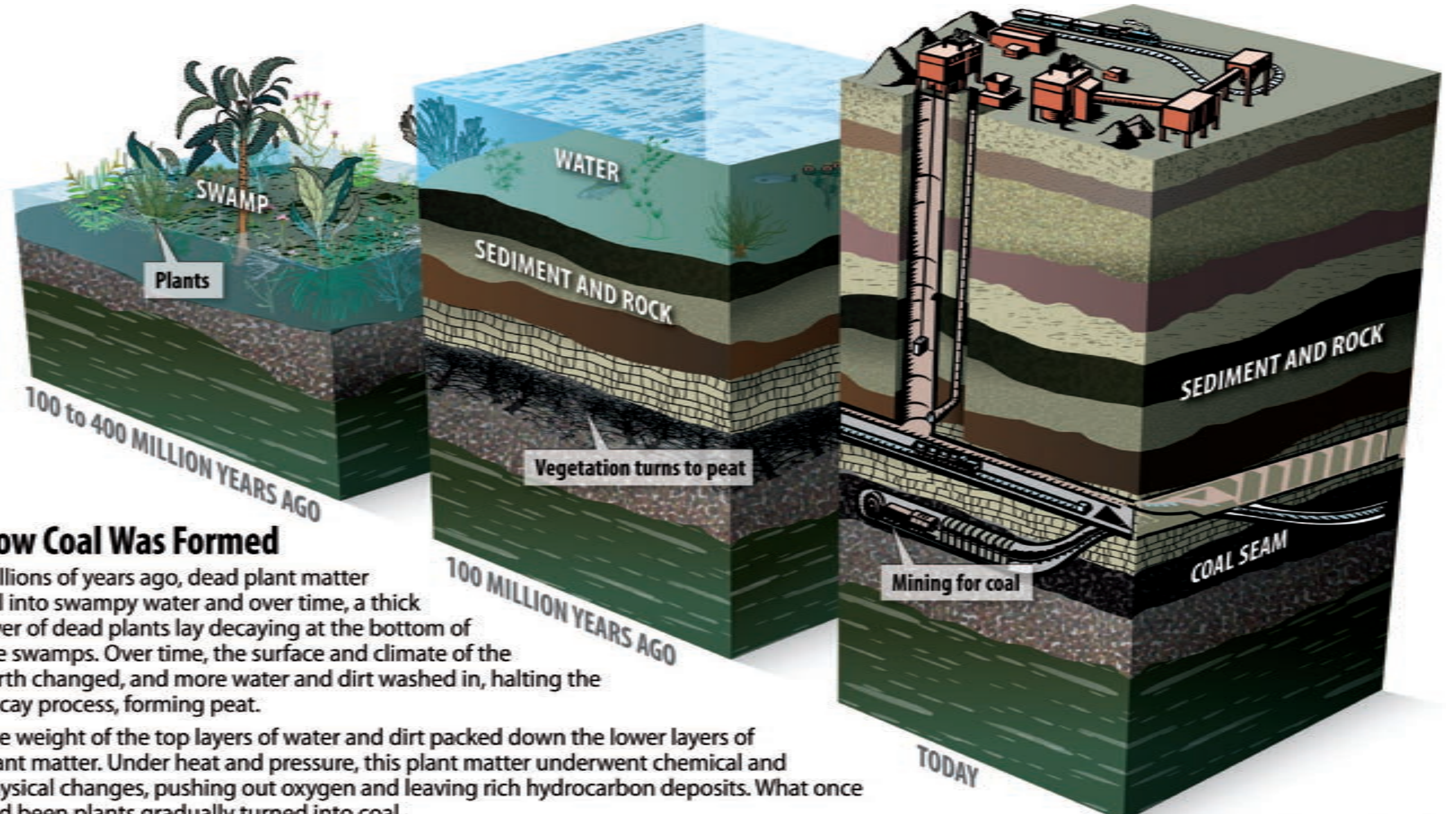
Coal was formed hundreds of millions of years ago, before the dinosaurs. Back then, much of the Earth was covered by huge swamps. They were filled with giant ferns and plants. As the plants died, they sank to the bottom of the swamps.

Over the years, thick layers of plants were covered by dirt and water. They were packed down by the weight. After a long time, the heat and pressure changed the plants into coal. Coal is called a **fossil fuel** because it was made from plants that were once alive. The energy in coal came from the sun.



How Coal Was Formed
Before the dinosaurs, many giant plants died in swamps.
Over hundreds of millions of years, the plants were buried under water and dirt.
Heat and pressure turned the dead plants into coal.

How Coal Was Formed

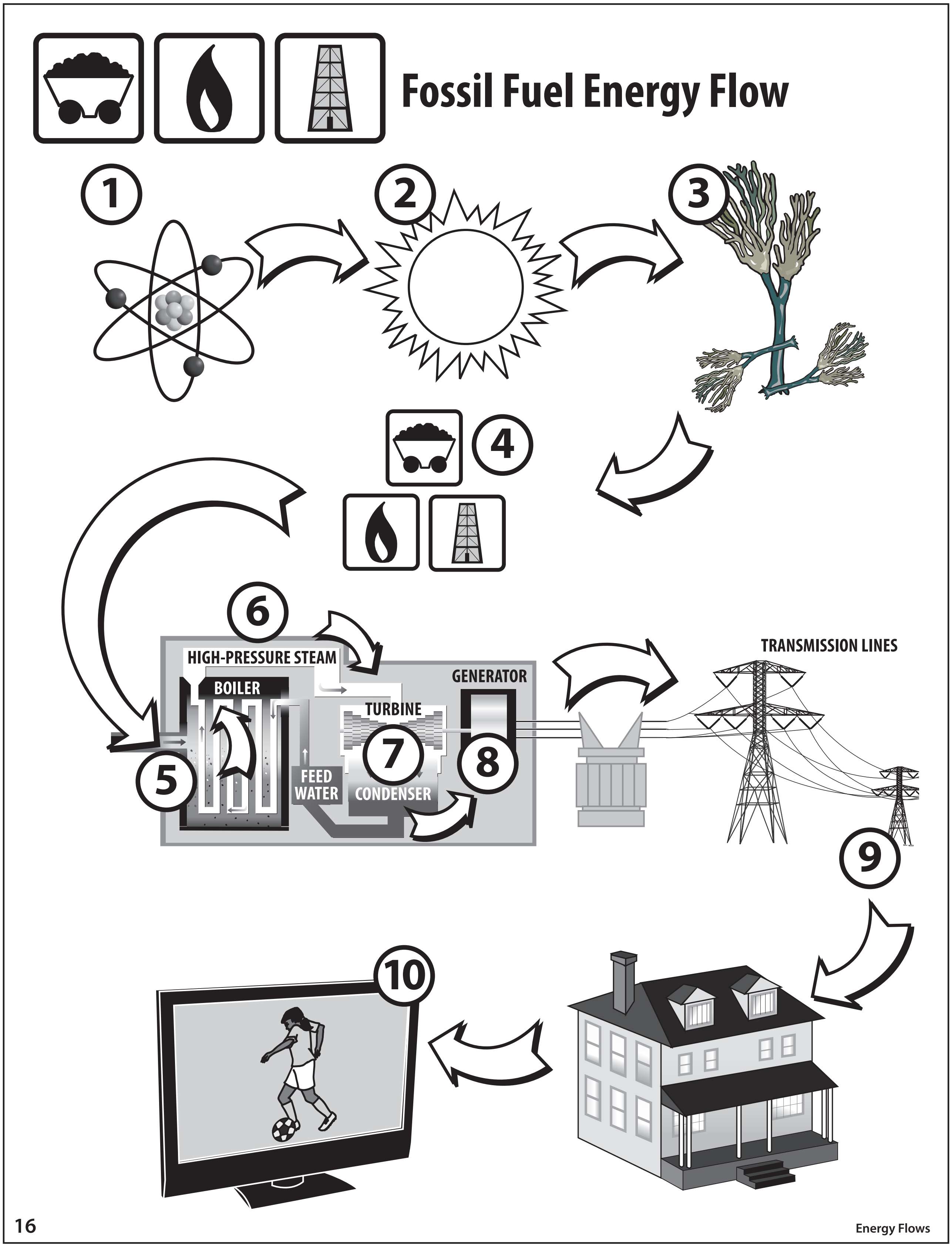


How Coal Was Formed

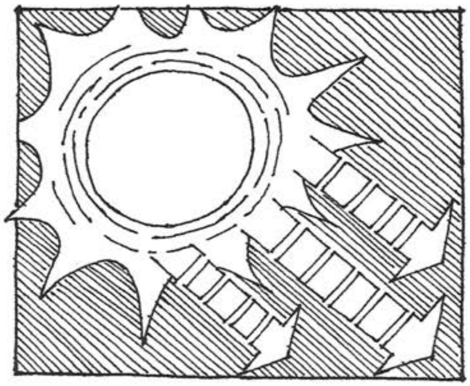
Millions of years ago, dead plant matter fell into swampy water and over time, a thick layer of dead plants lay decaying at the bottom of the swamps. Over time, the surface and climate of the Earth changed, and more water and dirt washed in, halting the decay process, forming peat.

The weight of the top layers of water and dirt packed down the lower layers of plant matter. Under heat and pressure, this plant matter underwent chemical and physical changes, pushing out oxygen and leaving rich hydrocarbon deposits. What once had been plants gradually turned into coal.

Coal can be found deep underground (as shown in this graphic), or it can be found near the surface.

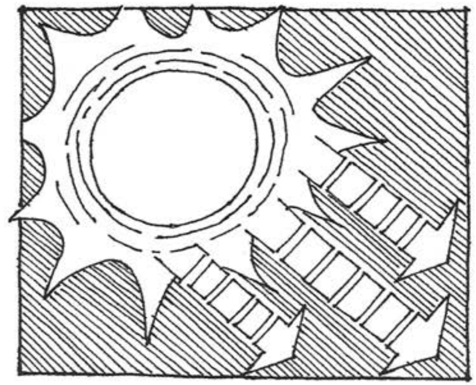

Fossil Fuel Energy Flow
1
2
3
4
6
HIGH-PRESSURE STEAM
BOILER
TURBINE
GENERATOR
FEED WATER
CONDENSER
5
7
8
TRANSMISSION LINES
9
10
16
Energy Flows

SOLAR



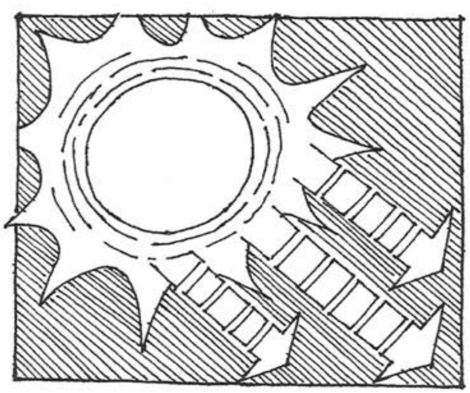
Energy Form
Radiant

SOLAR



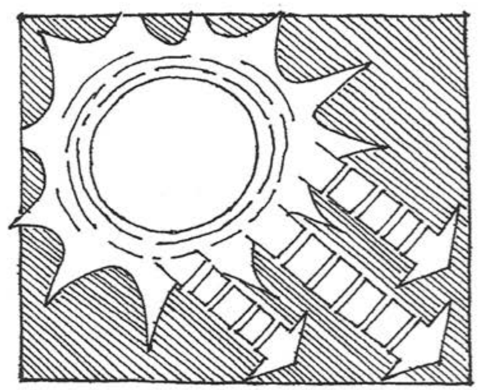
Energy Form
Radiant

SOLAR



Energy Form
Radiant

SOLAR



Energy Form
Radiant

The energy from this natural resource is available everywhere in the world. But the amount available changes depending on how cloudy it is, whether trees or buildings block its rays, whether it is winter or summer, and how close you are to the equator or to the poles.

Summer in Massachusetts occurs when the northern hemisphere is tilted toward this resource. Because of this, in the summer, the resource is available for more hours each day and its rays reach the earth more directly and so are stronger.

The southwestern states receive the most energy from this resource year round because they have fewer cloudy days and because of their southern location. Even so, Massachusetts and the northeast states receive plenty of this resource to use for energy.

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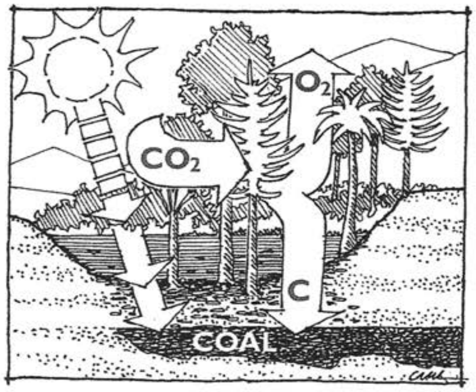
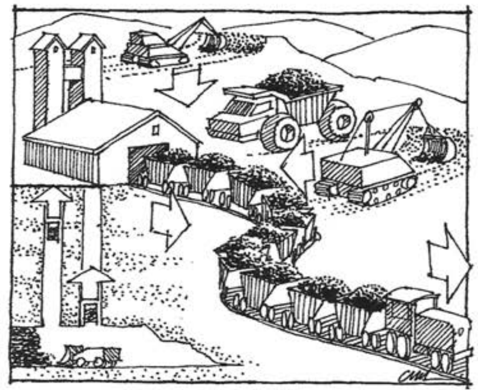
COAL



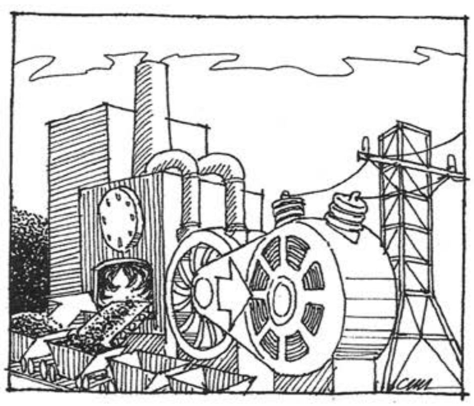
Initial Energy Form **Radiant** *Final Energy Form* **Chemical**

PROCESSING COAL



Initial Energy Form **Chemical** *Final Energy Form* **Chemical**

COAL-FIRED POWER PLANT



Initial Energy Form **Chemical** *Final Energy Form* **Electrical**

Mining, processing, and transporting coal requires energy and damages the environment. Modern environmental laws and technologies have reduced this impact, but coal mines still greatly disturb or alter large tracts of land, pollute water, and pose health risks to people living near mines. Blasting can damage nearby wells and foundations and the removal of vegetation and the filling of streams with debris can cause flooding.

There are two methods of mining: surface and underground. Two-thirds of U. S. coal comes from surface mining, where large machines and blasting are used to remove up to 200 feet of dirt and rock to expose shallow coal beds. Sometimes the land is returned to its original shape. Other times, mountaintops are removed and deposited in valleys. Once mining is finished, the land is replanted for use as cropland or for recreation, offices, or stores.

The energy in this resource comes from sunlight that fell on the earth 280 to 345 million years ago. Plants that grew in great swamps at that time used energy from the sun to grow, effectively converting and storing the sun's energy in the plants' tissues. Over millions of years, some of that plant matter was buried deep under layers of mud where heat and pressure changed it into sedimentary rocks that can burn and which humans now use for energy.

This energy resource is found on every continent, including Antarctica. It is the most abundant fossil fuel in the United States, with enough still in the ground to last over 200 years at today's level of use.

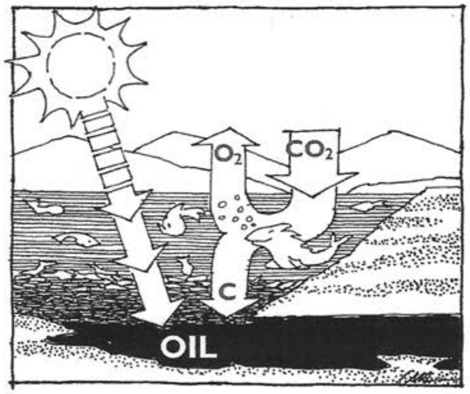
None of this resource, however, is found in Massachusetts and the state must import by train all it uses from Colorado and West Virginia.

With today's technology, burning coal emits more global warming gases and air pollution per amount of electricity produced than any other fossil fuel. Coal-fired power plants are a primary contributor to acid rain and give off mercury pollution, smog-forming chemicals, and particulate matter.

Newer technologies can help reduce the amount of air pollution given off, but many older coal plants have been slow to adopt these new technologies. Sometimes wood is mixed with coal to dilute the air pollution. In the future, "clean coal" technologies may be able to reduce or eliminate the amount of global warming gases they emit by pumping these gases deep underground or into the deep ocean.

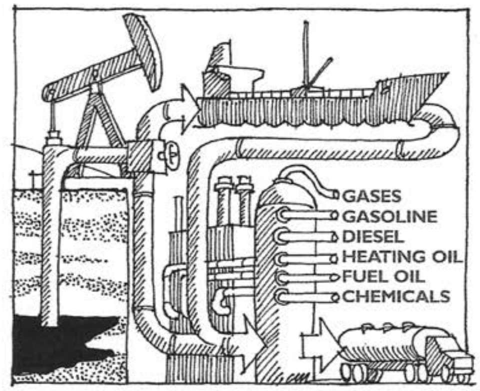
Almost one-quarter of the electricity produced for use in Massachusetts comes from burning coal.

CRUDE OIL



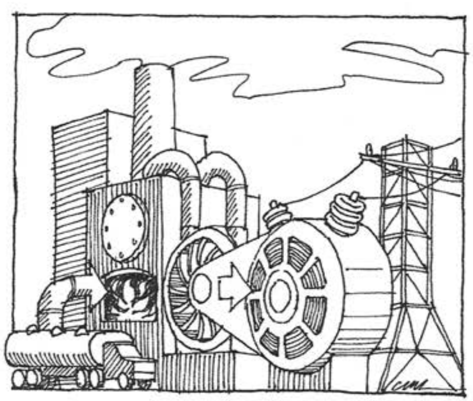
Initial Energy Form **Radiant** | *Final Energy Form* **Chemical**

PROCESSING CRUDE OIL



Initial Energy Form **Chemical** | *Final Energy Form* **Chemical**

OIL-FIRED POWER PLANT



Initial Energy Form **Chemical** | *Final Energy Form* **Electrical**

Crude oil is pumped from deep underground, is shipped through pipelines and on board tanker ships, and is stored in large oil tanks. Exploring and drilling for oil may damage land and ocean habitats and spills from pipelines, ships, and storage tanks can harm plants, wildlife, and water supplies. Changing crude oil into other products and transporting these products produces air and water pollution. Over the years, new technologies and laws have helped reduce, but not eliminate, these problems.

Crude oil is processed into many other products at oil refineries. These include gasoline, diesel fuel, fuel for power plants, heating oil, and petrochemicals used to make plastics, fertilizers, and pesticides.

Massachusetts must import all of its petroleum products—primarily by barges to Boston Harbor but also through small-capacity pipelines ending in Springfield.

The energy in this resource comes from sunlight that fell on plants growing in the oceans hundreds of millions of years ago. These plants and the tiny animals that ate them stored sunlight as chemical energy.

Over hundreds of millions of years, these plants and animals were buried under layers of mud where heat and pressure changed them into a smelly yellow-to-black liquid that can burn and which humans now use for energy.

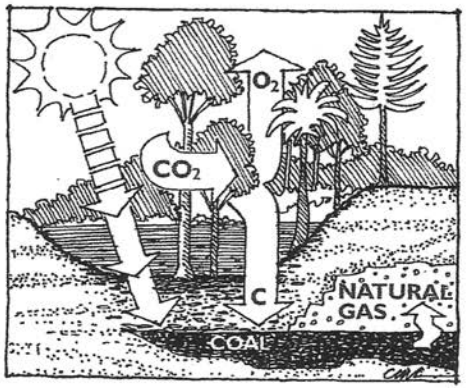
This resource is not found in Massachusetts; the state needs to import all that it uses from other states or countries.

In 2006, the U. S. needed to import almost two-thirds of this energy resource from other countries.

Gases emitted from oil-fired power plants contribute to global warming and can lead to acid rain and smog. Oil-fired power plants produce more global warming gases and air pollution than do plants that burn natural gas, but not as much as those that burn coal.

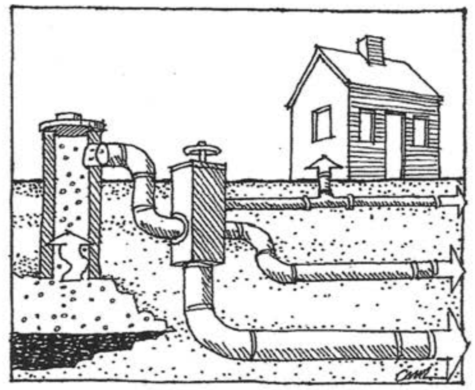
Massachusetts has seven oil-burning power plants however only a small fraction (about one-twentieth or four percent) of the electricity used in Massachusetts comes from burning oil.

NATURAL GAS



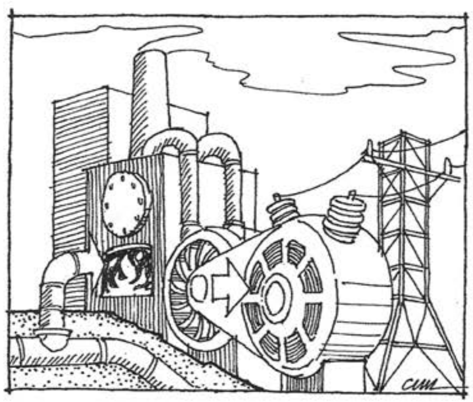
Initial Energy Form **Radiant** *Final Energy Form* **Chemical**

PROCESSING NATURAL GAS



Initial Energy Form **Chemical** *Final Energy Form* **Chemical**

NATURAL GAS-FIRED POWER PLANT



Initial Energy Form **Chemical** *Final Energy Form* **Electrical**

Natural gas is pumped from deep underground and is most often piped through high-pressure pipelines to power plants, homes, factories, and sometimes vehicles. Massachusetts has the only port in the Northeast that can receive ships loaded with liquefied natural gas.

If proper care is not taken, leaks in a gas pipeline can pose a fire or explosive hazard. Because natural gas is odorless, making leaks hard to detect, an odorant is added. Natural gas is the cleanest burning fossil fuel—it produces less global warming gases and other air pollutants than any other fossil fuel.

Pipelines from the Gulf Coast, Canada, and storage sites in the Appalachian Basin region carry natural gas to three out of seven Massachusetts households. Some vehicles use natural gas as a clean burning transportation fuel.

The energy in this resource comes from sunlight that fell on the earth hundreds of millions of years ago. Plants that grew in great swamps and in the oceans at that time used energy from the sun to convert air and water into plant matter. In this way, plants stored sunlight as chemical energy.

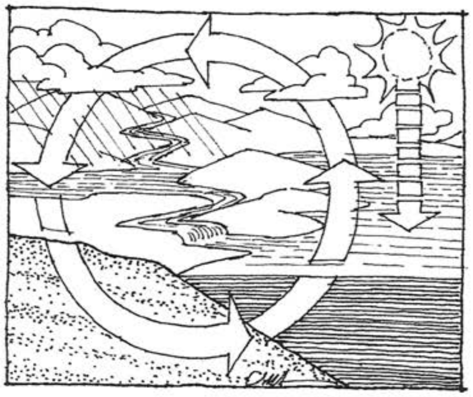
Over hundreds of millions of years, some of that plant matter was buried deep under layers of mud and rock where heat and pressure changed it into gases, liquids, and rocks that can burn and which humans now use for energy.

This energy resource is found as a gas with coal and crude oil deposits. The most abundant deposits in the United States are found in the Gulf of Mexico, Texas, and the Rocky Mountain states. This resource is not found in Massachusetts.

Natural gas-fired power plants produce global warming gases and other air pollutants. However, they produce significantly less air pollution and less global warming gases than burning other fossil fuels such as oil or coal.

Massachusetts has fourteen natural gas-fired power plants and produces about half of its electricity from natural gas—more than from any other energy resource.

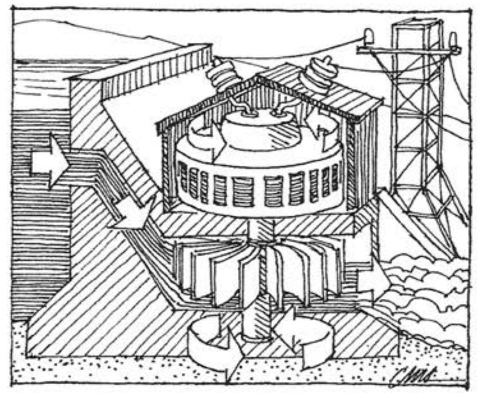
MOVING WATER



Initial Energy Form
Radiant

Final Energy Form
Gravitational (Potential)

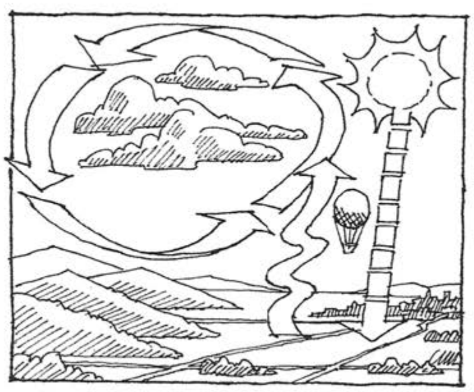
HYDROPOWER



Initial Energy Form
Gravitational

Final Energy Form
Electrical

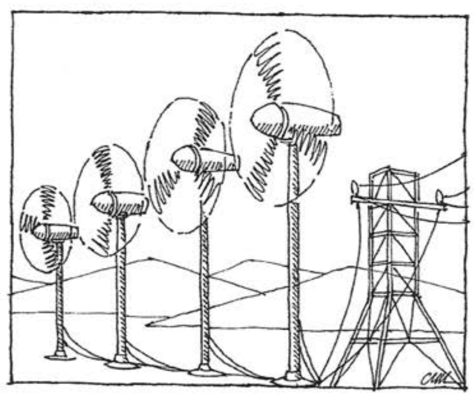
WIND



Initial Energy Form
Radiant

Final Energy Form
Mechanical (Kinetic)

WIND-POWER



Initial Energy Form
Mechanical

Final Energy Form
Electrical

Hydropower, or hydroelectric power, is the process of making electricity by using flowing water to spin a turbine connected to a generator. In some cases, the turbine is positioned in a river and the force of the river current spins the turbine blades. More commonly, water is collected behind a dam and is forced to fall through a pipe containing the turbine blades. The falling water spins the turbine blades to generate electricity.

Hydroelectric power does not generate any air or water pollution but dams can change the flow of a river, flood land, and hinder or stop the ability of fish to swim up or down river. To ease this last effect, many dams build channels, called fish ladders, around the dam for fish to travel. About one-fiftieth (or two percent) of electricity produced for use in Massachusetts is generated with hydroelectric power, a sizable part of which is imported from Canada.

Most often, this natural resource receives its energy from the sun when evaporation, convection and precipitation move water to higher ground. This imparts more gravitational or potential energy to the water. Large concentrations of this energy resource are needed to produce large quantities of electricity.

One of the best places to find this energy resource is in large rivers. In Massachusetts, the Connecticut and Merrimack river basins could provide a notable amount of additional electric power—more than is already being used from this natural resource—while the Housatonic, Thames, Hudson, and minor river basins in the state could provide even more.

This energy resource can also be found in waves and tides. In the case of tides, the energy comes from the gravitational pull of the moon and sun on our oceans.

Wind-power is the process of making electricity by using wind to spin turbine blades connected to a generator. A utility wind-power site, or wind farm, includes many wind turbines that are 300 to 500 feet tall (including their blades).

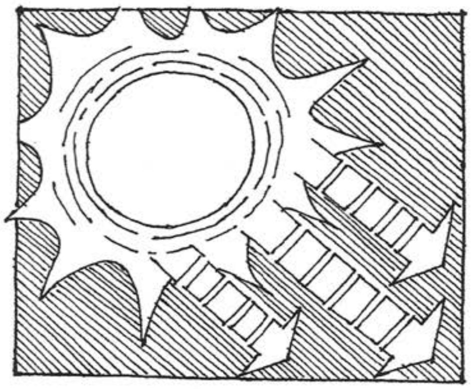
Wind-power produces no global warming gases or other pollutants. Some people object to wind farms if they intrude on the wilderness feel of a proposed site. Spinning blades have killed bats and birds, however modern turbine designs and closely evaluating wind-farm placement has almost eliminated this.

Wind power produced a trivial amount of Massachusetts's electricity in 2007, yet it is the state's fastest growing source of electricity. Projects proposed for the state in 2007 could power 1 out of 34 Massachusetts homes and create the Nation's first offshore wind farm while still leaving vast wind resources unused.

This resource forms as energy from the sun heats water bodies, landmasses, and the atmosphere to different temperatures, which, in turn, heat masses of air to different temperatures. The best places to find this energy resource are on the open plains, on ridge tops, on mountaintops, and over oceans and large lakes. This resource can be used to generate large amounts of electricity when it occurs often enough and at a fast enough speed (15 to 20 miles per hour).

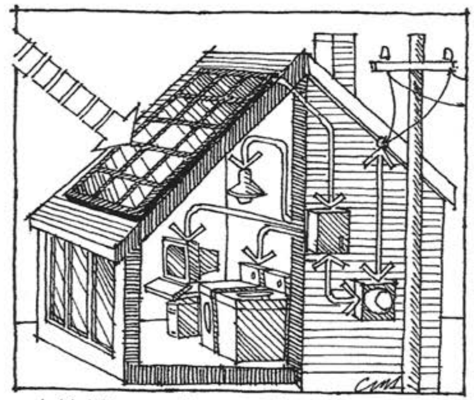
Massachusetts has good to outstanding supplies of this natural resource on ridgetops in the southwest and northwest corners of the state, along some ridges in Worcester County, and offshore along the eastern coast. The state has fair to good supplies on ridge tops throughout the Berkshire Mountains, on isolated hilltops throughout the state, and on Cape Cod.

SOLAR



Energy Form
Radiant

SOLAR-ELECTRIC



Initial Energy Form
Radiant

Final Energy Form
Electrical

Solar-electric systems convert sunlight directly into electricity. Solar-electric systems are also known as photovoltaic (PV) systems. The use of a PV system does not create any global warming gases or other pollutants.

PV systems are most often mounted directly on houses, schools or other buildings where they produce electricity for the building owner. This reduces the amount of electricity that the owner has to buy from the electric company. When the PV system produces more electricity than the building uses, the owner can sell the extra electricity to the power company. Buying a solar-electric system is expensive, although costs continue to go down and the fuel (sunlight) is free.

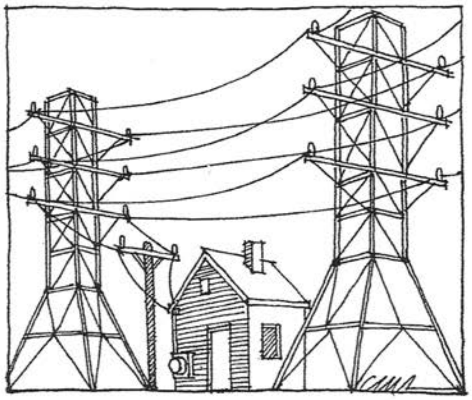
Far less than one percent of electricity produced in Massachusetts is generated with solar-electric systems.

The energy from this natural resource is available everywhere in the world. But the amount available changes depending on how cloudy it is, whether trees or buildings block its rays, whether it is winter or summer, and how close you are to the equator or to the poles.

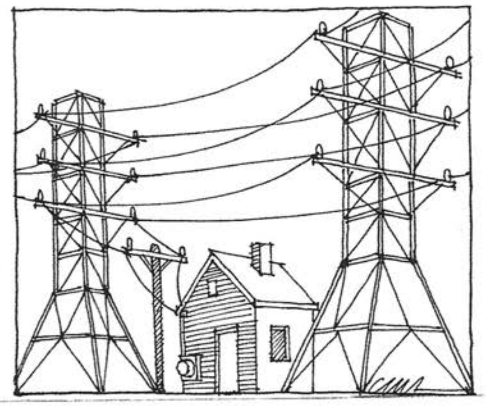
Summer in Massachusetts occurs when the northern hemisphere is tilted toward this resource. Because of this, in the summer, the resource is available for more hours each day and its rays reach the earth more directly and so are stronger.

The southwestern states receive the most energy from this resource year round because they have fewer cloudy days and because of their southern location. Even so, Massachusetts and the northeast states receive plenty of this resource to use for energy.

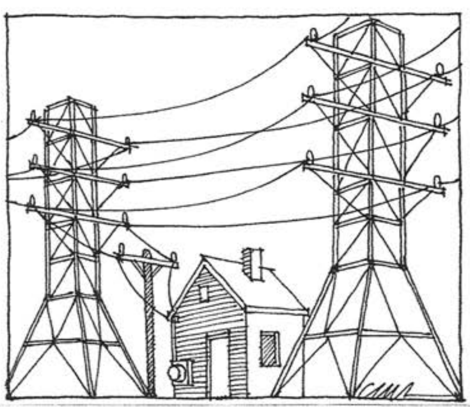
ELECTRIC POWER LINES



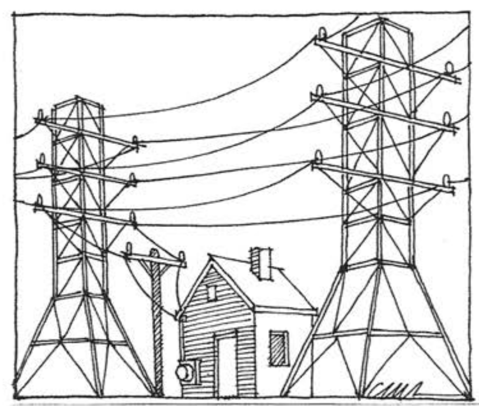
ELECTRIC POWER LINES



ELECTRIC POWER LINES



ELECTRIC POWER LINES



In order to use electricity produced by power companies, we need to transport it to our homes, schools, and businesses. Instead of a network of roads or rail lines, we transport electricity over a network of wires.

This network is called the *power distribution grid*, or *power grid* for short, and it is made up of both large and small power transmission lines. The power grid can receive electricity from many different power sources and deliver it to a lot of different users at the same time.

Although the power grid does not give off any air pollution or greenhouse gases, it does lose some of the power that is fed into it. Power companies must then produce more electricity to make up for these loses, and that *can* produce air pollution, greenhouse gases, and other unwanted side effects.

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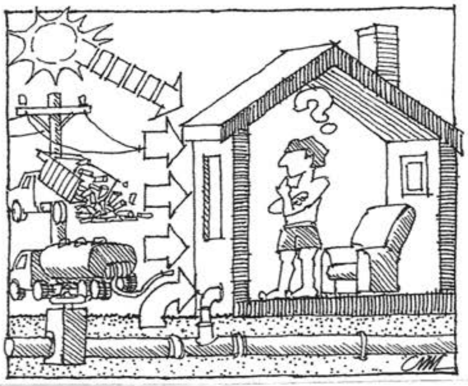
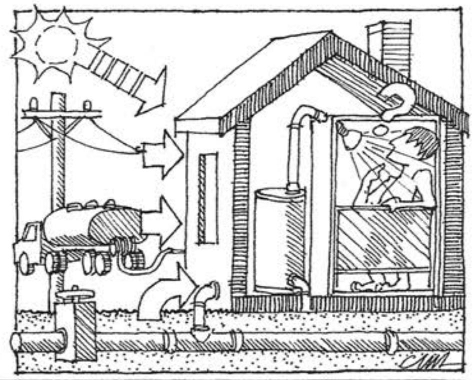
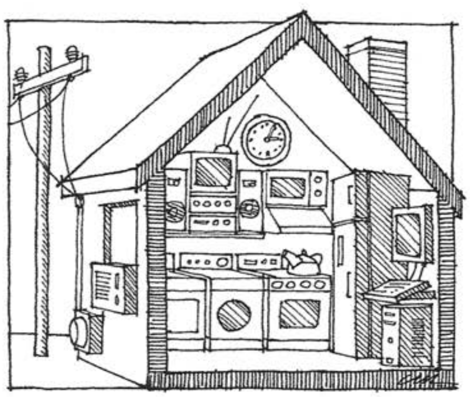
WARM HOME



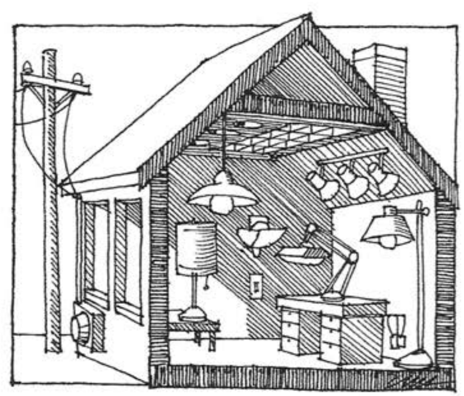
HOT WATER

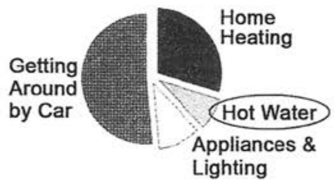


TASKS DONE BY APPLIANCES



LIGHTING

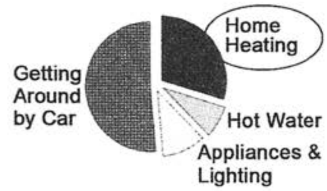




Energy Use per Household Activity

Heating water to use for showers, cleaning, washing dishes, or anything else takes energy. Using less hot water will reduce energy use. Some ways to do this include installing low-flow showerheads, fixing leaky faucets right away, and using cold water to wash clothes. (Modern clothes detergents do not need hot water to work well.)

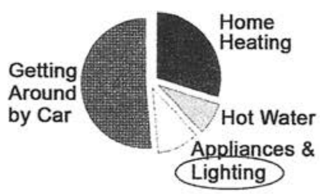
You can also reduce energy use by increasing efficiency. If your building's hot water system is old, your family may want to consider replacing it with a newer more efficient system, and insulate the hot water tank and pipes.



Energy Use per Household Activity

Keeping a home warm uses almost one-third of the energy used in a typical Massachusetts home. You can reduce energy use by sealing up air leaks, having the heating system (including air ducts) cleaned once a year, and keeping furniture and other objects away from heat registers. When appropriate, increase the level of insulation in walls and ceilings and replace old heating systems with efficient new ones.

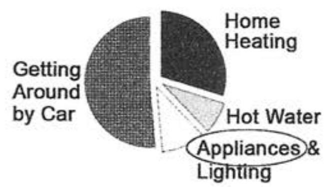
Turning down the heat when no one is home and at night can also save a significant amount of energy and money. Thermostats with timers can help make this task easy.



Energy Use per Household Activity

Inefficient electric lights can use almost as much electricity as a home refrigerator—one of the largest users of home electricity. Today's efficient compact fluorescent light bulbs use one-quarter of the electricity of incandescent bulbs.

Turning lights off when not in use, such as when you leave a room, when they are not needed or when sunlight is available, can reduce electricity use even more.



Energy Use per Household Activity

Appliances used for heating or cooling—such as refrigerators, air conditioners or clothes dryers—require the most electricity to run and changing to a high efficiency model can often substantially reduce electric bills. Refrigerators are one of the largest users of electricity because they need a lot of electricity to run and they are always on.

Many other appliances use electricity even when off, such as appliances with clocks or timers or remote controls. By plugging these appliances into a power strip, you can turn them off when the appliance is not in use. Or simply unplug them when not in use.

Renewable or Nonrenewable 2

Part 1

Calculate how much of the energy we use in the U.S. comes from renewable energy sources. Calculate how much comes from nonrenewable sources.

U.S. Energy Consumption by Source, 2011

NONRENEWABLE

Source	Percent	Uses
PETROLEUM	34.7%	*Uses: transportation, manufacturing*
NATURAL GAS	25.6%	*Uses: heating, manufacturing, electricity*
COAL	20.2%	*Uses: electricity, manufacturing*
URANIUM	8.5%	*Uses: electricity*
PROPANE	1.6%	*Uses: heating, manufacturing*

Data: Energy Information Administration

RENEWABLE

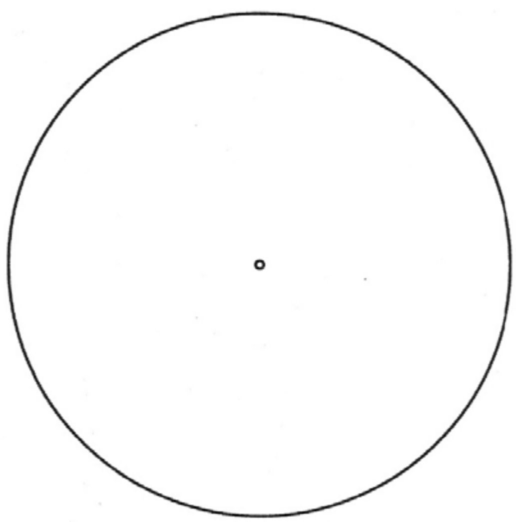
Source	Percent	Uses
BIOMASS	4.5%	*Uses: heating, electricity, transportation*
HYDROPOWER	3.3%	*Uses: electricity*
WIND	1.2%	*Uses: electricity*
GEOTHERMAL	0.2%	*Uses: heating, electricity*
SOLAR	0.2%	*Uses: heating, electricity*

Nonrenewable: ______________ %

Renewable: ______________ %

Part 2

Make a pie chart showing the percentage of energy that comes from nonrenewables and renewables. Color renewables and nonrenewables different colors.



Where We Get the Energy We Use

Make a graph showing how much energy each source provides the United States. Write the names of the energy sources in the boxes at the bottom of the graph. Fill in the columns to show the percentage each source provides. Use a different color or pattern for each column.

U.S. Energy Consumption by Source, 2011

NONRENEWABLE

PETROLEUM 34.7%
Uses: transportation, manufacturing

NATURAL GAS 25.6%
Uses: heating, manufacturing, electricity

COAL 20.2%
Uses: electricity, manufacturing

URANIUM 8.5%
Uses: electricity

PROPANE 1.6%
Uses: heating, manufacturing

RENEWABLE

BIOMASS 4.5%
Uses: heating, electricity, transportation

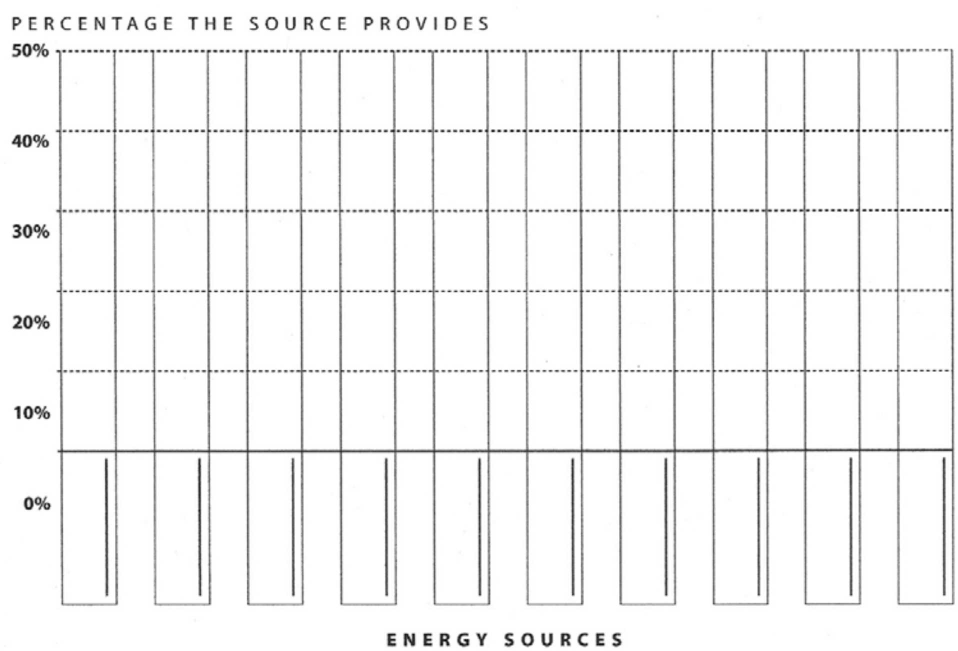
HYDROPOWER 3.3%
Uses: electricity

WIND 1.2%
Uses: electricity

GEOTHERMAL 0.2%
Uses: heating, electricity

SOLAR 0.2%
Uses: heating, electricity

Data: Energy Information Administration



Renewable or Nonrenewable 2

Part 1

Calculate how much of the energy we use in the U.S. comes from renewable energy sources. Calculate how much comes from nonrenewable sources.

U.S. Energy Consumption by Source, 2011

NONRENEWABLE		RENEWABLE	
PETROLEUM *Uses: transportation, manufacturing*	34.7%	BIOMASS *Uses: heating, electricity, transportation*	4.5%
NATURAL GAS *Uses: heating, manufacturing, electricity*	25.6%	HYDROPOWER *Uses: electricity*	3.3%
COAL *Uses: electricity, manufacturing*	20.2%	WIND *Uses: electricity*	1.2%
URANIUM *Uses: electricity*	8.5%	GEOTHERMAL *Uses: heating, electricity*	0.2%
PROPANE *Uses: heating, manufacturing*	1.6%	SOLAR *Uses: heating, electricity*	0.2%

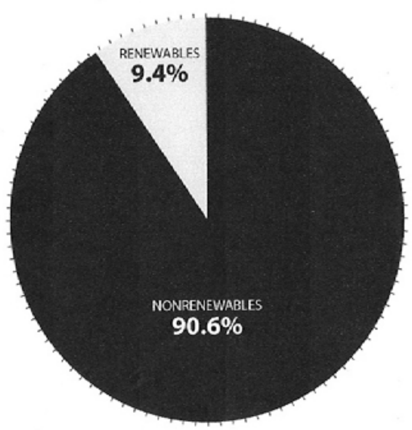
Data: Energy Information Administration

Nonrenewable: 90.6% %

Renewable: 9.4% %

Part 2

Make a pie chart showing the percentage of energy that comes from nonrenewables and renewables. Color renewables and nonrenewables different colors.



Where We Get the Energy We Use

Make a graph showing how much energy each source provides the United States. Write the names of the energy sources in the boxes at the bottom of the graph. Fill in the columns to show the percentage each source provides. Use a different color or pattern for each column.

U.S. Energy Consumption by Source, 2011

NONRENEWABLE		RENEWABLE	
PETROLEUM *Uses: transportation, manufacturing*	34.7%	BIOMASS *Uses: heating, electricity, transportation*	4.5%
NATURAL GAS *Uses: heating, manufacturing, electricity*	25.6%	HYDROPOWER *Uses: electricity*	3.3%
COAL *Uses: electricity, manufacturing*	20.2%	WIND *Uses: electricity*	1.2%
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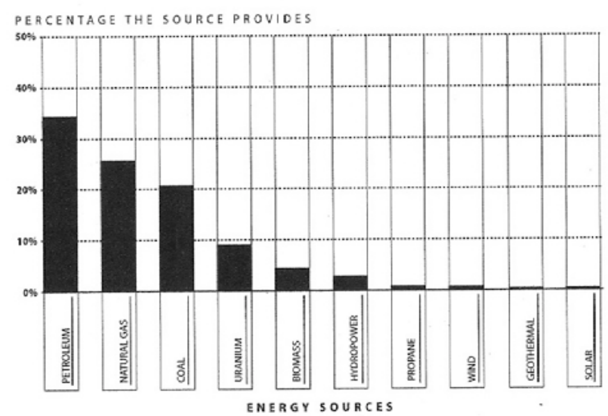
Data: Energy Information Administration



DAY 8 and 9 – RENEWABLE ENERGY SOURCES AND INVESTIGATIONS

(Explore, Explain, Elaborate)

OVERVIEW: These lessons will introduce students to renewable energy sources, specifically Wind and Solar Energy. Activities will include:

- Watching a NOVA Energy Lab video about renewable energy sources
- Reading Background information on renewable energy (refer to attached graphics from NEED)
- Engaging in a Wind Energy Investigation
- Engaging in a Solar Energy Investigation

NOTE TO TEACHERS: The renewable energy investigations can take 2 class periods. It can be done in one class period, but if you want students to have the opportunity to compare design variables, it's best if one day is devoted to wind energy exploration, and one to solar energy exploration.

These engineering design investigations provide the opportunity for students to explore what design variables would increase the efficiency/output of their system, collect and graph data. Suggestions for design options include as varying the number, angle and shape of wind turbine blades; or source of light and angles of solar photo-collectors.

WORKSHEET: The attached *Using Renewable Energy Worksheet* can be used by students to record observations during these investigations.

DAY 8 – WIND ENERGY INVESTIGATIONS

OVERVIEW: Our Earth is surrounded by an atmosphere composed of many different gases. As the sun shines on the earth, its surfaces are heated. The earth is not flat so the sun doesn't reach all surfaces evenly, or at the same time. More of the sun's energy reaches the equator than the North and South Poles. The warm air around the earth rises, while the cooler air descends. This process - called convection – causes the air to move. This moving air is WIND.

Recall Forms of Energy and Energy Transformations: The radiant (or light) energy of the sun is transformed into thermal (or heat) energy. The energy in the Wind came from the Sun.

(For background reading on Wind, and Wind Turbines, refer to the attached information from the NEED curriculum.)

- *ACTIVITY 1* - Watch NOVA Energy Lab VIDEO, *A Never Ending Supply* – This video is a great introduction to renewable energy resources (length 2:44 minutes).

http://www.pbs.org/wgbh/nova/labs/lab/energy/2/1/

- *ACTIVITY 2 - WIND ENERGY INVESTIGATION:*
  - ***Materials*** (See Materials List at end of Unit) :

    - Strong Table-top electric fans (preferably box fans)

    - Multimeter (one for each group)

    - Wire Leads with Alligator clips (at least two for each group)

    - Safety Goggles

    - KidWind Basic Turbine Building Parts kit, which includes the KidWind Hub, a wind turbine generator, and 25 dowels,

    - Wind Turbine Blades – there are 3 Options:

      1) KidWind blades

      2) Do-It-Yourself Wind Turbine Blade Materials:

         - cardboard, cardstock paper, or recylced sytrofoam trays for students to cut out wind turbine blades
         - good scissors
         - masking or duct tape

         NOTE: This low-cost, low-tech version of wind turbine blades is fun for kids – they can create lots of designs, without worrying about materials, and investigate which design is most efficient. Trial and error is an important componentt of science and engineering practice!

      3) Plastic fan blades (*Tiny Tornado Fans*)
         (Note: This design is very effective, but does not provide as many variables for investigations. The blade will attach directly to the central shaft of the generator. Students can still experiment with fan speed, distance from fan, and angle of the whole assembly relative to the fan.)

    - Rulers and meassuring tapes

    ADDITIONAL NOTE ON MATERIALS:

    The best materials for student use are the KidWind kits. If your budget is limited, individual components of kits can be purchased from KidWind. The KidWind Hub is useful for experimenting with wind blade variables. (See website link in resources section.) This can be used to attach Do-It-Yourself wind blade designs, constructed of wooden dowels and various blade materials.

  - *INVESTIGATION:* Tell students the following before starting the investigation:

- You will be working in small groups to construct Model Wind Turbines and engage in wind turbine investigations. Electric fans will be your wind source.
- You will use Multimeters to measure the amount of electricity produced by your model wind turbines.
- You will be attaching your wind blades to small generators. These generators are constructed with magnets attached to the central shaft, surrounded by coils of copper wires.
- All groups will start with the same benchmark design (unless using the pre-made plastic fan blades) then introduce variables to attempt to increase the output of their models.

- *INSTRUCTIONS FOR STUDENTS: (When using these materials, it is recommended that students use safety goggles.)*

  1) All groups begin with constructing the same Benchmark Model:
     - 3 Fan Blades, inserted in the openings in the plastic KidWind Hubs
     - No Angle or Pitch to the blades

  2) Attach the Hub (or plastic version) to the central shaft of the generator.

  3) Multimeter connections and settings: (Note to Teachers: Have the Multimeters pre-set to DC Voltage, DCV10 setting before handing out to kids.)
     - Connect the black and red lead wires to the wires coming out of your generator with the Alligator clips.
     - Generator wires are also black (for + charge) and red (for – charge). Always connect black-to-black, and red-to-red, or the current will not flow!

  4) Create a circuit by connecting the wires extending from the generator to the Multimeter with alligator clips.

  5) Place model two feet from the fan.

  6) Turn fan on lowest speed, and record the amount of voltage being generated. This will be your baseline reading based on all groups starting with the same design. (Note: Smaller fans may require a higher setting.)

  7) Create Data Sheets to collect and record your data as your group explores different designs.

- *STUDENT CHALLENGE:* Which team can generate the most electricity? This is the opportunity for students to experiment with variables to increase the output of their devices. They will be attempting to generate more Volts than were recorded in their benchmark designs.

- *VARIABLES*: Before giving students suggestions, have each group decided what variables they may want to test. Here are some possibilities:
  - Distance from Fan
  - Speed of Fan
  - Number of Blades attached to hub

- Angle or Pitch of the blades
- Blade Shape: Pointed, Rounded, Curved (This depends on which design your class is using.)

- *WRAP UP:* Have each group describe what conditions generated the most electricity. What was the highest reading for the class?
  Ask the following questions to assess student understanding of what had to happen to generate an electric current from their model wind turbines:

  1) What happens when the wind turbine spins?
  Answer: The shaft spins around, and the magnets moving inside the coils of copper wires generate electricity.

  2) Where does the electricity go?
  Answer: Out the wires, into the leads of the Multimeter, which makes the Multimeter respond so we can observe a reading.

- *JOURNAL REFLECTIONS:*

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1, 4-PS3-2, 4-PS3-3, 4PS3-4, 3-5-ETS1.1, 3-5-ETS1.2, 3-5-ETS1.3
Science and Engineering Practices: Asking Questions and Defining Problems, Planning and Carrying Out Investigations, Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ESS3.A, ESS3.C, ESS3.D, ETS1.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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WIND RESOURCES:

For Sources and Costs of Materials, Refer to the Energy *Materials List – Hitchcock Center Energy Literacy Project* inserted at end of unit.

Wind Wisdom teachers guide, Created by NESEA, and available for download on the Energy Teachers.org website:
http://energyteachers.org/download-doc.php?media_id=12

KidWind Project – Website for Wind Energy materials and downloadable curriculum, either whole kits or parts from their kits:
http://store.kidwind.org/ideas#teachers

NEED (National Energy Education Development Project): (See Wonders of Wind, and Elementray Infobook)
http://www.need.org/needpdf/PVCTurbineDirections.pdf

ATTACHMENTS TO DAILY LESSON:

Using Renewable Energy Worksheet

Names of People in Your Group______________________________

____

Solar Power:

1) How many volts does the solar panel generate? ____________

2) What can you do to make it generate half that number?

   ____

3) Will the solar panel make the LED bulb light? **yes** or **no**

4) Can you use the solar energy to light 2 LED bulbs? (Use 2 solar panels connected together.)
   yes or **no**

Wind Power:

1) How many volts does the wind turbine generate?____________

2) What can you do to make it generate half that number?

   ____

3) Will the wind turbine make the LED bulb light? **yes** or **no**

4) Can you use wind energy to light 2 LED bulbs? **yes** or **no**

What is Wind?

You can't see air, but it is all around us. You hear leaves rustling in the trees. You see clouds moving across the sky. You feel cool breezes on your skin. **Wind** is moving air.

The Sun Makes the Wind Blow

The energy in wind comes from the sun. When the sun shines, it heats the Earth's surface. The Equator gets more sunlight (**radiant energy**) than the North or South Poles. The Earth is not heated evenly.

Dark areas of land, like forests, **absorb** a lot of solar energy. Areas of water **reflect** solar energy. Light colored desert sand, snow, and ice reflect the sunlight, too.

As the Earth's surface absorbs the sun's energy, it turns the light into heat. The heat on the Earth's surface warms the air above it. The air over the **Equator** is warmer than the air over the **poles**. The air over land is warmer than air over water.

As air heats, it expands. Hot air rises. Cooler air rushes in to take its place. This moving air is wind. Wind is caused by the uneven heating of Earth's surface.

How Wind is Formed

Wind Energy is Renewable

As long as the sun shines, there will be winds on the Earth. We will never run out of wind energy. It is a **renewable** energy source. It is also free since no one can own the sun or the air.

We Can Capture the Wind

Some places have more wind than others. Areas near the water usually have a lot of wind. Flat land and mountain passes are good places to catch the wind, too.

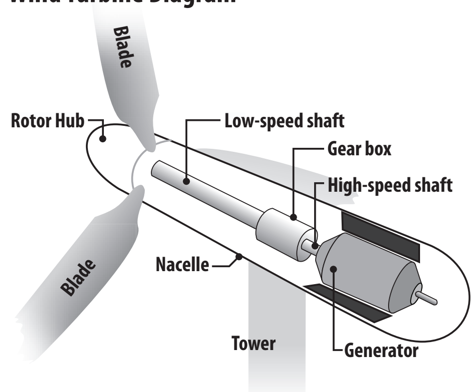
Today, we use big **wind turbines** to capture the wind. Sometimes, there are hundreds of wind turbines in one place. This is called a **wind farm**. Some wind turbines are as tall as 20-story buildings!

Wind Can Make Electricity

When the wind blows, it pushes against the blades of the wind turbines. The blades spin around. They turn a **generator** to make **electricity**. The wind turbines don't run all the time though. Sometimes the wind doesn't blow at all. Sometimes the wind blows too hard. Most wind turbines run between 65 and 90 percent of the time.

Today, wind energy makes a small amount of the electricity we use in the United States. Most of the big wind farms are in Texas. There are plans for many more all over the country and the world.

Wind Turbine Diagram



Wind is Clean Energy

Wind is a clean energy source. Wind turbines don't burn fuel, so they don't pollute the air. Wind is a renewable energy source and it is free.

Older wind turbines can make a lot of noise as they spin, but new ones do not.

One wind turbine doesn't make much electricity. Most wind farms have many wind turbines. Wind farms take up a lot of land; most of the land they are on can still be farmed or used to graze animals.

Wind is a safe, clean, renewable energy source for making electricity.

A Closer Look at Wind Turbines

How does a wind turbine generate electricity? When the wind blows, it pushes against the **blades** of the wind turbine. The blades spin around and turn a long pole called a **shaft**. This shaft spins slowly, because the turbine blades are spinning slowly. It is called a low-speed shaft.

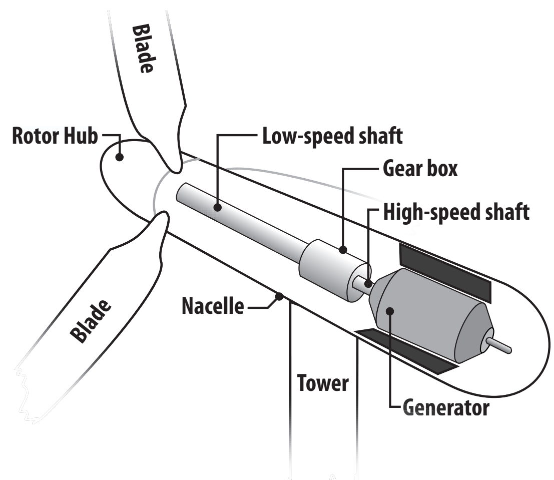
The low-speed shaft is connected to a **gear box**. The gears in the box increase the spinning motion. The gear box spins a small shaft very fast. This high-speed shaft spins inside a generator to make electricity.

The amount of electricity a turbine generates depends on its size and the speed of the wind. A small turbine may help to power one home. A large turbine may power 500 homes. Some wind turbines are as tall as 20-story buildings!

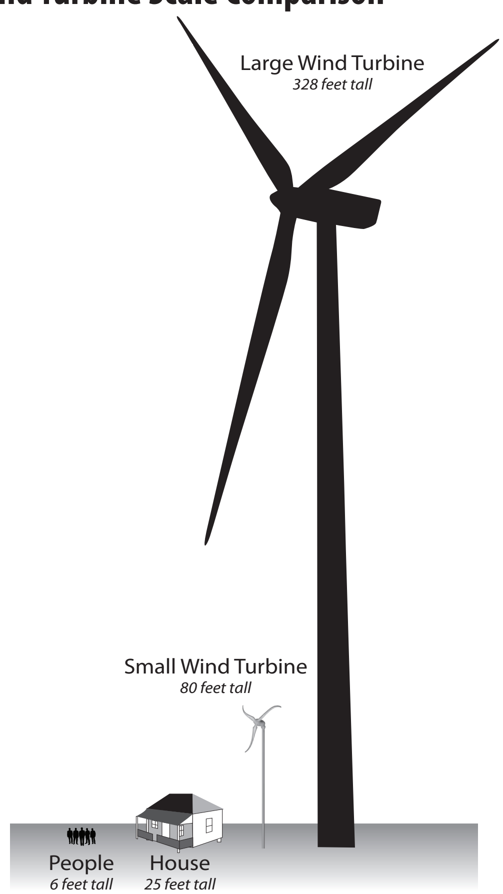
Small Wind Turbines

Wind turbines come in all sizes. Some turbines are small and can be used to help generate electricity on boats, in homes, and even schools. These turbines do not generate enough electricity to meet all of the demands of a home, but they do help reduce the amount of electricity people need to purchase from their electric company. They can be very helpful when people are far away from power lines, too!

Wind Turbine Diagram



Wind Turbine Scale Comparison



Wind Farms

Sometimes, there are hundreds of wind turbines in one place. This is called a **wind farm**, or wind power plant. The turbines work together to make a lot of electricity. This electricity is sold to **utility companies**, who sell the electricity to you at home.

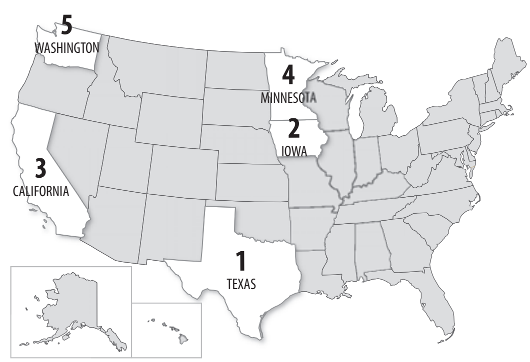
One wind turbine does not make much electricity. Most wind farms have many, many wind turbines. Wind farms take up a lot of land, but the land can be used to graze animals or grow crops.

Choosing where to build a wind farm is known as **siting** a wind farm. Scientists spend many years studying an area before they start to build a wind farm. They study the speed of the wind. They study the direction the wind blows. They think about the birds and animals that live in the area. Will the turbines hurt animal habitats? They decide if new roads or power lines need to be built near the wind farm. It costs a lot of money to build roads and power lines.

Wind farms can be built in the ocean, too. These wind turbines sit in the water, sometimes far away from shore. The wind is stronger offshore. There is nothing in the way to block the wind. These turbines make a lot of electricity. It is harder and more expensive to build offshore wind farms. Power lines must be buried deep under the water.

Today, wind energy makes only a little of the electricity we use in the United States. But wind power is growing. There are plans for many more wind farms all over the country.

Top Wind States (Net Electricity Generation), 2011



Data: Energy Information Administration

DAY 9 – SOLAR ENERGY INVESTIGATIONS

OVERVIEW: The sun has been shining on Earth since our planet was created. It shines every day, and is therefore a renewable energy resource. The suns energy powers almost everything we are dependent on. That is Solar Energy. If you remember from our first day in this lesson (Molly Bang's book *My Light*, and the NOVA *Sun Lab* videos) the energy of the sun travels to earth in very powerful electro-magnetic rays. Humans have developed technologies to capture this energy so we don't have to rely so much on nonrenewable energy sources, which have many Unwanted Outcomes. For this lesson we will focus on Solar Electric Energy Systems, also known as Photovoltaic (PV) Energy.

- *BACKGROUND INFORMATION:*

  SOLAR ENERGY: HOW SOLAR PANELS WORK. Photovoltaic (PV) cells are thin blue or black pieces of silicon, a glassy material. This is the basis for a solar panel. Two layers of silicon are used in creating a panel; each infused with a chemical. Sunlight energizes electrons in the cells of the panel. When the panel is connected to a generator and creates a circuit, electricity is produced and power is generated. The larger the panel, the more energized electrons are available to form a circuit. The more panels attached in a series, the higher the voltage. (NESEA Energy Thinkers Teacher Workshop.)

  PV systems are often mounted directly on buildings where they produce electricity for the building owner. Recently more large-scale solar PV facilities have been constructed, which helps to reduce our dependence on non-renewable energy sources. (Adapted from NESEA Energy Thinkers Teacher Workshop.)

  For additional background reading on Solar Energy, refer to the attached information from the NEED curriculum.

- *ACTIVITY - SOLAR ENERGY INVESTIGATION:*

  - ***Materials:***

    - One 2 or 3 volt mini solar panel per group
    - Wire leads with Alligator Clips
    - Red LED light bulbs
    - Hobby Motors (same as Wind Energy Investigation)
    - Light source:
      Gooseneck lamp with 100-Watt bulb
      Sun is best!

  - *INVESTIGATION:* Tell students the following before starting the solar investigation:

    - You will continue to work in small groups to engage in solar electric or Photovoltaic (PV) investigations.
    - You will be experimenting with mini-solar photovoltaic panels.

- You will continue to use some of the same materials as the wind investigation for observing and measuring electric currents - Multimeters, motors and wire leads with alligator clips.
- Your Energy Source will be table lamps, and the SUN if it's shining!

- *INSTRUCTIONS FOR STUDENTS:*

  1) **Important**: Turn on the lamp only when you are using it. The bulb will get hot so be careful.

  2) You will be creating a circuit using the solar panel and the Multimeter. Connect the wires coming out of the panel to the Multimeter, using the wire leads with alligator clips. How many volts does this solar panel generate?

  3) Create Data Sheets to collect and record your data as your group explores different designs.

- *VARIABLES/CHALLENGES*: Before giving students suggestions, have each group discuss what variables they may want to test. Here are some possibilities:

  - Change the distance from light source. What happens?
  - How many Volts are generated using Sunlight, if possible?
  - Change the angle of the solar panel relative to the light source. What happens?
  - What happens when part of the panel is covered?
  - Use the solar panel to light the LED bulb (Note: an LED works only when connected correctly.)
  - Use the solar panel to spin the motor from the wind activity.
  - Can you multitask, and spin a motor and light the LEDs at the same time?

- *WRAP UP:* Have each group describe what conditions generated the most electricity in their solar panel.

- *FOLLOW-UP QUESTIONS:* Use these questions to assess student understanding of what had to happen to generate an electric current from their solar panels:

  - What happens when the light shines on the solar panel? What were the different forms of energy? How did the energy change?
  Answer: The radiant energy from the sun excites the chemicals inside the panels, which causes electricity to flow through the attached wires.
  This electricity was then used to light the LED bulbs or spin the motors.

- *JOURNAL REFLECTIONS:*

- *FORMATIVE ASSESSMENT SUGGESTION:* Give students copies of the Energy Systems Thinking diagram from Day 2 of this unit.
  Have students fill in the diagram, starting with the GOAL of watching TV, INPUTS of Sun or Wind, the PROCESSES involved in power production, and OUTPUTS, both wanted and unwanted.
  Have students compare this sheet, to the diagram from Day 7 using Coal as the INPUT.

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1, 4-PS3-2, 4-PS3-3, 4PS3-4, 3-5-ETS1.1, 3-5-ETS1.2, 3-5-ETS1.3
Science and Engineering Practices: Asking Questions and Defining Problems, Planning and Carrying Out Investigations, Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ESS3.A, ESS3.C, ESS3.D, ETS1.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

SOLAR RESOURCES:

Note on Materials: Mini solar panels can be ordered from at science and technology education websites, or purchased from some electronic supply stores. Refer to the attached list at the end of this unit

NESEA Energy Thinkers Solar-Electric Activity. NESEA Energy Education Document, *Energy Thinking for Massachusetts:*
http://energyteachers.org/project_detail.php?project_id=13 - Energy Thinking for Massachusetts (pdf file format)

NEED (National Energy Education Development Project): (See Elementary Infobook and Wonders of the Sun Student Guide)
http://www.need.org

ATTACHMENTS TO DAILY LESSON:

Solar Energy

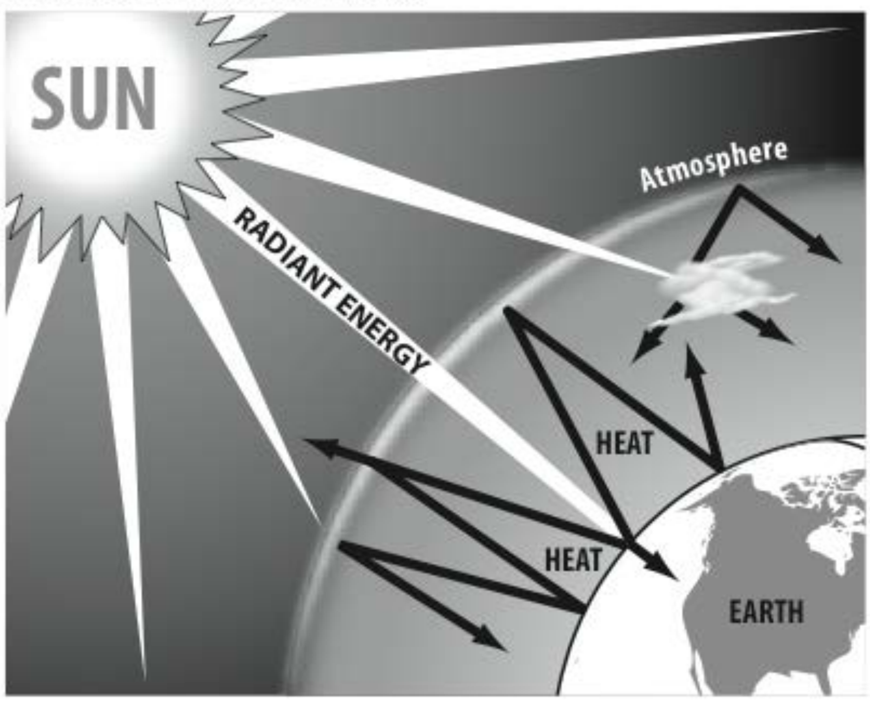
Our Earth gets most of its energy from the sun. We call this energy **solar energy**. The root *sol* refers to the sun.

Solar energy travels from the sun to the Earth in **rays**. Some are light rays that we can see. Some are rays we can't see, like x-rays. Energy in rays is called **radiant energy**.

The sun is a star, made of mainly hydrogen and helium. It sends out huge amounts of energy every day in every direction. Most of this energy goes off into space. Even though only a tiny fraction of the sun's energy reaches the Earth, it is still more energy than we can use.

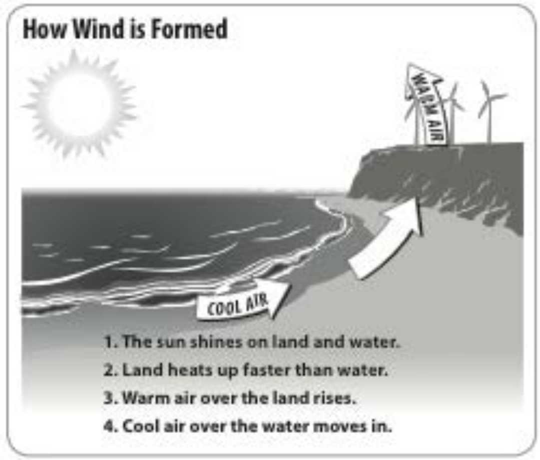
When the rays reach the Earth, some bounce off clouds back into space—the rays are **reflected**. The Earth **absorbs** most of the radiant energy. This solar energy becomes **thermal energy**, which warms the Earth and the air around it, the **atmosphere**. Without the sun, we couldn't live on the Earth—it would be too cold. This is called the **greenhouse effect**.

The Greenhouse Effect



The Sun Makes the Wind

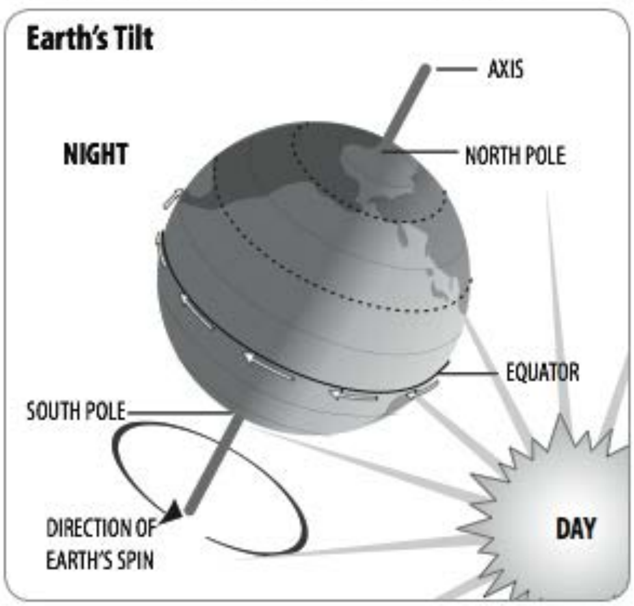
Solar energy is responsible for the winds that blow over the Earth. The sun shines down on the Earth. Some parts of the surface heat up faster than others. Land usually heats more quickly than water. Areas near the **Equator** receive more direct sunlight. These areas get warmer than regions near the North and South Poles. When air is warmed, it becomes less dense and rises. Cooler air moves in to replace the warm air that has risen. This moving air is called **wind**.



Wind **turbines** can capture the wind's energy. The wind turbines turn the energy in moving air into electricity. The wind pushes against the blades of the turbine and they begin to spin. A **generator** inside the turbine changes the motion into electricity.

Latitude and Intensity of Solar Energy

The Earth is not standing still in space. It moves around the sun in an orbit, taking one year to make a full **revolution** around the sun.



The Earth is slightly tilted on an **axis**. This tilt, combined with the revolution, are what cause the seasons of spring, summer, autumn, and winter. People who live in the southern **hemisphere**, south of the Equator, experience their hottest days when the northern hemisphere is experiencing winter.

The Earth also rotates on its axis. This **rotation** is what gives us sunlight during the day and darkness at night.

Why are areas closer to the Equator usually warmer than areas closer to the North or South Pole? This is due to the location's **latitude**, or distance from the Equator. The sun strikes different latitudes at different angles. Even during spring or fall, areas near the poles receive less direct sunlight than the Equator. This is because the Equator is always receiving its sunlight directly from overhead. As you move away from the Equator, you are actually walking on the surface of a sphere, and moving so the sun is no longer directly overhead.

Sunlight is most intense when it is directly overhead, and least intense when it is coming in from a low angle in the sky. This is why the hottest part of the day is when the sun is at its highest point compared to where you are, and why the days are cooler at sunrise and sunset.

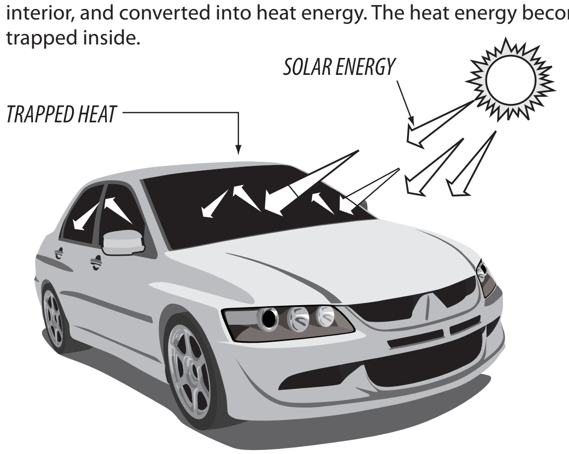
Solar Energy is Renewable

Solar energy is free and clean. Solar energy is **renewable**. We will not run out of it. The sun will keep making energy for millions of years.

Why don't we use the sun for all our energy needs? We don't have the technology to do it yet. The hard part is capturing the sun's energy. Only a little bit reaches any one place. On a cloudy day, some of the solar energy never reaches the ground at all. Although the sunlight is free, the equipment needed to capture and store the energy can be expensive. Scientists and engineers are working to create more efficient technology.

Solar Collector

On a sunny day, a closed car becomes a solar collector. Light energy passes through the window glass, is absorbed by the car's interior, and converted into heat energy. The heat energy becomes trapped inside.



We Can Capture Solar Energy

Lots of people put **solar collectors** on their roofs. Solar collectors capture the energy from the sun and turn it into heat. People heat their houses and their water using the solar energy. A closed car on a sunny day is a solar collector.

Solar Energy Can Make Electricity

Photovoltaic (PV) **cells** turn the sun's energy into electricity. The root *photo* means light and *volt* is a measure of electricity. Most PV cells are made of a piece of **silicon**, the main component in sand. Each side of the silicon has a different chemical added. When radiant energy from the sun hits the PV cell, the sides of the silicon work together to change the energy into electricity. Scientists are researching other materials to use in PV cells.

Some toys, calculators, and outdoor lights use small PV cells instead of batteries. Large groups of PV cells can make enough electricity for a house. They are expensive, but good for houses far away from power lines.

Some schools are adding PV cells to their roofs. The electricity helps reduce the amount of money schools must pay for energy. The students learn about the PV cells on their school buildings.

Today, solar energy provides only a tiny bit of the electricity we use. In the future, it could be a major source of energy. Scientists are looking for new ways to capture and use solar energy.

Schools use solar panels on their roofs to generate electricity.

DAY 10 - ENERGY ACTION PLAN: HOW CAN WE DO IT BETTER?
ENERGY EFFICIENCY AND CONSERVATION
(Explore, Explain, Elaborate)

OVERVIEW: Students will learn how to use a Kill-A-Watt Monitor to measure and compare the amount of electricity used by different lighting sources and common, small appliances. As a follow-up activity students will do an energy survey of their homes.

- *MATERIALS:*
  - Kill-A-Watt Monitor
  - Electrical Outlet Adapter
  - 2 gooseneck lamps
  - 1 60W incandescent bulb (or 100W)
  - 1 13W CFL bulb (or 23W)

- *MEASUREMENT* - Watts and Kilowatt-hours

  - A **watt** is a measure of how fast electricity is used or generated; it is a measure of power. For example: A 100-watt bulb uses electricity 10 times faster than a 10-watt bulb.
  - A **watt-hour** is a measure of electric energy. It is calculated by multiplying the number of watts by the hours of use.
  - A **kilowatt-hour** is 1,000 watt-hours. A **megawatt hour** is 1,000 kilowatt-hours. Your utility charges you for the number of kilowatt-hours you use.
    For example: Leaving a 100-watt bulb on for 10 hours uses 1,000 watt-hours (100 watts times 10 hours), or one- kilowatt-hour of electric energy.

- *KILL-A-WATT MONITOR*– Use this device to measure and compare the amount of electricity used by different lighting sources and small appliances that are available in the classroom, or can be brought in by a teacher (for example, blow dryer, coffee grinder).

- *LIGHT BULB COMPARISONS:*
  - Incandescent Bulbs (what we have traditionally used for lighting) are very inefficient, and produce lots of waste heat.
  - Compact Fluorescent Bulbs (CFL's) are 4X as efficient as incandescent bulbs, and last 10X longer.
  - Light-Emitting Diodes (LED's) are the most energy bulbs on the market, but are also very expensive.

  (See attached Facts of Light handouts from NEED)

- *ACTIVITY 1 - LIGHT BULB INVESTIGATION*:

  - *Instructions:*
    - Place the incandescent bulb in one lamp, and the CFL bulb in the other.
    - Plug the Kill-A-Watt Monitor into a heavy-duty extension cord, which is plugged into a wall outlet
    - Alternately plug the lamps with the different bulbs into the monitor; turn on the lamps; and record the wattage shown on the monitor.

- Discussion Questions:
  1) Which bulb uses more energy?
  2) Which bulb will cost less to use and why?
  3) Which bulb will result in more CO_2 being produced by a power plant and released into the atmosphere?

- *ACTIVITY 2 - APPLIANCE INVESTIGATION:* Do a similar investigation with small appliances

  1) Have students *MAKE PREDICTIONS* about what appliances they think will use more electricity. Write class predictions on chart paper, listing all the appliances that will be compared in the class. Compare the actual results of energy use to what students had predicted. (See attached *Energy Thinking – Efficiency and Use* student page from the NESEA curriculum.)

  NOTE OF CAUTION: Make sure you discuss electricity safety with students first. You may choose to do these investigations as a whole class demonstration, rather than having students handle the devices.

- *JOURNAL REFLECTIONS:*

- *EXTENSIONS or HOMEWORK:*
  - Have students complete a Home Energy Survey of their home (Sample Form attached.) See Activity and forms in NEED Energy Stories and More, p 48-55

  - Perform a school-wide energy conservation investigation (Sample Form attached.) If possible, arrange guest presentation from maintenance staff to learn about school heating, cooling, and lighting, and to take students on an Energy Tour of the School.

  - Follow-up Literacy activity – have students create an Energy Quest of their school to share with other students. (Inspired by Lebanon, NH Energy Quest, Vital Communities, Fall 2012)
    http://www.vitalcommunities.org/valleyquest/questdir.cfm

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1, 4-PS3-2, 4ESS3-1
***Science and Engineering Practices*:** Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ESS3.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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RESOURCES:

NEED (National Energy Education Development Project): (See Monitoring and Mentoring Teacher and Student Guides) http://www.need.org

ATTACHMENTS TO DAILY LESSON:

Lighting

In 2012, legislation under the Energy Independence and Security Act put restrictions on how much energy light bulbs use. Traditional bulbs, called **incandescent** bulbs, are being replaced with more efficient ones. More efficient bulbs like **halogens**, **compact florescents**, and LEDs will replace incandescents on store shelves.

About 14 percent of the electricity consumed in homes is used for lighting. Much of this is the result of using inefficient lighting. Many homes use incandescent lighting. Only 10 percent of the energy consumed by an incandescent bulb actually produces light; the rest is given off as heat. There are other more efficient lighting choices on the market, including halogens, fluorescents, and LEDs. Halogens are sometimes called energy-saving incandescent bulbs because they last longer, and use less energy than traditional incandescent bulbs, however they can burn hotter than incandescent lights do. Fluorescent lights produce very little heat and are even more efficient. Most schools use fluorescent tube lighting throughout the building, but may use incandescent bulbs in other spaces around the school.

Fluorescent lights use 75 percent less energy than incandescents and reduce environmental impacts. Converting to compact fluorescent light bulbs (CFLs) in your home is one of the quickest and easiest ways to decrease your energy bill. You can save about $6.00 in energy costs each year for every 100W incandescent bulb you replace. Compact fluorescent light bulbs provide the same amount of light and save energy.

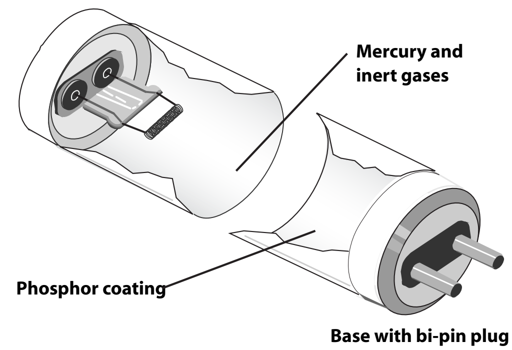
A fluorescent lamp is a glass tube lined inside with a phosphor coating. The tube is filled with argon gas and a small amount of mercury. At the ends of the tube are electrodes that generate an electric field when electricity flows through them. The energized electrons cause the mercury gas to emit UV (ultra violet) light. The invisible UV light strikes the phosphor coating, which emits visible light.

Fluorescent lights have ballasts that help move the electricity through the gas inside the bulb. There are two types of ballasts, magnetic and electronic. Electronic ballasts are more efficient than magnetic ballasts and can eliminate flickering and noise.

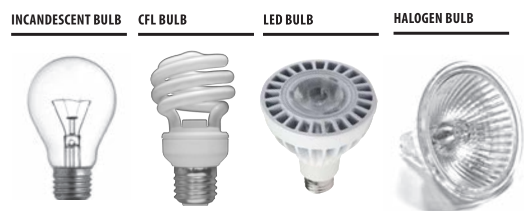
Light emitting diodes (LEDs) are commonly found in electronic devices and exit signs. Now they are offered as options in home lighting. ENERGY STAR® qualified LEDs use 75-80 percent less energy than incandescent bulbs and last 25 times longer. LED bulbs cost more than incandescent bulbs and CFLs, but prices are going down as more LEDs become available. LEDs are better suited for some locations than CFLs such as in outdoor or dimmable fixtures.

An LED light bulb is actually made of several light emitting diodes connected to produce a specific amount of light. Inside each LED, there are two areas; the N-type and the P-type. The material in the N-type contains substances that have free electrons. The materials in the P-type contain substances that can accept electrons. Electrons from the N-type naturally move to the P-type. When electricity is applied, electrons move from the P-type back into the N-type, and are energized. When the electrons release the extra energy, they move once again back into the P-type material and release light. The color of the light depends on which materials are used to make the N-type and P-type parts of the LED. Different materials make different colors of light.

Fluorescent Tube Lamp



In fluorescent tubes, a very small amount of mercury mixes with inert gases to conduct the electric current. This allows the phosphor coating on the glass tube to emit light.



Light emitting diodes (LEDs) offer better light quality than incandescent bulbs and halogens, last 25 times as long, and use even less energy than CFLs. Expect to see LEDs more widely used in the future as technology improves and costs come down.

Compact Fluorescent Lamps

Compact fluorescent lamps (CFLs) come in a variety of styles for different purposes. CFLs cut lighting costs about 75 percent.

Did You Know?

Only 10 percent of the energy used by an incandescent bulb produces light.

The rest is given off as heat.

Facts of Light

We use a lot of energy to make light so that we can see. About 30 percent of the electricity used by your school is for lighting! Our homes use a lot of energy for lighting, too. About 14 percent of the electricity used in your home is for lighting. Changing to energy efficient lighting is one of the quickest and easiest ways to decrease your electric bill. If your home uses inefficient incandescent bulbs – the same technology developed in 1879 by Thomas Edison - you are wasting a lot of energy and money. These bulbs are surprisingly inefficient, converting up to 90 percent of the electricity they consume into heat.

The Energy Independence and Security Act of 2007 changed the standards for the efficiency of light bulbs used most often. By 2014, most general use bulbs will need to be 30 percent more efficient than traditional, inefficient incandescent bulbs. What do the new standards mean for consumers? The purpose of the new efficiency standards is to give people the same amount of light using less energy. Most incandescent light bulbs will be slowly phased out and no longer for sale.

There are several lighting choices on the market that already meet the new efficiency standards. Energy-saving incandescent, or halogen, bulbs are different than traditional, inefficient incandescent bulbs because they have a capsule around the filament (the wire inside the bulb) filled with halogen gas. This allows the bulbs to last three times longer and use 25 percent less energy.

Compact fluorescent lamps (CFLs) provide the same amount of light as incandescent bulbs but use 75 percent less energy and last ten times longer. CFLs produce very little heat. Using CFLs can help cut lighting costs up to 75 percent and reduces environmental impacts. Today's CFL bulbs fit almost any socket, produce a warm glow and, unlike earlier models, no longer flicker and dim. CFLs have a small amount of mercury inside and should always be recycled rather than thrown away. Many retailers recycle CFLs for free.

Light Emitting Diodes, better known as LEDs, are gaining in popularity. Once used mainly for exit signs and power on/off indicators, improved technology and lowering prices are enabling LEDs to be used in place of incandescents and CFLs. LEDs are one of the most energy-efficient lighting choices available today. LEDs use even less energy than CFLs, and have an average lifespan of at least 25,000 hours. Today, LEDs are expensive, but they use even less energy than CFLs, saving more electricity and producing fewer carbon dioxide emissions. As the demand for LEDs increases, the cost will come down and become competitive with CFLs. The U.S. Department of Energy estimates that widespread adoption of LED lighting by 2027 would reduce lighting electricity demand by 33 percent. This would avoid construction of 40 new power plants.




	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
Brightness	850 lumens	850 lumens	850 lumens	850 lumens
Life of Bulb	1,000 hours	3,000 hours	10,000 hours	25,000 hours
Energy Used	60 watts = 0.06 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
Price per Bulb	$0.50	$3.00	$3.00	$30.00

Comparing Light Bulbs

The graphic on the previous page shows four light bulbs that produce the same amount of light. You might use bulbs like these as a bright overhead light. One bulb is an incandescent light bulb (IL), one is halogen, one is a compact fluorescent lamp (CFL), and another is a light emitting diode (LED). Which one is the better bargain? Let's do the math and compare the four light bulbs using the residential cost of electricity at $0.12/kWh.

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




All bulbs provide about 850 lumens of light.

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours				
x	Price per bulb	$0.50	$3.00	$3.00	$30.00
=	**Cost of bulbs for 25,000 hours of light**				
	COST OF ELECTRICITY	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total Hours	25,000 hours	25,000 hours	25,000 hours	25,000 hours
x	Wattage	60 watts = 0.060 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
=	Total kWh consumption				
x	Price of electricity per kWh	$0.12	$0.12	$0.12	$0.12
=	**Cost of Electricity**				
	LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Cost of bulbs				
+	Cost of electricity				
=	**Life cycle cost**				
	ENVIRONMENTAL IMPACT	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total kWh consumption				
x	Pounds (lbs) of carbon dioxide per kWh	1.3 lb/kWh	1.3 lb/kWh	1.3 lb/kWh	1.3 lb/kWh
=	**Pounds of carbon dioxide produced**				

Comparing Light Bulbs Answer Key




All bulbs provide about 850 lumens of light.

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours	25 bulbs	8.3 bulbs	2.5 bulbs	1 bulb
x	Price per bulb	$0.50	$3.00	$3.00	$30.00
=	**Cost of bulbs for 25,000 hours of light**	**$12.50**	**$24.90**	**$7.50**	**$30.00**
	COST OF ELECTRICITY	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total Hours	25,000 hours	25,000 hours	25,000 hours	25,000 hours
x	Wattage	60 watts = 0.060 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
=	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Price of electricity per kWh	$0.12	$0.12	$0.12	$0.12
=	**Cost of Electricity**	**$180.00**	**$129.00**	**$39.00**	**$36.00**
	LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Cost of bulbs	$12.50	$24.90	$6.30	$30.00
+	Cost of electricity	$180.00	$129.00	$39.00	$36.00
=	**Life cycle cost**	**$192.50**	**$153.90**	**$46.50**	**$66.00**
	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	1.3 lb/kWh	1.3 lb/kWh	1.3 lb/kWh	1.3 lb/kWh
=	**Pounds of carbon dioxide produced**	**1,950 lbs carbon dioxide**	**1,398 lbs carbon dioxide**	**423 lbs carbon dioxide**	**390 lbs carbon dioxide**

Kill A Watt™ Monitor Instructions

Kill A Watt™ Monitor

The Kill A Watt™ monitor 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 electrical power being used (watts). You can also obtain the actual amount of power consumed in kilowatt-hours (kWh) by any electrical device over a period of time from 1 minute to 9,999 hours. One kilowatt equals 1,000 watts.

Operating Instructions

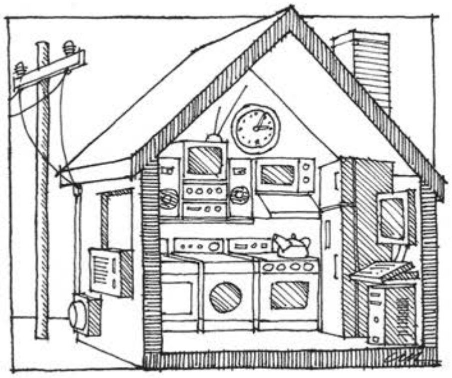
1. Plug the Kill A Watt™ monitor into any standard grounded outlet or extension cord.
2. Plug the electrical device or appliance to be tested into the AC Power Outlet Receptacle of the Kill A Watt™ monitor.
3. The LCD displays all monitor readings. The unit will begin to accumulate data and powered duration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

What is Power Factor (PF)?

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

Volts x Amps x PF = Watts Consumed

Energy Thinking—Efficiency and Use



Some appliances consume electricity faster than others. Typically, appliances that we use to heat or cool things (such as food, air, or water) consume electricity more rapidly than other appliances. When we use electricity faster, power plants need to generate electricity faster—which uses fuel faster.

WATTS AND KILOWATTS—HOW FAST WE USE ELECTRICITY:

Watts tell us how rapidly electricity is being consumed or is being generated. For instance, a 100-watt light bulb uses electricity 10 times faster than a 10-watt light bulb. A kilowatt is 1,000 watts.

KILOWATT-HOURS—HOW MUCH ELECTRICAL ENERGY WE USE:

The amount of electrical energy we use is measured by multiplying the watts used by the number of hours in use. When you use electricity to light a 100-watt bulb for ten hours, you use 1,000 watt-hours of electricity (100 watts x 10 hours = 1,000 watt-hours). Since utilities charge for how many kilowatt-hours (kWh) of electricity you use, it is important to know that a kilowatt-hour is 1,000 watt-hours. So lighting a 100-watt bulb for ten hours uses 1 kilowatt-hour of electricity.

COST OF ELECTRICITY:

The average cost of electricity to residents of Massachusetts is 16.6 cents per kilowatt-hour (kWh). A typical Massachusetts household consumes about 7,200 kWh per year, costing an average of $1,195 annually.

ENERGY EFFICIENT APPLIANCES:

Energy efficient appliances are designed to use electricity more slowly then a typical appliance while providing the same service. For instance, a compact florescent light bulb uses electricity four times more slowly than an old-fashioned incandescent light bulb while producing the same amount of light. By switching to energy efficient appliances, you can reduce the amount of electricity you use and reduce how much fuel power plants consume.

DON'T THROW ELECTRICITY AWAY:

Another way to reduce the amount of electricity you use—and how much fuel that power plants consume—is to turn appliances off when they are not needed. Leaving a light turned on in an empty room is similar to leaving the tap water running and walking away—a waste.

Home Energy Survey

1. What kind of energy heats our home in winter?

2. What kind of energy cools our home in summer?

3. What kind of energy cooks our food?

4. What kind of energy heats our water?

5. What kind of energy runs our car?

6. What kind of energy powers our lights and our appliances?

7. What kinds of things do we recycle?

8. How do we waste energy?

9. How do we save energy?

10. What things can we do to save more energy?

School Energy Survey

1. What kind of energy heats our school in winter?

2. What kind of energy cools our school in summer?

3. What kind of energy cooks our food?

4. What kind of energy heats our water?

5. What kind of energy runs our school buses?

6. What kind of energy powers our lights and our computers?

7. What kinds of things does the school recycle?

8. How do we waste energy?

9. How do we save energy?

10. What things can we do to save more energy?

DAY 11 - ENERGY CHAIN DRAWINGS
(Evaluate)

OVERVIEW: This is the final day of this unit, and will provide opportunities for students to demonstrate what they have learned.

- *ACTIVITY 1* **-** Follow-up on Home Energy Surveys (If given as homework). Have class discussion, and create summary chart of answers from their Home Energy Surveys, showing how many homes were heated by natural gas, oil, electricity, wood, solar, etc. (For a Math Extension of this activity, create a bar graph for the whole class.)

- *ACTIVITY 2* – Students create Energy Chain Drawings. This is an opportunity for students to put together all the pieces of an Energy Chain. This activity will serve as a summative assessment for this unit. (*Note:* If you want to allow enough time for the drawings to be elaborate and colorful, this could take an additional class period.)

  - Students can work individually or in small groups.

  - Long pieces of paper (3 feet) can be helpful to clearly see the multiple steps in the Energy Chain.

  - Provide students with colored markers, pencils or crayons.

  - SUGGESTIONS before students begin their drawings:

    - As a class, reflect on everything you have learned in the past several days about energy and electricity. They will be tracing the energy from the sun to a light bulb in their house.

    - Remind students about the concepts and images presented in Molly Bangs book, *My Light.* If time permits, reread this book having students pay particular attention to the yellow dots that represent the Suns energy, flowing through the book.

    - Refer students to the Energy Systems Diagram that has been discussed during this unit. Drawings should include components from the diagram, such as:

      1) Inputs – renewable or nonrenewable fuel source
      2) Processes – mining, extraction, transportation, electrical generation, delivery systems
      3) Outputs – Wanted (warm, light home); Unwanted (greenhouse gases)

    - For Examples of Energy Chains, refer to the attached graphic from the NESEA Energy Thinking Curriculum (Figure 3.1 Sample Energy Chain Poster), and Energy Chain Illustrations created by 4th graders in local classroom as part of a *Hitchcock Center for the Environment* Energy literacy class.

- *VARIATIONS:*

    - Literacy connection – Have students write a description of their Energy Chain drawings as if they were describing every step in the process to a new person.

    - Have children write poetry or a rap about their Energy chain. I've had great fun re-writing lyrics to Aretha Franklin's *Chain of Fools*!

    - Act out an Energy Chain

    - Build Table-top model of an Energy Chain:
        - Use cardboard, wooden sticks, glue, wires to build structures
        - Create circuit that actually lights up your house
        - Consider what source of energy is powering your system

- *JOURNAL REFLECTIONS*: Provide students with writing prompt. Write 3 questions onboard in front of room:

    - What Have We Learned?
    - How Can We Make Better Energy Choices?
    - How Can We Influence Our Families and Communities?

Correlation to the Next Generation Science Standards

Performance Expectations: 4-PS3-1***,*** 4-PS3-2, 4ESS3-1
***Science and Engineering Practices*:** Obtaining, Evaluating, and Communicating Information
Disciplinary Core Ideas: PS3.A, PS3.B, PS3.C, PS3.D, ESS3.A
Crosscutting Concepts: Energy and Matter; Cause and Effect; *Interd*ependence of Science, Engineering, and Technology; Influence of Engineering, Technology, and Science on Society and the Natural World; *Science is a Hu*man Endeavor; Systems and Systems Models

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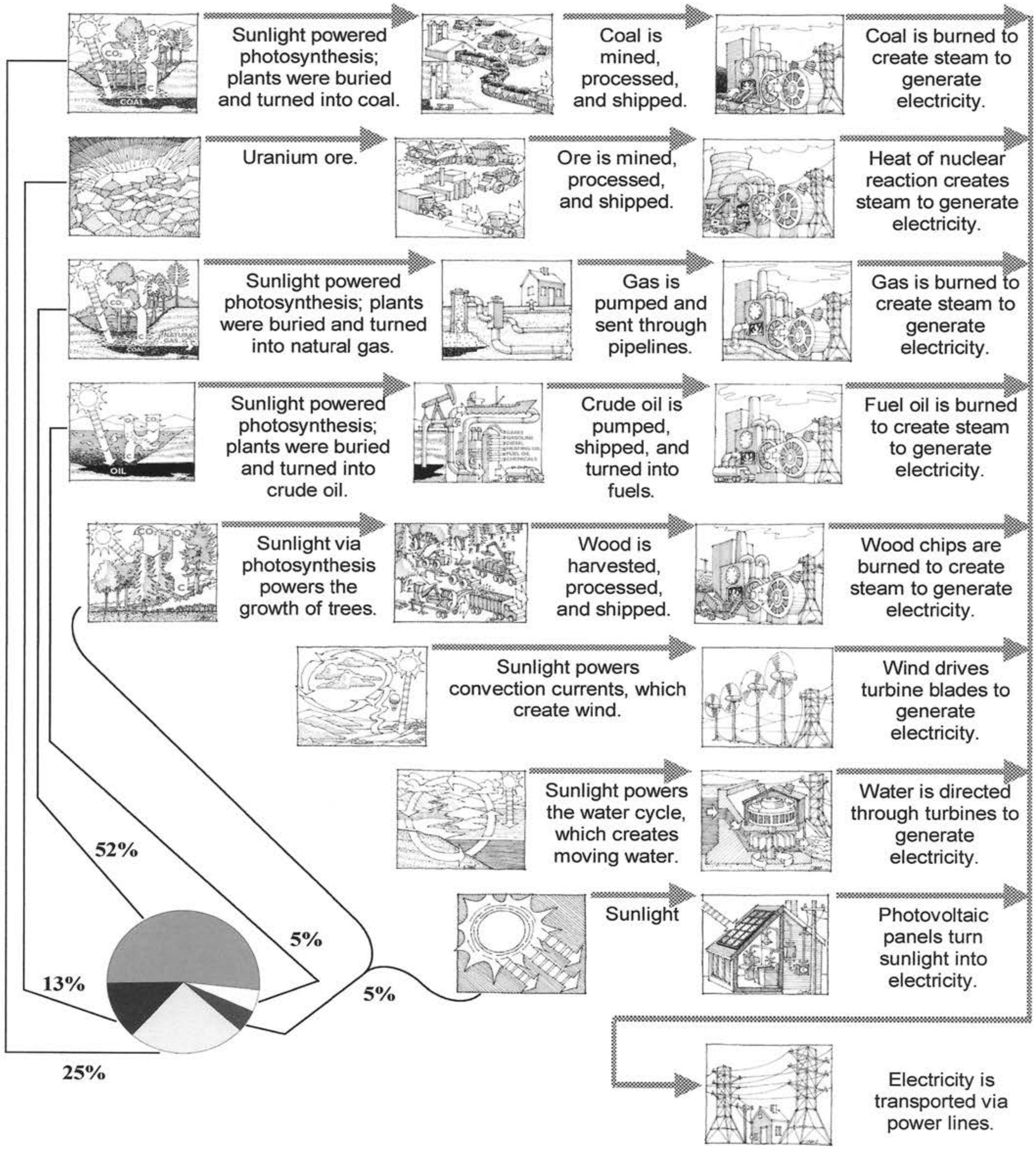
RESOURCES:

NESEA Energy Education Document, *Energy Thinking for Massachusetts:*
http://energyteachers.org/project_detail.php?project_id=13 - Energy Thinking for Massachusetts (pdf file format)

ATTACHMENTS TO DAILY LESSON:

Figure 3.1: Sample Energy Chain Poster




Energy chain
Energy Chain

Energy Materials List
Hitchcock Center Energy Literacy Project – 2013

Solar Panel (3 volt)- $11
KidWind.com or
Pitsco (2 volt) - $5.95

Ceramic Magnets - $6.50 (4 pack)
KidWind.com

28 Gauge Magnet Wire - $9.00
KidWind.com

Generator, hub, dowels - $12.00
Basic Turbine Building Parts
item # SKU; H0011
KidWind.com

Analog Multimeter - $8.99
Amazon

Kill A Watt Monitor - $19.88
Amazon

Alligator Test Leads - $6.50 (10 pack)
Amazon

LED Bulbs - $3.95 (package of 10)
Pitsco

1 Bag of 10 pieces of coal - .50
Bernardston Farmers Supply (sold in bulk rather than bags)

Adaptor (for the back of Kill A Watt Monitor) - .89
Home Depot or hardware store

Roll of Electrical tape - .69
Home Depot or hardware store

Fan Blades - $2.00 each
caframo.com
tiny tornado fan item #827-01BBG
1-800-223-7266

Heavy Shish-Kabob Skewers - $2.00
grocery store

My Light by Molly Bang - $5.50 (used)

APPENDIX:

NOTE TO READERS Regarding the Crosscutting Concept, Systems and Systems Models: Although not specifically indicated in the 4th grade Energy Standards, it would be difficult to teach about Energy without incorporating the crosscutting concept of *Systems and Systems Models*. I have referenced this often in this Energy Unit, and have attached excerpts from the from *Next Generation Science Standards, Appendix G – Crosscutting Concepts* to reinforce the importance of thinking about Energy as a System. Perhaps this omission was an oversight on the part of the editors of the document. Regardless, I have chosen to reference *Systems and Systems Models* because I find it highly relevant to the Energy Unit, and reflective of how we teach at the Hitchcock Center for the Environment.

4. Systems and System Models *…"are useful in science and engineering… Consideration of flows into and out of the system is a crucial element of system design. In the laboratory or even in field research, the extent to which a system under study can be physically isolated or external conditions controlled is an important element of the design of an investigation and interpretation of results…Models can be valuable in predicting a system's behaviors or in diagnosing problems or failures in its functioning… important to ask what interactions are occurring (e.g., predator-prey relationships in an ecosystem) and to recognize that they all involve transfers of energy, matter, and (in some cases) information among parts of the system...* (*NGSS Appendix G p. 7-8*)

This is followed by an explanation of the next Crosscutting Concept, Energy and Matter, which IS referenced in the standards for 4th grade Energy:

5. Energy and Matter *are essential concepts in all disciplines of science and atmosphere and its surface and subsurface reservoirs. Any such cycle of matter also involves associated energy transfers at each stage, so to fully understand the water cycle, one must model not only how water moves between parts of the system but also the energy transfer mechanisms that are critical for that motion.*

"Consideration of energy and matter inputs, outputs, and flows or transfers within a system or process are equally important for engineering. A major goal in design is to maximize certain types of energy output while minimizing others, in order to minimize the energy inputs needed to achieve a desired task." (*NGSS Appendix G p. 8-9*)

Furthermore, the next section in the NGSS Appendix presents how the Crosscutting Concepts are Connected. The following excerpt relates to Systems:

Systems and system models *are used by scientists and engineers to investigate natural and designed systems. The purpose of an investigation might be to explore how the system functions, or what may be going wrong. Sometimes investigations are too dangerous or expensive to try out without first experimenting with a model.*

Scale, proportion, and quantity *are essential considerations when deciding how to model a phenomenon. For example, when testing a scale model of a new airplane wing in a wind tunnel, it is essential to get the proportions right and measure accurately or the results will not be valid. When using a computer simulation of an ecosystem, it is important to use informed estimates of population sizes to make reasonably accurate predictions. Mathematics is essential in both science and engineering.*

Energy and matter *are basic to any systems model, whether of a natural or a designed system. Systems are described in terms of matter and energy. Often the focus of an investigation is to determine how energy or matter flows through the system, or in the case of engineering to modify the system, so a given energy input results in a more useful energy output.*

Stability and change *are ways of describing how a system functions. Whether studying ecosystems or engineered systems, the question is often to determine how the system is changing over time, and which factors are causing the system to become unstable.* (*NGSS Appendix G p. 12*)

RESOURCES (Referenced in this unit):

National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press, 2012.

National Research Council. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press, 2013.
http://www.nextgenscience.org/next-generation-science-standards

My Light, by Molly Bang, Blue Sky Press; First Edition (March 1, 2004)
Molly Bang also has a website which provides more detailed information about the science of electricity, for those who want more background information:
http://www.mollybang.com/Pages/mylight.html

Energy Thinking, NESEA (Northeast Sustainable Energy Association)
www.nesea.org

EnergyTeachers.org - The Internet network for educators interested in energy production and use
http://energyteachers.org

The NEED Project (National Energy Education Development Project) http://www.need.org/Educators

How Things Work Website.
http://science.howstuffworks.com/electricity5.htm

NOVA Labs, produced by PBS Online by WGBH, Boston (Energy Lab, Sun Lab, and Cloud Lab)
http://www.pbs.org/wgbh/nova/labs/educators/

Energy Literacy: Energy Principles and Fundamental Concepts for Energy Education
http://www1.eere.energy.gov/education/energy_literacy.html
NOTE: This document offers a framework for developing curriculum. The guide and associated documents are downloadable at the above website. *
* The Fundamental Concepts outlined here are based on a set of six guiding principles laid out in, "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas," National Research Council, Board on Science Education, 2011. Please see the NRC Framework for more discussion of these concepts and for further references.

KIDWIND - site for materials and downloadable curriculum
http://store.kidwind.org/ideas#teachers

Switch Energy Project
http://www.switchenergyproject.com

U.S. Department of Energy (DOE) education links
http://www.fossil.energy.gov/education/energylessons/index.html

U.S. Energy Information Administration
http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf

ENERGY KIDS Curriculum, developed by the U.S. Energy Information Administration
http://www.eia.gov/kids/index.cfm)

ADDITIONAL ENERGY RESOURCES:

ENERGY QUEST (linked from the Project Learning Tree/Energy website:
https://www.plt.org/energy---society-activity-1---energy-detectives)
Energy Quest is an effort by the California Energy Commission to provide resources to teachers and students all about energy: its different forms, how it is generated, its sources and how to protect and conserve it. The Energy Quest website is arranged in easy-to-use tabs that lead to rich, comprehensive supply of teaching material. The website's interactive interface is useful and educational to both teachers and students alike.
http://energyquest.ca.gov/index.html

Flick a Switch: How Electricity Gets to Your Home By Barbara Seuling and Nancy Tobin. Holiday House. 2003. ISBN 0823417298. Grades 4–6 (also referenced in NSTA Science and Children as an example of teaching through trade books, December 2009)

PROJECT LEARNING TREE, Energy Sleuths Curriculum
http://www.plt.org/prek-8-activity-39---energy-sleuths
Student Pages: **Energy Primer** (pdf)

Valley Quest - Valley Quest is an award-winning, place-based education program that uses treasure hunts to celebrate community, natural, history, cultural sites, stories and special places.
http://www.vitalcommunities.org/valleyquest/

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AFTERTHOUGHTS:

In the process of developing this curriculum, I found discussing energy issues and myself continually contemplating with my colleagues and family. As I researched the myriad of resources available about energy and climate change education, it became very clear to me that these are the biggest issues of our time. It is imperative that we understand the connection between our energy use and global consequences – environmentally, economically, socially and politically. It is essential that we teach about these issues. The prospects for the future can seem overwhelming; we must have hope that our choices and ingenuity can guide us forward. Let us give our children the knowledge base, the skills, and the inspiration to help us make batter choices to live responsibly and sustainably on our planet.

Patty O'Donnell
Hitchcock Center for the Environment
September 2013

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