Energy cannot be created or destroyed; however, energy can be converted from one form to another.

ENERGY TRANSFORMATIONS

CT Science Standard 9.1

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Imagine, Discover, Explore

Connecticut Science Center

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SUMMARY

Energy transformations occur in front of us every day - every movement of our bodies, every form of transportation. Can your students identify potential and kinetic energy forms and energy transformations? Explore transformations in your classroom using "*Cat-Traption*" and simple toys, and then "blow" your students away with a visit to the Connecticut Science Center, where students will learn about energy and the transformation of solar energy to wind to electricity. While visiting the Science Center, your students may deepen their experience by using Trail Guides as they visit the Exploring Space and Invention Dimension Galleries to answer questions about Content Standard 9.1.

This program has been developed as a unit to complement some of the core themes, content standards and expected performances of the CT Core Science Frameworks, as well as the National Science Education Standards. It is a supplemental series of "hands-on" investigations that are inquiry-based and designed to engage students as well as to enhance and build upon their prior content knowledge. It may be integrated with other subjects or it may be taught in its entirety within the science classroom.

The complete CT Core Science Curriculum Frameworks is available at the website http://www.state.ct.us/sde/curriculum/. See also: American Association for the Advancement of Science, *Atlas of Science Literacy*, Project 2061. Content standard 9.1 focuses on the concepts of Energy Transfer and Transformations.

Following are the specific sections from the CT Core Science Curriculum Framework that are addressed in this unit. The D INQ information reflects the process skills intended for grades 9-10 specifically representing the content standards of scientific inquiry, literacy, and numeracy.

Inquiry Standards

Grades 9-10 Core Scientific Inquiry, Literacy and Numeracy	
Content Standards	**Expected Performances**
SCIENTIFIC INQUIRY ♦ Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena. ♦ Scientific inquiry progresses through a continuous process of questioning, data collection, analysis and interpretation. ♦ Scientific inquiry requires the sharing of findings and ideas for critical review by colleagues and other scientists. **SCIENTIFIC LITERACY** ♦ Scientific literacy includes the ability to read, write, discuss and present coherent ideas about science. ♦ Scientific literacy also includes the ability to search for and assess the relevance and credibility of scientific information found in various print and electronic media. **SCIENTIFIC NUMERACY** ♦ Scientific numeracy includes the ability to use mathematical operations and procedures to calculate, analyze and present scientific data and ideas.	D INQ.1 Identify questions that can be answered through scientific investigation. D INQ.2 Read, interpret and examine the credibility and validity of scientific claims in different sources of information. D INQ.3 Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment. D INQ.4 Design and conduct appropriate types of scientific investigations to answer different questions. D INQ.5 Identify independent and dependent variables, including those that are kept constant and those used as controls. D INQ.6 Use appropriate tools and techniques to make observations and gather data. D INQ.7 Assess the reliability of the data that was generated in the investigation. D INQ.8 Use mathematical operations to analyze and interpret data, and present relationships between variables in appropriate forms. D INQ.9 Articulate conclusions and explanations based on research data, and assess results based on the design of the investigation. D INQ.10 Communicate about science in different formats, using relevant science vocabulary, supporting evidence and clear logic.

Grade 9 Core Themes, Content Standards and Expected Performances	
State Framework	CAPT Correlation
9.1 - Energy cannot be created or destroyed; however, energy can be converted from one form to another. ♦ Energy enters the Earth system primarily as solar radiation, is captured by materials and photosynthetic processes, and eventually is transformed into heat.	D 1. Describe the effects of adding energy to matter in terms of the motion of atoms and molecules, and the resulting phase changes. D 2. Explain how energy is transferred by conduction, convection and radiation. D 3. Describe energy transformations among heat, light, electricity and motion.

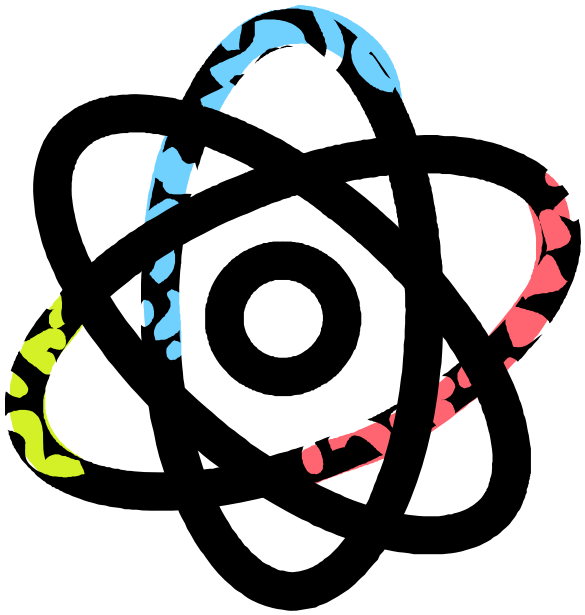
MASSACHUSETTS LEARNING STANDARDS

Physical Science
Grades 3-5
Standard #4

Identify the basic forms of energy (light, sound, heat, electrical, and magnetic). Recognize that energy is the ability to cause motion or create change.

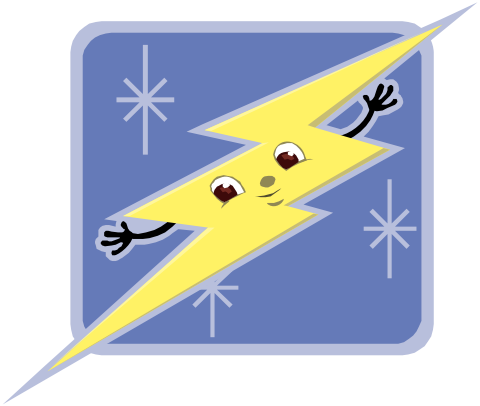
Physical Science
Grades 3-5
Standard #5

Give examples of how energy can be transferred from one form to another.



SAFETY STANDARDS

1. Review expectations for appropriate behavior, handling of materials and cooperative group procedures to be sure that the activities are accessible and safe for all students prior to beginning these investigations.
2. Make any necessary student modifications.
3. Monitor students to be sure they are acting appropriately, handling materials accordingly, and working cooperatively.
4. For more comprehensive information on science safety, consult the following guidelines from:
   Council of State Science Supervisors: http://www.csss-science.org/downloads/sciaf_cal.pdf
   CT State Department of Education:
   http://www.sde.ct.gov/sde/lib/sde/pdf/curriculum/science/safety/science_safety.pdf



MISCONCEPTIONS AND FACTS

Misconceptions	Facts
The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase. It may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.	Although the various forms appear very different, each can be measured in a way that makes it possible to keep track of how much of one form is converted into another.
Students believe energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable.	Energy cannot be created or destroyed; however, energy can be converted from one form to another.
Students do not distinguish well between heat and temperature when they explain thermal phenomena. Their belief that temperature is the measure of heat is particularly resistant to change.	Heat is the total energy of molecular motion in a substance while temperature is a measure of the average energy of molecular motion in a substance. Heat energy depends on the speed of the particles, the number of particles (the size or mass), and the type of particles in an object. Temperature does not depend on the size or type of object. For example, the temperature of a small cup of water might be the same as the temperature of a large tub of water, but the tub of water has more heat because it has more water and thus more total thermal energy. (http://coolcosmos.ipac.caltech.edu//cosmic_classroom/light_lessons/thermal/differ.html)
Middle- and high-school students tend to use their intuitive conceptualizations of energy to interpret energy movement and conservation ideas. For example, some students interpret the idea that "energy is not created or destroyed" to mean that energy is stored up in the system and can even be released again in its original form.	Whenever the amount of energy in one place or form diminishes, the amount in another place or form increases by an equivalent amount. Thus, if no energy leaks in or out across the boundaries of a system, the total energy of all the different forms in the system will not change, no matter what kinds of gradual or violent changes actually occur within the system.

Middle- and high-school students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy change focus only on forms that have perceivable effects.	Most of what goes on in the universe—such as the collapsing and exploding of stars, biological growth and decay, the operation of machines and computers—involves one form of energy being transformed into another.
Students don't always give up their naive notion that some substances (for example, flour, sugar, or air) cannot heat up, or that metals get hot quickly because "they attract heat," "suck heat in," or "hold heat well." Students have difficulty explaining the process of heating and cooling in terms of heat being transferred. Some students think that "cold" is being transferred from a colder to a warmer object, others that both "heat" and "cold" are transferred at the same time. Middle- and high-school students do not always explain heat-exchange phenomena as interactions. For example, students often think objects cool down or release heat spontaneously—that is, without being in contact with a cooler object. Middle-school students believe different materials in the same surroundings have different temperatures if they feel different (for example, metal feels colder than wood). As a result, they do not recognize the universal tendency to temperature equalization.	When heat is conducted or radiated in fluid, currents are set up that usually enhance the transfer of heat. Although materials that conduct or radiate heat very poorly can be used to reduce heat loss, it can never be prevented completely. The reason that heat tends always to diffuse from warmer places to cooler places is a matter of probability. Heat energy in a material consists of the disordered motions of its perpetually colliding atoms or molecules.

From *Benchmarks for Science Literacy and* From Science for All Americans, http://www.project2061.org/publications/sfaa/online/chap4.htm#26

Pre Visit Activities

ACTIVITIES SUMMARY

The visit to the CT Science Center begins in your classroom with pre-visit activities. It is suggested that you complete these activities as a prerequisite to prepare your students for the actual visit. It is also suggested that teachers complete the post activities and follow up assessment to integrate your visit into a meaningful unit of study.

Activity One: Cat-Traption - Where did the Energy Go?

In this activity students will raise questions regarding energy transformations through the use of common toys and an online demonstration.

Science Concept

♦ Energy enters the Earth system primarily as solar radiation, is captured by materials and photosynthetic processes, and eventually is transformed into heat.

Energy forms are grouped in two major categories:

- Potential Energy
  - *Energy that is stored, and the energy of position or gravitational energy*
- Kinetic Energy
  - *Energy in motion, including the motion of waves, electrons, atoms, molecules, substances, and objects*

Potential Energy Forms	Kinetic Energy Forms
Chemical Energy	Electrical Energy
Stored Mechanical Energy	Radiant Energy (light and solar)
Nuclear Energy	Thermal Energy
Gravitational Energy	Motion Energy
	Sound Energy

Materials for Each Student

- Science notebook
- Writing utensil

ENGAGING ACTIVITY

Pre-Assessment and Post-Assessment

On beginning the Cat-Traption activity, have students write a response to the following prompt:

> *"There are both potential and kinetic forms of energy. Name and categorize as many as you can."*

(At the completion of this activity, have students revisit their answer of the prompt, draw a "line of learning" below the first answer, and then reflect on how they would answer the same question now, with the additional question: "Tell how one form of energy may be transformed into at least 3 other forms of energy.")

1. Have students view the Cat-Traption animation that is available online from www.Learner.org at http://www.learner.org/channel/workshops/energy/cattraption/catrunthru.html
2. As students view the animation, ask them to record their observations in their science notebooks. As they review their observations, ask them to write down any questions they might have about what is occurring.

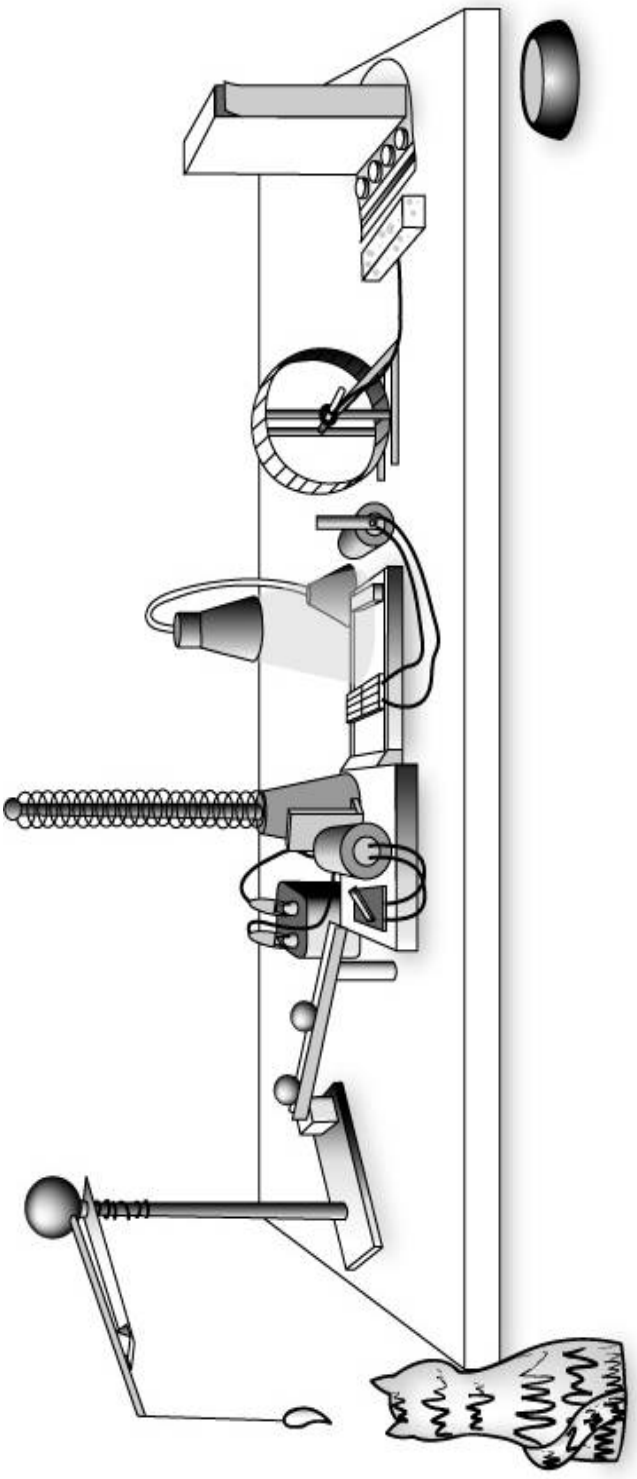
www.CTEnergyEducation.com has a lesson for this activity available online at http://www.ctenergyeducation.com/lesson.htm?id=0tv8ue4p. The demonstration shows a number of energy transformations. The worksheet allows students to label the transformations and to discuss what they think is happening in the animation.
As students view the animation and discuss the worksheet, ask them to record any further observations and questions they may have.

Cat-Traption—What Happened? Worksheet

1. Watch the online Cat-Traption animation at http://www.learner.org/channel/workshops/energy/cattraption/catrunthru.html
   You may have to watch the clip several times to see everything that happens.

2. Using the diagram, draw in at least 10 actions that you identify, labeling your steps.

3. For the 10 actions you identified, identify each energy form and describe the transition from one form to the next.



Activity Two

After the "Cat-Traption" activity, challenge your students to explore energy transformations using some common toys. This is an additional activity where students develop their own questions about what is happening to create the changes they observe, and what changes they can create with the toys given. Examples of toys include wind-up gadgets, rubber band driven cars or airplanes, and balloons. Common gadgets may be included, such as a no-battery squeeze or shake flashlight. These items may be found in most stores, or in science supply catalogs.

Materials for Each Student

- Science notebook
- Writing utensil

(For Each Group of 3-5 Students)

- 4-5 toys per table, include toys that demonstrate kinetic and potential energy
- wind-up gadgets
- rubber band driven cars or airplanes
- balloons
- no-battery squeeze or shake flashlight
- Toys may also show conversions of energy into heat, light and sound

Engaging Activity

1. Ask students to play with these toys for about 5 minutes.
2. Make observations and record these in their science notebooks.
3. Ask students to write down any questions that come up.
4. After the initial interaction with the toys, ask students to refer back to the "Cat-Traption" activity. Using questions from both activities choose some questions they have raised regarding energy transformations that remain unanswered or that they would like to further investigate.

The questions that the students developed are then sorted into those that can be investigated in the class, and those that cannot be investigated in the class. The teacher may further define what can be investigated by what materials will be made available for experimentation.

Added materials for the investigations might include: stop watches; string, balls or blocks or other objects that might be pulled or pushed; meter sticks; balance scales; board or other "ramp" making equipment. If solar powered toys were presented or available, provide different light sources for experimentation. Students may wish to refine their questions according to the equipment available.

Have students choose which question they will investigate and re-form groups accordingly. Circulate through the room checking to make sure students have an opportunity to confront any misconceptions that have arisen. Groups should create and share out a scientific analysis of what they have discovered, including data. Students should identify any energy transformations that are observed in their investigations.

After recording the salient points of their presentations, make sure you pull all of the learning together with a teacher synthesis and a content blast where you capture any missing information regarding energy transformations that did not arise from their investigations. If necessary, be prepared to have students perform another investigation to dispel any further misconceptions they still might have.

Activity Three

In this activity, students will explore the transformation of solar energy into wind energy.

Adapted from: "The roles of pressure and differential heating in wind" DLESE Teaching Boxes
http://teachingboxes.org/jsp/teachingboxes/weatherEssentials/wind/sequence/lesson2_activity1.jsp

Materials for Each Student

- Balloon
- Safety goggles

(Check for participants with latex allergies. This activity should not be used with latex sensitive people.)

Engaging Activity

1. Introduce the idea of pressure by asking students: What words are often used by meteorologists when they talk about winds and weather systems? You often see H and L on weather maps right? What are do they stand for? High and low what? *(Elicit the response of pressure.)*
2. Inflate a balloon *(Wear safety goggles while working with the balloon).*
3. While inflating the balloon, ask the class what's happening *(Air is going into the balloon, the pressure is increasing, the balloon is getting bigger).* As you add more molecules into a given space *(volume)*, does the pressure increase or decrease? *(It increases because there are more molecules. The pressure inside the balloon is greater than the surrounding air.)*
4. Release the air from the balloon. (*If possible have the students feel the air being released from the balloon.)*
5. Ask the students what happened when the balloon released the air. *(Emphasize that the pressure is equalizing suddenly; the air moved from the balloon to the surrounding room. Before the balloon was opened, the pressure gradient was high between the inside of the balloon and the surrounding air.)*
6. Review with the class what happened with the balloon. *(You filled the balloon with more air, the pressure inside increased and was greater than the pressure of air in the room, then the pressure was suddenly released when you opened the balloon.)*
7. Ask the class: which direction does air move when there is a pressure gradient? *(From the balloon to the surrounding air - from high pressure to low pressure)*
8. What is this movement of air called? *(Wind!)*
9. So, in nature, is someone blowing up big balloons to make wind? No? Where does that pressure difference come from?

Science Center Classroom Activity: Energy Transformations (45 minutes)

Standard:
9.1 Energy cannot be created or destroyed; however, energy can be converted from one form to another.

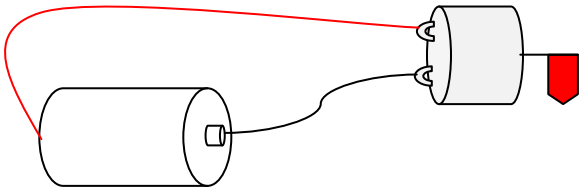
Grade Level Expectations:
D3. Students will be able to describe energy transformations among heat, light, electricity and motion.

Advance Preparation for the Teacher:
Before the visit to the Connecticut Science Center the students should already be familiar with the concept of energy and energy transformations. Students should also be aware of the many different forms of energy that exist in the world.

Introduction:
In this activity students will work with simple motors to explore a range of energy transformations. So that the instructor can appropriately gauge student understanding, the instructor will ask the students to list different forms of energy, and discuss where those different forms of energy can be found. Through these experiments and explorations, the students should gain a clear understanding of energy, and specifically electricity, in our lives.

Total Materials (For Each Group)
- 1 D Battery *(in holder)*
- 2 DC Hobby Motors *(Labeled "A")*
- 2 DC Hobby Motors *(Labeled "B")*
  (Motors A, and B each need to have unique specifications. The motors should be between 3V and 24V and designed to have clips attached directly to the motor. You should be able to find them in any hobby store.)
- 4 Fan Blades *(already attached to the shafts of the motors)*
- 2 Wire Connectors with Alligator Clips
- 1 Resistor
- 1 1.5V Incandescent Lamp
- 1 Solar Cell
- 1 Table Fan or Box Fan
- 1 Lamp w/ 40-60 W Incandescent Bulb

Electricity to Motion
Materials
- D Battery
- Motor A
- Motor B
- 2 Wire Connectors

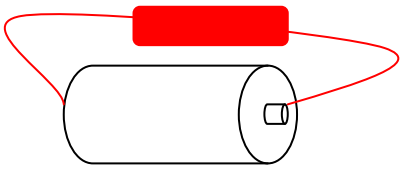


Task

1. Use the battery to get a motor to move.
2. Switch the wires so that they are connected to the opposite sides of the battery.
3. Remove the first motor and repeat the process with a second motor.
4. Do you get the same results each time? Why or Why Not?
5. List in your notebook the energy transformations that occurred.

Electricity to Heat

Materials



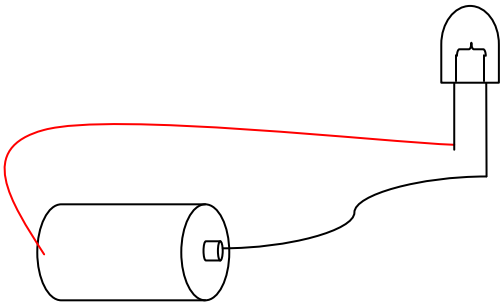
- D Battery
- 1 Resistor
- 2 Wire Connectors

Task

6. Observe energy transformations between the battery and the resistor.
7. Do ***not*** to leave the resistor connected to the battery for long periods of time.
8. Switch the wires so that they are connected to the opposite sides of the battery.
9. List in your notebook the energy transformations that occurred.

Electricity to Heat to Light

Materials



- D Battery
- 1.5V Incandescent Light Bulb (in holder)
- 2 Wire Connectors

Procedure

10. Light up the light bulb with the battery.
11. Switch the wires so that they are connected to the opposite sides of the battery.
12. List in your notebook the energy transformations that occurred.

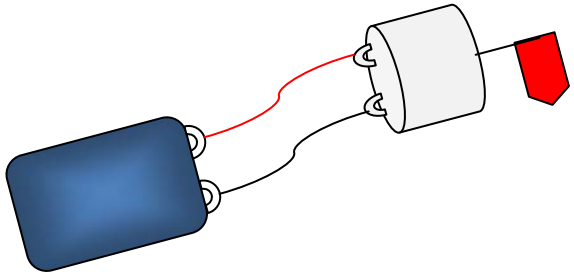
Motion to Electricity to Motion

Materials

- 2 Motor A
- 2 Motor B
- 2 Wire Connectors
- Fan

Procedure

13. Use wind from the fan to get the second of 2 motors to move.
14. Switch the wires so that they are connected to the opposite sides of the second motor.
15. Compare different combinations of motors, and compare the results.
16. Which combination of motors worked best?
17. List in your notebook the energy transformations that occurred.



Light to Electricity (To Motion)

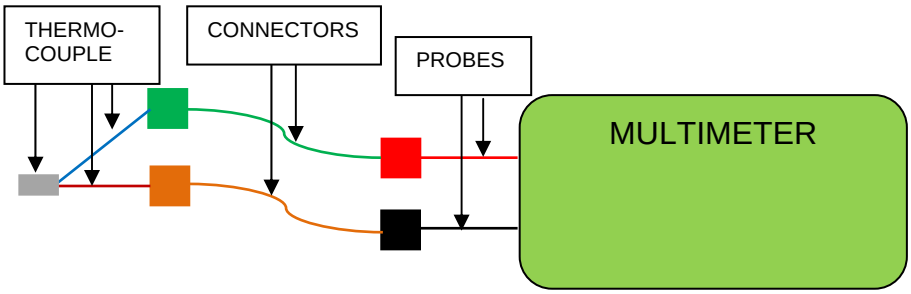
Materials

- Solar Cell
- Either Motor A or B
- 2 Wire Connectors
- Lamp w/ 40-60 W Incandescent Bulb

Procedure

18. Use the lamp to make the motor move.
19. Place the solar cell about 1 inch from the incandescent light bulb.
20. Move the solar cell to a distance of about 6 inches from the light.
21. Move the solar cell to a distance of about 1 foot from the light.
22. Switch the wires so that they are connected to the opposite sides of the motor.
23. List in your notebook the energy transformations that occurred.

Heat to Electricity (DEMO)



Materials

- Multimeter
- Thermocouple
- 2 Wire Connectors
- Lighter

Procedure

24. The instructor will connect the wires of the thermocouple to the wire connectors.
25. The instructor will attach the wire connectors to the probes on the multimeter. *(The multimeter should be set to read in the mV range.)*
26. The instructor will use the lighter to heat the point where the wires of the thermocouple are connected.
27. The instructor and students will record the change in voltage on the multimeter.
28. The instructor will switch the wires so that they are connected to the opposite sides of the thermocouple.
29. What results are you seeing when the thermocouple is heated?
30. Why is this change occurring?
31. Would having thermocouples made of different metals produce different results?

Conclusion

Once the students have completed the five activities, they will return as a group and discuss the different energy transformations they saw, and how they relate to everyday life. Students will also discuss any questions they may still have, and any questions that may have arisen during their investigations. Finally, the students will begin to discuss how different their lives would be without electricity.

STUDENT INSTRUCTIONS

Activity 1

1. Use the battery to get a motor to move.
2. Switch the wires so that they are connected to the opposite sides of the battery.
3. Remove the first motor and repeat the process with a second motor.
4. *Do you get the same results each time? Why or Why Not?*
5. *List in your notebook the energy transformations that occurred.*

Activity 2

6. Observe the energy transformations between the battery and the resistor.
7. Do *not* leave the resistor connected to the battery for long periods of time.
8. Switch the wires so that they are connected to the opposite sides of the battery.
9. *List in your notebook the energy transformations that occurred.*

Activity 3

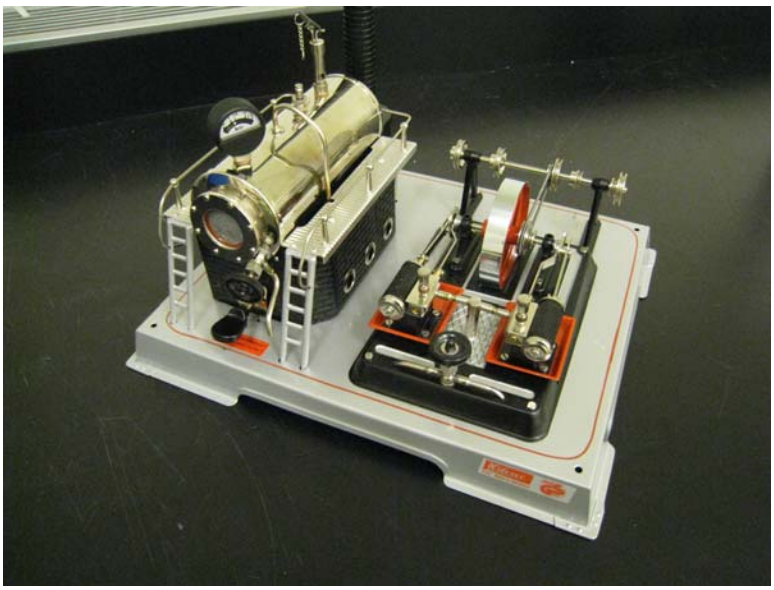
10. Light up the bulb with the battery.
11. Switch the wires so that they are connected to the opposite sides of the battery.
12. *List in your notebook the energy transformations that occurred.*

Activity 4

13. Use wind from the fan to get the second of 2 motors to move.
14. Switch the wires so that they are connected to the opposite sides of the second motor.
15. Compare different combinations of motors.
16. *Which combination of motors worked best?*
17. *List in your notebook the energy transformations that occurred.*

Activity 5

18. Use the lamp to make the motor move.
19. Place the solar cell about 1 inch from the lamp.
20. Move the solar cell to a distance of about 6 inches from the lamp.
21. Move the solar cell to a distance of about 1 foot from the lamp.
22. Switch the wires so that they are connected to the opposite sides of the motor.
23. *List in your notebook the energy transformations that occurred.*



TEACHERS TRAIL GUIDES

Trail Guide Renewable City: 9.1 Energy Transformations

Visit the **Energy City Gallery** on the 6th Floor

Renewable City

What forms of sustainable energy does the city use?

Which form of sustainable energy is most frequently used in the city?

Why are fossil fuels not considered sustainable?

Can the city survive on sustainable energy alone?

Teacher notes:
A sustainable environment should be able to continue without intervention. Would the Smart City be sustainable? If not, what forms of materials and energy would be needed to keep it going? Do you think the output (manufacture of food, water, and air) would produce more energy than the energy required to keep the city running? Note the Law of Conservation of Energy: Energy in a system may take on various forms (e.g. kinetic, potential, heat, light). The law of conservation of energy states that energy may neither be created nor destroyed. Therefore the sum of all the energies in the system is a constant.

Trail Guide Resources Required: 9.1 Energy Transformations

Visit the **Energy City Gallery** on the 6th Floor

Resources Required

Look at some of the products on display in the house.

Which products have the most energy transformations involved in their production?

Which products have the fewest energy transformations involved in their production?

How do these processes affect the planet?

Teachers Notes
Students may be surprised at the number of energy transformations involved in some of the products, such as the t-shirt and soda can. They should notice that the apple grown in Connecticut has significantly fewer energy transformations then the one grown in Washington State. The more energy transformations are involved the less efficient the process is, and the more risk there is for pollution.

Trail Guide A Year's Worth Of Weather: 9.1 Energy Transformations

Visit the **Exploring Space Gallery** on the 5th Floor

A Year's Worth of Weather

Look specifically at the footage of Hurricane Katrina and the Twin Typhoons in the Pacific Ocean

Do you see evidence of wind in the weather events in this display? Where and how do you know there is wind?

List the energy transformations as a hurricane or tropical storm develops, paying particular attention to the Category Level of the storm. The "Category" of a storm increases as the storm gets stronger.

What happens after the storm comes to land?

Where do you think the energy in the storm goes?

Teacher notes:
Wind is evidenced in many ways, including the swirls of clouds and movement/ progression/growth of storms. Students might also indicate evidence from temperature bands in oceans

Trail Guide Goldberg's Machines: 9.1 Energy Transformations

Visit the **Invention Dimension Gallery** on the 5th Floor

Goldberg's Machines

List the energy conversions in each of the three Goldberg Machines.

Where does the energy come from that starts the machine?

Which machine shows the most energy conversions?

What could you add to one machine for it to have more energy conversions?

Teacher Notes:
All machines utilize the transformation of energy to do work. Forms of energy to look for include:

Potential Energy Forms	*Kinetic Energy Forms*
Chemical Energy *Stored Mechanical Energy* *Nuclear Energy* *Gravitational Energy*	*Electrical Energy* *Radiant Energy (light and solar)* *Thermal Energy* *Motion Energy* *Sound Energy*

Trail Guide Circuit Hacks: 9.1 Energy Transformations

Visit the **Invention Dimension Gallery** on the 5th Floor

Circuit Hack

List the energy conversions in each of the circuit stations.

Where does the energy come from that starts the circuits?

Which circuit shows the most energy conversions?

What could you add to one circuit for it to have more energy conversions?

Teacher Notes:
All machines utilize the transformation of energy to do work. Forms of energy to look for include:

Potential Energy Forms	*Kinetic Energy Forms*
Chemical Energy *Stored Mechanical Energy* *Nuclear Energy* *Gravitational Energy*	*Electrical Energy* *Radiant Energy (light and solar)* *Thermal Energy* *Motion Energy* *Sound Energy*

STUDENTS TRAIL GUIDES

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What forms of sustainable energy does the city use?

Which form of sustainable energy is most frequently used in the city?

Why are fossil fuels not considered sustainable?

Can the city survive on sustainable energy alone?

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Resources Required

Look at some of the products on display in the house.

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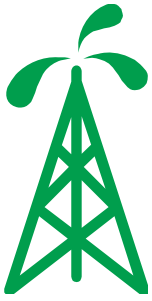
How do these processes affect the planet?



Trail Guide A Year's Worth Of Weather: 9.1 Energy Transformations

Visit the **Exploring Space Gallery** on the 5th Floor

A Year's Worth of Weather

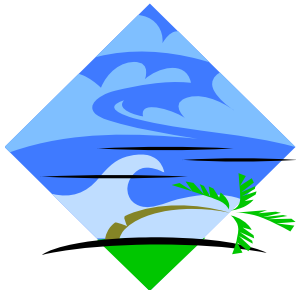
Look specifically at the footage of Hurricane Katrina and the Twin Typhoons in the Pacific Ocean

Do you see evidence of wind in the weather events in this display? Where and how do you know there is wind?

List the energy transformations as a hurricane or tropical storm develops, paying particular attention to the Category Level of the storm. The "Category" of a storm increases as the storm gets stronger.

What happens after the storm comes to land?

Where do you think the energy in the storm goes?



Trail Guide Goldberg's Machines: 9.1 Energy Transformations

Visit the **Invention Dimension Gallery** on the 5th Floor

Goldberg's Machines

List the energy conversions in each of the three Goldberg Machines.

Where does the energy come from that starts the machine?

Which machine shows the most energy conversions?

What could you add to one machine for it to have more energy conversions?

Trail Guide Circuit Hacks: 9.1 Energy Transformations

Visit the **Invention Dimension Gallery** on the 5th Floor

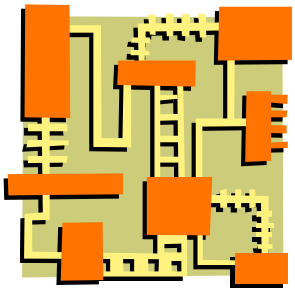
Circuit Hack

List the energy conversions in each of the circuit stations.

Where does the energy come from that starts the circuits?

Which circuit shows the most energy conversions?

What could you add to one circuit for it to have more energy conversions?

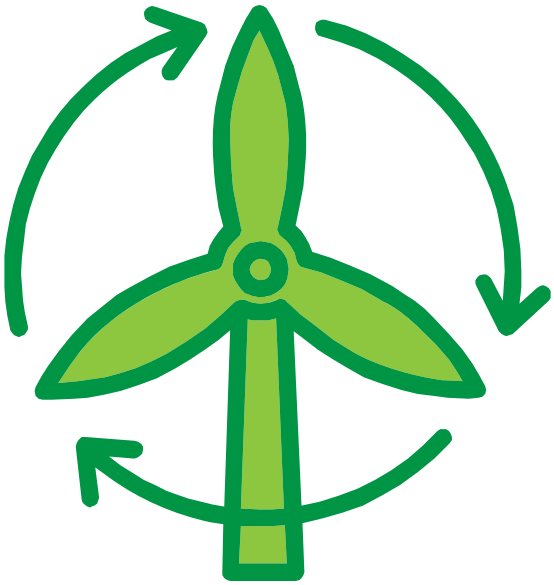


Post Visit Activities

OFFSHORE WINDFARMS IN THE UNITED STATES
This Webquest activity allows students to explore the complicated issues related to siting offshore windfarms.
http://www.web-and-flow.com/members/polson/webquest/webquest.htm

HOW ELECTRICITY IS GENERATED
CT Energy Education's lesson provides two student assignments designed to assist in learning the steps of electric power generation and the energy transformations involved in each of those steps. (This connects to Framework Standard 9.3 Fuel Sources)
http://www.ctenergyeducation.com/lesson.htm?id=s4kht2os

To reinforce the concepts learned in this introduction to energy, we suggest using the NEED Info Sheet "Introduction to Energy" found at
http://www.need.org/needpdf/infobook_activities/SecInfo/IntroS.pdf



Performance Task:

Have students build "Rube Goldberg" machines using whatever equipment and 'junk' you have available. Successful machines might be those which demonstrate the most energy transformations, or those that can accomplish an action (such as raising a box or ball 30 cm. and placing it in a container)

There is a Rube Goldberg Machine Contest – This contest changes annually, look for current contest on the Rube Goldberg home page. (http://www.rubegoldberg.com) The National Challenge for 2007 was to take a whole orange, juice it, and pour the juice from a pitcher into a cup. You and your students can find great inspiration from this link.

Alternative Task:

Have students build a "story board" of a proposed Rube Goldberg machine based on the following scenario.

The Connecticut Science Center has been approached by a wealthy donor who wishes to fund an energy exhibit at the Center. You are a designer and are asked to submit a proposal to the Center.

The donor has very specific requirements for the exhibit.

1. The theme of the exhibit is Energy Transformations
2. The exhibit will be located in the front lobby of the Science Center and can fill an entire 40 foot x 100 foot wall and nearby floor space as needed.
3. The donor is an "energy geek" and would like to demonstrate as many energy transformations as possible with the exhibit.

Potential Energy Forms	Kinetic Energy Forms
Chemical Energy	Electrical Energy
Stored Mechanical Energy	Radiant Energy (light and solar)
Nuclear Energy	Thermal Energy
Gravitational Energy	Motion Energy
	Sound Energy

4. The donor would like to give special recognition to some of the great scientists who researched energy topics and developed energy-related inventions. To meet this goal, the exhibit will feature the following:
   a. At least one falling apple, in recognition of Sir Isaac Newton's work on the Law of Universal Gravitation and his 3 Laws of Motion.
   b. At least one incandescent light bulb, in recognition of Thomas Edison and Lewis Latimer's work in modern lighting
   c. At least one electric motor, in recognition of Michael Faraday's 1821 invention.
   d. At least one demonstration of solar energy, in recognition of Edmond Becquerel's 1839 discovery of the photovoltaic effect.

e. At least one windmill in recognition of Connecticut machinist Daniel Halladay's 1854 invention of a rotating windmill.

5. The ending action of your exhibit machine must be something of interest to Center visitors (examples: folding an information brochure that visitors could take, spitting out a souvenir coin, or other action)

Grading Rubric

Criteria	Self assessment	Peer assessment	Teacher assessment
	Fully met 5 points each Partially met 3 points each Unmet 0 points each		
Has a well designed representation of the proposed energy transformations exhibit			
Clearly marks each step of the energy transformation machine			
Provides a clear written guide to the machine.			
Explains what each step involves			
Explains how energy is transformed on a step by step basis (from what form to what form)			
Gives reasons for choice in each energy transformation element to be used			
Includes at least 1 apple, incandescent bulb, electric motor, solar panel, & windmill			
Demonstrates 7 or more forms of energy			

This checklist is a sample of one way you may assess your students on the performance task.

Have the students trace the energy transformations as they eat, ride a bike, or watch TV. Create a transformation journal of the energy transformations they experienced during the course of a day.

Grades 9-10
Curriculum-Embedded Performance Task
Strand I: Energy Transformations

Solar Cooker

Laboratory Investigation
Teacher Materials

Renewable Energy

Teacher Materials

This curriculum-embedded science performance task is related to the content standards and expected performances for Grades 9-10, as described in the Core Science Curriculum Framework, under Scientific Inquiry, Literacy and Numeracy, Strand I – Energy Transformations.

Targeted Content Standard

9.3 Various sources of energy are used by humans and all have advantages and disadvantages.

Targeted Scientific Inquiry, Literacy and Numeracy Standards

D INQ. 1 Identify questions that can be answered through scientific investigation.

D INQ. 3 Formulate a testable hypothesis and demonstrate logical connections between the scientific concepts guiding the hypothesis and the design of the experiment.

D INQ. 4 Design and conduct appropriate types of scientific investigations to answer different questions.

D INQ. 5 Identify independent and dependent variables, including those that are kept constant and those used as controls.

D INQ. 6 Use appropriate tools and techniques to make observations and gather data.

D INQ. 7 Assess the reliability of the data that was generated in the investigation.

D INQ. 9 Articulate conclusions and explanations based on research data, and assess results based on the design of an investigation.

Learning objective:

Students will be able to use solar energy to heat water and understand the design factors that influence the effectiveness of capturing solar energy in this context.

Listed below are the suggested materials for the laboratory exercise. You may use additional materials if they are available.

Materials:

- heat lamps or sunlight
- tape
- cardboard
- thermometer
- aluminum foil
- water
- containers for water
- colored paper or paint
- safety goggles

Considerations:

Teams of two students are ideal for laboratory work, but circumstances may necessitate teams of three students. Students will need a minimum of 90 minutes to complete this laboratory exercise if you expect their lab reports to be written during class time. You should allow at least 60 minutes of instructional time for the students to design and conduct their experiment and a minimum of 30 minutes for the students to write about their results. As an alternative, the students can write their lab report for homework. These time frames are merely suggestions. Additional time is appropriate if the circumstances and schedule at your school call for it. A sample scoring rubric is provided for your convenience or you may design one of your own.

If the weather is unfavorable and the laboratory exercise must take place indoors, heat lamps can be used as an alternative to sunlight. If your students are unfamiliar with solar cookers, various designs and photographs of solar cookers may be found at these and many other sites:

http://solarcooking.org
http://pbskids.org/zoom/activities/sci/solarcookers.html

The curriculum-embedded task can be integrated into a unit on energy sources and used in any high school physical or Earth science course. The curriculum-embedded task is intended to be used as a formative assessment during the appropriate instructional unit. The Connecticut Academic Performance Test – Generation III will include some open-ended items that will assess scientific inquiry and communication skills in the same context as this task.

Curriculum-Embedded Laboratory Investigation
Scoring Rubric

Statement of Problem and Hypothesis

3 The problem and hypothesis are stated clearly and completely. Clear identification of independent and dependent variables.
2 The problem and hypothesis are stated adequately. Adequate identification of independent and dependent variables.
1 The problem and/or hypothesis are poorly stated. Poor identification of independent and dependent variable.
0 The statement of the problem and/or hypothesis is very limited or missing altogether. No identification of independent and dependent variables.

Experimental Design

3 The experimental design matches the stated problem. Variables are held constant. The procedures are clear, complete and replicable. A control is included when appropriate.
2 The experimental design generally matches the stated problem. Attempt at holding variables constant is made. Procedures are generally complete. Minor modifications or clarifications may be needed.
1 The experimental design matches the stated problem to some extent. Little attempt to hold variables constant. Procedures are incomplete. Major modifications or clarifications may be needed.
0 The experimental design does not match the stated problem, is very incomplete or missing. There is no attempt to hold variables constant.

Data Presentation

3 Data are well organized and presented in an appropriate manner.
2 Data are organized and presented in an appropriate manner. Minor errors or omissions may be present.
1 Data are poorly organized or presented in an inappropriate manner. Major omissions or errors may be present.
0 Data are very poorly organized or presented in an inappropriate manner or missing altogether.

Conclusions

3 Conclusions are fully supported by data and address the hypothesis. Reliability of data and validity of conclusions are thoroughly discussed.
2 Conclusions are generally supported by data and address the hypothesis. Minor errors in interpretation of results may be present. Discussion of reliability of data and validity of conclusions is limited.
1 Conclusions are supported by data and address the hypothesis to a limited extent. Major errors in interpretation of results may be present. There is little discussion of the reliability of the data or validity of conclusions.

0 Conclusions are not supported by data, do not address the hypothesis or are missing. There is no discussion of the reliability of data or validity of conclusions.

Excellent performance	10-12 points
Proficient performance	7-9 points
Marginal performance	4-6 points
Unsatisfactory performance	0-3 points

Student Name:_____ Class:_____

Solar Cooker

Laboratory Investigation
Student Materials

Solar Cooker

Student Materials

Most people in the United States use an electric stove or a natural gas stove to cook their food. This is not the case in much of the world. Approximately 50% of the people on Earth cook using fire from burning wood. However, due to overuse, wood is becoming a scarce commodity in many countries. In addition, burning wood is a major source of air pollution.

One alternative to cooking with wood is using solar cookers. These devices use energy from the sun to cook food without producing any pollution. While there are many designs for solar cookers, a simple solar cooker can be made from everyday materials. There are many factors that can influence the effectiveness of a solar cooker including the size of the collector, the orientation of the panel and the color of the container.

Your Task

You and your lab partner will design and conduct an experiment to investigate one factor that contributes to the effectiveness of a solar cooker in heating water. Factors you may want to investigate include: the shape of the collector, the shape of the water container, orientation of the collector, surface area or color of the container.

You have been provided with the following materials and equipment. It may not be necessary to use all of the equipment that has been provided.

Suggested materials:

heat lamps or sunlight	tape
cardboard	thermometer
aluminum foil	water
container for water	colored paper or paint
safety goggles	

Designing and Conducting Your Experiment

1. In your words, state the problem you are going to investigate. Write a hypothesis using an "If ... then ... because ..." statement that describes what you expect to find and why. Include a clear identification of the independent and dependent variables that will be studied.

2. Design an experiment to solve the problem. Your experimental design should match the statement of the problem and should be clearly described so that someone else could easily replicate your experiment. Include a control if appropriate and state which variables need to be held constant.

3. Review your design with your teacher before you begin your experiment.

4. Conduct your experiment. While conducting your experiment, take notes and organize your data into tables.

Safety note: Students must wear approved safety goggles and follow all safety instructions.

When you have finished, your teacher will give you instructions for cleanup procedures, including proper disposal of all materials.

Communicating Your Findings

Working on your own, summarize your investigation in a laboratory report that includes the following:

- A statement of the problem you investigated. A hypothesis ("If ... then ... because ..." statement) that described what you expected to find and why. Include a clear identification of the independent and dependent variables.

- A description of the experiment you carried out. Your description should be clear and complete enough so that someone could easily replicate your experiment.

- Data from your experiment. Your data should be organized into tables, charts and/or graphs as appropriate.

- Your conclusions from the experiment. Your conclusions should be fully supported by your data and address your hypothesis.

- Discuss the reliability of your data and any factors that contribute to a lack of validity of your conclusions. Also, include ways that your experiment could be improved if you were to do it again.

Teacher Resources

Safety Disclaimer:

The content of this Teacher's Resource section is intended to serve as an educational resource for teachers and students.

Preparing for the safety of yourself and your students is a critical step in planning for any hands-on science- related activities. Prior to conducting any of the activities included in this resource section, please familiarize yourself and your students with any potential hazards, and take the necessary precautions appropriate for each specific activity.

Connecticut Science Center is not responsible for the contents of any books, videos, websites or other resources to which we provide a reference and does not necessarily endorse the opinions, activities, services, products or information expressed within them.

Teacher Background Information

From Science for All Americans,
http://www.project2061.org/publications/sfaa/online/chap4.htm#26

Energy appears in many forms, including radiation, the motion of bodies, excited states of atoms, and strain within and between molecules. All of these forms are in an important sense equivalent, in that one form can change into another. Most of what goes on in the universe—such as the collapsing and exploding of stars, biological growth and decay, the operation of machines and computers—involves one form of energy being transformed into another.

Forms of energy can be described in different ways: Sound energy is chiefly the regular back-and-forth motion of molecules; heat energy is the random motion of molecules; gravitational energy lies in the separation of mutually attracting masses; the energy stored in mechanical strains involves the separation of mutually attracting electric charges. Although the various forms appear very different, each can be measured in a way that makes it possible to keep track of how much of one form is converted into another. Whenever the amount of energy in one place or form diminishes, the amount in another place or form increases by an equivalent amount. Thus, if no energy leaks in or out across the boundaries of a system, the total energy of all the different forms in the system will not change, no matter what kinds of gradual or violent changes actually occur within the system.

But energy does tend to leak across boundaries. In particular, transformations of energy usually result in producing some energy in the form of heat, which leaks away by radiation or conduction (such as from engines, electrical wires, hot-water tanks, our bodies, and stereo systems). Further, when heat is conducted or radiated into a fluid,

currents are set up that usually enhance the transfer of heat. Although materials that conduct or radiate heat very poorly can be used to reduce heat loss, it can never be prevented completely.

Therefore the total amount of energy available for transformation is almost always decreasing. For example, almost all of the energy stored in the molecules of gasoline used during an automobile trip goes, by way of friction and exhaust, into producing a slightly warmer car, road, and air. But even if such diffused energy is prevented from leaking away, it tends to distribute itself evenly and thus may no longer be useful to us. This is because energy can accomplish transformations only when it is concentrated more in some places than in others (such as in falling water, in high-energy molecules in fuels and food, in unstable nuclei, and in radiation from the intensely hot sun). When energy is transformed into heat energy that diffuses all over, further transformations are less likely.

The reason that heat tends always to diffuse from warmer places to cooler places is a matter of probability. Heat energy in a material consists of the disordered motions of its perpetually colliding atoms or molecules. As very large numbers of atoms or molecules in one region of a material repeatedly and randomly collide with those of a neighboring region, there are far more ways in which their energy of random motion can end up shared about equally throughout both regions than there are ways in which it can end up more concentrated in one region. The disordered sharing of heat energy all over is therefore far more likely to occur than any more orderly concentration of heat energy in any one place. More generally, in any interactions of atoms or molecules, the statistical odds are that they will end up in more disorder than they began with.

A discussion of Energy Sources, from *Science for All Americans*,
http://www.project2061.org/publications/sfaa/online/chap8.htm#14

Energy Sources

Industry, transportation, urban development, agriculture, and most other human activities are closely tied to the amount and kind of energy available. Energy is required for technological processes: taking apart, putting together, moving around, communicating, and getting raw materials, and then working them and recycling them.

Different sources of energy and ways of using them have different costs, implications, and risks. Some of the resources—direct sunlight, wind, and water—will continue to be available indefinitely. Plant fuels—wood and grasses—are self renewing, but only at a limited rate and only if we plant as much as we harvest. Fuels already accumulated in the earth—coal, oil and natural gas, and uranium—will become more difficult to obtain as the most readily available sources run out. When scarcity threatens, new technology may make it possible to use the remaining sources better by digging deeper, processing lower concentration ores, or mining the ocean bed. Just when they will run out completely, however, is difficult to predict. The ultimate limit may be prohibitive cost rather than complete disappearance—a question of when the energy

required to obtain the resources becomes greater than the energy those resources will provide.

Sunlight is the ultimate source of most of the energy we use. It becomes available to us in several ways: The energy of sunlight is captured directly in plants, and it heats the air, land, and water to cause wind and rain. But the flux of energy is fairly weak, and large collection systems are necessary to concentrate energy for most technological uses: Hydroelectric energy technology uses rainwater concentrated in rivers by runoff from vast land areas; windmills use the flow of air produced by the heating of large land and ocean surfaces; and electricity generated from wind power and directly from sunlight falling on light-sensitive surfaces requires very large collection systems. Small-scale energy production for household use can be achieved in part by using windmills and direct solar heating, but cost-efficient technology for the large-scale use of windmills and solar heating has not yet been developed.

For much of history, burning wood was the most common source of intense energy for cooking, for heating dwellings, and for running machines. Most of the energy used today is derived from burning fossil fuels, which have stored sunlight energy that plants collected over millions of years. Coal was the most widely used fossil fuel until recently. But in the last century, oil and its associated natural gas have become preferred because of their ease of collection, multiple uses in industry, and ability to be concentrated into a readily portable source of energy for vehicles such as cars, trucks, trains, and airplanes. All burning of fossil fuels, unfortunately, dumps into the atmosphere waste products that may threaten health and life; the mining of coal underground is extremely hazardous to the health and safety of miners, and can leave the earth scarred; and oil spills can endanger marine life. Returning to the burning of wood is not a satisfactory alternative, for that too adds so-called greenhouse gases to the atmosphere; and overcutting trees for fuel depletes the forests needed to maintain healthy ecosystems both locally and worldwide.

But there are other sources of energy. One is the fission of the nuclei of heavy elements, which—compared to the burning of fossil fuels—releases an immense quantity of energy in relation to the mass of material used. In nuclear reactors, the energy generated is used mostly to boil water into steam, which drives electric generators. The required uranium is in large, although ultimately limited, supply. The waste products of fission, however, are highly radioactive and remain so for thousands of years. The technical problem of reasonably safe disposal of these fission products is compounded by public fear of radioactivity and worry about the sabotage of nuclear power plants and the theft of nuclear materials to make weapons. Controlled nuclear fusion reactions are a potentially much greater source of energy, but the technology has not yet proved feasible. Fusion reactions would use fuel materials that are safer in themselves, although there would still be a problem of disposing of worn-out construction materials made radioactive by the process. And as always with new technology, there may be some unanticipated risks.

Professional Development

Come be a student for two days. Prior to bringing your class to the CT Science Center, you are encouraged to spend time at the Center and explore the exhibits and programs available to you and your students by participating in our two day Field Trip Professional Development Workshop.

During these two days, you will have an opportunity to explore the Invention Dimension Gallery and Exploring Space Gallery and other relevant galleries using our standards based Trail Guides. These guides will lead you and your students on the pathway toward enjoying the museum while maintaining focus on your grade level or content standard.

You will also have the opportunity to participate as a learner in the pre visit, visit and post visit activities provided by the CT Science Center. In addition, you will participate in an Embedded Task aligned with content standard 9.1. Afterward, you will process the various activities and discuss their applications in your classroom and in your students' learning.

Interdisciplinary Extensions

Political Science and Social Studies
Investigate how electricity is made in your state. What are the most efficient methods?

Write letters to government leaders in support of the most efficient methods of energy transformation to produce electricity.

Check on the Connecticut Legislative website www.cga.ct.gov for Energy related legislation. http://www.cga.ct.gov/asp/CGABillInfo/CGABillInfoRequest.asp allows you to search for key words. Follow a bill of interest through the legislative session (usually January- early May) Talk with your elected senator/representative and invite them to your class to discuss pending legislation and the process to enact a bill.

Social Studies and History (adapted from www.ctenergyeducation.com lesson Introduction to Energy Use)
Ask students to think about getting their family together for a holiday dinner (or traveling 50 miles or more to see a family member) Think about energy transformations as you answer the following questions:

1. How does your family travel? How long does it take? What equipment, fuel, and resources are needed? Describe the public infrastructure that exists to support travel. What food is on the table? (turkey? burgers? pasta? rice? fruit and vegetables?) Where did the food originate? How was it delivered to their community? How did they get it from the market to their home? How was the food processed before it came to the home? How was the food prepared and stored in the home?
2. If this same dinner were held in 1850, 1890, 1920, or 1950, how would the answers change? What issues were probably raised when the internal combustion engine first replaced the horse and buggy (for example, noise, smell, danger, health, refueling)? How have transportation options changed the kinds of foods that are available to Americans over the years? How did the community and the country change to accommodate new forms of transportation? How has electricity in the home changed how the meal is prepared or stored?
3. If this same dinner were held in 2020 or 2050, what kinds of changes would the students expect to see?

Mathematics
Visit The Franklin Institute's Blow, Wind Blow at http://sln.fi.edu/school/math/wind.html for seven wind-related mathematics word problems. (Designed for middle grades, this is a good review of basic skills for high school students, using wind as a theme.)

Mathematics and video, ties around Algebra in the Real World—a lesson in the mathematics of wind energy can be found at
http://www.thefutureschannel.com/dockets/algebra/electricity_from_the_wind/index.php
Language Arts

Clean Energy In Connecticut (adapted from www.ctenergyeducation.com lesson Writing Across the Disciplines)
Connecticut customers of the public electric utilities have a new option to buy renewable-source energy. As of fall 2005, more than 3000 customers have chosen these new options. Many towns in Connecticut have taken up the challenge to get 20 % of their electricity from renewable energy sources by the year 2010 ~ the ***20% by 2010 Campaign.***

Clean Energy In Connecticut: A CAPT writing option:
What are the Clean Energy Options for CT?(Visit http://www.ctcleanenergyoptions.com)
Is your town a member of the 20% by 2010 Campaign? Is your town a Clean Energy Community? Visit http://ctinnovations.com/communities and select your town to see this information.

Write to the following prompt:
Your town has decided to join the 20% by 2010 Campaign. Your job as the city engineer is to write a short essay to be included in a brochure that will be mailed to all residents to persuade them to purchase renewable electrical energy from Connecticut's Clean Energy Options.

When you write your paper, remember to do the following
- State the town's position
- Support - Did you support your position with accurate information from all the source materials?
- Be persuasive – include details that your reader will find persuasive, and
- Be concise - Since brochures are concise, be sure to organize your ideas well and present them clearly.
- Be organized – Stay focused

Extensions
- Marketing for Clean Energy – After learning about Connecticut's Clean Energy Options, discuss and design ways that students can promote Clean Energy in their homes, their school and their town. Marketing campaigns might include producing the brochure from the writing prompt, surveys, posters, flyers, advertisements, talking with administrators and town officials, and letters to the editor.
- Clean Energy Communities – Learn how you can turn your town into a Clean Energy Community. Visit http://ctinnovations.com/communities and select your town
- Learn More about Renewable Energy – US Environmental Protection Agency http://www.epa.gov/greenpower/ and The US Energy Information Administration http://www.eia.doe.gov/fuelrenewable.html and http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=CT offer information about renewable power and energy use in Connecticut.

Websites for Teachers

The Connecticut Wind Resource Map. This is a printable map from the US Department of Energy's Energy Efficiency and Renewable Energy Office. The home site also includes great resources and information about wind and other renewable energy sources.

Home site: http://www.eere.energy.gov

Connecticut Wind map at:
http://www.eere.energy.gov/windandhydro/windpoweringamerica/maps_template.asp?stateab=ct

KidWind Project at www.kidwind.org has a great listing of wind curriculum resources. This site includes free directions to build turbines, lesson plans, links to other sites, and a store with kits and materials.

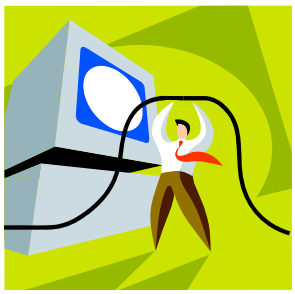
Wind with Miller http://www.windpower.org/en/kids/index.htm Education materials created by the Danish Wind Energy Association. Very thorough with web interactivity.

US Department of Energy's Energy Information Administration at
http://www.eia.doe.gov/kids/classactivities/teachers&students.html
A number of links for energy topics, including: Energy Analysis *(pdf)*- using energy graphs and data; Distributed Energy *(pdf)* - article; Oil Market Basics - teacher's guide*(pdf)*, webquest quiz*(pdf)* and answer key*(pdf)*; New Biomass Technologies *(pdf)*; Energy on Ice - Methane Hydrates *(html) - adapted from the NEED Project* ; Carbon Sequestration *(html)*; New Technologies - three short articles*(pdf)*; Controlling Hurricanes*(pdf)*; WIPP - Waste Isolation Pilot Project *(pdf)*; The Blackout of 2003 *(pdf)*; Gamma Ray Bursts *(pdf)*; Offshore Wind Energy, The Solar Sailor, and Marine Life on Offshore Rigs *(all in one pdf)*; Secondary School Energy Survey *(pdf)*; Drilling a Well Today *(pdf)*; Glow-in-the-Dark Toys *(pdf)*; Measuring Electricity *(pdf)*; Underwater Oil Recovery *(pdf)*, and careers information.

National Energy Education Development (NEED) at www.need.org has lessons on energy and wind (http://need.org/needpdf/ExploringWindTeacher.pdf) (http://need.org/needpdf/ExploringWindStudent.pdf for the 40 page student guide which has great background and activities) as well as a number of Energy Info sheets at various reading and interest levels (elementary to secondary)

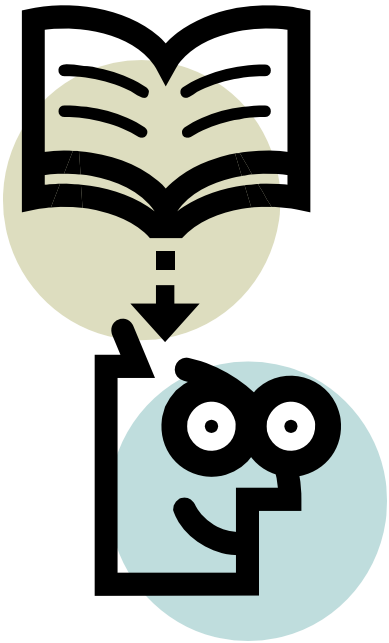
Connecticut Clean Energy Fund

For programs to increase awareness of clean energy:
http://www.ctcleanenergy.com/EducationalPrograms/tabid/61/Default.aspx



Literature Links

The KidWind website lists a number of books for students and readers of all ages and interests. They also sell some books.
http://www.kidwind.org/bibliography.html



Videos

Futures Channel Video - Wind Farming

http://www.thefutureschannel.com/dockets/science_technology/wind_farming
A five minute video on the installation of a wind farm in NY. Good overview of the process involved in the installation. Good intro for students.

Energy Transfer and a Trebuchet

http://www.teachersdomain.org/resources/hew06/sci/phys/maf/trebuchet/index.html
Teacher's Domain's 4:17, 11.8 MB video segment adapted from *NOVA*, a team of historians, engineers, and trade experts recreate a medieval throwing machine called a trebuchet. To launch a projectile, a trebuchet utilizes the transfer of gravitational potential energy into kinetic energy.

Home and School Connections

In Connecticut we have choices of our electric energy provider. Investigate the Choose An Electric Supplier tab on http://www.ctcleanenergy.com/ to learn what different companies are available to supply electricity in Connecticut. Community Energy (http://www.newwindenergy.com/) and Sterling Planet (http://www.sterlingplanet.com/state/Connecticut/) use a combination of energy production that includes wind power.

Visit http://www.ctinnovations.com/communities/ to see how many customers in your town participate in Clean Energy Options and to learn how your town can earn a free photovoltaic array.

What is the source of your family's electricity? After reading about the Connecticut Clean Energy Options, write a factual proposal to your family about the choices available, their costs and benefits.

Career Information

ENERGY JOBS
Have the students' interview school district personnel who work with energy use in the school. (fiscal department, maintenance staff) What decisions are made, how do they affect the students and their families, and what jobs are there in this field?

How is energy efficiency determined in the systems used in the school or district? What fuels are used and how are they chosen or purchased?

What could students do to help make these jobs easier and more effective in the school?

Ask students to research and report on an energy career that interests them. Use the resources at the following sites for information.

NEED (National Energy Education Development) features Career Currents, monthy pdf's with energy career information, features on energy workers, and other job information. Visit http://www.need.org/newsletters.php for an index of past issues. Energy Efficiency and Renewable Energy (www.eere.energy.gov) features energy careers at http://www1.eere.energy.gov/education/careers.html#career.

Student Resources

Safety Disclaimer:

The content of this Student's Resource section is intended to serve as an educational resource for students.

Preparing for the safety of yourself is a critical step in planning for any hands-on science- related activities. Prior to conducting any of the activities included in this resource section, please familiarize yourself with any potential hazards, and take the necessary precautions appropriate for each specific activity.

Connecticut Science Center is not responsible for the contents of any books, videos, websites or other resources to which we provide a reference and does not necessarily endorse the opinions, activities, services, products or information expressed within them.

Websites for Students

How Stuff Works has an extensive interactive article on How Wind Power Works at http://science.howstuffworks.com/wind-power5.htm
This includes: Introduction to How Wind Power Works; Parts of a Wind Turbine; Modern Wind-power Technology; Turbine Aerodynamics; Calculating Power; Wind-power Resources and Economics; Wind Power Usage in the U.S.; Wind Farms; and Government Incentives. Their article on How Electric Generators Work is at http://science.howstuffworks.com/electricity2.htm

The NEED Project's Exploring Wind Lesson guide for students has a great 40 page explanation of wind energy, along with some great activities at http://need.org/needpdf/ExploringWindStudent.pdf

http://www.quiz-tree.com/Energy_main.html
Features several online energy quizzes. Test your energy knowledge!

Learn more about the important people in the history of energy http://www.eia.doe.gov/kids/history/people/pioneers.html offers biographies of energy pioneers.

NEED (National Energy Education Development) features Career Currents, monthly pdf's with energy career information, features on energy workers, and other job information. Visit http://www.need.org/newsletters.php for an index of past issues.

Visit the energy web games at http://www.exxonmobil.no/Norway-English/PA/energy_energygames.aspx Select English (this is a bilingual site English is found by clicking the British flag!) As you play the games, note that the site is hosted by

Exxon Mobil, one of the world's largest oil companies. Do you find any bias in the games as you play them?

Try the Energy Flows game at http://www.sciencemuseum.org.uk/onlinestuff/games/energy_flows.aspx, from South Kensington, England's Science Museum.

Connecticut Clean Energy Fund

For programs to increase awareness of clean energy:
http://www.ctcleanenergy.com/EducationalPrograms/tabid/61/Default.aspx