The Pennsylvania Department of Education’s Office of Environment and Ecology, Northeast Sustainable energy Association, Sustainable Development Fund and a core of Pennsylvania teachers developed a curriculum to be used in Grades Five through Eight.

This curriculum examines the environmental and scientific concepts of energy sources, forms, transformations, efficiency and heat transfer. Students experiment with electric generators powered by wind, water and light. They also conduct tests heating model buildings with different types of insulation (thermal and radiant barriers) and sealing leaks.

By applying system concepts of goals, inputs, processes, outputs and feedback, students propose energy improvements at home and compose an action plan at school that could, if implemented, reduce the unwanted side effects of the school’s current energy use.

Construction guides for instructors to development classroom experiments and energy demonstrations is included in each unit. Assessment rubrics and expected student responses to worksheet and classroom activities are supplies as well.

A CDROM was developed for the curriculum by GreenTrex that introduces the alternate energy concepts and then looks at real life examples of each type of alternate energy and how it is being used in Pennsylvania.

An Energy Thinking Kit has been developed and can be borrowed from several environmental sites across the state. Kits can also be purchased at Science Kit and Boreal Laboratories.

To obtain a copy of the Energy Thinking Curriculum Guide and CDROM please return the form below to Patricia Vathis, Environment and Ecology Curriculum Advisor, Division of Curriculum and Standards, 333 market Street, 8th Floor, Harrisburg, PA 17126, pvathis@state.pa.us.

Energy Thinking Curriculum

Name: ______________________________________________________

Address:  ___________________________________________________

_________________________________________________________________

School District: ____________________________
Title: Warm and Cozy – Activity 4 from the Energy Thinking Curriculum

Introduction

Many people would agree that a warm home and hot water are two of the most treasured luxuries of modern living. A warm home and hot water provide comfort, help us to stay healthy, and give us freedom from wearing bulky winter clothes inside even during the winter.

This is the ideal, but many buildings are not quite this cozy. Some are drafty and others so overheated people open windows in the winter to cool down. Others use excessive amounts of fuel to provide the proper temperature. Only 20% of buildings built before 1980 are well insulated and most buildings build today are not built to the highest insulation levels. This results in reduced comfort and occupants and increased use of fuel.

Standard Areas (Environment and Ecology, Geography, etc…)

- Environment and Ecology
- Science and Technology

Standard Statements

**Environment and Ecology**

4.2.7.A Know that raw materials come from natural resources.
4.2.7.B Examine the renewability of resources.
4.2.7.C Explain natural resource distribution.
4.3.7.A Identify environmental health issues.
4.3.7.B Describe how human actions affect the health of the environment.
4.8.7.A Describe how the development of civilization relates to the environment.
3.1.7.A Explain the parts of a simple system and their relationship to each other.
3.1.7.B Describe the use of models as an application of scientific or technological concepts.
3.1.7.E Identify change as a variable in describing natural and physical systems.
3.2.7.A Explain and apply scientific and technological knowledge.
3.2.7.D Know and use the technological design process to solve problems.
3.4.7.B Relate energy sources and transfers to heat and temperature.
3.5.7.B Recognize earth resources and how they affect everyday life.
3.8.7.A Explain how sciences and technologies are limited in their effects and influences on society.
3.8.7.B Explain how human ingenuity and technological resources satisfy specific human needs and improve the quality of life.
3.8.7.C Identify the pros and cons of applying technological and scientific solutions to address problems and the effect upon society.

**Assessment Anchors for Science, Technology and Environment and Ecology**

<table>
<thead>
<tr>
<th>S8.A.1.2</th>
<th>Identify and explain the impacts of applying scientific, environmental, or technological knowledge to address solutions to practical problems.</th>
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<tbody>
<tr>
<td>S8.A.1.3</td>
<td>Identify evidence that certain variables may have caused measurable changes in natural or human-made systems.</td>
</tr>
<tr>
<td>S8.A.2.1</td>
<td>Apply knowledge of scientific investigation or technological design in different contexts to make inferences to solve problems.</td>
</tr>
<tr>
<td>S8.A.3.1</td>
<td>Explain the parts of a simple system, their roles, and their relationships to the system as a whole.</td>
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<tr>
<td>S8.A.3.2</td>
<td>Apply knowledge of models to make predictions, draw inferences, or explain technological concepts.</td>
</tr>
<tr>
<td>S8B.3.3</td>
<td>Explain how renewable and non-renewable resources provide for human needs or how these needs impact the environment.</td>
</tr>
<tr>
<td>S8D.1.2</td>
<td>Describe the potential impact of human made processes on change to Earth’s resources and how they affect everyday life.</td>
</tr>
<tr>
<td>S8D.1.3</td>
<td>Describe characteristic features of Earth’s water systems or their impact on resources.</td>
</tr>
<tr>
<td>Content Indicators</td>
<td>Process Indicators</td>
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<tr>
<td><strong>Students will know:</strong></td>
<td><strong>Students will be able to:</strong></td>
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<tr>
<td>• Identify which natural resources are used in Pennsylvania for home heat and hot water and which of these resources are available in Pennsylvania.</td>
<td>• perform three simple scientific explorations to identify conductive, convective, and radiant heat transfer and ways to slow down each</td>
</tr>
<tr>
<td>• Diagram how the sun is the ultimate source of energy in most non-renewable and renewable energy resources.</td>
<td>• run controlled heat transfer experiments on model buildings with varying types of insulation</td>
</tr>
<tr>
<td>• Propose renewable energy resources that can be used for home heat and hot water that could, if used to replace current energy resources, reduce waste, pollution, environmental impacts, and depletion of nonrenewable resources.</td>
<td>• graph and interpret data from controlled experiments to reveal effects of conduction, convection, and radiation on the loss</td>
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<tr>
<td>• Propose human actions regarding home heat and hot water that can reduce waste, pollution, environmental impacts, and depletion of nonrenewable resources.</td>
<td>• use readings and energy information cards to</td>
</tr>
<tr>
<td>• Apply the fundamental scientific concepts of heat transfer (conduction, convection, and radiation) to solve the practical problem of reducing unwanted heat loss or gain in a building or heat loss from a hot water tank.</td>
<td>a) identify renewable and non-renewable energy resources used for heat and hot water in Pennsylvania</td>
</tr>
<tr>
<td>• Predict the effects of changing insulation variables on the comfort level in buildings.</td>
<td>b) outline processes of extracting and delivering energy resources to homes</td>
</tr>
<tr>
<td>• Propose economic and environmental benefits of a well-insulated home.</td>
<td>c) estimate which energy processes lose the most and least amounts of useful energy</td>
</tr>
<tr>
<td>• Describe how energy transformations reduce the amount of useful energy available and how these losses are additive for chains of energy transformations.</td>
<td>d) identify and prioritize unwanted outputs of energy use</td>
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<td></td>
<td>• propose bolas for home heat and hot water that include topics important to the student – such as safety, human health, environmental friendliness, or economics</td>
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<tr>
<td></td>
<td>• conduct a home energy investigation and recommend actions to increase home comfort levels and reduce unwanted outputs of energy use.</td>
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</table>
**Assessment**

**Summative Assessment for the Unit**
Performance assessment of written response and classroom activities.

**Instructional Strategies**
- Group discussion
- Data collection
- Data analysis
- Develop criteria
- Compare/contrast

**Estimated Time**
Four class periods plus homework

**Materials**
For details, see Materials in each of the Preparation Sections as you move through the different hands-on activities in this lesson plan. This is a comprehensive list. (A kit has been developed by the Department of Education’s Office of Environment and Ecology and can be purchased through S&S Laboratories. Some kits are currently with facilitators across the State and may be borrowed by teachers. For a list go to [www.pa3e.ws](http://www.pa3e.ws) and click on alternate energy kits.)

- Juice box for model houses (construction instructions included in lesson)
- 10 oz plastic bottles
- Large hot-drink cups
- Bi-thermo thermometers
- Source of boiling water funnel
- Funnel
- Corks, metal hunger and wax for conduction test
- Table lamps
- Black construction paper
- Aluminum foil
- Draft-O-Meters
- Winterization products
- Energy information cards
- Student handouts
Vocabulary Words with Meanings

Renewable Energy – options for home heat and hot water in Pennsylvania re primarily wood and solar energy. Wood can be burned I chunk or pellet wood stoves or furnaces and solar energy can be captured through solar hot water panels and with well-designed south facing homes.

For Pennsylvania homes with electric heat or hot water, homeowners can choose to buy electricity certified to come from high percentages of renewable sources. (For more information, go to the Pennsylvania Office of Consumer Advocate website: www.oca.state.pa.us/Industry/Electric/elecomp/pricecharts.html.)

No mater what energy source it comes from, energy used to heat an indoor living space or hot water in a tank is wasted if it is allowed to dissipate easily to the outdoor environment. The easier that heat is transferred from inside to outside the building or from inside to outside a hot water tank, the more energy will be needed to keep the building warm and the water hot. Very often, this results in buildings using larger furnaces and more energy than would otherwise be needed.

Heat is transferred through three means: conduction, convection, and radiation. Understanding these three means of heat transfer enables us to analyze how well a building or hot water tank retains heat, or how well a building keeps heat out when it is being cooled.

Conduction – is the transfer of heat between objects in direct physical contact. Most conduction occurs in solids. The atoms and molecules that make up a solid cannot move out of a fixed position, but they can increase their rate of vibration and thus their thermal energy. This increased rate of vibration propagates out in all directions from the heat source and transfers the thermal (heat) energy through the solid. In a building, heat is transferred by conduction to the outside through materials that make up the walls, roof, and basement floor. Thermal insulation, such as fiberglass, blown in cellulose, and foam panels slow down the speed of heat transfer by conduction. A Styrofoam coffee cup does the same thing.

Convection – is the transfer of heat by the movement of gases or liquids due to density differences that result from temperature differences in the gas or liquid. In this case, the gas or liquid physically moves to a new location and takes the heat energy with it. This happens because a heated gas or liquid expands and becomes less dense than similar but cooler gases or liquids. This difference in density between hot and cold portions of the gas or liquid dictates that a flow develops between regions of different temperatures. This leads to the saying, “Hot air rises.” Mistakenly, this saying is sometimes shortened to “Heat rises,” which is not true. Heat energy, through conduction and radiation, propagates in all directions. But hot air does rise and cold air does fall relative to each other.
Buildings will be surprisingly leaky unless thought and planning go into sealing leaks around doors and windows, cracks in construction, and holes where plumbing and other items go through walls, ceilings, and roofs. Heat can be transferred by convection to the outside when the inside air is warmer than the outside air. This warmer air, being less dense than the cooler outside air, will flow up and out through cracks in the walls, roof, open chimneys, or out open windows, and draw colder air in through other cracks and openings such as in the basement.

In the case of cooling a building, all of this reversed. Heat can be transferred by convection into a building when the outside air is warmer than the inside air. In this case, the cooler inside air, being more dense then hotter outdoor air, will leak out through cracks in the walls, basement floor, or out open windows, and draw hot air in through other cracks and openings such as in the attic.

Because of this, opening windows to cool a building in hot weather can instead make the building hotter. If the cooler inside air is allowed to fall out open windows, it will pull warmer air from outside into the building. If this air comes into the building through a hot attic, it will increase the temperature in the building even more.

Sealing cracks in walls, around windows and doors, and holes between floors of a building slows down heat transfer by convection.

**Radiation** – transfers heat between two or more bodies through electromagnetic waves. This can happen even in a vacuum; the sun transfers heat to earth by radiation. Most of the time, heat is transferred as infrared radiation. Objects that are warmer than “red hot” transfer heat as visible light.

All objects radiate heat energy to and absorb radiant heat energy from objects around them. The net effect is that a warmer object transfers more energy to a cooler object than the other way around. When a person stands in front of a warm wood stove, they radiate heat energy to the stove, but the stove radiates far more heat energy to the person. The net effect is that the person gets warmer. If the person were to stand in front of a frosty cold plate glass window the opposite would be true – the person would radiate more heat to the window then they receive and the person would feel cold.

In buildings, the most obvious example of radiant heat transfer is bright sunlight shining in a window. But the building itself is constantly radiating some heat energy to its surroundings, and many windows easily allow radiant heat energy to pass through – in both directions. Newer energy efficient windows reduce the amount of infrared energy that passes through. Whether the building is gaining or losing heat energy depends on many factors, including the inside and outdoors temperatures, the type of windows, the color of the house, and whether the sun is shining on the building.
**Additional Background Information and Resources**

Energy audit lesson plans and information of home energy use – Alliance to Save Energy – [www.ase.org](http://www.ase.org)


Energy Efficiency Standards – Appliance Standards Awareness Project – [www.standardsasap.org](http://www.standardsasap.org)
Preparation

☐ If you have not already done so, prepare a letter home to alert parents of the home activities. See the Sample Letter Home following page 1.10 in Chapter 1.

For Warm and Cozy—Station Activities

Stations 1 and 2
An extra level of preparation is required the first year these activities are run in class. Eight “model houses” made from milk-carton type juice boxes, each with different combinations of insulation, will need to be constructed. Once made, these will be usable for many years. See the Model House Construction Instructions with the instructor information sheets following page 4.22.

☐ For each station, set out the model buildings as described in Table 4.1.

☐ Place a copy of Information Sheet 4.2: Stations 1 and 2 Instructions with each model building.

☐ Cut out and place with each model building the short story that goes with it. These are found on pages 2 and 3 of Student Worksheets 4.3 and 4.4.

☐ Place the hot-water bottles inside the foam cups and prepare the boiling water. Have the funnel available.

☐ Have available for each student Worksheet 4.1: Systems Thinking—Heating a Building. Students will use this handout for Stations 1 and 2.

Materials

- Eight “model houses” made from ½ gallon milk-carton type juice boxes
- Eight 10 oz plastic bottles (Use bottles made out of number 2 [HDPE] or number 7 [other] recyclable plastic. These are milky or foggy in appearance. Do not use clear plastic bottles made from number 1 [PETE] recyclable plastic. These will shrink when filled with near-boiling water.)
- Eight large foam hot drink cups
- Eight bi-therm thermometers (Meat thermometers with a range of at least 60 to 140°Fahrenheit work well)
- Eight props, 16 to 17 cm tall
- Source of boiling water such as an electric tea-pot
- Funnel
- Student handouts and short stories

At Station 1

☐ Have available for each student page 1 of Worksheet 4.3: Data Sheet for Station 1: Improving the Leaky Un-Insulated House.

At Station 2

☐ Have available for each student page 1 of Worksheet 4.4: Data Sheet for Station 1: Making the Best the BEST.

Table 4.1 Combinations of insulation techniques for test setups at Stations 1 and 2.

<table>
<thead>
<tr>
<th>Station 1</th>
<th>Station 2</th>
</tr>
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<tbody>
<tr>
<td>• no insulation</td>
<td>• insulated</td>
</tr>
<tr>
<td>• air leaks</td>
<td>• air leaks</td>
</tr>
<tr>
<td>• non-reflective interior</td>
<td>• non-reflective interior</td>
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<tr>
<td></td>
<td>• sealed</td>
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<td></td>
<td>• non-reflective interior</td>
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<td></td>
<td>• reflective interior</td>
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<td></td>
<td>• insulated</td>
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<td></td>
<td>• air leaks</td>
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<td>• reflective interior</td>
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<td>• insulated</td>
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<tr>
<td></td>
<td>• sealed</td>
</tr>
<tr>
<td></td>
<td>• non-reflective interior</td>
</tr>
</tbody>
</table>
For Station 3

Most of the props needed for the conduction, convection, and radiation activities made the first year will be usable for subsequent years as well. See the Teacher Information sheet: Station 3 Props Construction Instructions following page 4.22.

- Make a copy of Worksheet 4.5: Station 3 Notes for each student.

Conduction

- Drip wax drops onto the wire rods of the six conduction test props, as shown in the figure to the right, leaving room for a candle flame to reach the long wire rod near the cork. (See Teacher Information handout following page 4.22 on how to construct the conduction test props.)

Convection

- With masking tape, hang the spirals from the ceiling away from drafts or wind currents.

Note: You may wish to make a copy of the spiral handout for each student to decorate and hang around the classroom.

Radiation

- Gather materials and make sure the thumb-less “mittens” are in good shape.

Materials

**Conduction**
- Six conduction test props (See the Teacher Information sheet: Station 3 Props Construction Instructions following page 4.22.)
- Candle in holder
- Matches or lighter

![Figure 4.1: Conduction test prop (See handout following page 4.22 for construction instructions.)](Diagram)

**Convection**
- Paper spiral (see Teacher Information sheet: Station 3 Props Construction Instructions following page 4.22.)
- Masking tape
- Table lamp with incandescent bulb

**Radiation**
- Two table lamps with 60-watt incandescent bulbs
- 6 black construction paper thumb-less mittens
- 6 aluminum foil thumb-less mittens
For Warm and Cozy—Energy Thinking

- Review Student Worksheets 1.1, *Energy Around Us*, handed in during Chapter 1 activities and pull out any that pertain to space heat and hot water.
- Gather a selection of winterization products to show to students. Hardware or building supply stores probably have free samples and "how-to" pamphlets with pictures that you can show your class.
- Collect materials needed to make Draft-O-Meters. (See Student Worksheet 4.9, *Build a Draft-o-Meter.*)
- Make copies of handouts 4.7 – 4.10.

**Materials**
- Enlarged copy of the *Energy Thinker’s Diagram* from Chapter 1
- Selection of weather-stripping, caulk, insulation, and other home winterization products
- Materials for Draft-O-Meter (roll of plastic wrap, tape, pencils)

**Per team**

**Per student**
- Worksheets 4.7 – 4.10
Doing the Activity

Part I—Station Activities

The nature of exploring heat transfer dictates a need to use items that are hot, such as candle flames, hot plates, light bulbs, and boiling water. Although many students could reasonably handle most of the hot items used in this lesson, the activities here are presented with the teacher in control of the hot objects to ensure a safe classroom.

For these activities, students work in three groups that rotate through three stations. Because of the need for an adult to handle hot objects, an adult will need to spend a few minutes at Stations 1 and 2 and most of their time at Station 3. For expediency, it would be advantageous to have two adults in the classroom to implement this lesson—one to oversee Stations 1 and 2 and the second to teach students at Station 3.

1. Pass around the uncapped, leaky, un-insulated juice box. Explain how the class will use juice boxes to model the outer shell of a building. The shell does not include all of the stuff you find in a house (such as rooms, intermediate floors, and staircases), and these shells will not include windows.

2. Explain and show students that the shells will contain a heat source—a bottle of hot water.

3. Explain that students will be experimenting with what keeps a house warm and use what they learn to investigate heat flow in their own homes and at school.

4. Discuss with students whether a building shell similar to a milk carton would provide a warm living space on a cold night. Have them explain their answers.

   Use questions to help students categorize their ideas, in their own words, into the following three groups:
   - Stop air from moving—reduce convective heat loss.
   - Increase insulation—reduce conductive heat loss.
   - Reflect radiant (heat) energy—reduce radiant heat loss.

5. Divide the class into thirds and assign them to rotate between the three stations.

   Help those assigned to Stations 1 and 2 begin and then work with students at Station 3. Each station will take 30 to 40 minutes to complete.

Guiding Questions for Discussion

- What keeps heat inside your home, inside the school?

- Think of examples other than a building where you want to keep heat in or out of something. How do they work?
  - Some examples may include: sweaters, jackets, windbreakers, insulated lunch boxes, refrigerators, coolers, ovens, or window shades.

- What is the lightest jacket you could put on to keep you warm on a windy day? Why does this work?
  - A windbreaker works wonders on a windy day.

- Has anyone ever seen an emergency blanket? They look like large sheets of aluminum foil. Why would you want to wrap someone who is cold in a thin metallic-like blanket?
Station 1—Improving the Leaky Un-Insulated House
30 – 40 minutes for a group of 6 to 8 students

1. Hand out to each student Data Sheet for Station 1: Improving the Leaky Un-Insulated House (Worksheet 4.3, page 1) and, if the don’t already have it, Systems Thinking—Heating a Building (Worksheet 4.1) Students will use Worksheet 4.1 for Stations 1 and 2.

   Each student must fill out their own systems thinking and data sheets, as they will need these for follow-up work.

2. Divide the group into four subgroups of one or two students each and assign each subgroup to a model building.

3. Have students follow the instructions given on the Student Information sheet 4.2, Stations 1 and 2 Instructions and complete the worksheets.

   Students will need assistance at step four with the hot-water bottle “furnaces.”
   • Fill each bottle with boiling water, cap it, and put one bottle in each model building.
   • Direct students to insert the thermometers so that the tip is half way across the box and to rest the thermometer dial on the supplied prop.

Station 2—What Makes the Best the BEST
30 – 40 minutes for a group of 6 to 8 students

a. Hand out to each student Data Sheet for Station 2: Making the Best the BEST (Worksheet 4.4, page 1) and, if the don’t already have it, Systems Thinking—Heating a Building (Worksheet 4.1) Students will use Worksheet 4.1 for Stations 1 and 2.

   Each student must fill out their own systems thinking and data sheets, as they will need these for follow-up work.

b. Divide the group into four subgroups of one or two students each and assign each subgroup to a model building.

c. Have students follow the instructions given on the Student Information sheet 4.2, Stations 1 and 2 Instructions and complete the worksheets.

   Students will need assistance at step four with the hot-water bottle “furnaces.”
   • Fill each bottle with boiling water, cap it, and put one bottle in each model building.
   • Direct students to insert the thermometers so that the tip is half way across the box and to rest the thermometer dial on the supplied prop.
Station 3—Conduction, Convection, Radiation
This station is run by the teacher and consists of three short activities on conduction, convection, and radiation.

- Distribute to each student the Worksheet 4.5: Station 3 Notes.

Conduction
15 – 20 minutes for a group of 6 to 8 students

1. Show students the metal rods with wax dots. Demonstrate that the wire rod does not go all the way through the cork.

2. Challenge students—how can I get the three wax dots to melt off in order, starting with the dot nearest the cork, without applying heat directly to the wax?

3. Have students work briefly in teams of two or three to generate ideas. Have students share and justify their ideas and, as a group, select the idea most students feel will work. Try their idea.

   If the student’s idea doesn’t work, try another, or heat the metal rod between the wax dot and the cork on the side with three wax dots.


5. Use students’ ideas and their words to help you present the formal definition of conduction.

6. Ask students—how can conductive heat transfer be slowed down or stopped? Why didn’t the wax on the other side of the cork melt? Ask them for some additional examples of conduction being slowed down and ask them to justify why each example works.

7. Use students’ ideas and their words to help you explain that some materials transfer heat more slowly than others. These are called insulators. Air is a very good insulator. The cork acted as an insulator in this demonstration. Clothing and hot pad holders also make good examples.

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Thermal Insulators

Materials that transfer heat slowly are called thermal insulators.

Fiberglass insulation inserted into walls of buildings is one example.
**Convection**
5 – 10 minutes for a group of 6 to 8 students

1. Challenge students to get the spiral to turn using only the lamp. The lamp cannot touch the spiral.

2. Have students work briefly in teams of two or three to generate ideas and write them down. Have students justify their ideas. Let them try each idea they propose.

3. Use students’ ideas and their words to help you present the formal definition of convection.

4. Ask students how they can stop or slow down convective heat transfer.

5. Have them try to stop the spiral from spinning without touching it.

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**Convection**

Convection is the **transfer of heat by the movement of gases or liquids** due to density differences that result from temperature differences in a gas or liquid.

In this case, the gas or liquid physically moves to a new location and takes the heat energy with it.

Convection can be slowed down with physical barriers to stop the gas or liquid from flowing.

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**Radiation**
15 – 20 minutes for a group of 6 to 8 students

1. Ask students how they know when a light is on. Ask if they could tell if a light was on if they were blindfolded.

2. Have students close and cover their eyes with a hand and hold out their other hand palm-forward. Move the light bulb towards their hands and ask them to use their sense of touch to tell you when the lamp is near.

3. Ask them how they know the lamp is near? Ask them what is happening. Have students work briefly in teams of two or three to generate ideas and write them down. Have students justify their ideas.

4. Use students’ ideas and their words to help you present the formal definition of radiation.

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**Radiation**

Radiation is the process of emitting energy in the form of waves or particles. Heat can be transferred between two bodies through electromagnetic waves.

All bodies, including plants and animals, are constantly radiating electromagnetic waves in the infrared range.

The transfer of heat by radiation can be slowed down or stopped with materials that absorb and/or reflect radiant heat.
5. Ask students how they can stop or slow down radiant heat transfer.

6. Have each student put on a black construction paper mitten and hold his or her hand next to a bulb for 15 to 30 seconds. Then have them hold their hand with the mitten still on palm-to-palm with their other hand but without touching. Ask students what they felt.

Most students will feel heat a few seconds after putting the mittened hand next to the bulb. After they move the mittened hand away from the bulb and next to their other hand, most will feel heat from the black paper with both hands.

7. Ask students, did this material stop or slow down the radiant heat flow? What happened to the radiant energy that hit the black paper? Can black paper radiate energy?

8. Repeat this process with the aluminum foil.

9. Explain that all things, including people, are always radiating heat energy. As things heat up, they radiate more heat energy. If they radiate more heat energy than you do, you feel it as heat. If they radiate less heat energy than you do, you feel it as cold.

**Part II—Follow up Questions**

Have students work on the 2-page Worksheet 4.6, *Confirm Your Understanding* at home and then go over the questions in class.

**Part III—Energy Thinking**

1. Display the enlarged copy of the *Energy Thinker’s Diagram* from Chapter 1 and be prepared to review any questions having to do with heat or hot water that students may have listed on an *Energy Around Us* worksheet from Chapter one.

2. Review with students their written responses on Worksheet 4.1, *Systems Thinking—Heating a Building*.

**Goals**

3. Discuss any goals students may have added to the primary goal of a warm living space. Give students time to add more ideas and write all ideas on the board.

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**Black Construction Paper**

Black construction paper slows down the transfer of radiant heat energy by absorbing the energy, which heats up the paper.

The warm paper then re-radiates energy in all directions and thus it only slows down the heat transfer.

**Aluminum Foil**

Aluminum foil greatly slows down the transfer of radiant heat energy by reflecting most of it back toward the source.

The foil reflects more and absorbs less radiant energy than the black paper. Because the aluminum foil does not absorb as much energy, it does not get as warm and it re-radiates less energy.

**What is a Goal?**

A valid goal can include mention of wanted or unwanted outputs but should not describe how to achieve the goal. One example could be to provide us with hot water on demand, at low cost, and without causing global warming.
4. Discuss what goals students would list for domestic hot water systems. Write these suggestions on the board.

**Inputs**

5. Ask students to list the energy resources used to heat homes that were described in the short stories. Explain that in Pennsylvania the same energy resources are also used to heat domestic hot water.

6. Discuss whether students use other energy resources to heat their homes and hot water and what they are.

**Processes**

7. Ask students to list any energy transformations and modes transporting energy resources that were described in the short stories.

8. Have students work in teams of 2 or 3 to complete the 2-page Student Worksheet 4.7: Short & Long Energy Chains. Distribute Worksheet 4.7 and either a set of *A Warm Home* or a set of *Hot Water* energy information cards (see page I.11) to each team. Assign each team two energy resources to work with.

9. As a class, identify where energy is wasted or additional energy is required for each energy chain.

10. Ask students to estimate which of the resources used for home heat or hot water uses (or loses) the most useful energy during processing. Ask them to justify their reasoning.

11. Ask how students would adjust their estimates if electric heat and hot water were included.

12. Ask students to identify the most common energy resource used for heat and hot water in Pennsylvania. (See the back of the Natural Gas information card.)

**Alternative Activity**

Instead of using Worksheet 4.7, have students mimic different length process chains by attempting to use a spoon to move popcorn or plastic peanuts from cup to cup. The popcorn represents energy and moving it to a new cup represents one process. Dropped popcorn represents wasted energy.

**Optional - Use to reinforce concepts of energy forms**

Have students describe the different energy forms depicted in each energy chain. Remind students to identify wasted energy, which will often be in the form of waste heat.

**Energy Used for Heat and Hot Water in Pennsylvania**

<table>
<thead>
<tr>
<th>Energy For Processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• When converting energy from one form to another, useful energy is always lost—often as waste heat.</td>
</tr>
<tr>
<td>• It takes energy to convert energy from one type to another.</td>
</tr>
<tr>
<td>• It takes energy to transport energy resources.</td>
</tr>
</tbody>
</table>

**Outputs**

13. Have each student complete Worksheet 4.8: *Heat and Hot Water: Outputs*, while working in groups.
Feedback

14. Explain to students that they will investigate energy use at home and identify specific ways to reduce unwanted outputs of heating homes and hot water and using electricity for lighting and appliances.

15. Show students and let them investigate the sample winterization products and “how-to” pamphlets.

16. Distribute Worksheet 4.9, Build a Draft-O-Meter and materials and have students build and test a draft-o-meter. Explain that students will need to use this technique to search their homes for drafts. You may want to let students try it out around the classroom.

17. Hand out the Worksheets 4.10 and 4.11, Home Energy Investigation (6 pages) and Buying Green Electricity in Pennsylvania (2 pages) respectively. Have students complete 4.10 as homework. Have students bring their completed worksheets 4.1 and 4.8 home with them for ideas. Give students at least one weekend to complete.

Assessment

Use the following expected worksheet response, guiding questions, and the Chapter 4 Energy Thinking Assessment Sheet to evaluate students’ current knowledge and skills in thinking about energy for home heat and hot water and ability to apply a systems way of evaluating energy options.

Guide to Worksheet Responses

Systems Thinking—Heating a Building
Completion of this worksheet allows an instructor to assess students ability to identify parts of a system—goals, inputs, processes, outputs, and feedback—and assess reading and listening skill levels. Completion of this worksheet also provides students with information to consider during later activities.

Goal(s) of Energy System: In addition to the basic goal of a warm living space, students should identify the following potential goals from the short readings:
- reduce global warming pollution
- save money on fuel bills / reduce risk to rising energy costs
- stop tenants from complaining / increase comfort level
- decrease dependence on foreign oil
- stop pipes from freezing

Students should also have added topics specifically important to the student—such as safety, human health, environmental friendliness, or economics.

Energy Resources Used: Students should identify natural gas, heating oil, and electricity as the three main energy resources used for heat and hot water in Pennsylvania. They may have added other resources mentioned in classroom discussions.

Transformations and Transportation of Energy: Students should identify oil tankers and natural gas pipelines from the short stories. (They explore energy processing further with Worksheet 4.7, Short and Long Energy Chains.)

Things that Happen that We Want: Students should list a warm living space.
**Things that Happen that We Don’t Want:** Students should identify from the short stories:

- uncomfortable living space / cold drafts
- oil spills / destruction of marine ecosystems
- frozen water pipes
- more intense hurricanes
- melting glaciers / reduced summer water supplies
- heatwaves
- change in weather patterns
- global warming pollution
- dependence on foreign sources of oil
- unexpected energy price hikes
- complaining tenants

**Ideas on How to Do It Better:** Students should identify from the short stories:

- increase insulation
- add reflective barrier
- seal leaks
- change fuels (to wood or from oil to natural gas)

**Data Sheets for Stations 1**

Students should identify the leaky model with no insulation and no reflective barrier as the control. Although results will vary, the control model should show the lowest temperature over time. Insulated boxes may reach their warmest temperature later than other boxes due to the need to warm up the mass of insulation. Table 4.1 shows typical results.

<table>
<thead>
<tr>
<th>Time (hrs:min)</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>9:22</td>
<td></td>
</tr>
<tr>
<td>9:27</td>
<td>116</td>
</tr>
<tr>
<td>9:32</td>
<td>115</td>
</tr>
<tr>
<td>9:37</td>
<td>113</td>
</tr>
<tr>
<td>9:42</td>
<td>111</td>
</tr>
<tr>
<td>9:47</td>
<td>109</td>
</tr>
<tr>
<td>9:52</td>
<td>107</td>
</tr>
</tbody>
</table>

**Data Sheets for Stations 2**

Students should identify the sealed model with insulation and reflective barrier as the control. Although results will vary, the control model should show the highest temperature over time. The box with air leaks added should result in the lowest temperature. The box with no thermal
insulation may reach its warmest temperature quicker and reach an initial higher temperature than other boxes because it has less mass to warm up. Table 4.2 shows typical results.

Table 4.2: Typical Results for Station 2: Making the Best the BEST

<table>
<thead>
<tr>
<th>Time (hrs:min)</th>
<th>Control</th>
<th>Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Insulated</td>
<td>Un-Insulated</td>
</tr>
<tr>
<td></td>
<td>Leaks Sealed</td>
<td>Leaks Sealed</td>
</tr>
<tr>
<td></td>
<td>Reflective Interior</td>
<td>Reflective Interior</td>
</tr>
<tr>
<td></td>
<td>133</td>
<td>136</td>
</tr>
<tr>
<td></td>
<td>133</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>118</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>130</td>
<td>133</td>
</tr>
</tbody>
</table>

**Stations 3 Notes**

*Wax Dots on Metal Rod:* Heating the metal rod between the cork and the first of three wax dots will cause the wax dots to fall off in order.

Students should use their own words to describe that conduction is the movement of heat by direct contact.

Students should identify that certain materials conduct heat slower than others. The cork conducts heat more slowly than the metal.

*Paper Spiral:* Placing the paper spiral above a hot lamp will cause it to turn.

Students should use their own words to describe that convection is the movement of gases or liquids because of differences in density, which is caused by differences in temperature. Hot air rises is a concise layman’s way of describing this.

Students should identify that stopping the gas or liquid from moving will stop that gas or liquid from carrying the heat it contains to a new location.

*Is the Lamp On?*

Students should use their own words to describe that radiant heat transfer is the transfer of heat energy through radiation, or more precisely, infrared radiation.

Students should identify that reflecting back radiant energy can slow down radiant heat transfer.
Confirm Your Understanding

1. Thermal insulation slows down conduction because insulating materials conduct heat more slowly.

2. Sealing leaks slows down convection by keeping air that contains heat from leaving the building.

3. Installing a radiant barrier slows down radiant heat loss by reflecting radiant heat back into the building.

4. Following are typical results:

![Graph](Improving the Leaky Un-Insulated House)

Each of the three insulation methods improved heat retention in the model building.

5. Following are typical results:

![Graph](Making the Best the BEST)

Adding leaks had the greatest impact on increased heat loss.
6. Students should identify that a leaky building can greatly reduce the effectiveness of adding insulation. You are defeating the purpose of insulating a building if heated air is allowed to leave the building and be replaced by cold air. Heat loss by convection can be significant.

7. Students should identify that while just sealing leaks helps retain heat, a building can still lose a lot of heat energy through conduction; therefore increasing insulation and sealing leaks will reduce heat loss more than either by itself.

8. Student answers will vary and thinking about this question may inspire some students to conduct further experiments. Buildings do lose more heat on a windy day. Students may identify that a lot of this heat loss will occur through air infiltration (a type of convective heat loss). Some students will realize that the wind will cool down the outside walls through a combination of conduction and convection. The cooler outside walls will then cause more conductive heat loss.

9. Student answers will vary and thinking about this question may inspire some students to conduct further experiments. Responses should be similar to the responses for Question 6.

**Short and Long Energy Chains**

With this exercise, students identify that energy is lost during processing and transportation; describe energy forms and energy transformations; and use estimation to evaluate relative levels of waste energy associated with different energy resources.

Students should recognize that converting raw energy resources into electricity adds additional energy losses due to the need for additional processing and transportation of energy.

The following tables shows sample responses. Although student responses will vary, they should be close to the following:

<table>
<thead>
<tr>
<th></th>
<th>Useful Energy is Lost in Conversion</th>
<th>Energy is Used for Conversion</th>
<th>Energy is Used for Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Gas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas is pumped out of the ground</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas is pumped through pipelines</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas is burned for heat (chemical to thermal energy)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat is pumped through the house</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Heating Oil</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil is pumped out of the ground</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil is pumped through pipelines</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil is shipped in tankers</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil is processed into heating oil (chemical to chemical energy)</td>
<td>X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating oil is trucked to homes</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating oil is burned for heat (chemical to thermal energy)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat is pumped through the house</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Wood Heat

<table>
<thead>
<tr>
<th>Activity</th>
<th>Useful Energy is Lost in Conversion</th>
<th>Energy is Used for Conversion</th>
<th>Energy is Used for Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees are cut down</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wood is processed into cordwood (chemical to chemical energy)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wood is trucked to homes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood is burned for heat (chemical to thermal energy)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat is circulated through the house (if a blower is used)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Solar Hot Water

<table>
<thead>
<tr>
<th>Activity</th>
<th>Useful Energy is Lost in Conversion</th>
<th>Energy is Used for Conversion</th>
<th>Energy is Used for Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlight heats up water (radiant to thermal energy)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot water is circulated to the hot water tank</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hot water is pumped to faucets</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Solar Space Heat

<table>
<thead>
<tr>
<th>Activity</th>
<th>Useful Energy is Lost in Conversion</th>
<th>Energy is Used for Conversion</th>
<th>Energy is Used for Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlight heats up the air inside the house (radiant to thermal)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Heat and Hot Water Outputs

With this exercise, students begin to integrate what they have learned with their lives; evaluate how energy used for heat and hot water affects them, society, and the environment; and identify personal priorities. Responses will vary and reflect the environmental and social values they hold.

### Home Energy Investigation

Through a home energy investigation, students apply what they have learned and propose actions that could reduce unwanted outputs of energy use. The recommendations they formulate should address problems with energy use that they have identified and reflect environmental and social values they hold.

Students should be able to identify the type of heat loss that is slowed down by their recommendations. These should reflect the following:

- Increased insulation slows down conductive heat loss.
- Sealing air leaks slows down convective heat loss.
- Upgrading, repairing, or replacing windows could slow down radiant, conductive, or convective heat loss, depending on the action proposed.
- Improving heating or hot water systems could slow down radiant, conductive, or convective heat loss depending on the action proposed.
<table>
<thead>
<tr>
<th>Critical Thinking Level</th>
<th>Content</th>
<th>Score</th>
</tr>
</thead>
</table>
| Knowledge               | Identifies or lists:  
• components of the *Energy Thinker’s Diagram*  
• what energy is used for  
• means used to transport energy  
• energy resources  
• energy forms  
• technologies used to change energy forms | 4 3 2 1 |
| Comprehension           | Describes examples where:  
• different energy sources are used to accomplish the same objective  
• changing energy sources changes outputs  
• changing the way energy is used changes outputs  
• energy changes form | 4 3 2 1 |
| Application             | Uses an understanding of systems thinking (*goals, inputs, processes, outputs, and feedback*) to evaluate a new situation. | 4 3 2 1 |
|                         | Uses an understanding of energy forms to identify when energy is being used or converted. | 4 3 2 1 |
| Analysis                | Breaks down effects of energy use into wanted and unwanted outcomes. | 4 3 2 1 |
|                         | Infers from previous knowledge when:  
• different energy sources can be used to accomplish the same objective  
• changing energy sources will change outputs  
• changing the way energy is used will change outputs | 4 3 2 1 |
| Synthesis               | Creates an action plan:  
• based on evaluation of several potential solutions  
• that addresses a change in energy system goals | 4 3 2 1 |
| Evaluation              | Critiques benefits versus drawbacks to:  
• using different energy sources  
• changing energy efficiency  
• changing behavior of energy use | 4 3 2 1 |
|                         | Uses a wide array of criteria to assess benefits and drawbacks between different energy sources and uses. | 4 3 2 1 |
| Total Score =           |         |       |


**Extensions and/or Enrichments**

**Science and Technology**
Have students design, build, and test solar ovens made out of pizza-boxes.

Have students design, build, and test solar hand warmers made out of shoe boxes.

Have students compete to design a box that will keep an ice cube frozen for the longest (or shortest) period of time.

In all cases, provide students with plenty of resources they can use to block or allow air flow, add thermal insulation, and reflect radiant heat.

Use a dark-colored hose as a solar hot water heater. Have students design and build an insulated box to house it.

**Science and Mathematics**
Have students design, run, and evaluate their own experiments on heat transfer using the model “juice box” buildings.
Model House Construction Instructions

1. Use juice boxes with plastic screw top pour spouts. Open the juice box tops as you would a milk carton and clean with warm soapy water. Dry well. Remove and set the bottle caps aside.

2. Add insulation to the outside of four juice boxes.
   - Cut out lengths of felt 26 cm wide to wrap four times around each box.
     Suggestion: an 84 cm long piece, which is just under a yard, will go around a box twice. Two pieces will go around a box four times.
   - For each box, use a glue stick to glue the felt as you wrap it four times around the box.
   - Cut holes for the plastic pour spouts to fit through and glue the felt around the spouts.
   - Cut out sixteen 11 cm by 11 cm pieces of felt and glue four pieces to the bottom of each box.

3. Add an aluminum foil reflective barrier to the inside of four juice boxes.
   a) two with felt
   b) two without felt

   For each box:
   - Cut out a piece of aluminum foil to line the inside sides. (39 cm by 25 cm).
   - Roll the aluminum into a loose roll and insert into a juice box.
   - Unroll the aluminum inside the box, fitting it to the sides. Use a glue stick to secure the top edges to the walls of the juice box.
   - Cut holes to clear the plastic pour spout openings.

4. Paint the insides of the four boxes without aluminum foil black. Use non-shiny (matt or flat) paint.

5. Add leaks to the following four juice boxes:
   a) with felt insulation and aluminum reflective barrier
   b) with felt insulation and inside painted black
   c) with just aluminum reflective barrier (no felt)
   d) with just the inside painted black (no felt)

   • Mark and cut with an Exacto knife one 1 cm by 2 cm opening on each side. Position the openings 3 cm up from the bottom and centered horizontally. Make sure the bottle caps are removed from these four boxes.

Materials

- Eight ½ gallon milk-carton type juice boxes with plastic screw caps
- Eight 10 oz plastic bottles (Use bottles made out of number 2 [HDPE] or number 7 [other] recyclable plastic. These are milky or foggy in appearance. Do not use clear plastic bottles made from number 1 [PETE] recyclable plastic. These will shrink when filled with near-boiling water.)
- Eight large foam hot drink cups.
- Eight bi-therm thermometers (Meat thermometers with a range of at least 60 to 150° Fahrenheit work well.)
- Eight props, 16 cm to 17 cm tall
- Heavy duty aluminum foil
- Three yards of 36-inch wide felt
- Can of black spray paint, flat or matte finish
- Glue sticks
- Thumbtack
- Pencil
- Eight binder clips
- Source of boiling water such as an electric tea-pot
- Funnel
6. Seal the leaks in the remaining four juice boxes by replacing the caps on the four juice boxes that do not have leaks punched in their sides.

7. Insert a thermometer in each box. Bi-therm thermometers work well and are easy for students to read. A meat thermometer used for cooking is a bi-therm thermometer. Make sure to use thermometers with a temperature range of at least 60 to 150 degrees Fahrenheit.
   - Use a thumbtack to punch a hole in the side opposite the bottle cap. Center the hole horizontally and 1.5 cm from the top of the side.
   - Insert a thermometer through the hole so that the tip is halfway across the box. The thermometer will need to be removed to put a hot water bottle inside.

8. Test the 10 oz. plastic bottles for size and reaction to boiling water.
   - Place a bottle inside a large foam hot-drink cup and use a funnel to fill it with boiling water. The foam cup acts like a hot pad holder and will catch any hot water that may spill over. The boiling hot water should not deform the bottle. If it does, you need bottles made from a different plastic. (See materials.)
     After capping the bottle, it can be picked up by the cap to be placed inside a juice box.

9. Try it out.
   - After inserting the hot water bottles, seal the top of each box with a large binder clip and reinsert the thermometers.
   - IMPORTANT: During the experiment, rest all thermometer dials on 16 cm to 17 cm tall props to keep all thermometers’ tips at the same height inside the juice boxes. Anything stable of the right height will work as a prop.
Station 3 Props Construction Instructions

Conduction

Prepare six wire rods with wax dots and cork insulator.

- Cut six longer (11 – 13 cm) and six shorter (3 – 5 cm) wire rods from a metal clothes hanger.
- In each cork, push one longer rod in one end and one shorter rod in the other end. Use a thumbtack to start holes in the ends of the cork pieces if needed.
- Drip wax drops onto the wire rods as shown in Figure 4.1, leaving room for a candle flame to reach the long wire rod near the cork. Drip the wax on a little at a time.

Radiation

Construct three thumb-less mittens out of black construction paper and three out of heavy-duty aluminum foil.

- Fold a piece of black construction paper in half and staple, tape or otherwise seal two edges so as to make a thumb-less “mitten” that will fit over a student’s hand.
- Similarly, use a piece of heavy-duty aluminum foil about the size of a piece of writing paper to make a thumb-less aluminum foil mitten.

Convection

- Copy and cut out the paper spiral on the following page.
- With the sewing needle, run the long thread through the dot at the center of the paper spiral and tie off an end.
- With masking tape, hang the spiral from the ceiling away from drafts or wind currents.

Materials

- Wire clothes hanger
- Metal cutters to cut wire clothes hanger
- 6 cork bottle corks
- Candle
- Matches or lighter

Figure 4.1. Wax dots on metal rod with cork insulator

Materials

- 3 sheets black construction paper
- 3 sheets heavy-duty aluminum foil
- Stapler or tape

Figure 4.2: Making a thumb-less mitten

Materials

- Paper spiral from following page
- Long piece of thread
- Sewing needle
- Masking tape
Systems Thinking—Heating a Building

Use this worksheet at both Station 1 and Station 2

As each story is read, record any goals, inputs, processes, outputs, or feedback that is mentioned. The first and primary goal is already written.

Goal(s) of energy system  
A warm living space

Energy resources used (Inputs)

Transformations and transportation of energy (Processes)

Things that happen that we want (Outputs)

Things that happen that we don’t want (Outputs)

Ideas on how to do it better (Feedback)
Stations 1 and 2 Instructions

Names: ___________________________ Date: ___________________________

1. Describe the insulation or lack of insulation used with your model building to the group.

2. Write down which model building you think will retain the highest temperature and which you think will cool down the most. Give your reasons why.

3. Designate a person to be a timekeeper and one person for each model building to take temperature readings.

4. Ask an instructor to help you insert a hot water bottle “furnace” into each model.

5. Once all model buildings have a hot water bottle, clamp the tops closed with the binder clips and record the time on your data sheet as your Start Time.

6. Insert the thermometers as instructed by your teacher.

7. a. Give the models five minutes to warm up and then take a reading every five minutes. Everyone must write down all of the temperature measurements on their own data sheet. You will need this data later for homework.

   b. In between data readings, take turns reading to the entire workgroup each of the four “Who’s Interested” stories. Record on your energy systems handout any goals, inputs, processes, outputs, or feedback mentioned. You may wish to assign each person one topic to listen for and take notes on.

   c. Once you have finished with the four “Who’s Interested” stories, plot the data you are collecting on graph paper. Plot temperature on the vertical axis and time on the horizontal axis. Assume a temperature range of 30°F and a time range of 30 minutes.
In order to identify what effect adding insulation or a reflective barrier or sealing leaks will have on keeping heat energy inside a model building, the results need to be compared with those of an experimental control. Identify the model building that will act as the experimental control.

Each of the other buildings will have one variable that is different from this control model. For the other three models, circle the one variable that changes.

Make sure no other variables are introduced to your experiment (such as having only one model building in sunlight, placing some buildings closer to a heater, or positioning a thermometer differently in one model.)

- Record as the Start Time the time you seal hot water bottles into the model buildings.

- Every five minutes, record the time and temperatures of the model buildings.

<table>
<thead>
<tr>
<th>Time (hrs:min)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Time</td>
<td>Un-insulated</td>
</tr>
<tr>
<td></td>
<td>Leaky</td>
</tr>
<tr>
<td></td>
<td>Non Reflective</td>
</tr>
<tr>
<td></td>
<td>Interior</td>
</tr>
</tbody>
</table>
### Improving the Leaky Un-Insulated House

#### Stories for Station 1

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• no insulation</td>
<td><em>Landlords and Tenants</em></td>
</tr>
<tr>
<td>• air leaks</td>
<td>Jacob owns several houses that he rents out. They are all old but he feels he does a good job keeping them well painted and he is always ready to help fix a broken faucet or do other repairs. So he is irritated when his tenants complain that they feel cold. He pays for their heat and he knows how much fuel they go through – a lot! How could they be cold?</td>
</tr>
<tr>
<td>• non-reflective interior</td>
<td></td>
</tr>
<tr>
<td>• insulated</td>
<td><em>City Planner</em></td>
</tr>
<tr>
<td>• air leaks</td>
<td>The citizens of Anycity Pennsylvania just voted for the city government to find ways to reduce the city’s global warming pollution. Emily, the City Planner, is assigned the task of finding out how much carbon dioxide, a potent global warming pollutant, is produced by residential houses. In conducting her research, she discovers that, all things being equal, larger houses produce more global warming gases than smaller houses because they need to burn more fuel to heat the larger indoor space. She also discovers that older houses in her town probably produce a disproportionate amount of global warming gases, because many of them were built before insulation was considered important. Emily owns an old farmhouse herself and so has a contractor test it to see how well it is insulated. She is told it is poorly insulated and is full of leaks. She has the contractor blow cellulose insulation into the walls of her house and is now wondering whether she should pay someone to plug all of the leaks.</td>
</tr>
<tr>
<td>• non-reflective interior</td>
<td></td>
</tr>
</tbody>
</table>
## Improving the Leaky Un-Insulated House

### Stories for Station 1

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Utility Worker</strong></td>
</tr>
<tr>
<td>• no insulation</td>
<td>Tyler just landed a new job at the electric utility working on their low-income winterization program. He discovered that the state pays the utility, which pays him, to help low income households save money on their fuel bills by reducing the leaks in their house. Tyler is intrigued and goes home to check his own house. Sure enough, he can feel cold air seeping in around the windows and doors, and even around the electric wall sockets and the holes in the floor under the sinks where the plumbing comes through. When he looks up his fireplace chimney, he realizes there is no damper. It seems to Tyler like a reasonable thing to plug these leaks, particularly because it wouldn’t cost all that much. Tyler isn’t sure how much fuel and money it will save him since he is starting to realize that his house isn’t well insulated either.</td>
</tr>
<tr>
<td>• sealed</td>
<td></td>
</tr>
<tr>
<td>• non-reflective interior</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Paint Manufacturer</strong></td>
</tr>
<tr>
<td>• no insulation</td>
<td>Hannah, who works as a chemist for a house paint manufacturing company, also volunteers for the local fire department. She notices that some of the fire-personnel’s jackets have a shiny outer material on them and realizes that the shiny material helps reflect the heat of the fire. Her company is working on paints that may help buildings reduce heat loss by sealing leaky walls. She wonders if they can develop a paint that would reflect heat back into the building. But first, she wants to know if the concept works. Hannah uses two old sheds to conduct an experiment. She covers the walls of one with aluminum sheets and leaves the second shed as she found it. She has small gas heaters and thermostats installed and Hannah keeps track of the amount of fuel needed to keep both buildings at a comfortable temperature.</td>
</tr>
<tr>
<td>• air leaks</td>
<td></td>
</tr>
<tr>
<td>• reflective interior</td>
<td></td>
</tr>
</tbody>
</table>
Data Sheet for Station 2

In order to identify what effect removing insulation, a reflective barrier or adding leaks will have on keeping heat energy inside a model building, the results need to be compared with those of an experimental control. Identify the model building that will act as the experimental control.

Each of the other buildings will have one variable that is different from this control model. For the other three models, circle the one variable that changes.

Make sure no other variables are introduced to your experiment, (such as having only one model building in sunlight, placing some buildings closer to a heater, or positioning a thermometer differently in one model.)

- Record as the Start Time the time you seal hot water bottles into the model buildings.
- Every five minutes, record the time and temperatures of the model buildings.

<table>
<thead>
<tr>
<th>Time (hrs:min)</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Time :</td>
<td>Insulated Leaks Sealed Reflective Interior</td>
</tr>
<tr>
<td>:</td>
<td>:</td>
</tr>
<tr>
<td>:</td>
<td>:</td>
</tr>
<tr>
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<tr>
<td>:</td>
<td>:</td>
</tr>
</tbody>
</table>
# Making the Best the BEST

Names: __________________________________________________________________________ Date: ________________

## Stories for Station 2

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insulated</td>
<td>Architect</td>
</tr>
<tr>
<td>• sealed</td>
<td></td>
</tr>
<tr>
<td>• reflective interior</td>
<td></td>
</tr>
</tbody>
</table>

Sarah has been an architect for many years. Recently, many of Sarah’s clients have been asking for buildings designed to use less energy. Many of Sarah’s clients are concerned that society’s use of fossil fuels is leading to global warming. Others are concerned that the United States’ increased dependence on foreign sources of oil complicates national security issues. Still others are concerned that prices for natural gas, heating oil, and electricity (types of energy most often used in Pennsylvania to heat houses) are not as steady as they used to be. They don’t want to take the risk that if prices rise unexpectedly a building that uses lots of energy will cost them a lot more to heat than they planned on. Sarah has decided she needs to learn new ways to design buildings, ways that strictly limit how much air can leak in and out of the building, that use the best insulating materials, and that use reflective coatings where they are appropriate.

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• no insulation</td>
<td>Owner of a vacation cabin</td>
</tr>
<tr>
<td>• sealed</td>
<td></td>
</tr>
<tr>
<td>• reflective interior</td>
<td></td>
</tr>
</tbody>
</table>

Under the kitchen of Nick’s vacation cabin is an un-insulated crawl space with stone walls. The kitchen floor always feels cold in the winter and the water pipes that run through the crawl space sometimes freeze. A friend of Nick’s builds houses for a living and suggests that Nick might want to stop any wind from blowing through the stone walls of the crawl space and add insulation. Nick doesn’t want to spend much money, so he chooses to line the inside of the crawl space walls with a heavy-duty foil. His plan is to use the foil to block any wind from coming through and to slow down radiant heat loss, although he knows this plan won’t add any thermal insulation. He hopes that this will be enough to keep his pipes from freezing.
### Stories for Station 2

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• insulated</td>
<td><strong>Marine Ecologists</strong></td>
</tr>
<tr>
<td>• sealed</td>
<td>Mathew is a marine ecologist who has often been hired to study the impacts of oil spills on marine ecosystems. Personally, he has tried to do his small part to reduce the amount of oil that is shipped over the oceans by reducing his use of oil. To do so, he has chosen to drive a very fuel-efficient car and has added a wood stove to his house as his primary heating source. He would switch from oil heat to natural gas for backup heat if a natural gas pipeline ran through his town, but none do. Still, he wants to do more so he increased the amount of insulation in the walls of his home and sealed up all air leaks. He is considering adding a reflective barrier to the insulation in the crawl space under the house, but wonders how much it would help.</td>
</tr>
<tr>
<td>• non-reflective interior</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Building Description</th>
<th>Who’s Interested in Well Insulated Houses?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• insulated</td>
<td><strong>Atmospheric Scientist</strong></td>
</tr>
<tr>
<td>• air leaks</td>
<td>Samantha works as an atmospheric scientist at a university research center. Her research has led her to believe that it is very important to reduce the amount of greenhouse pollution humans are putting into the air. She believes that global warming could cause more intense hurricanes, melt glaciers that many people use for summer water supplies, trigger deadly heat waves, and change weather patterns that would affect farmers and hurt wildlife. She is concerned that heating the building she works in may produce more global warming pollution than it should, and asks around to find out how well insulated the building is. She discovers that the building has well-insulated walls and ceilings and has a reflective barrier built into the walls. But Samantha can feel cold air coming in around doors, windows, and electric outlets. She wonders if this should be a concern, even though the building was built with a high level of insulation.</td>
</tr>
<tr>
<td>• reflective interior</td>
<td></td>
</tr>
</tbody>
</table>
Station 3 Notes

Use this sheet to write down ideas and take notes.

Wax dots on metal rod
How can we get the three wax dots to melt off in order, starting with the dot nearest the cork?

What is conduction?

How can conductive heat transfer be slowed down or stopped?

Paper spiral
How can we get the spiral to turn using only the lamp?

What is convection?

How can convective heat transfer be slowed down or stopped?

Is the lamp on?
What is radiant heat transfer?

How can radiant heat transfer be slowed down or stopped?
Confirm Your Understanding

Names: _____________________________ Date: _____________________________

1. What type of heat transfer does adding insulation slow down? Describe why.

2. What type of heat transfer does adding a reflective barrier slow down? Describe why.


4. On graph paper, plot temperature versus time for the four model buildings at Station 1. Compare how well each of the three types of insulation—thermal insulation, sealing leaks, or adding a reflective layer—improved heat retention in the model.

5. On graph paper, plot temperature versus time for the four model buildings at Station 2. Which form of insulation—thermal insulation, sealing leaks, or a reflective barrier—had the largest impact on increased heat loss when removed?
6. Based on these experiments, what would you recommend to someone who spent a lot of money insulating their house but didn’t fix any leaks? Explain why.

7. Based on these experiments, what advise would you give to someone who sealed up all the leaks they could find in their house but still said their heating system couldn’t keep the house warm? Explain why.

8. What do you think would happen to the temperature in a leaky but insulated juice box if you doubled the layers of insulation? (Think about what would happen if you put on more sweaters on a cold windy day, or put on a warmer jacket but left the zipper unzipped.)

Short and Long Energy Chains

Names: ________________________________ Date: ____________________

- When converting energy from one form to another, useful energy is always lost—often as waste heat.
- It takes energy to convert energy from one type to another.
- It takes energy to transport energy resources.

Use the energy information cards to help you estimate which energy resources used for home heat and hot water lose the most useful energy to transportation and processing.

1. Use the energy information cards to help you identify the steps it takes to transform energy resources into warm homes and domestic hot water. Start with the Warm Home and Hot Water cards and work backwards (right to left) to lay out energy chains, one for each energy resource assigned to you by your teacher. Each chain will end (on the left) with a natural resource card. Each card states what other cards it can link to.

2. List all energy conversions and the transportation of energy resources for each chain in the tables on page 2 of this worksheet. Do not include the natural formation of the resource.

Energy conversions and transporting different resources can use (or lose) significantly different amounts of useful energy. For instance, shipping something around the world uses far more energy than shipping a resource between neighboring towns. Because of this, the number of conversions and the amount that a resource has to be transported cannot tell us exactly which resource will lose the most energy to processing—but it is an indicator. Resources that are transported long distances and go through multiple conversions will tend to use up more useful energy during processing than those with short energy chains.

3. Which energy resource used for home heat and hot water would you estimate uses the most useful energy during processing? Which would you estimate uses the least?

4. Would you adjust your estimate if you included electric heat and electric hot water? If so, how?
Short and Long Energy Chains

Names: ___________________________ Date: _________________________

<table>
<thead>
<tr>
<th>Natural Energy Resource ___________________________</th>
<th>Useful Energy is Lost in Conversion</th>
<th>Energy is Used for Conversion</th>
<th>Energy is Used for Transportation</th>
</tr>
</thead>
</table>

For each entry, check off how energy is used or lost during that process.

Description of Energy Conversion or Transportation of a Resource

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 

<table>
<thead>
<tr>
<th>Natural Energy Resource ___________________________</th>
<th>Useful Energy is Lost in Conversion</th>
<th>Energy is Used for Conversion</th>
<th>Energy is Used for Transportation</th>
</tr>
</thead>
</table>

For each entry, check off how energy is used or lost during that process.

Description of Energy Conversion or Transportation of a Resource

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
</table>
1. In your life, are current systems to provide warm living spaces achieving their most basic goal—a comfortably warm room? Briefly describe how well or how poorly they are working.

Think about your home, school, or other buildings where you spend a lot of time. Are these buildings usually at a comfortable temperature? Or are they cold and drafty or do people need to open windows to cool down overheated rooms?

2. Similarly, briefly describe if systems that you use for hot water are working well or poorly.

3. From information in the short stories (see the Systems Thinking—Heating a Building worksheet), on the backs of the energy cards, media articles, and your personal experience, list what you feel are the most important unwanted outputs of using energy for heat and hot water at this time.

4. Label your unwanted outputs in order of priority. You will consider these and how well your home heat and hot water system are performing during a home energy investigation.
Build a Draft-O-Meter

Adapted from the Alliance to Save Energy’s Green Schools Program

1. Cut a 13-cm by 25-cm strip of plastic wrap.

2. Tape the shorter edge of the wrap to a pencil and let the rest hang freely.

3. Test by holding the plastic wrap near a leaky window or one that is opened a slight crack. Notice how sensitive the wrap is to slight movements of air.
Apply what you have learned about energy to investigate energy use at home. Suggest changes that you or your household can make to reduce the negative consequences you identified in class of heating your home and hot water and using electricity while retaining the benefits of a warm home, hot water, and convenient electric power.

1. What energy source(s) is (are) used in your household for:
   - Space Heat
   - Hot Water

2. Would you suggest changing or adjusting which fuels you use to heat your home or hot water? Explain to what and why.

3. Where does your electricity come from? Check an electric bill to see if your provider lists their sources of energy.

4. Many electricity suppliers are now offering consumers the option of buying a higher percentage of renewable energy than the standard mix. Unless you have made specific arrangements with your electric utility, only a small amount of your electricity is generated from renewable energy sources such as wind, hydro, or solar power.

   Would buying electricity from a supplier certified to deliver 50% or 100% renewable energy help reduce the unwanted outputs of using electricity that you rated most highly?* Specify how.

5. Fill in the following table with your recommendations for each category.

* For information on electricity purchase options, see Student Information Sheet 4.11, Buying Green Electricity in Pennsylvania
### Home Energy Investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Insulation</strong></td>
<td></td>
</tr>
<tr>
<td><em>Ceiling</em> - If your attic has six inches or less insulation and more can fit in without compressing the insulation, recommend adding more. Are all attic floor surfaces insulated, such as the top of a trap door? A small uninsulated section can greatly reduce overall insulation value.</td>
<td></td>
</tr>
<tr>
<td><em>Walls</em> - If your house was built before 1980, there is a good chance it has little or no insulation—only 20% of homes built before 1980 are well insulated. If your house was built in the 1980s, you will have to judge how much insulation it has. One way is to feel the walls. On cold days, do outside walls feel cold to the touch?</td>
<td></td>
</tr>
<tr>
<td>If your house is less than 15 years old and has outside walls that are 6 to 7 inches thick, it probably has a medium amount of insulation. If the outside walls are 9 to 10 inches thick, it probably has a high amount of insulation.</td>
<td></td>
</tr>
<tr>
<td>• If your walls are not insulated, it will very likely be cost-effective to add insulation.</td>
<td></td>
</tr>
<tr>
<td>• If your walls have a medium amount of insulation, it will likely be cost effective to add more if the wall is opened up for any reason.</td>
<td></td>
</tr>
<tr>
<td><strong>Foundation</strong> - If you have a basement, inspect the outside walls to see if they are insulated.</td>
<td></td>
</tr>
<tr>
<td>• If there is no insulation, it may be cost-effective to add some.</td>
<td></td>
</tr>
</tbody>
</table>
### Home Energy Investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Recommendations</th>
</tr>
</thead>
</table>
| **Air Leaks** | Use your draft-o-meter to look for leaks along edges of windows and doors, near chimney openings, and by electric outlets on outside walls. Don't forget cellar doors and windows.  
Check for other openings between floors and in walls such as around pipes and electric wires entering walls, or exhaust fans (while turned off). Don't forget to check between the top floor and attic. Look for leaks in the building's foundation and between the foundation and house.  
Inspect windows and doors for the presence of weatherstripping; is it worn, does it need to be replaced? Are storm windows loose or poorly fitting?  
- It would likely be cost effective to seal leaks with appropriate weatherstripping, caulk, or foam insulation and to add chimney dampers and/or glass doors. |
| **Windows**   | Does your house have single pane windows? Almost half of U. S. homes do.  
Windows with double-pane glass or single pane with tight-fitting storm windows have better insulation value. Windows and storm windows with non-metal frames provide more insulation. The best windows today have what is called a low-e coating. This reflects radiant heat from inside the house in the winter and reduces radiant heat gain during the summer.  
Installing tight fitting, insulating window shades, closing shades or curtains at night, and keeping south-facing windows clean can also reduce heat loss. |
# Home Energy Investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heating System</strong></td>
<td></td>
</tr>
<tr>
<td>If your furnace or boiler was bought before 1992, you may want to consider replacing it with a high efficiency unit. Furnaces and boilers should be serviced once a year to reduce energy use. When was the last time yours was serviced? Check to make sure heating ducts for hot air and pipes for hot water or steam are wrapped with insulation. Check to make sure baseboard radiators or heating vents are clear from obstructions such as furniture, rugs, or drapes. Do you have a programmable thermostat? You can use these to reduce energy use by automatically lowering heat levels at night and when no one is home during the day.</td>
<td></td>
</tr>
<tr>
<td><strong>Hot Water System</strong></td>
<td></td>
</tr>
<tr>
<td>If your water heater was bought before 1992, you may want to consider replacing it with a high efficiency unit. The thermostat on your water heater should be set no higher than 120°F—factory-set temperatures may be much higher. Insulating your hot-water tank can reduce energy use. Is hot water use at your home unnecessarily high? Is water left running or do any hot-water faucets drip? If you have a good place in the sun to place a solar collector (such as on a south-facing roof), consider adding a solar hot water heater to lower energy bills even more. Although they take an initial investment to install, they can pay for themselves in lowered energy bills.</td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td>Recommendations</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td><strong>Lighting</strong></td>
<td></td>
</tr>
<tr>
<td>Are lights left on when not needed? How many fixtures have compact florescent light bulbs? The more the better for energy efficiency.</td>
<td></td>
</tr>
<tr>
<td><strong>Refrigerator</strong></td>
<td></td>
</tr>
<tr>
<td>If your refrigerator was bought before 1993, you should consider replacing it. The newest models use as much as one-quarter the energy of older models.</td>
<td></td>
</tr>
<tr>
<td><strong>Dishwasher</strong></td>
<td></td>
</tr>
<tr>
<td>Is the dishwasher always full when it is used? If your dishwasher was bought before 1994, you should consider replacing it. The newest models use much less energy than older models.</td>
<td></td>
</tr>
<tr>
<td><strong>Showerhead</strong></td>
<td></td>
</tr>
<tr>
<td>How fast does your shower fill up a one-gallon bucket? If it's less than 20 seconds, you should consider changing to a new low-flow showerhead.</td>
<td></td>
</tr>
<tr>
<td><strong>Air Conditioner</strong></td>
<td></td>
</tr>
<tr>
<td>How often is this used? If your air conditioner was bought before 1992, you should consider replacing it with a high efficiency unit.</td>
<td></td>
</tr>
</tbody>
</table>
### Home Energy Investigation

<table>
<thead>
<tr>
<th>Investigation</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clothes Washer and Dryer</strong></td>
<td></td>
</tr>
<tr>
<td>If your clothes washer or dryer was bought before 1994, you should consider replacing it with a high efficiency unit.</td>
<td></td>
</tr>
<tr>
<td>The lint filter on the dryer should be cleaned regularly.</td>
<td></td>
</tr>
</tbody>
</table>

**Phantom Loads**  
Many appliances use electricity even when turned off. Examples include appliances with clocks or timers, remote controls, instant-on features and wall cubes (a small box that plugs into an AC outlet to power the appliance). To avoid phantom loads, plug these appliances into a power strip and turn the power strip off when the appliance is not in use.

7. For each of the following, check off what type(s) of heat loss your recommendations, if implemented, would slow down.

<table>
<thead>
<tr>
<th></th>
<th>Conduction</th>
<th>Convection</th>
<th>Radiation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air Leaks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heating System</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot Water System</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Buying Green Electricity In Pennsylvania

One way to reduce the environmental impact of your school, home or community is to purchase electricity that comes from clean, renewable energy sources. Some electricity suppliers sell a product in Pennsylvania that has been certified as “green” by the Green-e certification process (www.green-e.org).

To qualify for certification, 50% or more of the electricity must come from one or more of the following renewable resources: solar, wind, geothermal, biomass, and small or certified low-impact hydro facilities. Electricity products that meet the Green-e Standard for environmental excellence are denoted by the Green-e logo.

In Pennsylvania, it is possible to choose your electricity supplier. If your family wishes to investigate this as an option, you can find more information on electricity products offered by Pennsylvania electrical providers from the following sources:

**Pennsylvania Office of the Consumer Advocate**
www.oca.state.pa.us/Industry/Electric/elecomp/pricecharts.html
Offers a Residential Electric Shopping Guide.

**Clean Your Air**
www.cleanyourair.org
Offers a comparison of clean energy prices in Pennsylvania.

**Power Score Card**
www.powerscorecard.org
Assess the environmental impact of different electricity products offered by Pennsylvania electrical providers.

**The Energy Cooperative**
www.theenergyco-op.com/
The Energy Cooperative has 6,500 members throughout the PECO service territory using a 100% renewable energy product known as Eco Choice 100.

Another way to reduce electricity’s environmental impacts is to help others displace non-renewable energy with new renewable energy generation. You can do this by buying tradable renewable certificates (TRC), or “green tags.”

Production of electricity from renewable energy sources is recognized as having a benefit to society that is worth money. When a renewable energy facility generates electricity, it also generates a monetary benefit to society that is recognized in a
Buying Green Electricity In Pennsylvania

certificate—a TRC—that the power generator can sell. TRCs are valued at the additional cost of producing electricity from renewable sources over non-renewable power sources such as coal, oil, and natural gas. Buying TRCs helps power generators choose to generate power from renewable sources.

Several companies offer TRCs, or “green tags,” for sale in Pennsylvania. TRCs are purchased in addition to one’s regular electricity.

Compared to getting all your electricity from one of the green electricity suppliers above, TRCs can be a little more complicated, but they can be a good option if you can’t afford to get all your energy from green sources but want to purchase inexpensive TRCs to cover a certain share (perhaps 10 or 20%) of your home’s electricity. For example, a block of 100 kilowatt-hours of wind costs an extra $2.50 per month. Companies with Green-e certified tags include:

**Bonneville Environmental Foundation**
www.greentagsusa.org
Bonneville Environmental Foundation offers green tags from wind and solar from sites across the country.

**Community Energy**
www.newwindenergy.com
Community Energy offers green tags from 100% wind energy from sites in Pennsylvania.

**Renewable Choice Energy**
www.renewablechoice.com
Renewable Choice Energy offers green tags from 100% wind energy from sites across the country.

**Sterling Planet**
www.sterlingplanet.com
Sterling Planet offers green tags from solar, wind, biomass, geothermal, and low-impact hydro.
Student Energy Cards

Introduction

Student energy cards will be needed for activities in chapters 2, 3, and 4 and can support activities in Chapter 5. They can also be used for several extension activities.

Making Copies

Make one set of cards for each student team.

Print pages I.15 through I.42 front-to-back onto cardstock. Print graphics (odd page numbers) on the front and text (even page numbers) on the back. Cut each page into four cards using the guide marks on the front—graphic-side—for assistance.

One set of cards can be divided into the following subsets.

Subsets

For activities in Chapter 2 each student team will need the following cards:

<table>
<thead>
<tr>
<th>Common Transportation Choices Set</th>
<th>Renewable Transportation Fuels Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Getting Around</td>
<td>- Processing Soybeans into Biodiesel</td>
</tr>
<tr>
<td>- Increased Ways to Get Around</td>
<td>- Soybeans</td>
</tr>
<tr>
<td>- Fueling Station</td>
<td>- Processing Corn/Sugarcane into Ethanol</td>
</tr>
<tr>
<td>- Processing Crude oil</td>
<td>- Corn or Sugarcane</td>
</tr>
<tr>
<td>- Crude Oil</td>
<td></td>
</tr>
</tbody>
</table>

For activities in Chapter 3 each student team will need the following cards:

<table>
<thead>
<tr>
<th>Electricity Set</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Tasks Done By Appliances</td>
<td>- Oil-fired Power Plant</td>
</tr>
<tr>
<td>- Lighting</td>
<td>- Processing Crude Oil</td>
</tr>
<tr>
<td>- Electric Power Lines</td>
<td>- Crude Oil</td>
</tr>
<tr>
<td>- Coal-fired power Plant</td>
<td>- Hydro-power</td>
</tr>
<tr>
<td>- Processing Coal</td>
<td>- Moving Water</td>
</tr>
<tr>
<td>- Coal</td>
<td>- Wood-fired Power Plant</td>
</tr>
<tr>
<td>- Nuclear Power Plant</td>
<td>- Processing Wood</td>
</tr>
<tr>
<td>- Processing Uranium Ore</td>
<td>- Wood</td>
</tr>
<tr>
<td>- Uranium Ore</td>
<td>- Wind-power</td>
</tr>
<tr>
<td>- Natural Gas-fired Power Plant</td>
<td>- Wind</td>
</tr>
<tr>
<td>- Processing Natural Gas</td>
<td>- Solar-electric</td>
</tr>
<tr>
<td>- Natural Gas</td>
<td>- Solar</td>
</tr>
</tbody>
</table>

For activities in Chapter 4, each student team will need one of the following two sets of cards:

A Warm Home Set

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- A Warm Home</td>
<td>- Crude Oil</td>
</tr>
<tr>
<td>- Processing Natural Gas</td>
<td>- Processing Wood</td>
</tr>
<tr>
<td>- Natural Gas</td>
<td>- Wood</td>
</tr>
<tr>
<td>- Electric Power Lines</td>
<td>- Solar Space Heat</td>
</tr>
<tr>
<td>- Processing Crude Oil</td>
<td>- Solar</td>
</tr>
</tbody>
</table>
**Energy Cards**

**I.12  Energy Cards**

<table>
<thead>
<tr>
<th>Hot Water Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Hot Water</td>
</tr>
<tr>
<td>- Processing Natural Gas</td>
</tr>
<tr>
<td>- Natural Gas</td>
</tr>
<tr>
<td>- Electric Power Lines</td>
</tr>
<tr>
<td>- Crude Oil</td>
</tr>
<tr>
<td>- Solar Hot Water</td>
</tr>
<tr>
<td>- Solar</td>
</tr>
</tbody>
</table>

**Student Energy Cards In Use**

The energy cards provide an interactive and structured way for students to research energy systems. After using these cards, students will be able to identify energy inputs (natural resources), energy processes, wanted and unwanted outputs, and ideas on how to reduce unwanted effects of our energy use.

**Symbols**

Each card is identified with one of the following energy system symbols.

```
<table>
<thead>
<tr>
<th>goal</th>
<th>input</th>
<th>process</th>
</tr>
</thead>
</table>
```

The back of the cards includes information on energy system *outputs* and *feedback* ideas for student discussion but students should be encouraged to add their own information and ideas.

**Energy Chains to show Energy Processes**

In chapters 2, 3, and 4, students use the cards to build energy chains. Working from right to left they start with a specific goal or end use, (such as *A Warm Home*, or *Tasks Done by Appliances*) and work back to the energy resource(s) (such as *Crude Oil* or *Solar*).

Each card lists other card(s) it can link to. The last card in any chain will depict a natural resource that humans extract or gather and use to produce energy. This is the end of the chain and these cards do not list another card to link to. They do, instead, describe the source of energy for the natural resource.

See Figure 1 for an example that starts with the *Getting Around* card.

Students refer to the graphics on each card and record the chain of energy *processes* that takes place from natural resource to end use.

**Energy Inputs**

The last cards in each chain (cards on the left end) depict the energy resource *inputs*. In Figure 1, these are crude oil, corn or sugarcane, and soybeans.

**Outputs and Feedback**

On the back of each card is information for students to bring to class discussions and use in work assignments. This includes where each resource comes from, how much of each resource is used in Pennsylvania, impacts that each energy process has on humans and the environment, and some suggestions for reducing unwanted impacts. *This information is just a starting place and students should be encouraged to add their own information and ideas to any discussion.*
Energy cards can be used to both deepen and expand student knowledge of energy technologies and energy issues. Here are a few extension activities to consider.

**Renewable vs. Non-renewable**
Let students know that some energy resources are known as renewable and others as non-renewable. Have students look at the “Speed of Re-supply” listed on each natural energy (input) card. Then have...
students discuss how they would categorize each resource. Make sure to ask for their reasoning and to clarify their understanding of what energy resources are renewable and non-renewable.

**Energy Transformations**
All energy process cards and some energy resource cards list the initial and final form of useful energy in the energy process. For instance, the coal-fired power plant card shows that the energy started as chemical energy (coal) and ended up as electrical energy (electricity).

These cards can be used as a starting point for more detailed discussions on energy transformations, energy efficiency, and waste energy. Using the same example again, coal is burned (chemical to heat energy), which causes steam to turn a turbine blade (heat to mechanical energy), which in-turn turns a generator (mechanical to mechanical energy), which finally generates electricity (mechanical to electrical energy). Each of these processes produces some waste energy.

**Energy Resource Jeopardy**
Natural energy resource (input) cards can be used in a Jeopardy-style game. The descriptions on the back of these cards do not mention the resource itself. A student can read part or all of a description to other students in a competition to see who can be first to determine which resource is being described. The following Energy Cards can be used for this activity.

- Coal
- Corn or Sugarcane
- Crude Oil
- Moving Water
- Natural Gas
- Solar
- Soybeans
- Uranium
- Wind
- Wood

**Student Research**
Students can create new energy cards on topics not covered by these cards. For instance, fuel cells, hydrogen as an energy carrier, and energy used for manufacturing are not covered. Students may think of other topics as well. Identifying what information is needed to make a card can provide students and the teacher with a framework for research and presentation.
CRUDE OIL

Initial Energy Form: Radiant
Final Energy Form: Chemical

Processing CRUDE OIL

Initial Energy Form: Chemical
Final Energy Form: Chemical

Speed of Re-supply: Millions of Years

Link to: CRUDE OIL

CRUDE OIL

Initial Energy Form: Radiant
Final Energy Form: Chemical

Processing CRUDE OIL

Initial Energy Form: Chemical
Final Energy Form: Chemical

Speed of Re-supply: Millions of Years

Link to: CRUDE OIL
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. 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.

Changing crude oil into other products and transporting these products produces air and water pollution. Because of this, governments monitor these activities to make sure they meet environmental standards.

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.

In 1859, the world’s first commercial well to recover this energy resource was drilled in Pennsylvania. Today, nearly all of this resource is gone from Pennsylvania and total proven deposits in the U. S. are shrinking. In 2005, the U. S. needed to import almost two-thirds of this energy resource from other countries.
Initial Energy Form | Final Energy Form
---|---
Radiant | Chemical

Speed of Re-supply
Millions of Years

Link to:
CRUDE OIL

---

Initial Energy Form | Final Energy Form
---|---
Chemical | Chemical

Link to:
CRUDE OIL
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Natural gas is pumped from deep underground and is piped through high-pressure pipelines to power plants, homes, and factories. 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 carry natural gas to about two-thirds of Pennsylvania’s households to use for heat, cooking, and hot water. Pennsylvania produces only a small fraction (one-twentieth or five percent) of its electricity from natural gas. Some buses and cars 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. Pennsylvania has significant quantities of this resource.
Initial Energy Form | Final Energy Form
---|---
Radiant | Chemical
Chemical | Chemical

Speed of Re-supply: Millions of Years

Link to: NATURAL GAS
Natural gas is pumped from deep underground and is piped through high-pressure pipelines to power plants, homes, and factories. 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.

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**COAL**

<table>
<thead>
<tr>
<th>Initial Energy Form</th>
<th>Final Energy Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiant</td>
<td>Chemical</td>
</tr>
</tbody>
</table>

Speed of Re-supply: Millions of Years

Link to: COAL

**URANIUM ORE**

<table>
<thead>
<tr>
<th>Initial Energy Form</th>
<th>Final Energy Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>Nuclear</td>
</tr>
</tbody>
</table>

Speed of Re-supply: No more is being formed

Link to: URANIUM ORE

**PROCESSING COAL**

**PROCESSING URANIUM ORE**
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 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. Pennsylvania has 260 mines that produce enough of this energy resource to meet the demand of three average-sized states.

Uranium ore is mined, transported, and processed into ceramic fuel pellets for use in nuclear power plants. Each pellet is about the size of a fingertip and produces the same amount of energy as 150 gallons of oil.

Mining and processing uranium ore into nuclear fuel requires energy and produces low-level radioactive waste. Trucks and trains are used to transport uranium ore and nuclear fuel.

This energy resource is a metal and is one of the few energy resources that does not obtain its energy from the sun. Instead, energy in this natural resource is held by its atoms and is released when humans split those atoms.

This resource is found throughout the world. Most of what is used in the United States, including Pennsylvania, comes from mines in the western United States. The only high-grade deposits are in Canada.

All high-level radioactive products and wastes must be shipped in special shipping casks that have been tested to withstand severe traffic accidents. These tests include engulfment in fire for 30 minutes and submersion under 50 feet of water. Despite these requirements, some people argue that bad enough accidents could still release highly dangerous levels of radioactivity.
Initial Energy Form | Final Energy Form
--- | ---
Radiant | Chemical

Speed of Re-supply
Decades

Link to:
WOOD

Initial Energy Form | Final Energy Form
--- | ---
Chemical | Chemical

Initial Energy Form | Final Energy Form
--- | ---
Chemical | Chemical

Speed of Re-supply
Decades

Link to:
WOOD
Most of the trees harvested (cut down) in Pennsylvania are trucked to lumber yards and manufacturing plants and processed into wood products. Some wood is cut for firewood for use in home wood stoves and some is cut and ground into chips to be burned in electric power plants. Waste sawdust can be turned into wood pellets for use in home pellet-burning stoves.

Cutting down and processing wood results in wood waste such as sawdust, scrap lumber, and small branches. Many manufacturers of wood products burn this wood waste for heat or electricity.

In Pennsylvania, one out of five trees cut for energy production is burned in home wood stoves, two out of five are used by industry and two out of five are used to make electricity.

The energy stored in this natural resource comes from the sun. Plants use sunlight to convert air and water into leaves, branches, roots, and other plant structures. In this way, all plants store the energy they receive from sunlight as chemical energy.

The plants that produce this natural resource take several decades to grow. Although people use this energy resource to heat homes and make electricity, people also use this natural resource for many other things.

The largest quantities of this energy resource are found in forests. Over half of Pennsylvania is forested and an estimated half of that land is available for harvesting this natural resource.
**MOVING WATER**

**Initial Energy Form**
Radiant

**Final Energy Form**
Gravitational (Potential)

**Speed of Re-supply**
Daily

**HYDROPOWER**

**Initial Energy Form**
Gravitational

**Final Energy Form**
Electrical

**Link to:**
MOVING WATER

**WIND**

**Initial Energy Form**
Radiant

**Final Energy Form**
Mechanical (Kinetic)

**Speed of Re-supply**
Daily

**WIND-POWER**

**Initial Energy Form**
Mechanical

**Final Energy Form**
Electrical

**Link to:**
WIND
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. Less than one-fiftieth (or two percent) of electricity produced in Pennsylvania is generated with hydroelectric power.

Most often, this natural resource receives its energy from the sun when evaporation and convection lift 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 Pennsylvania, the Allegheny, Beaver, Delaware, Monongahela, Ohio Main Stream, and Susquehanna River basins all could provide a significant amount of energy from this natural resource, more than is currently being used.

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 100 to 150 meters tall (including their blades). Some people object to wind farms if they intrude on the wilderness feel of forested ridge tops. Also, spinning blades have killed bats and birds, although newer turbine designs and closely evaluating wind-farm placement has almost eliminated this.

Wind power is the fastest growing source of electricity in the U. S. and in the world. This is largely because it costs about the same as other sources of electricity and it produces no global warming gases or other pollutants. In 2004, less than one percent of electricity produced in Pennsylvania was generated by wind.

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).

Pennsylvania has good to excellent supplies of this natural resource on ridge tops in the southwestern and northeastern parts of the state.
**COAL-FIRED POWER PLANT**

Initial Energy Form: Chemical
Final Energy Form: Electrical

Link to: PROCESSING COAL

**NUCLEAR POWER PLANT**

Initial Energy Form: Nuclear
Final Energy Form: Electrical

Link to: PROCESSING URANIUM ORE

**OIL-FIRED POWER PLANT**

Initial Energy Form: Chemical
Final Energy Form: Electrical

Link to: PROCESSING CRUDE OIL

**NATURAL GAS-FIRED POWER PLANT**

Initial Energy Form: Chemical
Final Energy Form: Electrical

Link to: PROCESSING NATURAL GAS
Nuclear power plants do not produce global warming gases or pollutants that lead to acid rain. They do, however, release small amounts of radioactive particles into the atmosphere and produce highly radioactive waste that must be stored safely for thousands of years.

If a plant’s many safety features fail and the uranium fuel pellets melt, massive quantities of radiation can be released to the environment. A meltdown has only happened once in the U. S. at the Three Mile Island plant near Middletown, PA. Although significant amounts of radiation were released during that accident, the worst-case situation was avoided.

Pennsylvania has five nuclear power plants with nine reactors that produce a little more than one-third of the electricity in the state. Pennsylvania ranks second among the fifty states in nuclear capacity.

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.

A small fraction (one-twentieth or five percent) of the electricity produced in Pennsylvania comes from burning natural gas.

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.

Over one-half of the electricity produced in Pennsylvania comes from burning coal.

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.

Only a very small fraction (one-fiftieth or two percent) of the electricity produced in Pennsylvania comes from burning oil.
**WOOD-FIRED POWER PLANT**

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

*Link to:*  
PROCESSING WOOD

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**ELECTRIC POWER LINES**

*Link to any or all of the following power plants:*
COAL-FIRED • NUCLEAR • NATURAL GAS-FIRED • OIL-FIRED • HYDROPOWER • WIND-POWER • WOOD-FIRED • SOLAR-ELECTRIC
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.

In general, wood-fired power plants produce more air pollution than natural gas, but much less than coal. If wood-burning plants burn scrap lumber that contains paint or metals, they can emit hazardous chemicals into the atmosphere.

Although wood-fired power plants do give off greenhouse gasses, they do not increase the amount of greenhouse gases in the atmosphere. This is because trees absorb greenhouse gases from the atmosphere as they grow. Trees, as they grow, remove as much greenhouse gases from the atmosphere as is released when they are burned.

Pennsylvania produces less than one percent of its electricity from wood.
Energy Form: Radiant

Speed of Re-supply: Daily
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 Pennsylvania occurs when the northern hemisphere is tilted toward this resource. Because of this, 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, Pennsylvania and the northeast states receive plenty of this resource to use for energy.

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.

Less than one percent of electricity produced in Pennsylvania 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 Pennsylvania occurs when the northern hemisphere is tilted toward this resource. Because of this, 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, Pennsylvania and the northeast states receive plenty of this resource to use for energy.
CORN OR SUGARCANE

PROCESSING CORN/SUGARCANE INTO ETHANOL

SOYBEANS

PROCESSING SOYBEANS INTO BIODIESEL

Initial Energy Form
Radiant

Final Energy Form
Chemical

Speed of Re-supply
Annual

Link to:
CORN OR SUGARCANE

Initial Energy Form
Chemical

Final Energy Form
Chemical

Link to:
SOYBEANS
Plant sugars and fibers can be converted to ethanol, a clean-burning alcohol that can be used to power cars. Processing plant sugars and fibers into ethanol and transporting ethanol to the market requires energy and produces some pollution and greenhouse gases.

Most ethanol made in the U. S. is made from corn sugars. Growing corn uses lots of energy and fossil fuels. This produces lots of greenhouse gases and pollution, which greatly reduces the environmental benefits of using ethanol made from corn.

Ethanol made in other countries, such as Brazil, is made from sugarcane and U. S. scientists are trying to make ethanol from switch grass. Both of these plants take far less energy and fossil fuels to grow than corn; so there are more environmental benefits to using ethanol made from sugarcane or switch grass than from corn.

Vegetable oils can be converted to biodiesel, a fuel that can be used in most diesel vehicles. Processing plant oils into biodiesel and transporting biodiesel to the market requires energy and produces some pollution and greenhouse gases.

Most biodiesel made in the U. S. is made from soybean oil. To grow soybeans, farmers use energy and fossil fuels to plant and harvest the beans. This produces greenhouse gases and pollution. Even so, using biodiesel instead of regular diesel greatly reduces the amount of greenhouse gases added to the atmosphere and burning biodiesel produces fewer pollutants than burning regular diesel.

This energy resource comes from a farm. It uses sunlight to convert air and water into leaves, branches, roots, and other plant structures—such as sugars. In doing so, it absorbs greenhouse gases from the atmosphere and stores sunlight as chemical energy.

Humans can use plant sugars to make a form of fuel that can be used in many cars, trucks, and tractors. Burning this fuel is much cleaner than burning gasoline and gives off no more greenhouse gases than the plants absorbed while they grew. Therefore, burning this fuel adds no new greenhouse gases to the atmosphere.

Unfortunately, in the U. S., growing the plants most often used to make this fuel uses lots of energy and fossil fuels. This does produce lots of greenhouse gases and pollution, which greatly reduces the environmental benefits of this type of fuel.

This energy resource comes from a farm. It uses sunlight to convert air and water into leaves, branches, roots, and other plant structures—such as oils. In doing so, it absorbs greenhouse gases from the atmosphere and stores sunlight as chemical energy.

In the U. S., humans use the oils in this plant to make a form of fuel that can be used in diesel cars, trucks, and tractors. This fuel produces less pollution when burned than regular diesel fuel and gives off no more greenhouse gases than the plants absorbed while they grew. Therefore, burning this fuel adds no new greenhouse gases to the atmosphere.

Most farmers use fossil fuels to power farm equipment used to grow this resource, so growing this resource does produce some greenhouse gases and pollution.
WARM HOME

Link to any or all of the following:
PROCESSING NATURAL GAS • ELECTRIC POWER LINES • PROCESSING CRUDE OIL • PROCESSING WOOD • SOLAR SPACE HEAT

HOT WATER

Link to any or all of the following:
PROCESSING NATURAL GAS • ELECTRIC POWER LINES • PROCESSING CRUDE OIL • SOLAR HOT WATER

TASKS DONE BY APPLIANCES

Link to:
ELECTRIC POWER LINES
SOLAR-ELECTRIC

LIGHTING

Link to:
ELECTRIC POWER LINES
SOLAR
SOLAR-ELECTRIC
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.

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.

Appliances used for heating or cooling—such as refrigerators, air conditioners or clothes dryers—require the most electricity to run. 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 turned off. Examples include appliances with clocks or timers, remote controls, instant-on features, and wall cubes (a small box that plugs into an AC outlet). 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.
FUELING STATION

Link to:
PROCESSING CRUDE OIL • PROCESSING SOYBEANS INTO BIODIESEL • PROCESSING CORN/SUGARCANE INTO ETHANOL

GETTING AROUND

Link to:
FUELING STATION

INCREASED WAYS TO GET AROUND

Attach to the GETTING AROUND card to increase your choices.

Link to:
FUELING STATION
ELECTRIC POWER LINES
PROCESSING NATURAL GAS
Americans use as much energy getting around in family cars and trucks as they do for all other household activities combined. America’s family cars discharge millions of tons of hazardous gases and particles into the air every year making transportation a major contributor to air pollution and global warming.

Different automobiles can burn vastly different amounts of gasoline and produce different amounts of pollution for every mile they travel. In general, vehicles that are lighter, have a streamlined shape, and have efficient engines burn less gasoline and produce less pollution.

The most common form of automobile fuel used today is gasoline. Because of this, we call stations where people fill up their car or truck’s fuel tank, gas stations. Many gas stations also sell diesel fuel and some are selling biodiesel, ethanol, or a blend of fuels.

Handling fuels of any kind can cause pollution. In total, more oil is washed into the oceans from day-to-day automobile use than is spilled by large tanker ships—including major oil spills.

In addition, gasoline vapors evaporate and gasoline can spill while filling up a vehicle’s gas tank. Cars and trucks leak oils and other petroleum products onto roadways and parking lots. Eventually, rain and snow wash the gasoline vapors out of the atmosphere and wash spilled gasoline and oil from roads and parking lots into rivers, lakes, and oceans.

Most of the U.S.’s current transportation pathways are designed solely to move cars and trucks. This can limit people’s choices on how to get around.

Other ways to get around include trains, buses, bicycles, and walking. All of these use less fuel and produce less pollution per person than do cars and trucks. Many communities are now building bikeways and walking paths to give people more choices on how to get around.

Scientists and engineers are also looking for different ways to power cars, trucks, and buses. One idea is to use hydrogen gas, which can either be made from water using electricity or can be extracted from fossil fuels or minerals. Another idea is to run cars on electricity using rechargeable batteries. Still other ideas are to use natural gas or use fuels made from plants. What do you think?
**SOLAR HOT WATER**
Attach to a HOT WATER card.

Initial Energy Form: Radiant
Final Energy Form: Heat

Link to: SOLAR

**SOLAR SPACE HEAT**
Attach to a WARM HOME card.

Initial Energy Form: Radiant
Final Energy Form: Heat

Link to: SOLAR
Building designers can use radiant solar energy to help heat a building. If they do so, they can install a much smaller and less expensive heating system that will burn less fuel and create less pollution and global warming gases.

To do this, designers place more windows on the south side of a building and less on the north side. They also use high-quality insulating windows and insulate the building well. To keep the building from overheating in the summer, builders build outside overhangs above the windows to block sunlight in the summer but still allow it to enter in the winter.

Although clouds can block sunlight for several days in a row in Pennsylvania, the sun can still be used to greatly reduce the amount of other more costly and more polluting energy resources needed to keep a building warm.

Sunlight can be used to heat water using solar hot water panels that are often mounted on the roof of a building. This system produce no global warming gases or other air pollutants and the energy resource is free.

During the day, the solar hot-water panels can get quite warm. The heat that they collect is piped to a hot water storage tank where it is used to heat water.

In Pennsylvania, where clouds can block the sun for several days in a row, people often combine a solar hot water system with other heating systems to ensure they always have hot water. In this way, they can greatly reduce the amount of other more costly and more polluting energy resources used.