Step 1

Discover how trees conserve energy

BASIC ACTIVITY

Classroom Activity:

- **Design an Energy Wise Community Using Trees**

Objectives:

Students will be able to:

- **describe several ways appropriately placed and planted trees can conserve energy**
- **demonstrate best planting locations for different types of trees to conserve or produce energy**

Time Recommended:

- **One 60 minute or two 30 minute class periods**

Materials Needed:

- **Fan**
- **Water in mist bottle or bucket**
- **2 thermometers (optional)**
- **11" x 17" or larger sheet of paper and pencils (one per child or group)**
- **Handout of *Rubric and Vocabulary* on page 13**
- **Photocopies of the *Planting Trees for Energy Conservation Handout* (one per student or group) on pages 14 and 15**

National Science Education Standards Correlation:

As a result of the activity, students should develop an understanding of:

- **populations, resources, and environments**
- **diversity and adaptations of organisms**
- **designing a solution or product in light of information at hand**

National Social Studies Education Standards Correlation:

As a result of the activity students should be able to:

- **explore the causes, consequences and possible solutions to persistent, contemporary, and emerging issues (Global Connections)**

Teacher Background Information:

Trees are widely appreciated for the bountiful products they produce and the beauty they contribute to our environment, but they also provide many conservation benefits as well.

Trees' roots grip and hold the topsoil, slowing runoff and reducing erosion and water pollution. Leafy tree canopies conserve moisture, slow the wind, keep the air clean, help quiet loud traffic noises, and provide shade from the hot summer sun. They also create a welcome home for birds and wildlife.

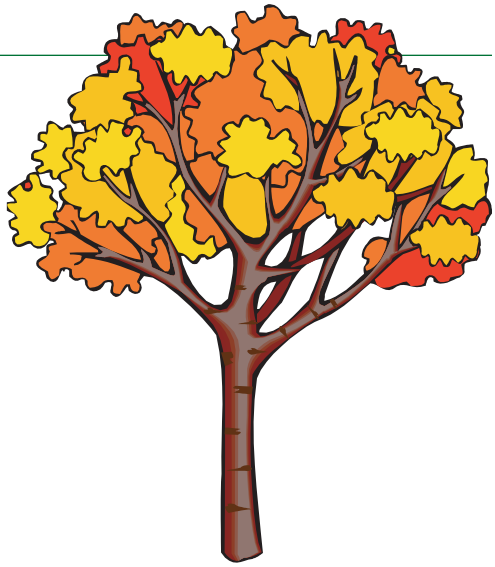
One thing people don't always realize, though, is that trees are vital for converting and producing energy for human use, as well as conserving energy when properly placed in the landscape.

Energy is defined as the ability to do work; it powers everything in nature. Energy warms and cools our homes, fuels our cars, powers our TVs and DVD players, and runs our manufacturing plants. It takes energy for us to walk, talk, digest our food, and even breath.

Many different sources of energy exist. Some sources are **nonrenewable**, such as fossil fuels like coal, oil, and natural gas. Once the supply of a fossil fuel has been depleted, it is gone forever. Some energy sources are **renewable** – like wind, sun, water, trees, and plants. These are energy sources that can be replenished through natural processes or careful management. Energy that comes from plants, like trees, is considered **biomass**. It is renewable as long as new trees or plants are planted.

Some of this information is included in the student handouts, but additional information is provided here for you to include as a part of the classroom discussion as you go through the handouts with students as time allows.

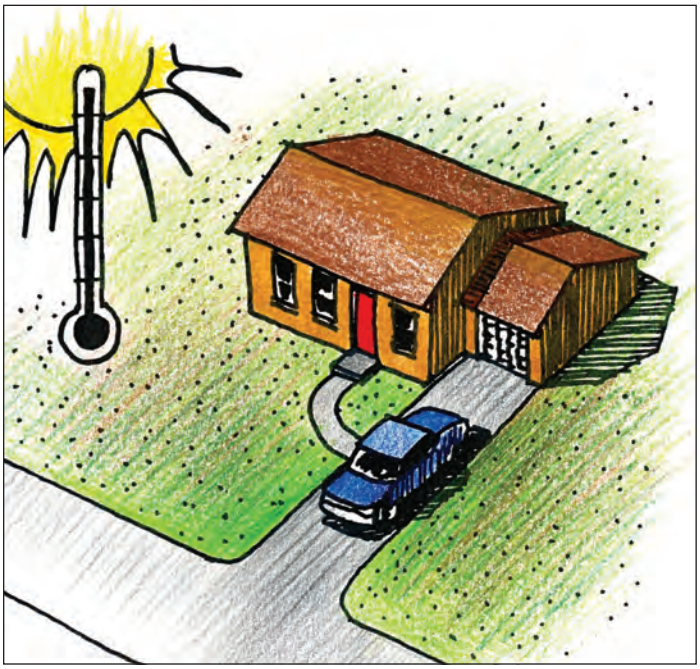
Concept: Trees Can Help Conserve Energy



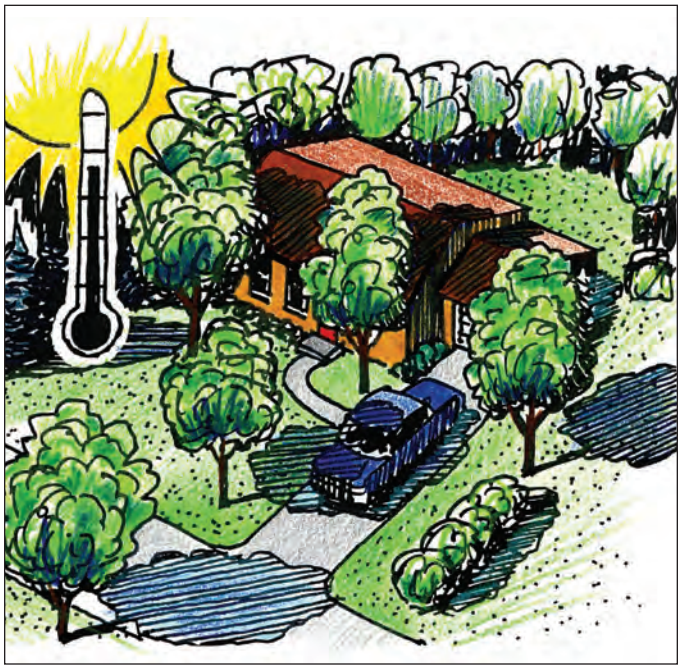
Most people living in cities and towns don't have enough available land to grow their own individual biomass plantations to **produce energy**. Biomass is a homegrown source of energy. Wood, animal waste, crops, and even garbage can be used as a biomass energy source. Agricultural biomass crops like corn and soybeans can be burned directly or turned into other liquid fuels. However, by properly locating and planting a few trees around their home, people can **conserve energy**, lessen the use of nonrenewable fossil fuels, save money, increase property value, and help the environment. Proper landscaping with trees and shrubs is often the best long-term investment for reducing heating and cooling costs while also bringing improvements to the home and the community. Planting trees that incorporate practices from the three Guidelines described below can have a significant impact on conserving energy resources and money.

GUIDELINE 1: Plant Trees to Shade Your Home

Carefully positioned trees can save up to 25% of a household's energy needs for heating and cooling. According to the U.S. Department of Energy, this can save the average household between $100 and $250 in energy costs each year. What could your family do for fun with the money saved from cutting energy costs?



A lack of trees around houses means less comfort and higher energy costs.



Carefully planned trees annually save money and add comfort to a home.

The most energy savings and the best use of shade generally come from **deciduous, broadleaf trees** planted about 10 to 20 feet from the walls to the west, east, or northwest of the house, depending on species. These trees shade the house and air conditioning unit during the summer, reducing the energy needed for air conditioning and increasing the efficiency of the unit by as much as 10%. When they lose their leaves in the winter, trees correctly planted allow the sun to reach and warm the houses, making maximum use of winter solar heat, and thus saving energy for heating.

Because the sun is more directly overhead at midday during the summer months, planting shade trees on the south is discouraged. Trees on the south will not shade the house unless planted very close to it and they will make unwanted shade in the winter when the sun is at a lower angle. Trees planted to the south of a home may also block beneficial summer breezes.

Broadleaf trees have leaves that are flat and thin. They are usually deciduous, shedding their leaves annually. Oak, ash, and maple are several examples of broadleaf trees. Broadleaf trees generally provide the best summer shade.

Deciduous, Broadleaf Tree

In Summer **In Winter**

Select broadleaf species trees that are right for your site considerations.

Because the sun is more directly overhead in summer, trees planted on the south will not provide shade unless planted very close. Trees planted on the south also block beneficial summer breezes. Trees planted on the east, west, and northwest sides of a house provide the best shade during the summer mornings and afternoons.

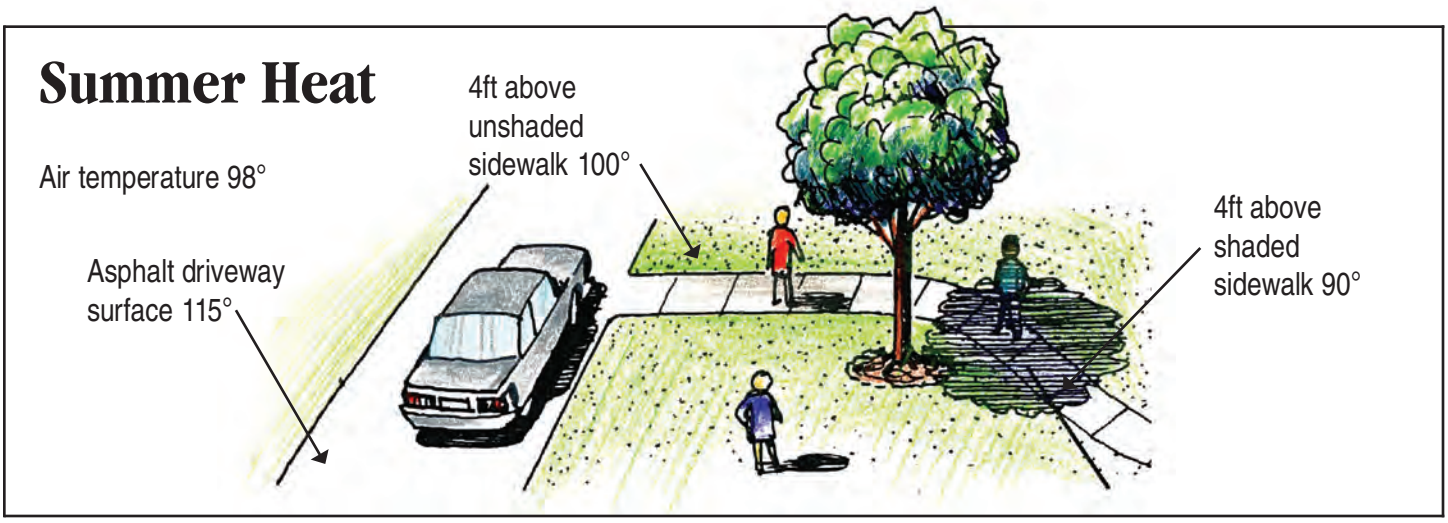
Summer

In the winter, trees planted on the south side of a house may produce unwanted shade. Trees planted on the east, west and northwest sides minimize unwanted winter shade.

Winter

GUIDELINE 2:
Plant Trees to Shade Paved Areas

Trees shading paved areas, like driveways and asphalt parking lots, will greatly decrease surface heat. In the summer, a city with trees shading paved areas can be 12 degrees cooler than one without trees.



Cities with unshaded stretches of concrete streets and parking lots are sometimes referred to as "heat islands" that are 5-12 degrees hotter than surrounding areas. Planting trees on rooftop gardens in these areas helps alleviate the heat island effect – which saves both energy and money.

The net cooling effect of a young, healthy tree is equivalent to ten room-sized air conditioners operating 20 hours a day. In the process of **transpiration**, water escapes from small openings in a tree's leaves. This water evaporates in hot weather. The evaporated moisture cools the air around the tree. Since cool air is heavier than hot air, this cool air moves toward the ground making us feel cooler. (The evaporation activity you may choose to do with your students on p.12, Step 5, illustrates how this works.)

Heat Island Effect

If it seems hotter downtown than in the suburbs, and cooler in the park than in your backyard, it is not simply your imagination. Cities are heat islands – zones of summer air temperatures that can be as much as 12 degrees Fahrenheit higher than surrounding areas.

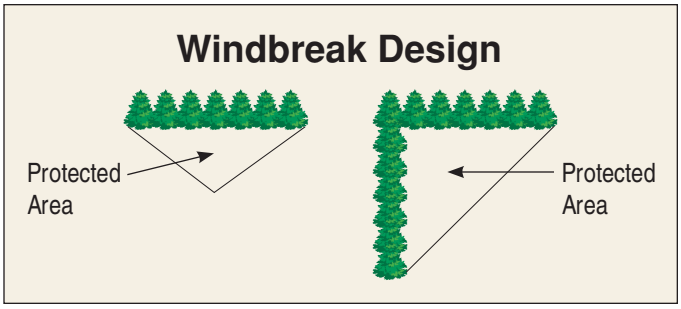
GUIDELINE 3:
Plant Trees as Protection from Hot or Cold Winds

Windbreaks are barriers used to reduce and redirect wind. Planting a windbreak around a home can provide an energy savings of up to 30 percent and reduce blowing snow, noise, and dust. Since most homes in the United States are heated by natural gas or electricity generated from burning coal, this energy savings means a reduction in fossil fuel use as well.

An effective windbreak should be planted at a right angle (perpendicular) to **prevailing winds**. In the southern United States, hot, drying winds can erode soil and increase energy demands for cooling. Hot winds often come from the south or southwest, so an effective windbreak would be planted to the south and/or west of the home or housing development. In the northern United States, bitter cold winds can dramatically increase heating costs. Winter winds are often from the north or northwest, so an effective windbreak would be planted to the north and/or west of the home or housing development.

Since winds vary, multiple legs of windbreaks, or windbreak systems often provide the best protection and greatest energy savings.

Evergreen conifers with branches close to the ground form the best windbreaks. Pine, red cedar, and Douglasfir are species often used in windbreak plantings. Choose trees adapted to your region.

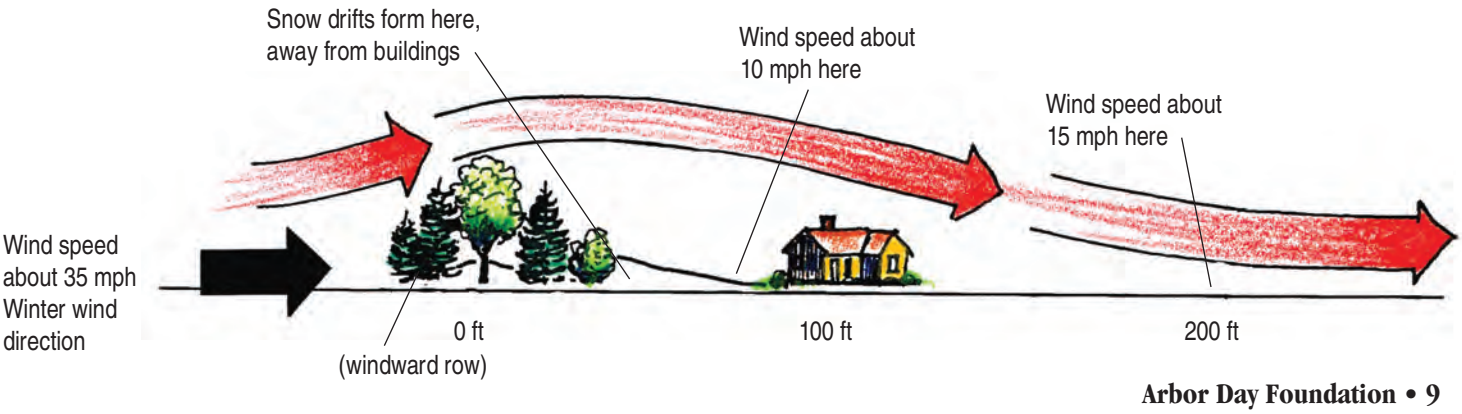


Two-sided windbreaks offer protection over a larger area for greater energy conservation.

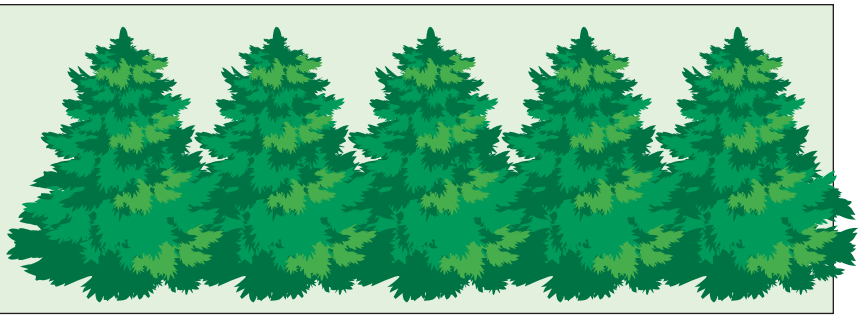
The effectiveness of the windbreak also depends on the density of the windbreak and its height. Three or more continuous rows of trees in staggered formation provide the best wind protection, but even a single row of trees will have an effect. Trees, bushes, and shrubs are often planted together to better block the wind from ground level to the treetops. The tallest row of trees is often planted in the center. Trees should be planted fairly close together. Spacing between rows should be about 12 feet.

Windbreaks offer protection for a distance of up to 8 to 10 times the height of the mature trees. Snow and stagnant air can collect in the area directly behind a windbreak so, in regions that receive lots of snow, buildings to be protected should be located no closer than 100 feet from the windward row (front row facing the wind). A good rule of thumb is that the area to be protected should be within a downwind distance of 2 to 5 times the expected height of the tallest windbreak row. (For planning purposes, 20 feet is often used as the height of the tallest trees.)

If open wind speed is 35 miles per hour (mph), the windbreak reduces wind speed to:

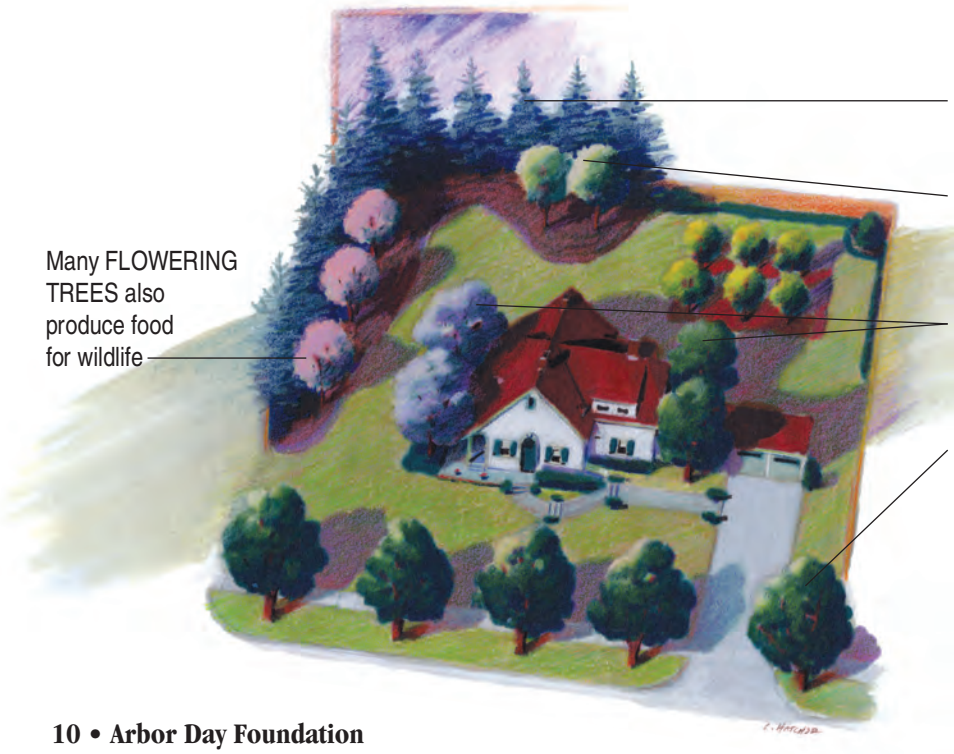


Conifers bear cones and have needle-like or scale-like leaves. Most conifers are evergreens since they do not lose all their leaves at once. Pines, firs, cedars, and spruces are conifers. Conifers generally provide the most effective buffer in windbreaks.



The greater the number of trees in a neighborhood, the more effective the trees are in reducing the wind. New housing developments benefit from windbreak plantings that border the neighborhood.

A well-placed windbreak can protect several homes or an entire development from chilling winter winds and drifting snow.



An Energy Wise example of trees well-planted around a home that incorporates all three guidelines.

Activity
Instructional Sequence

Step 1. Begin by asking students what comes to mind when they hear the word "tree." Record responses on the board without comment. Remind students of additional things trees do for the environment, if they are not already listed, then continue discussion by asking if energy should also be included on the list. After student discussion, explain that trees are vital for converting and producing energy for human use, as well as conserving energy when properly placed in the landscape.

Step 2. Write the words "**renewable energy**" and "**non-renewable energy**" on the board. Have students think of sources of energy and work together to determine into which of the two categories each energy source falls. Tell them that most of the energy used today for transportation and in factories, offices, and homes comes from fossil fuels. Fossil fuels such as coal, oil, and natural gas take millions of years to form and are nonrenewable. Sun, wind, trees, and water are renewable energy resources because supplies are not limited and with proper management we can always grow trees.

Step 3. Pass out the two-page *Tree Planting for Energy Conservation Guidelines Handout* (pg 14 & 15). Explain that this Handout has three important guidelines. Each guideline describes both what they should know and what they can do to conserve energy by planting trees in specific locations. They will need to understand this information to do the activity. As you review each of the energy conservation guidelines, incorporate additional material provided in the Background Information section into the discussion.

Step 4. Start with Guideline #1: Plant Trees to Shade Your Home.

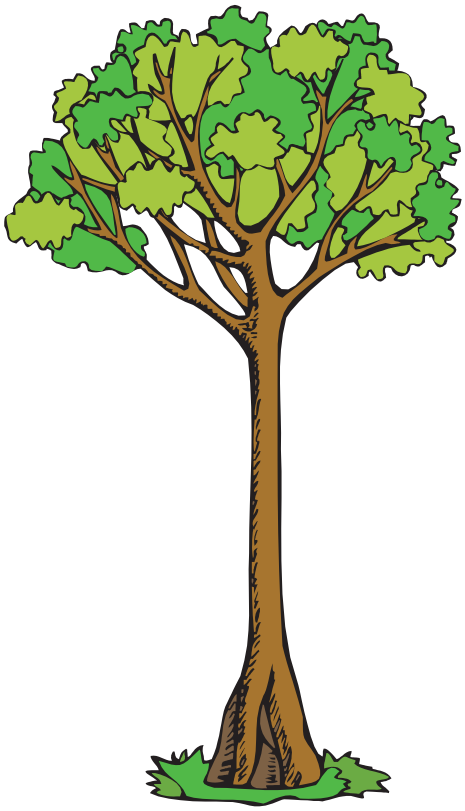
Ask … *Look at the thermometer on the two top pictures.*
Which home is cooler?
Why do you think that is?
Which home looks more appealing to live in?

Review the "*What you should know*" information in Guideline #1.

Ask …*Now look at the bottom two pictures in this section. If you know that north is marked at the top of each picture, which sides of the house are the trees planted on?*

Draw a compass on the board with the cardinal directions (north, south, east, and west) to help students gain orientation. Then review the "*What you can do*" information with students, referring to the visual examples as you go through the text.

When you get to the term "deciduous, broadleaf trees" direct student attention to the illustration examples of broadleaves and conifers. *Ask students to comment on the trees' differences. Ask what kinds of trees they see around their school? In their neighborhood?* Explain that both kinds of trees play important roles in creating an ENERGY WISE community.



Step 5. Explain that trees not only provide shade from the sun, they also **transpire** (release water vapor) through their leaves. This is an additional cooling benefit. Tell them you'll show them how this works. Have students line up and file by the bucket of water. Ask each student to dip just one hand in the water to wet it, then hold both hands briefly in front of the fan. After all children have tried this, ask which hand felt cooler. Explain that the warmth of your skin and the air from the fan caused the water to evaporate. That process cools your skin. Nature uses evaporative cooling everyday. When we sweat, our perspiration evaporates, cooling us off. When a tree transpires, releasing moisture, that moisture evaporates, cooling the air. Tell students that the net cooling effect of just one young, healthy tree is equivalent to ten room-sized air conditioners operating 20 hours a day. Amazing!

Step 6. Introduce Guideline #2: Plant Trees to Shade Paved Areas

Review the content. *Ask students what temperature differences they notice in the different areas of the illustration*. You might wish to add information about heat islands from the background information.

If the sun is out, have students go outside and measure the temperature difference between the sidewalk areas and the area in the shade. Discuss results.

Step 7. Introduce Guideline # 3: Plant Trees as Protection from Hot or Cold Winds.

To illustrate how a windbreak works, have one student stand about 8 feet from the fan and ask if he or she can feel the air movement. Then have other students come up and stand as a windbreak between the first student and the fan. Ask the first student the difference he or she feels. *Ask students what direction the prevailing winds come from in their area…in the summer and in the winter.*

See a great teacher idea at www.arborday.org/teacheridea.

Step 8: The Activity

Determine if you wish to have students work individually or in small groups. Pass out the *Vocabulary and Assessment Rubric Handout* and review with students (page 13). Give each student or student group a large sheet of paper.

Tell students to imagine they are community planners or landscapers. They are going to have an opportunity to design a new neighborhood development. Their job is to design & draw a landscape plan that shows some important community features (a school, several homes, a small business) and also incorporates tree planting that will help the home owners and the neighborhood conserve energy. Tell students they should refer to the *Tree Planting for Energy Conservation Guidelines Handout* to determine the best tree planting locations…both around the neighborhood AND around the homes and school. An optional worksheet can be found on p. 16 or downloaded at www.arborday.org/reproducibles.

Remind students it is important to indicate north, south, east, and west on their design so they can know where to properly place trees for best energy conservation and windbreak protection. They should also indicate on the plan which trees are broadleaf trees and which trees are coniferous trees. Remind them of the direction of prevailing winds in their area. Review the assessment details in the rubric with students before they begin.

When the landscaping projects are complete have students explain their plans and their choice of tree locations to the class. Provide the opportunity for peer review and redesign.

Authentic Assessment

Have students use the *Tree Planting for Energy Conservation Guidelines Handout* to evaluate real plantings around the school building, area homes, or business sites. Have them determine if efficient use of tree planting was made to conserve energy. They could select areas on the grounds where new trees might be planted on Arbor Day. If available, they can observe and comment on areas where windbreaks have been planted.

Alternative Assessment

Make an enlarged photocopy of the Energy Wise example on page 10 and have students point out energy conserving features.

Other Ideas!

1. Take a field trip to a tree farm
2. Invite a landscape architect to speak to the class
3. Build a 3-D model of an energy wise neighborhood
4. For additional outdoor activities, visit natureexplore.org.

Vocabulary Words

Biomass Energy – Energy that comes from plants. Biomass gets its energy from the sun. It is renewable as long as new trees or plants are planted.

Broadleaf – Trees with leaves that are thin, flat, and usually shed annually. Broadleaf trees are often good for shade.

Conifer – Trees that bear cones and have needle or scale like leaves that usually remain on the tree into the next growing season. Conifers are often good for windbreaks.

Deciduous – Trees that shed their leaves each year.

Diversity – Variety of many different kinds.

Energy – The ability to do work.

Energy Conservation – Efforts that reduce energy use...especially use of non-renewable energy sources.

Evergreen – Trees that keep their leaves into the next year.

Fossil Fuels – Fossil fuels come from organisms that lived long ago and have been buried underground for thousands of years. These are nonrenewable energy sources that include coal, oil, and gas which people use to create energy that powers our cars, homes, and factories. Fossil fuels can produce pollution when burned to create energy.

Heat Island Effect – City areas with lots of concrete and few shade trees that are hotter during the summer than nearby areas that have shade trees.

Nonrenewable Energy – Energy sources like coal, oil and gas that have limited supply.

Prevailing Wind – The most common direction of the wind.

Renewable Energy – Energy that is continuous or can be replaced naturally. Examples include energy created by the sun, wind, or biomass.

Windbreak – Rows of trees planted to slow the force of the wind.

Windward Row – The front row of trees facing the wind in a windbreak.

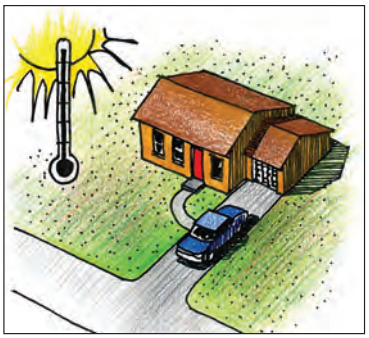
RUBRIC: RATE YOUR ENERGY CONSERVATION LANDSCAPE PLAN

1- 2 Points POOR PLAN	3-5 points AVERAGE PLAN	6-8 Points GOOD PLAN	9-10 points EXCELLENT PLAN
• Only one or no *Trees for Energy Conservation Guidelines* are included with trees correctly located in the community design. • Student cannot describe how trees in the landscape design conserve energy. • Only a few broadleaf and conifers are identified in the plan. • Only one aspect of a community is included.	• Two of the *Trees for Energy Conservation Guidelines* are included with trees correctly located in the community design. • Some of the ways trees in the landscape design conserve energy and can be correctly described. • Broadleaf and conifers are included in the design with most trees correctly placed for good energy conservation. • Several aspects of a community are included.	• Three of the *Trees for Energy Conservation Guidelines* are included with trees correctly placed in the community design. • Most of the ways that the trees in the landscape design conserve energy and can be correctly described. • Broadleaf and conifers are included in the design with all trees correctly placed for good energy conservation. • Work is neat with several aspects of a community included.	• All three of the *Trees for Energy Conservation Guidelines* are included with trees correctly placed in the community design. • All of the ways that the trees in the landscape design conserve energy and can be very well described. • Many broadleaf and conifers are included in the design with all trees correctly placed for good energy conservation. • Work is very neat with many aspects of a community included.

Guideline #1: Plant Trees to Shade Your Home

What you should know – Trees shading a home can reduce the need for air conditioning. Carefully placed trees can save up to 25 percent of an average household's energy needs for cooling - up to 65 percent in the case of mobile homes. According to the U.S. Department of Energy, proper placement of only three trees can save the average household up to $250 in energy costs each year. Think about what fun things your family could do with that extra money!

What you can do – The most energy savings and the best use of shade generally comes from deciduous, broadleaf trees planted about 10 to 20 feet from the walls to the west, east or south of the house, depending on the species. These trees shade the house during the summer, reducing the energy needed for air conditioning. When they lose their leaves in the winter, trees correctly planted allow the sun to reach and warm the house, saving energy for heating as well.



A lack of trees around houses means less comfort and higher energy costs.

Carefully planned trees annually save money and add comfort to a home.

2 Main Types of Trees

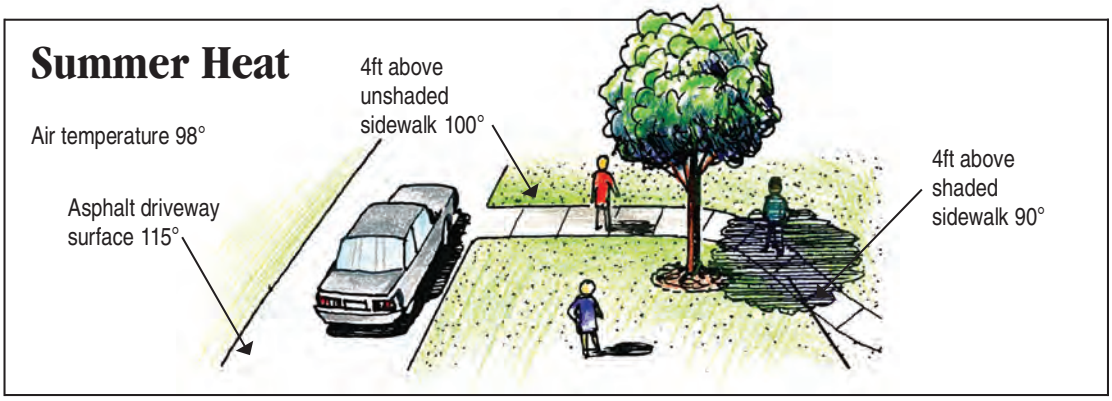
Different kinds of trees can be part of an energy wise plan.

Broadleaf trees have leaves that are flat and thin. They are usually deciduous, shedding their leaves annually. Oak, ash, and maple are several examples of broadleaf trees. Broadleaf trees generally provide the best summer shade.

Conifers bear cones and have needle-like leaves. Most conifers are evergreen since they do not lose all their leaves at once. Pines, firs, cedars, and spruces are conifers. Conifers generally provide the most effective buffer in windbreaks.

Guideline #2: Plant Trees to Shade Paved Areas

What you should know – Trees shading concrete or asphalt driveways and parking lots will greatly decrease surface heat. In the summer, a city area with trees shading paved areas can be 12 degrees cooler than one without trees.



What you can do – Plant broadleaf trees near, but not right against, sidewalks and driveways. Create areas in large parking lots or along city streets where trees can be planted for shade. Plant rooftop gardens.

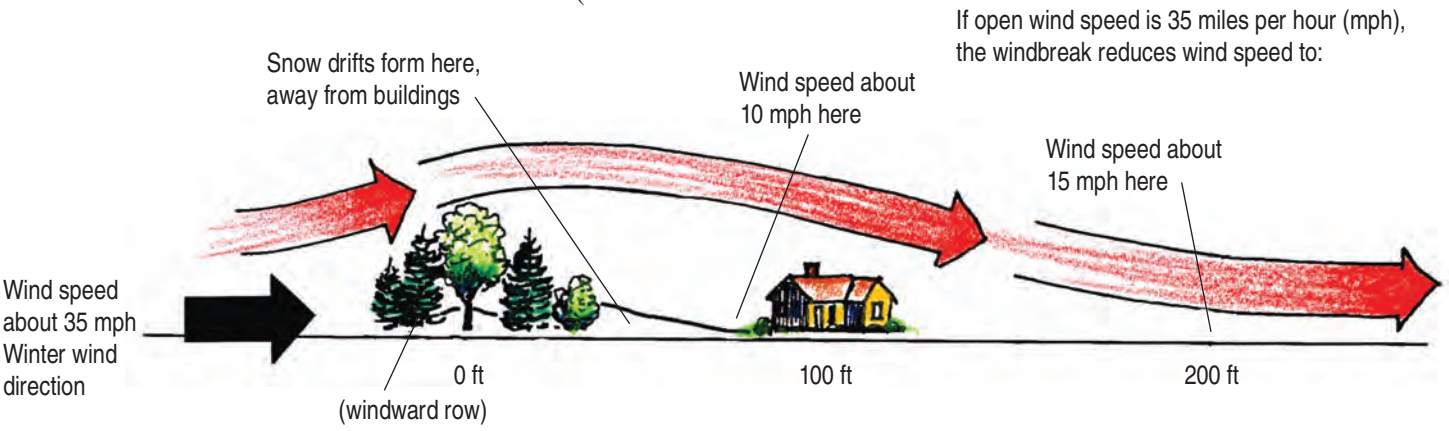
Guideline #3: Plant Trees to Break the Wind and Reduce Blowing Snow and Dust

What you should know - Windbreaks are rows of trees used to reduce the force and direction of the wind. Planting a windbreak around a home or housing development can provide an energy savings of up to 30 percent and reduce blowing snow, noise, and dust.

Windbreaks should be planted in an L-shape (right angle) toward the common wind direction. For best protection, windbreaks may be planted on more than one side of the property. Effectiveness of the windbreak also depends on the density (thickness) of the windbreak and its height. Three or more rows of trees in staggered formation provide the best wind protection. Conifers generally form the best windbreaks but some windbreaks include a few broadleaf trees as well. Windbreaks are effective for a distance of up to 8 to 10 times the height of the mature fully grown trees.

A well-placed windbreak can protect several homes or an entire development from chilling winter winds and drifting snow.

What you can do – Plant conifers several rows deep in a continuous line facing **prevailing winds**. Since snow and stale air can collect in the area directly behind a windbreak, buildings to be protected should be located no closer than 100 feet from the **windward row** (front row facing the wind). The area to be protected should be within a downwind distance of 2 to 5 times the expected height of the tallest windbreak row. (For planning purposes, 20 feet is often used as the height of the tallest trees.)



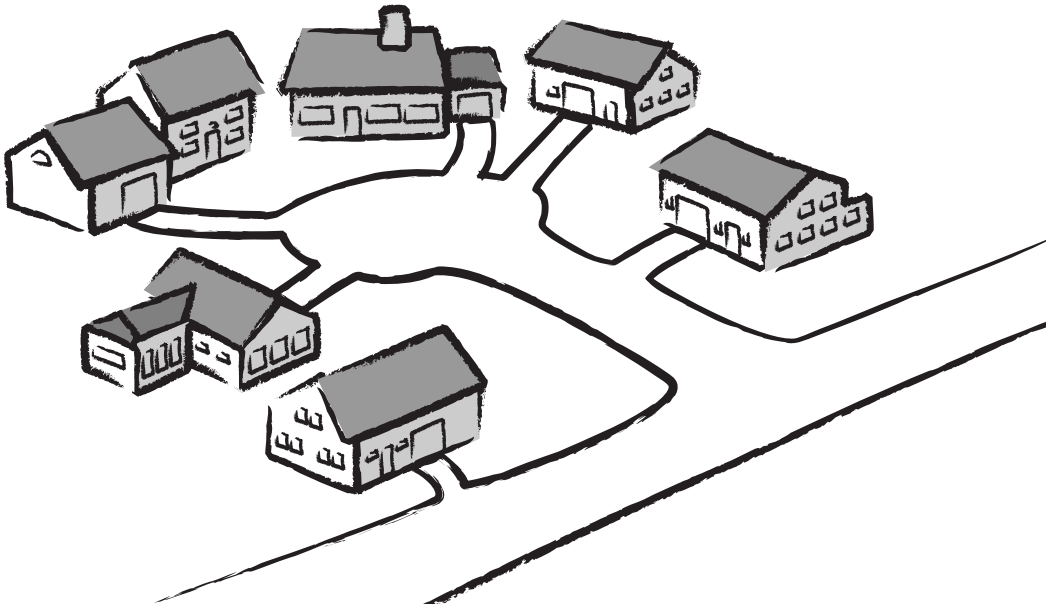
DIRECTIONS- Imagine you are a city planner or landscaper. Using the "*Tree Planting for Energy Conservation Guidelines*" in this handout, design a new, energy saving neighborhood development plan. Draw in homes and a school. Indicate north, east, south, and west on your plan. Remember to think about what sides of the homes to plant trees on for the best energy savings. Consider carefully where to plant deciduous, broadleaf trees and where to plant conifers. In your plan, draw in the best kind of trees to shade each home, to shade streets and driveways, and to serve as a neighborhood windbreak. Then describe why you planted trees where you did to be energy wise.

Name: _____

Design an Energy Wise Community Using Trees - Student Worksheet

Directions: Imagine you are a city planner or landscaper. Using the "*Tree Planting for Energy Conservation Guidelines*" you have just reviewed, plant (draw) trees into the design for this new neighborhood to save energy. Plant trees in this development plan to shade homes, paved areas, and serve as a windbreak. In your plan, consider carefully where to plant deciduous, broadleaf trees and where to plant conifers . Remember to think about what sides of the homes to plant trees on for the best energy savings. Then, in the space below, describe why you planted trees where you did to be energy wise.

Wind direction



Describe your tree planting plan here:

EXTENSION ACTIVITY #1

Classroom Activity:

- Conduct temperature and transpiration experiments to show how trees shade and cool their surroundings

Objectives:

Students will:

- Make predictions about how trees affect temperature
- Set up a scientific experiment
- Measure the difference in temperature in tree shaded and unshaded areas
- Demonstrate the process of transpiration

Time Recommended:

- Two 30 minute class periods

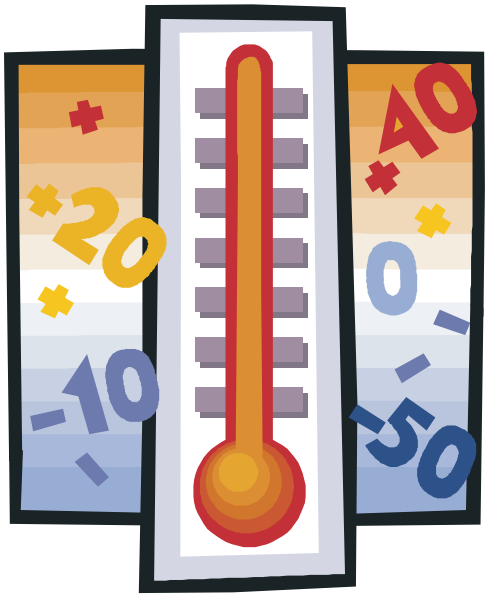
Materials Needed:

- Several plastic baggies with twist ties
- 2 or more different kinds of leafy plants if there are no available leafed-out broadleaf trees
- Grow light or sun lamp (if no access to a sunny location)
- Two or more thermometers with same scale (F or C)
- Pencil and Paper
- Fan and container of water (optional)*
- Several microscopes
- Microscope slides and cover glass
- Lettuce leaf
- Iodine stain
- Eyedropper
- Forceps or tweezers

National Science Education Standards Correlation:

As a result of the activity students should develop an understanding of:

- nature of science
- populations and ecosystems
- abilities necessary to do scientific inquiry
- understanding about scientific inquiry



Building off the knowledge gained in the Basic Activity, these experiments are designed to show how trees can cool their surrounding spaces. If you choose to just do these Extension Activities rather than the Basic Activity, you may wish to include the evaporative cooling demonstration from the Basic Activity (page 11) here.

Background Information:

Temperature is a measurement of hotness or coldness. It is measured on a standard Fahrenheit or Celsius scale.

Transpiration is the process by which water evaporates from plant tissues, primarily leaves. Most plants in temperate climates transpire about 99 percent of the water taken in by the roots. The other one percent is incorporated into the plant's structure. The vast majority of the water transpired by trees escapes through small openings on the underside of the leaf, the side away from the sun. Different species of trees and plants transpire at different rates depending on temperature, wind, light, and humidity. Plants in arid climates need to retain the limited moisture they take in, so their transpiration rate is much less than plants in more temperate climates.

Anticipatory Set: The students will be setting up experiments using the scientific method. If students have not done any experiments it will be important to review some of those terms with them. Write the words hypothesis, variable, and constant on the board.

Tell students they are going to do two simple experiments. Explain that scientists have guidelines they follow when they set up experiments. They start with a question, then they make a prediction (educated guess) about what the answer might be. That prediction is called a hypothesis.

Next scientists determine the ONE specific thing they need to test and compare to prove their hypothesis. For example, a scientist may wish to see if corn grows faster using fertilizer. To test that, the scientist will plant corn. Half of the corn planted would not have any fertilizer while the other half of the corn would have fertilizer. The ONE thing that changes, or is different, is called the experiment variable. The one thing in this example that is different is fertilizer. Everything else in the experiment needs to be the same or constant.

Using this same experiment example, ask students what things would need to be constant. List these things on the board. (Same brand of corn seed, same kind of soil, equal amounts of water, equal amounts of sunlight, same temperature, similar location area, same planting date.) Remind students that to prove that fertilizer makes a difference, everything else that affects the corn must be the same.

Temperature Experiment

Tell students they are going to get to conduct experiments to see if trees do make a difference in temperature of an area. Assign them to groups and help each group develop an experiment that has one variable involving temperature. One group might compare the temperature of grass in the sun to the temperature of grass in the shade. Another group might compare the temperature of a sidewalk surface in the sun to the sidewalk surface in the shade. A third group might measure the difference in temperature of asphalt in the sun to asphalt in the shade. (In each location, the variable is sun/shade.) Have each student make a prediction about what they think their own group results might be.

Remind students that everything else in their experiment needs to be constant. Have them brainstorm a list of what those constants need to be. The list might include time of day temperature is taken, amount of time they leave the thermometer before reading the temperature, the location site for each group...group one – grass; group 2 – sidewalk; group 3 – asphalt, etc.

Go outside and find a spot for each group where there is the appropriate mix of sun and shade. Each group must record the temperature after a specified amount of time. (10 minutes is plenty.) When tests are complete, ask the groups to describe the results of their investigations to the whole class.

Transpiration Experiment

Using a transparent bag, have each group wrap a leaf on the potted plant or a small portion of a leafy broadleaf tree branch that is exposed to full sun. Seal the end of the bag as tightly as possible. Do this on several kinds of plants or trees.

Have students check on the leaf periodically making notes on what they see. Ask them to indicate how long it takes for water droplets to form inside the bag and record results. Compare results from the experiment. Do different kinds of leaves transpire at different rates?

As students are waiting to check their leaves, discuss the process of transpiration with them. If you have not done the evaporative cooling demonstration with the fan and water from the Basic Activity, you may wish to do that here. If you have done that, remind students of how the water that transpires from the leaves evaporates like the water on their hand, cooling the air around it.
Explain that plant leaves have tiny openings, called stoma or stomates. These little openings are where carbon dioxide enters the leaf and oxygen and water moisture leave the leaf. Surrounding each stomate are guard cells that open and close the stomate. Guard cells are shaped like two tiny green jelly beans on each side of the stomate. Tell students they will have a chance to see a stomate and the surrounding guard cells through a microscope.

If there are enough microscopes in the class for each group to use, you may wish to have each group prepare

their own slide. Otherwise prepare the slide using the following procedure and allow each group a chance to come look at the slide.

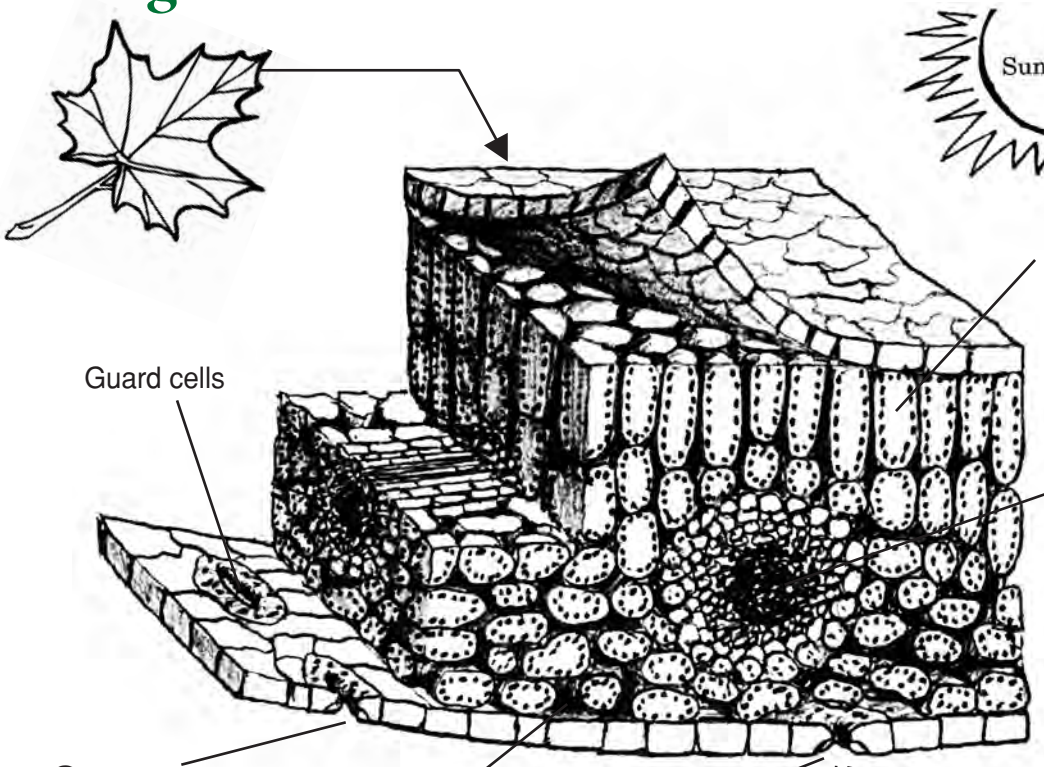
Procedure:

1) Put one drop of iodine stain on the center of the slide.
2) Break the lettuce leaf and pull off the thinnest layer of epidermis possible.
3) Carefully spread out this thin layer in the iodine on the slide making sure it is flat and not folded over on itself.
4) Carefully place a cover slip over the epidermis, trying to avoid any air bubbles.
5) Carefully and slowly bring the slide into focus. Move the slide around until you find some stomates and guard cells.
6) Change the lens to high power to observe the stomates in more detail.
7) If time permits, draw a picture of what you see.

Authentic Assessment:

After students evaluate the two experiment results, they will determine what other experiments they might like to do related to trees. Each student will describe their experiment idea, list a hypothesis, constants, variable, materials needed, and outline the procedure they would use.

Looking inside a leaf



Palisade Cells with Chlorplasts
Photosynthesis occurs in chloroplasts.

Guard cells

Vein
Phloem cells in leaf veins take manufactured sugars to living cells throughout the tree and to the roots, while they bring water from the xylem.

Stoma
Carbon dioxide in air enters through tiny pores (stomas).

Intercellular Spaces

Stoma

Water is released into the air from transpiration through the stomas.

Oxygen is released into the air through the stomas.

Step 1

Discover How Trees Produce Energy

EXTENSION ACTIVITY #2

Objectives:

Students will be able to:

- **trace the flow of energy in various forms, from plants to humans, by creating an energy chain**
- **describe several ways trees provide energy for human use**

Time Recommended:

- **One 30 minute class period**

Materials Needed:

- **Photocopied *Trees Produce Energy* handout (one per child) on page 21**
- **Pencil and Paper**
- ***Neighborhood Design Plan* created in Basic Activity**

National Science Education Standards Correlation:

As a result of the activity students should develop an understanding of

- **transfer of energy**
- **populations, resources, and environments**

Introduction: This activity can be used to enrich and expand on the Basic Activity. It helps students understand that trees can produce, as well as conserve, energy. This activity will use the neighborhood design plans that students create in the Basic Activity.

Instructional Sequence:

Discussion: *Ask students how they would define the word "energy."* Allow student responses. Let them know energy is defined as the ability to do work; it powers everything in nature. Energy warms and cools our homes, fuels our cars, powers our TVs, and runs our manufacturing plants. It takes energy for us to walk, talk, digest our food, and even breathe.

Tell them that in the previous activity they learned how well-planted trees can play a key role in energy conservation. In this activity they will learn how trees and other plants can produce energy in ways that also benefit the environment.

Pass out the *Trees Produce Energy Handout* and review the content with students.

- As you discuss Concept 1, review the illustration "Energy Food Chain." Ask students to come up with other examples of energy food chains.
- As you discuss Concept 2, you may wish to include some of the Additional Information shown below.

Additional Information: Two hundred years ago wood accounted for over 90% of the world's energy/heating needs. Today some nations still use wood as an important fuel source for cooking and heating, but in the United States wood and other plant-based biomass fuels account for less than 5% of the fuel used for energy production. The United States depends heavily on fossil fuels, which will eventually run out.

Only through wise use and proper forest management can wood and other biomass fuels be considered a renewable resource. Trees must be replanted as they are used. According to the National Renewable Energy Laboratory, more than 36 million acres of land in the United States, considered unfit to grow food, could be used to grow energy crops.

"Each generation takes the Earth as trustees. We ought to bequeath to posterity as many forests and orchards as we have exhausted and consumed."

Arbor Day Founder, J. Sterling Morton

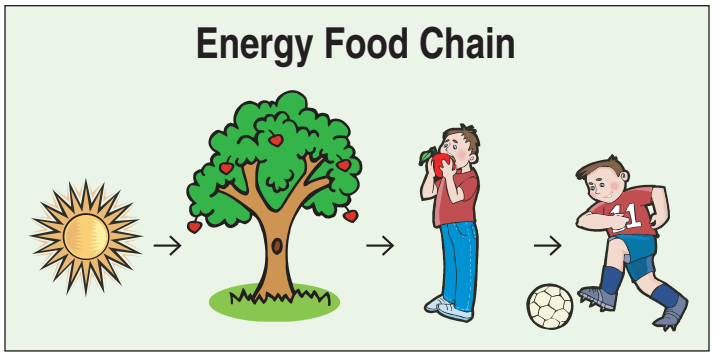
Trees Produce Energy - Handout

Energy is defined as the ability to do work; it powers everything in nature. Energy warms and cools our homes, fuels our cars, powers our TVs and DVD players, and runs our manufacturing plants. It takes energy for us to walk, talk, digest our food, and even breathe. The following two concepts will help you understand how you can plant trees to produce energy.

Concept 1: Plant Trees to Produce Food Energy for People and Wildlife

What you should know – Trees and other green plants are the source of energy for all animal life to live and grow. Through the process of photosynthesis, plants change light energy from the sun into chemical energy that is stored in the plant as carbohydrates (sugars) as it grows. All animal life, including human life, depends on that stored energy. When you eat an apple, the chemical energy stored in the fruit becomes the energy "fuel" that allows you to work, play, run, and grow. Every living animal either gets its energy directly from plants or depends on other animals that depend on plants for food.

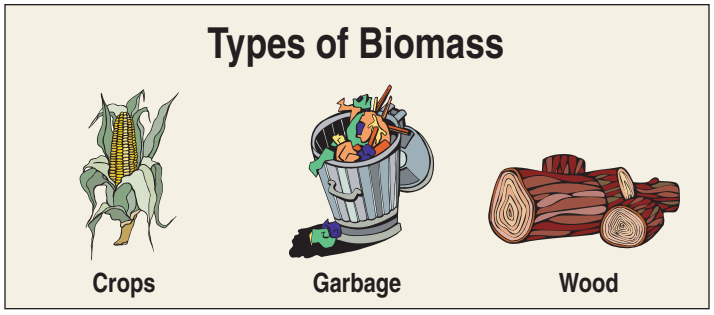
What you can do – Plant many different kinds of trees that have high food value. This will increase healthy food energy for people as well as provide food and habitat for many kinds of wildlife. Plant fruit and nut trees that will grow in the climate where you live. Trees or shrubs with high-energy food value for people or wildlife can include: apple, orange, cherry, peach, oak, hazelnut, plum, etc.



Concept 2: Grow Trees as an Energy Crop

What you should know – While the fruits, seeds, and nuts of trees provide fuel (either directly or indirectly) to run our bodies, the wood from trees can be burned to release energy for heat to keep us warm or power to make things run. This homegrown source of energy is referred to as **biomass energy**...it is energy you can grow. Wood, animal waste, crops, and even garbage can be used as a biomass energy source. Agricultural biomass crops like corn and soybeans can be burned directly or turned into other liquid fuels (ethanol, methanol, and biodiesel) that can be used to power vehicles or machinery. When not burned efficiently, wood and other biomass products can cause air pollution. However, modern heating/cooling systems, and even efficient wood burning stoves, burn the biomass at such a high temperature and so completely that there is often less pollution with it than with conventional fuels like oil and coal.

Wood manufacturing waste and wood from street tree trimmings can also be burned for fuel, which saves fossil fuels and landfill space. Biomass not only produces energy, but it is good for the environment too.



What you can do – Plant trees or other biomass energy crops on land that is considered unfit to grow food crops. Plant new trees when trees are cut down. Take care of the soil in which our crops grow. With careful management, wood and other biomass fuels will always be a renewable resource.

Activity Directions: Research what tree species will grow in your community. Look at the *Neighborhood Design Plan* you created in the last activity. Add trees to your plan that will produce either food or biomass energy. Label your tree species. Discuss how these changes benefit the neighborhood.