Purdue University

Purdue Extension

4-H-1015

Energy Investigators

Facilitator's Guide

Note to Facilitators

General Suggestions

Welcome to *Energy Investigators!* As a project facilitator you will work with youth interested in learning about energy – where it comes from and how to conserve it. This facilitator's guide provides some answers and suggestions.

Your main role is provide a safe, supportive environment for youth to practice important life skills as they explore the world of energy. You can help youth get the most out of this project by being enthusiastic about their efforts and asking thoughtful questions. Team up with youth to help them select goals, identify resources, gain confidence, and evaluate their own progress. The activities are designed so youth have an opportunity to "learn by doing" with your help and guidance.

Parents and other adult role models can be a big help if they are involved with their child's learning, especially for younger children. As youth mature, they should take on more responsibility for their own learning, but parent involvement is still important in grades 6 through 8. Encourage parents to show interest in what their child is learning and doing. Their interest reinforces what youth learn. High school-aged youth are able to direct their own learning experiences and may even teach their parents and others!

Here are some tips for presenting this curriculum:

Practice Safety First!

Keep safety in mind at all times.

Gather Materials

Youth should collect the materials listed in the Tool Box before doing the activity. Most supplies used in these activities can be found around the home or purchased at minimal cost.

Read and Understand the Activity

Each activity is self-contained and often leads seamlessly into another activity.

Show Relevance of Each Activity

Use the additional information in this guide to help youth explore the relevance and interconnectedness of the activities to the real world.

Use Available Resources

Expand the learning activity and get additional supporting information from your county Extension office. The Internet can provide a wealth of information to enrich learning. Take care to use sites that are supported by educational organizations (*.edu), professional societies, national organizations, and not-for-profit groups.

Acknowledgments
Generously funded by Duke Energy through a grant to the Indiana 4-H Foundation

Authors
Natalie J. Carroll, *professor, Youth Development and Agricultural Education, Purdue University*
Jennifer Kruse, *student, Purdue University*

Reviewer
Dan Weiss, *Duke Energy*
Chad Martin, *Renewable Energy Extension Specialist, Purdue University*

Editor
Denise Dorsey-Zinn

Design and Layout
Cover: Russell Merzdorf; Text: Jennifer Mazonas

Electronic copies of this publication are available at Purdue Extension's Education Store, **www.the-education-store.com**.

Contents

Resources

Electric Energy on TV

Indiana Expeditions series by public television station WFYI:

- Discover how real science impacts our lives every day through video clips.
- "Electrical Energy" (episode 301), **www.wfyi.org/IndianaExpeditions/**

Learn about Saving Energy

- Energy Star, United States Environmental Protection Agency (US EPA), **www.energystar.gov**
- Energy Savers, **www.energysavers.gov**
- U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy, **www.eere.energy.gov** (includes a DOE Consumer Guide to Energy Efficiency and Renewable Energy)
- U.S. Department of Energy (DOE), Tips for Energy Savings, **http://www1.eere.energy.gov/consumer/tips/**
- American Council for an Energy-Efficient Economy, **www.aceee.org/consumer/**
- Home Energy information, National Institute of Food and Agriculture (NIFA), **www.eXtension.org** (Choose "Resource Areas," followed by "Energy: Home Energy")
- Purdue Extension Renewable Energy, **www.extension.purdue.edu/renewable-energy**

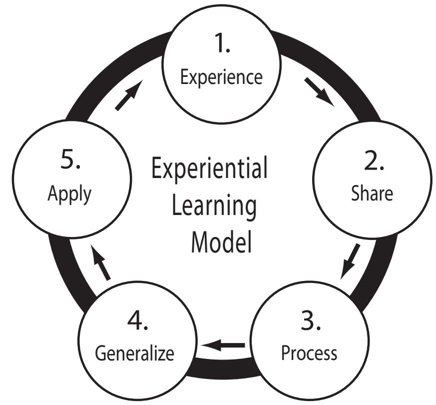
Learn about Energy and the Environment

- Carbon Dioxide, **www.epa.gov/climatechange/emissions/co2.html**
- Carbon Footprint, **www.epa.gov/climatechange/emissions/individual.html**
- Geologic Sequestration, **www.epa.gov/climatechange/emissions/co2_geosequest.html**

The Experiential Learning Model

These activities are designed based on the Experiential Learning Model. This approach to learning helps youth gain the most from their activities by encouraging them to:

- Do an activity before being told or shown how (experience).
- Describe their experience and reaction (share).
- Discuss what was most important about what they did (process).
- Relate the life skill practiced to their own everyday experiences (generalize).
- Share how they will use the life skill and project skill in other parts of their life (apply).



Pfeiffer, J.W., & Jones, J.E., "Reference Guide to Handbooks and Annuals"

The advantages of using the experiential learning process include:

- The adult can quickly assess the student's knowledge of the subject.
- The student builds on past experience or knowledge.
- The adult functions as a coach rather than a teacher.
- The youth relate the experience to their own lives and experiences.
- Mentors may use a variety of methods to involve the youth in the experience.
- Youth with many different learning styles can be successful.
- Discussions can move from the concrete to the abstract and analytical, which is particularly beneficial for middle and high school students.
- Youth are stimulated to learn through discovery and to draw meaning from the experience.
- Youth can work together, share information, provide explanations, and evaluate themselves and others.
- Youth take responsibility for their own learning.

(Source: Excerpted and Adapted from "Experiential Learning in 4-H Project Experiences 4-H Volunteer Leaders' Series," University of Arkansas Cooperative Extension Service, Dr. Darlene Z. Baker. You may view the entire document at: **http://publications.uaex.edu/**.)

Evaluate youth learning and interest in the activity. Are there changes that you could make to enhance the learning experience? Are there ways that the youth could enhance their own learning? Youth will have different levels of interest and motivation for different activities and at different stages of their lives. Learning how much coaching is needed for a particular youth, on a particular day, can be a challenging and rewarding experience.

Youth Development Stages

Understanding the physical, mental, social, and emotional development of youth will help you when working with the 4-H members in your club. No two youth develop at the same rate and transitions are often gradual. Your teaching and involvement helps 4-H club members grow and mature and makes 4-H a rewarding and fulfilling experience.

Activities at 4-H club meetings do not always work as you had planned. Sometimes youth talk among themselves rather than listening to you; sometimes no one comes to a planned field trip; and sometimes no one speaks up when you are trying to initiate a discussion.

Youth of the same age can vary greatly in physical, mental, social, and emotional growth and interests. These differences are even more marked between age groups. If you are working with a broad age range, the activity may be too simple for the older youth and too difficult for the younger ones. Giving the older 4-H members leadership opportunities can be very effective.

Research has shown that there are some generalities that can help you understand how to plan activities for different age groups.

Early Elementary (Mini 4-H)

This is a very active age, so it is important to keep these children busy. They are concrete thinkers and need to understand what you want them to do and how to do it. They are generally more interested in making something than in completing a project (process is more interesting than product). Youth in this age group tend to seek adult approval and depend upon adults, although the opinions of their peers are beginning to be important. They do best in small groups with set rules and rituals. Competition is inappropriate for this age group.

Upper Elementary

This is also a very physically active age, so hands-on activities work best. Youth in the upper elementary grades are still fairly concrete thinkers (things are black/white or right/wrong), but are beginning to think logically and symbolically. Because this age group has a strong need to feel accepted, it is best for an adult to evaluate each product rather than hold competition among peers with only one winner. This age child likes to know how much they have improved over past efforts and how to improve in the future.

These youth are beginning to identify with peers, but continue to value adult guidance. They are also beginning to discover the benefits of making other people happy, but more for the benefits to themselves rather than the benefits to others. They begin to take responsibility for their actions at this age and begin to develop an increased independence of thought, which may allow them to try new things. Letting this age group help in the decisions of the club helps them start to learn about leadership.

Middle School

Middle school youth are beginning to move to more abstract thinking. Justice and equality are important to this age. (Therefore, project judging may now be viewed in terms of what is fair, as well as being regarded as a reflection of self-worth.) They prefer to find their own solutions, rather than to be given solutions by adults. Try to provide supervision without interference. Independence of thoughts and actions begins to emerge. Avoid comparing middle school youth with each other. Performance should be compared with past accomplishments.

Junior volunteer organizations often are popular with teens toward the end of this age group, particularly if there are opportunities for developing leadership.

High School

Most high school-aged teens know their abilities, interests, and talents. They tend to be very concerned with themselves and their peer group. While they can understand the feelings of others, they tend to be self-absorbed, particularly in the earlier years of high school. Relationship skills are usually fairly well developed. Getting a driver's license increases both independence and dating. Acceptance by members of the opposite sex is very important.

High school-aged youth begin to think about the future and make realistic plans. They enjoy career exploration and preparation. Their vocational goals influence the activities they select.

Projects requiring research and creativity give teens an opportunity to demonstrate how much they have learned and what they can accomplish. Teens set goals based on their personal needs and priorities. Goals set by others are generally rejected.

As teens master abstract thinking, they may try new ideas in ways that confuse adults. Teens can generally initiate and complete tasks without supervision. A leader can help by arranging new experiences in areas of interest to teens, but must be sure to allow them plenty of input. Assume the role of advisor/coach for independent workers rather than teacher/lecturer. Club meetings, rituals, and uniforms do not generally appeal to this group. But many teens enjoy looking back on their achievements in 4-H and appreciate special recognition for leadership activities. By the time they graduate from high school and begin college or a career, youth feel they have reached the stage of full maturity and expect to be treated as such.

Some Final Thoughts

These guidelines only give a brief overview of child and youth development. They are intended as a resource to help you plan your activities as a volunteer leader. The publication, *Ages and Stages of Child and Youth Development*,* has more in-depth information.

You are a valuable asset to your community and to the members of your club. The guidelines for the stages of child and youth development, in combination with your special skills and interests in youth, will help you plan and carry out a successful 4-H program and make a positive impact on the lives of young people.

* *Ages and Stages of Child and Youth Development, A Guide for 4-H Leaders*, Extension publication NCR-292, available at your county Extension office or at Purdue Extension–The Education Store, **www/the-education-store.com**.

Essential Elements of 4-H

There are four essential elements of all 4-H programs. They are:

- ***Belonging***: feeling a part of a supportive community.
- ***Mastery***: having opportunities for success, the source of self-esteem.
- ***Independence***: learning self-sufficiency and responsibility.
- ***Generosity***: gaining a feeling of purpose and usefulness.

Youth feel they ***belong*** when they can have a positive relationship with a caring adult and participate in activities in a safe and inclusive environment.

You can help youth feel they ***Belong*** by:

- Encouraging peer group cohesion (ice breakers, games, social time)
- Encouraging cross-age linkages, adult-youth bonding
- Modifying teaching strategies to enhance sense of belonging
- Encouraging ties with family and community

- Making small group time available to allow the development of close relationships with peers and staff
- Encouraging collaborative and cooperative learning
- Showing respect for the value of diverse cultures
- Providing multiple opportunities for youth to develop relationships with adults
- Encouraging supportive peer relationships

Youth are more likely to achieve ***mastery*** when they are engaged in their learning and have plenty of opportunities for mastering tasks.

You can help youth achieve ***Mastery*** by:
- Mixing hands-on activities with paper and pencil exercises to build job and vocational skills
- Supplementing competition with cooperative activities or games to develop interpersonal skills and self-management
- Focusing on the long-term goals of learning; provide prompt feedback; and model and teach that failure and frustration are learning experiences
- Including communication and basic content skills
- Teaching life skills (money management, decision making, etc.)

Youth are more likely to achieve ***independence*** when they are given opportunities for self-determination and gain the ability to see themselves as active participants in the future.

You can help youth gain ***Independence*** by:
- Allowing youth to make decisions whenever possible and provide opportunities for them to take responsibility for meeting obligations
- Including youth in planning discussions and encourage input
- Focusing on decision-making rather than obedience
- Asking youth to do something, instead of telling them to do it
- Giving youth responsibility to carry out responsibilities, with minimal reminders
- Allow youth to overcome obstacles – don't jump in too quickly to help
- Commending youth who recognize the limits of their independence and seek counsel
- Sharing power with young people through self-governance in significant areas

Youth are more likely to learn to be ***generous*** when they have an opportunity to value and practice service for others.

You can help youth develop ***Generosity*** by:
- Offering mentoring/tutoring programs for cross-age linkages, service projects, and community service
- Tying learned skills/abilities to how they can be used in positive ways
- Respecting and encouraging bonds of friendship among young people and between adults and children
- Using as many opportunities as possible to encourage young people to imagine the feelings of others
- Highlighting the effect of a young person's behavior on others (both positive and negative), reinforce gestures of caring and concern, and ask young people to take responsibility

Generating Electricity

Big Picture

Youth begin to learn how electricity can be generated using pennies and nickels in this activity. Only a small amount of electricity is generated (about 1 volt) but it is measurable.

Facilitating the Activity

This experiment shows how electricity can be generated by the reaction between the metal in pennies and nickels. A difference in the charge between two metals can cause free electrons to detach from atoms and move in a solution. The electron movement creates electricity. This is an electrochemical reaction.

Youth should measure about one volt of electricity. When they begin removing coins they will likely still measure the same voltage (about 1 volt) until only four coins remain. At this point they may be able to measure ½ volt.

The coins should be rinsed when the experiment is done to remove the solution. Otherwise, a reaction with the copper in the pennies will discolor the coins. The green discoloration occurs when the copper in the pennies react with the vinegar to make a copper acetate.

This experiment is modeled after an activity called “A Battery That Makes Cents” found at **www.sciencebuddies.org/science-fair-projects/project_ideas/Energy_p015.shtml.** This site has additional information about how batteries work and the terms and concepts contained in this experiment for those who want to learn more.

Connections

The website **www.sciencebuddies.org** has many activities of interest to budding scientists, science fair project ideas, science news, and resources.

Life Skills

- Specific Skill – Generating energy using two different metals.
- Science Standard –
  - **7.3.15** Describe how electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy, such as light or heat.
  - **8.3.9** Demonstrate, using drawings and models, the movement of atoms in a solid, liquid, and gaseous state. Explain that atoms and molecules are perpetually in motion.
  - **8.3.15** Identify different forms of energy that exist in nature.
  - energy: what is needed to make things move
  - metals: one class of substances that are mostly shiny, bendable, and good conductors of heat and electricity
  - Success Indicator – Creating electricity with coins and measuring the voltage.

Comparing Electricity Options

Big Picture

Electricity has made many household tasks much easier. Without electricity to power lights, refrigerators, dishwashers and washing machines and dryers, household chores would take much, much longer than they do now. Entertainment devices (radios, televisions, DVD players) require dependable, uninterrupted electric power. It is difficult to imagine life without electricity!

Facilitating the Activity

This activity is intended to start youth thinking about sources of electricity and the pros and cons of each. They are not expected to know all the answers and may enjoy this most if they can work together to guess the answers and then have a discussion about the different sources of power for electricity. The facilitator should use the chart below to help with the discussion. Do not be in a hurry to "give the right answers," instead, let the youth explore and discuss each option.

Connections

The Department of Energy website, **www.energy.gov**, has a wealth of information. Seven major areas are listed: Science & Technology; Energy Sources; Energy Efficiencies; The Environment; Prices & Trends; National Security: and Safety & Health. The Energy Sources section (**http://www.energy.gov/energysources/**) has information on all the sources listed in this activity (see the list on the left hand side of the page). The Environment section has information about keeping our air, soil, and water clean as well as information about climate change.

Fuel Source Chart

Fuel Type	Power Availability		CO_2 Emissions			Renewable
	Constant	Variable	Low	Med	High	
Coal	x				x	
Natural Gas	x			x		
Nuclear	x		x			
Wind		x	x			x
Solar		x	x			x
Hydropower (from reservoir)	x		x			x
Hydropower (streaming)	x		x			x
Geothermal	x	x	x			x

Notes

- Power Availability is considered "constant" when power is available 24/7, 365 days per year.
- Coal emits about 200 pounds CO_2 for every kWh of power produced.
- Natural gas emits about 130 pounds CO_2 for every kWh of power produced.
- Wind power availability varies with wind direction and speed.
- Solar power availability is unavailable at night unless stored and varies with cloud cover.
- Hydropower is generally available 24-7, but may be affected by seasonal precipitation.

Fuel Type	Potential Environmental Impact
Coal	*Strip mining concerns (loss of habitat & wildlife, etc.)* *Groundwater contamination* *Airborne mercury contamination*
Natural Gas	*The same concerns as coal, but burns cleaner and emits significantly fewer harmful emissions than coal* *• Groundwater contamination*
Nuclear	*Dangerous toxic waste*
Wind	*Highly visible* *Noise issues* *Possible disruption of bird flyways*
Solar	*High energy used in manufacture* *Toxic silicon tetrachloride waste*
Hydropower (from reservoir)	*Flooding behind dam* *Impact on fish migration (if not mitigated)*
Hydropower (streaming)	*Reduction in stream water flow*
Geothermal	*Hydrogen Sulfide released from steam*

References

- **www.whyhydropower.com/HydroTour3b.html**
- **http://videos.howstuffworks.com/hsw/18618-electricity-and-magnetism-generating-electricity-video.htm**

Life Skills

- Specific Skill: Quantifying energy knowledge
- Science Standards:
  - **7.3.15** Describe how electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy, such as light or heat.
  - **7.3.16** Recognize and explain that different ways of obtaining, transforming, and distributing energy have different environmental consequences.
  - **8.3.15** Identify different forms of energy that exist in nature.
- Success Indicator: Youth determine their Energy IQ. The equation is:
- (the number of correct answers)/24 * 100 (%) The answer gives the percentage correct.

Measuring Electricity

Big Picture

American families, on average, spend 31% of their energy budget to heat their homes; 12% for air conditioning; 12% for water heating, and 11% for lighting (*see figure*). Electronic equipment is often considered a necessity. While the data show computers and electronics use about 9% of the average bill, this value has been increasing as energy efficient appliances are increasingly used (reducing the relative costs) while the number of computers and electronics increases. Home entertainment systems account for a major household energy use. More than half of all American households have two or more TVs and over 5 million households have four or more TVs. Furthermore, these systems generally consume significant amounts of power even while turned off (standby power). The average U.S. household consumes 50 watts of standby and off-mode power constantly, amounting to about 440 kWh per year.

Facilitating the Activity

An electricity meter is required to complete this activity. These meters can be purchased from many hardware or discount stores for $20 to $25. The best kind to use is one that the electrical device can be plugged into and then the meter plugged into the wall. Adult supervision is recommended.

Youth will explore the amount of electricity that is being used by different items in their house by using an electricity usage monitor to measure the current being drawn in amperes (amps) and wattage (watts).

- Current (Amperes, Amps) – The energy that flows to a device to provide heat, light, motion, sound, technological processes (computers), or chemical changes. Electricity that is provided to homes and businesses is alternating current, meaning that it changes direction periodically. Direct current (as in batteries) always flows in one direction.
- Wattage (Watts) – The measurement of the rate of the energy used.
- Voltage (Volt) – The force that causes the electrons to move in an electrical circuit. The normal outlet provides 120 volts of alternating current in the United States, but this value will vary slightly when measured. Electric stoves and dryers utilize much more power so are on 220 volt circuits.
- Frequency (Hertz, Hz) – The measurement of the changing directions in the electrical cycle of direct current. Youth will measure about 60 Hz although the actual value will vary some.

The voltage and frequency values will always be about the same so youth are not asked to record them, although they should notice the values (around 120 volts and 60 Hz). Some electric usage monitors will also calculate the power used (kWH) if left plugged in for a period of time so youth can see how much power is used over time. The device currents and wattage values given in Table 1 were measured at the author's home and are given as general information.

Electricity User	Current (amps)	Energy (watts)
Cell phone – off or on, while charging	0.03	1.9
Clock radio	0.02	1.3
Cordless phone – calling	0.01	0.4
Cordless phone – on base	0.02	1.3
Dehumidifier	0.56	65
Heating blanket – off	0.07	0.5
Heating blanket – on	0.59	49
Lamp – 1 fluorescent bulb	0.13	9.3
Lamp – 1 incandescent bulb	0.39	46.7
Lamp – 2 fluorescent bulbs	0.36	25.1
Laptop computer (on and powered down)	0.49	32
Night light	0.02	2.5
Phone, land line & answering machine	0.01	1.2
Phone/answering machine	0.01	1.2
Power strip for entertainment system with all devices turned off	0.04	4.1
Power strip for entertainment system with all devices turned on	1.45	162
Refrigerator	0.1	8.7
Satellite dish – on	0.31	20.8
Toaster	6.21	7.4
Washing machine (filling)	0.05	4.1
Total (sum of all values)	4.69	407

Voltage: approximately __120__ volts (values will vary slightly)

Frequency: approximately __60__ Hz (values will vary slightly)

Dig Deeper

Items that were measured over time:

	Power used (kW)	Time elapsed (hours)	kW/hour	Est. for month* (kW)
TV, Tuner, VCR/DVD	2.27	14.48	0.16	113
Satellite dish	0.19kW	9.32	0.02	15
Laptop computer	0.12	8.26	0.01	10
Refrigerator	0.4	7.12	0.06	40
Washing machine	0.23	0.43	0.53	**

*The last column gives the estimated power used for each device by multiplying the kW/hr by the number of hours in a typical month (value*24*30).

**The estimate for a month assumes that the device is used continuously, which a washing machine would not be. Assuming that the machine is used for five loads of laundry each week and it takes ½ hour per load, the monthly cost would be estimated to be 5 kW/month (0.53 * 5/0.5 * 4 weeks/month).

Connections

The typical U.S. family spends about $1,900 a year on home utility bills (U.S. Department of Energy, 2008). Youth can review their utility bill to find out how many kWH were used and the average daily cost. The three items in the Dig Deeper activity used an estimated 138 kW/month. The author uses 900kWH/month on average, so the three items would account for about 15% (138/900) of her bill if they were turned on for the entire month. This calculation can be done with any appliance to compare to the national averages.

Life Skills

- Specific Skill: use an electric usage monitor; compare the electricity used by various items
- Science Standard:
  - **7.2.6** Read analog and digital meters on instruments used to make direct measurements of length, volume, weight, elapsed time, rates, or temperatures, and choose appropriate units.
  - **7.3.15** Describe how electrical energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy, such as light or heat.
- Success Indicator: Ability to measure electric usage and verbalize which household items use the most electricity.

Talk It Over Answers

Share What Happened

Question – Do any of the Electricity Users continue to use electricity when turned off? If so, why do you think this is so? (Many items continue to use power to light clocks, night lights, etc., so they will turn on instantaneously. This is particularly true for satellite dish/cable receivers that continually downloads program information.)

Apply

- How much electricity (total wattage) is being used by the Electricity Users you measured? (The answer is obtained by summing the watts.)
- How could you use the data you collected to calculate the total electricity used in your house? (Youth need to estimate the power each electric item uses and sum them up. They do not need to measure each one. For example, take measurements of one or two lights and use that value times the number of lights in the house.)
- How could you compare this to what is actually used? [Youth need to estimate their daily electricity used and compare to their family's electric bill. If youth measure the watts that a device uses, they multiple the Watts measured by the time (Hr) the device is used and divide by 1,000. For example, a 60 Watt light bulb burning for one hour would equal 60 Watt Hours. If it burned for 1,000 Hours then it would be 1,000 Hr * 60 Watts = 60,000 Watt Hours which is equal to 60 KWH (kilowatt hours).]

CO_2 Production and Absorption

Big Picture

The carbon cycle is the biogeochemical cycle that explains how carbon moves throughout the earth (in the air, water, and on land). It is one of the most important cycles of the earth and allows for carbon to be recycled and reused throughout the biosphere and all of its organisms.

Facilitating the Activity

This activity uses Bromothymol blue (BTB) to show how burning depletes oxygen and how a plant can replace the lost oxygen. BTB is an indicator used for relatively low acidic or basic levels (near neutral pH). It measures reactions by changing color in response to changes in acid levels.

- A bottle of Bromothymol Blue solution (BTB), available from Carolina Biological Supplies, **http://www.carolina.com/**, enter "bromothymol blue" and get 0.04% aqueous solution:
  - 100 mL, $2.95 (the size in the kit from National 4-H, enough for 50 trials)
  - 500 mL, $6.25
  - 1 liter, $9.25
- When the candle burns, it uses oxygen and emits carbon dioxide, causing the BTB to change color. The candles will burn out and the BTB should turn greenish or have a green tint as the oxygen is used up.
- The plant will use the carbon dioxide to make oxygen through photosynthesis in sunlight and the BTB will return to its original blue. A container placed in direct sunlight may get too warm, causing the water to evaporate before the color change back to the original blue can be observed.

Life Skills

- Specific Skill: Observing, record keeping, understanding that burning uses oxygen and plants replace oxygen.
- Science Standard:
  - **7.4.7** Describe how plants use the energy from light to make sugars from carbon dioxide and water to produce food that can be used immediately or stored for later use.
  - **Env.1.9** Diagram the cycling of carbon, nitrogen, phosphorus, and water.
- Success Indicator: creating a closed system that can show the carbon cycle

Connections

(The following information is found at **http://www.epa.gov/climatechange/emissions/index.html**.) Greenhouse Gas Overview: Gases that trap heat in the atmosphere are often called greenhouse gases. This section of the EPA Climate Change Site provides information and data on emissions of greenhouse gases to Earth's atmosphere, and also the removal of greenhouse gases from the atmosphere. For more information on the science of climate change, please visit EPA's climate change science home page at **http://www.epa.gov/climatechange/science/index.html**.

Some greenhouse gases such as carbon dioxide occur naturally and are emitted to the atmosphere through natural processes and human activities. Other greenhouse gases (e.g., fluorinated gases) are created and emitted solely through human activities. The principal greenhouse gases that enter the atmosphere because of human activities are:

Carbon Dioxide (CO_2): Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

Methane (CH_4): Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Nitrous Oxide (N_2O): Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

Fluorinated Gases: Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

Carbon Sequestration and Storage

Big Picture
Many scientists are working to determine how we can reduce the amount of carbon dioxide (CO_2) in the atmosphere. One of the most promising ideas is to capture carbon and transport it to safe storage areas. Geologic storage may be possible in oil and gas reservoirs, deep saline aquifers, unmineable coal seams, oil and gas rich shale, or basalt. While some of these areas may be found to be possible storage areas, there are potential risks, including movement of the CO_2 from its initial storage place, unforeseen leakage to the earth's surface, and earthquakes causing leakage. Any movement of CO_2 could pose a risk to drinking water.

Facilitating the Activity
- Rock samples (limestone, sandstone, and shale) are available from the Indiana Geological Survey and are often handed out at the Hoosier Association of Science Teachers, Inc. (HASTI) Conference in February. They can also be ordered through Carolina Biological Supply Company (www.carolina.com, search "Sedimentary rock specimens").
- Oil will soak into limestone and sandstone. It will run off the shale and form a pool below the stone.

Connections
Characteristics of a cap stone include low porosity and permeability. Another thing geologists look for is a layer that is porous underneath the capstone where the carbon can be stored.

Life Skills
- Specific Skill: observation, record keeping
- Science Standard:
  - **7.3.16** Recognize and explain that different ways of obtaining, transforming, and distributing energy have different environmental consequences.
  - **7.4.14** Explain that the environment may contain dangerous levels of substances that are harmful to human beings. Understand, therefore, that the good health of individuals requires monitoring the soil, air, and water as well as taking steps to keep them safe.
  - **Env.1.13** Understand and describe how layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. Recognize that by burning these fossil fuels, people are passing stored energy back into the environment as heat and releasing large amounts of carbon dioxide.
- Success Indicator: Observing the difference in rock permeability

PURDUE AGRICULTURE

Produced by Agricultural Communication 04/12