Air Quality and Transportation Curriculum

San Antonio, Texas
Summer 2006

Better education now
Better protection for our future

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The Alamo Area Council of Governments (AACOG) would like to thank the following agencies for permission to use and adapt their education resources for this curriculum:

Alliance to Save Energy (ASE)	www.ase.org
Department of Earth Science at the University of Northern Iowa	www.earth.uni.edu/
Energy Information Administration (EIA)	www.eia.doe.gov
Environmental Protection Agency (EPA)	www.epa.gov/
Northwestern Indiana Regional Planning Commission (NIRPC)	www.nirpc.org/
Texas Commission on Environmental Quality (TCEQ)	www.tceq.state.tx.us/index.html
Texas State Energy Conservation Office	www.infinitepower.org/lessonplans.htm
West Michigan Clean Air Coalition	www.wmcac.org

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Key to Symbols:

= **Air Quality Lesson/Activity**

= **Transportation Lesson/Activity**

= **Activity**

= **Lesson**

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Introduction

This purpose of this curriculum, compiled and developed by the Alamo Area Council of Governments (AACOG), is to assist teachers in the San Antonio region and throughout Texas in educating students on air quality issues as they relate to health and transportation. As of the date of this printing, Summer 2006, ground-level ozone pollution is the San Antonio region's most pressing air pollution problem, which creates significant public health concerns. The lessons within this curriculum will help students understand ground-level ozone pollution and its sources, and it will teach them how their daily choices can help keep our air clean and help us all breathe a little easier.

AACOG gathered these lessons from organizations and agencies throughout the United States and wishes to express sincere gratitude to all of the air quality educators who have allowed us to adapt and reprint their work. AACOG modified each lesson for Texas and especially for the San Antonio region, and correlations to the Texas Essential Knowledge and Skills (TEKS) have been provided.

As you use this curriculum, please contact AACOG Natural Resources Department staff at (210) 362-5200 or via the website, www.aacog.com/air , with any questions or requests for guest speakers. AACOG technical and outreach staff are happy to visit as guest speakers and have a number of interactive lessons to supplement those already contained in the curriculum.

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What is Air?

Target Grade Levels
Kindergarten - Fifth

Time
20 minutes

Materials
None

Knowledge and Skills (TEKS)

- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment;
  - Give examples of scientific discoveries and technological innovations that have shaped the world;
  - Compare ways living organisms depend on each other; and
  - Know that organisms need food, water, light, air, and habitat.
- Language Arts
  - Listen and talk about experiences; and
  - Make contributions to small or large group discussions.

Overview
In this discussion activity, students will be asked a series of questions to see what they know about air—some possible answers are provided. Teachers can then choose from the accompanying series of activities to help students check their assumptions about air.

Background Information
Before understanding air pollution and what it means to our air, students need to be able to recognize air itself. Air is all around us and is a primary ingredient for life—without air; there would not be any life as we know, so we need to take care of our air.

Procedure

1) Vocabulary
   a) air
   b) gas
   c) atmosphere
   d) water vapor
   e) smoke
   f) oxygen
   g) carbon dioxide
   h) smokestacks
   i) transportation
   j) molecules
   k) atoms

2) Activities
   a) Ask students to back up their answers with evidence. Questions for students with possible answers included below each question:
      i) What do you know about air?
         (1) We breathe air.
         (2) Air is a gas.
         (3) Air makes up the atmosphere.
      ii) What are some things you have observed about air?
         (1) Air moves (wind).
         (2) Air can change temperature.

(3) Air can smell.

(4) Air can be seen (water vapor, smoke).

(5) You can feel air when it moves (wind).

(6) You can see air moves things (storms, trees, leaves, dust, litter).

(7) Moving air makes weather.

(8) Hot air rises (hot air balloon).

iii) How do living things use air?

(1) Living things use air to breathe oxygen.

(2) Plants use air (carbon dioxide) to make food.

(3) Birds use air to fly.

(4) Seeds are distributed by the wind.

iv) How does air become polluted?

(1) Industry, such as smokestacks, pollutes the air.

(2) Individuals' actions (driving, mowing) create pollution by burning gas.

(3) Air coming from other areas of the U.S. pollutes the air.

(4) Transportation (cars, planes, trucks, trains) helps create ozone pollution.

v) Is all air clean?

(1) Some air is polluted.

(2) Sometimes we can see air pollution.

(3) Sometimes we can smell pollution.

(4) Sometimes we can't see it or smell it, but special equipment shows that there is air pollution on in the air.

vi) What are the properties of air?

(1) Possible Answers

(a) Air is transparent.

(b) Air has weight.

(c) Air takes up space.

(d) Air is a gas.

(e) Air is made up of molecules and atoms.

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Adapted from: "Ozone Action! Let's Clear the Air:
Educational Activities Kindergaten-5th grade." West Michigan Clean Air Coalition. 2003.

What is Air? *Air is a Gas!*

Target Grade Levels
Kindergarten - Fifth

Time
One hour

Materials
- 3 glass containers, such as jars
- solid object that will fit in the container
- water

Knowledge and Skills (TEKS)
- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment;
  - Give examples of scientific discoveries and technological innovations that have shaped the world;
  - Compare ways living organisms depend on each other; and
  - Know that organisms need food, water, light, air, and habitat.
- Language Arts
  - Listen and talk about experiences;
  - Write to express, discover, record, develop, reflect on ideas, and problem solve; and
  - Make contributions to small or large group discussions.

Overview
Students will learn the differences between gas, solid, and liquid while viewing the teacher's experiment.

Background Information
We need to breathe air to live. If our air is not clean, it affects our health. Just because we cannot see pollution does not mean it is not in the air we breathe. Clean air actions all year help keep our air clean.

Procedure
1) Vocabulary

a) gas	d) air
b) solid	e) compress
c) liquid	f) molecules

2) Activities
   a) Set the three glass containers on a desk, one containing the solid object, another containing some water and the third containing "nothing".
   b) Have students describe the relationship of these three states of matter. Possible answers include:
      i) Solid has its own shape inside the jar.
      ii) Liquid takes the shape of the container but has one free surface.
      iii) Gas fills the entire container.
   c) They may be able to name some other properties. Ask students what they notice about these states of matter when they are compressed.
   d) How might we know if our air is not clean? Have students draw pictures of or list things they think make our air dirty.
   e) What are some simple actions students can take that can help clean the air?

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Adapted from: "Ozone Action! Let's Clear the Air:
Educational Activities Kindergaten-5th grade." West Michigan Clean Air Coalition. 2003.

What is Air? *It Moves and It Smells*

Target Grade Levels
Kindergarten - Fifth

Time:
One hour

Materials

- small container
- household ammonia
- classroom map (included)
- four colored pencils or crayons
- large clock with second hand

Knowledge and Skills (TEKS)

- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment;
  - Give examples of scientific discoveries and technological innovations that have shaped the world.
- Math:
  - Measure distance;
- Language Arts:
  - Compose journals, letters, reviews, poems, narratives, and instructions;
  - Listen and talk about experiences;
  - Make contributions to small or large group discussions; and
  - Know that organisms need food, water, light, air, and habitat.

Overview
This demonstration and exercise will help students understand the development of the movement of air, assist them in learning how to gather and analyze data, and hone their skills in both math and science.

Background Information
After pollutants are released, they are moved to other communities by the wind. Our own actions affect other people who might not even live near us, such as Corpus Christi.

Procedure

1) Vocabulary

a) ammonia	c) wind speed
b) odor	d) wind velocity

2) Activities

a) Set a small, sealed container of household ammonia on your desk during a discussion on air.

b) When all of the students are seated and you are discussing things we observe about air, open the lid on the ammonia container.

c) See how long it takes for the first student to notice the smell.

d) Students should observe that the odor moves from the source to the farthest place from the source. Does anything affect how the smell is carried through the room (such as a breeze from an open window or air flow from a vent)?

e) Students can plot the time and distance, tracking how air (and the odor) moves through the room using the student handout, classroom map.

f) Discuss with students activities that they or their parents do that affect the air?

3) Review

   a) Discuss wind patterns over Texas, how we receive other communities' pollution and who might receive ours based on wind velocity and direction. Students can perform math word problems to see how long it takes pollution from one Texas city to reach another Texas city based on wind velocity.

   b) Discuss national and global wind patterns and how pollution can be carried to different parts of the Earth. Texas frequently experiences ozone pollution from different parts of the U.S. and even receives dust or smoke from places as far away as China and the Sahara Desert. A good resource for recent national and global transported pollution events is:

   www.tnrcc.state.tx.us/updated/air/monops/airpollevents/2004/sigevents_2004.html

4) Evaluation

   a) Students can be quizzed on transported pollution math problems based on wind velocity, destination city, and time to destination city.

   b) Students can be asked to name three things they can do to reduce pollution

   c) Students can perform the following extension activities as graded exercises.

5) Extension

   a) Students can time and mark distance from what points in their home they can smell dinner cooking. Then they can draw a floor plan of their home and track travel of smell.

   b) Students can make a smell diary. Many of us remember easily what we see or hear throughout the day, but we don't consciously recognize what we smell. Students could, for instance, journal what they smell on their way home from or to school.

   c) As an additional in-class activity, students can chart what are good smells and what are bad smells, sparking a discussion on the concept that different people may have different ideas of "smell pollution" and that a better definition of pollution is something that does damage to our health or livelihood.

Adapted from: "Ozone Action! Let's Clear the Air:
Educational Activities Kindergaten-5th grade." West Michigan Clean Air Coalition. 2003.

Air Carries Odor and Moves
Classroom Map

Back of classroom

Front of classroom

Step One
Students will list the 15-second intervals for three minutes. At each interval, students will plot the intensity level (shown below) of the odor.

Intensity
1 - No Odor detected at all

2 - Begin to smell odor

3 - Odor is strong

4 - Odor is very strong

Step Two
Record the data on the map to track how the odor moved through the classroom. Create a separate map for each 15-second interval. Color only the areas where students claimed they began to smell the odor (intensity level number two). Plot the times where students began to smell the odor.

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What is Air? *How Living Things Use It*

Target Grade Levels
First - Third

Time
One hour

Materials
- student-made pictures of bones, liver, heart, lungs, small intestine, large intestine, brain, kidneys, muscles, stomach or mouth
- thirty to forty ping-pong balls in two colors, one color representing clean air, one color representing pollution

Knowledge and Skills (TEKS)
- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment;
  - Give examples of scientific discoveries and technological innovations that have shaped the world;
- Math:
  - Represent as in a graphic organizer;
  - Summarize making charts; and
  - Produce visuals.

Overview
This lesson will help students understand how the body uses air and is very helpful in teaching them to appreciate the necessity of clean air.

Background Information
Toxic air pollutants are poisonous substances in the air that come from natural sources (for example, radon gas coming up from the ground) or from anthropogenic sources (for example, chemical compounds given off by automobile exhaust) and can harm the environment or your health. Inhaling (or breathing) toxic air pollutants can increase your chances of experiencing health problems. For example, inhaling the benzene fumes that are given off when you pump gas into your car can increase your chances of experiencing health effects that have been associated with exposure to benzene, such as leukemia.

Health risks, put simply, are a measure of the chance that you will experience health problems. Exposure to toxic air pollutants can increase your health risks. For example, if you live near a factory that releases cancer-causing chemicals and inhale contaminated air, your risk of getting cancer can increase. Breathing air toxic air pollutants could also increase your risk of noncancer effects such as emphysema or reproductive disorders.

Procedure
1) Vocabulary

a) respiratory tract
b) oxygen
c) bones
d) lungs
e) small intestine
f) large intestine
g) anthropogenic
h) brain
i) air
j) liver
k) heart
l) kidneys
m) muscles
n) stomach
o) mouth
p) pollution

2) Activities

   a) Students should be assigned as homework or in-class preparation prior to the activity the task of drawing life-sized internal organs needed for in-class activity. Each student should learn the basic definition for his or her internal organ.

   b) Have the class count the number of times they breathe per minute.

   c) Does each student breathe at the same rate? What would change their breathing rates?

   d) Can they figure out how many times they breathe in one day?

   e) Share the following information with the students:
   Oxygen is inhaled through the nose and mouth. It enters the lungs and is transported to other organs through the blood. Once used, leftover air, or waste air, moves back to the lungs so that it can be exhaled through the mouth.

   f) Review with students the sources and types of air pollution (smoke, ozone). The Air Pollution Gremlins poster included with this curriculum binder can act as a good visual. Start the simulation

      i) Choose students to act as the body parts. They will tape a picture to their shirts. Provide a handful of balls to other students who will serve as inhalation and exhalation.

      ii) To begin, "clean air" is handed to the mouth who then passes it on to the lungs. The lungs in turn, pass the air to the heart who keeps the ball before passing the rest to another organ who does the same. Eventually, all organs have air and the waste air is returned to be exhaled through the mouth.

      iii) In the next part of the activity, pollution mixes with air. Students, taking air, must close their eyes when choosing the balls. In the end, we will see that polluted air has interfered with the delivery of clean air to the organs that need it.

3) Review

   a) Each organ should be reviewed in terms of function and why it needs clean air.

   b) Each organ should be reviewed in terms of what might happen to the body (how you might feel) if the organ couldn't work properly because it wasn't fueled by clean air.

4) Evaluation

   a) Students can be quizzed on organ function and the body's need for clean air.

   b) Students can be quizzed on what they can do to help keep the air clean.

5) Extension

   a) Write a story about a villain pollutant and its journey around the body doing damage.

   b) Research how pollutants might damage each organ (remember that not all pollutants enter the blood stream) and what happens if each organ doesn't function properly.

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Adapted from: "Ozone Action! Let's Clear the Air:
Educational Activities Kindergaten-5th grade." West Michigan Clean Air Coalition. 2003.

Background information adapted from: Environmental Protection Agency (EPA).
www.epa.gov/

What is Air? *Is It Clean?*

Target Grade Levels
Second - Fifth

Time
30 minutes

Materials
None

Knowledge and Skills (TEKS)

- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment; and
  - Give examples of scientific discoveries and technological innovations that have shaped the world.
- Math:
  - Represent as in a graphic organizer; and
  - Summarize making charts.
- Visual Arts:
  - Produce visuals.

Overview
Students will be introduced to the three forms of oxygen and will then discuss how some of the gases in the air can be harmful.

Background Information
Ozone that exists as part of the "ozone layer" up high in the stratosphere is good. It protects us, and the earth, from the sun's, however, harmful ultraviolet rays. Ozone at the ground-level is bad for us. Ground-level ozone affects people's breathing, especially children, elderly, people with respiratory conditions, such as asthma, and those who exercise strenuously outdoors. At the ground-level, in the troposphere, ozone is formed when pollution from cars, factories, and other sources is "baked" by the sun. This bad ozone is likely to form on days when the temperature is above the 80°F and there is little wind or cloud cover. When the ozone at ground-level is really bad, you may see brown haze from nitrogen oxides (NO_x) or particles, but never ozone. Sometimes the whole hazy pollution layer is called smog.

Thinking about how we contribute to air pollution and taking actions to prevent it will help ensure we keep our clean air.

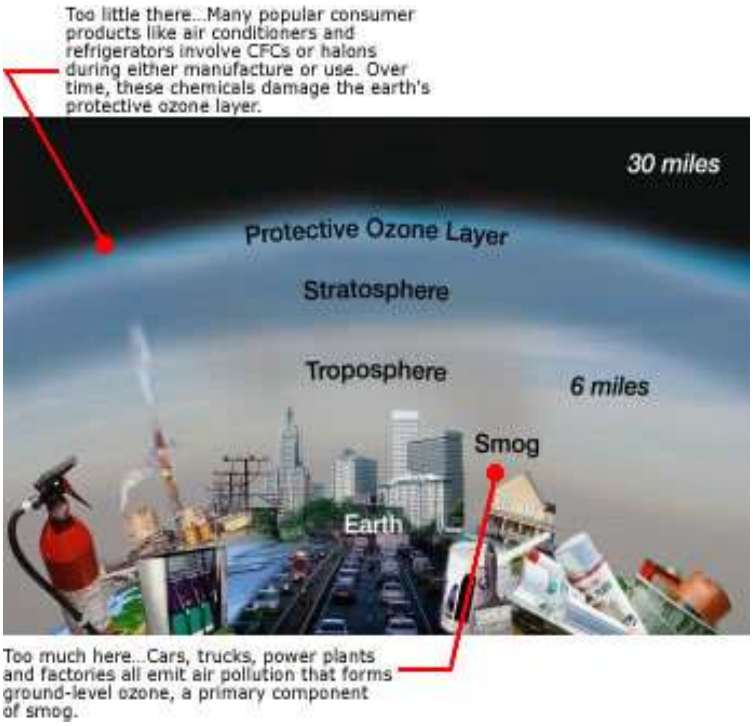

Image courtesy of: www.epa.gov/oar/oaqps/gooduphigh/

Procedure

1) Vocabulary
   a) elemental oxygen
   b) molecular oxygen
   c) ozone
   d) stratosphere
   e) troposphere
   f) nitrogen oxides
   g) ozone layer
   h) smog
   i) ground-level ozone
   j) pollution
   k) volatile organic compounds
   l) haze

2) Activities
   a) Discuss the fact that some of the gases we find in air can be harmful. One of these gases is ozone (O_3). In the atmosphere, we have three forms of oxygen:
      O = elemental oxygen
      O_2 = molecular oxygen
      O_3 = ozone
   b) Discussion questions with possible answers:
      i) Besides people, what needs clean air to live?
         (1) All living organisms—plants, animals, bus, etc.
      ii) Can students cite examples of activities that pollute our air (make it "dirty")?
         (1) Driving, factories, smokestacks, smoking, etc.
      iii) Can students identify weather conditions that might cause ground-level ozone?
         (1) Sunny weather, no wind, no clouds, etc.
      iv) Why is ozone a problem for us from April to October?
         (1) Lots of heat, long summer, etc.
      v) What are some simple actions students can take that can help clean the air?
         (1) Bike, walk, scooter (drive less), use less electricity, etc.

3) Review
   Discuss with students how their actions directly help reduce the pollutants that contribute to ground-level ozone formation. (e.g. driving less creates less NO_x and VOC pollution, thus reducing the ingredients available to make ground-level ozone)

4) Evaluation
   a) Students can be quizzed on basic concepts.
   b) Students can perform the following extension activities as graded exercises.

5) Extension
   a) Students can track and chart weather conditions and maximum daily ozone levels via the Texas Commission on Environmental Quality's websites:
      i) Map of Current Ozone Levels for San Antonio

http://www.tceq.state.tx.us/cgi-bin/compliance/monops/select_curlev.pl?region13_cur.gif

ii) Animated map of Region 13

www.tceq.state.tx.us/cgi-bin/compliance/monops/ozone_animation.pl?13

iii) Air Quality Index

http://www.tceq.state.tx.us/cgi-bin/compliance/monops/ozone_actionday.pl

b) Students can research other uses for ozone (such as water purification) and how its destructive properties can be put to good use.

c) Students can create posters to educate their schoolmates on ozone's harmful health effects and/or how to reduce air pollution.

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Adapted from: "Ozone Action! Let's Clear the Air:
Educational Activities Kindergaten-5th grade." West Michigan Clean Air Coalition. 2003.

Moving Air!

Target Grade Levels
Kindergarten - Fifth

Time
One hour

Materials
- marble
- ball of yarn
- clothes pin
- rubber ball
- crayon
- leaf
- small pebble
- pencil
- facial tissue
- inflated balloon
- feather
- sand
- graph paper
- masking tape
- yardstick

Knowledge and Skills (TEKS)
- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment; and
  - Give examples of scientific discoveries and technological innovations that have shaped the world.
- Math:
  - Represent as in a graphic organizer; and
  - Summarize making charts.
- Visual Arts:
  - Produce visuals.

Overview
The movement of air masses can be confusing and difficult for students to conceptualize. This activity aids in the understanding of how air and its contents move.

Background Information
Wind is moving air. Wind has energy and can push objects. For example, wind can move things we can see, such as, tree leaves, grass, your hair, and sand. Wind can also move very small objects that you cannot see, such as ozone, a colorless, odorless gas.

People hear in weather reports about how fast the wind is blowing. If the wind is moving ten miles per hour, that means it can push pollution ten miles in a single hour—faster than most people run! The air can push things, such as leaves and balloons, and air pollution, from one place to another. Sometimes wind is good; people love to fly kites, or find pretty colored leaves. Sometimes, wind is bad; we don't like it when a horrible smell comes our way from somewhere else. All of those things, good and bad, move with the air, pushed by the wind.

Procedure
1) Vocabulary

a) wind	e) gas
b) energy	f) air
c) ozone	g) wind velocity
d) wind speed	

2) Activities

a) Read the background information to the class and ask them to imagine that if they had to move an object without touching it, what would they do? Write answers on the board.

b) Have they ever blown a strand of hair out of their eyes? Have they ever had their hair dried with a blow dryer? What happens? Wind moves things.

c) Show the students some of the objects (listed in the materials section) and have them name them. Do the students think they can move all of these objects with wind?

d) Present rules for the activity to the class (low voices, only one person out of their seat at a time, no running or throwing, and keep hands to yourself).

e) Make sure that the tabletops are clean and dry for the "race". Place a piece of masking tape about two feet long on one end of the students' tables for the starting line. Three feet away, place another piece of tape about two feet long for the finish line. Gather all of the objects for the "race" and place them in boxes; one for each group.

f) Form the students into groups of five. Then have the students count off, if necessary. Pass out role labels according to numbers. All the ones are "Getters" twos are "Wind," threes are "Timekeepers," fours are "Recorders" and fives are "Encouragers."

g) Announce to the class that they now are going to find out if they can use wind to move all of these objects and explain the instructions. If there are no questions, have the "Getters" come up to the front and pick up the materials they need.

h) Have the "Getters" place one object on the desk and say: "On your mark, get set, go!" The "Wind" will then blow on the object until it crosses the finish line. "Recorders" will count the number of blows it takes to move the object the entire distance and the "Encouragers" will record the number on their graph by coloring in the corresponding number of blocks. "Timekeepers" will monitor the length of time given for the race.

i) The race continues until all of the objects have crossed the finish line or until time is up.

j) Note: Have the students read the names of the objects printed at the bottom of the graph to be sure they know where to record the data for each object, or have the students draw pictures to identify each object.

3) Review

Use the following questions (anticipated responses included) to encourage a class discussion about the results.

a) What made the objects move? *Your breath, air, wind, number of blows...*

b) What is wind? *Wind is moving air. The wind has energy and can push object in the direction in which it is blowing.*

c) Which objects took the most blows to move? *Clothes' pin, pebble, crayon, pencil…*

d) Why? *Bigger, heavier, not round…*

e) Which objects took the least amount of blows to move? *Hats, windmills, leaves, flags, dust, clouds, paper, balls…*

f) Do you think it makes a difference what direction the wind comes from in order for something to move in a certain direction? *Hint: Think about your investigation. Yes, you have to blow it in the direction you want it to go (finish line). Yes, if you blow from an angle it might not move or it might go in a different direction.*

4) Evaluation

   a) Students' record keeping on the activity can be evaluated as a graded task.

   b) Students can be quizzed on transported pollution math problems based on wind velocity, destination city, and time to destination city.

   c) Students can perform the following extension activities as graded exercises.

5) Extension

   a) Wind-powered puffs: Discuss ways in which the wind is helpful to us and how we might use the wind to help us accomplish tasks. For example, we use hair dryers, clothes dryers, fans and we even blow on hot food to cool it before we eat it. Encourage the students to think of other ways to use wind. Invite children to use their wind power to accomplish a task. Divide the class into four or five equal teams. Have one person from each team kneel behind a starting line. Place a cotton ball in front of each person. On the start signal, have each student blow the cotton ball with just one puff. Measure how far the cotton ball went. Repeat until each student has had a turn. Graph the results. Discuss the results. Discuss some of the problems with using wind, such as harnessing its energy and controlling its effects and the way it can bring unwanted things (like pollution and odors) into the area.

   b) Wind-powered rocket: Show the students a picture of a wind turbine and explain how wind can help generate power that can be used to create energy. Demonstrate how to build a wind-powered rocket with the following instructions:

      i) Stretch a string tightly from one side of the room to the other.

      ii) Thread the string through a plastic drinking straw.

      iii) Blow up a balloon and hold the end with a finger to prevent air from escaping.

      iv) Using tape, attach the balloon to the underside of the straw.

      v) Let the air out of the balloon and watch the "rocket" fly across the room on the string.

      vi) Give each student a plastic drinking straw and a balloon. Have students work in pairs to stretch a string between two points and launch their rockets. After they experiment, discuss the scientific principle of the wind-powered propulsion.

   c) Wind picture: Give each student a 9"x12" sheet of black construction paper and a straw. Drop a few drops of diluted white paint in the center of each child's paper and encourage students to aim the straw at the paint and blow into it to create an interesting, wind-blown design. It is important that the straw does not touch the paint. For variety, try using bright colors of paint on white construction paper.

   d) Make stuffed clouds: Have students put two pieces of butcher or construction paper, one on top of the other, and cut a large cloud shape through both layers. Then have students paint, color, or decorate (with glitter, tissue, etc.) both of the outer layers. Staple the edges, leaving an opening to stuff with newspaper; then staple the remaining opening. Hang the clouds around the room.

   e) Cross curricular extension activities—Language Arts:

i) Read a poem about wind and have students write their own rhymes and poems about wind. (Recommended: “Who Has Seen the Wind” by Christina Rossetti.)

ii) Read the book The Wind Thief, by Judi Barrett. Make hats out of newspaper and masking tape by placing two sheets of paper on your head and having someone else take the tape and wrap it around your head where the newspapers are. Fold the sides up or down to create a unique design, students can then decorate their hats. If it is a windy day, take the students, while wearing their hats, outside and let them see what happens.

f) Cross curricular extension activities—Social Studies:

i) Ask the students what significant historical events has wind been involved in? For example:

(1) Wind blew in the sails of the Niña, the Pinta, and the Santa Maria to take Columbus across the Atlantic Ocean to the Americas.

(2) A strong, dry wind spread the great Chicago fire of October 8, 1871.

ii) Does the wind ever change direction? How can you tell? For study, have the students construct a wind vane and investigate the direction of the wind for three days. To make a wind vane, you need an eraser, a pencil, a straw, oak tag and a straight pin. Cut the point and tail arrow out of oak tag and tape them to the straw. Put the pin through the straw into the eraser end of the pencil. Stick the pointed end of the pencil into a flat eraser, and glue to a square piece of oak tag. Label the sides of the oak tag base North, East, South, and West and set the wind vanes outside with the north sides facing north. Record the direction of the wind for three days.

g) Cross curricular extension activities—Environment:
Make an imaginary map of an imaginary city where people live on the south side of town; factories manufacture things on the north side of town and there are many cars, trucks and buses; the east side of town is surrounded by lakes, and the west by forests. Encourage students to imagine they live in a town on a day when the wind came from the east. What would they feel? Water? Warm air or cold air? Why? What would they smell? Fish? Ask students to imagine the wind changes direction and is now blowing from the west. What would they see? Leaves blowing? Dirt blowing? What might they smell? Animals? Trees? Flowers? Ask students to imagine the wind came from the north side of town. What would that be like? Would there be pollution? Would it smell bad? Look funny? Ask student to consider their own pollution and how it blows other places, too. Ask students to think about the sources of pollution and what they can do to reduce the amount of pollution they put into the air that moves, blown by wind.

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Adapted from: “Ozone Action! Let’s Clear the Air:
Educational Activities Kindergaten-5th grade.” West Michigan Clean Air Coalition. 2003..

Making an Alphabet Book

Target Grade Levels
Kindergarten - Fifth

Time
Two to five class periods, depending on the choice of books.

Materials
- access to dictionaries, encyclopedias, and the library
- air quality Tip cards
- meteorological forecasting notes
- air quality glossary
- magazines
- scissors
- glue or tape
- pencils, crayons, etc.

Knowledge and Skills (TEKS)
- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment;
  - Give examples of scientific discoveries and technological innovations that have shaped the world;
- Math:
  - Represent as in a graphic organizer; summarize making charts; and
- Visual Arts:
  - Produce visuals.

Overview
Making an air quality alphabet book is a fun learning experience for students. It can be used in many subjects as well as help students learn about a topic through research, drawing, writing and completing a finished product.

Background Information
Learning about air quality helps people to protect themselves and others from ground-level ozone pollution by teaching them about things they can do to reduce air pollution all year long.

Air Quality Health Alert days are the hot, sunny days that meteorologists forecast as being the most likely to produce excessive amounts of ground-level ozone in the air we breathe. They occur during ozone season, between April 1 and October 31, when the San Antonio area has the most sun and the most heat. The Texas Commission on Environmental Quality's team of meteorologists forecasts Air Quality Health Alert days based on weather conditions. Certain weather conditions, like sun and heat, are part of the conditions that turns pollution into ozone. On Air Quality Health Alert days, people can protect their health by limiting outdoor activity, or staying indoors where ozone pollution is up to 50% less than outdoors.

Ground-level ozone is unhealthy in the air we breathe. It can hurt our eyes, noses and lungs. It is especially bad for people who have asthma or other breathing problems, people who work or play strenuously outdoors or for the elderly. Even when it's not ozone season in San Antonio, we can still take actions by helping teach people about ozone, pollution and activities that reduce air pollution year round.

Procedure

1) Vocabulary
   See full vocabulary list in Appendix A for words students can use.

2) Activities
   a) Look at other alphabet books. (Recommended: *Animalia* by Grahame Base.)
   b) Assign letter of the alphabet to individuals, partners, or groups.
   c) Have students do research to find the core word for each page, if brainstorming does not help them agree on a particular word. Research can include air quality terms in Appendix A, Internet search, or visiting the school library.
   d) Have the students create sentences for each of the pages that include nouns, verbs, adjectives, and adverbs plus other words if wanted or necessary. The sentences should explain the word's role in air quality
   e) The students will work together designing the pages of the book, putting pictures of the words/activities/etc. in context, and including other relevant air quality words that begin with the same letter.
   f) When they are finished, students will share their pages, explaining their work to class.
   g) Make the book available to others.

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Learning From Stories

Target Grade Levels
Kindergarten - Fifth

Time
One or more class periods, depending on the choice of books.

Materials
- book from the provided reading list

Knowledge and Skills (TEKS)
- Science:
  - Make wise choices in the conservation of resources;
  - Describe ways technology influences human capacity to modify the environment;
  - Give examples of scientific discoveries and technological innovations that have shaped the world;
  - Compare ways living organisms depend on each other; and
  - Know that organisms need food, water, light, air, and habitat.
- Language Arts:
  - Listen and talk about experiences;
  - Draw inferences from text and support these conclusions and generalizations with evidence from the text; and
  - Make contributions to small or large group discussions.

Overview
This exercise uses fiction designed for young children as a basis for lessons about ecology and environmental responsibility. It can be used independently or in conjunction other classroom activities.

Background Information
Storytelling is a time-honored teaching tool used in many cultures. The storybooks listed below all have environmental themes. They can serve as a starting point for conversations that call on children to synthesize information and experiences and think creatively about themselves and the world around them.

Procedure
1) Vocabulary
   a) ecology
   b) environment
   c) rainforest
2) Activities
   a) Choose a book from the following reading list
      i) *Keepers of the Earth* by Michael J. Caduto and Joseph Bruchac
      ii) *Chadwick Forever* by Pricilla Cummings
      iii) *The Violators* by Gunnard Landers
      iv) *The Great Kapok Tree* by Lynne Cherry
      v) *The Talking Earth* by Jean Craighea George
      vi) *Mushroom Center Disaster* by N.M. Bodecker
      vii) *Alvin Fernald, Superweasel* by Clifford B. Hicks
      viii) *Canyon Winter* by Walt Morey
      ix) *Poison Factory* by John Branfield

x) *Baney's Lake* by Nan Hayden Agle

xi) *Beaver Valley* by Walter Dumau Edmonds

xii) *Who Really Killed Cock Robin?* by Jean Craighea George

xiii) *The Lorax* by Dr. Seuss

xiv) *If I Built A Village* by Kazue Mizumura

xv) *All Upon A Stone* by Jean Craighea George

xvi) *The Salamander Room* by Anne Mazer

xvii) *Once There Was A Tree* by N. Natali Romanov

xviii) *Tree House Town* by Miska Miles

xix) *The Wump World* by Bill Peet

b) Depending on your students' reading level, you may choose to read the story aloud to the class or have children take turns reading.

c) Follow up the story by leading children in a conversation about it. Ask questions that challenge their thinking. For example, explore why things happened or people acted in given ways, what changed during the story, how something in the story is alike (or different) from something the child knows or believes. Challenge students to find ways they can use the lesson in the story. For example, what can they do to help save the rain forests, or take care of animals, or help their parents conserve energy?

d) Whenever possible, create activities to follow up on the lessons taught by the stories to enhance the experience. Use your imagination. If the story is about industrial pollution, take students for a walk and have them point out smokestacks and other things that might be visible examples.

e) Suggested modifications

i) For older students, you may wish to assign book reports based on fiction involving environmental themes. Have students present book reports to the class and discuss the environmental messages gleaned from the stories. Following is a list of books you may want to consider for this purpose:

(1) *A Most Unusual Lunch* by Robert Bender

(2) *Dear Children of the Earth* by Schim Schimmel

(3) *California Blue* by David Klass

(4) *Covered Bridge* by Brian Doyle

(5) *Astrid Spark, Fixologist* by Justin D'Ath.

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Acid Rain: The Disappearing Statue

Target Grade Levels
Second - Fifth

Time
45 minutes

Materials
- sticks of chalk
- vinegar
- small plastic glasses for each group
- eyedroppers or straws
- three-penny nails

Knowledge and Skills (TEKS)
- Science:
  - Acquire data through the senses;
  - The student shall be given opportunities to observe properties and patterns of objects, organisms, and events in the environment; and
  - The student shall be given opportunities to describe objects, organisms, and events from the environment, describe changes that occur to objects and organisms in the environment.
- Language Arts:
  - Communicate data and information in appropriate oral and written form.

Overview
To demonstrate the negative effect of acid rain on statues and buildings.

Background Information
Acid rain is more acidic than normal rain and forms through a complex process of chemical reactions involving air pollution. The two most important pollutants that contribute to the formation of acid rain are nitrogen oxide (NOx) and sulfur dioxide (SO_2), which react with moisture in the atmosphere to form nitric (HNO3) and sulfuric acid (HSO_4). The sulfur and nitrogen compounds that contribute to acid rain primarily come from anthropogenic sources, such as cars. Emissions also come from automobiles and other forms of transportation and industrial processes, such as smelting.

Acid rain can harm forests and crops, damage bodies of water, and contribute to the damage of statues and buildings. Researchers are considering the possible effects of acid rain on human heath. These acidic pollutants can be deposited through rain, snow, fog, dew, or sleet. Large quantities can also be deposited in a dry form, dust. Pollutants that contribute to acid rain may be carried hundreds of miles before being deposited on the earth. Because of this, it is sometimes difficult to determine the specific sources of these acid rain pollutants.

Procedure
1) Vocabulary

a) acid
b) pH
c) base
d) nitrogen oxides
e) sulfur dioxide
f) anthropogenic
g) limestone

2) Activities

a) Explain that acids react with bases, and limestone is a base.

b) Further explain that vinegar is an acid and chalk is limestone.

c) Fill a glass 1/3 full with vinegar for each group.

d) Use a nail to carve a statue out of one of the chalk halves. Be creative. Some chalk may need a light sanding to make it easier to carve. Place the statue into the glass filled with vinegar.

e) Using the eyedropper, drop single drops of vinegar onto your chalk statue.

f) What is happening to the chalk statue?

g) Discuss the slow deterioration of statues and buildings due to the weak acid rain that falls on some statues and buildings. If the stone is limestone or has limestone in it, the deterioration is more rapid. Note: The Alamo is made of limestone.

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Adapted from: Acid Rain: The Disappearing Statue" *Texas Commission on Environmental Quality.*
http://www.tceq.state.tx.us/assets/public/assistance/education/air/acid_rain_statue.pdf

Acknowledgment: Lois Richardson, Stephen F. Austin University Nacogdoches TES Course 1994

Air Quality and Transportation

Target Grade Levels
Second - Eight

Time
Two class periods, one morning or afternoon data gathering session

Materials
- notebook paper

Knowledge and Skills (TEKS)
- Science:
  - Acquire data through the senses;
  - The student shall be given opportunities to observe properties and patterns of objects, organisms, and events in the environment, and explore the environment;
  - Classify, order, and sequence data;
  - The student shall be given opportunities to classify matter, forces, energy, organisms, actions, and events from the environment according to similarities and differences; and
  - The student shall be given opportunities to describe changes that occur to objects and organisms in the environment.
- Language Arts:
  - Communicate data and information in appropriate oral and written form.

Overview
This experiment will help us to see that using carpools and other alternative means of transportation are necessary to lessen air pollution.

Background Information
Air pollution is a problem in many areas. Air pollution is air that is dirty compared to its original state. Air pollution can be harmful to people, animals, plants, and structures. Vehicles produce a large percentage of air pollution. Vehicle exhaust contains nitrogen oxides and small traces of volatile organic compounds. These two types of pollution, on hot, sunny days with light winds, can produce ground-level ozone. Exposure to high levels of the air pollutant ozone can cause health problems. Ozone is a main component of smog. Another common pollutant, especially from car and diesel exhaust, is airborne particle pollution. Some examples are tiny particles of soil, ash, or emissions from some factories that can get into your lungs and cause health problems. In order to control air pollution and protect public health, the government has placed restrictions on how much of these pollutants can be released into the air. Four ways you can help reduce this pollution are to carpool, take the bus, or walk or ride a bike instead of driving.

Procedure
1) Vocabulary
   a) air
   b) pollution
   c) nitrogen oxides
   d) volatile organic compounds
   e) ground-level ozone

2) Activities
   a) Make a chart of transportation types on a sheet that has been categorized as follows:
      i) One passenger in car
      ii) Two passengers in car
      iii) Three or more passengers in car

iv) walker

v) bicycle rider

vi) bus rider

Note: Students should not count driver in this situation, however, in a carpool to work, the driver would count. Discuss why.

b) Have students go to the front of the school in the morning or afternoon when there is the most traffic.

c) Have students tally the transportation types for fifteen minutes.

d) Graph the outcomes of the experiment.

e) Return to the classroom and have the students discuss their observations.

f) Ask the students to discuss alternatives to driving alone.

g) Ask the students how they get to school in the morning. Categorize responses, count, and have students create a bar graph showing different types of home-to-school transportation used by the class.

h) Student can then discuss results and how they might overcome obstacles to help improve the use of alternative methods. Use www.aacog.com/commutesolutions for additional research; it provides excellent information on SchoolPool and other resources for the home-to-school commute.

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Adapted from: "Air Quality and Transportation" *Texas Commission on Environmental Quality.*

Reference: Integrated Thematic Unit Scholastic

Acknowledgment: Teresa Ayala, University of Texas at El Paso TES Course, 1995

Conserving Electricity: Turn It Off

Target Grade Levels
First - Third

Time
30 minutes

Materials
None

Knowledge and Skills (TEKS)

- Science:
  - Classify, order, and sequence data; and
  - The student shall be given opportunities to classify matter and forces, organisms, actions, and events from the environment according to similarities and differences.
- Language Arts:
  - Ask and answer relevant questions; and
  - Make contributions to small or large group discussions.

Overview
To discuss how the production of electricity causes air pollution and thus encourage reducing electrical use.

Background Information
Most of our electricity is produced in steam turbines. A power source, such as coal, gas, or oil, heats water in a boiler to produce hot, high-pressure steam. This steam expands against the blades of a turbine. A turbine is a device that spins when air or water is forced against it. You can think of it as a kind of enclosed windmill. The hot, expanding steam forces the turbine to spin. The spinning turbine then operates a generator that produces electricity.

Procedure

1) Vocabulary

a) electricity	f) boiler
b) steam turbine	g) turbine
c) coal	h) generator
d) gas	i) pollution
e) oil	j) fossil fuel

2) Activities

a) Tell the class you are going to tell a story about a wise old owl and his young pupil. Warn them that the story ends with a question that you will hope they will be able to answer.

b) Story**:**
One night, wise old Professor Owl was flying over a town with Ollie Owl, one of his pupils.

As they looked down, they could see so many lights shining in the windows of all the houses.

“The lights look pretty," said Ollie.

"They may look nice," said Professor Owl, "but I wish those humans would turn some of those lights off."

"How come?" asked Ollie. "They don't do any harm, do they?"

"They certainly do," said the professor. "They cause a lot of air pollution."

"You mean that yucky stuff that stinks and makes me cough? How could electric lights do that?"

i) Stop the story here, and ask the students how they think Professor Owl will answer. Explain that most of our electricity, like almost all the energy we use, starts with a fire. At the power plant, the heat from the fire boils water and turns it into steam. The steam operates a giant machine called a turbine that makes electricity, which then travels through wires to a local power station and to our homes. Tell them that air pollution comes from the fires and fuels we have to burn to make electrical energy.

ii) Remind the class that the answer makes sense because the energy to heat the water, keep the lights burning, and keep our homes warm starts with a fire. Burning fuel causes air pollution.

iii) Tell the class that you are going to ask three questions that all have the same answer. They will have one minute to guess the answer.

(1) Why should we not let the hot water run when we're not using it?

(2) Why should we not leave the lights on when we're not using them?

(3) Why should we not keep the heat turned up high instead of wearing sweaters when it's cold?

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Adapted from: “Conserving Electricity: Turn it off” *Texas Commission on Environmental Quality.* http://www.tceq.state.tx.us/assets/public/assistance/education/air/turn_it_off.pdf

Reference: Environmental Science, 1984, CBS College Publishing

Acknowledgment: Linda Abbott, Stephen F. Austin University, Nacogdoches, Texas. TES Course, 1994

Acid Rain

Target Grade Levels
Sixth - Tenth

Time
1 class period

Materials
- crushed limestone (enough to fill a 2-liter container; available at garden supply store)
- crushed granite (enough to fill a 2-liter container; available at garden supply)
- (2) 3-liter soda bottles or 1-gallon plastic containers
- (1) 1-gallon plastic bottle
- clear 1-pint collecting containers
- sulfuric acid
- pH indicator solution
- distilled water
- water test kit or pH meter

Knowledge and Skills (TEKS)
- Science:
  - Scientific inquiry and critical thinking;
  - Ask questions about organism, objects, and events in the environment;
  - The student shall describe changes that occur to objects and organisms in the environment; and
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions.
- Language Arts:
  - Communicate data and information in appropriate oral and written form;

Overview
Students will observe and explain a demonstration of the reaction of acid rain on different materials and predict the possible effects in our natural environment.

Background Information
Normal rainfall is slightly acidic (pH 5.6, where 7.0 is neutral) because of reactions with atmospheric carbon dioxide which form carbonic acid. Rainfall with a pH of less than 5.6 is referred to as acid rain. Acid rain contains sulfuric and nitric acids due to the reaction of the water in the air with sulfur dioxide and nitrogen oxide. The sources of these pollutants are both natural and anthropogenic. Sulfur dioxide and nitrogen oxide are produced naturally through geothermal emissions and biological processes, but our heavy use of fossil fuels is the most significant contributor by far. Emissions from vehicles, from electric power, utilities, and industries are the chief sources of acid-forming sulfur and nitrogen oxides. These compounds react with water to form acids. These acids reach the ground in rain and snow, finding their way into surface and groundwater systems. Sometimes the particles of oxidized material fall directly to the earth in dry form, called acid deposition, and then combine with surface water to produce acids.

Acid deposition, whether through rain, snow, or dust, is a problem in much of the United States, but the degree to which an area suffers from it varies according to the total acidity deposited and the area's sensitivity to that acid. One factor in sensitivity is the geology of a particular area. In areas where the bedrock is limestone, acid precipitation can be neutralized to some degree by acid-base reactions; limestone's buffering action lessens its impact. In mountainous areas, the bedrock is usually granite, which does not neutralize acid. In such areas, acid rain enters surface and groundwater systems virtually unneutralized, causing the acidity of these systems to increase and affecting sensitive plants and animals.

Procedure

1) Vocabulary

a) acid
b) base
c) buffer
d) sulfur dioxide
e) nitrogen oxides
f) anthropogenic
g) geothermal
h) limestone
i) granite
j) atmosphere
k) gas
l) gaseous
m) smog
n) carbon dioxide
o) pollution

2) Activities

a) Share the background information for this activity with the students.

b) Prepare a demonstration of the reaction of acid precipitation with limestone and granite.

i) Cut off the bottoms of two clean 3-liter soda bottles (or 1-gallon plastic milk containers). Turn them upside down and support them so that they are stable. (These will be filled with rocks, so strong supports are needed.) Place about two liters of crushed granite in one container and the same amount of crushed limestone in the other. Place a 1-pint collecting container beneath the neck of each bottle.

ii) Prepare simulated acid rain.

(1) Distill one gallon of tap water (or purchase a gallon of distilled water) and pour it into the clean container. Determine its pH (using a water test kit or pH meter).

(2) Carefully mix sulfuric acid into the distilled water to achieve a pH of 4.3 to 4.5. This will approximate the average range of acidities of rainfall in the Tennessee Valley, a major electric power production area.

c) Demonstrate the effects of the two rock materials on the pH of the simulated rainfall.

i) Place pH indicator solution in both collecting containers.

ii) Slowly pour one-half of the "acid rain" solution into each container of crushed rock. Observe as the solution infiltrates the crushed rock and as the leachate flows into the collection containers.

iii) Using the same means of determining pH as was used above, determine the acidity of the liquid in each collecting container.

iv) Have the students record the data using a table like the following:

(1) pH of acid rain _____

(2) pH of water after passing through the granite _____

(3) pH of water after passing through the limestone _____

d) Discuss the demonstration with the students. Make sure they understand what they have observed.

   i) Ask if there was a color change in the collection containers. If so, have the students explain this observation.

   ii) The non-neutralized and the neutralized "acid rain" solutions were different colors, indicating different acidities resulting from contact with the rocks.

   iii) Ask if there was a significant pH change in either container. If so, why?

   iv) Teacher's Notes on Results—The pH values obtained from the indicator chart show that there is a difference. Remember also that pH values are logarithmic, not linear, values and that a change from 5 to 6 means a power of 10 difference. A change from 5 to 7 means a power of 100 difference. The limestone neutralized some of the acid, but the granite did not.

e) Have your students research the chemical formulae of limestone and the components of granite. This may enable some students to write the chemical equations for the neutralizing reaction and to also see why the granite has no buffering action.

f) Continue with the follow-up below.

3) Review

a) Discuss the concept of pH with regard to everyday items, such as ketchup, ammonia, baking soda, soda pop, etc. (Reference the ability of ketchup to "clean" off a penny – removing metal and pollution deposits that are then left in the ketchup. If streams are allowed to suffer from acid rain enough that they become as acidic as ketchup, they are more vulnerable to heavy metals pollution, etc.)

b) Review some other types of rocks (dolomite, basalt, shale, etc.) and discuss how their chemical compositions might make them more or less able to buffer acid deposition. Discuss the type of bedrock in the local area and its buffering capabilities.

c) Discuss methods for measuring and tracking rain acidity in the local area. Discuss local sources of nitrogen oxides and sulfur dioxides.

d) Discuss wind patterns that might bring nitrogen oxides and sulfur dioxides here from other parts of the state, nation, and globe.

4) Evaluation

a) Ask the students how acidic precipitation could affect water quality.

b) Even a slight change in pH of an aquatic habitat can have a significant effect on the small organisms, which form the basis of aquatic food chains. In this way, wildlife can be greatly affected. Additionally, a pH change can change the normal concentrations of nutrients and other chemicals in the water. This too can have significant impacts on wildlife.

c) Ask the students to compare (from their knowledge and experiences) general trends in acid precipitation in the U.S. and abroad.

i) Are they aware of the results of eastern and midwestern industrialization on the eastern U.S. and Canada?

ii) Can they explain the role of prevailing winds?

iii) Are they aware that Europe's problems with acid rain are worse than ours?

5) Extension

a) What are the major sources of acid precipitation? Exactly how is it transmitted? Have the students contact the National Oceanographic and Atmospheric Administration (NOAA) for information on acid precipitation monitoring in the U.S. and in Canada. What do the students believe to be the best approach for reducing acid rain?

b) Collect some local bedrock samples for use in the above activity. Repeat the demonstration to determine if your local bedrock is an acid neutralizer. Regions with limestone rock have a natural ability to neutralize acid rain or other acidity and so are not generally affected as much as some other areas. On the other hand, regions with mostly granite rocks tend to be more sensitive to increases in acidity environment.

c) Use acidic water to water both land and aquatic plants

d) Study decomposition of major historical pieces due to acid rain (i.e. Roman statues, pyramids, etc.)

e) Study the major wind patterns across the continental United States, and then research inter-state acid precipitation problems, write a report discussing findings.

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Adapted from: “Acid Rain” *Alliance To Save Energy.* www.ase.org/educators/download.htm .

Air Pollution Word Search Activity

Target Grade Levels
Second - Sixth, Seventh - Twelfth

Time
20 minutes - 45 minutes

Materials
- word search puzzles

Knowledge and Skills (TEKS)
- Science:
  - Develop scientific inquiry and critical thinking.
- Language Arts:
  - Use a thesaurus, synonym finder, dictionary, and software to clarify meanings and usage.

Overview
To improve students' vocabulary and overall knowledge of air pollution.

Background Information
Air pollution is a problem in many areas of the United States. It can make people sick and damage trees, lakes, and animals. It can also damage buildings and other structures. Air pollution also can cause haze, reducing visibility in national parks and sometimes interfering with aviation. The federal government regulates air pollution in order to protect human health and the environment. There are several words that are used when discussing the subject of air pollution.

Procedure
1) Vocabulary

a) air pollution
b) ambient air
c) outdoor air
d) atmosphere
e) benzene
f) carbon dioxide
g) carbon monoxide
h) chlorofluorocarbons (CFCs)
i) combustion
j) contaminant
k) dispersion
l) emission
m) environment
n) fossil fuels
o) hydrocarbons
p) hazardous air pollutant (HAP)
q) meteorology
r) nitrogen oxides
s) ozone
t) particulate matter
u) photochemical process
v) plume
w) pollution
x) respiratory
y) catalytic converter
z) smog
aa) smoke
bb) stomata
cc) stratosphere
dd) toxic
ee) volatile organic compounds (VOCs)

2) Activities
   Print out the word search for the appropriate grade level and let the students use it to increase their vocabulary of air pollution and air quality terms.

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Adapted from: “Air Pollution Word Search Activity” *Texas Commission on Environmental Quality.* http://www.tceq.state.tx.us/assets/public/assistance/education/air/search_puzzle.pdf

Acknowledgement: "Better Air—You Hold The Key" school outreach program, prepared by the Junior League of Denver with technical assistance provided by the Colorado Department of Health, Air Pollution Control Division.

Word Search Puzzle for Second – Sixth Graders

Air Pollution Word Search

There are 15 words that are often used in connection with air pollution listed in the word search below. Can you find them?

I	X	I	H	A	V	L	C	F	H	N	F	X	B	O	J	D	D	V	L
K	U	S	Y	T	U	A	F	B	O	G	P	L	G	K	U	A	Q	K	C
Q	C	O	P	K	K	H	A	I	M	I	P	R	S	B	P	H	F	W	Y
T	F	G	O	P	C	I	T	C	E	L	Z	F	S	I	C	K	Q	D	I
H	T	Q	X	W	Y	Y	N	G	Q	K	X	M	L	T	R	P	I	U	N
J	X	V	H	V	Q	R	N	M	V	W	L	U	A	Q	K	O	H	S	T
U	I	S	O	N	Q	P	Q	R	Y	X	S	H	S	M	O	G	S	T	O
Z	M	F	R	E	S	H	M	C	O	P	O	L	L	U	T	I	O	N	X
M	X	B	W	R	V	G	D	O	Y	P	R	G	S	J	Z	N	J	I	Y
Q	X	Z	J	I	E	B	U	S	H	M	P	L	L	V	F	J	T	W	G
E	J	Q	U	S	T	N	E	O	A	E	B	C	U	W	X	P	R	B	E
Z	F	Y	T	V	W	E	U	S	C	M	I	V	N	K	G	D	U	H	N
H	F	G	Q	M	B	I	A	T	L	S	M	J	G	L	T	T	C	X	Y
T	F	R	T	W	O	C	I	G	O	I	A	B	S	U	Q	I	K	C	P
L	V	S	N	B	C	L	Y	U	U	E	R	V	T	B	S	I	R	A	X
W	O	X	Y	C	K	E	R	C	D	E	Z	E	N	J	S	E	K	R	X
H	S	O	X	Z	I	E	Y	E	S	P	M	Z	F	D	Z	Q	R	Z	I
P	N	C	L	G	W	D	N	T	X	N	S	N	D	L	E	Z	D	X	J
B	O	L	R	B	I	Z	A	F	L	A	F	U	M	F	N	O	S	E	Q
M	W	M	A	B	R	E	A	T	H	E	J	S	W	M	C	A	I	R	F

Here are the words to look for:

Air	Breathe	Bus
Car	Clouds	Dust
Eyes	Fresh	Lungs
Nose	Oxygen	Pollution
Sick	Smog	Truck

Word Search Puzzle for Seventh – Twelfth Graders

Air Pollution Word Search

There are 25 words that are often used in connection with air pollution listed in the word search below. Can you find them?

W	O	D	Q	F	B	I	O	O	V	N	I	Q	B	R	O	J	O	C	P	X	J	I	V	K
P	P	Y	M	O	Z	Y	N	R	N	B	O	G	P	S	E	N	J	O	N	F	A	X	K	D
Q	E	Q	W	O	O	P	Y	D	X	R	L	I	I	T	O	D	P	X	C	K	A	S	R	U
U	H	K	G	C	O	R	I	T	U	V	T	R	S	R	J	U	H	S	W	F	O	G	X	J
D	X	A	O	N	R	S	C	E	X	S	N	W	K	R	L	O	R	A	D	U	S	W	B	T
Y	I	Q	G	M	J	F	M	B	D	F	T	N	A	A	E	E	K	N	H	N	A	C	J	S
L	J	F	W	V	S	K	Y	Q	Y	I	I	R	T	W	T	V	Y	I	O	C	V	B	X	U
Z	X	P	Z	M	E	T	H	J	Z	G	X	I	Y	L	I	R	N	B	S	C	F	U	V	A
X	F	O	W	K	P	Z	B	X	Y	Q	O	O	I	E	I	L	R	I	D	R	O	J	T	H
M	D	L	E	R	Q	M	J	L	K	N	S	F	I	O	W	A	N	E	G	Y	X	O	T	X
B	X	L	C	D	S	E	P	H	L	X	A	Y	U	D	C	R	M	U	U	Q	N	N	S	E
A	X	U	A	R	V	A	S	F	B	O	O	E	Z	O	N	Z	H	R	X	Z	E	N	K	J
H	A	T	R	G	W	A	J	D	U	J	L	D	R	H	G	O	E	Z	B	M	H	F	J	L
K	L	I	P	X	T	C	N	D	Y	D	B	D	T	O	B	P	B	I	N	U	E	Q	Z	W
S	D	O	O	X	O	M	I	M	J	T	Y	J	M	S	H	B	U	R	I	A	A	I	S	V
U	W	N	O	F	Z	H	J	O	I	H	N	S	N	P	B	S	E	B	A	U	C	L	D	Q
C	X	Q	L	L	C	Q	Q	W	E	C	F	H	Q	W	C	V	U	R	T	C	C	G	P	A
U	E	D	O	X	O	N	O	M	N	O	B	R	A	C	O	Y	L	O	J	X	C	R	E	E
M	W	F	Y	T	B	E	K	E	R	V	S	S	L	G	D	I	M	C	F	L	C	H	S	H
E	R	E	H	P	S	O	M	T	A	G	E	N	V	I	R	O	N	M	E	N	T	A	O	R
N	T	I	A	Y	C	U	U	S	N	Q	L	M	R	S	B	T	Y	A	Z	A	E	K	L	M
S	V	S	J	I	U	A	D	U	H	Q	H	B	K	I	Q	K	N	Z	E	S	N	M	T	X
R	I	H	A	T	K	P	L	I	S	V	D	J	L	G	D	A	B	R	I	P	V	E	M	V
A	Z	L	V	W	I	J	I	H	Y	D	D	E	S	W	I	P	B	D	I	X	E	M	Q	L
N	Z	P	W	Y	C	U	F	C	L	A	W	P	Q	R	K	I	Z	P	Y	J	N	T	G	H

Here are the words to look for:

Ash	Atmosphere	Automobile	Breathe
Carbon Dioxide	Carbon Monoxide	Carpool	Clean Air
Disease	Dust	Environment	Exhaust
Filters	Government	Hydrocarbons	Industry
Inversion	Lungs	Mucus	Oxygen
Pollution	Population	Smog	Smoke
Waste			

The Day The Air Pollution Gremlins Came To Town

Target Grade Levels
Second - Fourth

Time
Two or three class periods, depending on how elaborately students perform the play

Materials
- play scripts for each student

Knowledge and Skills (TEKS)
- Language Arts:
  - Communicate data and information in appropriate oral form;
  - Monitor their understanding of a spoken message and appropriately seek clarification;
  - Use a thesaurus, synonym finder, dictionary, and software to clarify meanings and usage; and
  - Interpret speaker's messages (both verbal and nonverbal). Purposes and perspectives.

Overview
Students will learn what causes air pollution through their performance of the Air Pollution Gremlins play. Students will also learn the health hazards that air pollution creates.

Background Information
There are hundreds of pollutants that float around in the air that we breathe. The U.S. Environmental Protection Agency has established air quality standards for six of these pollutants: ozone, carbon monoxide, nitrogen dioxide, particle pollution, sulfur dioxide, and lead. These air quality standards are designed to protect the health and welfare of people, plants, and animals, and to protect buildings, monuments, water resources, etc.

Procedure
1) Vocabulary
   a) sulfur dioxide
   b) nitrogen oxide
   c) ozone
   d) particulate matter
   e) carbon monoxide
   f) lead
2) Activities
   a) Assign the following characters to students:
      i) Christina
      ii) Steven
      iii) The Air Pollution Gremlins:
         (1) Smelly Sulfur Dioxide
         (2) Nasty Nitrogen Oxide
         (3) Odious Ozone

(4) Pesky Particulate

(5) Cranky Carbon Monoxide

(6) Lumpy Lead

iv) The Gremlins may be cast singularly or as a group of actors. Note: Other responsibilities can be assigned, such as direction, prop production, costume design, and/or scene changes.

b) Setting
Christina and Steven are sitting in a living room with the television, radio, fan, and three or four lights on. They are watching a television show.

c) Perform the play.

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Adapted from: "The Day the Air Pollution Gremlins Came to Town" *Texas Commission on Environmental Quality.*
Reference: The Air Pollution Gremlins were created by the Texas Commission on Environmental Quality

Acknowledgment: Play written by Laura Venegas, University of Texas at El Paso TES Course, 1995.

The Day The Air Pollution Gremlins Came To Town

Christina: This is my favorite show!

Steven: Yeah, I just love the Power Rangers. The song that's playing on the radio right now is pretty cool too. It goes along with the action on the TV.

Christina: *(She gets up and looks outside the window)* Hey, Steven look at that! *(Points to the sky)*

Steven: Wow! I wonder what it is? Let's go outside and get a better look.

Steven and Christina go outside. A large cloud comes closer to them. Underneath or behind the cloud are the Air Pollution Gremlins. The cloud stops right in front of Steven and Christina. Immediately, the Gremlins start jumping around and making faces at the audience and Christina and Steven.

Steven: Who are you?

Smelly Sulfur Dioxide: We are the Air Pollution Gremlins. We've come to take over your town.

Christina: Why would you want to do that? Only nice people live around here.

Pesky Particulate: You may be nice people, but nobody seems to care about the air in this town. So, it looks like a good place to live. *(sneer)*

Steven: I notice each of you has a different name. Why is that? Aren't you guys all the same?

Cranky Carbon Monoxide: We have different names because we come from different sources and cause different problems.

David & Christina: Oh No!

Cranky Carbon Monoxide: I'm Cranky Carbon Monoxide. I mostly come from car exhaust. I like to make people dizzy and give them headaches. *(twists hands menacingly)*

Smelly Sulfur Dioxide: I'm Smelly Sulfur Dioxide. I come from smokestacks of power plants and industries. I can hurt your eyes, noses, and lungs. I can even eat away iron and steel. I like to make the air look hazy. *(lunges at audience)*

Nasty Nitrogen Dioxide: I'm Nasty Nirtrogen Dioxide. I have a yellow-brown color and I come from cars, electric power plants, and other large industries. I can make the air brown and hazy. I like to hurt lungs, plants, and metals. *(makes an evil laugh)*

Lumpy Lead: I'm Lumpy Lead. I can contaminate the air, food, and water. Also, I am found in some old paints. I'm very harmful to children and fish. *(does a little dance)*

Odious Ozone: I'm Odious Ozone. I'm invisible by myself, but when I get together with my friends, I can help form smog. I can make it hard to breathe. *(lunges at audience)*

Pesky Particulate: I'm Pesky Particulate. I live in the air and like to travel on the wind. I make things dirty and I can carry harmful chemicals into your lungs as well. *(makes a very loud and evil laugh)*

Christina: All of you sound so terrible! We don't want you to live around here.

Odious Ozone: You make it easy for us by wasting electricity and asking your parents to drive you everywhere you want to go!

Steven: You mean that just because we waste electricity and ride around a lot in the car, you guys are here to stay?

Nasty Nitrogen Dioxide: Bingo! Thank you for the invitation to live in your town!

Christina: Well from now on, you're not invited to our town. I'm not wasting electricity anymore and I'm going to walk or ride my bike if I want to go somewhere nearby.

Steven: Yeah! *(firmly)* We're starting right now!

Steven and Christina rush inside and turn off all the lights and appliances they had left on.

Gremlins:	OH NO! We can't live in this town if no one is wasting energy! This doesn't seem like a very good place to live after all.
Lumpy Lead:	I'm sure we can find another town where people are wasting energy. C'mon, let's go! The Gremlins leave in their cloud.
Christina:	What do you want to do now?
Steven:	Let's go outside and ride our bikes in the fresh, clean air.
Christina:	I hope those Gremlins don't come back.
Steven:	They won't come back as long as we continue to use energy wisely.

The End

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How We Know Air Is There

Target Grade Levels
First - Third

Time
20 minutes

Materials
- paper
- crayon

Knowledge and Skills (TEKS)
- Science:
  - Scientific investigations in the field and laboratory;
  - Scientific inquiry and critical thinking construct simple graphs, tables, maps, models, and charts to organize information;
  - Demonstrate that repeated investigations may increase reliability; and
  - Classify earth materials in local area as renewable, nonrenewable or inexhaustible.
- Language Arts:
  - Write to record ideas and reflections for a variety of audiences.

Overview
Students will use their senses to learn about the nature of air. Although we usually don't see air, we frequently experience the effects of air's actions.

Background Information
While air cannot be seen alone, it can be felt and seen through its actions. We feel air through wind and breezes. We can see air through an object's reaction to a gust of wind. What we do not want is to see air through particle pollution, haze, in the air.

Procedure
1) Vocabulary

a) air
b) sight
c) taste
d) smell
e) touch
f) feel
g) hear

2) Activities

a) Take students for a walk to the playground to determine how they know air is there.

b) Ask them to draw and record what they see or smell. (For example: a flag blowing in the breeze, leaves rustling in trees or on the ground, blowing dust, trees swaying, etc.)

c) Have students draw other examples of the presence of air.

d) Use this material for a bulletin board.

e) If they need help getting started, ask students to wave their hands and feel the air or "sip" it through their lips. Can they see anything move in the air, such as dust?

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Adapted from: "Concept Exploration Activity #1" *Northwestern Indiana Regional Planning Commission.*

Energy Activities

Target Grade Levels
Fourth - Seventh

Time
30 minutes

Materials
- watch or clock with second hand
- 2 thermometers
- 6 tart pans, 3 inches in diameter (one pan painted black)
- solar calculator
- desk lamp
- rock, about 4 inches high
- flat board, about 1 foot by 18 inches
- toy car
- newspaper
- 2 cups of ice
- paper cut into 3-inch by 6-inch strips
- paper cut into 3-inch by 2-inch squares (4 per experiment)
- tape
- unused pencil
- paper
- paper clips
- string

Knowledge and Skills (TEKS)
- Science:
  - Conduct experiments to learn about how energy works in our world;
  - Use scientific tools to collect, analyze, and record information to include dissecting equipment, calculators, riled equipment, computers, and probes;
  - Plan investigative procedures;
  - Observe changes that occur due to the forces of energy; and
  - Work in groups to explain the phenomena they observe.

Overview
Students will conduct experiments to learn about how energy works in our world, and observe changes that occur due to the forces of energy. Students will also work in groups to explain the phenomena they observe.

Background Information
Everything that occurs in the world comes about as an exchange of energy, but energy cannot be seen, heard, felt or touched. It is invisible, yet it is the force that makes life possible. Trying to explain energy can be very difficult. These simple activities allow children to observe the effects of energy. With some guidance, the students can develop their own explanations for how these events happened, and, in the process, gain greater understanding of energy.

Procedure
1) Vocabulary

a) energy	f) solar energy
b) potential energy	g) insulation
c) kinetic energy	h) work
d) gravity	i) urban heat island
e) physical energy	j) chemical energy

2) Activities

a) This activity is best conducted outdoors in an area protected from wind.

b) After a discussion of energy and its various forms, direct your students in these energy experiments. Divide the class into two groups. Hand out the Energy Experiments worksheet.

c) Have one group perform the solar, cooling, and heat experiments. Have the second group perform the gravity, physical, and insulation experiments.

d) Hand out the necessary materials to each group. Some experiments take longer than others. Students need to budget their time responsibly to complete each experiment.

e) Be available to assist your students in their experiments and explanations of what happened. Guide them through difficult explanations.

f) When all the experiments are completed, take a few minutes and have your students explain the experiments to each other. Have each group explain to the others what experiments they conducted and how they worked. Be sure they clean up the remains of the experiments.

g) When everyone is back in their seats, use this period to test for knowledge. Randomly ask students about each of the different experiments. If they communicated well with each other, each student should know the answer, or be able to guess at the answer. If necessary, explain the concepts again at this time.

3) Review

a) Discuss the concept of solar energy. How can students identify solar energy (light, heat) and how is it put to use (solar cells create electricity or heat water, used in cars, homes, calculators).

b) Discuss the concept of energy dispersion through cooling. Where did the heat go? Is that energy available to do other work now? How might trees and other cooling mechanisms (light colored roofs and pavement) help reduce the urban heat island effect and, hence, reduce ground-level ozone pollution?

c) Discuss the amount of physical energy it takes to move things and keep them moving. Relate this to the conversion of chemical energy in gasoline to physical energy used by an engine to move a car. It takes a lot of energy to move a 2,000-pound car with four people in it!

d) Discuss insulation and its use as an energy efficiency/energy conservation device. What items at home are insulated (e.g.: refrigerator)? What more should be insulated (whole house, water heater)?

4) Evaluation

a) Students can be graded on their record-keeping for experiments.

b) Students can be quizzed on vocabulary.

5) Extension

a) Discuss how solar energy is transformed into chemical energy through photosynthesis. Break down the ingredients of a pizza, which is fuel for the body, to see that their energy originated from the sun. (e.g.: Cheese comes from milk which is made by a cow which eats grass which captured its energy via photosynthesis of the sun's rays.)

b) There are a number of different units and terms associated with energy. Students can learn these units and terms and with which types of energy they are associated:

i) **calories (cal), kilocalories (kcal)** – chemical energy (e.g. stored as potential energy in food)

ii) **British thermal units (Btu)** – heat energy

iii) **kilowatt-hour (kWh)** – electrical energy

iv) **joule** – physical energy

c) Each time energy is converted, some energy is lost as heat. Students can research what are the most efficient energy conversions and which are the least efficient. (Examples of energy conversion: photosynthesis, burning gasoline in an engine, burning diesel fuel in an engine, digesting vegetables, digesting meat.)

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Adapted from: "Energy Activities" *Alliance To Save Energy.* www.ase.org/educators/download.htm .

Energy Experiments

Name_____

Energy Experiment #1

Materials

- watch or clock with second hand
- 2 thermometers
- 6 tart pans, 3 inches in diameter (one pan painted black)
- water
- solar calculator
- desk lamp

Solar:

1) Solar energy creates electricity using solar cells. A solar calculator provides an example of this. Using the calculator, make a simple calculation. Then find the solar cells and cover them with your finger for 30 seconds. Keep your finger on the solar cells and try to make the calculation again. What happens? _____
2) Set out an unpainted aluminum pie tin and a second tin, painted with black paint, in the sun. Fill both pans with exactly the same amount of water. After ten minutes, check the temperature of both pans. What are the differences? Why did this occur?

Cooling:

3) Place one aluminum pan with water in it in the sun. Place another in shade. After ten minutes, check the temperatures of the water in the pans. Which is warmer? Why?

Heat:

4) Place a desk lamp over an aluminum pan with water in it. Set a second one, with the same amount of water, away from the lamp. After ten minutes, check the temperature of each. Which is warmer? Why?

Energy Experiment #2

Materials

- rock, about 4 inches high
- flat board, about 1 foot by 18 inches long
- newspaper
- 2 cups of ice
- toy car

Gravity:

1) Place a board over a rock so one end is higher than the other. Place a toy car on the incline. What happens? Why? Try placing the board flat. Does the car move? Why not?

Physical:

2) Place a rock on the ground. What happens? Now place your hand behind the rock and push gently. The rock moves. What makes the rock move? _____

Insulation:

3) Place a cup filled with ice in the sun. Wrap newspaper around a second cup of ice, and place it in the sun. The ice in which cup melts faster? Why?

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Smog

Target Grade Levels
Third - Fifth

Time
20 minutes

Materials

- clean, dry, wide-mouth glass jar (such as a mayonnaise jar)
- heavy aluminum foil
- two or three ice cubes
- ruler
- scissors
- stop watch or watch with a second hand
- matches
- guest Presenters

Knowledge and Skills (TEKS)

- Science:
  - Recognize that invisible air pollutants and weather conditions are involved in creating smog;
  - Understand that not all air pollution is visible; and
  - Appreciate that human activities can cause air pollution.

Overview
This activity lets students create artificial "smog" in a jar. Teachers can use this module as an introduction to a planned visit from an air quality scientist, or as the basis for extended discussions on the health problems associated with smog.

Background Information
The expression "smog" was first used in turn of the century London to describe a combination of "smoke" and "fog." London has had several episodes of severe industrial smog. The most famous London smog event occurred during five days of December 1952, when calm, foggy weather lead to a smog buildup in the atmosphere that claimed thousands of human lives.

Today, what we call smog is made primarily of ground-level ozone that is produced by a photochemical reaction between nitrogen oxides and volatile organic compounds in the presence of sunlight. Ground-level ozone is an invisible, odorless gas. Ground-level ozone is produced by a combination of pollutants from many sources such as automobile exhausts, smokestacks, and fumes from chemical solvents like paint thinner or pesticides. When these smog-forming pollutants (called "precursors") are released into the air, they undergo chemical transformations and produce smog. Weather conditions, such as the lack of wind or a "thermal inversion," also cause smog to be trapped over a particular area. Smog causes health problems such as difficulty in breathing, asthma, reduced resistance to lung infections, colds, and eye irritation. The ozone ingredient in smog also damages plants and trees, while the haze reduces visibility. This is particularly noticeable from mountains and other beautiful vistas such as National Parks.

Suggested Reading

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- Study Finds Source of Canyon Haze." *National Parks*, 63 (July 1989) p. 10.
- Wald, Matthew L. "Northeast Moving Toward Auto-Emission Goals." *New York Times*, 142 (25 March 1993) p. A12.

Procedure

1) Vocabulary

   a) smog
   b) photochemical
   c) pollutant
   d) nitrogen oxides
   e) hydrocarbons
   f) volatile organic compounds
   g) ground-level ozone
   h) fumes
   i) precursor
   j) thermal inversion

2) Activities

   a) Explain that the class will perform an experiment in which they will create artificial "smog" in a jar. Make sure that students understand that the jar is only a model, and models by nature are limited. For example, the purpose of this model is to illustrate the appearance and behavior of smog, not the composition or effects. It is important to understand that smog is not just a "smoky fog," but a specific phenomenon.

   b) Select students to be part of a large demonstration team. Have them cut a strip of paper about 6 inches by 2 inches. Fold the strip in half and twist it into a rope.

c) Have them make a snug lid for the jar out of a piece of aluminum foil. Shape a small depression in the foil lid to keep the ice cubes from sliding off. Carefully remove the foil and set it aside.

d) Have the students put some water in the jar and swish it around to wet all the inside of the jar. Pour out the extra water.

e) Have them light the paper "rope" with a match and drop it and the match into the damp jar. Put the foil lid back on the jar and seal it tightly. Put ice cubes on the lid to make it cold. (The ice cubes will make the water vapor in the jar condense.) You must do this step very quickly, perhaps with some assistance.

3) Review

a) Ask students to describe what they see in the jar. How is this like real smog? What conditions in the jar produced "smog"? (Moisture plus soot particles from the burning matches plus carbon dioxide and other solvent vapors.)

b) Ask the students if they have ever seen smog (not fog). Have they ever breathed air outside that smelled funny?

c) Discuss with students the actual formation of smog in the local area, the sources of precursors (vehicles, power production, industry), and the conditions needed to transform those precursors into ground-level ozone. (Be sure to distinguish between ground-level ozone, which is invisible, and smog, which is primarily ground-level ozone, but accompanied by other pollutants which make it visible.)

4) Evaluation

a) Students can be quizzed on vocabulary.

b) Students can perform the following extension activities as graded exercises.

5) Extension

a) Have students put a glass thermometer (not plastic) into the jar before they do the experiment. Have them record the temperature before proceeding to step 4. Have them record the temperature during step five. Ask them to describe what the temperature did and why. Let them try it again without adding water.

b) For grades 7-12, assign students to small groups to answer the following questions and report back to class in two weeks. One group will consider the physical and chemical sciences and the other group will consider the health and ecological sciences. Each group should consider referring to several sources of information to answer the questions. Students could possibly interview the weather reporter or meteorologist at the local television or radio station or airport, or interviewing a health scientist from the city or county health department or air quality agency.

i) What conditions are necessary to produce smog in the air? Under what circumstances will these conditions exist in the city? How often are they likely? Can they be predicted in advance?

ii) What are the health effects of smog on people? On plants and trees? Why doesn't everyone in the city get sick or have similar symptoms from smog? What types of people are most sensitive to smog?

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Adapted from: "Activity 14—Smog" *United States Environmental Protection Agency–Project A.I.R.E.* 2003. Page 141.

Discovering Ways To Use Energy Wisely

Target Grade Levels
Third - Fifth

Time
Three 45 minute sessions

Materials
- resource list
- display of vocabulary words
- six large sheets of paper with one of the following assessment questions on each sheet:
  - How much energy do we use?
  - Are we using energy wisely?
  - Energy creates pollution.
  - An Energy Revolution
  - Efficiency and conservation saves you money.
  - What do conservation and energy efficiency mean?
- *The Paper Bag Prince* by Colin Thompson, Random House, 1997
- form of assessment questions

Knowledge and Skills (TEKS)
- Science:
  - Students make wise choices in the use of natural resources and the recycling of materials;
  - Construct explanations;
  - Communicate valid conclusions; Construct graphics, tables maps and charts;
  - Analyze explanations; and
  - Draw inferences related to promotional materials.

Overview
This lesson's main idea is that everything uses energy, and the more energy we use, the more pollution we create. It also focuses on the roles of efficiency and conservation as ways to reduce overall energy needs. Students will engage in a class discussion, read and discuss a recommended text, create a word wall and work in groups and gather information about specified topics in energy efficiency. Students will present a topic using written explanation, graphics or other visual aids.

Background Information
Imagine how much energy your family car would use in 156 years. That is how much energy the world uses every second. In the time it takes you to snap your fingers, the world uses the equivalent of 85,000 gallons of gasoline.

To put it another way, every person in the United States use about seven gallons of gasoline every day.

Everything we do requires energy:
- growing our food
- lighting our schools
- cooking our food
- driving to our offices
- manufacturing products
- keeping our homes cool or warm

Procedure
1) Vocabulary

a) carbon dioxide	g) equivalent
b) carbon monoxide	h) illumination
c) compact fluorescent light bulb	i) incandescent light bulb
d) conservation	j) nitrogen dioxide
e) consume	k) pollution
f) efficiency	l) sulfur dioxide

2) Activities

a) Assess Current Level of Knowledge

i) Create a way of visually organizing information to display what students already know about conservation and efficiency.

ii) To assess what students know, prompt a whole class discussion with questions such as: What does it mean to be efficient? Are the classroom surroundings, such as desks, windows, books, etc., created with energy? Do you think that Americans use energy wisely? How is pollution created? Can we do anything to reduce the amount of pollution we create?

b) Literature Link
Read The Paper Bag Prince by Colin Thompson to the class. Either verbally (as a whole class or in groups) or as a written assignment, have your students summarize the story and identify the types and amounts of wasted energy in schools, homes, communities, etc.

c) Language Arts

i) Have your students use dictionaries to find the definitions of the vocabulary words and record them in their science notebooks. They should create meaningful sentences with each word that reflect an understanding of the definition.

ii) As a class activity, review or present the creation of an outline of information. Create and display a model outline during the rest of the unit of study.

d) Cooperative Group Work

i) Explain to the class that each group will give a class presentation on one of the six Using Energy Wisely topics. Let the students know that each group must be able to:

(1) summarize in clear and concise language the information within its topic;

(2) support its summary with details; and

(3) present some type of visual aide, different from any found in the Using Energy Wisely fact sheet, to help explain and teach its topic. A written explanation should accompany the visual aide.

ii) As a class, create clear expectations for presentations by writing down what the students and teacher agree upon to be a quality presentation and what are effective behaviors by listeners during presentations. This could lead into developing a rubric, for grading purposes if the teacher desires.

iii) Display the six pieces of paper with the topic headings. (These will also be used later in the lesson to assist students in developing an outline of the fact sheet's material.) Divide the class into groups of three or four and assign roles. Suggested roles include: recorder, discussion leader, researcher, and graphics person. Assign or allow groups to choose the topic for which they will be responsible.

iv) Allow groups adequate time for this part of the assignment. If using only the information in the fact sheet, 45 minutes should be adequate. If additional research

is done through the Internet and reference sources, more time will be needed according to the class' abilities.

v) Have each group present its topic with the mandatory elements. The listeners should be encouraged to generate questions in order to broaden their scope of understanding. After each presentation, the class as a whole should generate an outline of the information on the chart paper for that topic. If time allows, students can copy the outline into their science notebooks. After each group presents, new information can also be added to the graphic information-organizer that was created at the beginning of the lesson.

3) Review

a) Each group that presents could also submit quiz questions that go along with their presentation. The students can receive a grade based on the quality of the questions they submit and whether or not the answer was given during their presentation.

b) Students can turn in their notes for each presentation as a graded activity.

c) Students can be quizzed using the questions submitted by each group, compiled into one large quiz.

4) Evaluation

a) Have the students answer the questions below in complete sentences, reflecting the question in their answers. Alternatively, the class can answer the questions as a group discussion either in place of a written assignment or as a review before a test.

i) List five activities that require energy.

ii) How is the efficiency of an automobile defined?

iii) What effects do sulfur dioxide, nitrogen dioxide and carbon monoxide have on your health and the health of the environment?

iv) What are some products now in use that incorporate energy efficient technology?

v) How can the consumer make choices to be more conservative with energy?

vi) What is the difference between an incandescent light bulb and a compact fluorescent light bulb?

vii) Which one is more energy efficient?

viii) When determining the overall cost of a product, what are some factors to considered when deciding which product to buy?

ix) What are some of the ways people can conserve energy without giving up comfort?

x) How is ground-level ozone formed?

b) Possible answers to assessment questions

i) Possible activities that require energy include: lighting buildings, cooking food, drying clothes in a dryer, washing clothes in a washing machine, driving to school, keeping homes cool or warm, and manufacturing products.

ii) Automobile efficiency is defined by the miles per gallon rating.

iii) These three chemical compounds are poisonous to living creatures and pollute the air we breathe and the water we drink.

iv) Some products using energy efficient technologies are refrigerators, clothes dryers, windows, air conditioning and heating units, and compact fluorescent light bulbs.

v) Consumers who cannot purchase energy efficient products can aim for the same efficiency by turning off lights when not in a room; walking to the store instead of driving; turning off the water while brushing their teeth; keeping the refrigerator door closed when not in use; or drying clothes on a clothes line, and washing only full loads of clothes.

vi) An incandescent light bulb gives off the same light as a compact fluorescent bulb but uses much more energy. It also has a shorter lamp life, thereby requiring more frequent replacement, and therefore ultimately costs more.

vii) The compact fluorescent bulb is more efficient.

viii) How much energy is consumed to utilize the product must be considered, as well as the quantity of environmental pollutants released during its use, and/or manufacture and transportation to site of use.

ix) Some of the ways people can conserve energy without giving up comfort are: to install fans in their homes and use less air conditioning, to put on a sweater and turn the heat down, and to let the sun and wind dry their clothes.

5) Extension

a) A Day Without Energy —As a homework assignment or an in-class assignment, have the students imagine a day without energy and write a scenario of that day. Instruct them to use as many of the vocabulary words as possible.

b) Using Less Energy—As a separate assignment, have the students write creative ways in which they will use less energy. This could also be used as part of the final assessment, since synthesis of the concepts would have to be used to create solutions.

c) Culminating Activity—Using the visual aides developed for the class presentations, have the students create a bulletin board displaying the concepts they learned during their study of this fact sheet. This is a good reviewing tool.

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Adapted from: "Discovering Ways to Use Energy Wisely" *Texas State Energy Conservation.* *www.infinitepower.org/lessonplans.htm* .

Using Energy Wisely

FACT SHEET 3 A RESOURCE FOR CLASSROOMS AND TEACHERS

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

Highlights

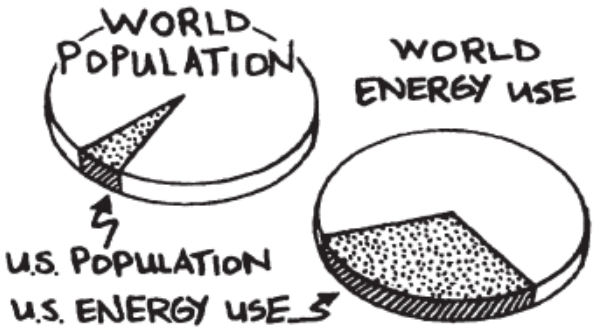
- Almost everything uses energy
- Less energy, less pollution
- Efficiency revolution
- Energy efficiency saves money

How Much Energy Do We Use?

Imagine how much energy your family car would use in 156 years. That is how much the world uses every second. In the time it takes you to snap your fingers, the world uses the equivalent of 85,000 gallons of gasoline.

That means that you and I and every person in the United States use an equivalent of seven gallons of gasoline every day.

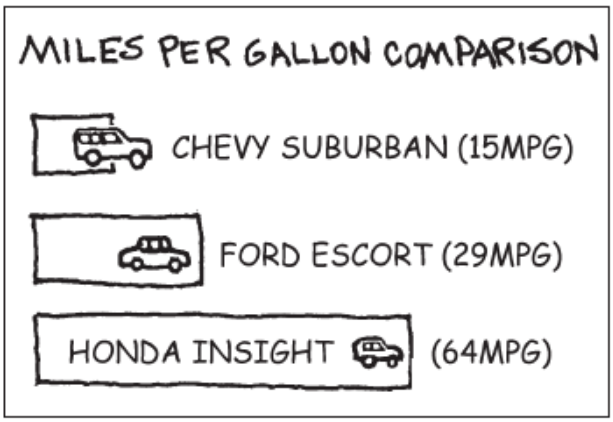
Everything we do requires energy:
- *growing our food*
- *lighting our schools*
- *cooking our food*
- *driving to our offices*
- *manufacturing products*
- *keeping our homes cool or warm*



WORLD VS. U.S. The United States has about 5% of world's population, yet consumes about 25% of world's energy.

Energy is such a basic part of our lives, we could not make it through the day without it.

Scientists point out that everything from cars, to light bulbs, to factories, to our homes could use energy more efficiently. We could have the same level of comfort while using one-half of the energy we now consume.



FUEL EFFICIENCY OF DIFFERENT CARS Some automobiles are dramatically more efficient than most cars we see on the road today. Honda's Insight is more than 4 times as efficient than a Chevy Suburban.

Energy Creates Pollution

If you burned seven gallons of gasoline at an assembly in your school gymnasium it would make a very dramatic demonstration. It also would create a considerable amount of pollution. The air in your school would be filled with pollutants such as carbon dioxide, sulfur dioxide, nitrogen oxide and carbon monoxide.

Imagine when every person at your school and in your city uses the equivalent of seven gallons of gasoline every day. Using energy creates pollution. Saving energy prevents pollution.

An Energy Revolution

Students in school today will be the most efficient energy-using generation of Americans in history! The energy efficiency of practically every product is improving. We are starting to use energy more wisely.

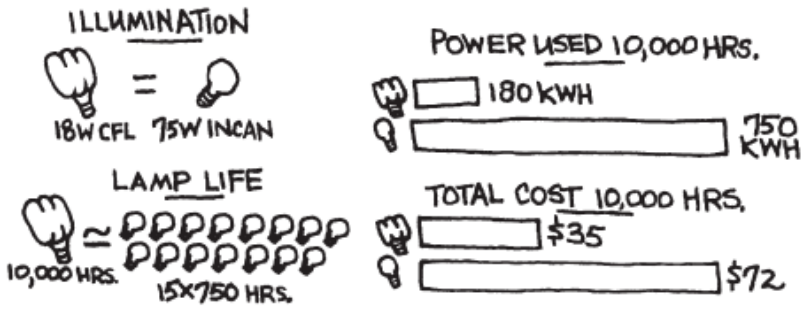
New refrigerators are three times as efficient as the oldest refrigerators still found in America's kitchens. Windows are available today that have eight times more resistance to heat loss than standard single-pane windows. You can buy a car today that drives nearly 65 miles on a gallon of gasoline.

And even more efficient models of these items and others are on the way: cars that can drive from coast to coast on one tank of gas; windows that cloud up on hot days to keep the heat out; and refrigerators that use one-half the electricity of today's most efficient ones. It's truly a revolution in efficiency.

Efficiency and Conservation Save Money

You have a choice when you use energy. Consider light bulbs. Some bulbs use much less energy than others. You also have a choice in air conditioners, most appliances and cars. Some conserve energy and save money.

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS



COMPACT FLOURESCENT BULBS VS. INCANDESCENT BULBS
You have a choice when you use energy. Light bulbs and many other products are available that save energy and money.

A 75-Watt incandescent light bulb may be replaced with an 18-Watt compact fluorescent light bulb. Both produce the same amount of light, but changing bulbs will mean you save $37 in energy costs during the 10,000-hour life of the fluorescent bulb.

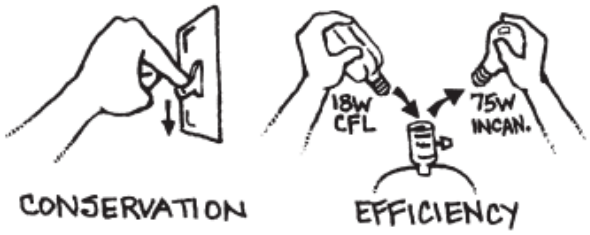
When the cost of energy is included, the cheapest product is the one with the lowest overall cost to own and operate. Not only does the compact fluorescent light bulb save money, but it also reduces pollution. Look for efficient products and calculate how much energy they will use. Add the cost of energy over the lifetime of the products to their purchase price. Choose to use energy wisely.

WHAT IS ENERGY CONSERVATION AND ENERGY EFFICIENCY?

Energy conservation is turning off the lights when you leave the room, or setting the thermostat lower in the winter and wearing a sweater around the house. It is using energy without waste.

Energy efficiency is replacing a regular light bulb with a compact fluorescent bulb that uses one-fourth as much energy, or buying an efficient refrigerator. It is substituting improved technology for energy use.

Some people think energy conservation means keeping their house too cold in the winter or too hot in the summer. But it is never necessary to be uncomfortable when conserving energy or using it more efficiently. When applied intelligently, conservation and efficiency will not even be noticed. In fact, you will be more comfortable in most cases. Energy conservation and energy efficiency are important ways to use our energy wisely.



CONSERVATION & EFFICIENCY Conservation is using energy without waste. Efficiency is substituting improved technology for energy use.

InfinitePower.org

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A DAY WITHOUT ENERGY: TRY IT!

Imagine how you would spend a day without using any energy. When you wake up (to your wind-up alarm clock) you could mix some water with powdered milk to have with your dry cereal. (Oops. How much energy does it take to make cereal and powdered milk?) You could at least squeeze some oranges for juice.

Remember, no electricity to watch TV or use lights; read only by daylight. No gas for the car; walk or bike everywhere. It's OK to use free, natural energy like sunshine to dry your clothes, but be sure to wash them by hand in cold water.

What other ways do you use energy? What foods require energy to cook or keep fresh? (Remember, ice cream needs electricity to keep it frozen.) How will you get to school? Does your classroom have enough windows to provide light? Will the temperature be comfortable without air conditioning or heat? Would meeting outside under a tree be better?

- *Think how you will get through a day without energy.*
- *Tell the class what you will do all day to use less energy.*
- *What is the smallest amount of energy you need for a day?*

Resources

FREE TEXAS RENEWABLE ENERGY INFORMATION

For more information on how you can put Texas' abundant renewable energy resources to use in your home or business, visit our website at **www.InfinitePower.org** *or call us at 1-800-531-5441 ext 31796. Ask about our free lesson plans and videos available to teachers and home schoolers.*

ON THE WORLD WIDE WEB:

Lighting Energy Brief
www.rmi.org/sitepages/pid171.asp

School Energy Doctor
solstice.crest.org/efficiency/sed

The Home Energy Saver **hes.lbl.gov**

Texas Watt Watchers Program
wattwatchers.utep.edu

Sierra Club Suggestions to Reduce Global Warming
www.sierraclub.org/globalwarming/tenthings.asp

Florida Solar Energy Center
www.fsec.ucf.edu

VIDEO:

Toast, *Bullfrog Films, 1974*
Wake Up Freddy, *Bullfrog Films, 1994*

BOOK:

Homemade Money, *Richard Heede, Rocky Mountain Institute, 1995*

Full lesson plans can be found at: http://www.infinitepower.org/pdf/No3%2096-807B.pdf

Exploring Alternative-Fuel Vehicles

Target Grade Levels
Third - Fifth

Time
Three 45 minute sessions

Materials
- resources
- display list of vocabulary words
- computers with Internet access
- large sheets of butcher paper
- markers or tempera paint
- grid paper
- four large sheets of paper with one of the following topic headings on each:
  - Model solar cars
  - Solar car races
  - Electric cars
  - Gasoline, cars and smog
- form of assessment questions
- model solar car kits
  1 kit per 3 students

Knowledge and Skills (TEKS)
- Science:
  - Make wise choices in the use and conservation of resources and the disposal or recycling of materials;
  - Analyze and interpret information to construct reasonable explanations from direct and indirect evidence;
  - Analyze, review, and critique scientific explanations; and
  - Identify the sun as the major source of energy for the earth and understand its role in the growth of plants, in the creation of winds, and in the water cycle.
- Language Arts:
  - Communicate valid conclusions.
- Math:
  - Construct simple graphs, tables, maps and charts to organize, examine, and evaluate information.

Overview
Students will learn about using vehicles that are powered by renewable forms of energy. Students will engage in a class discussion, create a word wall, and work in groups and gather information about specified topics in renewable energy. Students will present a topic using written explanation and various visual aids.

Background Information
Renewable energy was used for transportation long before any other energy source.

For hundreds of thousands of years, humans used only their own energy to get around. Later, they learned to use animals for this. People and animals get their energy from food. Since the energy in food comes from sunlight, food is a form of renewable energy.

We eat plants, and plants are sometimes called biomass. Biomass can also be used to produce biofuels, like ethanol, to power our automobiles.

A few thousand years ago people discovered that they could use the wind to move them around. Think about how fast sailboats can move. Wind is another form of renewable energy.

Less than 200 years ago, people started using fossil fuels (such as coal and oil) to power vehicles for transportation. These fuels can't last forever, so they are not renewable. And they cause air pollution.

With new technology, there are new we can use renewable energy to reduce air pollution.

Procedure
1) Vocabulary
   a) alternative
   b) biomass
   c) ethanol

d) fossil fuel
e) green electricity
f) kilocalorie
g) pollution
h) renewable energy
i) solar
j) sustainable
k) SUV

2) Activities

a) Assess Current Level of Knowledge

i) Create a way of visually organizing information to display what the students already know about renewable forms of energy production. To assess what students know, prompt a class discussion with questions such as:

(1) What is the difference between renewable and non-renewable energy?

(2) What types of nonrenewable forms of fossil fuels are used in Texas?

(3) Why has coal, oil, and natural gas been the primary energy source used in the 20th century to produce electricity?

(4) How do these affect our environment? What are the major types of renewable energy in Texas?

(5) Why are wind and sun renewable forms of energy?

(6) How do these affect the environment?

(7) How is wind energy used in Texas to produce electricity?

(8) What are some of the good reasons to depend upon renewable energy sources?

(9) Are there enough renewable forms of energy to provide all our needs?

b) Language Arts

i) Create a “word wall” by displaying the key vocabulary words.

ii) Working in groups, have students write down the vocabulary words in their science notebooks and find the definitions in the dictionary or from reading the fact sheet. Evaluate understanding by having the students either create meaningful sentences with the words or create a story using the words.

c) Cooperative Group Work

i) Explain to the class that each group will give a class presentation on one of the four Solar and Electric Cars topics (Model Solar Cars; Solar Car Races; Electric Cars; and Gasoline, Cars and Smog). Let the students know that each group must:

(1) summarize in clear and concise language the information within its topic;

(2) support its summary with details; and

(3) present some type of visual aide, different from any found in the fact sheet, to help explain and teach its topic. A written explanation should accompany the visual aide.

ii) As a class, create clear expectations for presentations by writing down what the students and teacher agree upon to be a quality presentation and what are effective behaviors by listeners during presentations. This could lead into developing a rubric, or system of standards for grading purposes, if the teacher desires.

iii) Display the four pieces of paper with the topic headings. Divide the class into groups of four or five. Assign or allow groups to choose the topic.

iv) Instruct the model solar cars group to use grid paper and design a schematic of a model solar car using information from this Internet site: http://www.nrel.gov/docs/gen/fy01/30828.pdf and the fact sheet. Have them answer the question: How does a model solar car get its power to move?

v) Have the solar racecars group research this Internet site: http://solarcar.arizona.edu/ Have them answer the following questions: What is the racecourse and about how long does it take the winning car to complete it? What do engineers have to keep in mind, when designing their cars, to allow them to run at optimum potential?

vi) The electric cars group can research other forms of electric transportation at this site: www.electricbikes.com /. Have them answer the following questions: How does an electric car work? How is it different from a solar car?

vii) Have each group present its topic with the mandatory elements. The listeners should be encouraged to generate questions in order to broaden their scope of understanding. After each presentation, the class as a whole should generate an outline of the information on the paper for that topic. If time allows, students can copy the outline into their science notebooks. After each group presents, new information can also be added to the graphic information-organizer that was created at the beginning of the lesson.

3) Review

a) Each group that presented a topic can verbally quiz the class on the topic they presented (do this at least One hour after the presentation took place to ensure long-term memory recall).

b) The teacher can then further quiz the students that presented each topic to further draw out their opinions on how alternative fuels can be more widely and better applied in the local area, inviting the class to discuss as a whole.

4) Evaluation

a) Have the students answer the questions below in complete sentences, reflecting the question in their answers. Alternatively, the class can answer the questions as a group discussion either instead of a written assignment or as a review before giving it to them as a test.

i) Explain what biomass is and give three examples.

ii) How can biomass help produce fuels to power our automobiles?

iii) Wind is another form of renewable energy. How can wind be used to help with our transportation needs?

iv) List two disadvantages of depending on fossil fuels for our transportation needs?

v) What are two alternative types of transportation that don't use fossil fuels?

vi) List two ways electric cars are different from solar cars.

vii) How are solar and electric cars alike?

viii) Are gasoline-powered cars more efficient or less efficient than electric cars?

ix) How does a model solar car get its power to move?

x) Which uses more energy: an SUV or an electric car?

b) Possible Answers to Assessment Questions:

i) Biomass is all living matter. In terms of energy sources, biomass comes from plants, like corn or quick grass, and from garbage.

ii) Corn is biomass, and it can be used to produce ethanol, a renewable biofuel.

iii) Wind generators can produce "green" electricity to supply energy or power for electric cars.

iv) We cannot depend on fossil fuels because their supply is limited, and they pollute our atmosphere.

v) Two alternative forms of transportation are solar and electric cars.

vi) Electric cars plug into an electric outlet for energy while a solar car uses a solar panel. However, the panel could be separately built. Electric cars don't have to carry fragile solar panels so they can be larger and carry more people.

vii) Both solar and electric cars don't burn gasoline, so the motor does not produce air pollution. However, electricity to charge-up the vehicle may be from coal, oil or gas power plants.

viii) Gas-powered cars are less efficient than electric cars.

ix) A model solar car gets its power from a solar panel that converts light from the sun into electrical power. It is then transmitted by a wire to the motor, causing the drive shaft to turn, which causes the wheels to spin and moves the car.

x) A sport utility vehicle takes a great deal more energy to run than a compact sedan because they are heavier and therefore less fuel-efficient.

5) Extension

a) Class Discussion

Introduce the following scenario to the class and prompt discussion: The year is 2005 and fossil fuel reserves, especially oil, have drastically declined because of increased use and population growth. Oil prices have soared so high most people are not able to purchase gasoline for their vehicles. As a community, use the information you have discovered and develop a plan for becoming sustainable. As the students begin to brainstorm ideas, use graphic-organizers, such as webs, to display their concepts.

b) Narrative Writing
Have the students write a narrative story from the class discussion. Students need to develop the setting with "who, when and where" statements and develop a story line leading to a climax and a conclusion.

c) Building Model Solar Cars
If model solar car kits are available, divide the class into groups of three and have them follow the instructions for building a solar car. With help from outside mentors, this takes about 4 hours of class time. The best approach to conduct this activity is to first build a car. Once you have built a car, you can determine the best way to use this activity in your classroom: either strictly following the kit instructions or allowing the students to be flexible in their design and construction; or you may simplify or expand on the instructions yourself and distribute them to the class. The following are guidelines to instruct students on the activity that can be posted:

i) Examine and test all your parts, and make sure you have all the parts and test them.

ii) Design and draw your solar car by using your imagination and creativity as a team to design your car. Think about the important features of the car. Should it be lightweight? Low to the ground? Motor in the front or rear? What gear ratio?

iii) Construct the body of the car by using your design; construct the body of the car.

iv) Install the motor, wheels and solar panel with the assistance of a mentor or teacher, install the final parts. Soldering the wires to your motor and alligator clips make a better electrical connection.

v) Test the car and make final adjustments, and then take the car out into the sun and do a test run!

vi) Race your car with others!

d) "Comparing Energy Used" Bulletin Board
Create a classroom or hallway bulletin board depicting the concept of "doughnut energy" from the fact sheet to compare transportation energy used. Encourage students to be creative in how they want to transfer the information onto the bulletin board. Suggest they choose an object other than doughnuts for comparison.

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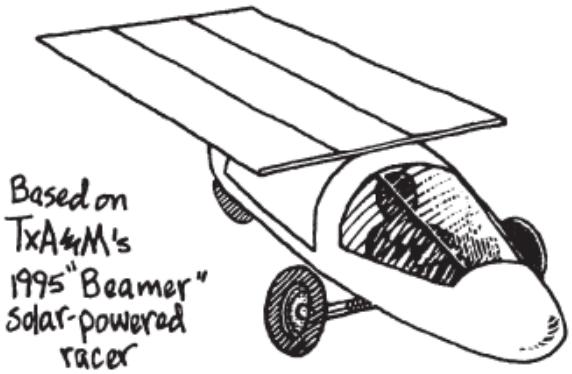
Solar and Electric Cars

FACT SHEET 7 A RESOURCE FOR CLASSROOMS AND TEACHERS

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

Highlights

- Renewable energy for transportation
- Solar-powered model cars: The Junior Solar Sprint Project
- Electric- and gasoline-powered cars and air pollution
- Compare the doughnut energy used



POWERED BY THE SUN A solar-powered car has a panel of photovolatic cells that convert sunlight into electricity.

Renewable Energy and Transportation

Renewable energy was used for transportation long before any other energy source.

For hundreds of thousands of years, humans used only their own energy to get around. Later, they learned to use animals for this. People and animals get their energy from food. Since the energy in food comes from sunlight, food is a form of renewable energy.

We eat plants, and plants are sometimes called biomass. Biomass can also be used to produce biofuels, like ethanol, to power our automobiles.

A few thousand years ago people discovered that they could use the wind to move them around. Think about how fast sailboats can move. Wind is another form of renewable energy.

But less than 200 years ago, people started using fossil fuels (such as coal and oil) for transportation. These fuels can't last forever, so they are not renewable. And they cause air pollution.

But with new technology, there are new ways we can use renewable energy to get around and reduce air pollution.

Model Solar Cars

Model solar-powered cars have some parts that are similar to a family car, but the power system is very different. Here is how they work:

- a solar panel converts light energy from the sun into electrical power
- that power is transmitted by a wire to the motor, causing the drive shaft to turn
- the drive shaft causes the wheels to spin
- the spinning wheels move the car forward

Solar Race Cars

Since a full-sized race car's solar panel is much larger than a model car's, it can capture more solar energy and produce more electricity. Solar race cars have a battery bank that stores some of the sun's energy while it is stopped or driving slowly.

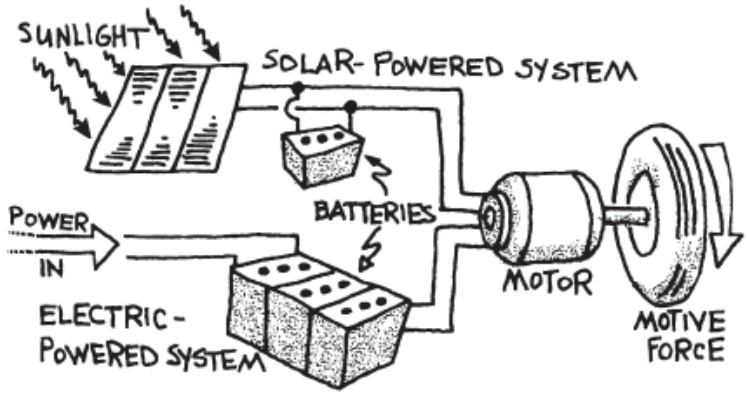
If the car is driving fast, all of the power from the solar panel is used by the motor. In some cases, the car may need more power than the panel can provide. Then the motor uses energy stored in the batteries.

THE JUNIOR SOLAR SPRINT PROJECT

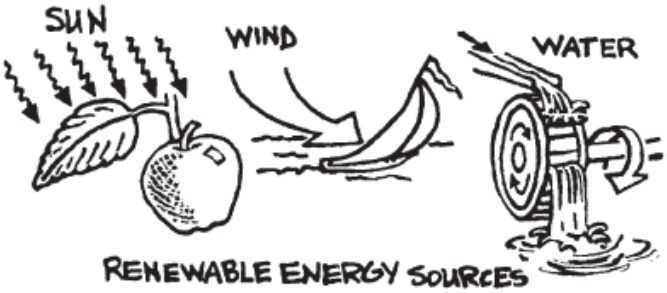
In this project, students form small teams to design and build model solar-powered cars. Teams then compete to determine the fastest car. For more information, check the internet at **www.txses.org/tjss** or send an e-mail to **solarsprint@txses.org**

Electric Cars

Electric-powered cars are very similar to solar-powered cars. But instead of carrying a solar panel for energy, electric cars plug into an electric power outlet, similar to the ones in your classroom or at home. The electricity from the outlet can come from renewable energy sources.



SOLAR AND ELECTRIC-POWERED CARS Sunlight or electricity can be used to power a car's motor instead of gasoline or diesel.



CLEAN POWER SOURCES FOR ELECTRIC CARS Many renewable energy sources can be converted to electricity to power electric cars.

Because electric cars don't have to carry the fragile solar panels, they can be larger and can carry more people.

Just like solar cars, electric cars don't burn gasoline, so the motor does not produce air pollution. If they use power from nonpolluting power plants, like wind turbine farms, then they don't produce any pollution.

If you drove an electric car, you would recharge its battery bank overnight while you slept.

Gasoline, Cars and Smog

Gasoline-powered cars are much less efficient than electric cars. They also produce air pollution, such as smog. Air pollution can be harmful to your health. It also can make the air look dirty and make it hard to see pretty sights like city skylines and mountain ranges.

LET'S COMPARE THE ENERGY USED

We can compare the amount of energy used by four kinds of transportation: a bicycle, a solar car, an electric car and a gasoline-powered sport utility vehicle. There are a number of ways to measure energy. For this comparison, we'll use doughnuts.

1. A 60-pound girl. riding her bike at 10 miles per hour burns up 24 kilocalories per mile. A typical glazed doughnut provides her body 245 kilocalories. About how much doughnut-energy does she burn per mile?

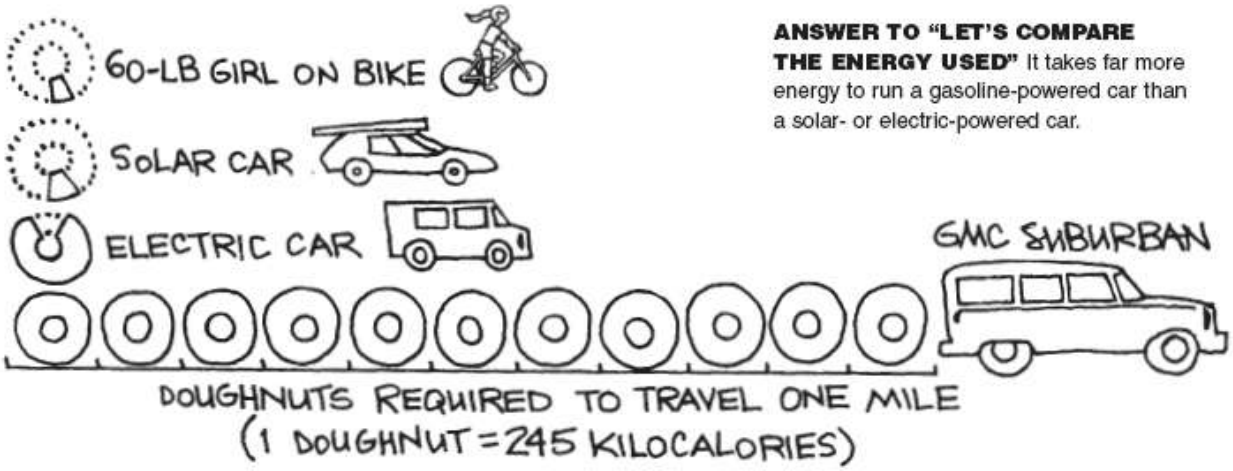
2. The fastest solar car is almost as efficient as the girl on her bike. It uses 30 kilocalories per mile. How much doughnut-energy does it use?

3. One of the most efficient electric cars you can buy is the General Motors EV-1. Since it can store more energy than a solar car. it doesn't have to be as efficient as the solar car. The EV-1 would use 214 kilocalories per mile. How much doughnut-energy would it use per mile?

4. One of the least efficient cars you can buy is the General Motors Chevy Suburban. A Suburban uses 2,729 kilocalories per mile. How much doughnut-energy would it need per mile?

ANSWERS

1. The girl burns about one-tenth of a doughnut per mile.
2. It uses about one-eighth of a doughnut per mile.
3. It would need about nine-tenths of the doughnut.
4. About 11 doughnuts!



ANSWER TO "LET'S COMPARE THE ENERGY USED" It takes far more energy to run a gasoline-powered car than a solar- or electric-powered car.

Studying the Sun

Target Grade Levels
Third - Fifth

Time
Five hours, including building model solar cars (4 hrs)

Materials
- one sheet of notebook paper
- a piece of aluminum foil
- scissors
- white glue
- scrap of wood
- magnifying glass
- large cooking pot with glass lid
- rack
- 8”x10” reflectors (cardboard)
- pot holder
- brownie mix
- thermometer
- large sheet of paper listing selected cultures chosen from: solar-centerstanford.edu/folklore.html.
- large sheet of paper with the displaying the assessment questions

Knowledge and Skills (TEKS)
- Science:
  - Demonstrate safe practices;
  - Make wise choices in conservation;
  - Observe and measure;
  - Interpret information to construct explanations from evidence;
  - Problem solve to make informed decisions; and
  - Collect and analyze using tools;
  - Identify the sun as the major source of energy.
- Language Arts:
  - Communicate valid conclusions.
- Math:
  - Construct simple graphs, tables, maps and charts to organize and evaluate information.

Overview
Students will read and discuss how the sun produces heat, which can be used to do many things that require energy. Students will make and collect data from several projects that are outlined in the fact sheet, including making a reflector, cooking with a solar oven, and drying fruit with the sun’s help. Students will explore, through folklore research, the sun’s role as a part of many cultures.

Background Information
The sun’s rays are made up of photons. They are the smallest pieces of light that exist. Photons travel from the sun across space at a little over 186,000 miles per second. They keep moving until they hit something. If there is nothing in the way, they hit things on earth.

Everything in the universe—you, your school, the food you eat—is made up of tiny molecules.

When a photon hits a molecule, it gives it a shove. The molecule moves faster and heat is produced. The faster molecules move, the more heat they produce.

Procedure
1) Vocabulary

   a) photon
   b) molecules
   c) nuclear reactor
   d) hydrogen
   e) helium

2) Activities

   a) Assess Current Level of Knowledge

      i) Have the students read and follow the directions for making a reflector provided in the Heat From the Sun fact sheet. This should take about 10 minutes.

      ii) Then take the students outside and allow them to experiment with turning the reflector to focus and intensify the rays from the sun.

iii) Ask the students why the sun's rays are causing heat. Accept the students' responses as they experiment with their reflectors.

b) Class Instruction
Review the information on photons and molecules presented in the fact sheet to the class. Review the definitions from the key vocabulary list and have the students write the words and definitions in their science notebooks.

c) Cooperative Group Work

i) Divide the class into pairs. Display the large sheet of paper with the ten questions and let the groups pick which question they would like to research. All the answers can be found through the following web site: www.howstuffworks.com/sun.html . Another excellent site at a lower reading level is http://starchild.gsfc.nasa.gov/docs/StarChild/StarChild.html. The students will learn a great deal about the sun from searching these sites for their answers. Links are included as well. The time needed for this part of the lesson will depend upon availability of computers. The teacher might go through the menus on the sites and talk about where the students will find the answers to specific questions, if the students need this assistance (20-30 minutes, depending on students' skill levels).

ii) Have the groups report their findings and record the information on the paper with the questions. Have the students record this information, questions and answers, in their science notebooks.

d) Literature Link – Solar Folklore

i) For centuries, humans have attempted to explain the sun in terms of their own worldviews. The sun can has been described as a god, a demon, a mischievous spirit, an omnipotent creator or a ruthless taker of life. Whatever role it plays, most cultures have recognized the significance of the sun as the prime controller of all life on earth. Display the choice sheet for "Solar Folktales" and allow groups to choose their culture or assign a culture to each group. Students can do a web search at http://solar-center.stanford.edu/folklore/ to find their culture. Allow students to choose the title of the folktale, download it, and read the tale.

ii) Groups should write a short, informational and creative summary of the tale to be presented to the class.

iii) Each student should create a small, simple line drawing on his or her scrap of wood to represent his or her folktale or the culture from which it originated. This will be used later in the lesson.

iv) Have the groups present their summaries to the class and add information to the Solar Folktales paper.

3) Review

   a) Many solar myths or folktales regard the sun as a deity or as the origin of all life. In what way does this hold true or might it have seemed true to early humans?

   b) Discuss how solar energy is transformed into chemical energy through photosynthesis. Break down the ingredients of a pizza, which is fuel for the body, to see that their energy originated from the sun. (e.g.: Cheese comes from milk which is made by a cow which eats grass which captured its energy via photosynthesis of the sun's rays.)

   c) Discuss the process of fusion, the way in which the sun produces its energy, and fission, a nuclear power source here on Earth. What are the differences?

   d) Call on students to research and repeat interesting sun facts and the source of information for these facts. Example: Right now, about half of the amount of hydrogen in the core of the Sun has been fused into helium. This took the sun about 4,5 billion years. (www.michielb.nl/sun/kaft.htm)

4) Evaluation

   a) Have the students answer the questions below in complete sentences. Alternatively, the class can answer the questions as a group discussion either instead of a written assignment or as a review before giving it to them as a test.

      i) The sun is in a vacuum in space. Does the sun actually "burn"?

      ii) What is the sun made of?

      iii) What keeps the gas from leaking out in space?

      iv) The sun's corona is the _____ layer of the sun's atmosphere.

      v) What is a photon and how does it produce heat?

      vi) How old is the sun?

      vii) How much longer is the sun going to burn?

      viii) Is the sun like other stars?

      ix) When doing projects with the sun, list three safety tips that should be followed.

      x) What are red, white, and black dwarves?

   b) Possible answers to assessment questions

      i) The sun does not burn like wood; it is a huge nuclear reactor.

      ii) The sun is made of hydrogen and helium.

      iii) The sun is so massive it creates a gravitational pull that holds the hydrogen and helium around it. Therefore, the gases cannot escape into space.

      iv) The sun's corona is the outer layer of the sun's atmosphere.

      v) A photon is the smallest piece of light from the sun's rays. Photons travel through space until they hit a molecule. The impact causes the molecule to move faster. The faster a molecule moves, the more heat it produces.

vi) The sun is about 4.5 billion years old.

vii) The sun's life span is probably about 10 billion years, so it will burn about another 5.5 billion years.

viii) The sun is like other stars in space. It appears bigger because it is closer to us.

ix) When doing projects involving the sun, you should wear sunscreen, sunglasses, a cap, use pot holders for handling hot objects and ask an adult for help when needed.

x) Red, white and black dwarves are different stages that stars go through.

5) Extension

a) Homework Activity—Drying Fruit
Have the students copy the instructions from the fact sheet under "Drying fruit with the sun's help" in their science notebook. Assign this project as homework, instructing the students to write down the results to report back at an assigned date and to bring samples of their fruit to class.

b) Culminating Activity—Bake Brownies in a Solar Oven
With the teacher as the director, follow the directions in "Cooking With a Solar Oven" found in the fact sheet and bake brownies, melt s'mores, or make nachos to share. To enhance this activity, an oven thermometer can be used to collect data (time needed will depend on the intensity of the sun).

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Adapted from: "Studying the Sun" *Texas State Energy Conservation.* www.infinitepower.org/lessonplans.htm.

Heat From The Sun

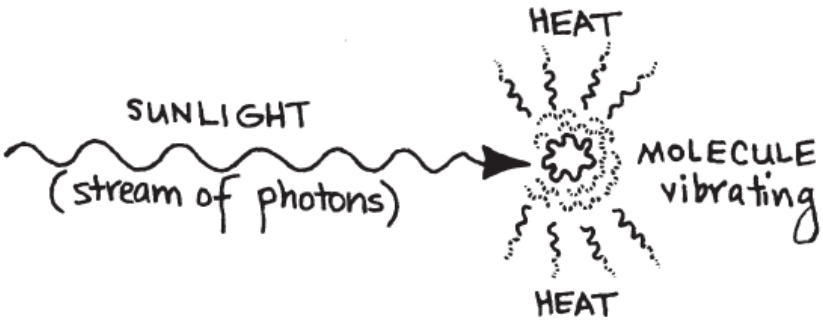
FACT SHEET 5 A RESOURCE FOR CLASSROOMS AND TEACHERS

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

Highlights

What can the sun do for you?

- heat your house
- cook your food
- make the plants grow
- dry your clothes
- what else can you think of?



HEAT FROM THE SUN The sun's rays warm things by making molecules move around faster.

Photons and Molecules

The sun's rays are made up of photons. They are the smallest pieces of light that exist. Photons travel from the sun across space at a little over 186,000 miles a second. They keep moving until they hit something. If there is nothing in the way, they hit things on earth.

Everything in the universe – you, your school, the food you eat – is made up of tiny molecules.

When a photon hits a molecule, it gives it a shove. The molecule moves faster and heat is produced. The faster molecules move, the more heat they produce.

Fun in the Sun: Projects you can do

Be safe: *With any project involving the sun, be careful not to burn yourself. Wear sunscreen, sunglasses and a cap. Use pot holders for handling hot objects. Ask an adult to help you.*

MAKE A REFLECTOR

Materials: *a piece of notebook paper; a piece of aluminum foil; scissors; white glue*

Cut a piece of notebook paper and a piece of aluminum foil the same size. Brush white glue onto the back of the foil. Smooth it carefully

SOLAR COOKER Cook for yourself and your friends with the sun.

over the paper. Let it dry. Point the reflector at the sun.

Try curving it around. Feel the heat reflected onto your hands.

COOKING WITH A SOLAR OVEN

Materials: large cooking pot with clear glass lid; smaller black pot with glass lid; rack; reflectors; brownie mix; pot holders

This works best if you do your cooking at noon.

Make two reflectors on stiff cardboard with foil and white glue. (See Make a Reflector activity) Set large pot in front of reflectors. Angle the reflectors so they focus the sun's rays on the large pot. Put rack in large pot.

Mix the brownies according to the instructions. Put them into the small cooking pot. Set the small pot on the rack inside the large pot. Put the lid on the small pot and then the lid on the large pot.

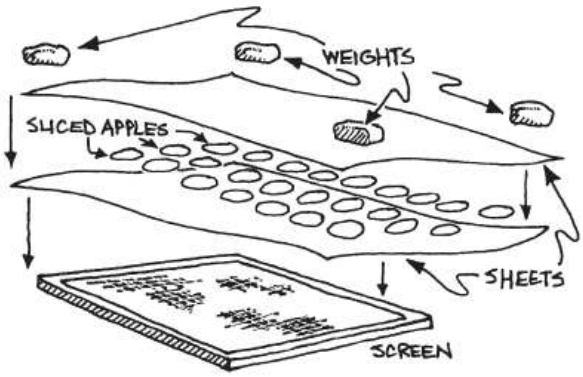
Cook the brownies one and one-half times the cooking time listed on the package.

Try making nachos by melting cheese on tortilla chips this way. Remember to use pot holders and start with food that is as close to room temperature as possible. It will take less time to cook.

DRYING FRUIT WITH THE SUN'S HELP

Materials: a window screen; a clean, dry bed sheet, cut into pieces; one dozen apples

Wash and peel about one dozen apples. Remove the seeds and slice thinly. Sprinkle Fruit Fresh® or powdered vitamin C on both sides so your fruit won't turn brown. Lay one piece of the bed sheet on the screen. Lay the apple slices in a single layer on the bed sheet,



SUN DRIED FRUIT Dry fruit for snacks, just like your grandparents did.

making sure the pieces don't touch. Cover with the other piece of bed sheet.

Put this in a safe place where animals cannot get to it, like on a table outdoors. Weigh the cloth down with something heavy and clean.

Check the apples every day. When they are dehydrated and light brown, put them in an airtight container. They will keep for a long time and make a great snack.

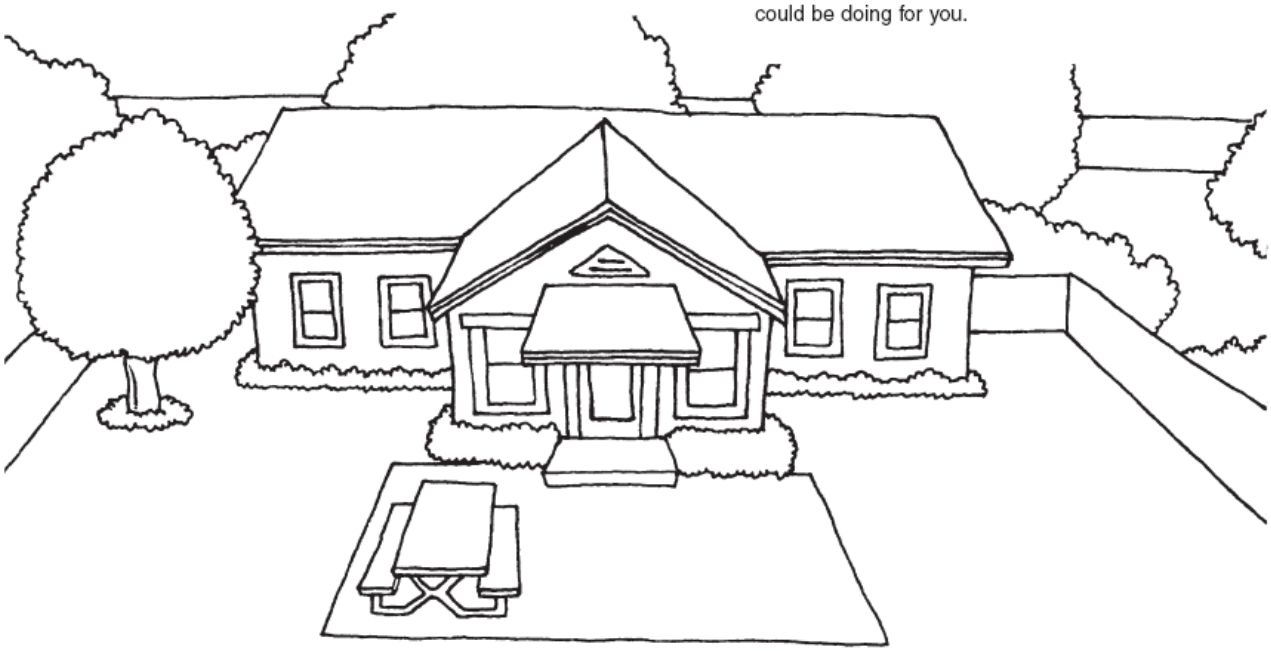
HEAT FROM CONCENTRATED SUNLIGHT

Materials: a soft lead pencil; a scrap of soft wood (like a 2-inch by 4-inch piece of lumber); and a magnifying glass

Use the pencil to draw a picture on the wood with dark lines. Go outdoors. Hold the design so that it faces the sun. With your pencil drawing as a guide, hold the magnifying glass in front of the drawing so that it focuses the light on the lines you have drawn.

Watch carefully and the wood will start to smoke. Move the magnifying glass around so that the point of light burns a line over your pencil line.

WHAT CAN THE SUN DO FOR YOU? This could be your house and backyard. Draw yourself in your backyard and draw all the things the sun could be doing for you.



Using Alternative Energy In the Home

Target Grade Levels
Third - Fifth

Time
Three hours

Materials

- 8 large sheets of paper with one of the following topic headings on each:
  - Heating Your Home
  - Cooling Your Home
  - Clothes Drying Without Using Gas or Electricity
  - Heating Water
  - Cooking With Renewable Energy
  - Electricity Generation, The Renewable Way
  - Water pumping
  - Playing/Working the Clean Way
- 1 shoebox
- construction paper
- 16 oz. plastic soda bottle with cap
- thermometer
- aluminum foil

Knowledge and Skills (TEKS)

- Science:
  - Students make wise choices in the use of natural resources and the recycling of materials;
  - Observe and measure;
  - Analyze, review and critique scientific explanations;
  - Draw inferences based on promotional;
  - Collect and analyze using tools; and
  - Identify the sun as the major source of energy.
- Language Arts:
  - Construct explanations; and
  - Communicate conclusions.
- Math:
  - Construct graphics, tables maps and charts using tools.

Overview
This lesson focuses on using natural and simple renewable energy sources to heat and cool homes without giving up comfort. Students will learn that by using nature to cook our foods, dry our clothes, work and play, we can save money, reduce dependence on fossil fuels and help clean up our environment.

Students will engage in a class discussion, read and discuss a recommended text, create a word wall and work in groups to gather information about specified topics in renewable energy. Students will present a topic using written explanation with visual aids.

Background Information
You can make use of earth-friendly, renewable energy sources in your home. Renewable energy comes from sources that we cannot use up, such as the sun and wind. It almost always causes less pollution than our more typical sources of energy, such as oil, coal, natural gas and nuclear.

Renewable energy is sustainable, so it can provide for your energy needs now and in the future without doing great harm to the environment and human health. This kind of energy can also save you money.

Procedure
1) Vocabulary

a) convert	f) overhangs
b) demolish	g) photovoltaic system
c) eliminate	h) sanitize
d) hornos	i) sustainable
e) minimize	j) transport

2) Activities

a) Assess Current Level of Knowledge
Create a way of visually organizing information to display what the students already know about conservation and efficiency. To assess what students know, prompt a class discussion with questions such as:

i) What does sustainable mean?

ii) Can a community be sustainable?

iii) How does our community get most of its electricity?

iv) What are alternative ways of generating electricity without the use of fossil fuels?

v) How can we reduce the amount of energy used from the burning of fossil fuels?

b) Cooperative Group Work

i) Explain to the class that each group will give a class presentation on one of the eight Renewable Energy for the Home topics. Let the students know that each group must be able to:

(1) summarize in clear and concise language the information within its topic, including the definitions of the vocabulary found in their topic;

(2) support its summary with details; and

(3) present some type of visual aide, different from any found in the fact sheet, to help explain and teach its topic. A written explanation should accompany the visual aide.

ii) As a class, create clear expectations for presentations by writing down what the students and teacher agree upon to be a quality presentation and what are effective behaviors by listeners during presentations. This could lead into developing a rubric, if the teacher desires.

iii) Display the eight pieces of paper with the topic headings. (These will also be used later in the lesson to assist students in developing an outline of the fact sheet's material.) Divide the class into groups. Assign or allow groups to choose the topic for which they will be responsible.

iv) Allow groups adequate time for this part of the assignment. If using only the information in the fact sheet, 30 minutes should be adequate. If additional research is done through the Internet and reference sources, more time will be needed.

v) Have each group present its topic with the mandatory elements. The listeners should be encouraged to generate questions in order to broaden their scope of understanding. After each presentation, the class as a whole should generate an outline of the information on the paper for that topic. If time allows, students can copy the outline into their science notebooks. After each group presents, new information can also be added to the graphic information organizer that was created at the beginning of the lesson.

c) Additional Activity—Making a Solar Water Heater

i) Post the following instructions on a large sheet of paper:

(1) Gather materials for each group:

(a) shoebox

(b) construction paper

(c) 16 oz. plastic soda bottle with cap

(d) thermometer

(e) aluminum foil

(2) Line the inside of a shoebox with a sheet of aluminum foil to make solar oven.

(3) Wrap the plastic bottle with a sheet of construction paper. (Each group will be given a specified color.)

(4) Fill bottle with tap water.

(5) Place bottle in your oven and locate oven in direct sunlight. Adjust placement to reflect as much light as possible onto the bottle. Start your water temperature measurements. Record the measurements in a table in your science notebook.

ii) Have the students create a table in their science notebooks for recording their water temperature measurements in 15- or 30-minute intervals. (Regulate the length of data collection to fit your schedule.)

iii) Divide the class into groups. Have groups gather their materials according to the instructions. Give each group a different color of construction paper (color will be the variable) and compare results later. Make sure groups measure the beginning water temperature, before the heater is placed in the sun. Have the class draw conclusions about the qualities of the different colors as they pertain to heat absorption.

3) Review

a) Groups can quiz their fellow students on the contents of their presentation.

b) Discuss the community's current power generation portfolio. Ask the class if this is acceptable and, if not, how the community could diversify.

c) Discuss the concepts made evident in the activities and who these are applied to actual, residential situations.

4) Evaluation

a) One way to authentically assess student 's knowledge is to assign a TAAS process writing practice. A language arts grade could then be taken from this science assignment. Have the students write a "How To" paper on making their solar water heater. Students should write down the chronological steps used to make their water heater. They need to use transitional words such as first, next, then, after that, etc. Make sure they include all of their steps.

b) Have the students answer the questions below in complete sentences, reflecting the question in their answers. Alternatively, the class can answer the questions as a group discussion either in place of a written assignment or to review before giving the questions as a test.

   i) If you want to heat your home in the winter, where (direction) would be a good place to put large windows and why?

   ii) Explain how roof overhangs can help keep heat out of your house in the summer. You may use a diagram.

   iii) If you were gathering wood for a wood stove or fireplace, recommend what type of wood you would choose and why.

   iv) Explain how a thermal chimney works to help cool your house in the summer.

   v) If you wanted to use thermal mass to help make your home more comfortable, what kind of flooring would you install in your house?

   vi) When considering efficiency, why is drying your clothes on a line outside a good choice? Include at least three reasons.

   vii) Create a diagram that explains how a solar water heater works. Be sure to label your diagram!

   viii) How does a solar cooker work to cook food without the use of gas or electricity?

   ix) If you wanted to generate electricity using a renewable resource, what renewable energy sources would you use and why?

   x) What is hydropower? What are the advantages and disadvantages of using this renewable resource to generate electricity?

c) Possible Answers to Assessment Questions:

   i) If you want to heat your house in the winter, it would be a good idea to have large, south-facing windows to allow sunshine to enter and warm your house.

   ii) In the summer, when the sun is higher in the sky, an overhang shades the window and keeps out the hot sun.

   iii) Most people will first try to find dying or diseased trees to burn; however, even fallen stumps or dead branches lying on the ground, have their place in the ecological web, too. A better choice for wood to burn might be compressed logs made from the sawdust scrap of wood mills. This way, people are re-using something that otherwise would have gone to the landfill. If people are instead gathering in a situation where compressed logs aren't available, dying or diseased trees is good. Ultimately, green wood (fresh-cut) doesn't burn well and taking it will not doing the Earth any good, either.

   iv) Thermal chimneys use the principle that warm air rises to the top of tall spaces and is replaced by cooler air from below. In a two story house, opening the first floor windows and a window at the top of the stairs will allow hot air to escape at the top and draw in cooler air from below.

v) Floors made of tile, concrete, stone or earth can make a house feel much cooler in the summer.

vi) Hanging your clothes on the line saves the energy cost of using a dryer, keeps your clothes newer looking, and sanitizes your clothes, eliminating the need for harsh chemicals such as bleach. Plus you get to hear the birds singing!

vii) Accept your student's drawings of their water heaters. Make sure that they have labeled their diagrams.

viii) A solar cooker works by concentrating the heat-producing rays of the sun through one or two layers of glass or other see-through material like plastic.

ix) Wind and solar generated electricity are both good choices in Texas because they are both plentiful. I would also build my house in a way that would help keep me cool in the summer and warm in the winter.

x) Hydropower is using the energy in falling water to produce electricity. It is an inexpensive way to generate energy and it produces no air pollution. One of the disadvantages of using hydropower is that dam construction can hurt aquatic life and reduce water quality.

5) Extension

a) Wind is a significant power source in Texas. Students can examine wind power by building miniature sailboats and having races with wind or using their own wind power by blowing in the boats' sails.

b) Students can research wind power – how the power of the wind helps reduce pollution by reducing the need to burn fossil fuels for energy.

c) Students can research storms and tornadoes and how wind moves, carries pollution, and destroys things, and then present their findings in a report.

d) Students can make conceptual drawings of wind or write creative pieces pretending that they are wind's diary, discussing what they have carried, seen, or done in a day.

e) Students can find out how their own home is powered, surveying all of the major appliances, the heat and cooling, and water heating, and see how diversified their home energy portfolio is. They can also research residential applications of alternate energy, such as solar water heaters.

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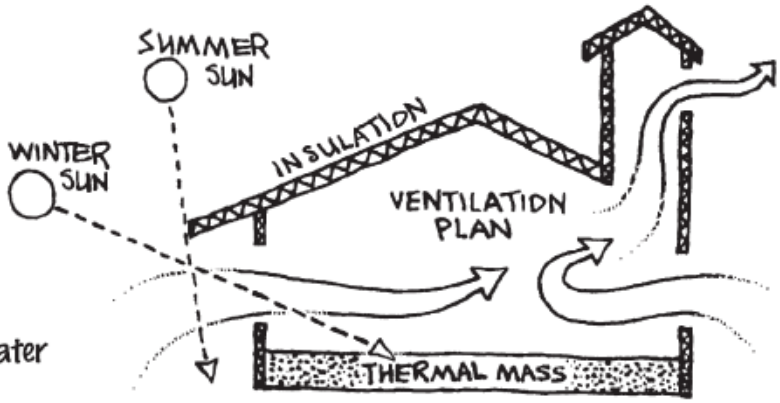
Renewable Energy For The Home

FACT SHEET 4 A RESOURCE FOR CLASSROOMS AND TEACHERS

RENEWABLE ENERGY
THE INFINITE POWER OF TEXAS

Highlights

- Heating and cooling your home
- Drying clothes without gas or electricity
- Cooking with renewables
- Using renewables to pump water
- Playing and working the clean way



NATURAL HEATING & COOLING OF THE HOME Low winter sun through south-facing windows helps heat the home in the winter. Overhangs keep the high summer sun out, while windows allow cooling breezes through.

Earth-Friendly Energy

You can make use of earth-friendly, renewable energy sources in your home. Renewable energy comes from sources that we cannot use up, such as the sun and wind. It almost always causes less pollution than our more typical sources of energy, such as oil, coal, natural gas and nuclear.

Renewable energy is sustainable, so it can provide for your energy needs now and in the future without doing great harm to the environment and human health. This kind of energy can also save you money.

Using Renewable Energy for your Home

HEATING YOUR HOME

- *PASSIVE SOLAR ENERGY*

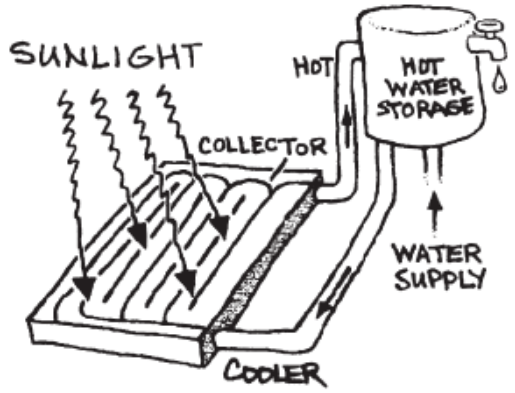
Have you ever felt how hot it gets in a car on a sunny, winter day? The sun's rays can also be used to heat your home. South-facing windows allow sunshine in when the sun is low in the

winter sky. A proper roof overhang above these windows can keep out the hot sun in the summer when it is high in the sky.

■ WOOD STOVES AND FIREPLACES
Under certain circumstances, burning wood can be an earth-friendly, renewable source of heat. But the wood should come from dying or diseased trees, or trees that had to be cut down for other reasons. And well-designed stoves and fireplaces can limit the amount of smoke these fires produce, minimizing air pollution.

COOLING YOUR HOME

■ NATURAL BREEZES
Natural breezes offer free cooling in the fall, spring and summer. Open the windows on the side of the house facing the breeze and also on the opposite side of the house. This allows the breeze to flow easily through your home.



SOLAR WATER HEATING Renewable energy from the sun can be used to heat water for household use.

■ THERMAL CHIMNEY
This uses the principle that warm air rises to the top of tall spaces and is replaced below by cooler air. In a two-story house, open the first floor windows and a window at the top of the stairs.

■ THERMAL MASS
Have you noticed how cool a well-shaded concrete sidewalk feels even when the summer air is hot? Floors made of tile, concrete, stone or earth can make a house feel much cooler in the summer. This can help minimize or eliminate the need for air conditioning.

CLOTHES DRYING WITHOUT GAS OR ELECTRICITY

■ CLOTHESLINE IN THE WIND
Hang the wash on a clothesline instead of throwing it into an energy-guzzling dryer. You will be using free energy from the wind and sun. The sun helps whiten and sanitize the wash, eliminating the need for harsh chemicals, such as bleach, in the washer.

HEATING WATER

■ SOLAR WATER HEATERS
Water easily absorbs heat from the sun. A passive solar water heater uses a solar collector, usually on the roof, to heat water. Then the natural movement of the heated water, a process called convection, transports it into the water tank in your home. A passive solar water heating system can supply 50 percent or more of your household's hot water needs.

COOKING WITH RENEWABLES

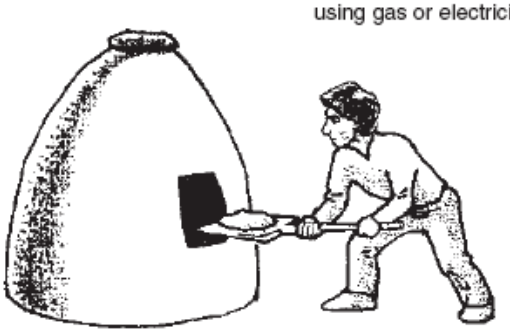
■ *SOLAR COOKERS*

A solar cooker works by concentrating the heat-producing rays of the sun through one or two layers of glass onto food that is placed in an insulated box. A dark-colored cooking pot with a glass lid also will work.

■ *HORNOS*

Hornos are outdoor, wood-fired brick or earthen ovens that cook food using radiant heat. Heat the oven with a wood fire for three or four hours. Then remove the embers. The oven remains hot, and several hours of baking can begin.

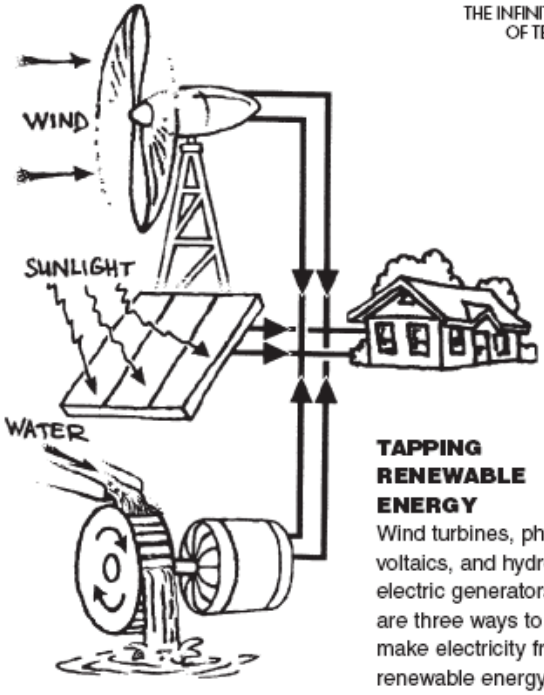
HORNOS Bake food without using gas or electricity



ELECTRICITY GENERATION THE RENEWABLE WAY

■ *PHOTOVOLTAICS*

Photovoltaic, or PV, systems convert sunlight, the world's most abundant source of energy, into electricity. This power can be used in rural places where an electrical connection isn't available, or they can provide power for a house in the city.



TAPPING RENEWABLE ENERGY
Wind turbines, photovoltaics, and hydroelectric generators are three ways to make electricity from renewable energy.

■ *WIND*

The power of wind can be seen in a hurricane or tornado when trees are uprooted and buildings demolished. Wind energy can be harnessed for useful purposes with wind turbines throughout Texas. The mountains of west Texas and the plains of the Panhandle, which are very windy areas, are especially good places for this.

■ *WATER*

Hydropower, or water power, has historically been used for grinding grains in grist mills. Today it is one of the cheapest ways to produce electricity. While hydropower creates no air pollution, dam construction can hurt aquatic life and reduce water quality.

WATER PUMPING

- WINDMILLS

There are about 80,000 windmills operating in Texas. Most of these pump water for livestock, but windmills can be used to pump water for people as well.

PLAYING & WORKING THE CLEAN WAY

- ENERGY SAVING TOYS

Many toys require batteries or electricity to make them operate. Look for solar-powered toys such as race cars and speedboats. Or choose manual toys for which you supply the power. Battery operated toys can be powered by reusable batteries re-energized in a solar recharger.

- ENERGY SAVING TOOLS

Mowing the lawn is more fun, and better for the environment, with a manual push mower instead of a gasoline powered one. Manual mowers, trimmers and rakes use renewable human power and cost less to buy, operate and maintain. Solar rechargeable flashlights and lanterns, portable solar showers and water purifiers are also good choices.

Wasting Energy at Home?

Target Grade Levels
Third - Fifth

Time
45 minutes, plus take home activity

Materials
- crayons or colored markers

Knowledge and Skills (TEKS)
- Science:
  - Demonstrate safe, environmentally appropriate, and ethical practices;
  - Learn to use and conserve, dispose and recycle resources;
  - Plan and implement descriptive and simple investigations, ask well-defined questions, formulate hypotheses, select and use appropriate equipment and technology, collect, analyze and interpret information, observe and measure, and communicate valid conclusions; and
  - Sun is our major source of energy.
- Math:
  - Construct graphs, tables, maps, charts to organize, examine, and evaluate information.

Overview
Students will observe the places in their homes where they can make energy-efficient choices.

Background Information
Americans use more energy each year than we used the previous year. In fact, during the 20th century, the amount of energy our nation uses has doubled about every 20 years. The rates of increase in our energy consumption have slowed somewhat recently, but we continue to use more and more energy.

Energy conservation—the reduction of energy used in order to save energy—was not thought of before the energy crisis of the 1970s. When a shortfall in imported oil shipments and a dramatic rise in oil prices caused energy costs to skyrocket, we became concerned about saving energy Not only does energy conservation save us money on our energy bills now; it saves us (and consumers in the future) money in the long run by making our irreplaceable energy resources last longer.

Additionally, energy conservation reduces the need for the burning of fossil fuels by power plants that produce the electricity we use. The burning of fossil fuels creates large amounts of air pollution, especially nitrogen oxides and sulfur dioxide. Both of these pollutants contribute to acid rain and nitrogen oxides are a major precursor for ground-level ozone pollution. Ground-level ozone pollution damages the human respiratory tract and is particularly dangerous for sensitive individuals, including children, the elderly, and asthmatics. By increasing energy efficiency and conservation, students can help eliminate large amounts of air pollution.

Procedure
1) Vocabulary

a) appliance	d) ground-level ozone
b) conservation	e) nitrogen oxides
c) energy	f) sulfur dioxide

g) air

h) pollution

i) fossil fuel

j) efficiency

2) Activities

a) Define energy conservation and share the background information as appropriate.

b) Give each student a copy of the student sheet “WASTING ENERGY,” included.

i) Have the students draw an “x” on the ways energy is being wasted.

ii) Ask the students, “How can energy be conserved in this picture?” (turn off lights, turn off TV, close door; some students may suggest covering the window and/or carpeting the floor)

iii) Have the students list examples of how energy is conserved in their homes.

c) Activity

i) Give each student a copy of the student sheet “HOW TO CONSERVE ENERGY IN YOUR HOME,” included. Discuss the directions with the students. Have the students take the sheet home and complete it with the help of their parents.

ii) Have the students identify energy users and wasters in their homes.

(1) Give each student a copy of the “HOME ENERGY SURVEY”.

(2) Make a transparency of the teacher information sheet “APPLIANCE ENERGY USE,” included. Have the students list the home appliances pictured on the student sheet (“HOME ENERGY SURVEY’) and given on the transparency. Put the following headings on the board and divide the listed appliances into these categories—“Heavy Users of Energy,” “Moderate Users of Energy,” and “Light Users of Energy.”

(3) Discuss with the students which appliances shown on the “HOME ENERGY SURVEY” student sheet they have in their own homes.

(4) Have the students circle in red the depicted energy wasters they know occur in their own homes.

3) Review

a) Have the students write a definition (in his/her own words) of conservation.

b) Have the students list five ways to conserve energy in the home.

c) Have the students make a chart (similar to the one below) based on the information they marked on their “HOME ENERGY SURVEY” student sheets. For example:

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Home Energy Survey Data

Energy Users	Ways to Reduce Energy Use
1) Television, lights, radio, CD player, video games	1) Turn off when you are not using.
2) Range (stove)	2) Cover pots; thaw frozen foods before cooking; plan meals carefully.
3) Washer	3) Wash full loads; use cold water.
4) Car	4) Walk; ride in carpools; ride a bike; observe speed limits; keep car well-maintained
5) Bath	5) Take shorter showers or shallower bath (use less hot water).
6) Outside doors	6) Install storm doors; keep doors closed when using heat or air conditioning; install weather-stripping. Check for leaks and repair as necessary.
7) Thermostat	7) Set at 68 degrees in winter and turn down at night; wear warm clothes; set at 78 degrees in summer; wear cool clothes.
8) Fireplace	8) Close flue when not in use; install glass fire screen that can be closed when fireplace is not in use.
9) Windows	9) Close draperies at night; put shutters, blinds, or drapes on all windows; install storm windows; install weather-stripping. Check for and repair leaks.
10) Appliances	10) Do not use several heavy users at the same time, and turn off appliances when not in use.

4) Evaluation

   a) Students can turn in their home energy survey for evaluation based on completeness.

   b) Review and extension activities can be performed as graded exercises.

5) Extension

   a) Invite a speaker from your local power distributor to speak to the class about ways to conserve energy.

   b) Have the students, with the help of their parents, compare several months utility bills and discuss ways to conserve electricity.

   c) Have the students project what will happen to electrical costs by the year 2025, and write a skit to perform depicting a family receiving and paying an electric bill in that year.

Adapted from: "Wasting Energy at Home?" *Alliance To Save Energy.* www.ase.org/educators/download.htm.

Credit: "The Energy Sourcebook: Elementary Unit" (1990) Tennessee Valley Authority.

Resources:

Alabama Department of Economic and Community Affairs, Science, Technology and Energy Division Energv Savers Activity Book With the Energy Robots. Montgomery, AL: Author, n d. (p.17) (Address 3465 Norman Bridge Road, Montgomery, AL 36105.)

Alabama State Department of Education. Energv Activities: A Resource Guide for Grades K – 4. Montgomery, AL: Author, n.d. (p. 84) (Address: State Office Building, Montgomery, AL 36130.)

Energy Source Energy Education Program. Energv in American History. Lakewood, CA: Author, 1982. (pp. 20-21)

McDonald's Corporation. McDonald's Ecologv and Energy Action Pack. Oak Brook, IL: Author, 1977. (p. 14) (Address: Director-Corporate Responsibility, McDonald's Corporation, One McDonald Plaza OakBrook, IL 60521.)

Nebraska Energy Office. Energy Conservation Activity Packet. Lincoln, NB: Author, n.d. (Telephone 402-471-2867.)

Tennessee Valley Authority. "How to Insulate Your Attic,' 1984.

Tennessee Valley Authority. "How to Insulate Your Electric Water Heater" 1984.

Tennessee Valley Authority. "How to Read Your Electric Meter" 1987.

Tennessee Valley Authority. "How to Save on Your Electric Bills" 1984.

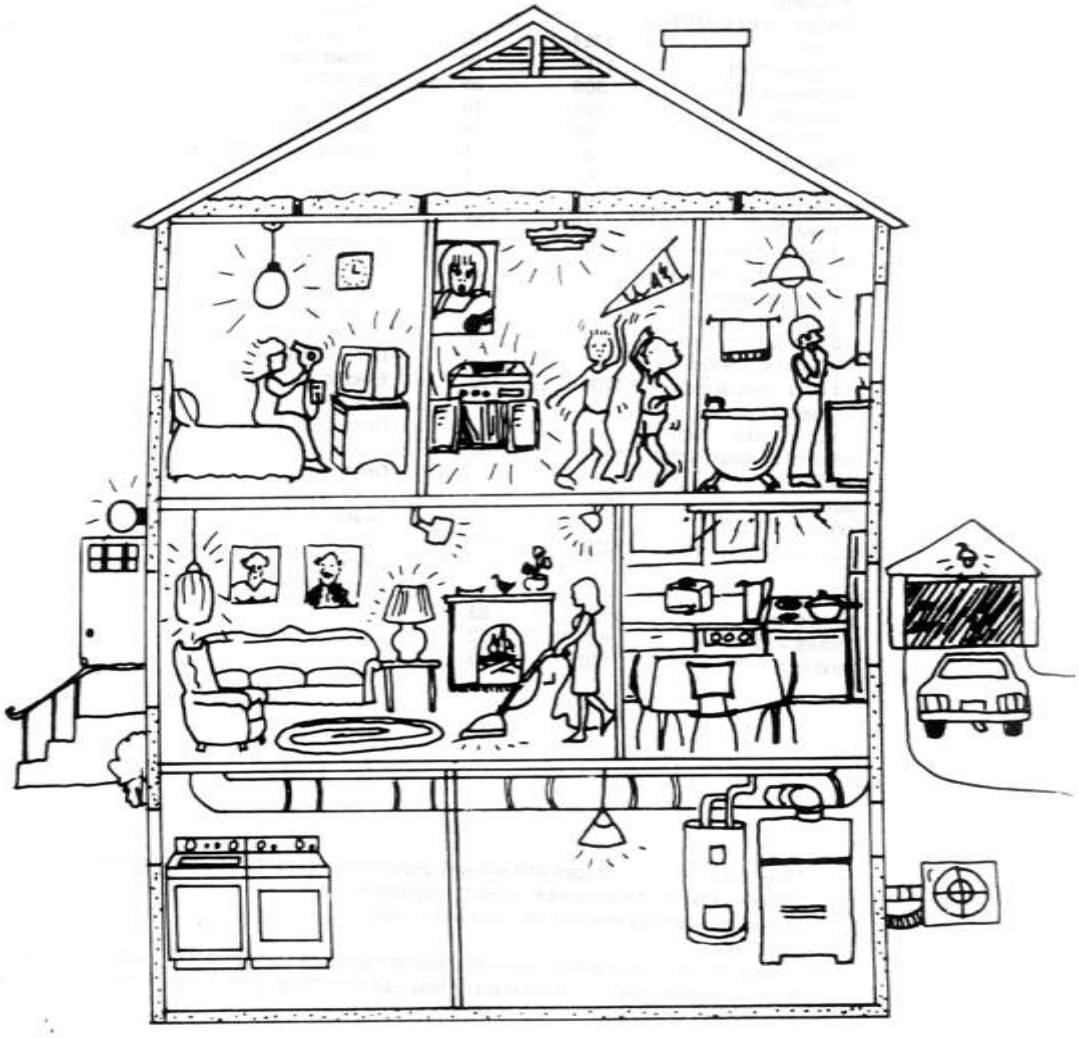
WASTING ENERGY

Put an “X” on all the ways you observe energy being wasted.

HOW TO CONSERVE ENERGY IN YOUR HOME

Directions: Read each triangular shape. Color the triangular shape light blue if you and your family observe the energy conservation rule. Color the triangular shape yellow if you and your family do not observe the energy conservation rule. Discuss with your family ways to save energy in your home.

HOME ENERGY SURVEY



APPLIANCE ENERGY USE

Appliance	Average KWh Used	
	Annually	Monthly
Kitchen		
Range w/self-cleaning oven	1,224	102
Range w/oven	1,152	96
Microwave Oven	300	25
Frying pan	190	16
Coffee maker	110	9
Toaster	40	3
Mixer	10	1
Food disposer	30	3
Dishwasher	1,560**	130
Refrigerator/Freezer (16-25 cu ft side-by-side model, auto defrost)	2,160	180
Refrigerator/Freezer (14 cu ft, auto defrost)	1,800	150
Refrigerator/Freezer (14 cu ft, manual defrost)	1,200	100
Refrigerator/Freezer (17 cu ft, two-door, high efficiency, auto defrost)	1,200	100
Freezer, 15 cu ft, auto defrost	1,800	150
Freezer, 15 cu ft, manual defrost	1,200	100
Laundry		
Clothes Dryer	1,000	83
Clothes Washer	624***	52
Hand Iron	150	13
Entertainment		
Color TV		
Tube Type	660	55
Solid State	440	37
B&W TV		
Tube Type	350	29
Solid State	120	10
Radio/phonograph	110	9
Comfort		
Electric Furnace	13,200*****	(seasonal)
Heat Pump	6,600****	(seasonal)
Air Conditioning, central, per ton	1,500*****	(seasonal)
Air Conditioning, room, 1 ton	1,500	(seasonal)
Dehumidifier	400	33
Electric Blanket	150	(seasonal)
Attic Fan	300	(seasonal)
Ceiling Fan	130*	(seasonal)
Other		
Quick Recovery Water Heater	4,200	350
Vacuum Cleaner	50	4
Clock	18	1.5
Toothbrush	0.5	0.04

*Figures are averages and will vary depending on user habits and lifestyles.
**Includes kWh for heating water used by appliance.
***Based on warn water wash and cold water rinse.
****Heat only.
*****Based on 1,500 sq. ft. house insulated to meet TVA standards for energy efficiency. If your house does not meet these standards it may use considerably more electricity during the heating and cooling seasons.

Energy Sources

Target Grade Levels
Third - Sixth

Time
30 minutes to start, then as a homework assignment.

Materials
- sun picture (optional)
- fruit or vegetable
- container of vegetable oil
- piece of firewood
- piece of charcoal or coal
- container of motor oil
- gas lighter
- cup of water and an empty cup
- child's pinwheel
- lightning Picture or light bulb
- nuclear power plant picture
- piece of discarded trash
- battery

Knowledge and Skills (TEKS)
- Science:
  - Demonstrate safe, environmentally appropriate, and ethical practices;
  - Learn to use and conserve, dispose and recycle resources;
  - Plan and implement investigations, as well-defined questions, formulate hypotheses, select and use equipment, collect, analyze and interpret information, observe and measure, and communicate valid conclusions;
  - Describe light, sound, heat, and electricity as forms of energy; and
  - Differentiate forms of energy.
- Math:
  - Construct graphs, maps, and charts to organize and evaluate information. Investigate physical states of matter.

Overview
Students will observe different types of energy sources and learn more about energy and where it comes from. Students will then conduct their own research reports on energy sources.

Background Information
Sources of energy are all around us, and come in a variety of different forms. Energy for a person is different than energy for an automobile. In this activity, the teacher demonstrates several different types of energy, and assigns a research report topic for small groups of students.

Procedure
1) Vocabulary

a) energy	g) natural gas
b) solar energy	h) hydropower
c) chemical energy	i) electricity
d) fossil fuel	j) fission
e) coal	k) potential energy
f) oil	

2) Activities
   a) Using the information on pages 114-115, demonstrate the different energy sources. Write the names of the different types of energy sources on the chalkboard.
   b) Once students have received their introduction to energy sources, inform them that they will be conducting research reports to find out more about their energy sources.

c) Break the class into groups of two or three students and assign each group a different energy source. Instruct each group to complete a three-page report about the energy source. Since the project will be a collaborative effort between two or three students, encourage the students to divide the work, so that each student contributes a section to the final report.

d) Take a trip to the library. Work with the librarian to show the students how to find the information they need to complete the report on their energy source. Be sure they know how to use the encyclopedia and other resources. Provide time for the students to do their research, work together in their groups and write the report.

e) After all the presentations have been given, initiate a discussion with your class about what they learned. Ask your class to choose the safest energy source, the most efficient energy source, the energy source that's least destructive to the environment and the cheapest energy source. Then, write a list of the energy sources on the board, and have the class vote for the "best" source. You may have them vote for the top two or three.

3) Review
After the reports are completed, have each group give a five-minute presentation about the energy source they studied.

4) Evaluation

a) Students can be quizzed on vocabulary.

b) Students can perform the following extension activities as graded exercises.

c) Each group that presents could also submit quiz questions that go along with their presentation. The students can receive a grade based on the quality of the questions they submit and whether or not the answer was given during their presentation.

d) Students can turn in their notes for each presentation as a graded activity.

e) Students can be quizzed using the questions submitted by each group, compiled into one large quiz.

5) Extension

a) As a simpler version of this activity, assign the energy words as homework vocabulary assignments to your students. Have them complete sentences using the words.

b) An even simpler version of the activity would be to simply conduct the demonstration as described in the activity.

c) To extend this activity, have each student write a one-page essay on which three energy sources they would choose as the "best" sources of energy for the world. Tell them to explain why they chose what they did. This can be given as an in-class assignment or as a homework assignment. When the essays have been completed, ask some students to read theirs aloud. Display the completed essays in the classroom.

d) Students can keep an energy diary for a day, listing their activities and the types of energy used to do them. Examples:

i) Ate breakfast

(1) Consumed chemical energy in the form of food.

(2) Kitchen lights were on, powered by electrical energy.

(3) Used chemical energy stored from previous food consumed to run body.

ii) Took bus to school

(1) Bus consumed chemical energy in the form of fossil fuel and converted it to mechanical energy to make the wheels run.

(2) Used chemical energy stored from previous food consumed to run body.

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Adapted from: "Energy Sources" *Alliance to Save Energy (ASE).* www.ase.org/educators/download.htm.

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Energy Sources

Sunlight: Look at a picture of the sun. The light that comes to the earth from the sun is pure energy, the original energy source. Nearly all other energy sources got their energy from the sun. Organic matter, like plants, convert solar energy into leaves, flowers and fruits. Animals, which eat organic matter, convert the energy into body mass. When animals die, their energy is decomposed and, over extensive time, becomes stored as oil, coal or natural gas.

Food: Hold up a piece of fruit or vegetable. People use food for energy. Food that we eat is digested, and the stored energy is used by the body to keep the heart beating, the blood pumping and the body growing. When a body has "low blood sugar," the body needs to eat and process more energy, so we can continue working, playing and growing.

Organic Oils: Hold up a bottle of vegetable oil. Vegetable oils, like olive oil, corn oil or safflower oil, are often used in cooking. Jojoba oil (from the jojoba bean) is used in cooking or lubricating, as well as in lotions and soaps. Animal oil, like that from whales, seals and livestock, was used in the past for lighting lamps as well as for waterproofing.

Wood: Hold up a piece of firewood. Wood comes from trees, which are, of course, plants. The plants got their energy from the sun. When trees are cut down and burned, they release their energy in the form of heat and light. Many homes are heated with wood-burning stoves.

Fossil Fuels

The following three energy sources come from prehistoric fossils. Ancient plants absorbed the energy from the sun and converted it into more plants. Ancient animals, like dinosaurs, ate the plants. When the plants and animals died, their remains collected under mountains of earth to decompose over millions of years into a source of fuel. The remains of these plants and animals are what we refer to as fossil fuels.

Coal: Hold up a piece of charcoal, or, if possible, a piece of real coal. Coal is burned to heat homes and run electrical machinery. About 20 percent of the energy we use comes from coal. There are four grades of coal: lignite, subbituminous, bituminous, and anthracite. The first grade, lignite, is the youngest kind of coal; it has the lowest carbon content and the largest amount of impurities that add to air pollution. Each grade after that has an increased carbon content and reduced impurity content. Bituminous is the most plentiful kind of coal in the United States.

Oil: Hold up a container of motor oil (preferably in clear plastic so students can see the oil). Other petroleum products similar to motor oil are burned to fuel motor vehicles and heat homes. About 45 percent of energy used comes from oil.

Natural Gas: Hold up a lighter, and light it. Natural gas is used to heat the homes of many people. About 25 percent of the energy we use comes from natural gas. The fuel used in lighters is not the same as the natural gas used to heat homes, but the lighter can be used as an example. Most of the energy used by people today comes from these fossil fuels. But fossil fuels are limited in their supply, can pollute, and are sometimes hard to find.

Other Energy Sources

The following energy sources do not require the sun. They are derived from other aspects of the earth's ecosystem.

Water: Pour water from one cup to another, simulating a waterfall. Water is not an energy source, but water is used to generate energy. Water falling downhill is used to run turbines, which generate electricity. This is called hydroelectric power. About 5 percent of the world's power is now produced by hydroelectric dams. A similar type of energy comes from geothermal energy. Pockets of boiling water under the earth's surface send steam to the surface of the earth. This hot water also can be used to generate electricity. Dams can impede the movement of fish up and down river to reach spawning grounds or for other migratory purposes.

Wind: Hold up a pinwheel and blow on it. Winds that blow can be used to turn windmills, which generate electricity. Windmills have been used for centuries in some parts of the world, like Holland. Windmills are also used in the United States.

Electricity: Hold up a picture of lightning, and/or a light bulb. An electrical storm contains a great deal of natural electrical energy. Benjamin Franklin first proved that lightning was electricity in 1752. His discovery helped scientists learn how to harness electricity and how to generate electricity from other methods. The electricity we use today was created by other sources, not by the energy released by lightning.

Nuclear Power: Hold up a picture of a nuclear power plant. Nuclear power comes from the radioactive ore uranium. It produces far more power per ton than any other energy source. Nuclear power does not contribute to air pollution. However, radioactive waste is hazardous to living things. Exposure to radioactive materials can result in mutations, illness or death. The drawback to using nuclear power is finding a safe place to dispose of the nuclear waste. About 6 percent of the energy used in the world comes from nuclear power.

Refuse-derived fuel: Hold up a piece of discarded trash. Now, we are able to extract energy from garbage! Garbage is burned in a waste to energy facility. As it burns, water pipes are heated. This hot water is used to generate electricity. Most waste to energy facilities produce enough energy to run the plant and supply additional power to the community. This is a small but growing source of energy.

Chemical energy: Hold up a battery. Batteries create energy through chemical reactions. When different chemicals react with one another, energy is released. Eventually the reaction stops, and the battery must be replaced. Batteries are used in motor vehicles and many smaller appliances, such as clocks, hearing aids and toys.

How Much Energy Do You Use?

Target Grade Levels
Third - Sixth

Time
15 minutes preparation, one day's homework, 20 minutes class work

Materials
- calculators
- handout
- energy Home Survey worksheet

Knowledge and Skills (TEKS)
- Science:
  - Demonstrate safe, environmentally appropriate, and ethical practices; and
  - Plan and implement investigations, as well-defined questions, formulate hypotheses, select and use equipment, collect, analyze and interpret information, observe and measure, and communicate valid conclusions.
- Math:
  - Problem solving;
  - Collect information, measure, and compare using tools such as a calculator; and
  - Number, operation, and quantitative reasoning.

Overview
Students will observe the items that use energy in their own homes, as well as calculate the energy cost. Then students will compare this cost with others in their class and with the national average.

Background Information
U.S. residents use more energy now than in the past. There are many reasons for this. As more people populate the country, energy needs rise. Technology advances, such as industrial processes, sophisticated machinery and computers, also require increased energy. Our everyday lives are filled with electrical appliances that our grandparents never used.

Why is our energy bill so high? This activity gives your students a chance to work on some real-life math problems. This activity bases its numbers on cost figures from one utility. Energy figures in your area may be different. Your local energy utility can give you figures that show the average expenditure per household in your community.

For more information, visit the City Public Service (CPS) website at http://www.cpsenergy.com/.

Procedure
1) Vocabulary

a) energy
b) electricity
c) watt
d) kilowatt
e) kilowatt-hour

2) Activities

a) Start by asking your students if they ever heard their parents complain about the cost of energy. Explain that the monthly utility bill is directly related to the amount of energy the household uses, and that this activity will help them find the "energy-eaters" in the house.

b) Distribute the Energy Home Survey worksheet and assign the homework.

c) When students have completed the homework assignment, assist them in answering the questions and completing the math.

d) Ask them if they found appliances in their homes they think they could live without, such as an electric can opener or an electric plate warmer.

3) Review

a) Have the class work in groups to add and average their numbers into a whole class average. Then open up a discussion as to why students' personal home's numbers might have been higher or lower than the class average.

b) Students should estimate their usage of each of the appliances and ways they can reduce usage.

4) Evaluation

a) Students can be quizzed on energy conservation concepts.

b) Students can be quizzed using math questions related to energy usage.

c) Students can perform the following extension activities as graded exercises.

5) Extension

a) A good introduction to this activity is to encourage students to ask a grandparent, or older relative or neighbor about what life was like when they were children. Many grandparents grew up before television, commuter flights and digital clocks.

b) The student could interview the senior and write a report comparing an aspect of energy use "then" vs. "now."

c) Students can be assigned particular home appliances on which to do consumer research. Reports should cite information on at least three different brands. Information should include basic appliance capabilities (e.g. for a refrigerator, cubic feet, icemaker, in-door water dispenser), energy usage, Energy Star rating or lack thereof, cost, expected monthly cost due to energy usage, and time it would take for a less expensive, less efficient model to equal and surpass the cost of a more efficient model when both initial cost and monthly energy cost are taken into account.

d) Students can research home improvements (such as installation of additional insulation, replacement of windows, or replacement of thermostat with electronic thermostat) that improve energy efficiency and write a report including process and cost for improvement and time to recoup initial investment with savings from reduced energy usage.

Adapted from: "How much energy do you use?" *Alliance to Save Energy (ASE).* www.ase.org/educators/download.htm.

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Energy Home Survey

Do this survey twice: once on a weekday before dinner and once on a weekend day. It will help you determine how much energy you use.

Appliance Electrical Appliances	Multiply by	Subtotal	Total per day
Incandescent Lights: Number of lights on =	1 cent per hour		
Fluorescent lights: Number of lights on =	1 cent per every 4 hours		
Television: Number of sets on =	4 cents per hour		
Radio: Number of sets on =	1 cent per hour		
Stereo: Number of sets on =	2 cents per hour		
Microwave oven: Number of ovens on =	15 cents per hour		
Computer: Number of computers on =	1 cent per hour		
Vacuum cleaner: Number on =	9 cent per hour		
Portable heater: Number on =	15 cents per hour		
Air conditioner: Number on =	55 cents per hour		
Total for all subtotal usage			
Total usage in one day			

Add up all the numbers in the Subtotal column. This subtotal is the total cost for these appliances in one hour.

Some of these appliances will be on for more than one hour, some less. Based on what you know about your household, write the total number of hours and the total cost in one day for these appliances in the Total per day columns above.

(Example 1: If two stereos are on for eight hours a day, you multiply 2 (stereos) x 2 cents per hour x 8 hours = 32 cents per day. Example 2: If you vacuum for 1/2 hour, multiply by 9 cents per hour x .5 hours = 4.5 cents per day.)

Periodic Appliances
Some items are not used all the time. They create a cost only when they are used.

Periodic Appliances **Appliance and loads per month**	**Multiply by**	**Total per month**
Dishwasher:		
Loads =	10¢ per load	
Washing machine:		
Loads =	5¢ per load	
Electric clothes dryer:		
Loads =	67¢ per load	
Gas clothes dryer:		
Loads =	16¢ per load	
Total usage for one month		

These answers give you the total cost per month, based on how much your family uses these appliances.

Periodic Appliances: **Appliance and average use per month**	**Total per month**
Gas water heater:	$13.00
Electric water heater:	$45.00
Refrigerator:	$16.00
Extra freezer:	$18.00
Electric heating system:	
Small home:	$85.00
Large home:	$250.00
Gas heating system:	
Small home:	$28.00
Large home:	$120.00
Total for 1 month	

With your teacher's help, try to figure out your home energy costs for one month. Compare it to the bill that your parents receive each month. How do they compare?

My estimate: _____

My home's bill: _____

Did your estimate come close to the actual cost? If not, why do you think they differ?

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Making Decisions

Target Grade Levels
Third - Ninth

Time
40 minutes

Materials

- chalk
- chalkboard (or a flip chart and markers)
- guest presenters: *air quality professionals, economists, EPA specialists, EPA policy analysts, or meteorologists*

Knowledge and Skills (TEKS)

- Science:
  - Demonstrate safe, environmentally appropriate, and ethical practices;
  - Learn to use and conserve, dispose and recycle resources;
  - Observe and record changes in states of matter caused by heat and conduct tests, compare data, and draw on conclusions about physical properties of matter-states, conduction, density, and buoyancy; and
  - Identify and observe effects of events that require time for change to become noticeable.

Overview
This exercise lets students explore how decisions are made. Students will practice solving problems that have choices.

Background Information
Making decisions is an important part of life for everyone—students, executives, homemakers, shopkeepers, or scientists. Solving a problem requires comparing alternatives and thinking about the probable results of one's choices. Every choice, or decision, leads to certain direct results and more indirect results. Many choices will end up influencing or limiting future decisions. For example, choosing a hamburger for lunch might mean that one is less inclined to choose meatloaf for dinner. Or deciding to spend money for a new bike now may mean forfeiting the money for a new computer game. The worst kind of decisions are those made on a whim, without thinking through the consequences. The best kind of decisions are those made after thinking about the possible alternatives, and the advantages and disadvantages of each.

One way to begin a thoughtful decision-making process is to ask yourself questions and find honest answers for them. Typically, a number of limitations affect the quality or cost of the decisions we make. Cost does not necessarily mean money. It could also be any valuable thing that is given up in order to implement the choice, such as time or lost opportunities. Clearly, there is a trade-off between getting all the best information and spending too much time fussing over the choice. Sometimes, you spend so much effort collecting or weighing alternatives that you run out of time or money or both and loose much of the benefits of careful decision-making. Sometimes, what we all call "common sense" is the best decision, but if you think about it, simple common sense usually has a good reason behind it.

Many important decisions are made after a careful and formal analysis, some-times called a "benefit-cost" analysis. It usually is structured by writing down all the advantages or "pros" on one side of a page, and all the disadvantages or "cons," on the other side. Then by comparing the pros and cons one can systematically arrive at a "best" decision. One mark of a good decision based on careful thought is that none of the results or consequences of the decision—good or bad—should come as a surprise. If one makes a decision with too little information about its consequences, then there is a greater "risk" involved that the decision may not solve the problem or that the decision may cause an unforeseen problem. Making good decisions is a skill that comes about with practice and experience. Nobody is "born" with it. Also, the confidence that comes with practice often results in better and quicker decisions.

Additional complexities must be considered in the realm of environmental decision-making. True environmental costs are hard to determine with conventional methods, yet everything we do has myriad effects on the environment. Even breathing adds to carbon dioxide in the atmosphere and could worsen global climate change. When participating in any decision-making process, it is important to consider the following special environmental factors:

1) What natural resources must be used to create this item?
2) What natural resources must be used to operate this item?
3) Are there renewable resource alternatives that can reduce long term cost for creation and operation?
4) What types of waste and pollution will this create?
    a) Solid waste
    b) Hazardous waste
    c) Water pollution
    d) Air pollution
    e) Soil contamination
5) Who will be affected and or put at increased health risk by this item?
    a) Individuals living nearby
    b) Individuals in the watershed
    c) Individuals in the airshed
    d) Individuals living near a landfill that will accept waste produced by this item?
6) What economic harm might waste/pollution from this item cause the groups named above?
7) What might be the additional cost if negative effects from the waste and/or pollution result in lawsuits from the individuals named or additional taxes needed to clean up the environment as a whole due to mass pollution problems?
8) How can the item or process be better designed to create less waste, use less energy, emit less pollution, and use fewer natural resources?

When true environmental costs are considered, more environmentally-sensible options are usually better for the bottom line.

There are seven steps in good public decision-making:

1) What is the problem or issue? Ignore all the complicating issues, or "red herrings," and articulate a clear, simple problem. Identify who and what may be affected by the problem, and who and what may benefit from the decision.
2) What are the options for solving the problem? Leave out all the really unlikely solutions, and just list the ones that are most realistic. Keep them as straightforward as possible.
3) Do I know enough about each alternative? Compare each alternative solution to the problem, and write down what is known and what needs to be researched for each.
4) What are the advantages and disadvantages of each alternative? Sometimes, advantages or disadvantages include the effort required to get all the necessary information. If it seems that the effort, or "cost," of getting the necessary information outweighs the benefits, the decision-maker may need to consider his or her willingness to accept the consequent risks.
5) Which advantages and disadvantages are critical? Cross out those that don't really matter; these are just confusing extras.
6) Which of the options seem to best solve the problem, considering the advantages and disadvantages of each?
7) Finally, share and discuss results publicly and with those affected by the decision even if you have already involved some of them in the process.

Suggested Reading

- Berry, Joy. E*very Kid's Guide to Decision Making and Problem Solving*. Children's Press (1987).
- *Citizenship with Bambi and Friends* (Filmstrip). Walt Disney (1988).
- *The Environment* (Apple II computer program). Tom Snyder (1990).
- A role-playing simulation in which students address crucial environmental questions.
- *I Don't Know What To Do: Decision-Making Skills* (Videotape). Guidance (1988).
- *A Kid's Guide to Decisions* (Filmstrip). Learning Tree (1988).
- *The Oil Game* (Apple II computer program). AV System (1988).
- Smith, Sandra Lee. C*oping with Decision-Making*. New York, NY: Rosen Publications Group (1989).
- Ulrich-Hagner, Linda. D*ecisions in Action*. South-Western Publishers (1988).
- *Understanding Decisions* (Filmstrip). Learning Tree Publishing (1990).
- Y*es? No? Maybe? Decision Making Skills* (VHS videotape). Sunburst (1990).

Procedure

1) Vocabulary
   a) benefit
   b) cost
   c) risk
   d) environmental justice
   e) airshed
   f) watershed

g) solid waste

h) hazardous waste

i) landfill

2) Activities

a) Introduce the topic of decision-making to the class, write the seven decision-making steps on the chalkboard or flip chart and explain them.

b) Have the students suggest several real or invented air pollution problems that require decisions to solve, such as, “Should I convert all my electric lights to energy-savers at home?” or “Why should we work to save the rain forest?” or “What is the best way I can contribute to the reduction of greenhouse gases?” or “How can we control the quality of the air in the classroom or school?” Assign one student to record on the chalkboard or flip chart suggestions by the students during the problem solving process. You can use current events articles that raise issues yet unresolved as a means of jogging students’ thoughts on selecting problems. Have students formulate a problem statement for each question suggested.

c) Select a few problems to focus on and have students volunteer answers to each of the first six problem-solving steps. For each answer, get the student to specify which problem it addresses and which step it fits under. Note that the class can be considering all the problems at once. Allow students to question or comment on each others' suggestions.

d) Once each problem has answers under each of the first six steps, begin narrowing the selections by encouraging the class to evaluate each of the steps. Have the scribe annotate the chalkboard or easel as decisions are made. Encourage dissenters or skeptics, but get the class to consider all angles.

3) Review

a) Review the students’ answers to each of the steps and ask a different student why that answer was used and whether or not that student agrees.

b) Present the class with this decision-making scenario on which they must go through the steps together. “The San Antonio region has a problem with excess ground-level ozone pollution. Ground-level ozone pollution is created when nitrogen oxides and volatile organic compounds react in sunlight. Major regional sources of nitrogen oxides include: vehicles, power plants, off-road construction equipment, industry, and landscaping equipment. Major regional sources of volatile organic compounds include: vehicles, gasoline stations, industry, off-road construction equipment, and landscaping equipment. Something must be done to reduce these two types of pollution so that they cannot react to make ground-level ozone, which is dangerous for your health. There are a number of different strategies to reduce these pollutants, but each has benefits and costs. Evaluate the following strategies:

i) Mandating less-polluting but more expensive gasoline

ii) Restrictions on the amount that industry is allowed to pollute

iii) Restrictions on the amount that the power plant is allowed to pollute

iv) Mandatory emissions inspections for all vehicles to make sure that they're not polluting more than they're supposed to

v) Others?

4) Evaluation

a) Students can be quizzed on vocabulary and concepts.

b) Extension activities can be performed as graded exercises.

5) Extension

a) Suggested Modification

i) For lower grades, decision-making can be fun but also frustrating. Use a decision-making exercise that addresses group activities such as the best way to spend time. Let the students decide how the day or an hour should be spent, and why. Modify the seven decision-making steps, as appropriate, and use them to facilitate such a discussion. For lower grades, the decision-making steps may have to be stated more simply to help students participate in the process.

ii) For upper grades, have students develop a subset of questions (between the lines) to explore each of the seven decision-making steps in more depth. Use the expanded list to facilitate the discussion.

iii) You may want to ask a guest presenter to add to the list some real world problems or issues with which he or she is currently working.

iv) Have students select a news clipping that raises a problem or issue that others are working to resolve. Assign a special project in which students will use the steps presented here to research and develop a potential resolution. When completed have the student present his or her findings and the rationale for the selected option.

b) Students can research the different strategies to reduce ozone pollution and write a short paper answering each of the steps and coming to a conclusion on which strategy or strategies they would implement.

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Adapted from: "Warm-up G - Making Decisions" *Environmental Protection Agency (EPA) - Project A.I.R.E.* 2003. Page 19.

How Green Are We?

Target Grade Levels
Fifth - Twelfth

Time
Two class sessions and one week to conduct the audit

Materials
- paper
- pencil
- chalk
- chalkboard
- guest presenters: *air quality professionals, economists, ecologists, conservationists*

Knowledge and Skills (TEKS)
- Science:
  - Collecting data, observing, drawing conclusions, making oral presentations;
  - Demonstrate safe, environmentally appropriate, and ethical practices;
  - Learn to use and conserve, dispose and recycle resources;
  - Record changes in matter caused by heat and conduct tests, compare data, and draw on conclusions about physical properties of matter-states, conduction, density, and buoyancy; and
  - Identify and observe effects of events that require time for change to become noticeable.

Overview
This activity enables students to audit their homes, their school, and their community to evaluate steps being taken to prevent or reduce air pollution.

Background Information
Air pollution is a major problem in many areas of the United States. Even though some of this pollution comes from natural sources, such as volcanoes, forest fires, and other natural occurrences, much of it can be traced to manmade sources. Air pollution from human sources is the result of our increasing use of fuel to produce electricity and to power automobiles, trucks, and other vehicles.

Many of these air pollutants come from burning coal, oil, wood, and other fuels used to run factories, cars, and the power plants that generate heat and light for our homes. Many air pollutants are not only harmful, but also tend to be concentrated in urban areas where industrial activity is greatest and energy use by the community is highest. There are things that individuals and families, schools, and communities can do to become more energy-efficient.

Individuals and families can play a role in reducing pollution by cutting electrical and fuel consumption. Electricity consumption costs can be reduced by using fluorescent or compact fluorescent bulbs in the home, adjusting the setting of the thermostat appropriately during the summer and winter, turning off appliances when they are not in use, and using alternative sources for accomplishing tasks that traditionally use electricity, such as drying clothes outdoors instead of using a clothes dryer.

Other measures can be taken, such as using sunlight instead of electricity for warmth and light, buying appliances with low wattages and favorable efficiency ratings, and keeping filters clean on furnaces, air conditioners, and refrigerators. Fuel consumption can be reduced by proper car maintenance, walking or bicycling instead of using the car, or by combining errands so that only one trip needs to be made to accomplish many tasks.

Schools also can cut down on electrical and fuel consumption by taking similar measures to those taken in the home. Turning off lights at night, using solar energy to help heat the building, and keeping the temperatures at 68°F (20°C) in the winter and 78°F (25.56°C) in the summer are just a few measures they can take to conserve energy. In addition, they can alter bus routes to accommodate more students so that fewer buses are on the road and encourage their employees to use public transportation, walk, bike, or carpool to get to work, implement SchoolPool and Walking School Bus programs, institute anti-idling policies, or adjust the start and end dates of the school.

Communities can help reduce air pollution by participating in the "Green Lights" program, which is a clean air effort sponsored by EPA. The program works with business and industry to help them reduce electricity usage and save money. The program focuses on upgrading lighting systems and encourages the use of fluorescent and compact fluorescent light bulbs, which last ten times as long as traditional incandescent bulbs and emit more light per watt. The direct result is improved lighting and cost savings for participating schools, as well as a reduction in air pollution. Communities also can reduce air pollution by promoting use of public transportation, designating High-Occupancy Vehicle lanes on major roads during rush hour, improving bus routes to reach more citizens, and designating bike routes to encourage use of bikes instead of cars. This could reduce harmful emissions from cars, as well as heavy congestion on major roads.

The focus of this exercise is to learn about energy conservation practices in the home and to have students investigate how energy efficient their families are. To do this, the students will compile an audit. This audit will be conducted by filling out the student worksheet on conservation practices in the home. It is important to emphasize that the point of the audit is to discover ways in which we can all take action to improve air quality, rather than to criticize anyone's home energy usage or transportation choices.

Suggested Reading

- Gutfeld, Greg, Linda Rao, and Maureen Sangiorgio. "Pollution-Fighting Plants." *Prevention*, 44 (September 1992) p. 10.
- Javna, John, et al. *50 Simple Things Kids Can Do To Save the Earth*. Andrews and McMeel (1990).
- "What You Can Do To Reduce Air Pollution." U.S. E*nvironmental Protection Agency*. Washington, DC. EPA/450/Kindergarten - 92/002 (1992).
- Willis, Terri, and Wallace B. Black. C*ars: An Environmental Challenge*. Children's Press (1992).

Procedure

1) Vocabulary
   a) compact fluorescent
   b) energy-efficiency incandescent
   c) anthropogenic
   d) biogenic
   e) fluorescent

2) Activities
   a) Class #1
      i) Discuss with students the causes of air pollution and how air pollution can be reduced through the use of energy efficient appliances and light bulbs and fuel-efficient cars.
      ii) Introduce the exercise by telling the students that they will be conducting an audit. Explain to them that the audit will be a formal examination of each student's home and family practices related to energy use. Data will be collected and observations will be recorded on the student worksheets.
      iii) Hand out "Student Worksheet 1" with specific instructions to answer all of the questions. Explain to the class that data collected from the audit will be used as part of a future in-class discussion to assess the energy efficiency of their homes and to discuss the importance of energy conservation.
      iv) Give the students one week to complete the audit of their home. Be sure to tell them that they should feel free to make additional observations and to collect data related to energy use that is not necessarily on the student worksheets.
   b) Class #2
      i) Meet with the class to discuss the data collected from their audits.
      ii) Discuss the importance of energy conservation and how it relates to the reduction of air pollution. Explain to students that there are many measures their families can take to conserve energy, such as purchasing new appliances that have energy efficiency ratings or setting the thermostat to 68°F (20°C) in the winter and 77°F (25°C) in the summer.
      iii) Explain how energy conservation measures not only reduce air pollution, but save money as well.
      iv) Discuss the importance of fuel conservation and how it relates to air pollution.
      v) Discuss how car emissions contribute to air pollution, but that this can be combated by more people using public transportation, carpools, and biking or walking.

3) Review
   a) Have the class tally answers and ascertain the high values, low values, and median values for the class.
   b) Go over each value, encouraging students to discuss why some homes are low and others are high in that value and to postulate what additional energy conservation habits they can practice.

4) Evaluation
   a) Completion of the home energy audit can be a graded exercise.
   b) Class participation can be a graded exercise.
   c) Extension activities can be performed as graded exercises.

5) Extension
   a) For grades 7-9, have students conduct an audit of the school in addition to auditing their homes. Using "Student Worksheet 2," they can answer questions related to energy conservation by the school and its students and personnel.
   b) For grades 10-12, expand the activity to include an audit of the community. Have students use "Student Worksheet 3." This additional activity will require time to do research outside of class and includes an evaluation of energy use by industry and businesses in the community and the efforts that the community takes to encourage energy efficient practices by its citizens.

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Adapted from: "Activity 3 - How Green Are We?" *Environmental Protection Agency (EPA) - Project A.I.R.E.* 2003. Page 19.

STUDENT WORKSHEET 1

HOW GREEN ARE WE?
Home Audit

1) How many light bulbs do you have in your home?

   _____

2) How many are fluorescent or compact fluorescent bulbs?

   _____

3) What is the total wattage of all bulbs in your home?

   _____

4) What temperature does your family set your thermostat set at in the winter?

   _____

   Summer?

   _____

5) Is your home properly insulated to help keep the house warm in the winter and cool in the summer?

   _____

6) What locations in the house should be insulated the most?

   _____
   _____
   _____
   _____
   _____

7) Does your family wait until there is a full load of laundry to wash clothes?

   _____

8) Do you dry washed clothes outside or use a clothes dryer?

   _____

9) How many miles per gallon does your family's car get?

   _____

10) How many gallons of gas does your car use in a week?

    _____

11) What kind of gas does your family use in their car?

    _____

12) How often do you walk, ride your bike, or use public transportation instead of riding in a car per month?

    _____

STUDENT WORKSHEET 2
HOW GREEN ARE WE?
School Audit

1) How long do the lights stay on in the school after the students have left for the day?

_____

2) Who is responsible for turning off the lights?

_____

3) Do you ever see the lights turned on in the evening hours?

_____

4) What kinds of light bulbs are used in the lighting fixtures at the school?

_____

5) Are the windows in the school properly insulated? (Hold a tissue next to the windows.)

_____

6) What are ways to fix the windows?

_____

7) Who is responsible for getting this done?

_____

8) How do you and your friends get to school each day?

_____

9) Does the bus reach enough students so that no one has to rely on other transportation?

_____

10) If a parent drives you, do other students ride with you?

11) What other modes of energy-efficient transportation could students use to get to school?

_____

12) Can you make arrangements to pick up a friend or several friends to ride to and from school with you and your parents?

_____

13) How do most teachers and other school personnel (such as the principal, teachers, or your guidance counselor) get to school each day?

_____

14) How else may teachers travel to and from school each day?

_____

15) Do you see parents picking up children from school?

_____

16) If so, do they leave their car running while they wait?

_____

17) What measures could the school take to discourage drivers from doing this?

_____

STUDENT WORKSHEET 3
HOW GREEN ARE WE?
Community Audit

1) What industries in your community are major polluters?

_____

2) What federal regulations that relate to air pollution affect their business?

_____

Do they abide by these regulations?

_____

If not, why?

_____

3) What local regulations affect their business?

_____

4) What other businesses in your community indirectly contribute to air pollution?

_____

5) What measures do these companies take to cut down on air pollution?

_____

6) Are there enough buses and subways to help people get around town easily without having to get into their car

_____

Could the routes be changed to accommodate more people?

_____

7) Do major streets have bicycle lanes to make it easier for people to ride bikes as an alternative to driving their car?

_____

8) Does the community sponsor a car pool program?

_____

How many people are participating?

_____

9) Do the major roads in your community encourage carpooling by designating High-Occupancy Vehicle (HOV) lanes during rush hour?

_____

10) Are traffic signals timed to reduce the amount of time that cars sit at lights?

_____

11) Are gas stations required to install special devices on pumps to capture gas fumes that can be released into the atmosphere, causing air pollution?

_____

12) Does your community require emissions inspections for all registered vehicles?
How often are these inspections required?

_____

What is RideSharing?

Target Grade Levels
Third - Twelfth

Time
One hour

Materials
- glossary (Appendix A)
- rideshare Information (visit: www.aacog.com/commutesolutions for more information)
- ozone Information (visit: www.aacog.com/air for more information)
- magazines/Newspapers
- construction Paper

Knowledge and Skills (TEKS)
- Science:
  - The student shall be provided opportunities to identify and demonstrate an individual's responsible behavior for protecting and preserving the environment;
  - The student shall be provided opportunities to identify and classify natural and human resources in the community and explain the interdependence of people and products in the world;
  - The student shall describe the relationship between people and their environment; and
  - Identify an environmental issue in the community and analyze it to propose possible solutions.

Overview
To help students understand what the term ridesharing means and why it is important to air quality. Educational tools include: spelling, creative writing, and word association.

Background
If you can't avoid traffic, help reduce traffic. Carpooling or any other type of alternative transportation will help drivers lower personal stress, improve air quality, and save money on gas and parking.

Procedure
1) Vocabulary

a) transit
b) congestion
c) environment
d) fossil fuel
e) contaminant
f) fumes
g) pollution
h) particulate
i) ambient air
j) gasoline
k) vanpool
l) bicycling
m) carpool
n) pollutants
o) RideSharing
p) electricity
q) atmosphere
r) stratosphere
s) tires
t) troposphere
u) walking
v) ozone
w) emission
x) alternative fuel
y) SchoolPool
z) walking school bus
aa) bike buddies

2) Activities

a) Before beginning, it will be helpful for you to read the RideShare and ozone information listed under materials to familiarize yourself with ridesharing issues. To assist the students in understanding the unit, begin with a spelling/vocabulary list.

b) Have your class cut out magazine/newspaper pictures and articles pertaining to ridesharing and air quality to create a collage or design a classroom display or bulletin board. These pictures can be organized according to categories of ridesharing or students may choose to paste them to a landscape. Discuss with the students how they can participate in programs relating to the activities in the cutouts to protect air quality in their area.

c) Have a discussion about what ridesharing means.

i) Examples of why ridesharing is important for our community.

- It decreases air pollution and traffic congestion, etc.

ii) Examples of why it is important to reduce air pollution.

- Improve quality of life and health, etc.

iii) Examples of how air pollution affect each of us?

- Damage to lungs, irritates eyes, etc.

iv) What are some things we can we do about air pollution and traffic congestion?

- Ride a bicycle,
- walk,
- bus or
- carpool to and from school, carpooling with classmates to after school activities, encourage parents to drive one or two of your friends to school with you, etc.

v) How are you already helping to reduce air pollution by ridesharing in your area?

- Riding the school bus to and from school,
- riding your bicycle or
- walking to school,
- encouraging your fellow students and parents to rideshare, etc.

d) Have the students to write a short story relating to their rideshare collage and using the vocabulary words they have learned in this lesson. Begin by starting the story for the students. Write an introductory sentence on the chalkboard. For example: Ridesharing is good for the environment because... or, Anyone can participate in ridesharing. Here is how I plan on participating.

For younger classes, ask the students to explain their collages and explain how they plan to participate in ridesharing activities now and in the future. A story about transportation can be read. (See list of suggested reading material following Glossary.)

e) Make a large sign for the classroom showing what rideshare elements your class uses traveling to and from school.

Example:
RIDESHARING = CARPOOLING + SCHOOL BUS + BICYCLING + WALKING

Divide the class into four groups. Each group can work on one section of the sign and add their own ideas and art about their topic. The sign should be displayed in the classroom to remind students of the definition of ridesharing and how it can benefit air quality in your area.

f) Have students create a bar graph and a pie chart showing the forms of transportation they use traveling to and from school.

g) Extension
Have students track their transportation modes for all the trips they take in one school week. Then have them create bar graphs and pie charts showing that week's results. Have a class discussion on the forms of transportation used most and for which trips students might have been able to use an alternate mode. (Make sure that safety concerns and parent's permission are emphasized if encouraging students to walk or bicycle as alternate modes.)

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Adapted from: "What is RideSharing?" *Texas Commission on Environmental Quality.*

Resource: *Ease on Down The Road*, Sacramento Area Council Of Government Rideshare Program. California.

Acknowledgment: Kim Herndon, Texas Commission on Environmental Quality (TCEQ) Mobile Source Division, Commute Options Team, 1997

Particle Pollution:
How Dirty is the Air We Breathe?

Target Grade Levels
Fourth

Time
One hour

Materials
- index cards
- petroleum jelly
- masking tape
- block of wood
- white paper for each child or each group of children

Knowledge and Skills (TEKS)
- Science:
  - Acquire data through the senses; and
  - The student shall be given opportunities to observe properties and patterns of objects, organisms, and events in the environment.

Overview
To make a simple device that can be used to collect and observe the pollution in our air.

Background Information
The atmosphere is almost completely made up of invisible gaseous substances. Most major air pollutants are also invisible, although large amounts of them, concentrated in areas such as cities, can be see as smog. One often visible air pollutant is particle pollution, especially when the surfaces of buildings and other structures have been exposed to it for long periods of time or when it is present in large amounts. Particulate matter is made up of tiny particles of solid matter and/or droplets of liquid. Natural sources include volcanic ash, pollen, and dust blown about by the wind. Coal and oil burned by power plants and industries and diesel fuel burned by many vehicles are the chief sources of manmade particulate pollutants, but not all important sources are large scale. The use of wood in fireplaces and stoves also produces rather significant amounts of particle pollution in localized areas, although the total amounts are much smaller than those from vehicles, power plants, and industries.

Procedure
1) Vocabulary

   a) air
   b) pollution
   c) particle
   d) particulate matter
   e) anthropogenic

2) Activities

   a) Tell the students, "As we look outside, we see a clear blue sky. Where is the pollution? We are going to make a simple test for air pollution so we can see the pollution."

b) Coat the plastic square with a thin, even coat of petroleum jelly. With masking tape, fasten the square, jelly side up, to the wooden block.

c) Let the students examine the pollution which was collected on the petroleum jelly

d) Let the groups record the findings of their tester.

e) Have groups share their findings with the other groups.

   i) Did your collect any dirt particles?

   ii) How does your square compare to those of the other groups?

   iii) In what places does the air seem to be the dirtiest?

f) We have seen dirt collected by devices where our eyes could detect nothing. We must have air to live. We must do everything we can to clean the air we have and keep our future air clean.

3) Review

   a) Discuss results, encourage students to brainstorm the likely types of particles collected and the sources of those particles.

   b) Brainstorm the likely amounts and types of particles that would be collected if these devices were placed in different parts of the school and school grounds.

4) Evaluation

   a) Students can be quizzed on vocabulary.

   b) Extension activities can be performed as graded exercises.

5) Extension

   a) Have students write a paper and explain the differences they observed among the plastic squares.

   b) Have students take their tester home to test the pollution for 24 hours. Students will then report to the class of their findings.

   c) Ask students to leave the tester outside for a week, a month (shelter from precipitation). Students will keep a journal of its progress each day and report to the class.

   d) Have students compile data on their findings and write the mayor about their samples.

Adapted from: "Particulate Matter: How Dirty is the Air We Breathe?" *Texas Commission on Environmental Quality.*

Reference: Holt Science 6th. Holt, Rinehart, and Winston Publishers, New York. p. 257.

Acknowledgement: Alica L. Smith and Stacy Butler, Stephen F. Austin University Nacogdoches TES Course, 1994

Designing a Clean-Air Environment

Target Grade Levels
Fourth - Ninth

Time
30 minutes in first class
40 minutes in second class with guest presenter

Materials
- chalk
- chalkboard
- pencils a plastic

Knowledge and Skills (TEKS)
- Science:
  - Independent and group exercises;
  - Acquire data through the senses; and
  - The student shall be given opportunities to observe properties and patterns of objects, organisms, and events in the environment.

Overview
This activity gives students an opportunity to explore how air pollution in a city can be minimized due to the arrangement of living areas, working areas, and urban landscaping.

Background Information
By giving some thought to the location of different required elements of a city, we can reduce the use of polluting fuels and use environmental processes to aid us in our goals. If the places we go to often are near one another, we drive less and pollute the air less.

The number one pollution problem in the San Antonio area is ground-level ozone. Ground-level ozone is an odorless, colorless gas that can damage the respiratory system, causing symptoms including coughing and wheezing or difficulty breathing. Over the long-term, excess ground-level ozone exposure can cause lung damage. Children, the elderly, and individuals with lung diseases such as asthma and emphysema are especially susceptible. Ground-level ozone is created by a reaction between nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in sunlight. Major sources of these precursor pollutants include vehicles, fueling stations, construction equipment, landscaping equipment, and power generation.

The NO_x and carbon dioxide (CO_2) in automobile exhaust contribute to the greenhouse effect. The global temperature rise that is a predicted result of the greenhouse effect could cause major shifts in global weather patterns and a rise in sea levels.

Reductions in overall traffic volume and congestion are important solutions to air pollution problems; however, population growth and economic growth tend to increase both traffic volume and congestion. Therefore, to accommodate growth and protect air quality, planners must plan for and consider various transportation modes and planning elements to help make citizens “Drive Clean Across Texas.”

By planting trees near highways, CO_2 in automobile exhaust will be absorbed by the leaves and turned into oxygen through photosynthesis. By planting trees and shrubs to shade the roofs, windows, and air conditioning units of our homes in the summer, we don't need to run the air conditioner as much. This, in turn, reduces air pollution because it reduces the need to burn fossil fuel to generate electricity generation at power plants. Power plants that run on fossil fuels typically emit many pollutants, including sulfur dioxide, carbon monoxide, nitrogen oxides, and particles. Burning fossil fuels or wood also produces large amounts of carbon dioxide, which contributes to the greenhouse effect. While designing a city with these considerations in mind, students will see that their choices have important consequences and that not all problems have satisfactory solutions. This is related to real tradeoffs, such as short-term gain versus long-term benefit and convenience versus conservation.

Suggested Reading

- Bruning, Nancy. *Cities Against Nature*. Chicago, IL: Children's Press (1992).
- Shaffer, Carolyn. *City Safaris: A Sierra Club Explorer's Guide to Urban Adventures for Grownups and Kids*. San Francisco, CA: Sierra Club Books (1987).

Procedure

1) Vocabulary
   a) carbon cycle
   b) electricity
   c) energy
   d) greenhouse effect
   e) planning
   f) smog

2) Activities
   a) Explain that the students are going to do two related activities. They will work alone on the first project. Hand out a copy of the attached worksheet to each student and ask them to cut out and arrange the elements from the worksheet on another piece of paper to layout a "city" that looks like the one they live in. For this exercise, define the boundaries of the city: the neighborhood near the school, each student's home neighborhood, or the whole city. You may want to get them started by identifying the relative location of a few important landmarks or highways. You can decide which of the elements on the worksheet the students are to use.
   b) While the students are working, lead a discussion about how much time families must spend driving around in their cars because of the distances between places. Does the layout of the city contribute to air pollution by separating, for example, working and living areas? Students can analyze their city layouts as the discussion progresses. Have them save their layouts for the second part of the exercise on another day.
   c) For the second exercise, you or the guest presenter will need to review with students the concepts of air pollution and smog, and how the production and use of energy (heating, electricity, cooling) causes air pollution.
   d) This second exercise will be done in small groups. Form the groups and hand out a clean worksheet to each group. Explain that the students are going to pretend to be urban planners. Urban planners are professionals who determine the arrangement of

roads, buildings, and parks in a city. Students are to design a city from the ground up. When deciding on the placement of the necessary elements and choosing energy sources, their primary goal will be to minimize air pollution.

e) After the students have designed their "perfect" cities, lead a discussion with the goal of coming to consensus on the best location for each element. Layout the elements on the students' worksheets. Reposition the elements as students debate the best arrangement of elements.

3) Review
Compare the drawings of the actual cities from the first class to the "perfect" cities designed in the second. Have the class discuss the following questions:

a) How are the two cities different?

b) What are some reasons you would want the workplaces—factory, office building—near homes? Far from homes? (They are more convenient if they are nearby. The farther away, the more pollution caused by cars.)

c) Does the city have a public transportation system? Why or why not? Do people use them? Why or why not?

d) What are the advantages of urban areas and their high population density? Disadvantages? (Fewer trees per person need to be cut down in order to build apartments as compared to suburban single-family homes. Smog is more apparent in downtown areas.)

e) What are advantages of suburban areas and their lower population density? Disadvantages? (Residents have to use cars more often for everyday activities, but residents get to have yards, trees, landscaping, and gardens.)

f) Is there a limit to the size a city can be for it to be efficient?

g) How can the placement of trees help lower the use of utilities? (Examples: shading buildings to lower the use of air conditioning, as windbreaks to lower use of heating.)

4) Evaluation

a) Group participation can be evaluated.

b) Participation in discussion can be evaluated.

c) Extension activities can be performed as graded exercises.

5) Extension
Students may enjoy trying this activity using commercially available computer programs like Sim City™. While the program allows the user to design a city, numerous built-in modules reflect the effects of the user's decisions. For example, if the user builds a freeway, air pollution levels rise and are displayed in a pop-up graph. If the user builds ten new office buildings, smoke starts belching from the stacks at the power plant.

a) Suggested Modifications

b) For higher grades, expand the project to be a multi-session activity, exploring in more depth each of the pollutant sources and reduction measures discussed in the activity. A different guest presenter could be invited to discuss each topic.

c) For grades 8 and 9, have students collect data to support the decisions they made during the discussions in the second exercise. For example, they may locate actual figures on energy savings from not running the air conditioner, data on air pollution from cars, and case studies that show how the use of public transportation reduces pollution or ways factories can cut emissions. Have them make presentations on their findings.

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Adapted from: "Activity 8 - Designing a clean-air environment" *Environmental Protection Agency (EPA) - Project A.I.R.E.* 2003. Page 109.
http://www.epa.gov/region01/students/pdfs/activ8.pdf

STUDENT WORKSHEET 1

DESIGNING A CLEAN AIR ENVIRONMENT

single-family homes

office buildings

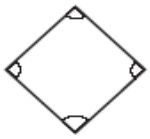
walking & jogging trails

industries

apartments & townhouses

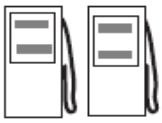
trees, parks, forests

bike trails



playgrounds & ballfields

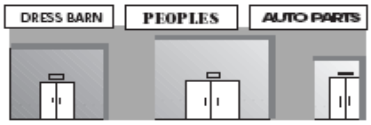
schools



gas stations

restaurants

highways



stores & shopping malls

bus & subway routes

Acid Rain: An Air Pollutant

Target Grade Levels
Fourth - Sixth

Time
30 minutes in first class
40 minutes in second class with guest presenter

Materials
- chalk
- vinegar
- glasses for each group

Knowledge and Skills (TEKS)
- Science:
  - Acquire data through the senses;
  - The student shall be given opportunities to observe properties and patterns of objects, organisms and events in the environment; and
  - The student shall be given opportunities to describe objects, organisms and events from the environment, describe changes that occur to objects and organisms in the environment.
- Language Arts:
  - Communicate data and information in appropriate oral and written form.

Overview
To demonstrate the effect of acid rain on statues and buildings.

Background Information
Acid rain is more acidic than normal rain and forms through a complex process of chemical reactions involving air pollution. The two most important pollutants that contribute to the formation of acid rain are nitrogen oxide and sulfur dioxide, which react with moisture in the atmosphere to form nitric and sulfuric acid. The sulfur and nitrogen compounds that contribute to acid rain primarily come from manmade sources, such as industries, utilities, automobiles, and other forms of transportation and industrial processes, such as smelting.

Acid rain can harm forests and crops, damage bodies of water, and contribute to the damage of statues and buildings. Researchers are considering the possible effects of acid rain on human heath. These acidic pollutants can be deposited through rain, snow, fog, dew, or sleet. Large quantities can also be deposited in a dry form through dust. Pollutants that contribute to acid rain may be carried hundreds of miles before being deposited on the earth; because of this, it is sometimes difficult to determine the specific sources of these acid rain pollutants.

Procedure
1) Vocabulary

a) acid	d) acetic acid
b) base	e) nitrogen oxides
c) limestone	f) sulfur dioxide

2) Activities
   a) Acids react chemically with bases. Many culturally significant statues and buildings are made from limestone, which is a base.

b) Explain that vinegar is an acid and chalk is processed limestone.

c) Fill a glass 1/3 full with vinegar for each group.

d) Add a piece of chalk to the glass.

e) Have the students write about what they see happening in the experiment.

f) Discuss their observations and inferences.

g) Add corrected notes to notebook.

h) Discuss the slow deterioration of statues and buildings due to the weak acid rain that falls on some statues and buildings. If the stone is limestone or has limestone in it, the deterioration is more rapid.

3) Review

a) Discuss what buildings or important edifices (such as the Alamo) in the region are made of limestone and how they might be affected by acid rain.

b) Discuss and encourage students to brainstorm acid rain's other effects, concentrating on the importance of pH in aquatic and soil ecosystems.

4) Evaluation
Extension activities can be performed as graded exercises.

5) Extension

a) See the Acid Rain "Information, Activities and Data" page for suggested activities using acid rain data collected by the Texas Commission on Environmental Quality.

b) Gather pictures of examples of acid rain (chemical weathering).

c) Research effects of acid rain on great art works.

d) Research causes of acid rain.

e) Suggest solutions to the problem of acid rain.

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Adapted from: "Acid Rain: An Air Pollutant" *Texas Commission on Environmental Quality.*
http://www.tceq.state.tx.us/assets/public/assistance/education/air/acid_rain_pollutant.pdf
Acknowledgment: Lois Richardson, Stephen F. Austin University Nacogdoches TES Course, 1994

Air Terms: The Flash Card Game

Target Grade Levels
Fourth - Sixth

Time
30 minutes in first class
40 minutes in second class with guest presenter

Materials
- 3”x5” index cards, white
- magazines
- typing paper
- art supplies

Knowledge and Skills (TEKS)
- Language Arts:
  - Use a thesaurus, synonym finder, dictionary, and software to clarify meanings and usage;
- Science:
  - Classify, order, and sequence data; and
  - The student shall be given opportunities to classify matter, forces energy, organisms, actions, and events from the environment according to similarities and differences.

Overview
To learn important vocabulary terms regarding air quality.

Background Information
Air pollution is a problem in many of areas of the United States. It can damage trees, lakes and animals, and make people sick. It can also damage buildings and other structures. Air pollution also can cause haze, reducing visibility in national parks and sometimes interfere with aviation. The federal government regulates air pollution in order to protect human health and the environment. There are several words that are used when discussing the subject of air pollution.

Procedure
1) Vocabulary

a) air pollution
b) ambient air
c) atmosphere
d) benzene
e) carbon dioxide
f) carbon monoxide
g) catalytic converter
h) chlorofluorocarbons (CFCs)
i) combustion
j) contaminant
k) dispersion
l) emission
m) environment
n) respiratory
o) fossil fuels
p) hydrocarbons
q) hazardous air pollutant
r) meteorology
s) nitrogen oxides
t) ozone
u) particle pollution
v) photochemical process
w) plume
x) pollution
y) smog
z) smoke
aa) stomata

bb) stratosphere

cc) toxic

dd) volatile organic compounds

2) Activities

a) Make flash cards from Vocabulary by using 3:x5” index cards—write the term on one side, and the definition on the other side.

b) Divide students into groups of five. The students will number off from one to five. This group will be the base team.

c) Next, ask all of the ones to sit together, the twos to sit together, the threes to sit together, and the fours to sit together, etc.

d) Give each group six air quality terms on flash cards that will be placed in the middle of the table. (The list of terms and definitions are provided. A formatted set of terms and definitions ready for double-sided photocopying is available at the end of this lesson.)

e) The students will decide who will be first to take the top card. The first student will read the term and then the definition of that word from the card. The group will look in magazines for pictures that represent the air quality term. Each member of the group must find a picture or draw a picture to share with the base team.

f) After all the groups have completed illustrating the terms, the students will return to their base team.

g) Each member of the group will share the illustrations.

h) Each group will then practice reading the terms and definitions.

i) Show the aerosol can again. Ask the students how many air quality terms do they think relate to the can.

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Adapted from: “Air Terms: The Flash Card Game” *Texas Commission on Environmental Quality.*
http://www.tceq.state.tx.us/assets/public/assistance/education/air/air_flashcard_game.pdf

Reference: Spencer Kagan: Cooperative Learning, 1992.
Acknowledgement: Lea Land, Stephen F. Austin Universtiy Nacogdoches TES Course, 1994

Air Pollution Control

Target Grade Levels
Sixth - Eighth

Time
One hour

Materials
None

Knowledge and Skills (TEKS)

- Science:
  - Properly demonstrate the use of laboratory equipment;
  - Observe physical and chemical properties of matter; and
  - Measure physical and chemical properties of matter.
- Language Arts:
  - Writes complete sentences accurately, using various types of sentences and both dependent and independent clauses;
  - Evaluates own research for accuracy and completeness and then frames questions for further study; and
  - Follows accepted format (MLA) for writing research, including bibliography and endnote preparations.

Overview
To show how air pollution is controlled.

Background Information
Air contaminants are emitted into the atmosphere as particles, aerosols, vapors, or gases. The most common methods of eliminating or reducing pollutants to an acceptable level are destroying the pollutant by thermal or catalytic combustion, changing the pollutant to a less toxic form, or collecting the pollution by use of equipment to prevent its escape into the atmosphere. Pollutant recovery may be accomplished by the use of one or more of the following: baghouses, cyclones, electrostatic, precipitators and wet scrubbers.

Procedure

1) Vocabulary

a) baghouses
b) cyclones
c) electrostatic precipitators
d) wet scrubbers
e) atmosphere
f) aerosol
g) particle
h) vapor
i) gas
j) combustion
k) catalyst
l) toxic
m) pollutant

2) Activities
Here are two activities to help demonstrate how a wet scubber and an electostatic precipitator work.

i) Activity 1 Follow the link below to demonstrate how to build a wet scrubber.

ii) Activity 2 Follow the link below to demonstrate how to build an electrostatic precipitator.

3) Review
   Discuss with students the following questions:
   a) Which type of air cleaner would be the best for removing particles?
   b) Which type of air cleaner would be the best for removing waste gases?
   c) Does a wet scrubber clean up all of the pollutants?
   d) What problems are produced by having too many pollutants in the air we breathe?
   e) If industry is just part of the problem, what can we do to control the amount of air pollution that we cause?

4) Evaluation
   Extension activities can be performed as graded exercises.

5) Extension
   Students can choose and industry that creates air pollution in the local region, then research the methods and equipment they use and/or are required to use to control air pollution, then write a report including the information on the following
   i) The type of pollution control device
   ii) How it works
   iii) The principle behind how it works
   iv) Current purchase and operations costs
   v) What other processes, purchasing, and planning the company does to reduce the amount of pollution that leaves their facility.

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Adapted from: “Air Pollution Control” *Texas Commission on Environmental Quality.* http://www.tceq.state.tx.us/assets/public/assistance/education/air/air_pollution_control.pdf

Reference: Activities from Holt, Winston's Environmental Science.

Acknowledgment: Lyn Mock, Stephen F. Austin University Nacogdoches TES Course, 1994

Converting Fuels to Obtain Energy

Target Grade Levels
Sixth - Eighth

Time
One period for introductory discussion and Worksheet A.

Two to three periods for researching the fuel terms and energy conversion devices found on Worksheets B and C.

Two periods for completing Worksheets B and C and discussing questions.

Materials
- copies of worksheets A, B, and C
- reference books
- library time

Knowledge and Skills (TEKS)
- Language Arts:
  - Uses writing as a tool for research, for example, learning logs, posters, timelines, outlines, and summaries;
  - Uses a variety of word recognition strategies such as context, roots, prefixes;
  - Offers observations, makes connections, reacts, speculates, interprets, and raises questions in response to a variety of texts; and
  - Ability to find information in dictionaries, encyclopedias, and other references (library skills).
- Science:
  - Understand that various devices are used to transform the energy in fuels into work, no energy conversion device is 100% efficient, and that different devices have different efficiencies; and
  - The energy that is wasted in a conversion is usually in the form of heat.

Overview
At the completion of this activity, will be able to identify several fuels and describe several uses for the energy obtained from fuels. Students will also learn to identify devices that convert energy in fuel to some other form of energy, and recognize that some energy is wasted in every fuel conversion process.

Background Information
When we use energy we often convert it or change it from one form to another. The energy in fossil fuels or other sources of energy is not always in the form we need. The purpose of energy conversion is to change energy resources into more usable forms.

Fuel is matter-containing energy stored in chemical form. Food, wood, and coal are all examples of fuels. Energy is packed into the chemical structure of the fuel, and we release it when we convert or change that chemical structure.

For example, food contains Calories, units of energy content. We eat food, which our bodies then convert into energy as motion and heat. It is actually the energy from our food that allows us to move, and that which keeps our bodies at their normal temperature.

A similar process takes place when we burn other fuels. The chemical energy stored in them is released when they are changed or broken down by some conversion device. For example, we use a conversion device (gasoline engine, diesel engine) to change chemical energy into thermal and mechanical energy, to make a motor vehicle move.

Each American has over fifty "workers" performing energy conversion tasks every day, yet most Americans do not realize the energy required to feed these technological helpers. The more complex the society the greater its energy use per individual by these motors, engines, pumps, heaters, etc.

Electricity, a common form of energy, is produced by turbines and generators, which are conversion devices. These devices are powered by various sources of energy, such as fossil fuels, hydropower, wind, nuclear, etc. The electricity produced is converted or changed into other end use forms of energy such as heat, light, mechanical energy, and others.

The efficiency of conversion devices is important in obtaining the best change in energy form with the least amount of undesirable "loss" in the form of heat or waste fuel. It is important to use the most efficient and effective conversion technology to do the job and thus conserve our nonrenewable energy supplies.

Human beings depend on fuels. We use many kinds of energy conversion devices to get the energy from fuels and transform it into useful work.

There are two problems with using fuels. First, the supplies of some fuels are limited. If we use them up, they are gone for good. Oil, coal, and natural gas are like that, and are called nonrenewable for that reason.

The second problem with using fuels is that when we convert them to obtain usable forms of energy we always waste some of the fuel. No conversion device is 100% efficient, not even the human body. Some of the energy in fuels is not converted and remains in chemical form, and some energy is given off as waste heat. This is a problem of efficiency.

As an energy consumer, you should know when you are using nonrenewable fuels. You should also be aware of the efficiency of the conversion devices you use.

Procedure

1) Vocabulary

a) chemical energy
b) combustion
c) conversion
d) conversion efficiency
e) conversion loss
f) fuel
g) fuel cell
h) mechanical energy
i) nuclear energy
j) nuclear fuel
k) electrical energy
l) electric generating plant
m) energy
n) energy conversion device
o) fossil fuels
p) photosynthesis
q) solar cell
r) solar energy
s) thermal energy
t) gasoline
u) diesel
v) oil
w) coal
x) natural gas

2) Activities

   a) Your teacher will introduce you to the ideas and terms on Worksheet A.

   b) Look at Worksheet B. Use a dictionary, encyclopedia, and other energy reference materials to find the information necessary to complete the worksheet.

   c) Look at Worksheet C. Using the information found in the reference materials, fill in the blank spaces on the chart.

   d) With a partner or in a small group, list other energy conversion devices you can think of at the bottom of Worksheet C. See if you can find the required information about each of these devices to fill in the spaces on the worksheet.

   e) Compare worksheets with your partners, and share information. Then see if you can answer the questions below.

3) Review
   Have class review their answers to the worksheet out loud. Discuss any significant differences in answers or information found.

4) Evaluation
   Questions

   i) Is a "conversion device" the same as a machine? Why or why not?

   ii) Are you an energy conversion device? Where do you get your energy? What do you convert it to?

   iii) Does a conversion device transform all the energy in a fuel to another form of energy, or does it waste some? If some energy is lost, in what form(s) is it lost?

   iv) Which energy conversion device (from Worksheet C) is most efficient? Which energy conversion device is least efficient?

   v) Which energy conversion devices do you yourself use? Which devices do other people operate to do things for you?

   vi) Are there other fuels that could be added to Worksheet B? Are there substances that are not used as fuels now that may be used as fuels in the future?

   vii) What conversion devices can you imagine for the future that might be able to use fuel more efficiently?

5) Extension

   a) Have students figure out how to improve the efficiencies of some of the conversion devices listed on Worksheet C.

   b) Send students to the library to investigate environmental effects of each conversion device listed on Worksheet C.

c) Modifications

i) Add other conversion devices to the chart. Examples: solar collector, wind powered electric generator, solar power tower, hydropowered electric generator.

ii) Contrast renewable and nonrenewable forms of energy on a chart which lists the end uses (such as heat, light, mechanical energy, etc.) of those forms.

iii) Research one type of conversion in great detail, such as the conversion of electricity to heat.

iv) Build friction loss devices. Examples: model cars for testing on inclined planes, model boats or airplanes.

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Adapted from: "Converting Fuels to Obtain Energy" *Alliance to Save Energy (ASE).* www.ase.org/educators/download.htm .

References:

Electrical and Chemical Experiments...from Edison , by Robert F. Schultz (Thomas Alva Edison Foundation, Cambridge Office Plaza, Suite 143, 18280 West Ten Mile Rd., Southfield, MI 48075, 1980.)

Energy . National Geographic Special Report. (National Geographic Society, 17th and M Streets, Washington, D.C. 20036 February 1981.)

Energy Conservation Education for New York State. (New York State Energy Office, Office of Communications, Two RockefellerPlaza, Albany, NY 12223.)

Energy: Sources of Power , Anthony E. Schwaller. (Davis Publications, Inc., 50 Portland St., Worcester MA 01608, 1980, $18.95.)

Man, Energy, Society, Earl Cook. (W.H. Freeman & Co., 660 Market St., San Francisco, CA 94104, 1976, $13.95.)

Worksheet A

A Glossary of Energy Terms

General

energy - the ability to do work or make things move. Energy exists in a variety of forms (electrical, mechanical, gravitational, light, nuclear, chemical, heat or thermal) and can be converted from one to another. Common units for measuring energy are calories, joules, Btu, and kilowatt-hours.

Forms of Energy

chemical energy - the energy released when substances combine or break down and form new substances.

electrical energy - energy in the form of a flow of electrons that can be produced by chemical activity in a battery, by friction, or by generators. Electrical energy can be transformed to other forms of energy such as light, heat, mechanical, or sound.

mechanical energy - energy due to the motion of an object. Example: the energy of the moving parts of an automobile engine.

nuclear energy - energy from radioactive decay or from fission or fusion reactions. In a controlled situation it can be used to produce electricity.

thermal energy - heat energy; the energy of moving particles within a solid, liquid, or gas.

Sources of Energy

fossil fuels - coal, oil, and natural gas; this term applies to any fuels formed from the fossil remains of organic materials (plants and animals) that have been buried for millions of years.

solar energy - the radiation emitted by the sun. The earth receives this energy mostly in the forms of heat and light.

nuclear fuel - material containing atoms whose nuclei split or undergo fission, which produce heat energy.

Energy Conversion (Transformation)

conversion - the changing of a substance or the energy in it from one form to another

photosynthesis - the process by which green plants use solar energy to convert simple substances into complex ones which contain chemical energy. Carbon dioxide and water are combined, in the presence of sunlight and chlorophyll, into carbohydrates such as sugars, starches, and cellulose.

combustion - the process of burning a fuel to release heat energy

fuel - any substance that can be burned to produce heat. (With nuclear energy, a substance that undergoes fission in a chain reaction to produce heat.)

conversion loss - the amount of energy lost in the changing of one form of energy to another form. Much of this energy loss is in the form of waste heat.

energy conversion device - a machine that changes one form of energy to another form.

conversion efficiency - the percentage of usable energy that is left after an energy conversion.

EFFICIENCY = (Energy output / Energy input) x 100

Energy Conversion Devices

fuel cell - a device that changes the energy in fossil fuels to electricity.

solar cell - a device that changes sunlight to electricity

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Worksheet B

Using Fuel Energy

Directions: Find information about the following fuels, and complete this chart.

Energy is often stored in chemical form. Here are two common forms of chemical energy.

	Definition	Example	Use	How Converted for Use
carbohydrates				
hydrocarbons				

Matter that has energy stored in it in chemical form is called fuel. Some common fuels are:

	Definition	**Example**	**Use**	**How Converted for Use**
food				
wood				
oil				
natural gas				
coal				

Worksheet C
Converting Fuel Energy

Directions: Find information about the following energy conversion devices and then complete the chart.

Energy Conversion Device	Fuel Used	Average Conversion Efficiency	Conversion Loss	Forms of Energy Produced in the Conversion Processes
fuel cell	hydrocarbon, hydrogen, etc.	60%	40%	chemical -> electrical
gas furnace		80%		
oil furnace		80%		
Wood stove		60%		
fireplace		14%		
diesel engine		38%		
gasoline engine		25%		
Fossil fuel powered electric generating plant		40%		
nuclear fuel powered electric generating plant		30%		
solar cell		10%		

Looking at Data

Target Grade Levels
Sixth - Eighth

Time
Two Class Periods

Materials
- handout/overhead: Looking at Data: Monitoring Network
- handout/overhead: Looking at Data: Monitoring Data

Knowledge and Skills (TEKS)
- Language Arts:
  - Demonstrates effective communication skills during interviewing, reporting, providing information, role playing, or answering questions;
  - Writes complete sentences accurately, using various types of sentences and both dependent and independent clauses;
  - Conducts research using multiple sources such as electronic texts, experts, and non-print resources to locate information relevant to research;
  - Produces research projects and reports in effective formats for various audiences;
  - Uses writing as a tool for research, for example, learning logs, posters, timelines, outlines, and summaries; and
  - Evaluates own research for accuracy and completeness and then frames questions for further study.

Overview
Understanding the causes of pollution – from industrial to natural sources – can be challenging to students. Studying the atmosphere, urban life, and weather helps to put things in perspective, providing opportunities for education in science, math and environment.

Background Information
Air pollution comes from many different sources such as factories, power plants, dry cleaners, cars, buses, trucks and even windblown dust and wildfires. Air pollution can threaten the health of human beings, trees, lakes, crops, and animals, as well as damage the ozone layer and buildings. Air pollution also causes haze, which reduces visibility in national parks and wilderness areas.

Procedure
1) Vocabulary

a) atmosphere
b) ozone
c) anthropogenic
d) biogenic
e) CAMS
f) ground-level ozone
g) Air Quality Index

2) Activities

a) Have a class discussion about ozone and the effects on the health, and the environment.

b) Talk to the class about the air quality program and how choices that people make that can contribute to ground-level ozone.

c) Distribute the monitoring network worksheet. The picture on the left indicates where all the monitors are in San Antonio and Austin areas. The pictures on the right indicate the highest eight hour levels that were recorded on September 13, 2002. Have the students answer the questions. For current ozone levels go to http://www.tceq.state.tx.us/cgi-bin/compliance/monops/monitors.pl?region=13.

d) Distribute the Monitoring Data worksheet. Have students create graphs showing each monitor's reported ozone concentration for every hour of the day. This sheet shows the ozone levels at different times throughout the day. Have the students answer the questions. For current local ozone levels go to http://www.tceq.state.tx.us/cgi-bin/compliance/monops/monitors.pl?region=13.

3) Review

a) Discuss students' answers to questions and students' graphs.

b) Discuss differences in monitor readings and what might have affected those differences.

4) Evaluation

a) Students' in-class work can be performed as a graded exercise.

b) Extension activities can be performed as a graded exercise.

5) Extension

a) Have students do web research as a class and choose another day for which each student will, as homework, produce a report containing the following data:

i) A bar graph of hourly ozone levels at all of the region's ozone monitors.

ii) The highest recorded hourly ozone level at each monitor.

iii) The highest eight-hour average ozone level at each monitor.

iv) The maximum AQI category reached for the day

v) Maximum temperature for the day

vi) Wind speed and wind direction for the day

vii) Difference in maximum ozone concentration from the upwind to the downwind monitor.

viii) Student's conclusions as to why ground-level ozone did or did not build up that day, whether significant pollution was transported into the area from somewhere else (and if so, where else), and the health advisory associated with the maximum AQI category for that day.

Notes:

A table of all of these parameters can be generated for any day for which records exist at the following TCEQ website: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/monitors.pl?region=13.

These reports may lead students to ask questions about transported pollution and what can be done about it. Students should be encouraged to investigate the Clean Air Act's stance on transported pollution – that exceptional, international incidents can be excused from regulatory oversight and control measures, but that, in essence, no region is exempt from their responsibility to reduce their own pollution

because they receive significant transported pollution. The concept is that San Antonio (for example) can't become exempt from clean air laws by blaming their bad air on pollution transported from Houston, because then Houston might blame Baton Rouge and Baton Rouge might blame Atlanta – thus playing a national "blame game" while the air gets no cleaner. Each region must protect the health of its citizens by reducing its contribution to pollution.

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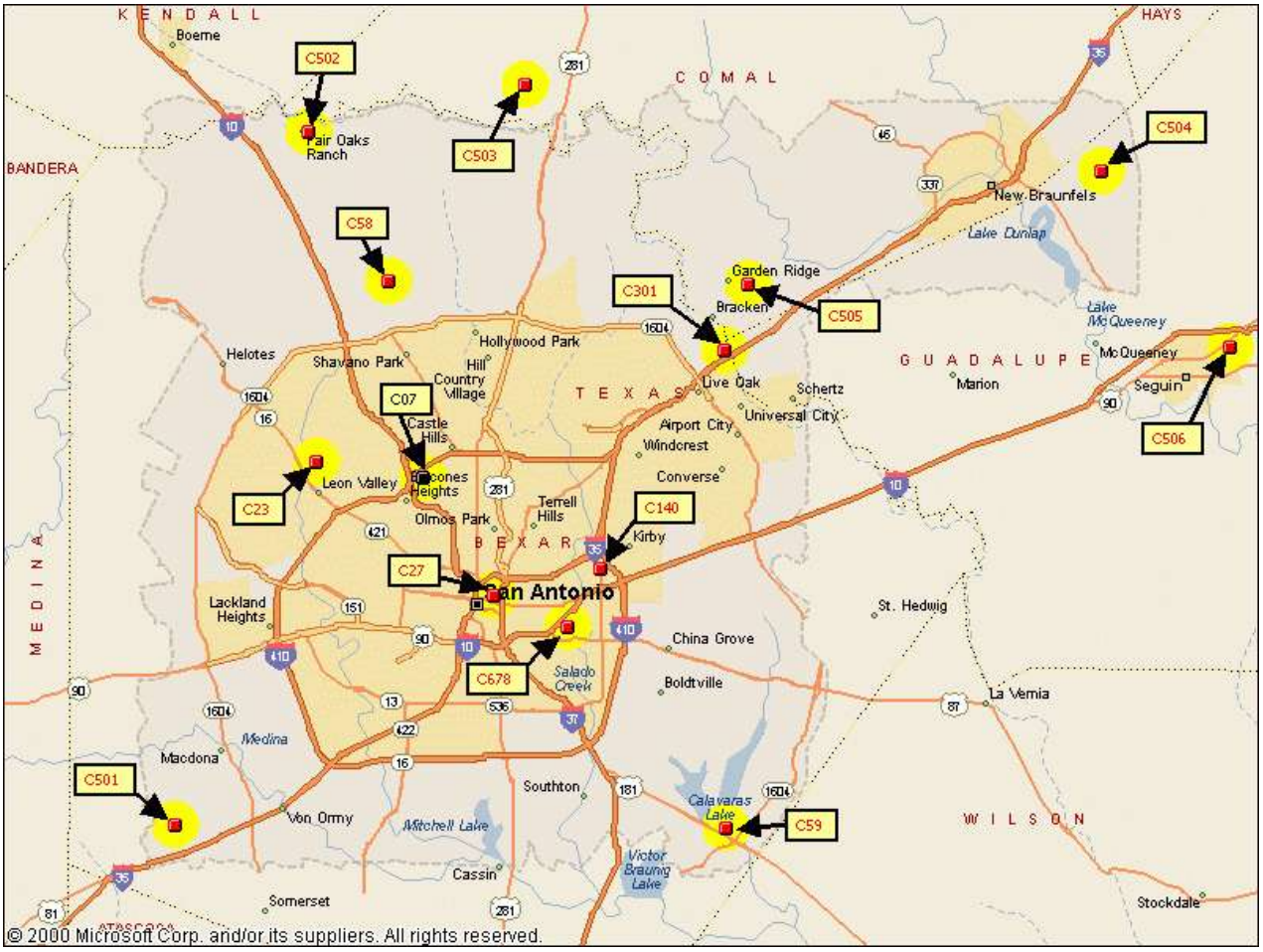
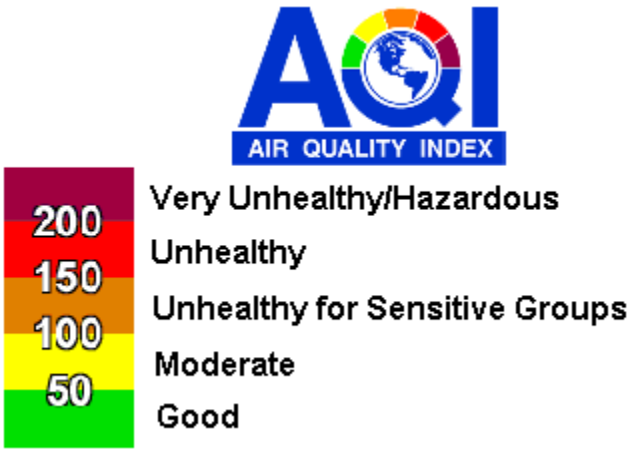
Worksheet

Looking at Data: Monitoring Network





Reporting for September 13, 2002			September 13 2002 Select a Different Date												
Monitoring Sites in the San Antonio Metro Area	Air Quality	Critical Pollutant	Air Quality Index Rating												
			Ozone				Carbon Monoxide		Sulfur Dioxide		PM-10		PM-2.5		
			1-Hour		8-Hour		8-Hour		24-Hour		24-Hour		24-Hour		
			AQI	ppb	AQI	ppb	AQI	ppm	AQI	ppb	AQI	ug/m3	AQI	ug/m3	
Bexar County	Unhealthy for sensitive groups	Ozone	*	104	**132**	**97**	22	1.9	1	1			105	42.8	
San Antonio Northwest C23	Unhealthy for sensitive groups	Ozone	*	99	**124**	**94**									
San Antonio Downtown C27	Good	Carbon Monoxide					**18**	**1.6**							
Camp Bullis C58	Unhealthy for sensitive groups	Ozone	*	104	**132**	**97**									
Calaveras Lake C59	Unhealthy for sensitive groups	Ozone	*	101	**114**	**90**							92	36.5	
Selma C301	Unhealthy for sensitive groups	PM-2.5											**104**	**42.0**	
Elm Creek Elementary C501	Moderate	Ozone	*	86	**92**	**81**									
Fair Oaks Ranch C502	Unhealthy for sensitive groups	Ozone	*	92	**101**	**85**									
CPS Pecan Valley C678	Unhealthy for sensitive groups	PM-2.5	*	91	100	84	22	1.9	1	1			**105**	**42.8**	
Comal County	Unhealthy for sensitive groups	Ozone	*	106	**124**	**94**									
Bulverde Elementary C503	Unhealthy for sensitive groups	Ozone	*	106	**124**	**94**									
Guadalupe County	Unhealthy for sensitive groups	Ozone	*	116	**150**	**104**									
New Braunfels Airport C504	Unhealthy for sensitive groups	Ozone	*	116	**150**	**104**									

* There is no AQI associated with hourly ozone averages less than 0.125 ppm (125 ppb).

1) What monitor recorded the highest ozone levels?
2) According to the Air Quality Index for ozone what category would the highest monitor fall into (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy)? Generally, an AQI of 100 for ozone corresponds to an ozone level of 0.08 parts per million.
3) What monitor recorded the lowest ozone levels?
4) According to the Air Quality Index, what category would the lowest monitor fall into (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy)?

Worksheet
Looking at Data: Monitoring Data

Area	CAMS	Morning												Afternoon												CAMS
		Mid	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	
San Antonio																										
	23	5	7	7	7	9	6	6	7	24	69	88	92	**99**	99	99	97	96	88	70	43	36	15	9	5	23
	58	8	9	8	7	7	4	4	10	30	65	84	94	99	103	**104**	103	100	90	63	35	25	11	9	5	58
	59	35	40	25	8	9	16	4	7	26	43	74	87	94	94	99	**101**	93	79	47	23	17	17	39	35	59
	501	4	5	4	5	4	3	2	12	31	63	73	81	83	**86**	86	84	82	74	47	19	10	9	6	7	501
	502	26	23	17	18	22	13	9	21	40	63	78	78	81	83	90	**92**	90	88	72	47	41	39	29	30	502
	503	12	14	10	6	4	3	2	6	22	65	74	83	89	101	**106**	102	101	94	81	60	34	22	20	12	503
	504	3	3	4	4	3	3	5	9	38	69	85	98	105	110	111	**116**	107	100	79	60	42	38	44	49	504
	678	0	0	0	0	0	0	0	0	8	55	71	88	86	86	86	**91**	89	82	60	25	4	2	0	0	678

5) At 2a.m., what was the ozone level?
6) Why do ozone levels get higher in the afternoon?
7) What was the highest recorded value at the Holland monitor?
8) Why do the ozone levels go down in the evening?
9) At what time did the Muskegon monitor record its highest reading?
10) What others things are happening at this time that may contribute to higher ozone levels?

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Oxygen and Ozone

Target Grade Levels
Sixth - Eighth

Time
Two Class Periods

Materials
None

Knowledge and Skills (TEKS)

- Language Arts:
  - Uses active listening skills to critique a speaker's message;
  - Demonstrates effective communication skills during interviewing, reporting, providing information, role playing, or answering questions;
  - Uses rate, volume, pitch, and tone effectively for audience and setting.
  - Clarifies spoken ideas with evidence and elaboration.
- Science:
  - Organize, analyze, evaluate, make inferences, predict trends from direct and indirect evidence.

Overview
This activity allows students to look at the chemistry of ozone in the upper atmosphere (stratosphere) and ozone formation at ground-level, while learning the difference between good/bad ozone, and the chemical process of its formation.

Background Information
Good ozone: stratospheric ozone is "good" ozone. In 1985, scientists discovered that the ozone layer is thinning. The ozone layer protects us from the harmful rays of the sun. In the stratosphere, ozone (O_3) absorbs ultraviolet radiation and is split into an oxygen molecule and an oxygen atom.

$$O_3 \xrightarrow{\text{Ultraviolet light}} O_2 + O$$

Oxygen molecules can also be split by ultraviolet light to form oxygen atoms.

$$O_2 \xrightarrow{\text{Ultraviolet light}} 2O$$

These changes allow ozone to be reformed to react with more ultraviolet light.

$$O_2 + O \longrightarrow O_3$$

This process allows most of the ultraviolet light to be filtered out before it reaches the earth.

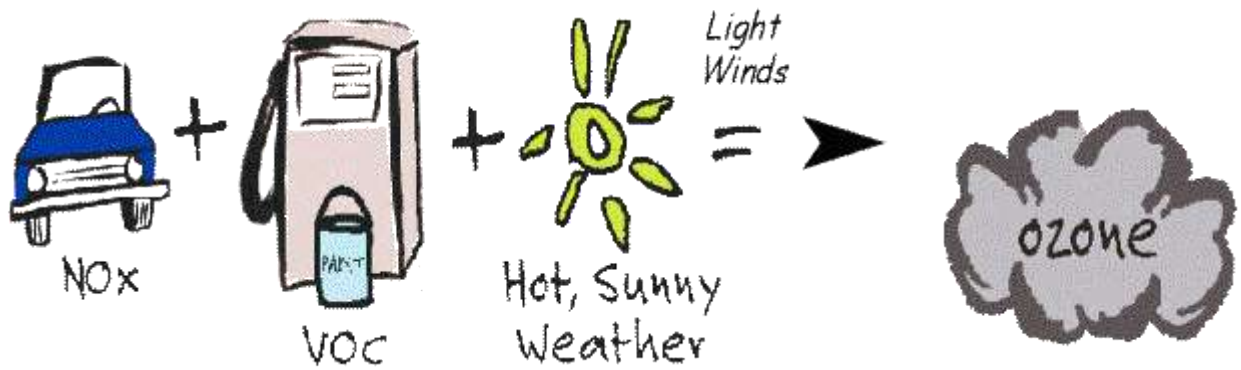
Humans have introduced chlorofluorocarbons (CFCs) to the atmosphere and the chlorine in CFCs reacts with the ozone and changes the whole process. Most of the chlorine found in the depleted areas of the ozone layer comes from human activities. CFCs can be found in aerosol spray cans such as hair spray, cleaning products and spray paint.

The main carriers of chlorine are hydrochloric acid (HCl) and chlorine nitrate ($ClONO_2$), which form the breakdown products of the CFCs. Dinitrogen pentoxide (N_2O_5), a carrier of nitrogen oxide, also has a role in the chemical process, and nitric acid (HNO_3) sustains high levels of active chlorine. Hydrochloric acid and chlorine nitrate are converted into active forms of chlorine on the surface of the polar stratospheric clouds, in which the most important of these reactions are:

HCl	+	$ClONO_2$	→	HNO3	+	Cl2
ClONO2	+	H2O	→	HNO3	+	HOCl
HCl	+	HOCl	→	H2O	+	Cl2
N2O5	+	HCl	→	HNO3	+	ClONO
N2O5	+	H2O	→	2 HNO3		

What happens when this chlorine travels up into the air In these reactions, the chlorine also acts as a catalyst. Before the chlorine is finally removed from the atmosphere (in one to two years by precipitation), each chlorine atom will have destroyed approximately 100,000 “good” ozone molecules—exposing the earth to more harmful ultraviolet rays.

Through vehicles, nitrogen oxides (NO_x) are emitted into the air and mix with volatile organic compounds (VOCs). When they cook in the sun, the chemicals form ozone down here in the air we breathe. Troposphere (ground-level) ozone is “bad”. When ozone forms in high concentrations, it can be a health hazard. Ozone is formed in a photochemical reaction between volatile organic compounds (emissions from gasoline stations and paint), nitrogen oxides and the sun. High temperatures, with minimal or no cloud cover, and stagnant winds are perfect conditions for ground-level ozone formation.



Procedure

1) Vocabulary

a) stratosphere
b) stratospheric ozone
c) ozone layer
d) ultraviolet light
e) chlorofluorocarbons
f) catalyst
g) troposphere
h) photochemical
i) Air Quality Health Alert Days
j) hydrocarbon

2) Activities
   a) Discuss background information with students.
   b) Invite students to answer questions in section four, under Evaluation, and to do research using air quality related articles they find. Resource websites listed below:
      i) Alamo Area Council of Governments (AACOG) air quality page: www.aacog.com/air
      ii) Texas Commission on Environmental Quality (TCEQ) ozone in Texas webpage: http://www.tceq.state.tx.us/cgi-bin/compliance/monops/select_curlev.pl
      iii) AIRNOW page (regional and national ozone maps): www.epa.gov/airnow/
   c) Have students answer the "A.Q." (Air Pollution Quotient) quiz. Then have them quiz friends, fellow students, and families, writing up summaries of their findings and including information about any differences in attitudes toward air quality among these different groups.

3) Review
   a) Review the formation and health effects of ground-level ozone.
   b) Ask the students to compile the results of their quizzing of friends and family's A.Q. – discuss the average results.
   c) Ask students why they think their friends and families know so little (or so much) about the ozone pollution problem. Encourage students to note common misconceptions and well-known points of information.
   d) Discuss how students might help to educate friends, family, fellow students, and the public regarding ozone pollution issues.

4) Evaluation
   Have students answer the following questions citing their research.
   a) What are the differences between "good" ozone and "bad" ozone?
   b) When are Air Quality Health Alert days declared?
   c) What is the purpose of Air Quality Health Alert days?
   d) What actions can you take to protect the stratospheric ozone layer?
   e) What actions can you take to reduce ozone in the troposphere?

5) Extension
   Have students create an ozone pollution outreach and education plan or project and put it into action. They can make posters, write a play to be performed for younger grades, write a lesson, design a billboard or other advertisement, or whatever they think will work best. Note: AACOG outreach and education staff would be happy to serve as a guest presenter on this topic and guide students through the process.

Adapted from: "Ozone Action! Let's Clear the Air Educational Activities 6th Grade - 8th Grade" *West Michigan Clean Air Coalition.* http://www.wmcac.org/documents/educational_packet_6-8.pdf.

What is your A.Q. (Air Pollution Quotient)?
For students, their parents, and friends

Directions: Read the question and circle the appropriate answer.

---

1) Air pollution is only a problem in big cities.

True **False**

---

2) Dirty air is costly to each American.

True **False**

---

3) When the air is polluted, you can always see and smell it.

True **False**

---

4) Clean air is the responsibility of industry alone.

True **False**

---

5) The only effect of ozone air pollution is on the human body.

True **False**

---

6) Cars contribute little to the air pollution problem.

True **False**

---

7) Air pollution is now under control and will not be a problem in the future.

True **False**

See next page for answers

What is your A.Q. (Air Pollution Quotient?)
Answer Sheet

1) Air pollution is a problem only in big cities.
   a) *False*. Everyone is affected by air pollution. The air we breathe does not stay in the same place, hovering over us. It moves. Wind carries pollution to us from all over the world as weather systems travel. Likewise, the pollution that we produce, no matter how small an amount it may seem, is significant when we combine it with everyone else's "small amounts".

2) Dirty air is costly to each American.
   a) *True*. We pay in health problems caused by air pollution. As consumers, we pay costs hidden in the price of things we buy…the cost of new technology to prevent air pollution.

3) When air is polluted, you can always see and smell it.
   a) *False*. Some pollutants are odorless and colorless. That is why it is important to look in the newspaper, listen to or watch your favorite news station or visit www.aacog.com/air

4) Clean air is the responsibility of industry alone.
   a) *False*. We all have an important role to play in clearing our air. What choices can you make (and what actions can you take) to start clearing the air today?

5) The only effect of ozone air pollution is on the human body.
   a) *False*. Ozone pollution affects our: lungs, eyes, materials, vegetation, and animals.

6) Cars contribute little to the air pollution problem.
   a) *False*. The automobile industry has made some improvements in pollution-control devices – individual cars and buses emit fewer hydrocarbon emissions into the air today than ever before. However, more people are driving today than ever, and that adds up to a lot of pollution.

7) Air pollution is now under control and will not be a problem in the future.
   a) *False*. Though we are working hard to control the sources of ozone pollution precursors, nitrogen oxides emitted from vehicles, power generation, and other combustion engines as well as volatile organic compounds emitted from fueling stations, painting operations, and vehicles, advancements in pollution-reduction technology are often balanced out or over-matched by the growth in population and increased demand for driving and electricity. The long-term solution to ozone pollution will have to involve better planning of development, increased transportation choices, and individual efforts, including: regular vehicle maintenance, reduced vehicle idling, and energy conservation.

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Highs and Lows

Target Grade Levels
Sixth - Eighth

Time
One Class Period

Materials
- teacher-made/student-made signs indicating “High” or “Low”
- balloons
- scissors or pins

Knowledge and Skills (TEKS)
- Language Arts:
  - Uses writing as a tool for research, for example, leaning logs, posters, timelines, outlines, and summaries.
- Science:
  - Organize, analyze, evaluate, make inferences, predict trends from direct and indirect evidence.

Overview
The movement of air masses can be confusing and difficult for students to conceptualize. This activity aids in the understanding of high and low pressure behavior, vacuums, and molecular structure.

Background Information
The formation of ground-level ozone is a photochemical process that requires energy in the form of ultraviolet radiation to complete the chemical process that turns pollutants (nitrogen oxides and volatile organic compounds) into ozone. In forecasting Air Quality Health Alert days the meteorologists must be very attentive to high and low pressure systems that are associated with destructive weather conditions.

Typically, high-pressure systems bring high temperatures and clear skies to areas, creating the potential for high amounts of ultraviolet radiation, which enhances ground-level ozone production. Low-pressure systems, associated with cloudy skies and rain, are not at all conducive to ground-level ozone formation and can help dissipate amounts of the pollutant already in the air.

Knowing why and when areas experience systems of high and low pressure is very important to both weather forecasting and air quality concerns.

Procedure
1) Vocabulary

a) aneroid barometer	g) hurricane
b) cumulonimbus	h) tornado
c) ground-level ozone	i) jet stream
d) stratus	j) anvil cloud
e) cirrus	k) photochemical
f) cumulus	l) ultraviolet radiation

2) Activities

a) Read the background information to the class and tell them to imagine that all of the students in every class in the school were tightly packed into their classroom with standing room only.

i) Tell them that all doors and windows are closed. The heat they would feel is indicative of a high-pressure area.

ii) Now, imagine that no one is in the hall outside the classroom. It is completely empty and is indicative of a low-pressure area.

iii) If someone opened the door, where would the students in the classroom want to go? Out the door! Yes, that is exactly what happens with pressure systems. High pressure always seeks to move to low-pressure areas.

iv) Discuss the activity at the doorway. Would the flow be slow and easy or fast and furious?

b) Now imagine that some students are moving from right to left, or in a counterclockwise direction in the hallway. As the students moved out of the classroom, they were allowed to exit only by moving left to right or clockwise direction. Ask for ideas about what might happen. There could be pile ups (clouds); bumping and rubbing friction (lightning) may occur if everyone was not moving in one direction. Explain the following facts:

i) Geographic areas, caught between high and low pressure systems, often experience violent storms as areas of high pressure seek to relieve pressure by moving toward the low pressure area, causing cumulonimbus clouds that produce lightning, thunder, heavy rains, hail, strong winds, and tornadoes. Cumulonimbus clouds are the tallest of all clouds and can span all cloud layers and extend above 60,000 feet. They usually have large, anvil-shaped tops which form because of the stronger winds at those higher levels of atmosphere.

ii) Divide the students in pairs. Have each pair blow up balloons leaving a peak in the top of the balloon. The first student ties the end and holds the balloon securely. They have just made a cumulonimbus cloud. The second student will then prick the peak of the balloon (anvil cloud) with a pin as the first student, simultaneously, releases the balloon. This activity represents the behavior of a cumulonimbus cloud, with the peak of the balloon representing the part of the cloud that becomes the anvil that occurs when the jet stream passes over. This action could cause a tornado like the one they just experienced.

c) Students may actively participate by wearing signs indicating they are part of the high or low pressure area. They would then move in the clockwise or counter-clockwise direction. Other students could represent the front that occurs where they meet.

3) Review
   Discuss results and relate results back to cloud formation and behavior.

4) Evaluation
   Have students create a “Clouds and Weather Diary” in which they sketch and name the clouds they see each day, whether the clouds were moving and, if so, in what direction, record surface wind direction, record the high and low temperature for the day, any precipitation that occurred, and other general weather observations. Then, for each day’s entry, students should draw conclusions about how the clouds observed are related to that day’s other weather observations and make a prediction for the next day’s clouds based on the televised weather report. The length of this diary is up to the teacher.

5) Extension
   a) Use newspaper weather maps to give students practice in predicting the weather.
   b) Allow students to examine an aneroid barometer, used to measure air pressure.
   c) Design a map with an imaginary area showing highs and lows. Each student must predict the weather for the spot marked “X” on the map and explain in a paragraph, using the correct vocabulary, why he/she believes this prediction to be correct.
   d) Students will decide which areas of the map experienced conditions conducive to ozone formation and explain what the conditions were and how they contributed.
   e) Have students describe things they and their families can do to reduce the threat of ground-level ozone in high pressure systems.

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How Does a Cloud Form?

Target Grade Levels
Sixth - Ninth

Time
Aspects of this lesson plan can stand alone, in one class session, or extend for a number of days and follow up.

Materials
- jar
- warm water
- a plastic bag of ice that fits over jar top
- a sheet of black paper
- flashlight
- matches
- notepad

Knowledge and Skills (TEKS)
- Language Arts:
  - Demonstrates effective communication skills during interviewing, reporting, providing information, role playing, or answering questions;
  - Clarifies spoken ideas with evidence and elaboration; and
  - Uses writing as a tool for research, for example, learning logs, posters, timelines, outlines, and summaries.
- Science:
  - Plan investigative procedures; and
  - Collect data through observation, measuring, and communication of valid conclusions.

Overview
Cloud formation and its effect on weather are important to scientific understanding of both weather forecasting and air quality concerns. This activity aids in the understanding of cloud formation, assisting in student education in the subjects of science, environmental studies and mathematics.

Background Information
Air warmed by the earth rises into the sky. As the air cools, the water in the air condenses to form clouds.

Clouds are part of weather. A cloud is a mass of fine drops of water or tiny crystals floating in the air above the earth, formed by water vapor in cool air. The three main types of clouds are cirrus, cumulus, and stratus. Cirrus clouds are located high in the sky, where temperatures are well below freezing; they are white, thin and look like feathers because they are made up of tiny crystals. Cumulus clouds are white clouds that form closer to the earth and are thin, with a cotton-like appearance. Due to their closeness to the earth, these clouds primarily consist of water droplets. They can produce showers and thunderstorms when they get bigger and thicker. Stratus clouds are grey, flat clouds that spread out over the sky. They are located low in the sky and are usually associated with widespread rain. These clouds do not grow bigger and thicker but usually spread wider.

When air quality meteorologists forecast Air Quality Health Alert days, one of the things they consider is cloud cover and cloud type. Air Quality Health Alert days are days that experience a lot of sun and ultraviolet radiation, considering cloud cover is crucial. Clouds can block the sun, create rain, or allow the sun to shine through and create conditions favorable for ground-level ozone formation.

Typically, due to their thickness and low position, cumulus clouds are capable of blocking the sun and stopping formation of high amounts of ground-level ozone. However, cirrus clouds in the sky, thin and high, can allow enough sunlight in to engage the photochemical process that turns pollutants in the air into ozone.

Knowing how, why and when certain clouds form help meteorologists determine whether or not tomorrow is an Air Quality Health Alert day.

More information on studying clouds can be found at the following websites:

- http://asd-www.larc.nasa.gov/SCOOL/cldchart.html
- *http://archive.globe.gov/sda-bin/m2h?gl/clouds.men*

Procedure

1) Vocabulary
   a) clouds
   b) cirrus
   c) cumulus
   d) stratus
   e) Air Quality Health Alert
   f) ultraviolet radiation
   g) ground-level ozone
   h) cirrostratus
   i) nimbostratus
   j) altostratus
   k) stratocumulus
   l) altocumulus
   m) cirrocumulus
   n) cumulonimbus
   o) meteorologist

2) Activities
   a) Do this activity on a dry day when the sky includes a variety of clouds. Take the students outside and have them lie on the grass and look up at the sky. Have them observe the sky for one minute, then ask them about the clouds they see. Are they the same or different? What characteristics do they notice about the clouds? Are they high or low, thick or thin, fat or skinny, etc.? What do they know about how clouds form? List answers on the notepad.
   b) Review when class comes inside.
   c) Write observations from notepad on blackboard. Tell the students that the activity they will participate in today will show them a little bit more about how clouds form.
   d) Cut out or draw pictures of five different types of clouds and then give each student a picture of a cloud. Have the student walk around the room and try to find other pictures that look like their own. The groups that the students end up in will be their group for the lesson.
   e) Note: There are three main cloud types – cirrus (light, feathery/curly and high in the sky, they are common in fair weather), cumulus (puffy, flat and low, they are seen in fair weather and in foul), and stratus (flat like blankets and usually grey, they are associated

with fog, drizzle and snow, depending on their temperature, size and thickness) – and alterations of each: cirrostratus, nimbostratus, altostratus, stratocumulus, altocumulus, cirrocumulus and cumulonimbus ("alto" means "high"; "nimbo" means precipitation (rain or snow); "cirro" means it is layered, made up of many parts).

f) Once they are in their groups, have the students count off: one through five (if necessary). Pass out role labels according to numbers: all of the ones are "technician", twos are "principal scientist", threes are "timekeepers", fours are "recorders", and fives are "reviewers".

g) Explain the instruction and discuss safety precautions (i.e. the importance of being careful with glass, what to do if glass breaks, etc.). Only teachers and other adult assistants will handle broken glass and matches. Student Instructions: The "technicians" will go to the front of the room and gather the materials necessary for the investigation. "Principal scientists" will place the jar on the sheet of black paper or tape the paper on the back of the jar so they cannot see through it. With the bag of ice nearby, they will fill about one third of the jar with warm water. The teacher or assistant will light the match and hold it over the jar opening. After a few seconds, the match is dropped into the jar and the "Taskmaster" will cover the top of the jar with the ice bag. While the "Encourager" shines the flashlight into the jar, "Timekeepers" record the length of time that it takes to create a cloud inside the jar. What is happening? "Recorders" will write observations on a separate piece of paper.

h) Ask if anything needs to be repeated. When there are no more questions, ask the "technicians" to come up and gather the materials.

i) Perform the experiment. Discuss observations.

j) Invite the different groups to gather as much information as possible about their type of cloud, using sources in the library.

k) Have each group make a large poster of their cloud type.

l) Have each "Cloud Club" present their cloud to the class by displaying the poster and sharing the information they have learned.

3) Review

a) After their research, ask the students about other types of clouds (cirrocumulus, cirrostratus, altostratus, altocumulus, nimbostratus, and cumulonimbus). What types of weather do the other clouds bring? Rain, snow, steady rain or snow, thunderstorms and fog. How does each of these weather systems affect ground-level ozone?

b) Have each cloud club quiz the class on the material they presented. The cloud clubs can compete for points by writing down the group's answer to each question, then, all answers are held up at once and the groups with the correct answers receive points. The winning group can be named Cloud Champions. (Note: this game makes it advantageous for all students to take notes on the cloud presentations and for groups to come up with difficult questions.)

4) Evaluation
   a) Questions
      i) What did you see in the jar?
      ii) Thinking about your observations, how might a cloud form?
      iii) Why was the smoke from the match important to cloud formation?
      iv) From our investigation could we say that “a cloud is visible body of very fine droplets of water which hang in the atmosphere above the earth’s surface”?
      v) What makes up weather?
   b) Possible Answers to Questions
      i) A cloud, smoke, dust, fog.
      ii) The warm air is cooled (by the ice cubes) and little drops of water come out of the air (water condenses). The drops of water are so little that they stay in the air. We see them as clouds.
      iii) So you could see the cloud better. It provided particles for vapor to “grab on to”.
      iv) Yes.
      v) Clouds, wind, rain, temperature.
   c) The “reviewers” will ask their group the following questions:
      i) Why might the weather forecast be important?
      ii) What do the students know about how clouds affect sunlight?
      iii) How do clouds influence ground-level ozone and air quality?
   d) Possible answers to the “reviewers” questions
      i) It helps us plan our daily activities, which helps us determine what to wear, whether or not it is going to be an Air Quality Health Alert day.
      ii) Blocks the sun or filters the sun.
      iii) When they block the sun, clouds can stop the formation of pollution. They can cause rain, clearing the air of ozone. Meteorologists have to see what kind of clouds are in the sky before calling an Air Quality Health Alert day.

5) Extension
   a) Every morning have each student go outside and look at the clouds. Have them draw the clouds on the page and identify the cloud. Have students try to predict the weather by looking at the clouds. Do this for two weeks. At the end of that time, have the students look at their journals and see how accurate their weather predications were.
   b) Have the students draw a picture showing the processes that lead to cloud formation.
   c) Have the students draw and/or label three main types of clouds.

d) Have the students write a story about a cloud which includes where in the sky it is found and what type of weather it might bring.

e) Have students observe and record cloud types daily for a month on a graph, by making a space next to the appropriate cloud name. Make a graph analyzing the amount of each type of cloud cover per day, week, month, etc. This activity provides essential skills in mathematics.

f) Example: Our Cloud Chart for May

Type of Cloud	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cirrus	X			X	X					
Cumulus	X	X	X	X			X			
Stratus	X									

In the first week of May, 57 percent of the days experienced cirrus clouds, 71 percent experienced cumulus clouds and 14 percent experienced stratus clouds.

g) Have students write a story about the cloud, including its location in the sky and what type of weather it might bring; have students write poems and rhymes about clouds.

h) Display the weather pages from the newspaper and read them aloud daily. Discuss with students the elements of a weather report. Have students write weather reports to broadcast at the beginning or end of the school day. They may want to draw a picture to include with their forecast.

i) Have students write poems or rhymes about clouds.

j) On a day the sky has cumulus clouds, take the students outside to observe the clouds and the changing shapes. Have the students then write stories about what figures they see in the clouds.

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Temperature Inversion

Target Grade Levels
Sixth - Eighth

Time
45 minutes

Materials
- 4 identical small, clear glass jars (baby food jars work well)
- very hot tap water
- ice water (about 50^0F)
- index cards
- red food coloring
- shallow pans or baking dishes

Knowledge and Skills (TEKS)
- Science:
  - Extrapolate from information to make predictions; Identify and demonstrate everyday examples of chemical phenomena;
  - Make inferences and draw conclusions about effects of human activity on Earth's renewable, nonrenewable, and inexhaustible resources; and
  - Analyze effects of regional disposition and weathering.
- Language Arts:
  - Communicate valid conclusions; and
  - Uses active listening skills to critique a speaker's message.

Overview
To demonstrate what happens when a temperature inversion occurs, which can trap air pollutants near the surface of the earth.

Background Information
Air temperature can play an important role in the buildup or dispersion of surface air pollution. In general, air temperature decreases as you move upward in the atmosphere. Under most circumstances, the air close to the earth warms as it absorbs surface heat and begins to rise. Wind is caused when air rushes in to take the place of the rising warm air. Wind movements cause “mixing” in the atmosphere and thereby carry away and dilute pollution.

During a temperature inversion, a layer of warm air aloft acts as a lid above a layer of cold air. The colder, denser air close to the ground does not readily circulate (mix). Pollutants such as carbon monoxide and particle pollution and ozone-producing hydrocarbons are “trapped” in the cold air by the lid. The quantity of pollution tends to increase until the lid is destroyed by heating or by wind.

Procedure
1) Vocabulary

a) temperature inversion	d) particle pollution
b) carbon monoxide	e) hydrocarbons
c) ground-level ozone	f) dispersion

2) Activities
   a) Normal Conditions
      i) Place two jars in a shallow pan.

ii) Fill one jar with hot water and the other jar with ice water (Note: fill jars to brim). If you use ice cubes to cool the water, do not leave any ice in jar.

iii) Put several drops of red food coloring (pollution) in jar with hot water. Place the plastic square over the top of the jar with the cold (clear) water and quickly flip the jar on top of the jar with the hot (red) water. Align the jar openings. Carefully pull the plastic square or index card out. Let the jars stand.

b) Temperature Inversion

i) Note: fill jars to the brim. Place the remaining two jars in a shallow pan.

ii) Fill one jar with hot water and the other jar with ice water.

iii) Add several drops of red food coloring to the ice water. Place the plastic square or index card over the jar with the hot (clear) water and quickly flip the jar on top of the cold (red) water jar. Align the jar openings. Carefully pull the plastic square or index card out. Observe.

3) Review

Discuss results with students. Make sure to note that it doesn't take much temperature difference to create an inversion. Inversions usually happen at night when the ground cools and cools the air touching it faster than air aloft cools off. Inversions happen even during the summer months, when it seems that no air aloft could be hotter than air at ground level, they may not be very strong, but they do happen!

4) Evaluation

a) Questions

i) What happens?

ii) Why do the hot and cold water mix in the first instance (normal conditions)?

iii) Why do the hot and cold water not mix together during the second instance (temperature inversion)?

iv) Ask students to identify sources of pollution that might get trapped down near ground-level during a temperature inversion.

b) Answers

i) In the first instance, the hot (clear) and cold (red) water mix immediately and water in both jars turn red. In the second instance, the cold (red) water is trapped and can not escape upward. The jar on top (hot) stays clear.

ii) The cold water (air) is on top of the hot water (air). In this case the water colors mix, illustrating that the air can move upward and disperse pollution during normal temperature conditions.

iii) The hot water (air) prevents the cooler water beneath (air close to the ground) from rising and dispersing into the atmosphere. This action traps the pollution down where we breathe.

iv) Answers will vary.

5) Extension
Have a local television meteorologist visit with the class to discuss weather phenomena and local weather patterns. Contact information for local media (ask for the weather department):

- WOAI (210) 226-4444
- KSAT (210) 351-1200
- KENS (210) 366-5000
- KABB (210) 366-1129

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The Awful Eight Lesson Plan

Target Grade Levels
Sixth - Eighth

Time
One hour in class;
Students to review lines as homework

Materials
- markers
- yardsticks
- large pieces of poster board
- background information on air pollution
- library books that cover air pollutants
- materials for "costumes"
- copies of play for each student
- video camera.

Knowledge and Skills (TEKS)
- Science:
  - Extrapolate from information to make predictions;
- Language Arts:
  - Demonstrates effective communication skills during interviewing, reporting, providing information, role playing, or answering questions;
  - Uses rate, volume, pitch and tone effectively for audience and setting;
  - Recognizes rhythm, power, and beauty of language;
  - Uses active listening skills to critique a speaker's message;
  - Identify and demonstrate everyday examples of chemical phenomena;
  - Make inferences and draw conclusions about effects of human activity on Earth's renewable, nonrenewable, and inexhaustible resources; and
  - Uses active listening skills to critique a speaker's message.

Overview
To become aware of different air pollutants and their causes and effects.

Background Information
The U.S. Environmental Protection Agency (EPA) has established national ambient air quality standards for six air pollutants—ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, respirable particle pollution, and lead.

Volatile organic compounds (VOCs) are emitted from sources, such as automobiles, refineries, chemical manufacturing, dry cleaners, paint shops, and other sources using solvents. VOCs are precursors to ground-level ozone, and some of the VOCs are toxic.

Chlorofluorocarbons (CFCs) are a family of chemicals commonly used as coolants in air conditioners and refrigerators and also as solvents and aerosol propellants. CFCs drift into the upper atmosphere where their chlorine components destroy upper-level ozone. CFCs are thought to be a major cause of the ozone hole over Antarctica.

The main anthropogenic source of carbon monoxide emissions is fossil fuel combustion for energy-use and transportation. Methane comes from landfills, cud-chewing livestock, coal mines, and rice paddies. The extent of the effects of climate change, the "greenhouse effect", on human health and the environment is still uncertain, but could include increased global temperature, increased severity and frequency of storms and other "weather extremes," melting of the polar ice cap, and sea-level rise.

Ground-level ozone is a photochemical oxidant and the major component of smog. Ground-level ozone is not emitted directly into the air but is formed through chemical reactions between natural and anthropogenic emissions of VOCs and nitrogen oxide in the presence of sunlight. Peak ground-level ozone concentrations occur in the summer months due to the increased sunlight. Elevated levels above the national standard may cause lung and respiratory disorders. Short-term exposure can result in shortness of breath, coughing, chest tightness, or irritation of nose and throat. Individuals exercising outdoors, children, the elderly, and people with pre-existing respiratory illnesses are particularly susceptible.

Nitrogen dioxide is formed both by the combustion of nitrogen and the reaction of nitric oxide with oxygen in the atmosphere. Nitrogen dioxide emissions result almost entirely from fuel combustion by industry, energy producers, and motor vehicles. In addition to being a precursor to ground-level ozone, nitrogen oxide react chemically in the atmosphere to form nitrates. These pollutants can be transported long distances from the source and can contribute to acid rain and impair visibility. Nitrogen dioxide can harm humans at levels above the national standard. In particular, may cause increased respiratory illness such as chest colds and coughing with phlegm in children. For asthmatics, can cause an increased breathing difficulty.

Carbon monoxide is produced by incomplete combustion of carbon in fuels. The majority of carbon monoxide emissions come from transportation sources, principally from highway motor vehicles. Carbon monoxide reduces blood's ability to deliver oxygen to vital tissues, affecting primarily the cardiovascular and nervous systems. Lower concentrations have been shown to adversely affect individuals with heart disease and to decrease maximal exercise performance in young. Higher concentrations above the national standard can cause symptoms such as dizziness, headaches, and fatigue.

Sulfur dioxide results primarily from combustion of sulfur-bearing fuels, smelting of sulfur-bearing metal ores, and industrial processes. Major sulfur dioxide emission sources are power plants, refineries, some types of chemical plants, primary metal smelters, and cement plants. These pollutants can be transported long distances from the source and can contribute to acid rain and visibility impairment. Sulfur dioxide becomes sulfuric acid once it comes in contact with moisture, including that on moist mucous membranes in the body. At elevated levels above the national standard, it irritates the respiratory tract, causing restricted airflow and breathing difficulty. Individuals with pre-existing pulmonary disease are particularly susceptible to these effects.

Respirable particle pollution includes dust, dirt, soot, smoke, and aerosols emitted into the air by various sources. Major sources of particulate pollution are factories, power plants, refuse incinerators, motor vehicles, construction activity, fires, and natural windblown dust. These microscopic particles can be inhaled and deposited deep in the lungs where they can be trapped on membranes. If trapped, they can cause excessive growth of fibrous lung tissue, which leads to permanent injury. Children, the elderly, and people suffering from heart or lung disease are especially at risk.

The primary sources of lead in the atmosphere are lead-containing gasoline additives, nonferrous smelters, and battery plants. There has been a steady decline in lead levels in the air as a result of the phase out of leaded gasoline and pollution control programs. Elevated levels above the national standard can adversely affect mental development and performance, kidney function, and blood chemistry. Young children are particularly at risk due to their increased sensitivity of young tissues and organs.

Your group can learn about some of the major air pollutants by putting on a play called The Awful 8. By performing the play, they can teach other people about the pollution problems in our atmosphere.

Assign each part under the "Cast of Characters" and pass out copies of the play. Give the kids time to learn their lines, design costumes, and plan any special effects they might want to add. After the group performs the play, review the eight major air pollutants by having each "pollutant" come out and take a bow. The Pollutants should state their name; what causes them; how they affect people, wildlife and the environment; and what people can do to help reduce this type of pollution. Or you can have the audience supply this information to see how much they learned from watching The Awful 8.

Procedure

1) Vocabulary
   a) ozone
   b) carbon monoxide
   c) sulfur dioxide
   d) nitrogen dioxide
   e) respirable particle pollution
   f) lead
   g) volatile organic compounds (VOCs)
   h) ground-level ozone
   i) chlorofluorocarbons (CFCs)
   j) carbon dioxide
   k) methane
   l) photochemical oxidant
   m) smog
2) Activities
   a) Text of play included at end of lesson. Text also available at: http://www.tceq.state.tx.us/assets/public/assistance/education/air/awful8.pdf.
   b) Have class read play aloud, following seating arrangement for each part.
   c) Assign students to different roles; for homework practice lines and bring own props.
   d) Next three days—practice play.
   e) Present and/or video record play when students are ready.

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Adapted from: "The Awful Eight Lesson Plan" *Texas Commission on Environmental Quality.* http://www.tceq.state.tx.us/assets/public/assistance/education/air/awful8.pdf.

The Awful 8: The Play

A Play About Eight Major Air Pollutants

CAST OF CHARACTERS

The number of characters and some suggestions for props and costumes are in parentheses.

- Connie Lung, reporter (1; props: microphone, notebook)
- Harry Wheezer, reporter (1; props: microphone, notebook)
- The Particulates (3; prop: dirt; costume: dirty jeans and brown t-shirts, smear dirt on face)
- Carbon Monoxide (1; costume: sneakers, hat, trench coat, and sunglasses)
- The Toxins (5; props: gasoline cans made from cardboard; costume: black clothing)
- Sulfur Dioxide (1; prop: water gun or spray bottle filled with water; costume: torn t-shirt, yellow and white streamers attached to clothing)
- Nitrogen Oxides (Nitros) (5; props: dead branches; costume: each Nitro can wear one of the letters in "nitro")
- Bad Ozone (1; costume: sunglasses, sophisticated clothing for a "big city look")
- Good Ozone (1; costume: sunglasses and light-colored clothing with bits of cotton attached to represent clouds)
- Chlorofluorocarbons (CFCs) (4; costume: heavy coats and jackets with the initials "CFC" stapled to the lapel and on the back, gloves and scarves)
- EPA Scientists (2; prop: notebooks)
- Carbon Dioxide (2; costume: t-shirts and shorts, black costume makeup wiped on clothing, legs and faces)

Tips For Putting On The Play

- Have the Pollutants make picket signs by taping large pieces of poster board to yardsticks and writing slogans on the poster board. (See slogan suggestions in description of the play's setting.)
- If some kids prefer non-speaking roles, you can let them carry picket signs or be camera people filming the report. They could also take on the responsibilities of stage manager, costume designer or set designer.
- Go over these pronunciations with the kids playing the Toxins; benzene (BEN-zeen), xylene (ZI-leen), toluene (TOL-you-een).
- If your audience is small, have Harry and Connie come up with some ways that people can help reduce air pollution at the end of the play.

Setting: *In front of the Environmental Protection Agency (EPA) building. The air pollutants are picketing the EPA. Some carry picket signs with phrases such as "Dirty Air! Let's Keep It That Way," "Down with the Clean Air Act" and so on. TV reporters Connie Lung and Harry Wheezer are at center stage. In turn, each pollutant comes over to be interviewed, while the other pollutants continue to picket in the background.*

Connie: Hi! I'm Connie Lung.

Harry: And I'm Harry Wheezer. We're here at the Environmental Protection Agency to cover a late-breaking story. Eight of the world's worst air pollutants are picketing the EPA to protest clean-air legislation.

Connie: In tonight's special report, we'll give you the scoop on where these pollutants come from and the ways they can hurt people and other living things.

Harry: Our first interview is with the Particulates.
(Particulates walk over, carrying signs and chanting.)

Particulates: Dust, soot and grime.
Pollution's not a crime
Soot, grime and dust,
The EPA's unjust!

Connie: *(coughs)* So, you're the Particulates.

Particulates 1(Soot): Yeah- I'm Soot, this is Grime and this is Dust.

Harry: You guys are those tiny bits of pollution that make the air look really dirty?

Grime: Yeah! Some of us are stirred up during construction, mining and farming. *(throws some dirt in air)*

Soot: But most of us get into the air when stuff is burned-- like gasoline in cars and trucks or coal in a power plant and even wood in a wood-burning stove!

Dust: And we just love to get into your eyes and make them itch and make your throat hurt and...

Grime: *(interrupts)* Come on, Dust, quit bragging! We gotta get back to the picket line. *(Particulates return to picket line. Carbon Monoxide sneaks up behind Harry.)*

Harry: Let's introduce the folks at home to our next pollutant, Carbon Monoxide. Hey, where did he go? Oh, there you are! Pretty sneaky, Carbon Monoxide!

Carbon Monoxide: Yeah, sneaking up on people is what I do best. I get into the air when cars and trucks burn fuel inefficiently—but you can't see or smell me.

Connie: Then how can we tell when you're around?

Carbon Monoxide: You'll find out when you breathe me in! I can give you a bad headache and make you really tired. *(gives an evil laugh)*

Harry: *(yawns)* Oh-- I see what you mean. Thanks for talking with us Monoxide. *(yawns again) (Carbon Monoxide returns to picket line.)* Connie: *(checking notes)* Next we'd like you to meet some of the most dangerous air pollutants-- The Toxins. *(Toxins walk over, carrying signs and chanting.)*

Harry: You Toxins are made up of all kinds of poisons. How do you get into the air?

Toxins 1: Hey, man, we come from just about everywhere. Chemical plants, dry cleaners, oil refineries, hazardous-waste sites, paint factories...

Toxins 2: Yeah, and cars and trucks dump a lot of us into the air too. You probably don't know it, but gasoline is loaded with us toxins.

Toxins 3: Wow, that's for sure. There's benzene, toluene- all kinds of great stuff in gas.

Connie: Scientists say you cause cancer and other kinds of diseases. What do you think of that?

Toxins 4: They can't prove a thing!

Toxins 5: That's why we're here-- to make sure you people don't pass any more laws that might keep us out of the air. C'mon, Toxins--we're outta here! *(Toxins return to picket line. Sulfur Dioxide walks over.)*

Connie: Next we'd like you to meet Sulfur Dioxide. *(Turns to face Sulfur Dioxide)* I understand you just blew in from the Midwest.

Sulfur: Hey, I wouldn't miss this for all the pollution in New York City!

Harry: I'm sure the folks at home would like to know how you get into our air.

Sulfur: Well, heck, don't they read the newspapers? I've been making the front page at least once a week! Most of the time, I shoot out of smokestacks when power plants burn coal to make electricity.

Connie: And what kinds of nasty things do you do?

Sulfur: Nasty-- that's me! *(snickers)* I think it's cool to make it hard for some people to breathe. And I can make trees and other plants grow more slowly. But here's the most rotten thing I do: When I get way up into the air, I react with oxygen in water in the sky, and presto! You get acid rain! *(sprays water at audience)*

Harry: Acid rain is a big problem. It can hurt or kill fish and other animals that live in lakes and rivers and some scientists think it makes trees sick. Acid rain can even eat away at statues and buildings.

Sulfur: *(proudly)* That's right. Hey, I can even travel a long way to do my dirty work. If I get pumped out of a smokestack in Ohio, I can ride the wind for hundreds of miles and turn up as acid rain in Vermont!

Connie: I sure hope we can get rid of you soon, Sulfur Dioxide!

Sulfur: Good luck, guys! I gotta do some more picketing before I catch the next east wind! *(Sulfur Dioxide returns to picket line. Nitros walk over.)*

Harry: *(to the audience)* He's really rotten!

Nitros: *(all together)* You think Sulfur Dioxide is rotten? You haven't met us!

Connie: You must be the Nitrogen Oxides.

Nitro 1: Just call us the Nitros for short. (turns to audience) Give me an "N"!

Audience and other Nitros respond: "N"!

Nitro 2: Give me an "I"!

Audience and other Nitros respond: "I"!

Nitro 3: Give me an "T"!

Audience and other Nitros respond: "T"!

Nitro 4: Give me a "R"!

Audience and other Nitros respond: "R"!

Nitro 5: Give me an "O"!

Audience and other Nitros respond: "O"!

Nitro 1: What's that spell?

Audience and other Nitros: NITRO!

Nitro 2: What's that mean?

Other Nitros: DIRTY AIR!

Harry: Hey, I didn't know pollutants could spell.

Nitro 4: Very funny, Harry.

Connie: So, how do you Nitros get into the air?

Nitro 5: We get airborne when cars, planes, trucks and power plants burn fuel.

Harry: And what happens once you're in the air?

Nitro 1: We can make people's lungs hurt when they breathe--especially people who already have asthma.

Nitro 2: And, like Sulfur Dioxide, we react with water in the air and form acid rain.

Nitro 3: But we also make another form of pollution. And here she is-- BAD OZONE! *(Bad Ozone waves and walks over. Nitros return to picket line.)*

Bad Ozone: Well, my friends, the Nitros, pour into the air, they get together with some other pollutants. As the sun shines on all these lovely pollutants, it heats them up, and creates me, Bad Ozone. And where there's ozone, there's smog.

Harry: *(to audience)* Smog contains a lot of ozone.

Connie: That's right, Harry. And smog can really make city life miserable. It can make your eyes burn, your head ache and it can damage your lungs.

Harry: But what I want to know is, if ozone is so bad, why are people worried about holes in the ozone layer? *(Good Ozone walks in from offstage.)*

Good Ozone: That low-level ozone is my rotten twin sister-- she's just a good gas turned bad! I'm the good ozone that forms a layer high above the Earth. I help absorb the harmful rays of the sun.

Bad Ozone: *(nastily to Good Ozone)* So what are you doing over here, sis?

Good Ozone: I'm here to support the clean air laws. If certain chemicals keep getting pumped into the atmosphere, I'll disappear. And without me, the harmful rays of the sun will kill some kinds of plants and give many more people skin cancer and eye disease!

Harry: But what kinds of chemicals are making you disappear?

Good Ozone: It's those terrible CFCs! *(CFCs walk over from the picket line.)*

CFC 1: Hey, we're not so bad! People have used us CFCs in coolants for refrigerators and air conditioners for your home and car.

CFC 2: So what if we destroy a little bit of ozone? There's enough to last for years!

CFC 3: Yeah, who needs ozone anyway?

Good Ozone: People do! Tell them what else you CFCs are doing!

CFC 4: What's Ozone complaining about now- global climate change? *(EPA scientists walk in from offstage. Good and Bad Ozone walk offstage.)*

Scientist 1: Excuse me, but did I just hear someone mention global climate change?

CFC 2: Yeah. What do you want?

Scientist 2: We just happen to be experts on the global climate change process.

Connie: Are CFCs really changing the world's climate?

Scientist 1: Well, we're not positive. But over the past 100 years or so, people have been pouring gases, such as CFCs and carbon dioxide, into the air.

Scientist 2: And as they build up in the atmosphere, these gases may be acting like the glass in a greenhouse.

Scientist 1: That's right. They let the radiation from the sun in—but they keep the heat from getting out. And this may be causing the Earth's climate to become warmer.

Harry: I've read that if the temperature goes up, sea levels may rise. Wow, some cities on the coast might be flooded some day!

Scientist 1: Well, nice talking with you all, but we've got to do some more research so that we can really nail these pollutants. *(Points to CFCs. CFCs give scientists a dirty look, stick out tongues. Scientists walk offstage.)*

CFC 1: Hey, we're not even the biggest cause of global climate change. You gotta talk to another of the big pollutants about that.

Harry: *(checks notes)* There's only one other pollutant on the list: Carbon Dioxide. *(CFCs return to picket line. Carbon Dioxide 1 and 2 walk over.)*

Dioxide 1: Did we hear you mention our name? We aren't really a bad gas, in the right amount. About a hundred years ago, there was just the right amount of us in the air.

Dioxide 2: But then people started burning more and more things--they built power plants that burn coal, and cars and trucks that burn gasoline. And they started cutting down and burning forests! Every bit of that burning releases extra amounts of us into the air.

Dioxide 1: As more and more of us got into the air, people started saying that the Earth was warming up-- because of us!

Dioxide 2: Yeah, like it's our fault! (to audience) The reason you're in such a mess is because you use so much fuel and cut down so many trees!

Connie: You're right, Carbon Dioxide. Maybe we should be doing a special report on people--we're the ones who are really causing most air pollution.

Harry: But people can change! (turns to audience) How about you? Can you think of some ways that people can help fight air pollution? (Audience responds with ideas, such as driving cars less, using less electricity, conserving forests, planting trees and so on.)

Connie: And that's the end of our special report. The bottom line? These air pollutants are a pretty tough bunch-- but people help create much of them, and people can reduce the amounts that are in our atmosphere. Thank you and good night.

Pollutant curtain call.

The End.

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Tracking Air Quality

Target Grade Levels
Sixth - Tenth

Time

- Class #1: 15 minutes
- Classes #2-5 (over 2-to-6-week period), 5 minutes each
- Class #6: 40 minutes

Materials

- five sheets of white (or light colored) poster board or heavy construction paper each measuring 2 feet by 2 feet
- felt-tip markers in black, green, blue, red, purple, orange (1 in each color)

Knowledge and Skills (TEKS)

- Language Arts:
  - Uses writing as a tool for learning, such as: formulating questions, compiling information from primary and secondary sources, representing information by using graphics, conceptual maps, and learning logs, compiling written ideas into reports, summaries, or other formats, and analyzing strategies used by writers in different fields.
  - Listens attentively in order to engage in critical, empathetic, appreciative, and reflective responses;

Overview
Students will graph changes in the weather that have implications for air quality in the community. This exercise is best conducted over a long period of time (especially in the fall) in order for students to observe significant variations in the Air Quality Index and correlate them with weather parameters.

Background Information
Graphing—the ability to depict information, relationships, and trends—is a basic skill for communicating ideas and sharing information. It is a skill that supports endeavors in science and mathematics. It is with graphical analysis that scientists and engineers at EPA look for relationships and processes that are not immediately apparent with single, one-time measurements.

Conceivably, this activity could be conducted through the year or periodically to build a data set large enough to establish seasonal trends and determine indicators of change. When the same collecting techniques are applied to air pollutants, the accuracy, frequency, location, and testing protocol become critical for obtaining useful data with which to explain the movement of pollution in the environment and the extent to which we are exposed to air pollutants.

Pollutants in the air come from many sources. Natural air pollution caused by volcanoes, forest fires, and other natural sources has always existed, and naturally produced pollutants are present in greater amounts than those made by humans. They do not present as serious a problem as anthropogenic pollutants, however, because they are dispersed over large areas and many are less harmful. Air pollutants from anthropogenic sources are the result of our increasing use of large quantities of fuel to produce electricity and to run everything from factories to automobiles and other vehicles.

Not only are some of these pollutants very harmful, but also they tend to be concentrated in urban areas where most people live and work. Six of the major anthropogenic pollutants—sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, lead, and particle pollution—have been designated "criteria" pollutants and are regulated by the federal government.

Daily weather conditions directly affect whether and how much we are exposed to pollutants in the air. Shifting air masses (weather systems) and wind can move pollutants from one place to another. On the other hand, stationary air systems, like thermal inversions, can trap harmful pollutants over an area for days at a time. Rain, snow, and other forms of precipitation help wash pollutants from the air and onto the ground. While precipitation cleanses the air we breathe, it also may increase pollution of the land and surface water.

Meteorologists use the Air Quality Index to classify and measure contaminants in the air and report conditions to the public. The index is used to convert data from air monitoring stations at various locations around a community to a scale that indicates the potential effects of measured levels of various contaminants, including the "criteria" pollutants (listed above), on human health, property, and vegetation. This information enables local government officials to take appropriate protective steps in the conditions like thermal inversions and smog.

Suggested Reading

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- Freiman, Chana, and Nancy Karkowsky. "Weathering the Summer of 1993." *Science World*, 50 (22 October 1993) p. 10.
- Gibbons, Gail. W*eather Forecasting*. New York: Chelsea House Publishers (1992).
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Procedure

1) Vocabulary

a) Air Quality Index
b) carbon monoxide
c) criteria pollutant
d) lead
e) nitrogen oxides
f) ozone
g) particulate matter
h) precipitation
i) relative humidity
j) sulfur dioxide
k) temperature
l) thermal inversion

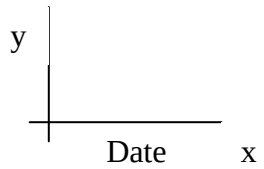
2) Activities

a) Class #1

i) Divide the class into five teams and assign each team one of the following five weather parameters: Temperature, Wind Direction/Speed, Precipitation, Air Quality Index, and Relative Humidity.

ii) Explain that each team will record daily changes in these aspects of the weather on posted graphs over a period of time (specify the period). At the end of the selected period, each team will prepare their findings and make a short presentation defining the aspect of the weather they have been tracking. Where appropriate, students should record the range of values (for example, the high and low temperatures for the day) and a mean value.

iii) Give each team a sheet of poster board. Instruct them to draw a graph on their posters that will allow them to track published information about the weather aspect they have been assigned. (Teams should share the black markers for this task.) The "x" axis for all the graphs should be "date."



iv) Encourage students to call the local weather bureau or the weather reporter at the local television station for help in determining the appropriate "y" axis range for the parameter they have been assigned. Suggest that the students obtain data to fill in their graphs from the local weather bureau, weather reporter, or newspaper.

v) Hang or otherwise display the posters in the classroom where students can see them and record data on them each day. The teams should be given the flexibility to organize themselves to ensure that the recording of data is accomplished every day.

b) Classes #2-5

i) Take five minutes during each class to call attention to the status of the graphs and give students a few questions to consider in preparation for the discussion at the end of the exercise. For example: Would you expect some aspects of the weather to have more (or less) influence on the quality of the air we breathe? If so, which ones and why? The Air Quality Index is usually expressed for particular contaminants—such as ozone, sulfur dioxide, and particle pollution. From your observation, does it appear that changes in weather have more (or less) effect on air quality for some contaminants? If you have found no correlation, does that mean there is no effect? Is there another, better approach for determining a correlation?

ii) During one of the classes near the end of the data collection period, give students a few additional questions to address in the presentations to be made in the final class. For example: How would you describe the weather in our area? What causes the weather to be like it is? Is the weather different elsewhere? If so, what causes it

to be different in different places? Suggest that students brainstorm with their teammates and present the group's perspective in their presentations.

c) Class #6

i) Before teams prepare their data for presentation, repeat the questions you posed during the periodic status checks—Would you expect some aspects of the weather to have more (or less) influence on the quality of the air we breathe? If so, which ones and why? The Air Quality Index is usually expressed for particular contaminants—such as ozone, sulfur dioxide, and particle pollution. From your observations, does it appear that changes in weather have more (or less) effect on air quality for some contaminants? Encourage discussion.

ii) Have each team make 5-minute presentations defining the weather parameter they have been assigned, reporting on the data collected, and addressing the general questions you posed in an earlier class. (See item 2 in the previous section.)

iii) Ask the teams to compare the graphs. Now that they have seen all the data, ask if they would change their answers to any of the questions discussed at the beginning of class. Ask them to explain why (or why not).

iv) Give each team one of the colored felt-tip markers. Encourage students to use the markers to point out similarities (or wide variances) between data on different graphs to illustrate and support their answers.

v) Have students discuss what the results of this exercise might mean (for example, if the data collection period is “typical” for this time of year, how the weather might stress people with asthma or other respiratory problems, and how it might affect plants and trees in the area, or even their pets.) Have them discuss possible options for making the air quality better in these kinds of weather conditions.

vi) Ask the students how they would determine the accuracy of their assumptions and conclusions. End the class by recording on the chalkboard a list of their ideas. (The list should include going to the library to do research and talking to the local weather bureau, meteorologists, physicians, or local Health Department personnel.)

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Deciding to Clean the Air

Target Grade Levels
Sixth - Twelfth

Time
2 class periods (80-90 minutes)

Materials
- guest presenters

Knowledge and Skills (TEKS)
- Science:
  - Analyzing information by sequencing, categorizing, identifying cause and effect relationships, comparing, contrasting, finding the main ideas; and drawing inferences and conclusions; and
  - Using problem-solving and decision-making skills, working independently and with others, in a variety of settings.
- Language Arts:
  - Plans, prepares, organizes, and presents oral messages with attention to thesis statement, valid evidence, effective appeals, appropriate language, and purpose fitted to the audience;
  - Produces own increasingly more complex visual representations that communicate with other;
  - Creating written, oral, and visual presentations of social studies information; and

Overview
This activity lets students practice making choices and experience the sometimes difficult process of making decisions related to air pollution.

Background Information
Whether we are children or adults, our lives are influenced by a constant series of choices. Some choices we make for ourselves. Some are made by parents for their children, and many are made by people we don't even know. The combinations of all of these choices determine the quality of each of our lives. Making these choices is not easy because sometimes what a person perceives as the right choice for him or her may be perceived as the wrong choice for the neighborhood, the community, or the Nation.

The combination of choices made by individuals, business and industry owners, and government over the years has had a huge impact on the quality of the air we breathe and the air pollution problems the world faces today. For example, as a country, we have chosen to pay the higher prices for cars with emission control systems in order to reduce the pollution from motor vehicles.

Auto exhaust is a major contributor to air pollution. Automobiles emit several pollutants that EPA classifies as probable or definite carcinogens, including benzene, formaldehyde, acetaldehyde, and particulates (soot or smoke, especially from diesel vehicles). EPA estimates that toxic emissions from cars, trucks, and buses could be responsible for as many as 1,500 cases of cancer each year.

In addition, automobile exhaust contains hydrocarbons and nitrogen oxides that react with sunlight to create ozone, the major component of smog. Ozone at ground-level is responsible for the choking, coughing, and stinging eyes associated with smog.

Ozone also inhibits plant growth and can cause widespread damage to crops and forests. In typical urban areas, at least half of the hydrocarbons and nitrogen oxides come from motor vehicles. Nitrogen oxides also are produced by power plants, factories, and even lawnmowers. Hydrocarbons are found in many consumer products, including paints, hair spray, charcoal starter fluid, solvents, and plastic "popcorn" or "bubble" packaging. EPA sets national standards for ozone (one of the six widespread “criteria pollutants”), and the states must take action to ensure that standards are met. Areas that fail to meet the standards for at least one criteria air pollutant are called “nonattainment areas.” (See reading material on "The Clean Air Act.”)

Many of the smog clean-up requirements involve motor vehicles (cars, trucks, buses) because virtually everyone is exposed to their emissions. Also, as the pollution gets worse, pollution controls are required for smaller sources. Strategies that may be required by law to reduce and control these toxic emissions include state permitting programs, changes in the composition of gasoline, use of alternative fuels (such as natural gas and electricity), and use restrictions imposed by individual communities.

Many new and innovative approaches are being taken by local governments across the country to reduce air pollution in nonattainment areas. Some of these options include:

1) Banning charcoal barbecues and wood burning in stoves or fire places when pollution levels are high
2) Developing high-occupancy vehicle (HOV) programs for local highways to encourage drivers to carpool
3) Restricting traffic in specific areas of the city
4) Providing incentives for citizens to use public transportation systems
5) Expanding public transportation systems using clean-fueled vehicles, such as municipal buses that use compressed natural gas (CNG) or electric trolley buses
6) Eliminating payments by employers that reduce parking costs of employees who do not choose to carpool
7) Requiring employers to contribute to employee mass transit costs
8) Assessing “smog fees” on cars in proportion to the number of miles driven and vehicle emissions produced
9) Requiring more stringent vapor recovery at gas stations
10) Requiring large companies to purchase fleet cars that run on clean fuel
11) Buying and scrapping older cars

Suggested Reading

- Asay, Gregory. “Acting Locally (Students and College Administration Work Together on Environmental Programs).” *Environmental Action Magazine*, 24 (December 1993) p. 21.
- Becklake, John. *Thinking for the Future: Pollution*. New York: Gloucester Press (1990).
- *Environmental Crisis—Opposing Viewpoints*. San Diego, CA: Greenhaven Press (1991).

- Krupnick, Alan J., and Paul R. Portney. "Controlling Urban Air Pollution: A Benefit-Cost Assessment." *Science*, 252 (26 April 1991) p. 522.
- Leinwand, Gerald. *The Environment: American Issues*. New York: Facts on File (1990).
- Watson, Bates, and Kennedy. *Air Pollution, the Automobile, and Public Health*. National
- Academy Press (1988).
- Willis, Terri, and Wallace B. Black. *Cars: An Environmental Challenge*. Children's Press (1992).
- Worldwatch Paper 98: *Alternatives to the Automobile*. Washington, DC: Worldwatch (1990).

Procedure

1) Vocabulary

   a) acetaldehyde
   b) auto emissions
   c) benzene
   d) carcinogens
   e) clean fuel
   f) criteria pollutants
   g) formaldehyde
   h) hydrocarbons
   i) mass transit
   j) National Ambient Air Quality Standards
   k) nitrogen oxides
   l) nonattainment
   m) ozone
   n) particulate matter
   o) particulates
   p) smoke
   q) soot
   r) vapor recovery

2) Activities

   a) Class #1

      i) Explain that the class is going to act out a situation that illustrates the difficult process of making clean air choices. For the exercise, students are to assume that there has been a proposal brought before the city (town) council to close the downtown commercial district to automobile traffic because of the pollution level and traffic congestion. Under the proposal, only fire and police emergency and public transit (buses) vehicles would be allowed on downtown streets between the hours of 8 am and 6 pm.

      ii) Divide the class into eight teams. Explain that each team will represent one of the "players" in this drama: three city (town) council members, two citizens, two downtown business owners, and one impartial expert that has been paid to evaluate the impacts of the proposal and report to the council (you may choose to be more specific about the roles to approximate the makeup of your community). Assign a role to each team and explain that each team will have to choose (not now) one team member to be the actor when the drama is played out at next week's class (give a specific date but allow a few days to prepare).

iii) Explain that in order to act out the role they have been assigned; each team will have to define the characteristics and views of that person. Does the character live in the city (town) or out in the suburbs (in a rural area)? What does the person do for a living and where does he or she work? How does the person get to and from work? Does the person have a family? Where does the person shop? The last page of this activity is a sample "Character Attributes" worksheet that each team can fill out to help define its role.

iv) Explain that once each team has defined its character, the team should define the character's concerns related to the proposal. Stress that this should go beyond deciding whether the character would be "for" or "against" the proposal and should include defining why this particular character might feel one way or the other. Encourage students to talk to their parents, local city (town) council members, and business owners to help develop these perspectives.

v) Explain that for the role-play activity, the actor from each team will have to describe the team's character and make a statement about that person's views on the proposal as if the character were addressing the council members during a meeting. (Remind the council members that they have a broader responsibility to the community and should be prepared, if necessary, to make a choice between their own individual views and what's best for the community as a whole.)

vi) Give students the remainder of the class to work together and assign them to continue work outside of class in order to be prepared for the role-play activity.

b) Class #2

i) Arrange desks or a table at the front of the room with chairs to accommodate the three city (town) council members. Place a lectern, desk, or small table somewhere else in the room from which the expert, citizens, and business owners will be able to give their statements.

ii) Instruct the actor from each team to describe the team's character (based on the worksheet completed by the team). Have the expert deliver his or her impartial report to the council members and audience at the council meeting. Have the citizens and business owners state their views on the proposal. Have each council member make a similar statement.

iii) In the event that all teams take the same position on the proposal, be prepared to offer an opposing argument yourself, so that both sides of the issue will be heard by the class.

iv) Ask the council members to vote.

3) Review

a) Examine the results.

b) How did each member vote?

c) How did they decide what to vote?

d) Discuss the results and the choices involved with the class.

4) Evaluation
   Have each student write a paper (at least two pages) on what decision they would have made and why.

5) Extension
   Have students bring in examples throughout the year, from the newspaper or local television news, of real air pollution-related decisions made by your local government or major local businesses. Set aside time periodically to discuss the choices involved in these decisions and their impact on the quality of life.

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STUDENT WORKSHEET 1

DECIDING TO CLEAN THE AIR

CHARACTER ATTRIBUTES

Name: _____

Family Members (include ages of children, if any): _____

_____

Occupation (include type of business, if any): _____

Where Do You Live (in the city, suburbs, rural area)? _____

Where Do You Work (in the city, suburbs, rural area)? _____

How Do You Get To And From Work? _____

How Long Does Your Commute Take? _____

Where Do You Do The Shopping? _____

Are There Other Occasions You Need To Be Downtown During The Restricted Hours? _____

_____

What Do You Like About The Proposal? _____

_____

What Don't You Like About The Proposal? _____

_____

_____

Are You For Or Against The Proposal? How Strongly Do You Feel About It? _____

_____

Are There Any Modifications To The Proposal You Want to Suggest to the Council?_____

_____

Inventing a Monitor

Target Grade Levels
Sixth - Twelfth

Time
45 minutes

Materials
- chalkboard
- chalk
- monitoring equipment (if available)
- paper
- pencils
- guest presenters

Knowledge and Skills (TEKS)
- Science:
  - Conduct field and laboratory investigation; and
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions.
- Language Arts:
  - Organizes and records new information in systematic ways; and
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
This activity lets students brainstorm and problem-solve methods for collecting particulates, a first step in finding what pollutants may be in their classroom or outdoors.

Background Information
Air pollution is caused by many types of contaminants, including chemicals, microorganisms, and particle pollution. Particle pollution includes visible and invisible particles of liquids and solids, including dust, smoke, and other matter carried in the air. Particle pollution containing acids (dry deposition) can deteriorate buildings and other structures. Particles larger than about ten micrometers (microns) in diameter is filtered out in the nose or caught by mucus in the respiratory tract and propelled up to the throat by tiny hairs (cilia). Although the cilia can be damaged by air pollutants, the particles smaller than ten microns in diameter (PM-10) is of greatest concern to human health, because it is not filtered and thus reaches the critical areas of the lungs where oxygen exchange takes place and where there are no cilia or mucus to remove it. (See reading material on “Air Pollution.”) The most common source of PM-10 and other suspended particles in air is smoke from commercial and industrial combustion sources, forest fires, burning leaves, fireplaces, wood stoves, diesel engines, and poorly maintained motor vehicles. Dust is another important source of particle pollution. Windstorms carry dust and fine sand. Farmland, when plowed or left ex-posed to wind, construction sites of all kinds (including highway sites), and logging and mining operations are major sources of dust.

Suggested Reading
- Gutnik, Martin J. T*he Challenge of Clean Air*. Hillside, NJ: Enslow Company (1990).

Procedure

1) Vocabulary
   a) carbon monoxide
   b) cilia
   c) lead
   d) micrometer (micron)
   e) monitoring
   f) mucus
   g) nitrogen oxides
   h) ozone
   i) particulate matter
   j) sulfur dioxide
   k) toxic release inventory

2) Activities
   a) Explain the importance of monitoring to determine if air pollutants are being released. The air around us is more polluted than ever before, and with the increasing number of pollution sources, especially in urban and industrialized areas, reducing the risks to human health and the environment presents a major challenge to society. In order to design and evaluate pollution reduction programs, it is necessary to determine which air pollutants are reaching harmful levels. An extensive monitoring and emissions tracking program is in place for ambient carbon monoxide, lead, nitrous oxides, sulfur dioxide, ozone, and PM-10, but there is no similar program for the emissions of 189 hazardous air pollutants considered toxic to people. The EPA's Toxic Release Inventory (TRI) is currently the only database available for assessing trends in emissions of these air toxics. The TRI requires certain facilities emitting above specified quantities of air toxics to submit annual reports to EPA on their releases. Some non-manufacturing facilities such as mining, electric utilities, and mobile sources are not required to report. Monitoring equipment generally is expensive and difficult to maintain. Consequently, cost-effective air monitoring devices are needed.
   b) Explain that for the purposes of this activity students are to assume they have to design a monitoring device to collect particle pollution (PM) in the air in this classroom. Ask what would be their first step? Remember, many pollutants cannot be easily seen or smelled. If necessary, prompt the discussion with some of the following questions: What kind of particle pollution is likely to be in the classroom—smoke, dust? How is it likely to enter the classroom air—via the ventilation system, windows, peoples' clothing? Is there likely to be more than one type of particle pollution in the classroom air? Would it be necessary to monitor them all, or would monitoring one be adequate to draw conclusions about the others? Could molds, bacteria, and other pollutants affect monitoring results? Could the humidity (high or low) of the air in the room affect the accuracy of the results? Would it be necessary to control the movement of air through the room? If so, how would you do it?

c) Help students brainstorm different ideas for collecting particulates (for example, filters, collection dishes, electrostatic materials). Record their ideas on the chalkboard. Encourage students to explain how and why their suggestions would work. (Their suggested designs should show consideration of the size of the particle pollution they are trying to monitor, how to eliminate bogus materials, and how the particle pollution collected in the monitor could be measured—for example, with a microscope, by washing and counting electronically, or through chemical analysis.)

d) Poll the rest of the class to see if they agree or disagree with each suggestion. Ask them to explain why. When you have elicited two or three good, supportable alternatives, ask the class to choose the best one and explain the choice.

e) When some consensus has been reached on the best method for collecting particulates, ask if one of the chosen monitoring devices will be sufficient to get accurate results. What would be the advantage, if any, in locating monitors in several locations around the classroom? Record students' answers on the chalkboard.

f) Have students draw the outline of the classroom on a sheet of paper. Instruct them to mark the locations of the classroom's doors and windows. Assuming they would use the monitor chosen by the class, have students mark on this “map” where they think the device, or devices, should be placed to ensure the best results. When the activity is completed, encourage students to share their suggestions and explain their choices. (You may want to draw a classroom “map” on the chalkboard for students to use in presenting their ideas.)

g) Have students discuss the alternatives presented and choose the best one. Suggest that accurate monitoring only yields part of the answer to what is in the air.

3) Review

a) Help the students examine what they can do to reduce particulate air pollution in their classroom. If necessary, prompt the discussion by asking the following questions: What factors influence the quality of the air in the classroom? For example, what kinds of pollutants do humans generate? Which of those do we bring into the indoor environment? Can all of these pollutants be measured? Can you or the school change any of those factors?

b) Record answers on the chalkboard. (Make sure the following suggestions are brought out in the discussion: Change the filters in the ventilation system; clean the ventilation system regularly; close the windows on high smog days (not relevant for many schools with sealed windows); increase the air humidity.

4) Evaluation
Extension activities can be performed as graded exercises.

5) Extension

a) If a light microscope is available and the classroom has an electronic device like a computer or television that is used often, place a glass slide on the electronic device (for example, on top of the computer monitor) for at least three days before the lesson.

(Electronic devices tend to attract particulates.) During the lesson, examine the slide under the microscope, and discuss the magnification limits of the microscope.

b) Have students research actual monitors used by the Texas Commission on Environmental Quality (TCEQ).

c) Have TCEQ staff come and present information on the monitors.

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Adapted from: "Activity 7 - Inventing a monitor" *Environmental Protection Agency (EPA) - Project A.I.R.E.* 2003. Page 145. http://www.epa.gov/region01/students/pdfs/activ7.pdf

Hop On the Bus, Gus!

Target Grade Levels
Sixth - Twelfth

Time
Two class periods

Materials
- paper
- drawing supplies

Knowledge and Skills (TEKS)
- Science:
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions;
- Language Arts:
  - Plans, prepares, organizes, and presents oral messages with attention to thesis statement, valid evidence, effective appeals, appropriate language, and purpose fitted to the audience;
  - Organizes and records new information in systematic ways; and
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
Students will identify structures of a typical school bus that have high air resistance and will be able to suggest alternative structures with lower air resistance.

Background Information
There are two kinds of air resistance (drag) that are important in car design. Form drag occurs when airflow breaks away completely from the car's surface. Mirrors, fenders, hood ornaments and other features that stick out from the car's surface all cause the air to swirl around them. This swirling air saps energy from the moving car, slowing it down.

Friction drag acts along the surface of a car. Air moves over a hood causing winds to build in thin layers. The layer closest to the car's surface moves the slowest. Other layers of airflow slide over this slow boundary layer causing friction. It requires extra energy to overcome this friction.

Procedure
1) Vocabulary

   a) air resistance
   b) drag
   c) friction drag
   d) form drag
   e) fuel efficiency

2) Activities

   a) Begin by explaining to students the two types of drag explained in the Background section. It will be the form drag, which plays the largest role in reducing fuel efficiency in vehicles.

   b) Here in Texas, a great deal of energy is used each year transporting students to and from school by bus. Students also make many trips each year by school bus for athletic events and other school-related events. A lot of the energy and money that could be saved each year if school buses could use energy more efficiently.

c) One way to increase fuel efficiency would be to redesign school buses to be more aerodynamic. This is where your challenge comes in. Your challenge is to design a new style school bus. The bus saves fuel due to its special low-drag features.

d) One way to approach this task is to think about those structures on a typical bus that stick out from the car, increasing air resistance. These would be good targets for reducing air resistance. Think about different ways and places to attach license plate numbers, headlights, windows and side mirrors. Don't be afraid to come up with a totally new look. Since you do not need to worry about details such as the material of which the body is composed or the size of the engine, you can concentrate on an innovative design. Don't be afraid to try something new!

e) The bus must conform to these guidelines: Guidelines for Low Resistance School Bus

   i) Prepare detailed drawings of your school bus. Show both the front and side views. Include close-up sketches of some special features on your vehicle.

   ii) Specify the actual length, width, and height of your vehicle. Indicate how passengers and freight enter and exit the vehicle. Show this in your drawing and also explain it in words. Remember, a school bus must have at least two main exits.

   iii) List the features on the bus that help to reduce air resistance. Try to incorporate into your vehicle, at least six different design features for reducing air resistance. Be sure to explain each of these and point them out in your drawings.

   iv) Devise a catchy name for your bus. To be really creative, you may develop an advertising slogan designed to interest other schools in purchasing your vehicle.

f) Ask students to hypothesize about the relationship between the amount of drag on a vehicle and its fuel consumption. (The lower the drag, the less fuel consumption.) With this in mind, challenge students to create a design for a new style school bus. The challenge is outlined on the student page. Once students have made their designs on paper, you may wish to challenge students to build a model of their bus. The model could be made from cardboard and would not need to be a working model (in terms of actually rolling).

g) Home/Community Connection
   Challenge students to go out to the parking lot and find the five most aerodynamically designed cars and the five least aerodynamic vehicles. Ask students to design their own checklist with an appropriate rating scale. Include a brief explanation of the important aerodynamic features written so the general public can easily understand it. Give the completed checklist to the car owners.

3) Review
   Have students go home and search through the magazines their family has to find pictures of different vehicles. Each student must bring in a picture of a vehicle, along with that vehicle's descriptive statistics (make, model, production year, weight, number of passengers, and EPA rated fuel efficiency) and present to the class their vehicle and their ideas on why the vehicle gets the fuel efficiency it gets. This can lead to a comparative discussion of vehicles. Students can be grouped based on the type of vehicle they brought (sports car, sedan, minivan, SUV, etc.) to discuss the different factors that affect fuel

efficiency and how the vehicles might be redesigned for better fuel efficiency. Results of group discussion should also be presented to the class. These review exercises can also be performed as graded activities or as extension activities.

4) Evaluation
   a) Questions
      i) Make a list of the special low drag features of your bus. Present your design to the class. Be sure to point out the low drag features as part of your presentation.
      ii) While listening to all of the ideas of their classmates, pool your favorite ideas for a "super bus". Make a drawing of this revised bus.
   b) Sample Answers Questions
      i) Once students have completed their drawings, ask the students to present their designs to the class. Ask each student to include mention of the low drag features as part of their presentation.
      ii) After listening to all of the ideas of their classmates, ask for suggestions for a "super bus". If students pool the best ideas from everyone, they should be able to make a truly unique design.

5) Extension
   a) Invite a representative from a bus manufacturing company to visit with your class about bus designs and fuel efficiency.
   b) Prior to their coming, ask each student to write three questions to ask the bus manufacturer. Remind students to inquire about bus designs, as well as fuel efficiency.

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Adapted from: "Hop on the Bus, Gus!" *Department of Earth Science at the University of Northern Iowa.* www.earth.uni.edu/EECP/mid/mod3_sc.html .

Hot & Cold Running Oil

Target Grade Levels
Sixth - Twelfth

Time
45 minutes

Materials
- sealed test tubes containing regular and synthetic oils
- thermometers
- cooler containing ice cubes
- warm water baths (buckets of warm water will be fine)
- stop watch or clock with second hand
- overhead of challenge question

Knowledge and Skills (TEKS)
- Science:
  - Conduct field and laboratory investigation;
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions; and
  - Organizes and records new information in systematic ways.
- Language Arts:
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
The purpose of this experiment is to discover how the viscosity of oil changes with temperature. This relationship plays a vital role in the efficient running of a car engine.

Background Information
A challenge for motor oils is maintaining protection during high temperature conditions. According to http://smartsynthetic.com/, without a quality motor oil protecting it, an engine can be damaged through motor oil breakdown, viscosity increase and deposits—all caused by excessive heat.

Procedure
1) Vocabulary

a) viscosity	c) non-synthetic oil
b) synthetic oil	d) W (as in 5W30)

2) Activities

a) You will need to prepare a number of test tubes containing regular motor oil and a sample of synthetic oil, ahead of time. (Mobil 1 would be a good synthetic oil to use and is available at most auto and discount stores.) Longer test tubes are preferred over shorter ones. Students will time how long it takes the oil to run from one end of the tube to another. They will observe a greater time difference between the fast and slow flowing oil when using longer test tubes. A length of 15 centimeter (cm) works well. If you have longer tubes available, try them. If using shorter test tubes, experiment with the amount of oil added to each test tube to determine which volume works best with a small test tube. Three to five cm of oil placed in a corked 15 cm test tube works well.

b) The student challenge is to test how the viscosity, speed of "flow", for two different oils changes at different temperatures.

c) Students will design their own experiment to show how the viscosity of each oil is affected by different temperatures.

d) Warm water baths and cold water baths are available for you to use. Your big restriction is that you are not to unseal the test tubes containing the oil. With this in mind, get together with your partners to set up a plan that will allow you to determine the effect of temperature on oil viscosity.

e) Before beginning to collect data, write a few sentences describing how you will compare the viscosity of the two types of oil.

f) Place a heading in the first column of a data table on the next page. Use the table to record all of your findings.

g) Even though the oil is sealed test tubes, do not have any open flames in your classroom at while carrying out this experiment. In this experiment students will try to discover what it is about synthetic oil that makes it so much better than regular motor oil. A short synopsis of the student challenge is provided below.

h) You are to test how the viscosity for two different oils changes at different temperatures. Design your own experiment to show how the viscosity of each oil is affected by different temperatures. Warm water baths and cold water baths are available for you to use. Your big restriction is that you are not to unseal the test tubes containing the oil. With this in mind, get together with your partners to set up a plan that will allow you to determine the affect of temperature on oil flow-ability.

i) You may be surprised at the different ideas students use in determining oil viscosity. Some students will likely suggest marking the side of the test tube by centimeters. Students could tip the cooled or warmed test tube and time how long it takes for a certain number of centimeters to flow from one end to the other. There is no one correct way to do this. Encourage creativity, allowing time after the data has been collected to discuss how the data was gathered.

3) Review
Discuss results with students, reviewing the topics they will have to know for the evaluation.

4) Evaluation

a) Questions:

i) Which type of motor oil flowed faster under warm conditions?

ii) Which type of motor oil flowed faster under cold conditions?

iii) Much of the wear and tear on a car engine occurs during the first few minutes after the car is started. When all of the moving parts of the engine are well oiled, they run smoothly and efficiently. But in order to reach all the moving parts, the oil must move throughout the engine's moving parts when the engine is started. If it gets too thick, it won't get to the moving parts right away. Using these ideas, explain whether one of the oils tested would be better for your car in winter months than the other.

Be sure to use your data about the flow-ability of the oils at different temperatures in answering this question.

b) Sample Answers to Questions:

i) The synthetic motor oil should flow the fastest under warm conditions, although the oils are fairly similar at warm temperatures. Many students will likely get similar results for both the oils under warm conditions.

ii) The synthetic oil will also flow the fastest under cold conditions.

iii) Students should come to the conclusion that the synthetic oil would be best for your car in winter months. This is true because the synthetic oils remain pretty runny at cold temperatures. This means that it can still circulate in your engine to those parts in need of lubrication. If the oil was thick, it would be slower in reaching all parts of your engine.

5) Extension

a) Find out what the weight numbers mean on oil labels. Design an experiment to discover the relationship between oil weight and viscosity.

b) Why are frequent oil changes important? Have students do research to answer their question in relation to viscosity.

c) Find out what kind of oil is used in your family vehicle. Ask one of your parents o show you how to check the oil.

d) Find out where in your community, oil is recycled. Where does your oil go when you have it changed at a local garage? Can synthetic oil be recycled?

e) Invite a local mechanic to class to discuss some of the ideas covered in this activity. Perhaps one of the parents of a student in class would be able to present information of oil from a mechanics perspective.

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The Pressure's On

Target Grade Levels
Sixth - Twelfth

Time
One hour

Materials
- basketballs (one per group)
- meter sticks or tape measure
- tire pump with needle for inflating balls
- large rubber bands (if students choose sling-shot approach)
- ramp (if students choose this approach)
- tape or chalk
- stop watch
- overhead of research question

Knowledge and Skills (TEKS)
- Science:
  - Conduct field and laboratory investigation; and
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions.
- Language Arts:
  - Plans, prepares, organizes, and presents oral messages with attention to thesis statement, valid evidence, effective appeals, appropriate language, and purpose fitted to the audience;
  - Organizes and records new information in systematic ways; and
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
Students will observe how friction changes with the pressure in an inflated ball. This example will then be applied to the desired tire pressure in an automobile.

Background Information
Students may not realize it, but the pressure in a car's tires plays a big role in fuel efficiency. In this activity, students will discover the relationship between tire pressure and fuel efficiency. Rather than using an actual car, the situation can be simulated using a ball. Place a copy of the research question on the overhead or chalkboard.

Procedure
1) Vocabulary
   a) fuel efficiency
   b) pounds per square inch (psi)
   c) tire pressure
2) Activities
   a) Research question: How does the amount of air pressure in a ball affect its speed when rolled across the floor?
   b) For Students:
      i) We call this a research question, because you will need to conduct your own research to discover the answer. Your teacher may give you a few hints about how to control variables in your experiment. However, the main design for the experiment is your job. Not everyone will come up with the same design. This is good. There is no one right way to answer the research question. Lots of different experimental designs will help to answer the question.

ii) Your first job is to discuss possible plans with your partners. Once your group has decided on a plan, make a list of the materials you will need for your experiment. Draw a picture of your experimental set-up. The picture should show how you will be collecting data. Describe the steps you will follow in collecting data for your experiment. To keep your thoughts straight, here are a few headings you should have on your paper.

(1) Materials

(2) Drawing of experimental set-up

(3) Steps in our experiment

iii) Once you have written down your ideas, ask your teacher to check your plan. Your teacher will then help you to gather the materials you will need to collect your data.

iv) Use a table to collect your data. Label the first two columns with headings that fit your experimental design. Notice that the third column should contain room for conducting three trials. It is a good idea to perform an experiment more than one time so that you may then average your results, or even omit data that you can see is "way off".

c) If time permits, it would be desirable for students to set up their own experimental design for answering this question. The degree of direction you wish to provide will be up to you and will be dependent upon the expertise of your class in controlling variables. The paragraphs that follow contain one possible approach to organizing this activity.

d) Hold up a ball and tell students they will be using balls like this one to find the answer to the research question. Also show students a bike tire pump and show them how you can add air to the ball:

i) Unscrew the needle.

ii) Insert it into the ball and show students how air can be removed from the tire.

iii) Ask for their ideas on how they might go about collecting data.

iv) There are a number of variables that must be controlled. Throughout the discussion, as students share their ideas, be sure to question their control of variables along the way. In this manner, the class is likely to devise a relatively controlled experiment that will provide sufficient data to answer the question.

e) A sample design might go as follows: (You may wish to simply provide students with the directions below if time does not allow you the opportunity for class discussion of experimental design.)

i) Use a meter stick or tape measure to mark off a straight distance of 10 meters. Mark the start and end points with tape or chalk.

ii) Unscrew the needle of a tire pump. Push the needle into the ball and release enough air to allow the ball to still roll, but with some difficulty.

iii) Prepare a rubber band slingshot by tying several rubber bands together. While your partners hold the sides of the slingshot, carefully pull the ball back with the stretched rubber band.

iv) Mark the exact point at which the ball is released, so that it may be released from this same spot for each trial. Using the stopwatch, determine the amount of time it takes when the ball is released until it crosses the finish line. Do several trials and average your results.

v) Now repeat the same procedure, but inflate the ball by two pump strokes. Record the results of several trials and determine the average time required to cross the finish line.

vi) Add two more pump strokes of air and repeat the procedure. Keep testing different inflation levels until the air pressure indicates the ball is "full."

f) Home/Community Connection:

i) Challenge students to find out how often the tire pressure is checked on their family vehicles and if there is a tire gauge at their home. Also ask students to read the recommended tire pressure rating on the tires of their family vehicle. If they have a tire gauge, ask their parents to help them check the air pressure. Students should always check with their parents before checking the tires.

ii) Help students to find out what happens to used tires in your community. Have them summarize their findings in a poster or with a short paragraph.

iii) Set up a "tire check" service at your school. Invite an individual from a local automotive garage or car dealership to speak to the class about tires and tire pressure. He or she may also give a short lesson on how to detect weak spots in tires and how to tell if new tires are needed. Issue tickets to teachers in your school. If they want their tires checked, they can place their ticket under the windshield wiper blade on the designated day. This will show students which cars in the parking lot to check. Students should create a summary sheet to record their findings and to give to those whose tires are checked. This sheet might contain a diagram of the car and a place to record the pressure that was measured in each tire. It might also have a place for students to comment on the general state of the tire treads and whether to recommend new tires be purchased. As part of this effort, students could also design an informational brochure about tire pressure and fuel efficiency. The brochure could be given to those whose tires have been checked.

3) Review

After discussing student findings and their answers to the first two Summing Up questions, ask students if they know how often the tire pressure is checked on their family vehicle. How many know if they have a tire gauge at home? Encourage students to find out and to share what they have learned with their parents.

4) Evaluation

a) Questions for Summing Up

i) Study your data. What is your conclusion about how the amount of air pressure in a ball affects its rolling speed?

ii) Apply your findings to car tires. What affect do you think the air pressure in car tires has on fuel efficiency? Explain your answer.

iii) Devise a plan to convince the drivers in your family of the importance of keeping the correct air pressure in their tires. Write a summary of your ideas. Be sure to include any reasons you might provide for wanting to drive with the correct amount of air in the tires.

b) Sample Answers to Summing Up:

i) Students should have data supporting the conclusion that the lower the air pressure, the slower the ball moves. With higher air pressure, the ball should roll faster.

ii) Students will likely conclude that the fuel efficiency will improve as tire pressure increases. This is true because tires low on air pressure will have greater friction between the pavement and the tires, causing an increased drag on the car.

iii) Student plans will vary. Encourage creativity in student writing. Insist that students include a logical rational for driving with the correct tire pressure.

5) Extension

a) Use acrylic paint to paint the ball, then examine marks made by painted ball on paper. Compare total area of paint marks and draw conclusions re: friction and its relationship to drag, engine strain handling, and safety.

b) Find out how often the pressure in the bus tires are checked. What is the recommended tire pressure for school bus tires? Write a persuasive letter to your school's transportation director informing him or her of the relationship between tire pressure and fuel efficiency. Use some of the ideas from question #3 of the Summing Up questions to help you make a strong case for keeping tire pressure at the recommended level.

c) The recommended tire pressure for most cars is in the 25 to 35 pound range. Based on this figure, predict the amount of pressure that would be recommended for a bicycle tire. How much tire pressure do you think is recommended for large tractor tires? What about airline jet tires? After you have made your predictions, do some research to discover the answers.

d) Do some research to discover if there is a relationship between the recommended pressure in the front and rear tires and whether the vehicle is a rear-wheel drive or a four-wheel drive vehicle.

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Adapted from: “Hop on the Bus, Gus!” *Department of Earth Science at the University of Northern Iowa.* www.earth.uni.edu/EECP/mid/mod3_sc.html.

What a Drag!

Target Grade Levels
Sixth - Twelfth

Time
One class period

Materials (one per student group)

- stop watch or clock with a second hand
- modeling clay (about 24 grams per student group)
- graduated cylinder or other tall tube
- fishing line or other lightweight monofilament line
- counterweight (washer, clay, etc.)
- large box (computer size,
- approximately 1 cubic meter)
- rubber bands
- shapes for testing (Styrofoam works best)
- window (box) fan
- ruler
- knife for cutting cardboard

Knowledge and Skills (TEKS)

- Science:
  - Conduct field and laboratory investigation; and
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate valid conclusions.
- Language Arts:
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
The purpose of this activity is for students to discover the relationship between the shape of an object and the air resistance (aerodynamics) of that object. Students will then relate their findings to the shapes of automobiles and their resulting fuel efficiency.

Background Information
Drag is the resistance any object feels while moving through the air. If you hold your hand out the window of a moving car, drag is the wind resistance pushing it back. According to the Center for Energy and Environmental Education at the University of Northern Iowa nearly 60% of the fuel a car uses to drive at a constant 55 mph goes into overcoming wind resistance. So reducing a car's drag can greatly improve its gas mileage (miles per gallon).

The "Cd" or Coefficient of drag, measures how well a shape cuts the wind. It can be calculated for any object from a brick to a blimp. The lower the Cd, the more aerodynamic the shape. For cars and trucks, a low Cd translates directly into better gas mileage. A drop in the average Cd of all road vehicles in the U.S. from 0.4 to 0.3 could reduce the nation's gasoline consumption by 10 percent. This would add up to a yearly savings of over 10 billion gallons of gasoline.

Many students may not realize it, but air is a fluid. A fluid can be a liquid or a gas. It is typically considered anything that can flow and which responds to changes in pressure. Because of its fluid properties, water can be used to illustrate the amount of drag objects have when passing through a fluid. An object that has low drag when moving through air will also have a low drag when it is moved through water. Keep reminding students of this as they are collecting their drag data using water.

Procedure

1) Vocabulary
   a) aerodynamics
   b) drag
   c) coefficient of drag (Cd)
   d) fluid
   e) cube
   f) cone
   g) parachute
   h) airfoil
   i) sphere

2) Activities
   a) The fuel efficiency of cars would be greatly increased if air resistance could be reduced. Many students have likely held their hand out the car window while riding. You can feel your hand getting pushed back. This is largely the result of air resistance.
   b) The greater the air resistance, the more fuel it takes to move a car. Race cars are built with sleek designs to allow them to go faster on less fuel, but these cars lack extra room inside. They are not designed to carry passengers or other items. The challenge is to discover the relationship between the shape of an object and its speed through a fluid. To discover this the speed of objects will be measured through water, since it is easier to notice differences in speed through a liquid than it is through a mixture of gases like air. Be sure students realize that their findings in water will be analogous to what would happen to the object's speed as it travels through air. Air is considered a fluid. Be sure to communicate this to students. Present students with this challenge: How does the shape of an object affect its speed through water?
      i) Ask students to brainstorm possible shapes to test. Most students will likely name shapes such as a cone, a square, a sphere, an oval, a wedge and a torpedo. Ask students to predict which shapes will fall fastest through the water. Rather than explaining the lab set-up to students, it may be easier to demonstrate the technique, do so by:
         (1) Creating a shape out of clay.
         (2) Push one end of a piece of fishing line through the shape, securing it with a knot.
         (3) Show students how fast the shape drops through the water when it is dropped into a large graduated cylinder filled with water.
         (4) Now attach a counter weight to the other end of the string.
         (5) This will serve to slow down the clay as it drops through the water.
         (6) Ask students if they think this is a fair test of how fast the clay drops.
         (7) Hopefully students will realize that it is okay to use the counterweight as long as it is used for every trial.
         (8) Likewise, when the shape of the clay is altered, the same clay lump should still be used.

(9) This will ensure that the shape, not the mass, is the only factor being varied in this experiment.

ii) Using a stopwatch, record the time it takes for the object to fall through the water. Continue testing until three consistent trials have occurred. Ask students to devise their own data tables for recording their data.

iii) Before allowing students to investigate different shapes on their own, ask students how they can best control as many variables as possible in their experiment. Some suggestions might include always using the same line, drying off the line after each trial, always using the same lump of clay, performing several trials for each shape, and having the same person run the timer each trial and the same person release the clay each time.

iv) Once students have collected their own data, have students answer the Summing Up questions.

3) Review

Have students go home and search through the magazines their family has to find pictures of different vehicles. Each student must bring in a picture of a vehicle, along with that vehicle's descriptive statistics (make, model, production year, weight, number of passengers, and EPA rated fuel efficiency) and present to the class their vehicle and their ideas on why the vehicle gets the fuel efficiency it gets. Many automakers list the coefficient of drag under each car's specifications. Look for these figures and make a comparison between the Cd value, fuel efficiency, shape, and size of the car. Report your findings back to the class. Some students might want to prepare a bulletin board display containing pictures of various cars and their Cd values. Perhaps the bulletin board could be designed as a guessing game, where those looking at the board had to guess which cars had the lowest drag and which had the highest drag values.

4) Evaluation

a) Summing Up Questions

i) Which shapes had the least amount of drag and which had the most drag?

ii) Explain how the aerodynamics of a car relates to its fuel efficiency?

b) Sample Answers to Summing Up Questions

i) Students should find the shapes to fall from fastest to slowest in this order: torpedo, cone, wedge, sphere, and cube.

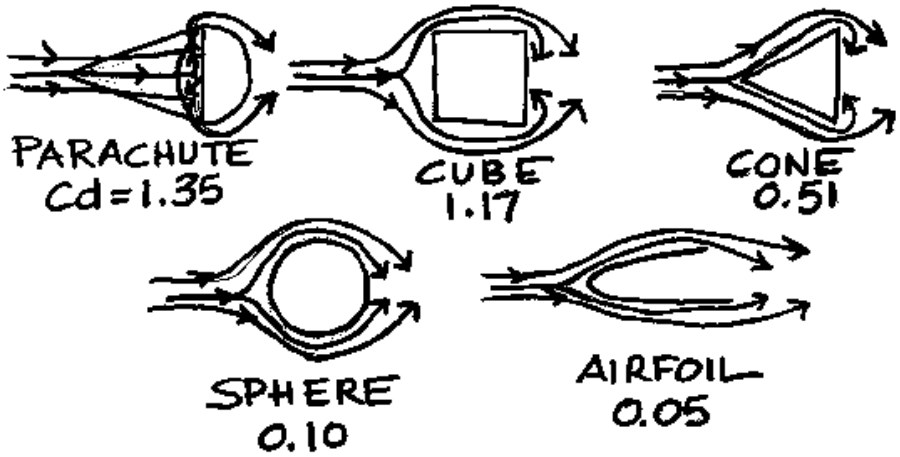
ii) The more aerodynamic the vehicle, the less gasoline it takes to move the vehicle.

c) Discuss results of experiment and answers to Summing Up Questions.

5) Extension

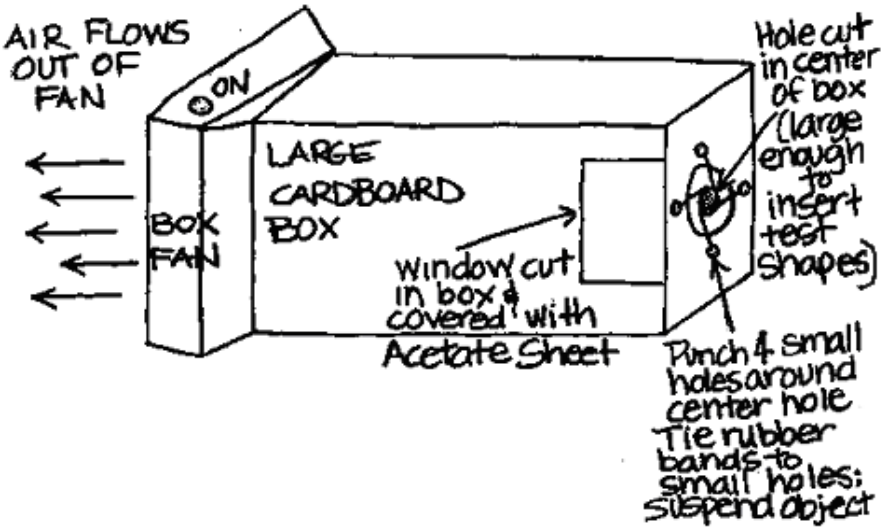
a) Challenge students to draw lines to represent the air current passing over each of the objects shown below. Rate the objects from the one with the largest drag to the object with the least drag.

b) Here are the actual findings



c) Some students might enjoy testing resistance in a homemade wind tunnel.

i) The drawing below illustrates how to prepare the wind tunnel.



ii) To test different shapes, turn on the fan. Looking through the window in the box, measure how far the object moves into the box when the fan is turned on. You will be surprised how well this simple design works. Students will need to make certain that the mass of their test objects is about the same. Remind them to control as many variables as possible.

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Adapted from: "Activity 14 - Smog" *United States Environmental Protection Agency–Project A.I.R.E.* 2003. Page 141. http://www.epa.gov/region01/students/pdfs/activ14.pdf

Harmful Effects of Acid Rain

Target Grade Levels
Fifth - Eighth

Time
30 minutes

Materials (one per student group)
- vinegar
- water
- 2 medium sized eggshell pieces
- 2 small green leaves
- two paper clips
- two containers with lids

Knowledge and Skills (TEKS)
- Science:
  - Acquire data through the senses; and
  - The student shall be given opportunities to observe properties and patterns of objects, organisms, and events in the environment.
- Language Arts:
  - Communicate data and information in appropriate oral and written form; and
  - The student shall be given opportunities to describe objects, organisms, and events from the environment, describe changes that occur to objects and organisms in the environment.

Overview
To demonstrate the harmful effects of an acidic solution. (Vinegar is a dilute solution of acetic acid.)

Background Information
Acid rain is more acidic than normal rain and forms through a complex process of chemical reactions involving air pollution. The two most important pollutants that contribute to the formation of acid rain are nitrogen oxide and sulfur dioxide, which react with moisture in the atmosphere to form nitric and sulfuric acid. The sulfur and nitrogen compounds that contribute to acid rain primarily come from anthropogenic sources, such as industries, utilities, automobiles and other forms of transportation.

Pollutants that contribute to acid rain may be carried hundreds of miles before being deposited on the earth. Because of this, it is sometimes difficult to determine the specific sources of these acid rain pollutants.

Acid rain can harm forests and crops, damage bodies of water, and contribute to the damage of statues and buildings. Researchers are considering the possible effects of acid rain on human heath. These acidic pollutants can be deposited through rain, snow, fog, dew, or sleet. Large quantities can also be deposited in a dry form through dust.

Procedure
1) Vocabulary

a) acid
b) solution
c) acetic acid
d) acid rain
e) nitrogen oxide
f) sulfur dioxide
g) sulfuric acid
h) nitric acid
i) pH

2) Activities

   a) Discuss acids, bases, pH, and acid deposition.

   b) Before activity, make predictions. If vinegar contains acid, then how will some items placed in vinegar change? If these items were placed in water, would they change in the same ways as in vinegar?

   c) Pour vinegar in one container. Place an eggshell piece, a leaf, and a paper clip in the container. Put the lid on the container.

   d) Pour water in the other container. Place an eggshell, a leaf, and a paper clip in this container. Put the lid on the container.

   e) Let the two sealed containers sit overnight.

   f) Remove the container lids. Observe any changes that took place in the two containers. Write down observations.

   g) Results—In the container of water, the items will not show noticeable changes. In the container of vinegar, the eggshell will be soft, the leaf will have brown spots on it, and the paperclip will not show a noticeable change. This activity indicates that acidic solutions can be harmful.

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Adapted from: "Warm-Up D: Learning from Stories" *United States Environmental Protection Agency–Project A.I.R.E.* 2003. Page 15.
http://www.epa.gov/region01/students/pdfs/warm_d.pdf
Resource: Ecology Science Notes, Frank Schaffer Publications, Inc.

Acknowledgment: Peggy Matthews, Texas A&M Corpus Christi TES Course, 1996.

The Cost of Polluting

Target Grade Levels
Seventh - Twelfth

Time
30-40 minutes

Materials (one per student group)

- vinegar
- water
- 2 medium sized eggshell pieces
- 2 small green leaves
- two paper clips
- two containers with lids
- guest presenters

Knowledge and Skills (TEKS)

- Science:
  - Acquire data through the senses;
  - The student shall be given opportunities to observe properties and patterns of objects, organisms, and events in the environment; and
  - The student shall be given opportunities to describe objects, organisms, and events from the environment, describe changes that occur to objects and organisms in the environment.
- Language Arts:
  - Uses writing as a tool for reflection, exploration, learning, problem-solving, and personal growth.
  - Communicate data and information in appropriate oral and written form.

Overview
Though there are many laws restricting pollution, there are still polluters. This activity sheds light on why this occurs, focusing on the decisions that lawmakers and regulators have to make on the severity of penalties for violation of environmental laws. The lesson outlines the considerations leading up to the imposition of a non-compliance penalty so that will students will be able to understand how the government determines the severity of those penalties.

Background Information
The primary goal of pollution control laws is to protect human health. There are several different types of pollution control measures that the government imposes on polluters to achieve compliance with environmental regulations. “Point source” controls impose standards on the discharge coming out of any facility (such as a factory), typically through the issuance of a permit and a compliance monitoring system. Other types of pollution control measures may focus on overall environmental quality. One such overall environmental quality protection system is the set of National Ambient Air Quality Standards (NAAQS) set forth by the Clean Air Act. This set of standards places limits on the amount of certain pollutants, called “criteria pollutants”, allowed in the ambient air in order to protect human health. The criteria pollutants are ground-level ozone, lead, nitrogen oxides, carbon monoxide, particulate matter, and sulfur dioxide. The amount of Hazardous Air Pollutants (HAPs), or “air toxics” allowed in the ambient air is also regulated. The one thing all pollution control methods share are penalties imposed on violators of environmental laws and regulations.

Although most of the regulated community complies or intends to comply with environmental laws and regulations, each year there are cases where regulated entities violate regulations and risk being caught and penalized, or fail to make themselves aware of the laws and regulations and are penalized. Penalties usually serve three functions: restitution, retribution, and deterrence. Restitution, usually through compensation, serves to cover any damage caused by the violation. Retribution is the penalty imposed for the violation itself, while deterrence is meant to prevent future violations. In environmental regulatory practice, restitution can be difficult or impossible to quantify, since damage to the environment is not easily reduced to dollars. Most penalties for environmental law violations are meant to punish bad behavior and serve to deter others from the same behavior.

Monetary fines are the most common type of penalty for violating environmental regulations, though jail terms for more egregious violations (willful circumvention, outright fraud) serve as an important deterrent. Specific penalties are not written into the law, but are set by government officials that weigh a variety of factors in determining a penalty. To serve as an important deterrence signal to the regulated community, a penalty should reflect the degree of harm or potential harm to the environment. At a minimum, monetary penalties should recover any economic benefit a violator may have gained by ignoring the law. This type of penalty ensures that facilities are not economically disadvantaged for complying with the law. Other factors affect a penalty include the ability to pay, degree of cooperation with agencies, whether the violation was self-reported, and the strength of the case if litigation is likely.

Suggested Reading

- The Oil Game (Apple II computer program). AV System (1988).
- Sheridan, John H. “Pollution Prevention Picks Up Steam.” Industry Week, 241 (17 February 1992) p. 36.
- U.S. EPA. Principles of Environmental Enforcement. Washington, DC: U.S. EPA, Office of Enforcement (February 1992).

Procedure

1) Vocabulary

a) avoided costs
b) compliance
c) compliance monitoring
d) deterrence
e) laws
f) litigation
g) nitrogen dioxide (NO_2)
h) non-compliance
i) permit
j) point source
k) postponed costs
l) regulations
m) restitution
n) retribution
o) ground-level ozone
p) lead
q) nitrogen oxides
r) carbon monoxide
s) particulate matter
t) sulfur dioxide
u) Hazardous Air Pollutants (HAPs)

2) Activities

a) Before class begins the following "Problem Statement" on the chalk board: It has been discovered that Anytown Light and Power Company has been releasing nitrogen dioxide (NO_2) from its smokestack in concentrations of 75 parts per million (ppm) for the last 15 days. The company's permit allows the release of NO_2 in concentrations not to exceed 60 ppm.

b) When class begins:

i) Explain how environmental regulations are enforced like other laws, through the imposition of penalties, including fines and imprisonment.

ii) Call students attention to the "Problem Statement," containing the basic facts and circumstances surrounding a fictitious violation of an environmental regulation. Explain that the students will serve as government regulators and use this class period to determine a penalty to be imposed.

iii) Inform students that they will be limited to imposition of monetary fines. Ask the class to identify any other information that they would like to have about the situation before making this decision. List these on the chalkboard. If necessary, prompt students by suggesting they might want to know something about the seriousness of the violation.

iv) For example, did the violation cause potential or actual harm? The completed list could include any or all of the following considerations (which are actually weighed in determining penalties):

(1) Factor 1: Seriousness of the violation

(a) extent of deviation from requirements

(b) potential or actual harm

(2) Factor 2: Economic benefit for non-compliance

(a) costs avoided

(b) costs postponed

(3) Factor 3: Duration of the violation

(4) Factor 4: Degree of cooperation with regulators

(5) Factor 5: History of compliance

(6) Factor 6: Ability to pay

v) After the students have completed their list, compare it with the factors actually used by government regulators. (Use the list above, but the presenter should feel free to supplement it based on his/her own experience.) Discuss how the lists differ (if they do) and why. Then come to a consensus on the factors to be used in this class to determine the penalty for the problem violation.

vi) Hand out the worksheet. Divide the class into small groups if you wish. Explain that students should use the worksheet to compute the fine (or range of fines) to be

imposed. In order to do that, however, discuss how to quantify or attach a value to each factor. For each step in this process, ask students to suggest appropriate values, discuss the pros and cons of suggestions, and come to a consensus on the amount to be used. (If the class is working in small groups, each group should come to its own consensus.) The presenter's role should be to facilitate the discussion. The presenter also may add facts and circumstances to the case study, if required, to introduce more real-world issues into the decision-making experience.

vii) In facilitating the discussions, the presenter should introduce the following ideas if they do not surface on their own:

(1) In determining the seriousness of the violation, the class should consider what indicators or evidence it would use to determine potential harm. (More than any other element, this may be a judgment call since environmental damage is not easily quantified.) Students should recognize that seriousness is a function of personal judgment based on the two elements listed under Factor 1 above. On the chalkboard, you may want to draw the following payment calculation matrix bringing the two elements together. Have students decide the penalty amount to enter in each box.

Extent of Deviation from Requirements

Potential or Actual Harm	High	Medium	Low
High			
Medium			
Low			

(2) In determining any economic benefits that may have accrued for non-compliance, the class should recognize the difference between avoided costs (for example, the cost of required pollution reduction equipment), and postponed costs. Students also may want to consider other recoverable costs: costs the government has incurred in enforcing the law or the value of other advantages the violator may have held over competitors that complied with regulations. All economic benefits are simply added together.

(3) To help students in determining the relevance of the duration of the violation, explain that some environmental laws apply “seriousness” penalties for each day of non-compliance. In some cases, the total penalty attributed to the seriousness of the violation may be discounted for the number of days of non-compliance. For this activity, students should assume that 10 percent of the penalty accrues for each day of non-compliance. This means that 30 days of non-compliance would triple the penalty assessed for the seriousness of the violation.

(4) The other factors listed in step iv above are less important than the first three. The students should use them to fine-tune the penalty to reward good behavior or further punish bad behavior.

(5) It is important to understand that ability to pay is a baseline element. That is, it presumes that the violator has the ability to pay.

viii) When students have completed the worksheet, ask students if their decision might have changed for a case in which a business was unaware of the regulations and the risks of failing to act. Explain why, in reality, "ignorance of the law" is not a valid excuse. (If an EPA or TCEQ employee is a guest presenter, he or she may wish to cite examples of actual penalties assessed and discuss the factors EPA considered in setting the penalties, especially if factors, other than those cited in this activity, were considered.)

c) For grades 10 through 12, ask students to consider and suggest alternatives to the current penalty system. Sample questions: Why wouldn't all violators be automatically shut down? Why are environmental damages difficult to quantify?

3) Review

a) Discuss whether penalties system is working

b) Ask how the system might deal with a violation that is short, but extremely bad, and whether or not the penalties for such an accident are stringent enough.

4) Evaluation
Include actual noncompliance story, have students read and write why it was done and what they would or would not have done differently.

5) Extension

a) Have students discuss the following two questions:

i) If no penalties could be imposed, why would a business comply with regulations?

ii) Are there other "penalties" that may be associated with violating environmental regulations, such as damage to reputations, that serve as incentives for compliance?

iii) Discuss the implications of their answers in the context of "being a good citizen."

b) Discussion: are cars pint sources? Why or Why not? How are they (or are they not) regulated like point sources, and why?

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Adapted from: "Activity 19: The Cost of Polluting" *United States Environmental Protection Agency–Project A.I.R.E.* 2003. Page 181.
http://www.epa.gov/region01/students/pdfs/activ19.pdf

STUDENT WORKSHEET 1

THE COST OF POLLUTING
Calculate a Monetary Penalty

Facility Name: *Anytown Light and Power Company*

Money the Facility Saved by Not Complying with Regulations

Costs avoided		_____
Costs postponed		_____
Total	(a)	_____

Seriousness of the Violation

Penalty required based on potential for harm and extent of deviation from requirement	(b)	_____

Adjustment for the Duration of the Violation

Number of days of non-compliance	(c)	_____
Total = [(b) x (10%)] x (c)	(d)	_____

SUBTOTAL

Subtotal = (a) + (d)	(e)	_____

Penalty Adjustment Factors

1. Degree of cooperation (+/-)	(f)	_____
2. History of compliance (+/-)	(g)	_____
3. Supplemental environmental projects (+/-)	(h)	_____
4. Ability to pay (-)	(i)	_____
Total = [(f) + (g) + (h) + (i)] x (e)	(j)	_____

TOTAL PENALTY

Total Penalty = (e) + (j)		_____

Temperature Inversion

Target Grade Levels
Eighth - Tenth

Time
30 minutes

Materials
- wide-mouthed gallon jar with cover
- plastic bags
- chilled sand bags
- hot water
- funnel
- incense
- plastic tubing
- twist-ties
- masking tape

Knowledge and Skills (TEKS)
- Science:
  - Experience in drawing conclusions about the processes and outcomes of a scientific investigation.
  - The student shall relate objects, scientific principles, and activities to daily life, and explain natural processes and phenomena.

Overview
To demonstrate what happens when a temperature inversion occurs, which can trap air pollutants near the surface of the earth.

Background Information
Tiny solid particles from automobile exhaust, soot from factory smokestacks, fireplaces, and brush or trash burning are largely responsible for the formation of the haze that can be seen hovering over many large cities and industrial areas. Many people who breathe this particle pollution experience some discomfort and suffer some health problems. The severity of this form of pollution is increased when local weather conditions and/or the unique topography of a region cause the pollutants to be trapped in a layer of still air that prevents them from moving away from the area.

Usually, the air that is close to the ground is warmer than that which is found at higher altitudes. This is because there is less pressure at higher altitudes than near the ground and as a volume of air expands it cools. Since there is less pressure, there are fewer collisions of molecules because they have to travel farther before they encounter another molecule. (It is the collisions that give off heat, which we measure as air temperature.) However, this is only true for a column of air with uniform density. When the density of the air at the surface is dramatically different than the air above it (that is, dense, cold, dry air is at the surface and less dense, warmer, moister air is above) then we see a warmer temperature at say 5,000 feet than at the surface. This almost always happens at night and happens frequently during the day in the winter months.

When the air is especially still at times like these, the cooler air, because of its greater density, settles close to the ground, and the warmer air forms a blanket above it in a temperature inversion. Pollutants in the air, such as smoke and soot, are also trapped close to the ground. Fog, formed when moisture in the cool air condenses close to the earth's surface, becomes smog when combined with these pollutants.

Procedure

1) Vocabulary
   a) temperature inversion
   b) soot
   c) haze
   d) particle pollution

2) Activities
   a) Discuss the concept of temperature inversion.
   b) Place a wide-mouthed gallon jar on a table top where all students can view it easily.
   c) Place a very cold sand bag in the bottom of the jar.
   d) Fill a small plastic bag with very hot water. Use twist-ties to close the tops
   e) Suspend the plastic bag containing hot water inside the jar by taping their closed top edges to the rim of the jar.
   f) Attach one end of a length of plastic tubing to a funnel stem and place the free end in the jar.
   g) Position the mouth of the funnel over a small container of burning incense.
   h) Hold the jar top securely in place atop the jar and direct smoke from the incense through the funnel and tube into the jar.
   i) Observe the activity in the jar, discuss.

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Researching Renewable Energy

Target Grade Levels
Eighth - Tenth

Time
Three to four 1-hour periods for research, one 1-hour period for group presentations

Materials
- computer with Internet access, Microsoft Power Point or other available presentation software
- list of relevant web sites research materials, journals, data (such as found in World Watch, newspapers, energy companies, and organizations)

Knowledge and Skills (TEKS)
- Science:
  - Organize, analyze, evaluate, make inferences, and predict trends from data;
  - Draw inferences based on data related to promotional materials for products and services;
  - Analyze the efficiency of energy conversions that are responsible for the production of electricity such as radiant geothermal fossil fuels and the movement of water or wind;
  - Choose valid evidence, proofs, or examples to support claims; and
  - Evaluate the significance of major technological innovations, describe the impact of new technologies, new markets and revised perception of resources.
- Language Arts:
  - Use information acquired from a variety of sources including electronic technology; and
  - Apply appropriate vocabulary and skills to present geographic information.

Overview
Students will discover the great potential for using renewable energy resources and compare utility residential rates in Texas. The growing use of renewable energy in Texas will encourage student interests. Students will conduct research on the Internet and make presentations regarding their findings, using technology to prepare their materials.

Background Information
There are some advantages and disadvantages to all sources of energy, and comparisons can be made. Advantages to using renewable energy sources include convenience, low or no cost for fuel, small environmental impact, sustainability, independence from reliance on other nations or regions for fuel, no dangerous end products to clean up as a major expense, safety factors, and reduced carbon dioxide emissions. Disadvantages of some energy sources include unstable cost, transportation of raw materials and fuel, inconvenience, utilization of public water for production, pollution, limited supplies of fuel, non-sustainability, high cost of disposal of residues, dependence on foreign nations or other regions for fuel, climate change with more extreme weather, decrease in agricultural productivity, possible sea level rise, and species loss.

Procedure
1) Vocabulary

a) biomass
b) carbon dioxide
c) green pricing
d) public utility
e) fossil fuel
f) renewable energy
g) solar energy
h) sustainability
i) wind energy

2) Activities

a) Review background information with students.

b) Divide the class into groups of three to five students and have them prepare presentations for the class.

c) For presentations, students can be guided with numerous suggestions, such as:

i) each group can choose or be assigned a renewable energy resource to research, such as solar energy (passive and/or active), wind energy, biomass, geothermal energy, and hydroelectric power;

ii) oral presentations will be a product of student research with tables and graphs to be used during the presentation;

iii) each group can plan a division of labor;

iv) the class audience should be kept in mind, so the most important concepts are presented without lengthy details;

v) some generic questions might be raised, such as:

(1) How much energy does the assigned energy source currently produce in Texas, compared to its future potential production?

(2) How important is this source likely to become? Why?

(3) What are the assigned energy source's advantages/disadvantages?

(4) What position would the local electric company take regarding this source in your opinion? Why?

(5) Is the source constant and reliable? How?

(6) Will the technology be improved over the next 15 years? How?

(7) Is the resource affordable? *Describe associated consumer and total costs.*

(8) How does this energy affect the environment (greenhouse gases, air pollution, land, water)? *Groups should provide a one page handout as well as a complete source list.*

vi) the materials used and produced by each group for their presentation (i.e. their notes, outlines, summaries, transparencies, etc) are to be turned in after the presentation. Students could use a presentation software application, such as Microsoft Power Point, to make transparencies or to use in the presentation.

d) Students will research from a variety of sources, including the Internet, to review the current status of electricity production in Texas. They will review the current fuels being used to generate electricity and the potential in their futures for using renewable energy sources. Texas has vast stores of potential alternative energy resources, but currently only a fraction of Texas' electricity comes from renewable sources. Students can research the forms of energy most feasible for Texas in the future. The web site addresses suggested in this lesson are just a few possibilities for students to begin their searches. There are many links from these sites and additional places to research.

e) After all groups have completed their presentations, a discussion of what was learned could involve questions, such as what are:

   i) the safest energy sources?

   ii) the most efficient energy sources?

   iii) the most environmentally benign sources?

   iv) the most economical sources?

   v) the most abundant sources in the surrounding geographical area?

f) The teacher will direct you or your groups as to how the topic for research will be chosen and the work distributed among individuals and/or groups. You or your group should collect data on the current status of your renewable energy source, the benefits and disadvantages for its use, global impact and other topics of your choice.

g) There are many printed information sources, as well as Internet sites to utilize. A list of possible sites follows:

   i) Websites

      (1) Alliance to Save Energy, www.ase.org

      (2) American Council for an Energy Efficient Economy, www.aceee.org

      (3) American Electric Power, www.aep.com

      (4) American Solar Energy Society, www.ases.org

      (5) American Wind Energy Association, www.awea.org

      (6) Arizona Solar Center, www.azsolarcenter.com

      (7) Center for Renewable Energy, www.caddet-re.org

      (8) Center for Renewable Energy and Sustainable Technology, http://solstice.crest.org/

      (9) El Paso Solar Energy Association, www.epsea.org

      (10) Florida Solar Energy Center, www.fsec.ucf.edu

      (11) Integrated Water Services associates, www.wte.org

      (12) Midwest Renewable Energy Association, www.the-mrea.org

      (13) National Renewable Energy Laboratory, www.nrel.gov

      (14) The National Hydropower Association, www.hydro.org

      (15) North Carolina Solar Center, http://www.nesea.org/

      (16) Northeast Sustainable Energy Association, www.nesea.org

      (17) Renewable Energy: The Infinite Power of Texas, www.infinitepower.org

      (18) Renewable Energy Policy Project, www.repp.org

      (19) Solar Energy Industries Association, www.seia.org

(20) Texas Solar Energy Society, www.txses.org

(21) Union of Concerned Scientists, www.ucsusa.org/energy/brf.bene

(22) US Department of Energy, www.eren.doe.gov , http://www.eia.doe.gov/kids/energyfacts/index.html

(23) U.S. Department of Energy (Bioenergy), www.eere.energy.gov/RE/bioenergy.html

(24) U.S. Department of Energy Efficiency and Renewables, www.eren.nrel.gov

(25) U.S. Environmental Protection Agency, www.epa.gov

(26) Worldwatch, www.worldwatch.org

ii) Addresses and Phone Numbers

(1) American Solar Energy Society
2400 Central Ave G-1
Boulder, Colorado 80301
(303) 443-3130

(2) American Wind Energy
122 C. Street NW
Washington, DC 20001
(202) 383-2505

(3) Austin Energy
721 Barton Springs Road
Austin, Texas 78704
(512) 322-6300

(4) City Public Service
P.O. Box 1771
San Antonio, TX 78296-1771
210) 353-2222

(5) El Paso Solar Energy Association
P.O. Box 25384
El Paso, Texas 79926
(915) 772-7657 (SOLR)

(6) Public Utility Commission of Texas
1701 N. Congress Ave.
Austin, Texas 78701
(512) 936-7120

(7) National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401-3393
(303) 275-3000

(8) Texas Renewable Energy Industries Association
P.O. Box 16469
Austin, Texas 78761
(512) 345-5446

(9) Texas Solar Energy Society
P.O. Box 1447
Austin, Texas 78767-1447
(512) 326-3391

3) Review
Students should be encouraged to take questions from classmates and teacher to foster open discussion of each energy source's benefits and drawbacks.

4) Evaluation

a) Reports, Presentations, handouts, test on handout material

b) Multiple Choice Questions

i) Consumers want their energy sources to be:

(1) clean

(2) renewable

(3) affordable

(4) all of the above

ii) The most costly source to produce electricity in Texas is:

(1) wind

(2) biogas

(3) nuclear

(4) natural gas

iii) Green pricing means:

(1) paying extra money to use

(2) cost of trees

(3) prices in East Texas renewables

(4) none of the answers

iv) Renewable energy resources include:

(1) wind energy

(2) solar energy

(3) biomass

(4) all answers a, b, and c

v) Regarding renewable energies:

(1) you would strongly support

(2) they are of little importance

(3) they are important to the their use future

(4) a and c

c) Answers to Multiple Choice Questions

i) Question #1, 4

ii) Question #2, 3

iii) Question #3, 1

iv) Question #4, 4

v) Question #5, 4 (best answer)

5) Extension
   a) Have local utility representative present to the class on the utility's current alternative energy portfolio.
   b) Have class write letters supporting alternative energy to the utility board.
   c) Examine potential alternative energy applications for the school.

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Adapted from: "Researching renewable Energy" *Texas State Energy Conservation Office.* www.infinitepower.org/lessonplans.htm.

Testing a Windmill Generator & Wind Power Basics

Target Grade Levels
Ninth - Twelfth

Time
Two 1-hour periods

Materials
- small electric fan or hair dryer
- small DC toy motor
- cork (at least 2 cm in diameter)
- DC voltmeter
- stiff ruler
- 50 cm of thin electrical wire with alligator clips
- rubber band
- scotch tape
- paper clips
- wire cutters
- scissors
- piece of cardboard
- goggles

Knowledge and Skills (TEKS)
- Science:
  - Describe energy systems, observe change and consistency, and make inferences and predictions;
  - Analyze effects and record data of heating and cooling; and
  - Explain different types of climate and the factors that influence climate regions.
- Math:
  - Show relationships using tables; and
  - Construct graphic organizers.
- Language Arts:
  - Gather credible information; and
  - Develop drafts, revise, edit.

Overview
Students will learn the best locations in Texas for utilizing wind power. Students will construct and test a windmill to observe how design and position affect the electrical energy produced. Appreciation for the benefits of renewable energy sources is a focus.

Background Information
Wind power is one of the oldest renewable technologies. Wind is caused when warm air rises, and cooler air rushes in to fill the space. The turbines change this wind energy into mechanical power. Turbines require a minimum wind speed of about 15 miles per hour to generate electricity economically.
As wind speed doubles, power generation capability increases eightfold, and the higher the turbines are placed, for example, on a tall hill or tower, the greater energy production. Unlike fossil fuels, wind power cannot be depleted and produces little pollution.

Suggested Reading
- *Wind Energy and Wind Turbines*. Vaughn Nelson, AEI, Revised September 2000. (Available from the Alternative Energy Institute)
- *Introduction to Wind Energy*. Vaughn Nelson, Earl Gilmore and Kenneth Starcher, AEI Report 94-2. (Available from the Alternative Energy Institute)
- *Wind Characteristics, An Analysis for the Generation of Wind Power*. Janardan Rohatgi and Vaughn Nelson, 1994. (Available from the Alternative Energy Institute)
- *Wind Energy Basics, A Guide to Small and Micro Wind Systems*. Paul Gipe, Chelsea Green Publishing, 1999.

Procedure

1) Vocabulary

a) ammeters
b) convection
c) current
d) direct current (DC)
e) electrical power
f) electricity
g) fossil fuel
h) gearbox
i) kinetic energy
j) mechanical power
k) renewable energy
l) turbines
m) variable
n) voltage
o) voltmeter

2) Activities

a) The teacher should read the student activity first. This activity presumes that students can connect a small direct current (DC) motor and voltmeter (an electrical connector clamp can be used). Emphasize to the class safety precautions when taking current and voltage readings using volt- and ammeters. Use either meter leads that have alligator clips on the ends, or attach insulated alligator clips to the wire ends that come into contact with the meter leads. Students should never touch any bare or exposed metal in a circuit that is generating electricity (i.e. meter leads, bare wire, etc.). Students should read W*ind Power Basics*, before reviewing the activity. Safety instructions should be reviewed. Voltmeter readings should be taken safely. For example, attach insulated alligator clips on the ends of the wire to safely clip on to the voltmeter leads. Discuss safety procedures for using the fan.

b) Basic concepts of electricity, such as current flow, operation of a magnetic coil motor and generation of electricity can be discussed. Discuss the diagram of the major components for generating electricity in the W*ind Power Basics* handout. Students can draw a concept map for the wind turbine and the functions of its parts.

c) Students should outline the instructions, before class, using very few words to summarize. Before performing the experiment, students should plan some of the variations they will change in the design. Extra cardboard will be needed for altering blade sizes. Discuss the advantages of using a renewable energy source, rather than fossil fuels. Point out (from the W*ind Power Basics* handout) the results of doubling wind speed (which increases power output eight times) and where to locate wind turbines. Using the Internet for more information, students can research wind turbines as to what they are, where they are found, what uses they have, when they are most effective, and how they work.

d) Once the instructions to the initial lab exercise have been completed, experimenting with the variables provides students with opportunities to enhance their understanding. Variables can include changing length and width of blades, using different weights of cardboard for the blades, changing wind velocity, and using different angles for the blades. Students should record their variables and results in a data chart they create

during the activity. As students change blade length, width, weight or angle, they should predict whether the amount of voltage will increase or decrease.

e) Students can share and compare the variables they used and the effects on electricity generation. Research on historical uses of wind power will enrich their understanding. How wind develops from sunshine is a major concept. Students can keep track of wind speed in your area for two weeks and consider if wind power would be beneficial as an investment there.

f) Constructing the Windmill Generator (wear goggles)

   i) Use the rubber band to attach the small electric motor to the flat end of the ruler with the motor shaft extending towards the edge of the ruler.

   ii) If the motor doesn't already have wires attached, cut the piece of wire into two pieces and add these two wires to each of the motor's outlets.

   iii) Follow your teacher's safety instructions and attach the two wires to a DC voltmeter using the alligator clips.

   iv) Take four paper clips and straighten out the lower part of each clip. Clip off enough of this straight part, so that only one centimeter (cm) sticks out.

   v) Cut out four pieces of cardboard two cm by 25 cm. Tape these four blades onto the central part of each paper clip.

   vi) Using the one cm part of the paper clip that sticks out, insert the blades into the sides of the cork, .5 cm from the small end of the cork. Be sure to space the blades equally around the circumference of the small end of the cork.

   vii) Place the large cork end, which is furthest away from the wind blades, into the motor shaft. Make sure the shaft goes into the exact center of the cork.

g) Performing the Experiment (wear goggles)

   i) Rotate the blade in the cork so that it is at a 45° angle to the flat plane of the edge of the ruler. Place the windmill 30 cm away from the fan or hair dryer (your distance may vary depending on the strength of the wind source). Turn on the fan or hair dryer. Measure the voltage produced. Try rotating the blades of the windmill to see which angle produces the greatest voltage.

   ii) Design your own set of wind blades, discussing with your lab partner(s) which size and shape, and what number of blades, will work best. Attach these new blades to the motor and try adjusting them at various angles to produce the greatest voltage. Place the windmill at the same distance from the wind source. Measure the voltage again. Place all of your measurements in a data chart.

   iii) Determine the most efficient blade size and shape (sketch and record the dimensions). Next explore how wind velocity affects the amount of electricity produced by changing the fan speeds. (Be sure to keep the windmill at the same distance each time.) Record your measurements in a data chart. Discuss with your teacher other variables you might use.

3) Review
   Discuss results.

4) Evaluation
   a) Short Answer Questions
      i) What changes to a windmill can improve its efficiency?
      ii) Draw a map of Texas and shade in the areas where wind power is best generated.
      iii) Cite three reasons for using wind power, now and in the future.
   b) Answers for Short Answer Questions
      i) Improving efficiency can be accomplished by changing length and/or width of the blades, changing the angle of the blades, altering blade weight and also insuring that the windmill is positioned on an optimum site where the wind is quite constant.
      ii) Students can practice drawing a map of Texas from memory, which also aids their ability to locate major Texas cities. The areas in the Panhandle and West Texas as well as part of the coast should be shaded. Students can describe the kinds of environments they have shaded by doing some research, using a variety of sources.
      iii) Wind power is renewable, cost effective to use, will reduce our consumption of imported energy, does not pollute the environment and can be delivered through the existing power grid.
   c) Multiple Choice Questions
      i) As an engineer working with renewable energies you would:
         (1) place wind farms in valleys and low lying areas
         (2) place wind farms where weather fronts are calm
         (3) place wind farms on elevated sites
         (4) build wind farms everywhere
      ii) Wind power turns the kinetic energy of wind into:
         (1) direct heat
         (2) solar energy
         (3) hydroelectric power
         (4) both mechanical and electrical power
      iii) Wind power:
         (1) is one of the oldest renewable technologies
         (2) was used by early sailors
         (3) is used to pump water
         (4) all answers a, b, & c

iv) Wind:

(1) is moving air

(2) is created by the sun's energy

(3) has power proportional to the cube of its speed

(4) all answers a, b, and c

v) You will likely most often see wind turbines:

(1) on rivers

(2) on hilltops

(3) on lakes

(4) in cities

vi) Learning about renewable energy sources:

(1) is necessary for the future

(2) will help future decision making

(3) shows you other ways to create electricity

(4) all answers a, b, and c

vii) Wind energy is:

(1) an important energy source

(2) kinetic energy

(3) movement of energy from the air

(4) all answers a, b, and c

viii) Some of the devices used in wind power are:

(1) turbines

(2) sails

(3) windmills

(4) all answers a, b, and c

ix) Wind is:

(1) caused by convection

(2) a determiner of weather

(3) a form of fossil energy

(4) a and b

x) Hot air:

(1) is heavier than cold air

(2) rises

(3) sinks

(4) a and c

d) Answers to Multiple Choice Questions

i) Question #1, 3

ii) Question #2, 4

iii) Question #3, 4

iv) Question #4, 4

v) Question #5, 2

vi) Question #6, 4

vii) Question #7, 4

viii) Question #8, 4

ix) Question #9, 4

x) Question #10, 2

5) Extension

a) Have a representative of the local electric utility discuss their wind energy program.

b) Have a representative of a windmill manufacturer visit to discuss construction and use of windmills nationwide.

c) Have students research the drawbacks (bird kill, noise, etc.) of wind power and write a comprehensive paper citing pros and cons.

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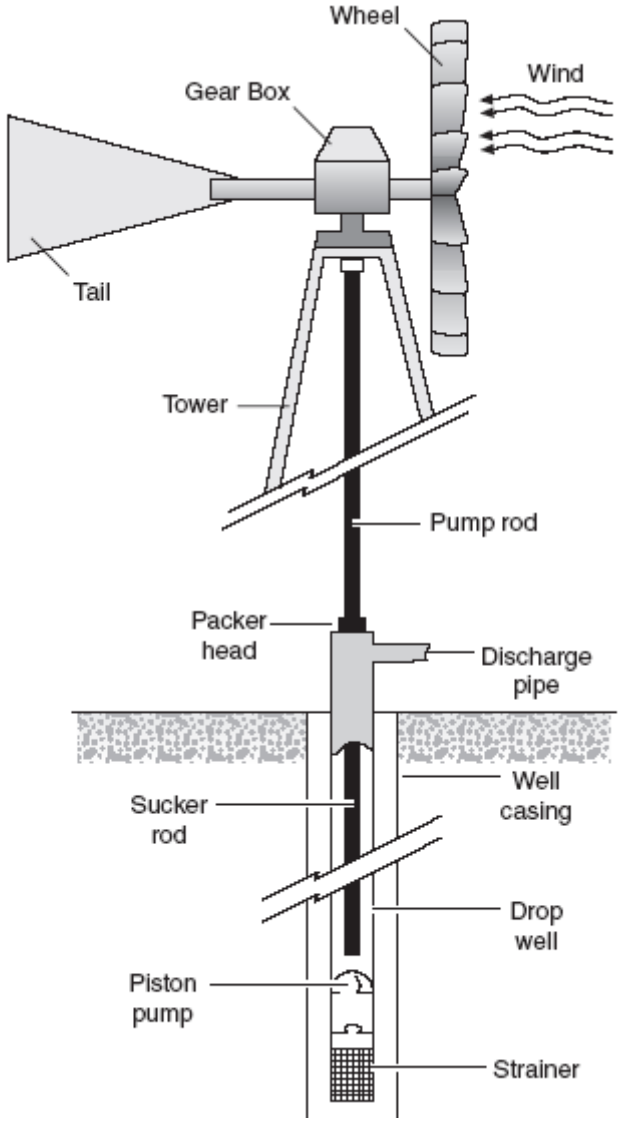
Wind Power Basics

HIGHLIGHTS

- Wind power is one of the oldest renewable technologies
- As wind speed doubles, power generation capability increases eightfold
- Higher is better: hilltops and tall towers lead to greater energy production
- Unlike fossil fuels, wind power cannot be depleted and produces no pollution



Mechanical pump windmill
These simple wind-driven machines, which utilize a long sucker rod to pump underground water to the surface, were a creitical tool in settling the West.

SUMMARY

Humans have been harnessing the wind ever since farmers in ancient Persia figured out how to use wind power to pump water. Wind power turns the kinetic energy of the wind into mechanical or electrical power than can be used for a variety of tasks. Wind offers an inexpensive, clean and reliable form of power.

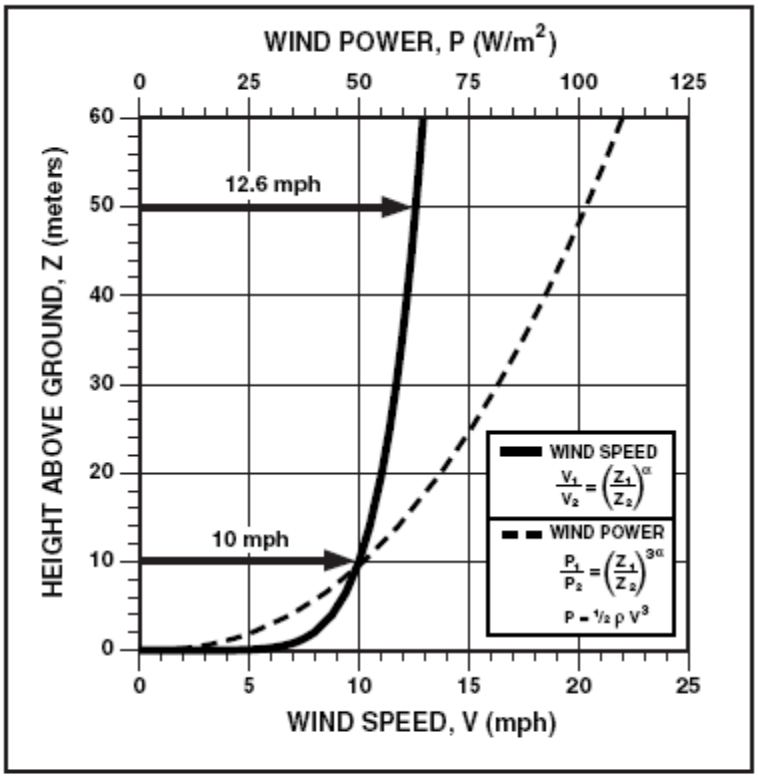
WIND ON THE WATER

Whether powering sailboats across the surface of the water or pumping water from one location to another, the wind is a good source of power. Wind provided early explorers with the engine they needed to cross oceans and discover new lands. On land, the oldest and most widespread use of wind power is for pumping water. In virtually every country on earth, humans are using wind power to either pump water from the ground or move it from one location to another. Here in Texas, where more than 80,000 windmills are in use, rural residents have long relied on windmills to provide water for livestock and human use.

WIND POWER

Wind is moving air. The engine that drives this movement is the sun. A good illustration is the sea breeze that blows along the Texas Gulf Coast. As the coastal land soaks up sunshine, the air above it heats up and rises. Air over the cooler ocean water then rushes inland. The result is a very dependable wind source suitable for making anything from electricity to windsurfing.

Although modern wind turbines can produce some electricity in light winds, the stronger the breeze the better. Why? The power available in the wind is proportional to the cube of its speed. That means that if the wind speed doubles, say from 10 to 20 miles per hour, the power available to a wind generator increases by a factor of eight, for instance from 1,000 to 8,000 Watts.

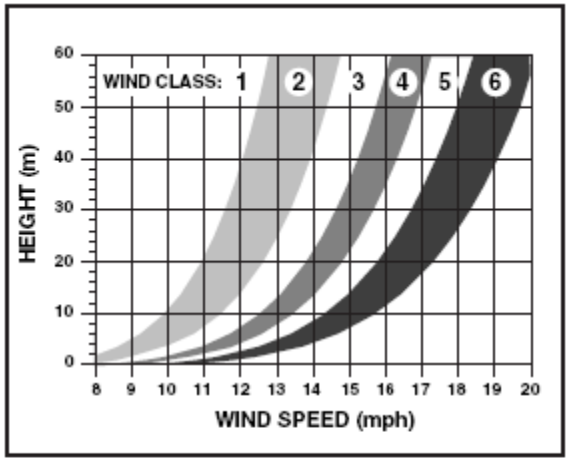


Typical wind shear profile *Speed and power available in the wind increases with increasing elevation. The relationship is commonly referred to as the one seventh power law (a=1/7)*

One easy way to access higher wind speeds is simply to go up. Winds high above the ground are stronger than winds near the ground. On average, a five-fold increase in elevation, say raising the height of the wind machine from 10 feet to 50 feet, will result in twice as much available wind power. That's why wind turbines are perched on tall towers and are often located on mountains or hilltops.

Given the need for strong winds, finding the best sites for commercial wind farms is critical. The location of power plants fueled by wind must be near existing power lines and in the windiest sites available. To compete head-to-head with fossil fuel generating technologies, wind turbines are best located in areas where wind speeds are 16-20 mph at 50 meters (m) height. Wind farms are located in the most windy areas and close to utility power lines. In Texas, the best locales are found in West Texas and the Texas Panhandle.

Air temperature is also an important factor in wind power generation. Cold air is more dense than hot air. Thus, wind turbines are able to generate about 5% more power at any given wind speed in the winter than they are during the hot days of summer.



Wind power depends on elevation and wind speed *Wind Class is a relative scale used to characterize wind potential of any location. Wind Class of 3 and above are generally regarded as being suitable for commercial wind farm development.*

MAKING WATTS FROM WIND

The blades on a wind turbine are similar to the propeller blades on an airplane. The rotor blades generate lift from the passing wind, causing them to rotate the hub of the turbine. The rotating action of the hub then turns a generator, which creates electricity. A gearbox is generally necessary to optimize the power output from the machine. That power is then either fed into the electric grid or stored in batteries for use on-site.

While wind speed is important, so is the size of the rotor. On a turbine, the power available to the blades is proportional to the square of the diameter of the rotor. In other words, simply by making the turbine blades twice as long and beefing up the generator, you increase the power producing capability of the turbine by a factor of four.

Modern wind turbines come in two varieties: horizontal axis and vertical axis. Horizontal axis turbines have blades that spin on an axis that is parallel to the ground. These systems often look like the propeller on an airplane. Vertical axis systems have blades that spin on a vertical axis giving them an appearance somewhat like giant egg beaters.

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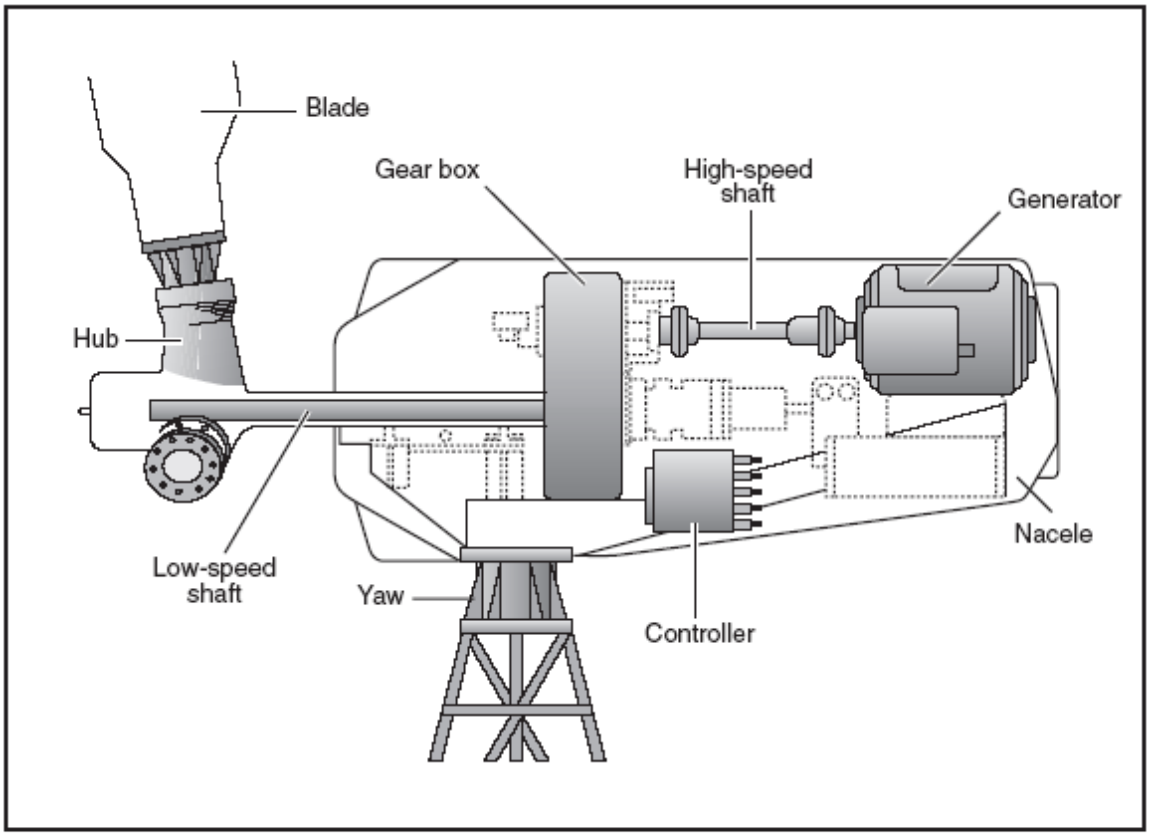

Electricity generating wind turbine *The major components of this device are the blades, shaft, gearbox and generator. On large machines, additional controllers and drive motors ensure that the machine is positioned for optimal capture of the wind.*

Although large utilities are getting the most attention for their move into wind power, rural residents in all 50 states and dozens of foreign countries have quietly been installing small-scale wind generation systems. These systems can be obtained for as little as $1,000 and are perfect compliments to photovoltaic systems. Several vendors sell readymade towers and turbines that are easily installed.

RESOURCES

FREE TEXAS RENEWABLE ENERGY INFORMATION

For more information on how you can put Texas' abundant renewable energy resources to use in your home or business, visit our website at www.InifinitePower.org or call us at 1-800-531-5441 ext 31796. Ask about our free lesson plans and videos available to teachers and home schoolers.

ON THE WORLD WIDE WEB:

Wind Energy Association
www.awea.org

Danish Wind Turbine Manufacturers Association
www.windenergy.dk

For home owner size wind turbines
http://www.homepower.com/view/?file=HP119_pg34_Sagrillo

ORGANIZATIONS

Alternative Energy Institute
Box 60215, WTAMU
Canyon, TX 79016
(806) 651 2295
www.wtamu.edu/research/aei or
www.windenergy.org

American Wind Energy Association
122 C Street, N.W.
Washington, D.C. 20001
(202) 383-2505
www.awea.org

CADDET Center for Renewable Energy
1617 Cole Blvd
Golden, CO 80401-3393
(303) 275-4373
www.caddet-re.org

National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393
(303) 275-3000
www.nrel.gov

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Austin, TX 78767-1447
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e-mail: info@txses.org
www.txses.org

Texas Renewable Energy Industries Association
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Finding Sources of Air Pollution

Target Grade Levels
Ninth - Twelfth

Time
40 minutes

Materials
- a large street map of the community
- push pins in several colors
- chalkboard
- chalk
- guest Presenters

Knowledge and Skills (TEKS)
- Science:
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate conclusions.
- Language Arts:
  - Plans, prepares, organizes, and presents oral messages with attention to thesis statement, valid evidence, effective appeals, appropriate language, and purpose fitted to the audience; and
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
This activity calls for students to locate on a map the potential areas of air pollution in their community.

Background Information
The atmosphere is necessary for plants, animals, and people to live. Air pollution is any visible or invisible particle or gas found in the air that is not part of the normal composition of air. Natural air pollution caused by volcanoes, forest fires, and other natural occurrences has always existed. Naturally produced pollutants are present in greater amounts than those of human origin. They do not present as serious a problem as anthropogenic pollutants, however, because they are dispersed over large areas, and many are less harmful than anthropogenic ones. Air pollution from anthropogenic sources is the result of our increasing use of large quantities of fuel to produce electricity and to power automobiles, trucks, and other vehicles and industrial activity. Not only are some of these pollutants very harmful, but also they tend to be concentrated in urban areas where many people live and work. Many of these air pollutants come from burning the coal, oil, wood, and other fuels we use to run factories, cars, and the power plants that generate heat and light for our homes. Six have been designated “criteria” pollutants: particle pollution, sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, and lead. (A table describing these pollutants, their sources, and their effects is included as a student handout.) The Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards to protect health and welfare in connection with these pollutants. When the standards are not met, the EPA can take steps to control pollutant emissions.

Suggested Reading
- Air and Water: Concerns for Planet Earth (VHS videotape). United Learning (1991).
- Bailey, Donna. What Can We Do About Noise and Fumes. New York: Franklin Watts (1991).

- Baines, John. Conserving Our World, Conserving the Atmosphere. Austin, TX: Steck-Vaughn Company (1990).
- Becklake, John. Thinking for the Future: Pollution. New York: Gloucester Press (1990).
- Gutnik, Martin J. The Challenge of Clean Air. Hillside, NJ: Enslow Company (1990).
- Hare, Tony. Save Our Earth: Acid Rain. New York: Gloucester Press (1990).
- Leinwand, Gerald. The Environment: American Issues. New York: Facts on File (1990).
- Moos, Shawna. "Pollution-Prevention Power to the People (EPA's Toxics Release Inventory Database)." Technology Review, 95 (October 1992) p. 15.
- O'Neill, Catherine. "Cleaner Air! Cough! Wheeze! Gasp!" Washington Post (Washington Health), 115 (6 October 1992) p. WH18.
- Penny, Malcolm. Our World: Pollution and Conservation. Englewood Cliffs, NJ: Silver Burdette Press (1988).
- Stille, Darlene. The Ozone Hole. Chicago: Children's Press (1991).

Procedure

1) Vocabulary

   a) acid rain
   b) air pollution
   c) atmosphere
   d) carbon monoxide
   e) Clean Air Act
   f) criteria pollutants
   g) lead
   h) National Ambient Air Quality Standards (NAAQS)
   i) nitrogen oxides
   j) ozone
   k) particulate matter
   l) respiratory tract
   m) sulfur dioxide
   n) toxic release inventory

2) Activities

   a) Explain that in a few days (use specific date if you have it) someone who works for the EPA or the Texas Commission on Environmental Quality (TCEQ) is coming to visit the class. To prepare for the visit, the class is going to talk air pollution.

   b) Pass out the worksheets. Ask the students if they think there is air pollution in your community. If they say yes, ask if air pollution is always visible. If they say no, ask how they can tell it's not there. What are some of the signs of pollution that they might see? Record the signs of air pollution suggested by students on the chalkboard and instruct students to list them on their worksheets under the "Signs of Pollution" heading. If necessary, prompt the brainstorming by listing "smoke" as a sign of pollution. The completed list should include smoke, odors, smog, stunted or discolored plants and trees, and damaged or discolored buildings and statues.

   c) Ask the students if air pollution affects people. If they say yes, ask how. Record students' answers on the chalkboard and instruct them to list them on their worksheets under the "Health Effects of Pollution" heading. (If necessary, prompt students by asking if they know anyone who has asthma or other breathing problems. The criteria air

pollutants can cause or contribute to problems like these, plus headaches; irritated eyes; and brain, heart, kidney, and lung damage.)

d) Ask students where they think the pollution in your community comes from. What are the sources of the pollution? Record the sources suggested by students on the chalkboard and instruct students to list them on their worksheets under the "Sources of Pollution" heading. (If necessary, prompt students by listing "cars and trucks" as the first example. The completed list should include cars and trucks, local industries, and local electric power plants, at a minimum. Other possibilities could include dry cleaners, gas stations, and windblown dust.)

e) Place the map on an easel or hang it on a wall where the students can see. Point out significant landmarks such as the school, the city/town hall, major factories, and shopping malls. Ask students to help you mark on the map some of the possible sources of air pollution in the community. Explain that the map will be used as a starting point for discussion when the EPA official comes to visit.

f) Divide the class into teams. Assign each team the responsibility for gathering information outside of class to help refine the map by adding other pollution sources and finding out what pollutants various sources release. Suggest that the local health department, planning department, or environmental board (office) can provide information on sources of pollution in the community. In addition, access to EPA's Toxic Release Inventory (TRI) may be available in your area. The TRI is a database containing information about the amount of toxic chemicals released into the air by manufacturing and other facilities. Information on the libraries and other facilities in your area with access to the database can be obtained by calling the Emergency Planning and Community Right-To-Know Hotline, 1-800-535-0202.

3) Review
Select (or let the class nominate) students to make short presentations on the information the students have developed about signs, effects, and sources of air pollution at the beginning of the EPA official's visit.

4) Evaluation

a) Presentations can be performed as graded group exercises.

b) Extension activities can be performed as graded exercises.

5) Extension

a) Assign each team the responsibility of designing an attractive way (possibly a poster) to present the lists developed in today's class. For example, one team could prepare a poster on signs of pollution; one team could work on health effects of pollution; the third team on sources.

b) Is Your Air Clean? Lesson page 263.

STUDENT WORKSHEET 1
FINDING SOURCES OF AIR POLLUTION

Signs of Pollution	
Health Effects of Pollution	
Sources of Pollution	

STUDENT HANDOUT
FINDING SOURCES OF AIR POLLUTION
MAJOR ANTHROPOGENIC AIR POLLUTANTS

Pollutant	Description	Sources	Signs/Effects
Carbon monoxide (CO)	• colorless, odorless gas	• vehicles indoor sources, including kerosene, wood-burning, natural gas, coal, or wood-burning stoves and heaters	• headaches, reduced mental alertness, death • heart damage
Lead (Pb)	• metallic element	• vehicles burning leaded gasoline • metal refineries	• brain and kidney damage • contaminated crops and livestock
Nitrogen oxides (NO_x)	• gaseous compounds made up of nitrogen and oxygen	• vehicles • power plants burning fossil fuels • coal-burning stoves	• lung disorder • react in atmosphere to form acid rain • combines to deteriorate buildings and statues • forest damage • form ozone & other pollutants (smog)
Ozone (O_3)	• gaseous pollutant	• vehicle exhaust and certain other fumes • formed from other air pollutants in the presence of sunlight	• lung disorder • eye irritation • respiratory tract problems • damages vegetation • smog
Particulate matter	• very small particles of soot, dust, or other matter, including tiny droplets of liquids	• diesel engines • power plants • industries • windblown dust • wood stoves	• lung disorder • eye irritation • damages crops • reduces visibility • discolors buildings and statues
Sulfur dioxide (SO_2)	• gaseous compound made up of sulfur and oxygen	• coal-burning power plants and industries • coal-burning stoves • refineries	• eye irritation • lung damage • kills aquatic life • reacts in atmosphere to form acid rain • damages forests • deteriorates buildings and statues

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Is Your Air Clean?

Target Grade Levels
Eighth - Tenth

Time
45 minutes (with possible extensions)

Materials
- the map prepared by students in the warm-up exercise
- an easel or some other method of displaying the poster
- chalk
- chalkboard
- guest Presenters

Knowledge and Skills (TEKS)
- Science:
  - Use scientific inquiry methods to plan and implement investigative procedures including asking questions, formulating testable hypotheses, collecting data, making measurements with precision, organize, analyze, predict trends, and communicate conclusions.
- Language Arts:
  - Plans, prepares, organizes, and presents oral messages with attention to thesis statement, valid evidence, effective appeals, appropriate language, and purpose fitted to the audience;
  - Uses writing as a tool for reflection, exploration, learning, problem solving, and personal growth; and
  - Uses effective listening strategies to provide appropriate feedback in a variety of situations such as informal conversations; formal debates; class discussions; and informative, persuasive, or artistic presentations.

Overview
This activity is a follow-up to the activity called "Finding Sources of Air Pollution" in which students located potential areas of air pollution on a map of the community. It calls on students to develop an action plan for investigating air pollution in the community more thoroughly and communicating their findings to different audiences. The activity begins with student presentations of the map and information developed in the Finding Sources of Pollution lesson.

Background Information
Every citizen has the ability to participate in building and protecting his or her community. But, in order to do so, citizens must be aware of the problems that exist. Citizens also must have some sense of confidence that they can have an impact. Knowing how to recognize pollution and identify its sources is the first step in protecting the environment in a community. This awareness, however, serves little purpose if students do not also learn to use research and investigation skills to verify their assumptions. Determining who controls sources of pollution and finding out what they are doing to limit adverse impacts are important next steps in becoming a responsible citizen.

Suggested Reading
- Edelson, Edward. C*lean Air*. New York: Chelsea House Publishers (1992).
- Moos, Shawna. "Pollution-Prevention Power to the People (EPA's Toxics Release Inventory Database)." *Technology Review*, 95 (October 1992) p. 15.
- O'Neill, Catherine. "Cleaner Air! Cough! Wheeze! Gasp!" *Washington Post* (Washington Health), 115 (6 October 1992) p. WH18.

What to Do
1) Vocabulary

a) pollution	c) ground-level ozone
b) nitrogen oxides	d) lead

e) toxic release inventory
f) carbon monoxide
g) particulate matter
h) sulfur dioxide
i) Hazardous Air Pollutants (HAPs)

2) Activities

a) Before class begins

i) Display the map prepared by the students in the “Finding Sources of Air Pollution” activity. Call on the three students for 5-minute presentations. These presentations will describe the signs, health effects, and possible sources of pollution in the community and the reasoning that led students to these conclusions.

ii) Following the presentations, begin the discussion by commenting on their observation and mapping effort.

iii) Now that they have developed a theory about the pollution sources in the community, ask how they would investigate and verify their information. How would they find out what is being done to control the pollution? Through this discussion students will identify some specific ways to carry out a more detailed investigation of the air pollution in the community. Most of the work involved may have to be done out-side of class.

iv) Ask for a student volunteer to record ideas contributed during the discussion on the chalkboard, and ask for a second volunteer to record them on paper, so they can be copied and distributed to the class later.

v) To begin, ask who in the community students would expect to know about air pollution. (If necessary, prompt students by asking if the local health department would know.) The completed list might include the local health department, the local library, doctors, someone who works for the EPA, the local Heart or Lung Association, and others.

vi) Ask students which of these knowledgeable people they would want to talk to. Do they think any one of these people would be able to answer all their questions? If not, how many others would they talk with? Ask what they would do if they got different, conflicting information from their sources. How would they decide what is correct? (The point here is to reinforce that it may be necessary to examine several sources to sort out the most definitive information.)

vii) Besides verifying that the information on the map is correct, ask what other kinds of information they would want to get? For example, would it help to know if the government has made any laws requiring the control of air pollution? How would they find out what laws exist? What would they need to know about them? (The list should include items such as what the requirements are, who is responsible for enforcing them, how they are being enforced, the penalties for breaking the laws, if there are plans for making the laws stricter or more lenient, and why these changes are being considered.)

viii) Ask how they would go about finding out what currently is being done to control air pollution. (If necessary, prompt students by suggesting they might interview some of

the polluters they have identified.) Encourage them to suggest others who might be doing things to control pollution? (The point here is to help students recognize that the local government and other organizations may be taking other actions to control pollution in the community and, therefore, they should be interviewed also.)

ix) Ask how they would use all the information once they have gathered it. Who would they want to tell about it? What would be the best, most effective way to present the information? (The point here is to elicit some ideas for presentation formats. The list might include writing a report, writing an article for the school newspaper, designing a display and putting it in the school lobby or taking it to local malls, making a presentation at a school assembly or at a PTA meeting.)

x) Explain that through this discussion the students have begun to develop an "action plan." At this point, suggest that copies of the plan be made and distributed to all students in the class and that they discuss (in class on another day) which, if any, of the actions they want to pursue.

3) Review
Discuss/review points of action plan with class.

4) Evaluation
Have each student write an action plan as a homework assignment.

5) Extensions Activities

a) Assign a student or a team of students to write an article for the school newspaper about the visit from the EPA representative and the action plan the class developed.

b) Divide the class into teams and assign each team a part of the "action plan" to pursue. (For example, one team would be responsible for interviewing potentially polluting industries and others about what kinds and how much pollutants they release and about what they are doing to control releases. Another team would research existing pollution control laws. Another would interview appropriate sources about what the local government is doing to control pollution. When their work is completed, the same EPA employee could be invited back to hear each team report on their activities. Teams also could be tasked to present the information in one of the formats suggested during class discussion (see step 10).

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Adapted from: "Activity 10 - Is your air clean?" *United States Environmental Protection Agency–Project A.I.R.E.* 2003. Page 121.
http://www.epa.gov/region01/students/pdfs/activ10.pdf

Lifestyles and the Environment

Target Grade Levels
Ninth - Twelfth

Time
40 minutes in class #1, with a take-home assignment;
40 minutes in class #2

Materials
- chalk
- chalkboard
- student worksheet
- guest Presenters

Knowledge and Skills (TEKS)
- Science:
  - Distinguish between renewable, non-renewable, and recyclable resources;
  - Recognize the impact that lifestyle changes have had on industrial activities that cause air pollution; and
  - Identify ways to use less resources and to reduce air pollution.
- Language Arts:
  - Expands vocabulary in a variety of ways.
- Social Studies:
  - Understand the effect of supply and demand on the price of resources; and
  - Recognize the relationship between population and consumption;

Overview
This activity demonstrates that our lifestyles are supported by complex industrial activities that consume vast quantities of natural resources and result in large quantities of air pollution. As the population grows and the standard of living increases, the consumption of resources and emission of pollutants also increase. These trends have significant implications for the lifestyles of students and their families.

Background Information
The manufacture and consumption of many goods and services results in the production of pollution as a side effect. Much pollution, if not controlled, can cause diseases in humans and other species, as well as property damage. In addition, these air pollutants can cause changes in the Earth's climate that may make it more difficult and, more costly to produce food and the resulting melting of polar icecaps may cause the sea level to rise. There have always been pollutants in the atmosphere, both from natural and human sources. The most important human source is combustion of fuels (wood, coal, natural gas, petroleum) for transportation, heating and cooling, electricity generation, and manufacturing. In the past, human sources represented just one of many sources of pollutants. However, the importance of human sources has increased in recent years because of several developments:

1) The products we use in our everyday lives (automobiles, electric equipment) have been growing more and more sophisticated, thereby requiring more industrial processes that emit large quantities of pollutants.

2) The per capita consumption of goods and services has increased substantially.

3) The U.S. and world populations have increased substantially over the past 100 years.

Because the Earth's atmosphere is a finite size, it will not sustain the continued growth of the current patterns of consumption. The following are among options available to us:

1) Continue our current practices: this strategy ultimately might result in a crisis sometime in the future.

2) Change our consumption patterns and, as necessary, our lifestyles to use fewer resources and use resources that pollute less.

3) Improve our technology so we can produce the materials and offer the services we want with fewer resources. For example, a solid state radio may consume less steel, plastic, and glass, and use less electricity, than an old vacuum-tube-based radio, and more efficient electronic data communications may lead to a reduction of travel, because many people can work at home several days a week.

Suggested Reading

- Bright, Michael. Traffic Pollution. New York, NY: Gloucester Press (1991).
- "Green, Greener, Greenest." *Economist*, 311 (6 May 1989) p. 67.
- "A Guilt-Free Guide to Garbage." *Consumer Reports* (February 1994) p. 91.
- Lowe, Marcia D. "Reinventing the Wheel: From Denmark to Japan." *Technology Review*, 93 (May 1990) p. 60.
- Rauber, Paul. "Key to Gridlock? The Free Ride Goes the Way of the Free Lunch." *Sierra*, 79 (March 1994) p. 45.
- "Recycling, Is It Worth the Effort?" *Consumer Reports* (February 1994) p. 92-98.
- Saunders, Linda. "Uneasy Riders (Cars and Pollution)." *Health*, 22 (February 1990) p. 46.
- Stambler, Irwin. "'We Can Meet Energy Needs and Not Destroy Our Environment' (William Ruckelshaus Tells Engineers)." *Research and Development*, 30 (September 1988) p. 32.
- What You Can Do To Reduce Air Pollution. Washington, DC: *U.S. Environmental Protection Agency EPA/450/Kindergarten* - 92/002 (1992).
- "Where Household Goods Go." *Consumer Reports* (February 1994) p. 99-100.
- Wood, Daniel S. "L.A. Sends Its Workers Home—To Work." *Christian Science Monitor*, 86 (1 December 1993) p. 7.

Procedure

1) Vocabulary

   a) atmosphere
   b) free good
   c) non-renewable resource
   d) raw material
   e) recyclable resource
   f) renewable resource
   g) scarce good
   h) supply and demand

2) Activities

   a) Class #1

      i) Distribute the student handout called "Major Anthropogenic Air Pollutants." Review the sources and the basic health and environmental effects of air pollution with the class.

ii) Present and discuss the concepts of a “free good,” “scarce good,” “supply and demand,” “renewable,” “non-renewable,” and “recyclable” resources. After defining each concept, ask the class for examples.

iii) Put the following table on the chalkboard and assign a student to fill it in as the class discussion progresses. Have the class list things they currently have (such as a car, TV, PlayStation) and their typical activities (such as traveling to school, playing sports, going to the movies). Then list the associated raw materials and direct and indirect pollutants. (The first entry is provided as an example.)

Current Goods and Activities	**Raw Materials Required**	**Pollutants Directly Resulting**	**Pollutants/Activities Resulting**
Driving to school	Fuel, oil, lubricants	CO_2, NO_x, lead, hydrocarbons	Steel, rubber, glass, electricity to manufacture car

iv) Put a second table (shown below) on the chalkboard and assign a student to fill it in as before. Have the class list things they would like to have and activities they would like to undertake in the future. Then, list the associated raw materials and pollutants. (A call to local manufacturing companies prior to the class may be useful in helping students with the quality and quantity of the information.)

Future Goods and Activities	**Raw Materials Required**	**Pollutants Directly Resulting**	**Pollutants/Activities Resulting**

v) Compare the two tables. Ask the class what conclusions they can draw from the comparison and speculate about the implications for our store of raw materials and pollution.

vi) Discuss the historical trends in consumption of raw materials, as well as trends of population and energy consumption. Have students enumerate products and activities in our daily lives that use these materials and speculate what the future consumption of these materials might be. In discussing these topics, note the following as needed:

(1) Per capita use of lumber has been declining. This decline was caused by several factors: Diminishing supply and relative to the growing population, substitution of other materials such as plastics and metals for wood, and increased price of wood over time.

(2) According to the Energy Information Administration (EIA), the United States on average accounts for 25 percent of world petroleum consumption as of January 2004. If per capita consumption does not change, the U.S. would consume 26.8 million barrels of oil per day, which is about 26 percent of current annual production. It is not known whether there is enough petroleum in the ground to increase world production substantially higher than current production.

(3) The per person consumption of steel and aluminum decreased from 1960 to 1990. This is not necessarily indicative of the long-term trend. During this period, imports of products such as automobiles and electrical and electronic equipment that contain these metal have also increased.

vii) Assign different students or teams of students to take a raw material and prepare a graph illustrating the data on the handout and their projections for the future.

3) Review

a) Review the graphs prepared in the previous class.

b) Have the class discuss potential problems if we continue current consumption and production patterns. Focus on the following questions:

i) What does this imply for the prices and availability of the goods you want?

ii) If you earned a fixed amount each month, would you be able to afford all the things you want?

iii) If everyone could afford all the things they wanted in the future, what would happen to air quality?

c) Ask for ideas on how we could reduce these problems and obtain the things we want. If necessary, prompt students with the following:

i) Change our desires?

ii) Change how products are designed to use fewer resources and pollute less (smaller cars, simpler packaging of consumer products)?

iii) Use more recyclables and renewable materials?

iv) Reduce consumption of fuels for transportation, heating, and cooling?

4) Evaluation
Extension activities can be performed as graded exercises.

5) Extension

a) Give students a library assignment to compare the energy use of different models of cars. Include small, medium, large, sports, “muscle” and utility vehicles, and vans. They can estimate the average miles driven per year by their families, compare these to National averages, and look up EPA fuel consumption estimates for specific car models. (Consumer Reports, which is available at most libraries, publishes this information in the April edition each year.) Have them do the calculations in both gallons of fuel and dollars per year. Then have them discuss the following questions:

i) If the cost of gasoline doubles by the year 2004, will you buy a different car?

ii) What characteristics of the car (size, comfort, acceleration, safety) would you be willing to trade for better fuel consumption?

b) Ask the students to take an inventory of their families’ energy use for a typical week (or year) using the student worksheet called “Family Resource Use.” Have them take the

worksheet home, fill it in with their family's help, and bring it back to class. After the worksheets have been completed, have students discuss the reasons for differences and how their families could improve their resource use. (To facilitate this discussion, you may want to divide students into groups according to the type of fuel used, then record the fuel usage on the chalkboard for heating, cooling, and water heating. Within each group, have students discuss differences by referring to the other factors on the worksheet such as insulation, storm windows and doors, and the use of set-back thermostats.)

c) Ask students to look up in the library, or in articles you may supply, the energy required (in kilowatt-hours) and the air pollution emitted (in pounds or tons) in the manufacture a ton of aluminum, steel, and paper.

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Adapted from: "Activity 1 - Lifestyles and the Environment" *United States Environmental Protection Agency–Project A.I.R.E.* 2003. Page 181.
http://www.epa.gov/region01/students/pdfs/activ1.pdf

STUDENT WORKSHEET

LIFESTYLES AND THE ENVIRONMENT
FAMILY RESOURCE USE

Use the following questions and table to record your family's energy use for a typical year or week. This information is most likely available in your home. Discuss it with your family.

Home Heating (indicate the following):

- Type of fuel (for example, oil, natural gas, coal) _____
- Volume used last year (in gallons, cubic feet, therms, or other measure) ____
- Cost last year $____
- Do you use a programmable thermostat? ___,
- Days of the week are they used? ____, hours used? ____
- Size of your house in square feet, not including garage, basement, or unfinished attic___

Water Heating (indicate the following):

- Type of fuel (for example, natural gas, electricity) _____
- Do you use a programmable thermostat? ___,
- Days of the week are they used? ____, hours used? ____
- Size of water heater in gallons ____

Home Cooling (indicate the following):

- Type of fuel (for example, natural gas, electricity) _____
- Volume used last year (in cubic feet, therms, or kilowatt hours) ____
- Cost last year $____
- Do you use a programmable thermostat?
- Days of the week are they used? ____ hours used? ____
- Size of your house in square feet, not including garage or basement _____

Home Insulation (indicate the following):

- Roof insulation material (for example fiberglass, rockwool, cellulose, none)_____
- Roof insulation thickness (for example, 3.5 inches, 6 inches, 7.5 inches) ____
- Wall insulation material (for example fiberglass, rockwool, cellulose, none) _____
- Wall insulation thickness (for example, 3.5 inches, 6 inches, 7.5 inches) ____
- Type of wall (for example, masonry, wood frame) _____
- Do most of the windows have storm windows? ____
- Do most of the windows have double glazing, where two panes of glass separated by an air space offering both thermal and acoustic insulation? ____

Recycling:

- What products do you recycle in your home (plastic, aluminum foil, aluminum cans, steel cans, plastic jars and bottles, newspaper, other paper)?
  _____

Travel:

- How do you get to school (school bus, public transportation, auto, car pool)?
  _____
- Distance from house to school? _____
  - How long would it take to walk? _____
  - How long would it take to bike? _____
  - How long would it take to skate? _____
- How do your other family members travel to school or work? ____
- What other methods might they use?_____ Why are these not used?
  _____

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Appendix A

Glossary

Glossary

acetaldehyde—(1a) a colorless volatile water-soluble liquid aldehyde $c_2h_4o_2$ used chiefly in organic synthesis. (1b) Acetaldehyde is mainly used as an intermediate in the synthesis of other chemicals. It is ubiquitous in the environment and may be formed in the body from the breakdown of ethanol. Acute (short-term) exposure to acetaldehyde results in effects including irritation of the eyes, skin, and respiratory tract. Symptoms of chronic (long-term) intoxication of acetaldehyde resemble those of alcoholism. Acetaldehyde is considered a probable human carcinogen (group b2) based on inadequate human cancer studies and animal studies that have shown nasal tumors in rats and laryngeal tumors in hamsters.

acetic acid—a colorless, pungent, liquid acid with a chemical formula of $c_2h_4o_2$ that is the chief acid of vinegar and that is used especially in synthesis (as of plastics)

acid—any of various typically water-soluble and sour compounds that in solution are capable of reacting with a base to form a salt, redden litmus, and have a ph less than 7, that are hydrogen-containing molecules or ions able to give up a proton to a base, or are substances able to accept an unshared pair of electrons from a base

acid rain—acid precipitation in the form of rain

aerodynamics—a branch of dynamics that deals with the motion of air and other gaseous fluids and with the forces acting on bodies in motion relative to such fluids

aerosol—a suspension of fine solid or liquid particles in gas; e.g. smoke, fog, and mist

air—the mixture of invisible odorless tasteless gases (as nitrogen and oxygen) that surrounds the Earth

airfoil—a body (as an airplane wing or propeller blade) designed to provide a desired reaction force when in motion relative to the surrounding air

air pollution—the soiling of the atmosphere by contaminants to the point that may injure health, property, plant or animal life, or prevent the use and enjoyment of the outdoors.

air quality health alert days—ozone pollution occurs mostly during hot summer days with little or no wind. Forecasters can predict when the ozone level is expected to exceed standards for healthy air. If unhealthy ozone levels are predicted, an "air quality health alert" is announced to the media and public for the following day so that people can take steps to protect their health and help to reduce the pollution emissions that eventually become ozone.

air quality index—an index for forecasting and reporting daily air quality. EPA gathers the forecasts for every city in the nation. The AQI tells you how clean or polluted your air will be, and warns of any associated health concerns you should be aware of.

air resistance—resistance to movement of an object provided by the fluid properties of air

airshed—a geographic area that, because of topography, meteorology, and/or climate, is frequently affected by the same air mass

alternative—different from the usual or conventional

alternative fuel—any fuel for a vehicle other than a petroleum based fuel

altocumulus—a fleecy cloud formation consisting of large whitish globular cloudlets with shaded portions; they are lower than cirrus clouds, but still quite high. They are made of liquid water, but seldom make rain.

altostratus—a cloud formation similar to cirrostratus but darker and at a lower level

ambient air—outdoor air, the air we breathe

ammeters—an instrument for measuring electric current in amperes

ammonia—a pungent, colorless, gaseous, alkaline compound of nitrogen and hydrogen (NH_3) that is very soluble in water and is easily condensed to a liquid by cold and pressure.

aneroid barometer—an instrument for measuring atmospheric pressure. It is constructed on the following principles: an aneroid capsule (vidie capsule, which is a thin, disk-shaped box or capsule, usually metallic) is partially evacuated of gas, and is restrained from collapsing by an external or internal spring. The deflection of the spring will be nearly proportional to the difference between the internal and external pressures. Magnification of the spring deflection is obtained both by connecting capsules in series and by mechanical linkages.

anthropogenic—human-made; of, relating to, or resulting from the influence of human beings on nature

anvil cloud—also referred to as cumulonimbus, a large storm cloud with explosive vertical development that creates an anvil shape

appliance—an instrument or device designed for a particular use; specifically a household or office device (as a stove, fan, or refrigerator) operated by gas or electric current

atoms—(1) one of the minute indivisible particles of which according to ancient materialism the universe is composed; (2) a tiny particle; (3) the smallest particle of an element that can exist either alone or in combination

atmosphere—the whole mass of air surrounding the Earth

auto emissions—the gases and particles emitted from an automobile, which can include but are not limited to nitrogen oxides, carbon monoxide, carbon dioxide, volatile organic compounds, and sulfur dioxide, and which vary with the type of fuel being burned and the efficiency of the combustion process

avoided costs—costs which are avoided by an action

baghouses—a device or facility in which particulates are removed from a stream of exhaust gases (as from a blast furnace) as the stream passes through a large cloth bag; also, the bag used to filter the gas stream

base—any of various typically water-soluble and bitter tasting compounds that in solution have a ph greater than 7, are capable of reacting with an acid to form a salt, and are molecules or ions able to take up a proton from an acid or able to give up an unshared pair of electrons to an acid

benefit—something that promotes well-being

benzene—a colorless, hazardous hydrocarbon emitted during gasoline storage and transfer and from refining processes

bicycling—moving from one place to another by pedaling a two-wheeled vehicle, or “bicycle”

Bike Buddies—a program in which two or more individuals bicycle together to or from school or work for increased safety and camaraderie

Biogenic—describing changes in the environment resulting from the activities of living organisms

biomass—(1) the amount of living matter (as in a unit area or volume of habitat); (2) plant materials and animal waste used especially as a source of fuel

boiler—the part of a steam generator in which water is converted into steam and which consists usually of metal shells and tubes, or a tank in which water is heated or hot water is stored

bones—the hard, largely calcareous connective tissue of which the adult skeleton of most vertebrates is chiefly composed

brain—the portion of the vertebrate central nervous system that constitutes the organ of thought and neural coordination, includes all the higher nervous centers receiving stimuli from the sense organs and interpreting and correlating them to formulate the motor impulses, is made up of neurons and supporting and nutritive structures, is enclosed within the skull, and is continuous with the spinal cord

buffer—a substance capable in solution of neutralizing both acids and bases and thereby maintaining the original acidity or basicity of the solution; also: a solution containing such a substance

bus—a large vehicle that can carry many passengers, usually along a regular route

CAMS—(Continuous Air Monitoring Stations) an air quality monitor which monitors ozone levels to help determine if a region is in attainment of ozone standards

car—a four-wheeled vehicle for passenger transportation, propelled by an engine

carbon cycle—a complex series of processes through which all of the carbon atoms in existence rotate.

carbon dioxide - a colorless, odorless gas formed during breathing, combustion, and decaying that adds to the greenhouse effect

carbon monoxide - a colorless, odorless, poisonous gas produced when carbon-containing substances such as coal, oil, gasoline, wood, or natural gas do not burn completely

carcinogens—a substance or agent producing or inciting cancer

carpool(ing)—an arrangement by which two or more people to travel to and from work, school or other activities together in one automobile

catalyst—(1) a substance (as an enzyme) that enables a chemical reaction to proceed at a usually faster rate or under different conditions (as at a lower temperature) than otherwise possible (2) an agent that provokes or speeds significant change or action

catalytic converter - an air pollution control device that uses a chemical reaction to reduce emissions from motor vehicles

chemical energy—the energy released when substances combine or break down and form new substances.

chlorofluorocarbons (CFCs) - chemicals used as coolants in refrigerators and air conditioners that can harm the ozone layer in the upper atmosphere

coal—black or brownish black solid combustible substance formed by the partial decomposition of vegetable matter without free access of air and under the influence of moisture and often increased pressure and temperature that is widely used as a natural fuel; having four main types: lignite, sub-bituminous, bituminous, and anthracite

cilia—a minute short hairlike process often forming part of a fringe; especially, one on a cell that is capable of lashing movement and serves especially in free unicellular organisms to produce locomotion or in higher forms a current of fluid

cirrocumulus—these high altitude clouds take the form of individual puffs. They often form in patchy groups with spaces between the individual members. Composed almost entirely of ice crystals, their base altitudes typically range from about 16,500 to 45,000 feet.

cirrostratus—these high clouds have a more continuous appearance that the other high altitude clouds. They are composed almost entirely of ice crystals, and often blanket large areas of the sky. They are typically so thin that you can easily see the sun or even the moon through them. Their base altitudes typically range from 16,500 to 45,000 feet.

cirrus—these high clouds are composed almost entirely of ice crystals. They display a wispy, feathery appearance. Their base altitudes typically range from 16,500 to 45,000 feet.

Clean Air Act—congress created the Clean Air Act (CAA, Amended in 1990) to protect our health and air from further damage, and to begin to reverse some of the damage caused by decades of air pollution. the simple fact is that air pollution can make you sick, damage the environment, damage property, and cause haze that reduces visibility in national parks and interferes with aviation. The Clean Air Act aims to improve air quality in the United States.

clean fuel—a fuel which produces less, little, or no pollution when compared with conventional fuels

clouds—a visible mass of particles of condensed vapor (as water or ice) suspended in the atmosphere of a planet (as the Earth) or moon

coal combustion—coal burning or the production of heat and light energy through a chemical process involving coal

Coefficient of drag (Cd)—the ratio of the drag on a body moving through air to the product of the velocity and the surface area of the body

combustion—(1) an act or instance of burning; (2) a usually rapid chemical process (as oxidation) that produces heat and usually light; also: a slower oxidation (as in the body) (3) the process of burning a fuel to release heat energy

compact fluorescent (light bulb)—a bulb that produces visible light by electromagnetic radiation; a glass tube whose inner wall is coated with a material that lights when an electrical current causes a vapor within the tube to discharge electrons

compliance—conformity in fulfilling official requirements

compliance monitoring—the monitoring of emissions from pollution sources to track and ensure compliance with environmental regulations

compress—to press or squeeze together

cone—solid bounded by a circular or other closed plane base and the surface formed by line segments joining every point of the boundary of the base to a common vertex

congestion—the condition resulting from filling a street or freeway to excess with traffic; the condition of being overcrowded or clogged

conservation - a careful preservation and protection of something; planned management of a natural resource to prevent exploitation, destruction, or neglect

consume - to eat or use up

contaminant - an element or pollutant that soils the air

convection—(transport of heat by the movement of parts of a fluid (air or water); cool air is denser than warm air and as it settles the cool air pushes the warm air upward

conversion—the changing of a substance or the energy in it from one form to another

conversion efficiency—the percentage of usable energy that is left after an energy conversion.

Efficiency = (energy output / energy input) x 100

conversion loss—the amount of energy lost in the changing of one form of energy to another form. much of this energy loss is in the form of waste heat.

convert—to change something into another form

cost—the amount of money needed for payment

criteria pollutants—The EPA uses six "criteria pollutants", ozone, lead, respirable particulate matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide as indicators of air quality and has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called National Ambient Air Quality Standards (NAAQS).

cube—the regular solid of six equal, square sides

cumulonimbus—these clouds are also known as thunderstorm clouds. Especially strong upward convection associated with extreme instability in the atmosphere can lead to the nearly explosive vertical development of these clouds. While their bases range from near the ground to about 6,500 feet, their tops can extend well into the region of the high clouds.

cumulus—these low clouds have a puffy appearance that resembles cotton balls or popcorn. They frequently have flat bases with lumpy tops. With bases usually ranging from near the surface to 6,500 feet, these clouds form in air from heated areas on the ground.

current—a flow of electric charge; also, the rate of such flow

cyclones—(1a) a storm or system of winds that rotates about a center of low atmospheric pressure, advances at a speed of 20 to 30 miles (about 30 to 50 kilometers) an hour, and often brings heavy rain

demolish—tear down, raze, do away with, destroy

deterrence—the inhibition of criminal behavior by fear especially of punishment

diesel—a type of fuel commonly used to power large vehicles, such as long-haul trucks, garbage trucks, buses, and off-road construction equipment, or vehicle driven by an engine fueled with diesel fuel

Direct Current (DC)—an electric current flowing in one direction only and substantially constant in value—abbreviation DC

dispersion—the process of breaking up or diluting high concentrations of something, particularly air pollutants

drag—the retarding force acting on a body (as an airplane) moving through a fluid (as air) parallel and opposite to the direction of motion or friction between engine parts; also, retardation due to friction

ecology—(1) a branch of science concerned with the interrelationship of organisms and their environments (2) the totality or pattern of relations among organisms and their environment

efficiency - being effective with minimum waste, expense, or unnecessary effort

electrical energy—energy in the form of a flow of electrons that can be produced by chemical activity in a battery, by friction, or by generators. Electrical energy can be transformed to other forms of energy such as light, heat, mechanical, or sound.

electrical power—the product of voltage and current

electric generating plant—a facility composed of one or more pieces of equipment connected to or part of a structure and designed to provide a service such as heat or electricity or water or sewage disposal; "the price of the house included all utilities"

electricity—created when a metal wire is moved through a magnetic field; a flow of energy involving electrons and other subatomic particles

electrostatic precipitators—he type of air cleaners which gives particles of dust a charge by passing the dust-laden air through a strong (50-100 kv) electrostatic field. This causes particles to be attracted oppositely charged plates so they can be removed from an airstream. These devices are primarily used for stack gas cleaning.

elemental oxygen—the element symbolized by the letter O, an atom having an atomic number of eight and an atomic weight of 15.9994

eliminate—to remove or do away with

emission—a discharge or release of pollutants into the air, such as from a smokestack or automobile engine

energy—the ability to do work or make things move. Energy exists in a variety of forms (electrical, mechanical, gravitational, light, nuclear, chemical, heat or thermal) and can be converted from one to another. Common units for measuring energy are calories, joules, Btu, and kilowatt-hours.

energy conversion device—an entity that changes energy from one form to another.

energy-efficient incandescent—reduced-wattage incandescent bulbs are slightly more energy-efficient than standard incandescent light bulbs. They save energy by producing slightly less light at a lower wattage. Tungsten-halogen incandescent lamps have a similar light output as standard incandescent bulbs but use 40 percent less energy and last four times longer.

environment—the combination of all external conditions and influences relating to the life, development, and survival of all living things

environmental justice—the fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development and enforcement of environmental laws, regulations, and policies. Fair treatment implies that no population should be forced to shoulder a disproportionate share of exposure to the negative effects of pollution due to lack of political or economic strength.

equivalent—equal in value, force or meaning

ethanol—a colorless, volatile, flammable liquid with a chemical formula of C_2H_5OH that is the intoxicating agent in liquors and is also used as a solvent

feel—to handle or touch in order to examine, test, or explore some quality

fission—the splitting of atomic nuclei resulting in the release of large amounts of energy

fluid—(1a) having particles that easily move and change their relative position without a separation of the mass and that easily yield to pressure, capable of flowing

fluorescent—(1) able to emit light of a certain wavelength when activated by light of a shorter wavelength; (2) a discharge lamp in which a phosphor coating transforms ultraviolet energy into visible light; (3) a bright vivid color that glows under a black light

fossil fuels—coal, oil, and natural gas; this term applies to any fuels formed from the fossil remains of plants and animals that have been buried for millions of years.

formaldehyde—a colorless, pungent, irritating gas having a chemical formula of CH_2O used chiefly in aqueous solution as a disinfectant and preservative and in chemical synthesis

form drag—drag force created by the wind hitting the aircraft

free good—not scarce; available in as great a quantity as desired with zero opportunity cost to society, but not necessarily zero price

friction drag—friction drag occurs at the boundary layer. This is the area close to the airfoil of the plane where the average speed of the airflow is slower than the surrounding air. This "skin" of air is what slides against the surrounding airflow and causes friction. In the boundary layer, the flow can be laminar or turbulent. A uniform flow of air, parallel to the

airfoil, is the laminar portion of the boundary layer, found closer to the leading edge. A turbulent portion of the boundary layer, near the trailing edge, is irregular and disoriented. A boundary layer that is turbulent increases the friction drag. Somewhere between the leading edge and the trailing edge, the boundary layer changes from laminar to turbulent. In order to bring down the friction drag, engineers try to delay this change as much as possible. One way of achieving this is to keep the airfoil as smooth as possible. The smallest of irregularities, even tiny bugs that hit the airfoil, can have the overall effect of changing the boundary layer to turbulent sooner.

fuel—any substance that can be burned to produce heat. (With nuclear energy, a substance that undergoes fission in a chain reaction to produce heat.)

fuel cell—a device that changes the energy in fossil fuels to electricity.

fuel efficiency—the amount of work obtained for the amount of fuel consumed. In cars, fuel efficiency is commonly referred to as “miles per gallon”.

fumes—smoke, vapor or gas, especially when irritating or offensive

gas—the state of matter distinguished from the solid and liquid states by: relatively low density and viscosity; relatively great expansion and contraction with changes in pressure and temperature; the ability to diffuse readily; and the spontaneous tendency to become distributed uniformly throughout any container

gaseous—having the properties of a gas

gasoline—a volatile, flammable liquid made from a refined form of crude oil; currently the most commonly used fuel in vehicles

gearbox—a set of cog wheels which enable a car to travel easily at different speeds

global climate change—a change in the world's climate

generator—a machine that converts mechanical energy into electrical energy.

geothermal—pertaining to heat energy extracted from reservoirs in the Earth's interior, as in the use of geysers, molten rock and steam spouts.

granite—plutonic igneous rock having visibly crystalline texture; generally composed of feldspar, mica and quartz

gravity—the force of attraction between all masses in the universe; especially the attraction of the Earth's mass for bodies near its surface

green electricity—electric power produced from energy resources that emit little pollution

greenhouse effect—warming of the surface and lower atmosphere of a planet (as the Earth or Venus) that is caused by conversion of solar radiation into heat in a process involving selective transmission of short wave solar radiation by the atmosphere, its absorption by the planet's surface, and reradiation as infrared which is absorbed and partly reradiated back to the surface by atmospheric gases

green pricing—a program offered by some utilities to charge money above the standard fee, to customers who agree, in order to promote using renewable energies

ground-level ozone—ground level ozone can inflame breathing passages, decreasing the lung's working capacity. Symptoms can include shortness of breath, pain when inhaling deeply, wheezing and coughing. Ground-level ozone can cause eye and nose irritation and aggravates respiratory symptoms and further impairs the ability to perform normal activities. it can dry out the protective membranes of the nose and throat and interfere with the body's ability to fight infection thereby increasing susceptibility to illness.

growth—an increase in size, weight, power, population, etc.

Hazardous Air Pollutant (HAP) - a contaminant that may cause an increase in rates of death or serious illness

hazardous waste—a subset of solid wastes that pose potential threats to public health or the environment and meet any of the following criteria: - is specifically listed as a hazardous waste by EPA; exhibits one or more of the characteristics of hazardous wastes (ignitability, corrosiveness, reactivity, and/or toxicity); is generated by the treatment of hazardous waste; or is contained in a hazardous waste.

haze—fine dust, smoke, or light vapor causing lack of transparency of the air

hear—to perceive or apprehend by the ear

heart—a hollow muscular organ of vertebrate animals that by its rhythmic contraction acts as a force pump maintaining the circulation of the blood

helium—a light colorless nonflammable gaseous element found especially in natural gases and used chiefly for inflating airships and balloons, for filling incandescent lamps, and for cryogenic research

hornos—outdoor wood-fired ovens made of clay or brick for cooking

hurricane—a tropical cyclone with winds of 74 miles (118 kilometers) per hour or greater that occurs especially in the western Atlantic, that is usually accompanied by rain, thunder, and lightning, and that sometimes moves into temperate latitudes

hydrocarbons – also called volatile organic compounds, these are compounds found in fossil fuels, glues, paints, and solvents that can react with other pollutants to form ground-level ozone

hydrogen—a nonmetallic element that is the simplest and lightest of the elements, is normally a colorless odorless highly flammable diatomic gas, and is used especially in synthesis

hydropower—energy or power produced by moving water

illumination - the act of lighting up

incandescent light bulb - a bulb that emits visible light as a result of a filament being heated due to its resistance to electric current

insulation—a substance that resists the transfer of heat, generally by incorporating small pockets of air. Insulation is rated in terms of thermal resistance, called r-value, which indicates the resistance to heat flow. The higher the r-value, the greater the insulating effectiveness.the r-value of thermal insulation depends on the type of material, its thickness and density.

inventory—an itemized list of current assets or a survey of natural resources

jet stream—a long narrow meandering current of high-speed winds near the tropopause blowing from a generally westerly direction and often exceeding a speed of 250 miles (402 kilometers) per hour

kidneys—one of a pair of vertebrate organs situated in the body cavity near the spinal column that excrete waste products of metabolism, in humans are bean-shaped organs about 4 1/2 inches (11 1/2 centimeters) long lying behind the peritoneum in a mass of fatty tissue, and consist chiefly of nephrons by which urine is secreted, collected, and discharged into a main cavity whence it is conveyed by the ureter to the bladder

kilocalorie—unit of heat required to raise the temperature of 1 kilogram of water by $1^{o}C$

kilowatt—1,000 watts

kilowatt-hour—a unit of work or energy equal to that expended by one kilowatt in one hour or to 3.6 million joules

kinetic energy—energy that is produced by motion

landfill—a system of trash and garbage disposal in which the waste is buried between layers of earth to build up low-lying land—also called a sanitary landfill

lanes—divided sections of a roadway wide enough for a single line of cars

large intestine—the more terminal division of the vertebrate intestine that is wider and shorter than the small intestine, typically divided into cecum, colon, and rectum, and concerned especially with the resorption of water and the formation of feces

laws—a rule of conduct or action prescribed or formally recognized as binding or enforced by a controlling authority

lead—a heavy, soft, malleable, ductile, plastic but inelastic, bluish-white metallic element found mostly in combination and used in pipes, cable sheaths, batteries, and solder, known to shield against radioactivity but causes negative health effects if ingested

limestone—a rock that is formed chiefly by accumulation of organic remains (as shells or coral), consists mainly of calcium carbonate, is extensively used in building, and yields lime when burned

liquid—flowing freely like water

litigation—to contest in law

liver—large very vascular glandular organ of vertebrates that secretes bile and causes important changes in many of the substances contained in the blood (as by converting sugars into glycogen which it stores up until required and by forming urea)

lungs—one of the usually paired compound saccular thoracic organs that constitute the basic respiratory organ of air-breathing vertebrates

mass transit—travel by public transportation system such as bus or subway

mechanical energy (power)—energy due to the motion of an object. Example: the energy of the moving parts of an automobile engine.

meteorologist—a scientist that deals with the atmosphere and its phenomena and especially with weather and weather forecasting

meteorology - a science that deals with the atmosphere, weather, and weather forecasting

methane—colorless odorless flammable gaseous hydrocarbon ch_4 that is a product of decomposition of organic matter and of the carbonization of coal, is used as a fuel and as a starting material in chemical synthesis, and is the simplest of the alkanes

micrometer (micron) —an instrument used with a telescope or microscope for measuring minute distances

minimize—to reduce or make smaller

molecules—the smallest particle into which an element or a compound can be divided without changing its chemical and physical properties

molecular oxygen—a molecule that is composed of two oxygen atoms, O_2, that has no color, odor, or taste. It is present in both the atmosphere and the oceans, and solar radiation with wavelengths less then 242 nm can break it back into oxygen atoms, $O_2 \rightarrow O + O$. one of these oxygen radicals in turn can combine with O_2 to form ozone, $O_2 + O \rightarrow O_3$

monitoring—to watch, keep track of, or check usually for a special purpose

mouth—(1a) the natural opening through which food passes into the body of an animal and which in vertebrates is typically bounded externally by the lips and internally by the pharynx and encloses the tongue, gums, and teeth

muscles—a body tissue consisting of long cells that contract when stimulated and produce motion

mucus—a viscid slippery secretion that is usually rich in mucins and is produced by mucous membranes which it moistens and protects

National Ambient Air Quality Standards (NAAQS)—required by the clean air act for pollutants considered harmful to public health and the environment, the national ambient air quality standards is made up of two sets of standards. first, primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Second, the secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The U.S. Environmental Protection Agency (EPA) has established NAAQS for six air pollutants: ozone, lead, carbon monoxide, sulfur dioxide, nitrogen dioxide, and respirable particulate matter. The standards were established to protect the public from exposure to harmful amounts of pollutants. When the pollutant levels in an area have caused a violation of a particular standard, the area is classified as "non-attainment" for that pollutant. The EPA then imposes federal regulations on pollutant emissions and designates a time period in which the area must again attain the standard.

natural gas—gas issuing from the earth's crust through natural openings or bored wells; especially: a combustible mixture of methane and higher hydrocarbons used chiefly as a fuel and raw material

nimbostratus—often called rain clouds, nimbostratus exhibit a uniform dark gray appearance. Their bottoms are typically blurred and indistinct due to falling rain or snow. These

clouds have low bases, but may have considerable vertical development bringing the tops into the middle level range.

nitrogen dioxide - a poisonous, brown gas often found in smog and automobile exhaust

nitrogen oxides - gases that form when nitrogen and oxygen in the atmosphere are burned with fossil fuels at high temperatures

nitric—of or containing nitrogen

nitric acid—A colorless or yellowish fuming liquid, formula HNO3. It is highly corrosive and the vapor is very hazardous. Nitric acid and nitrates (mainly ammonium nitrate) occur in the atmosphere in the form of aerosols: the acid is formed from oxides of nitrogen and then reacts with ammonia to form ammonium nitrate (WHO 1997c).

nonattainment—a non-attainment area is one that does not meet the environmental protection agency's standards for air pollution and can be classified as "non-attainment" of those standards. For example, the current National Ambient Air Quality Standards do not allow areas to exceed .08 parts per million of ozone over an eight-hour period. Compliance is based on the fourth highest reading per year averaged over three years.

non-compliance—failure to obey; failure to act as prescribed by a law or regulation

non-renewable resource—something that has a limited supply that cannot be replaced

non-synthetic oil—also known as “dino oil”, natural, mineral-based oil; It is presumed that the remains of dinosaurs contributed to the formation of petroleum millions of years ago

nuclear energy—energy from radioactive decay or from fission or fusion reactions. In a controlled situation it can be used to produce electricity.

nuclear fuel—material containing atoms whose nuclei undergo fission, producing heat.

nuclear powered electric generating plant—a building in which electricity is produced by using the heat given off by nuclear fuel in a controlled chain reaction to make steam which powers the generator.

nuclear reactor—a device in which a fission chain reaction can be initiated, maintained, and controlled. Its essential components are fissionable fuel, moderator, shielding, control rods, and coolant

odor—the sensation that results when olfactory receptors in the nose are stimulated by particular chemicals in gaseous form

oil—a slippery or viscous liquid or liquefiable substance not miscible with water

outdoor air—air taken from the outdoors, ambient

overhangs—an extension of the roof to provide shade

oxygen – the part of air that we breathe in to fuel our bodies and make them go.

ozone - a colorless gas that is formed when pollutants react with sunlight and that is a major part of smog

ozone layer—an atmospheric layer that contains a high proportion of oxygen that exists as ozone. It acts as a filtering mechanism against incoming ultraviolet radiation. It is

located between the troposphere and the stratosphere, around 9.5 to 12.5 miles (15 to 20 kilometers) above the Earth's surface.

parachute—a drag producing device, generally hemispherical (half-sphere) in shape; generally made of light plastic.

particle—a minute quantity or fragment; a relatively small or the smallest discrete portion or amount of something

particle pollution—specks of solid matter, including dust, smoke, fumes, spray, mist, aerosols and fog

particulate—a very small solid suspended in air or water which can vary widely in size, shape, density, and electrical charge

particulate matter—specks of solid or liquid matter, e.g.: dust, smoke, fumes, spray and mist

permit—a legal document giving official permission to do something

ph—p(otential of) H(ydrogen); the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per liter; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (7 is neutral, greater than 7 is acidic, and less than 7 is basic)

photochemical—any chemical reaction which is initiated by light; such processes are process important in the production of ozone and sulfates in smog

photochemical oxidant—products of the degradation of atmospheric emissions resulting from photo oxidation processes. Products include ozone, nitrogen dioxide, and peroxyacetyl nitrate, all of which contribute to the total oxidant concentration.

photochemical process - any chemical reaction which is initiated by light. Such processes are process important in the production of ozone and sulfates in smog

photon—smallest piece of light that exists

photosynthesis—(1) the process of using sunlight as an energy source to produce food in plants (2) the process by which green plants use solar energy to convert simple substances into complex ones which contain chemical energy. carbon dioxide and water are combined, in the presence of sunlight and chlorophyll, into carbohydrates such as sugars, starches, and cellulose.

photovoltaic system—an energy generating system that converts sunlight into electricity

physical energy—also called kinetic energy, the form of energy that an object has by reason of its motion

planning—an act of formulating a program for a definite course of action

plume—the visible emission from a smokestack or chimney

point source—a stationary location or fixed facility from which pollutants are discharged or emitted. Any single identifiable source of pollution, such as a pipe or factory smokestack

pollutant—any substance introduced into the environment that adversely affects the usefulness of a resource.

pollution—material that is harmful to living things; impurities in air, water and land that create an unclean environment

postponed costs—costs that are postponed

potential energy—energy possessed by virtue of its state (not its motion); unlit fuel has potential energy

pounds per square inch (psi) —a unit for measuring pressure. One psi equals the pressure resulting from a force of one pound acting over an area of one square inch.

precipitation—liquid or frozen water falling to Earth, rain or snow

precursor—a substance from which another substance is formed

public utility—a service, as electricity or water, essential to the community; a company providing such a service, controlled by a nationalized or private monopoly and subject to public regulation

rainforest—a large, dense forest in a hot, humid region (tropical or subtropical). Rainforests have an abundance of diverse plant and animal life, much of which is still un-cataloged by the scientific community.

raw material—materials a manufacturer converts into a finished product.

recyclable resource—a resource which can be recycled and used again in another form

regulations—rules specifying the appropriate behavior of agencies, organizations or individuals in the securities industry.

relative humidity—the amount of water vapor (vapor pressure) in a given parcel of air divided by the maximum amount of water vapor the parcel of air could contain at a given temperature (saturation vapor pressure) before it would begin to condense into water droplets.

renewable energy—forms of energy that derive and quickly replenish from the natural movements and mechanisms of the environment, such as sunshine, wind, movement of the seas and the heat of the Earth

renewable resource—natural resource that can be replaced

respirable particle pollution—small respirable particles can penetrate deep into the lungs where they may stay a long time and cause acute or chronic illness. Larger particles may not penetrate as deep as small particles but can cause allergic reactions and other health problems.

respiratory—anything dealing with breathing, or the exchange of oxygen and carbon dioxide

respiratory tract—all of the body parts that help you breathe, including your mouth, nose, throat and lungs.

restitution—a sum of money paid in compensation for loss or injury

retribution—the act of correcting for wrongdoing

RideSharing—an alternative to traveling alone; carpooling, vanpooling, or using transit

risk—source of danger; a possibility of incurring loss or misfortune

sanitize—to make clean by disinfecting

savings—an amount of money not used or put aside for a specific purpose; discounts

scarce good—amount available less than amount people would want if it were free

SchoolPool—the act of a number of students regularly sharing a ride to and/or from school in which driving students or parents divide driving duties

sight—an instance of visual perception

small intestine—the section of the digestive tract between the stomach and the large intestine. Most of digestion occurs here as nutrients are absorbed from food.

smog—the ground-level haze resulting from the sun's effect on air pollutants, consisting primarily of ozone

smoke—gaseous products and small carbon particles resulting from incomplete combustion

smokestacks—pipe or funnel through which smoke and gases are discharged

smell—the sensation that results when olfactory receptors in the nose are stimulated by particular chemicals in gaseous form

solar—relating to the sun

solar cell—a device that changes sunlight to electricity

solar energy—the radiation emitted by the sun. the Earth receives this energy mostly in the forms of heat and light.

solid—a substance that is solid at room temperature and pressure

solid waste—any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous materials resulting from industrial, commercial, mining, and agricultural activities and from community activities

solution—(1) a homogeneous mixture of two or more substances; frequently (but not necessarily) a liquid solution

soot—a black colloidal substance consisting wholly or principally of amorphous carbon and used to make pigments and ink

sphere—a three-dimensional closed surface such that every point on the surface is equidistant from the center

steam turbine—turbine in which steam strikes blades and makes them turn

stomach—an enlarged and muscular saclike organ of the alimentary canal; the principal organ of digestion

stomata - tiny openings on the underside of leaves through which a plant exchanges gases (such as carbon dioxide and oxygen) with the surrounding air

stratocumulus—these low clouds take the form of irregular masses of cumulus clouds merged together with little or no spacing between the clouds. The bases of these clouds are usually found near the ground to around 6,500 feet.

stratosphere—the layer of air that extends from about 10 to 30 miles above the Earth's surface

stratospheric ozone—(1a) ozone found in the stratosphere. (1b) Stratospheric ozone is the same chemical as ground-level ozone, but because it is high above the Earth (instead of close down, where we could breathe it), stratospheric ozone is helpful, not harmful. it protects us by blocking the most harmful rays of the sun - ultraviolet rays - which can cause skin cancer.

stratus—these low clouds exhibit a fairly uniform light to dark gray appearance and typically blanket large areas of the sky. The bases of these clouds are usually found near the ground to around 6,500 feet. A stratus cloud with its base extending down to the ground is known as fog.

sulfur dioxide - a colorless, irritating gas generated in many industrial processes and in the production of electricity from coal; a criteria pollutant

sulfuric acid—a heavy, corrosive, oily, dibasic, strong acid with a chemical formula of H_2SO_4 that is colorless when pure; it is a vigorous oxidizing and dehydrating agent.

supply and demand—Supply is the amount of goods available at a given price at any time. Demand is how many consumers desire the goods that are in supply.

sustainable—able to supply necessities today without sacrificing future generation’s needs

sustainability—meeting the needs of the present without compromising the ability of future generations to meet their own needs, or the health of the planet.

SUV—sport utility vehicle, a large passenger car that holds many passengers and gear

synthetic oil—a non-mineral-based oil with a much higher resistance to heat; composed of molecules that are uniform in weight and shape, which makes its heat of vaporization is much higher

taste—the sensation that results when taste buds in the tongue and throat convey information about the chemical composition of a soluble stimulus

temperature—the degree of hotness or coldness of a body or environment (corresponding to its molecular activity)

temperature inversion—an increase in temperature with height above the Earth's surface, a reversal of the normal pattern.

thermal (energy)—heat energy; the energy of moving particles in a solid, liquid, or gas.

thermal inversion—a meteorological phenomenon in which air temperature increases with height and which can trap pollutants near ground-level.

tire pressure—the air pressure within a tire, customarily expressed in pounds per square inch (psi), which a significant effect on vehicle performance and fuel efficiency

tires—the rubber tube filled with air, fixed around the wheel of a vehicle to facilitate rotation

tornado—a violent destructive whirling wind accompanied by a funnel-shaped cloud that progresses in a narrow path over the land

touch—the event of something coming in contact with the body

toxic—something that can be poisonous or deadly if it is eaten, touched, or inhaled in large enough amounts

Toxic Release Inventory—a program created by the superfund amendments and reauthorization act of 1984 that requires manufacturing facilities and waste handling and disposal sites to report annually on releases of more than 300 toxic materials.

transit—buses, trains and subways used by the public

transport—to move from one place to another

transportation—a facility consisting of the means and equipment necessary for the movement of passengers or goods

troposphere—the innermost part of the 12-mile layer of air encircling the Earth

turbine—any machine that turns kinetic energy into mechanical power

ultraviolet light—short wavelength light that is beyond the visible spectrum at the violet end; rays of light that are invisible to the human eye but can damage objects

ultraviolet radiation—invisible rays that are part of the energy that comes from the sun. Ultraviolet radiation can burn the skin and cause skin cancer. it is made up of two types of rays, UVA and UVB. Skin specialists recommend that people use sunscreens that block both kinds of radiation.

Urban Heat Island—the condition in which temperatures in an urbanized area are significantly warmer than those in surrounding, rural areas, largely due to reduced plant shade and respiration and increased heat absorption by asphalt. Roofs and other dark surfaces; Urban Heat Islands are considered to aggravate some air pollution problems, notably ground-level ozone formation

vanpool—using a van to carry seven or more people to a destination

vapor—a substance in the gaseous state as distinguished from the liquid or solid state

vapor recovery—the recovery of vapors; usually used in reference to the capture and reprocessing of volatile organic compound fumes in an industrial setting or at a fueling station such that the fumes are prevented from polluting the atmosphere

variable—a value liable to change, as in size, number, degrees, etc.; one can manipulate variables in an experiment.

Volatile Organic Compounds - contaminants that can help form ozone near the ground and can be harmful to health

voltage—the term most often used in place of electromotive force, potential, difference or voltage drop, to designate electric pressure that exists between two points and is capable of producing a flow of current when a closed circuit is connected between the two points.

voltmeter—instrument for measuring electric potential;
voltage = resistance (ohms) 2current (amperes)

viscosity—resistance to flow of a liquid.

W—the W in automobile oil descriptions (e.g. “10W40”) stands for “winter” and signifies that the first number given is the oil’s viscosity in cold weather

watershed—a region or area bounded peripherally by a divide and draining ultimately to a particular watercourse or body of water

water vapor—water in the form of gas. Water exists in three phases at the Earth's surface depending on temperature: liquid water, water vapor, and frozen water (ice).

walking—to move from one place to another on foot

Walking School Bus—a program in which several students walk to school together chaperoned by a parent or older student

watt—the absolute meter-kilogram-second unit of power equal to the work done at the rate of one joule per second or to the power produced by a current of one ampere across a potential difference of one volt

wet scrubbers—Devices that trap suspended particles by direct contact with a spray of water or other liquid. In effect, a scrubber washes the particulates out of the dirty air stream as they collide with and are entrained by the tiny droplets in the spray.

wind—air moving (sometimes with considerable force) from an area of high pressure to an area of low pressure

wind energy—air in motion; kinetic energy related to the motion of the atmosphere; air heated by the sun when rising replaced by cold air

wind speed—the rate of the motion of the air on a unit of time. it can be measured in a number of ways. In observing, it is measured in knots, or nautical miles per hour. The unit most often used in the United States is miles per hour.

wind velocity—a vector term which includes both wind speed and wind direction.

work—activity directed toward making or doing something

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Appendix B

Reading List

Reading List

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