HEALTH, POLLUTION, AND SAFETY

TIME

10 days

OBJECTIVES

- *To understand the impact of our current transportation system on public safety and on the human and environmental health of our communities.*
- *To understand the global importance of reducing carbon dioxide emissions.*
- *To identify ways that alternative fuels can alter local and global impacts.*

MATERIALS NEEDED

For background reading and community research

Student handouts

- *Health, Pollution, and Safety: The Challenge*
- *Automobile-Related Emissions*
- *Who's Interested in AFVs? Who Cares About Health, Pollution, and Safety?*
- *Health, Pollution, and Safety: Guide to Community Research*

Other useful resources

- *Access to the library and Internet*
- *Telephone directory or list of phone numbers for these local resources: local or state police or fire department; Coast Guard; local or regional planning department; state department of environmental protection or management; board of health; American Lung Association and its web site; a regional Environmental Protection Agency office and its web site; service stations*
- *In-class speaker to talk about automobile emissions, air quality, global warming, or releases of toxic substances (Regional EPA offices or state environmental agencies often have people available for educational outreach if booked far enough in advance.)*

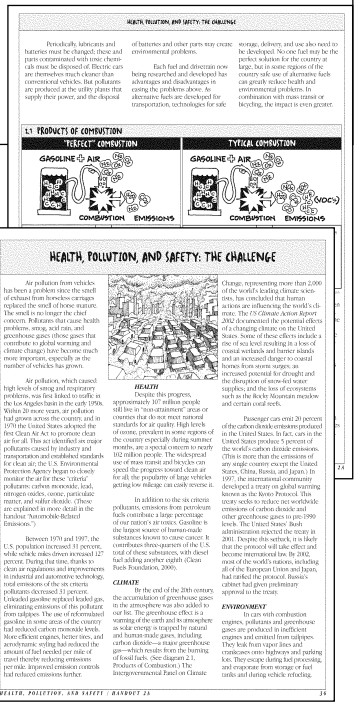
For fuel research and student presentations

Student handouts

- *Health, Pollution, and Safety: Guide to Fuel Team Research*
- *Comparing Alternative Fuels for Pollutants and Greenhouse Gases*
- *Fuel Review Worksheet: Health, Pollution, and Safety*
- *Alternative fuels fact sheets (to be distributed to appropriate teams)*
- *Resource Guide*
- *Evaluating Team Reports and Presentations*

Other useful resources

- *Access to the library and Internet*
- *Publications listed as references for this unit*
- *Flip charts, poster board, transparencies, and use of an overhead projector*
- *Access to word processing or presentation software*


HEALTH, POLLUTION, AND SAFETY: THE CHALLENGE

Periodically, lubricants and batteries must be changed; these and parts contaminated with toxic chemicals must be disposed of. Electric cars are themselves much cleaner than conventional vehicles. But pollutants are produced at the utility plants that supply their power, and the disposal of batteries and other parts may create environmental problems.

Each fuel and drivetrain now being researched and developed has advantages and disadvantages in easing the problems above. As alternative fuels are developed for transportation, technologies for safe storage, delivery, and use also need to be developed. No one fuel may be the perfect solution for the country at large, but in some regions of the country safe use of alternative fuels can greatly reduce health and environmental problems. In combination with mass transit or bicycling, the impact is even greater.

2.1 PRODUCTS OF COMBUSTION

"PERFECT" COMBUSTION

GASOLINE + AIR → COMBUSTION → EMISSIONS

TYPICAL COMBUSTION

GASOLINE + AIR → COMBUSTION → EMISSIONS (HOCs)

HEALTH, POLLUTION, AND SAFETY: THE CHALLENGE

Air pollution from vehicles has been a problem since the smell of exhaust from horseless carriages replaced the smell of horse manure. The smell is no longer the chief concern. Pollutants that cause health problems, smog, acid rain, and greenhouse gases (those gases that contribute to global warming and climate change) have become much more important, especially as the number of vehicles has grown.

Air pollution, which caused high levels of smog and respiratory problems, was first linked to traffic in the Los Angeles basin in the early 1950s. Within 20 more years, air pollution had grown across the country, and in 1970 the United States adopted the first Clean Air Act to promote clean air for all. This act identified six major pollutants caused by industry and transportation and established standards for clean air; the U.S. Environmental Protection Agency began to closely monitor the air for these "criteria" pollutants: carbon monoxide, lead, nitrogen oxides, ozone, particulate matter, and sulfur dioxide. (These are explained in more detail in the handout "Automobile-Related Emissions.")

Between 1970 and 1997, the U.S. population increased 31 percent, while vehicle miles driven increased 127 percent. During that time, thanks to clean air regulations and improvements in industrial and automotive technology, total emissions of the six criteria pollutants decreased 31 percent. Unleaded gasoline replaced leaded gas, eliminating emissions of this pollutant from tailpipes. The use of reformulated gasoline in some areas of the country had reduced carbon monoxide levels. More efficient engines, better tires, and aerodynamic styling had reduced the amount of fuel needed per mile of travel thereby reducing emissions per mile. Improved emission controls had reduced emissions further.

HEALTH

Despite this progress, approximately 107 million people still live in "nonattainment" areas or counties that do not meet national standards for air quality. High levels of ozone, prevalent in some regions of the country especially during summer months, are a special concern to nearly 102 million people. The widespread use of mass transit and bicycles can speed the progress toward clean air for all; the popularity of large vehicles getting low mileage can easily reverse it.

In addition to the six criteria pollutants, emissions from petroleum fuels contribute a large percentage of our nation's air toxics. Gasoline is the largest source of human-made substances known to cause cancer. It contributes three-quarters of the U.S. total of these substances, with diesel fuel adding another eighth (Glass Fuels Foundation, 2000).

CLIMATE

By the end of the 20th century, the accumulation of greenhouse gases in the atmosphere was also added to our list. The greenhouse effect is a warming of the earth and its atmosphere as solar energy is trapped by natural and human-made gases, including carbon dioxide—a major greenhouse gas—which results from the burning of fossil fuels. (See diagram 2.1, Products of Combustion.) The Intergovernmental Panel on Climate Change, representing more than 2,000 of the world's leading climate scientists, has concluded that human actions are influencing the world's climate. The *US Climate Action Report-2002* documented the potential effects of a changing climate on the United States. Some of these effects include a rise of sea level, resulting in a loss of coastal wetlands and barrier islands and an increased danger to coastal homes from storm surges; an increased potential for drought and the disruption of snow-fed water supplies; and the loss of ecosystems such as the Rocky Mountain meadow and certain coral reefs.

Passenger cars emit 20 percent of the carbon dioxide emissions produced in the United States. In fact, cars in the United States produce 5 percent of the world's carbon dioxide emissions. (This is more than the emissions of any single country except the United States, China, Russia, and Japan.) In 1997, the international community developed a treaty on global warming known as the Kyoto Protocol. This treaty seeks to reduce net worldwide emissions of carbon dioxide and other greenhouse gases to pre-1990 levels. The United States' Bush administration rejected the treaty in 2001. Despite this setback, it is likely that the protocol will take effect and become international law. By 2002, most of the world's nations, including all of the European Union and Japan, had ranked the protocol. Russia's cabinet had given preliminary approval to the treaty.

ENVIRONMENT

In cars with combustion engines, pollutants and greenhouse gases are produced in inefficient engines and emitted from tailpipes. They leak from vapor lines and crankcases onto highways and parking lots. They escape during fuel processing, and evaporate from storage or fuel tanks and during vehicle refueling.

HEALTH, POLLUTION, AND SAFETY / HANDOUT 2A

STEP 1 - Background Reading and Discussion

HEALTH, POLLUTION, AND SAFETY: PRESENTING THE CHALLENGE

TIME: 45 minutes, depending on students' prior knowledge of air pollutants and global warming; may be assigned for homework

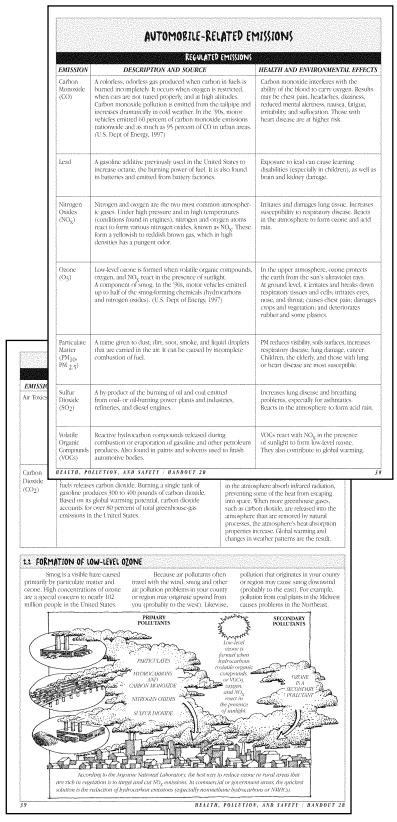
1) Copy and distribute the student handouts listed above for background reading and community research. Have students identify the major health and environmental issues related to a transportation system made up of private gasoline-powered cars. To stimulate discussion, refer to the student handout "HEALTH, POLLUTION, AND SAFETY: THE CHALLENGE."

A key point for students to understand is that with small numbers of vehicles in operation, their impact on public health and the environment is relatively small.

With large numbers of vehicles in use, the problem grows. In choosing new fuels for vehicles, we need to consider the health and environmental impacts of an ever-growing number of vehicles using them. In 1999, the world population reached 6 billion; it is expected to reach 9 billion by 2050. In addition to the rapidly growing world population is the even faster growth of energy consumption taking place as standards of living rise throughout the world, making it urgent to find ways to reduce our use of fossil fuels.

Use diagram 2.1, "Products of Combustion," to discuss the combustion process and past and current efforts to make gasoline burn more cleanly. A key point for students to understand is the contribution of gasoline-powered vehicles to global warming (through the emission of carbon dioxide). In 2000, new studies were released by the Intergovernmental Panel on Climate Change that demonstrate the connection between human-made greenhouse-gas emissions, global warming, melting of the ice caps, and a rise in sea levels.

2) Refer to the student handout "AUTOMOBILE-RELATED EMISSIONS," which describes the health and environmental effects of various emissions and includes the diagram "Formation of Low-Level Ozone." Use the diagram to help students understand how ozone is formed and how it travels, and that large numbers of people live in areas that do not meet clean air standards for ozone. Make sure that students understand the difference between the high atmospheric ozone—needed to protect us from ultraviolet cancer-causing rays—and low-level ozone, which is a respiratory irritant. A key point is that automobiles contribute directly to the development of low-level ozone, a pollutant with serious health effects, which threatens 107 million people in the United States. Through the Community Research Activity, students will discover if their own region meets EPA air-quality standards for ozone.


AUTOMOBILE-RELATED EMISSIONS

REGULATED EMISSIONS

EMISSION	DESCRIPTION AND SOURCE	HEALTH AND ENVIRONMENTAL EFFECTS
Carbon Monoxide (CO)	A colorless, odorless gas produced when carbon in fuels is burned incompletely. It occurs when oxygen is restricted, when cars are not tuned properly, and at high altitudes. Carbon monoxide pollution is emitted from the tailpipe and increases dramatically in cold weather. In the '90s, motor vehicles emitted 60 percent of carbon monoxide emissions nationwide and as much as 95 percent of CO in urban areas. (U.S. Dept of Energy, 1997)	Carbon monoxide interferes with the ability of the blood to carry oxygen. Results may be chest pain, headaches, dizziness, reduced mental alertness, nausea, fatigue, irritability, and suffocation. Those with heart disease are at higher risk.
Lead	A gasoline additive previously used in the United States to increase octane, the burning power of fuel. It is also found in batteries and emitted from battery factories.	Exposure to lead can cause learning disabilities (especially in children), as well as brain and kidney damage.
Nitrogen Oxides (NO_x)	Nitrogen and oxygen are the two most common atmospheric gases. Under high pressure and in high temperatures (conditions found in engines), nitrogen and oxygen atoms react to form various nitrogen oxides, known as NO_x. These form a yellowish to reddish-brown gas, which in high densities has a pungent odor.	Irritates and damages lung tissue. Increases susceptibility to respiratory disease. Reacts in the atmosphere to form ozone and acid rain.
Ozone (O_3)	Low-level ozone is formed when volatile organic compounds, oxygen, and NO_x react in the presence of sunlight. A component of smog. In the '90s, motor vehicles emitted up to half of the smog-forming chemicals (hydrocarbons and nitrogen oxides). (U.S. Dept of Energy, 1997)	In the upper atmosphere, ozone protects the earth from the sun's ultraviolet rays. At ground level, it irritates and breaks down respiratory tissues and cells, irritates eyes, nose, and throat, causes chest pain, damages crops and vegetation, and deteriorates rubber and some plastics.
Particulate Matter (PM_{10}, $PM_{2.5}$)	A name given to dust, dirt, soot, smoke, and liquid droplets that are carried in the air. It can be caused by incomplete combustion of fuel.	PM reduces visibility, soils surfaces, increases respiratory disease, lung damage, cancer. Children, the elderly, and those with lung or heart disease are most susceptible.
Sulfur Dioxide (SO_2)	A by-product of the burning of oil and coal emitted from coal- or oil-burning power plants and industries, refineries, and diesel engines.	Increases lung disease and breathing problems, especially for asthmatics. Reacts in the atmosphere to form acid rain.
Volatile Organic Compounds (VOCs)	Reactive hydrocarbon compounds released during combustion or evaporation of gasoline and other petroleum products. Also found in paints and solvents used to finish automotive bodies.	VOCs react with NO_x in the presence of sunlight to form low-level ozone. They also contribute to global warming.

HEALTH, POLLUTION, AND SAFETY / HANDOUT 2B

Carbon Dioxide (CO_2)

fuels releases carbon dioxide. Burning a single tank of gasoline produces 800 to 400 pounds of carbon dioxide. Based on its global warming potential, carbon dioxide accounts for over 80 percent of total greenhouse-gas emissions in the United States.

in the atmosphere absorb infrared radiation, preventing some of the heat from escaping into space. When more greenhouse gases, such as carbon dioxide, are released into the atmosphere than are removed by natural processes, the atmosphere's heat absorption properties increase. Global warming and changes in weather patterns are the result.

2.1 FORMATION OF LOW-LEVEL OZONE

smog is a visible haze caused primarily by particulate matter and ozone. High concentrations of ozone are a special concern to nearly 142 million people in the United States.

Because air pollutants often mixed with the wind, smog and other air pollution problems in your county or region may originate upwind from you (probably to the west). Likewise,

pollution that originates in your county or region may cause smog downwind (probably to the east). For example, pollution from coal plants in the Midwest causes problems in the Northeast.

According to the Argonne National Laboratory, the best way to reduce ozone in rural areas that are rich in vegetation is to target and cut NO_x emissions. In commercial or government areas, the quickest solution is the reduction of hydrocarbon emissions (especially nonmethane hydrocarbons or NMHCs).

39 HEALTH, POLLUTION, AND SAFETY / HANDOUT 2B

Make sure students understand how to read the chart "Automobile Emissions," by asking them to identify the health effects and environmental effects of ozone. Students will use this chart much more when doing the research in this section.

3) Ask students to identify various types of people who may be concerned with health and environmental issues, such as global warming, that are related to our transportation system. What would their chief concerns be? Refer to the student handout "WHO'S INTERESTED IN AFVS? WHO CARES ABOUT HEALTH, POLLUTION, AND SAFETY?" Do students identify with any of the people on this list? Which of these people are likely to live or work in their community? Which of these people may be in the audience during the students' presentations? Who else in their community may have an interest in AFVs, and what would their concerns be?


WHO'S INTERESTED IN AFVS? WHO CARES ABOUT HEALTH, POLLUTION, AND SAFETY?

A wide variety of people have a stake in a change to AFVs. They vary from human rights activists to auto salespeople to environmental scientists to physicians to diplomats.

This group wants to reduce the impact of transportation on the environment, reduce emissions of greenhouse gases, and improve the health of people in our communities.

RESOURCE MANAGER

Many costs of fuel don't show up at the gas pump. Oil spills are disgusting, stocks of fish, large tracts of forests and other ecosystems have already been damaged by acid rain; the runoff from highways and seeping underground fuel tanks is making our job of providing freshwater supplies difficult. Would using alternative fuels reduce the carcinogens in our water supplies? Would alternatives be less deadly to wildlife that drink from polluted rivers?

PHYSICIANS

We often treat young children with asthma and elderly patients who suffer from fatigue and heart disease, especially during months when ozone levels are high. Some of our patients can't go outside during hot weather. Our transportation system contributes a great deal to the pollution that irritates the lungs of young children. Could alternative fuels improve the quality of life for our patients?

EMERGENCY PERSONNEL: Police, Fire, Rescue, Medical

In case of accidents, we need to secure the area, get people out of their cars safely, and provide them with the care they need as soon as possible. How do alternative fuels behave? Does exposure to alternative fuels affect the human body differently from exposure to gasoline or diesel fuel? How do we protect ourselves and the community? What safety hazards might AFVs present? How do we prepare for them? What training will we need to provide the appropriate treatment?

INTERNATIONAL DIPLOMAT

As part of the international agreements to reduce global warming, the United States and other industrial countries have been asked to reduce carbon dioxide emissions. If the United States is to be seen as a responsible member of the international community, we need to reduce our use of fossil fuels. Could alternative-fueled vehicles be part of the answer?

ATMOSPHERIC SCIENTIST

Our chief concerns are reducing the levels of carbon dioxide and other greenhouse gases. Global warming and weather changes due to the buildup of atmospheric greenhouse gases could alter the planet considerably, bringing melting ice caps, rising sea levels, and changing crop patterns. Which fuels would most greatly reduce carbon dioxide emissions?

INSURANCE INDUSTRY

Where changing weather patterns have caused destruction to homes and businesses, we've had to review and modify insurance policies to keep our own industry profitable. Reducing carbon dioxide emissions and other greenhouse gases is essential to protecting our clients and their property from rising sea levels, hurricanes, and other storms.

HEALTH, POLLUTION, AND SAFETY / HANDOUT 2C

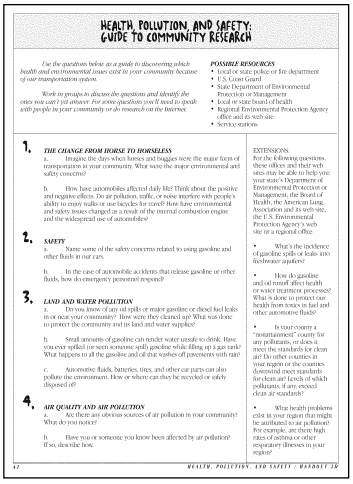
EXTENSION: Have students make up a sheet similar to the "WHO'S INTERESTED IN AFVS?" handout that represents actual people in your community.

STEP 2 - Discussion and Community Research

DISCOVERING HEALTH, POLLUTION, AND SAFETY ISSUES IN YOUR COMMUNITY

TIME: 45 minutes of discussion, followed by another 45 minutes over several days for research, coaching, and student reporting; requires out-of-class time for some students

1) In this exercise, students will discuss the impact of our current transportation system on the safety and health of their community and collect information (about levels of air pollution, occurrence of related health problems, the community's response to traffic accidents, and procedures for proper disposal of auto parts and fluids) from local or state resources.



HEALTH, POLLUTION, AND SAFETY:
GUIDE TO COMMUNITY RESEARCH

Use the questions below as a guide to discovering which health and environmental issues exist in your community because of our transportation system.

Work in groups to discuss the questions and identify the ones you can't yet answer. For some questions you'll need to speak with people in your community or do research on the Internet.

POSSIBLE RESOURCES
- local or state police or fire department
- U.S. Coast Guard
- State Department of Environmental Protection or Management
- local or state board of health
- Regional Environmental Protection Agency office and its web site
- Service stations

1. THE CHANGE FROM HORSE TO HORSELESS

a. Imagine the days when horses and buggies were the major form of transportation in your community. What were the major environmental and safety concerns?

b. How have automobiles affected daily life? Think about the positive and negative effects. Do air pollution, traffic, or noise interfere with people's ability to enjoy walks or use bicycles for travel? How have environmental and safety issues changed as a result of the internal combustion engine and the widespread use of automobiles?

2. SAFETY

a. Name some of the safety concerns related to using gasoline and other fluids in our cars.

b. In the case of automobile accidents that release gasoline or other fluids, how do emergency personnel respond?

3. LAND AND WATER POLLUTION

a. Do you know of any oil spills or major gasoline or diesel fuel leaks in or near your community? How were they cleaned up? What was done to protect the community and its land and water supplies?

b. Small amounts of gasoline can render water unsafe to drink. Have you ever spilled (or seen someone spill) gasoline while filling up a gas tank? What happens to all the gasoline and oil that washes off pavements with rain?

c. Automotive fluids, batteries, tires, and other car parts can also pollute the environment. How or where can they be recycled or safely disposed of?

4. AIR QUALITY AND AIR POLLUTION

a. Are there any obvious sources of air pollution in your community? What do you notice?

b. Have you or someone you know been affected by air pollution? If so, describe how.

EXTENSIONS:
For the following questions, these offices and their web sites may be able to help you: your state's Department of Environmental Protection or Management, the Board of Health, the American Lung Association and its web site, the U.S. Environmental Protection Agency's web site or a regional office.

- What's the incidence of gasoline spills or leaks into freshwater aquifers?
- How do gasoline and oil runoff affect health or water treatment processes? What is done to protect our health from toxics in fuel and other automotive fluids?
- Is your country a "nonattainment" country for any pollutants, or does it meet the standards for clean air? Do other counties in your region or the counties downwind meet standards for clean air? Levels of which pollutants, if any, exceed clean air standards?
- What health problems exist in your region that might be attributed to air pollution? For example, are there high rates of asthma or other respiratory illnesses in your region?

Divide the class into groups or four to six students and refer them to the student handout "HEALTH, POLLUTION, AND SAFETY: GUIDE TO COMMUNITY RESEARCH," which presents a mixture of questions for discussion and for out-of-class research. Provide student groups with 20 minutes to discuss the questions they can answer, identify the questions they can't answer, and think about places they might find the information they need.

2) Have student groups report a summary of their discussions to the class. They should be able to answer questions 1a and b, 2a, 3b, and 4a and b. For the questions that they may not be able to answer (especially 2c, 3a and c), ask where they might find the answers and work with them to develop clear questions to obtain the information they need. Possible answers and references to outside sources are listed below.

THE CHANGE FROM HORSE TO HORSELESS

#1a. Smell of horse manure, manure in the street, muddy shoes and clothing, infectious disease.

#1b. Change in odor and pollutants, change from infectious diseases to cancers and respiratory problems, more serious accidents, global warming.

SAFETY

#2a. Leaky storage tanks can contaminate aquifers; spilling of gas during fill-up exposes people to carcinogens; poorly designed cars can blow up; highway runoff of fluids can contaminate streams.

#2b. Refer students to the state or local police or fire department to get detailed information.

LAND AND WATER POLLUTION

#3a. Refer students to the Coast Guard, the state Department of Environmental Protection or Management, the regional office of the U.S. EPA.

#3b. Runoff from roadways, driveways, parking lots, and other paved surfaces can enter the watershed and pollute freshwater sources.

#3c. Refer students to the local or regional planning department, the state Department of Environmental Protection or Management, and the Board of Health. Some service stations have capabilities for recycling some fluids and parts.

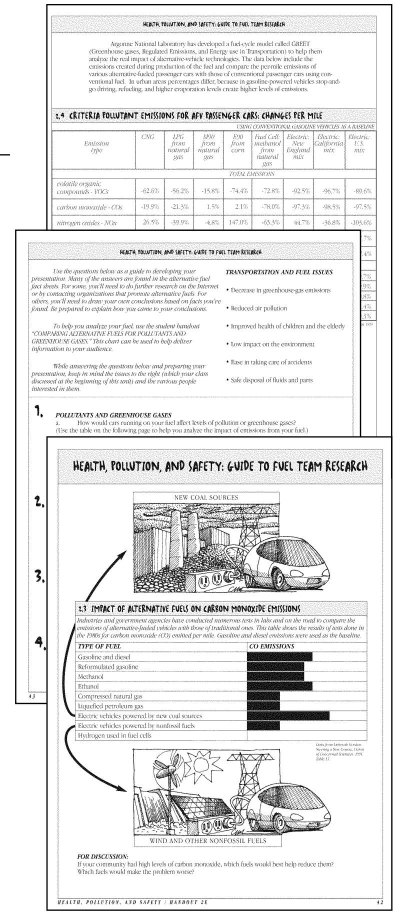
AIR QUALITY AND AIR POLLUTION

#4a. Answers depend on your own community. In polluted areas students may notice soot or gray or yellow atmosphere due to the presence of particulates or smog. Possible places where pollution is evident: highways, downtown, tunnels, drive-through windows, bus terminal, around the school or other buildings where people wait for riders.

#4b. Answers will vary. Possible responses describing the effects of pollution: burning or watery eyes, coughing, asthma, other respiratory infections.

3) Assign several students to make calls to the various agencies and offices and/or to research their Internet sites. (To avoid duplicate calls to the same agency, ask one student to get all the information needed from a particular agency. For example, one student may call the regional EPA for questions #3a and c; a second may contact state environmental agencies for the same information.) Coach students as they try to find this information. It may take several days for them to find their way through these complex organizations and obtain useful responses.

OPTIONAL: This may be a good time to have an in-class speaker to talk about automobile emissions, air quality, global warming, or releases of toxic substances. Regional EPA offices or state environmental agencies often have people available for educational outreach if booked far enough in advance.



STEP 3 - Class Discussion

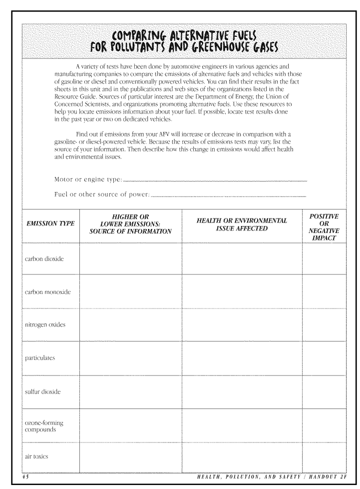
LEARNING HOW AFVS CAN AFFECT HEALTH, POLLUTION, AND SAFETY

TIME: 30 minutes

1) Distribute the student handouts listed above for fuel research and presentations. Explain that in the fuel research activity for this section, teams will investigate the impact of alternative fuels on public health and the environment. (Note: If this is the first or only research section you are teaching, please refer to the section "Availability and Distribution" for a list of alternative fuels and information about preparing teams to research a particular fuel.)

2) Introduce this research activity by discussing chart 2.3, "Impact of Alternative Fuels on Carbon Monoxide Emissions," found on the handout "HEALTH, POLLUTION, AND SAFETY: GUIDE TO FUEL TEAM RESEARCH." The chart compares the carbon monoxide emissions of various fuels to those of gasoline and diesel. (Remind students that carbon monoxide is a serious pollutant that interferes with the ability of blood to carry oxygen. High levels of carbon monoxide are a special concern to people in urban areas. For more information about its description, source, and effects, refer to the handout "AUTOMOBILE-RELATED EMISSIONS.") Ask students to identify the fuels that would increase (or decrease) carbon monoxide levels and consequently increase (or decrease) the associated health problems. If high carbon monoxide levels were a problem in your community, which fuels would alleviate the problem? Which fuels would make it worse?

3) In the section "Availability and Distribution," students researched the sources of fuel used in their own power grid. (If they didn't do this section, refer them to the regional information provided in diagram 1.4, "Where Electricity Comes From, by Fuel Type & Region.") Keeping in mind the makeup of your own power grid, have students compare the two listings for electric vehicles in chart 2.3. How would the widespread use of electric vehicles affect air quality in your region?



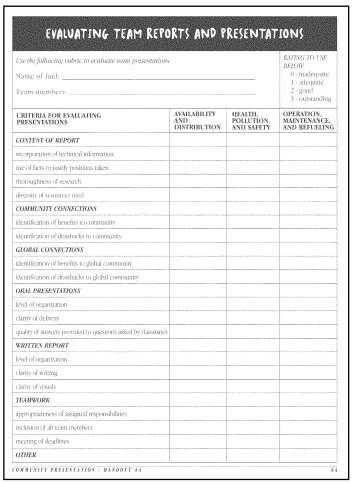
4) Refer students to the handout "COMPARING ALTERNATIVE FUELS FOR POLLUTANTS AND GREENHOUSE GASES." This worksheet will help them analyze the impact of their alternative fuel on pollutants and greenhouse gases. Explain that tests have been done on various types of vehicles, and the results are widely published, but they are not always consistent. Where possible, students should describe the test done on vehicles and identify the type of vehicle tested and the source of their data.

STEP 4 - Team Research and Preparation for Presentations

LEARNING TO SPEAK ABOUT HEALTH, POLLUTION, AND SAFETY

TIME: Three days

1) As they did in the section "Availability and Distribution," fuel teams will use the questions provided in their "GUIDE TO FUEL TEAM RESEARCH" to prepare a written report and a mini-presentation lasting 5 to 10 minutes. Discuss where the students might find the answers to the questions. Much information is already available in the fact sheets. Additional information can be found at the web sites listed for the alternative fuels in the Resource Guide. Some questions require that students pull together information and form their own opinions.



EVALUATING TEAM REPORTS AND PRESENTATIONS

Use the following rubric to evaluate team presentations.

Name of fuel: _____

Team members: _____

RATING TO USE BELOW:
0 - inadequate
1 - adequate
2 - good
3 - outstanding

CRITERIA FOR EVALUATING PRESENTATIONS	AVAILABILITY AND DISTRIBUTION	HEALTH, POLLUTION, AND SAFETY	OPERATION, MAINTENANCE, AND REFUELING
CONTENT OF REPORT			
incorporation of technical information			
use of facts to justify positions taken			
thoroughness of research			
diversity of resources used			
COMMUNITY CONNECTIONS			
identification of benefits to community			
identification of drawbacks to community			
GLOBAL CONNECTIONS			
identification of benefits to global community			
identification of drawbacks to global community			
ORAL PRESENTATIONS			
level of organization			
clarity of delivery			
quality of answers provided to questions asked by classmates			
WRITTEN REPORT			
level of organization			
clarity of writing			
clarity of visuals			
TEAMWORK			
appropriateness of assigned responsibilities			
inclusion of all team members			
meeting of deadlines			
OTHER			

COMMUNITY PRESENTATION / HANDOUT 4A 44

2) Over the next three days, provide students with the opportunity to meet in their teams, divide up the research tasks, and decide how they will present their findings and who will do it. Encourage them to develop diagrams and other graphics to help present their findings. Remind them that these presentation aids may be further developed for a public presentation.

3) Coach students as they do their research. It may be helpful for you to investigate some of the recommended web sites to have a better understanding of the information found there.

4) Distribute copies of "EVALUATING TEAM REPORTS AND PRESENTATIONS" (page 64), so students will know in advance what is expected in their presentations.

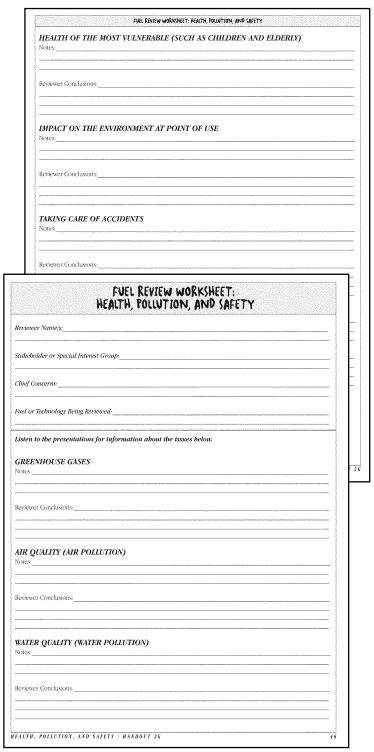
STEP 5 - Team Presentations and Class Discussions

HEALTH, POLLUTION, AND SAFETY

TIME: Four days (10 to 15 minutes for each team's presentation and questions, plus 20 to 30 minutes for follow-up panel and class discussion)

1) Make a list of stakeholders or special interest groups for the students to represent while listening to and evaluating the fuels being presented. Remind students that a wide variety of people are interested in these issues: physicians, resource managers, atmospheric scientists, emergency personnel, even the insurance industry, as you discussed earlier in "WHO'S INTERESTED IN AFVS? WHO CARES ABOUT HEALTH, POLLUTION, AND SAFETY?"

2) Decide if the students will evaluate the presentations as individuals or as part of a review panel. Then assign (or have the members of the class select) the stakeholders or special interest groups they will represent. If they're working in review panels, allow the panel members to sit together.



FUEL REVIEW WORKSHEET: HEALTH, POLLUTION, AND SAFETY

Reviewer Name/s: _____

Stakeholder or Special Interest Group: _____

Chief Concerns: _____

Fuel or Technology Being Reviewed: _____

Listen to the presentations for information about the issues below.

GREENHOUSE GASES
Notes: _____
Reviewer Conclusions: _____

AIR QUALITY (AIR POLLUTION)
Notes: _____
Reviewer Conclusions: _____

WATER QUALITY (WATER POLLUTION)
Notes: _____
Reviewer Conclusions: _____

HEALTH, POLLUTION, AND SAFETY / HANDOUT 3A 44

3) Refer students to the handout "FUEL REVIEW WORKSHEET: HEALTH, POLLUTION, AND SAFETY." They will use this worksheet as a guide for taking notes during a fuel presentation and writing down their (or their panel's) conclusions. (They will need one copy of this worksheet for each fuel presentation given.) Before the presentations, allow students time to make note of their interest group's chief concerns. After each presentation, allow them time to discuss and make note of their conclusions. How would each fuel affect their community and world?

4) Presentations should last 5 to 10 minutes, with additional time for the audience to ask questions. Remind presenters to keep in mind the concerns of the stakeholders in the audience. Encourage students in their audience to ask questions from the points of view of the stakeholders they represent.

5) At the end of each day and again after all presentations have been given, allow time for the panels to compare the fuels and discuss the advantages and disadvantages of each regarding its effect on emissions, health, and other environmental issues. Decide if the fuels would ease (or worsen) the health and environmental problems important to your community.

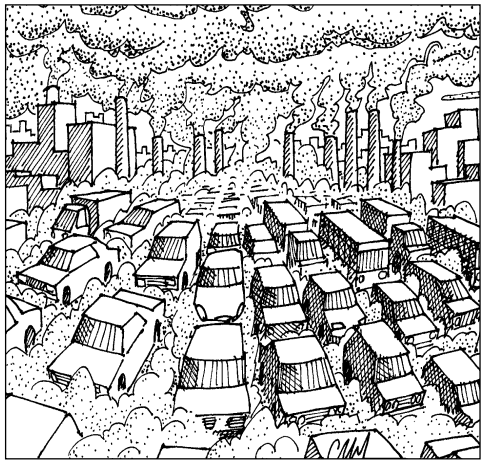
6) Have the review panels report their conclusions to the class and allow time for debate on their conclusions.

HEALTH, POLLUTION, AND SAFETY: THE CHALLENGE

Air pollution from vehicles has been a problem since the smell of exhaust from horseless carriages replaced the smell of horse manure. The smell is no longer the chief concern. Pollutants that cause health problems, smog, acid rain, and greenhouse gases (those gases that contribute to global warming and climate change) have become much more important, especially as the number of vehicles has grown.

Air pollution, which caused high levels of smog and respiratory problems, was first linked to traffic in the Los Angeles basin in the early 1950s. Within 20 more years, air pollution had grown across the country, and in 1970 the United States adopted the first Clean Air Act to promote clean air for all. This act identified six major pollutants caused by industry and transportation and established standards for clean air; the U.S. Environmental Protection Agency began to closely monitor the air for these "criteria" pollutants: carbon monoxide, lead, nitrogen oxides, ozone, particulate matter, and sulfur dioxide. (These are explained in more detail in the handout "Automobile-Related Emissions.")

Between 1970 and 1997, the U.S. population increased 31 percent, while vehicle miles driven increased 127 percent. During that time, thanks to clean air regulations and improvements in industrial and automotive technology, total emissions of the six criteria pollutants decreased 31 percent. Unleaded gasoline replaced leaded gas, eliminating emissions of this pollutant from tailpipes. The use of reformulated gasoline in some areas of the country reduced carbon monoxide levels. More efficient engines, better tires, and aerodynamic styling reduced the amount of fuel needed per mile of travel, thereby reducing emissions per mile. Improved emission controls cut emissions further.



HEALTH

Despite this progress, approximately 107 million people still live in "non-attainment" areas, or counties that do not meet national standards for air quality. High levels of ozone, prevalent in some regions of the country especially during summer months, are a special concern to nearly 102 million people. The widespread use of mass transit and bicycles can speed the progress toward clean air for all; the popularity of large vehicles getting low mileage can easily reverse it.

In addition to the six criteria pollutants, emissions from petroleum fuels contribute a large percentage of our nation's air toxics. Gasoline is the largest source of human-made substances known to cause cancer. It contributes three-quarters of the U.S. total of these substances, with diesel fuel adding another eighth (Clean Fuels Foundation, 2000).

CLIMATE

By the end of the 20th century, the accumulation of greenhouse gases in the atmosphere was also added to our list. The greenhouse effect is a warming of the earth and its atmosphere as solar energy is trapped by natural and human-made gases, including carbon dioxide—a major greenhouse gas—which results from the burning of fossil fuels. (See diagram 2.1, Products of Combustion.) The Intergovernmental Panel on Climate Change, representing more than 2,000 of the world's leading climate scientists, has concluded that human actions are influencing the world's climate. The *US Climate Action Report 2002* documented the potential effects of a changing climate on the United States. Some of these effects include a rise of sea level resulting in a loss of coastal wetlands and barrier islands and an increased danger to coastal homes from storm surges; an increased potential for drought and the disruption of snow-fed water supplies; and the loss of ecosystems such as the Rocky Mountain meadow and certain coral reefs.

Passenger cars emit 20 percent of the carbon dioxide emissions produced in the United States. In fact, cars in the United States produce 5 percent of the world's carbon dioxide emissions. (This is more than the emissions of any single country except the United States, China, Russia, and Japan.) In 1997, the international community developed a treaty on global warming known as the Kyoto Protocol. This treaty seeks to reduce net worldwide emissions of carbon dioxide and other greenhouse gases to pre-1990 levels. The United States' Bush administration rejected the treaty in 2001. Despite this setback, it is likely that the protocol will take effect and become international law. By 2002, most of the world's nations, including all of the European Union and Japan, had ratified the protocol. Russia's cabinet had given preliminary approval to the treaty.

ENVIRONMENT

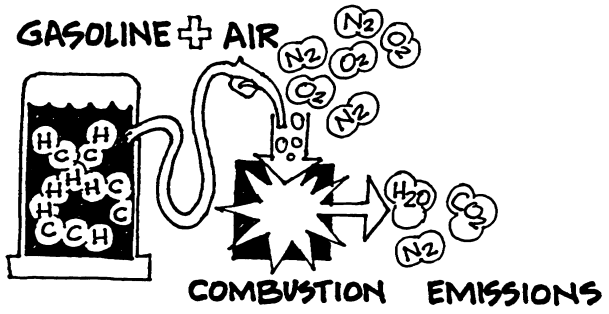
In cars with combustion engines, pollutants and greenhouse gases are produced in inefficient engines and emitted from tailpipes. They leak from vapor lines and crankcases onto highways and parking lots. They escape during fuel processing, and evaporate from storage or fuel tanks and during vehicle refueling.

Periodically, lubricants and batteries must be changed; these and parts contaminated with toxic chemicals must be disposed of. Electric cars are themselves much cleaner than conventional vehicles. But pollutants are produced at the utility plants that supply their power, and the disposal of batteries and other parts may create environmental problems.

Each fuel and drivetrain now being researched and developed has advantages and disadvantages in easing the problems above. As alternative fuels are developed for transportation, technologies for safe storage, delivery, and use also need to be developed. No one fuel may be the perfect solution for the country at large, but in some regions of the country safe use of alternative fuels can greatly reduce health and environmental problems. In combination with mass transit or bicycling, the impact is even greater.

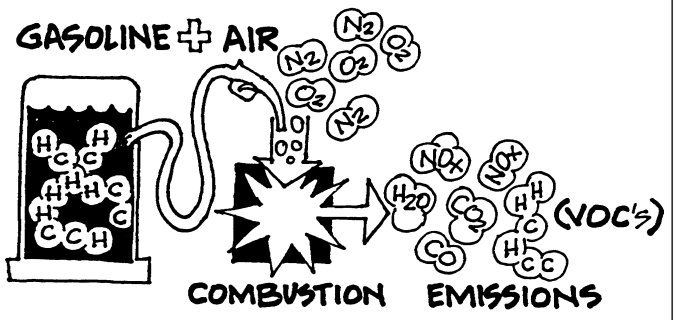
2.1 PRODUCTS OF COMBUSTION

"PERFECT" COMBUSTION



fuel (hydrocarbons) + air (oxygen and nitrogen)	=	carbon dioxide + water + unaffected nitrogen

TYPICAL COMBUSTION



fuel (hydrocarbons) + air (oxygen and nitrogen)	=	unburned hydrocarbons + nitrogen oxides + carbon dioxide + carbon monoxide + water

Source: EPA Office of Transportation Technologies, previously the Office of Mobile Sources.

PRODUCTS OF COMBUSTION

Gasoline and diesel fuels are formed from a combination of petroleum and natural gas. They are mixtures of hydrocarbons, compounds that contain hydrogen and carbon atoms.

In a "perfect" engine, oxygen in the air would combine with all the hydrogen in the fuel to produce water, and with all the carbon to produce carbon dioxide, a greenhouse gas. Nitrogen, which is naturally found in the air, would remain unaffected.

In reality, the combustion process is not perfect. The result is a mix of unburned hydrocarbons, nitrogen oxides, and carbon monoxide, which have ill effects on human health, on crops and vegetation, and consequently on animals.

All gasoline is not the same. While some fuels have additives that increase octane for more power, others contain ingredients to change the end products of combustion. For example, oxygenates (additives containing hydrogen, carbon, and oxygen) promote more complete combustion, reducing tailpipe emissions. Common oxygenates include ethanol and methyl tertiary butyl ether (MTBE), which is made from methanol. Oxygenated fuels are especially useful during cold winter months, when carbon monoxide levels increase.

Some fuel additives have been found to present serious health risks. At one time lead was added to gasoline to increase power, but it was phased out of use in the 1970s because of the health risks it presented, especially to children. MTBE is now being found unburned in the environment and is appearing in freshwater supplies. It is being phased out in some states because of its high toxicity.

"Reformulated gasoline," or RFG, is a blend of gasoline with a minimum of 2 percent oxygen and a maximum of 1 percent benzene (an air toxic), but no heavy metal additives such as lead (which increase octane). This formula reduces hydrocarbons and toxic emissions. It is considered a clean fuel, not an alternative fuel.

AUTOMOBILE-RELATED EMISSIONS

REGULATED EMISSIONS

EMISSION	*DESCRIPTION AND SOURCE*	*HEALTH AND ENVIRONMENTAL EFFECTS*
Carbon Monoxide (CO)	A colorless, odorless gas produced when carbon in fuels is burned incompletely. It occurs when oxygen is restricted, when cars are not tuned properly, and at high altitudes. Carbon monoxide pollution is emitted from the tailpipe and increases dramatically in cold weather. In the '90s, motor vehicles emitted 60 percent of carbon monoxide emissions nationwide and as much as 95 percent of CO in urban areas. (U.S. Dept of Energy, 1997)	Carbon monoxide interferes with the ability of the blood to carry oxygen. Results may be chest pain, headaches, dizziness, reduced mental alertness, nausea, fatigue, irritability, and suffocation. Those with heart disease are at higher risk.
Lead	A gasoline additive previously used in the United States to increase octane, the burning power of fuel. It is also found in batteries and emitted from battery factories.	Exposure to lead can cause learning disabilities (especially in children), as well as brain and kidney damage.
Nitrogen Oxides (NO_X)	Nitrogen and oxygen are the two most common atmospheric gases. Under high pressure and in high temperatures (conditions found in engines), nitrogen and oxygen atoms react to form various nitrogen oxides, known as NO_X. These form a yellowish to reddish-brown gas, which in high densities has a pungent odor.	Irritates and damages lung tissue. Increases susceptibility to respiratory disease. Reacts in the atmosphere to form ozone and acid rain.
Ozone (O_3)	Low-level ozone is formed when volatile organic compounds, oxygen, and NO_X react in the presence of sunlight. A component of smog. In the '90s, motor vehicles emitted up to half of the smog-forming chemicals (hydrocarbons and nitrogen oxides). (U.S. Dept of Energy, 1997)	In the upper atmosphere, ozone protects the earth from the sun's ultraviolet rays. At ground level, it irritates and breaks down respiratory tissues and cells; irritates eyes, nose, and throat; causes chest pain; damages crops and vegetation; and deteriorates rubber and some plastics.
Particulate Matter (PM_{10}, $PM_{2.5}$)	A name given to dust, dirt, soot, smoke, and liquid droplets that are carried in the air. It can be caused by incomplete combustion of fuel.	PM reduces visibility, soils surfaces, increases respiratory disease, lung damage, cancer. Children, the elderly, and those with lung or heart disease are most susceptible.
Sulfur Dioxide (SO_2)	A by-product of the burning of oil and coal emitted from coal- or oil-burning power plants and industries, refineries, and diesel engines.	Increases lung disease and breathing problems, especially for asthmatics. Reacts in the atmosphere to form acid rain.
Volatile Organic Compounds (VOCs)	Reactive hydrocarbon compounds released during combustion or evaporation of gasoline and other petroleum products. Also found in paints and solvents used to finish automotive bodies.	VOCs react with NO_X in the presence of sunlight to form low-level ozone. They also contribute to global warming.

AUTOMOBILE-RELATED EMISSIONS

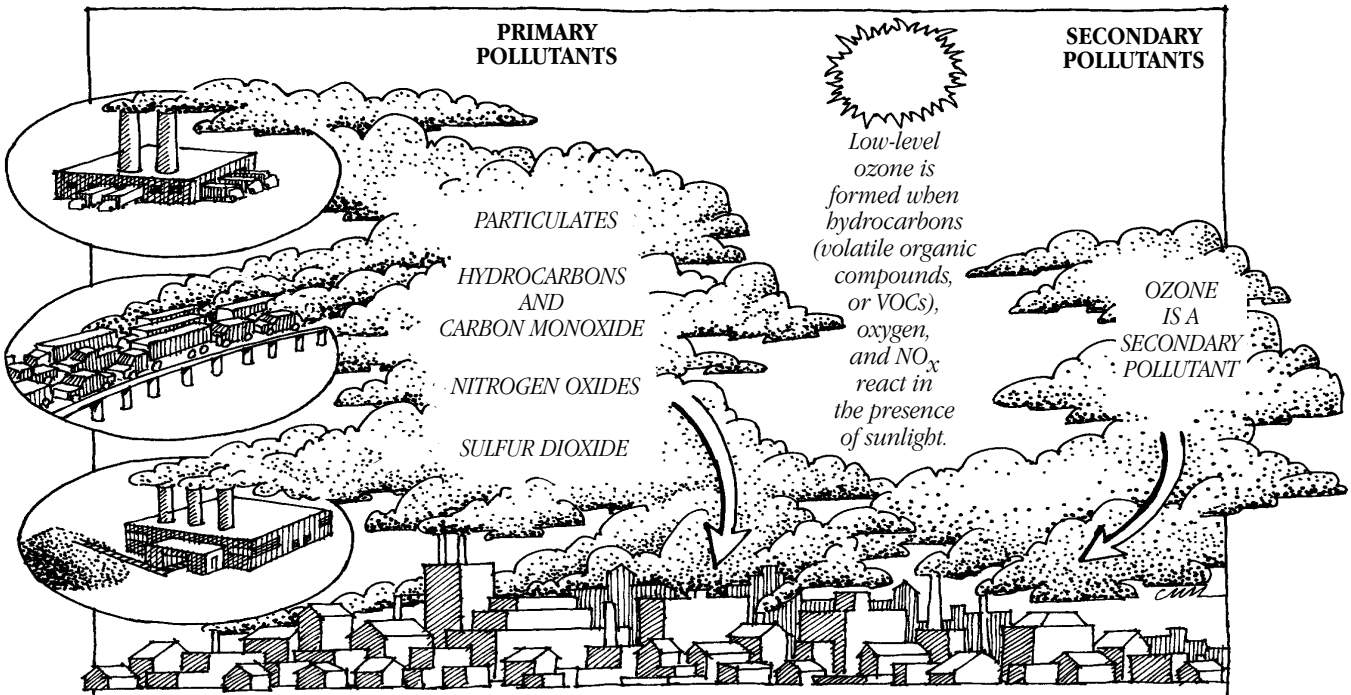
OTHER EMISSIONS

EMISSION	*DESCRIPTION AND SOURCE*	*HEALTH AND ENVIRONMENTAL EFFECTS*
Air Toxics	Most air toxics are hydrocarbon compounds. Some air toxics, including benzene, toluene, and xylene, are added to gasoline to increase power. Others, such as formaldehyde, are by-products of incomplete combustion. Air toxics are emitted with exhaust and/or evaporation and refueling. In the '90s, motor vehicles emitted more than half of the toxic chemicals classified as hazardous air pollutants. (U.S. Dept of Energy, 1997)	Adverse health affects include cancer, poisoning, or other immediate illness.
Carbon Dioxide (CO_2)	The most important human-made greenhouse gas. Any process that burns plant- and animal-based fuels or fossil fuels releases carbon dioxide. Burning a single tank of gasoline produces 300 to 400 pounds of carbon dioxide. Based on its global warming potential, carbon dioxide accounts for over 80 percent of total greenhouse-gas emissions in the United States.	The earth, warmed by the sun's rays, radiates infrared radiation (heat). Greenhouse gases in the atmosphere absorb infrared radiation, preventing some of the heat from escaping into space. When more greenhouse gases, such as carbon dioxide, are released into the atmosphere than are removed by natural processes, the atmosphere's heat-absorption properties increase. Global warming and changes in weather patterns are the result.

2.2 FORMATION OF LOW-LEVEL OZONE

Smog is a visible haze caused primarily by particulate matter and ozone. High concentrations of ozone are a special concern to nearly 102 million people in the United States.

Because air pollutants often travel with the wind, smog and other air pollution problems in your county or region may originate upwind from you (probably to the west). Likewise, pollution that originates in your county or region may cause smog downwind (probably to the east). For example, pollution from coal plants in the Midwest causes problems in the Northeast.

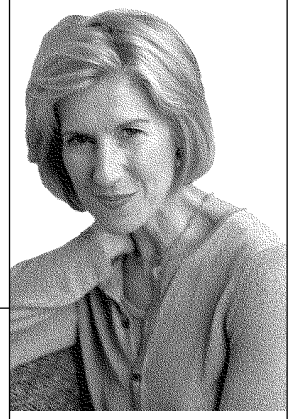


According to the Argonne National Laboratory, the best way to reduce ozone in rural areas that are rich in vegetation is to target and cut NO_x emissions. In commercial or government areas, the quickest solution is the reduction of hydrocarbon emissions (especially nonmethane hydrocarbons or NMHCs).

WHO'S INTERESTED IN AFVS? WHO CARES ABOUT HEALTH, POLLUTION, AND SAFETY?

A wide variety of people have a stake in a change to AFVs. They vary from human rights activists to auto salespeople to environmental scientists to physicians to diplomats.

This group wants to reduce the impact of transportation on the environment, reduce emissions of greenhouse gases, and improve the health of people in our communities.



ATMOSPHERIC SCIENTIST

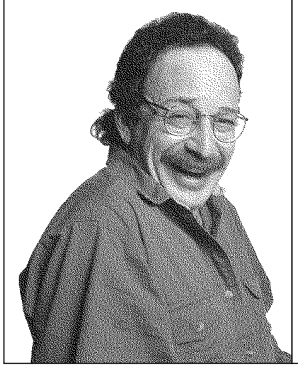
Our chief concerns are reducing the levels of carbon dioxide and other greenhouse gases. Global warming and weather changes due to the buildup of atmospheric greenhouse gases could alter the planet considerably, bringing melting ice caps, rising sea levels, and changing crop patterns. Which fuels would most greatly reduce carbon dioxide emissions?

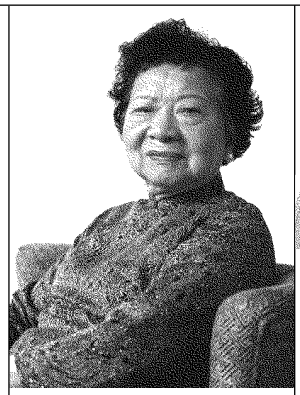
INSURANCE INDUSTRY

Where changing weather patterns have caused destruction to homes and businesses, we've had to review and modify insurance policies to keep our own industry profitable. Reducing carbon dioxide emissions and other greenhouse gases is essential to protecting our clients and their property from rising sea levels, hurricanes, and other storms.

RESOURCE MANAGER

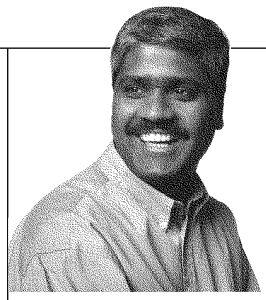
Many costs of fuel don't show up at the gas pump. Oil spills are degrading stocks of fish; large tracts of forests and other ecosystems have already been damaged by acid rain; the runoff from highways and seeping underground fuel tanks is making our job of providing freshwater supplies difficult. Would using alternative fuels reduce the carcinogens in our water supplies? Would alternatives be less deadly to wildlife that drink from polluted rivers?





PHYSICIANS

We often treat young children with asthma and elderly patients who suffer from fatigue and heart disease, especially during months when ozone levels are high. Some of our patients can't go outside during hot weather. Our transportation system contributes a great deal to the pollution that irritates the lungs of young children. Could alternative fuels improve the quality of life for our patients?

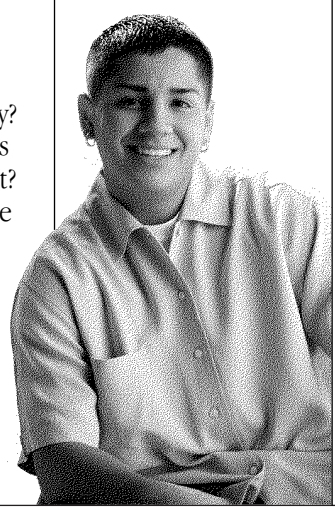


EMERGENCY PERSONNEL: Police, Fire, Rescue, Medical

In case of accidents, we need to secure the area, get people out of their cars safely, and provide them with the care they need as soon as possible. How do alternative fuels behave? Does exposure to alternative fuels affect the human body differently from exposure to gasoline or diesel fuel? How do we protect ourselves and the community? What safety hazards might AFVs present? How do we prepare for them? What training will we need to provide the appropriate treatment?

INTERNATIONAL DIPLOMAT

As part of the international agreements to reduce global warming, the United States and other industrial countries have been asked to reduce carbon dioxide emissions. If the United States is to be seen as a responsible member of the international community, we need to reduce our use of fossil fuels. Could alternative-fueled vehicles be part of the answer?



HEALTH, POLLUTION, AND SAFETY: GUIDE TO COMMUNITY RESEARCH

Use the questions below as a guide to discovering which health and environmental issues exist in your community because of our transportation system.

Work in groups to discuss the questions and identify the ones you can't yet answer. For some questions you'll need to speak with people in your community or do research on the Internet.

POSSIBLE RESOURCES

- Local or state police or fire department
- U.S. Coast Guard
- State Department of Environmental Protection or Management
- Local or state board of health
- Regional Environmental Protection Agency office and its web site
- Service stations

1. *THE CHANGE FROM HORSE TO HORSELESS*

a. Imagine the days when horses and buggies were the major form of transportation in your community. What were the major environmental and safety concerns?

b. How have automobiles affected daily life? Think about the positive and negative effects. Do air pollution, traffic, or noise interfere with people's ability to enjoy walks or use bicycles for travel? How have environmental and safety issues changed as a result of the internal combustion engine and the widespread use of automobiles?

2. *SAFETY*

a. Name some of the safety concerns related to using gasoline and other fluids in our cars.

b. In the case of automobile accidents that release gasoline or other fluids, how do emergency personnel respond?

3. *LAND AND WATER POLLUTION*

a. Do you know of any oil spills or major gasoline or diesel fuel leaks in or near your community? How were they cleaned up? What was done to protect the community and its land and water supplies?

b. Small amounts of gasoline can render water unsafe to drink. Have you ever spilled (or seen someone spill) gasoline while filling up a gas tank? What happens to all the gasoline and oil that washes off pavements with rain?

c. Automotive fluids, batteries, tires, and other car parts can also pollute the environment. How or where can they be recycled or safely disposed of?

4. *AIR QUALITY AND AIR POLLUTION*

a. Are there any obvious sources of air pollution in your community? What do you notice?

b. Have you or someone you know been affected by air pollution? If so, describe how.

EXTENSIONS:
For the following questions, these offices and their web sites may be able to help you: your state's Department of Environmental Protection or Management, the Board of Health, the American Lung Association and its web site, the U.S. Environmental Protection Agency's web site or a regional office.

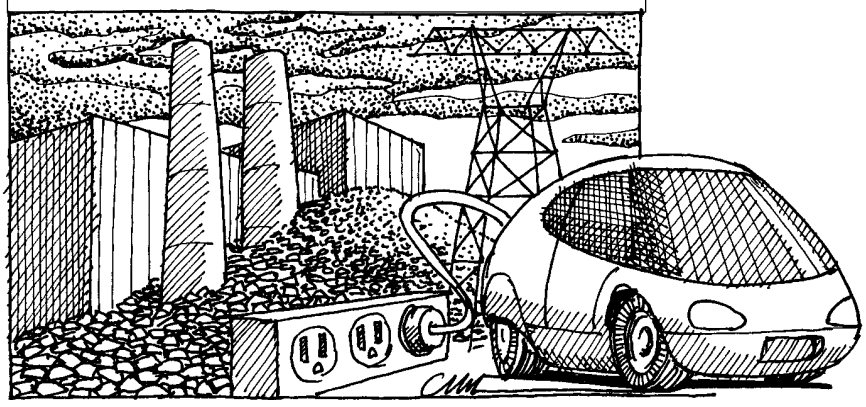
- What's the incidence of gasoline spills or leaks into freshwater aquifers?

- How do gasoline and oil runoff affect health or water treatment processes? What is done to protect our health from toxics in fuel and other automotive fluids?

- Is your county a "nonattainment" county for any pollutants, or does it meet the standards for clean air? Do other counties in your region or the counties downwind meet standards for clean air? Levels of which pollutants, if any, exceed clean air standards?

- What health problems exist in your region that might be attributed to air pollution? For example, are there high rates of asthma or other respiratory illnesses in your region?

NEW COAL SOURCES

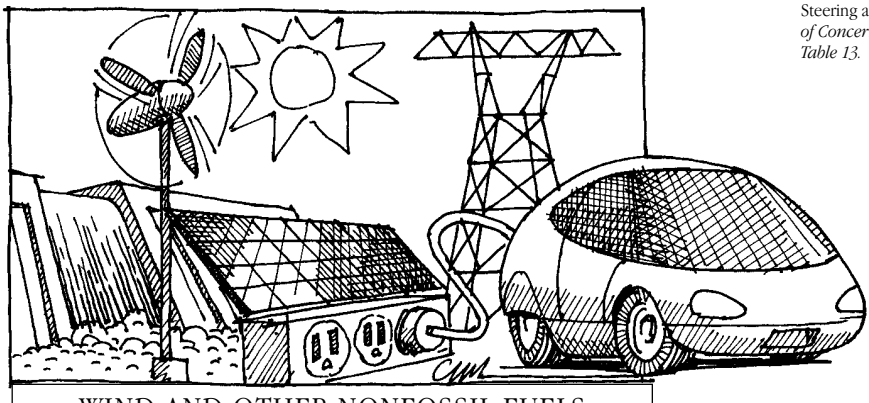


2.3 IMPACT OF ALTERNATIVE FUELS ON CARBON MONOXIDE EMISSIONS

Industries and government agencies have conducted numerous tests in labs and on the road to compare the emissions of alternative-fueled vehicles with those of traditional ones. This table shows the results of tests done in the 1980s for carbon monoxide (CO) emitted per mile. Gasoline and diesel emissions were used as the baseline.

TYPE OF FUEL	***CO EMISSIONS***
Gasoline and diesel	
Reformulated gasoline	
Methanol	
Ethanol	
Compressed natural gas	
Liquefied petroleum gas	
Electric vehicles powered by new coal sources	
Electric vehicles powered by nonfossil fuels	
Hydrogen used in fuel cells	

Data from Deborah Gordon, Steering a New Course, *Union of Concerned Scientists. 1991. Table 13.*



WIND AND OTHER NONFOSSIL FUELS

FOR DISCUSSION:

If your community had high levels of carbon monoxide, which fuels would best help reduce them? Which fuels would make the problem worse?

Use the questions below as a guide to developing your presentation. Many of the answers are found in the alternative fuel fact sheets. For some, you'll need to do further research on the Internet or by contacting organizations that promote alternative fuels. For others, you'll need to draw your own conclusions based on facts you've found. Be prepared to explain how you came to your conclusions.

To help you analyze your fuel, use the student handout "COMPARING ALTERNATIVE FUELS FOR POLLUTANTS AND GREENHOUSE GASES." This chart can be used to help deliver information to your audience.

While answering the questions below and preparing your presentation, keep in mind the issues to the right (which your class discussed at the beginning of this unit) and the various people interested in them.

TRANSPORTATION AND FUEL ISSUES

- Decrease in greenhouse-gas emissions
- Reduced air pollution
- Improved health of children and the elderly
- Low impact on the environment
- Ease in taking care of accidents
- Safe disposal of fluids and parts

1. *POLLUTANTS AND GREENHOUSE GASES*

a. How would cars running on your fuel affect levels of pollution or greenhouse gases? (Use the table on the following page to help you analyze the impact of emissions from your fuel.)

b. While battery electric vehicles themselves are very clean, their widespread use may increase levels of some pollutants emitted from power plants. The types and levels of pollutants depend on the sources of energy and types of technology used in your region's power plant. If you are researching electric vehicles, analyze the impact of increased power use at your region's power plant. How do emissions increases at the power plant compare with decreases at the tailpipe?

2. *IMPACT ON HEALTH AND OTHER ENVIRONMENTAL PROBLEMS*

a. If cars using this fuel became popular and replaced gasoline-run cars, what do you think would be the impact on the environment in your community or in communities downwind from yours?

b. Would health and environmental problems increase or decrease?

c. Would the impact be positive or negative? (Add this information to your table.)

3. *TAKING CARE OF ACCIDENTS*

a. What safety precautions would be needed to protect the community from fuel leaks?

b. Are there any special considerations in case of traffic accidents?

c. Who needs to be trained in order to keep the drivers and the community safe?

4. *DISPOSAL OF FLUIDS AND PARTS*

a. Do cars using your fuel have any special disposal issues; for example, fuel cells, batteries, or special lubricants?

b. How do you think your community would address these issues?

Argonne National Laboratory has developed a fuel-cycle model called GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) to help them analyze the real impact of alternative-vehicle technologies. The data below include the emissions created during production of the fuel and compare the per-mile emissions of various alternative-fueled passenger cars with those of conventional passenger cars using conventional fuel. In urban areas percentages differ, because in gasoline-powered vehicles stop-and-go driving, refueling, and higher evaporation levels create higher levels of emissions.

2.4 CRITERIA POLLUTANT EMISSIONS FOR AFV PASSENGER CARS: CHANGES PER MILE

USING CONVENTIONAL GASOLINE VEHICLES AS A BASELINE

Emission type	*CNG*	*LPG from natural gas*	*M90 from natural gas*	*E90 from corn*	*Fuel Cell: methanol from natural gas*	*Electric: New England mix*	*Electric: California mix*	*Electric: U.S. mix*
TOTAL EMISSIONS								
volatile organic compounds - VOCs	-62.6%	-56.2%	-15.8%	-74.4%	-72.8%	-92.5%	-96.7%	-89.6%
carbon monoxide - CO	-19.9%	-21.3%	1.5%	2.1%	-78.0%	-97.3%	-98.5%	-97.5%
nitrogen oxides - NO_X	26.5%	-39.9%	-4.8%	147.0%	-63.3%	44.7%	-36.8%	-103.6%
particulate matter -PM_{10}	-34.2%	-39.0%	-25.4%	409.1%	-49.5%	-8.2%	-36.7%	17.7%
sulfur oxides - SO_X	-34.1%	-71.8%	-60.0%	120.0%	-87.8%	147.0%	-26.2%	377.4%
URBAN EMISSIONS								
VOCs	-55.1%	-45.3%	-11.1%	-8.9%	-73.6%	-99.5%	-99.7%	-99.7%
CO	-19.4%	-20.0%	-0.2%	0.0%	-80.0%	-99.8%	-99.9%	-99.9%
NO_X	102.8%	-3.7%	-17.2%	9.4%	-82.8%	-60.2%	-75.5%	-80.8%
PM_{10}	-24.6%	-25.2%	-14.5%	-12.2%	-34.0%	-30.5%	-32.0%	-32.4%
SO_X	-80.6%	-91.5%	-77.9%	-82.9%	-97.0%	-78.7%	-96.5%	-89.3%

Source: Michael Q. Wang, GREET Model Results, Argonne National Laboratory, Argonne, Ill., August 1999.

FOR DISCUSSION:

1. If your primary concern were reducing particulate matter, which alternative fuels would be the best choice?
2. If your primary concern were reducing low-level ozone, which alternative fuels would be the best choice?
3. Given the current mix of power in the electric power grids of New England and California, in which area would electric cars produce fewer emissions?

COMPARING ALTERNATIVE FUELS FOR POLLUTANTS AND GREENHOUSE GASES

A variety of tests have been done by automotive engineers in various agencies and manufacturing companies to compare the emissions of alternative fuels and vehicles with those of gasoline or diesel and conventionally powered vehicles. You can find their results in the fact sheets in this unit and in the publications and web sites of the organizations listed in the Resource Guide. Sources of particular interest are the Department of Energy, the Union of Concerned Scientists, and organizations promoting alternative fuels. Use these resources to help you locate emissions information about your fuel. If possible, locate test results done in the past year or two on dedicated vehicles.

Find out if emissions from your AFV will increase or decrease in comparison with a gasoline- or diesel-powered vehicle. Because the results of emissions tests may vary, list the source of your information. Then describe how this change in emissions would affect health and environmental issues.

Motor or engine type: _____

Fuel or other source of power: _____

EMISSION TYPE	***HIGHER OR LOWER EMISSIONS: SOURCE OF INFORMATION***	***HEALTH OR ENVIRONMENTAL ISSUE AFFECTED***	***POSITIVE OR NEGATIVE IMPACT***
carbon dioxide			
carbon monoxide			
nitrogen oxides			
particulates			
sulfur dioxide			
ozone-forming compounds			
air toxics			

FUEL REVIEW WORKSHEET: HEALTH, POLLUTION, AND SAFETY

Reviewer Name/s: _____

_____

Stakeholder or Special Interest Group: _____

_____

Chief Concerns: _____

_____

Fuel or Technology Being Reviewed: _____

_____

Listen to the presentations for information about the issues below.

GREENHOUSE GASES

Notes: _____

_____

_____

Reviewer Conclusions: _____

_____

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AIR QUALITY (AIR POLLUTION)

Notes: _____

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Reviewer Conclusions: _____

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WATER QUALITY (WATER POLLUTION)

Notes: _____

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Reviewer Conclusions: _____

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HEALTH OF THE MOST VULNERABLE (SUCH AS CHILDREN AND ELDERLY)

Notes:_____

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Reviewer Conclusions:_____

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IMPACT ON THE ENVIRONMENT AT POINT OF USE

Notes:_____

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Reviewer Conclusions:_____

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TAKING CARE OF ACCIDENTS

Notes:_____

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Reviewer Conclusions:_____

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DISPOSAL OF FLUIDS AND PARTS

Notes:_____

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Reviewer Conclusions:_____

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