OPERATION, MAINTENANCE, AND REFUELING

T I M E

10 days

O B J E C T I V E S

- *To understand that the adoption of alternative-fueled vehicles will require changes in technology, consumer use, fueling infrastructure, and community design.*
- *To understand how traffic patterns and the need to service and park cars have influenced the design and growth of our communities.*
- *To identify performance characteristics, special maintenance problems, potential costs, and refueling schedules of an AFV.*
- *To identify the audiences who would appreciate these characteristics.*

M A T E R I A L S N E E D E D

For background reading and community research

Student handouts

- *Operation, Maintenance, and Refueling: The Challenge*
- *Who's Interested in AFVs? Who Cares About Operation, Maintenance, and Refueling?*
- *Getting Around Your Community: Guide to Community Research*

Other useful resources

- *Four to six maps of your community or region showing major roadways, shopping areas, and centers of employment.*

For fuel research and student presentations

Student handouts

- *Energy Content of Various Fuels*
- *Operation, Maintenance, and Refueling: Guide to Fuel Team Research*
- *How Do Typical 20th Century Vehicles Work?*
- *Fuel Review Worksheet: Operation, Maintenance, and Refueling*
- *Alternative fuels fact sheets (to be distributed to appropriate teams)*
- *Resource Guide*
- *Evaluating Team Reports and Presentations*

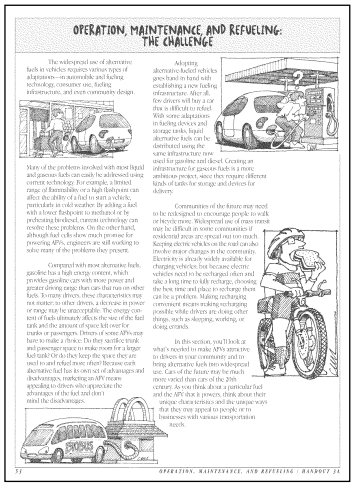
Other useful resources

- *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*

STEP 1 - Background Reading and Discussion

OPERATION, MAINTENANCE, AND REFUELING: PRESENTING THE CHALLENGE

TIME: 30 minutes; to save in-class time, readings may be assigned for homework


OPERATION, MAINTENANCE, AND REFUELING: THE CHALLENGE

The widespread use of alternative fuels in vehicles requires various types of adaptations—in automobile and fueling technology, consumer use, fueling infrastructure, and even community design.

Many of the problems involved with most liquid and gaseous fuels can easily be addressed using current technology. For example, a limited range of flammability or a high flashpoint can affect the ability of a fuel to start a vehicle, particularly in cold weather. By adding a fuel with a lower flashpoint to methanol or by preheating biodiesel, current technology can resolve these problems. On the other hand, although fuel cells show much promise for powering AFVs, engineers are still working to solve many of the problems they present.

Compared with most alternative fuels, gasoline has a high energy content, which provides gasoline cars with more power and greater driving range than cars that run on other fuels. To many drivers, these characteristics are not matters to other drivers, a decrease in power or range may be unacceptable. The energy content of fuels ultimately affects the size of the fuel tank and the amount of space left over for trunks or passengers. Drivers of some AFVs may have to make a choice: Do they sacrifice trunk and passenger space to make room for a larger fuel tank? Or do they keep the space they are used to and refuel more often? Because each alternative fuel has its own set of advantages and disadvantages, marketing an AFV means appealing to drivers who appreciate the advantages of the fuel and don't mind the disadvantages.

Adopting alternative-fueled vehicles goes hand in hand with establishing a new fueling infrastructure. After all, few drivers will buy a car that is difficult to refuel. With some adaptations in fueling devices and storage tanks, liquid alternative fuels can be distributed using the same infrastructure now used for gasoline and diesel. Creating an infrastructure for gaseous fuels is a more ambitious project, since they require different kinds of tanks for storage and devices for delivery.

Communities of the future may need to be redesigned to encourage people to walk or bicycle more. Widespread use of mass transit may be difficult in some communities if residential areas are spread out too much. Keeping electric vehicles on the road can also involve major changes in the community. Electricity is already widely available for charging vehicles (not because electric vehicles need to be recharged often and take a long time to fully recharge, choosing the best time and place to recharge them can be a problem. Making recharging convenient means making recharging possible while drivers are doing other things, such as shopping, working, or doing errands.

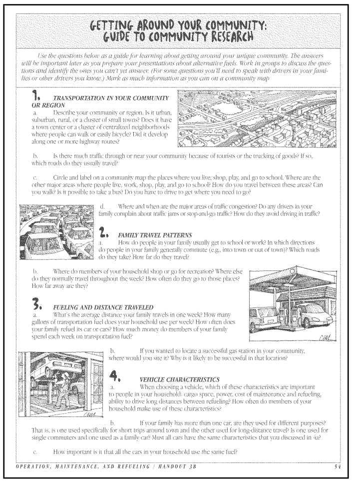
In this section, you'll look at what's needed to make AFVs attractive to drivers in your community and to bring alternative fuels into widespread use. Cars of the future may be much more varied than cars of the 20th century. As you think about a particular fuel and the AFV that it powers, think about their unique characteristics and the unique ways that they may appeal to people or to businesses with various transportation needs.

1) Ask students to put themselves behind the wheel of an AFV and imagine driving it throughout the week or maintaining it throughout the year. How would the experience differ from driving a gasoline powered-vehicle? Encourage them to think about the sound of the car, about refueling, about finding mechanics to fix a problem with their fuel tanks or motors. Explain that alternative-fueled vehicles (AFVs) are already in use around the world and their numbers are rising, but their full acceptance by the American public depends on the convenience of driving and refueling them.

2) Distribute the student handouts for background reading and community research. Have students read the student handout " OPERATION, MAINTENANCE, AND REFUELING: THE CHALLENGE." Ask if they would be willing to depend on an alternative- fueled vehicle to get them where they needed to go. If not, why not? Which vehicle characteristics are they most interested in (power, long distance between refueling, reliability, etc.)?

STEP 2 - Group Discussions and Community Research
GETTING AROUND YOUR COMMUNITY

TIME: 45 minutes of discussion, with another 20 minutes the following day for student reporting of research done at home



GETTING AROUND YOUR COMMUNITY: GUIDE TO COMMUNITY RESEARCH

Use the questions below as a guide for learning about getting around your unique community. The answers will be important later as you prepare your presentations about alternative fuels. 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 drivers in your families or other drivers you know.) Mark as much information as you can on a community map.

1. *TRANSPORTATION IN YOUR COMMUNITY OR REGION*

a. Describe your community or region. Is it urban, suburban, rural, or a cluster of small towns? Does it have a town center or a cluster of centralized neighborhoods where people can walk or easily bicycle? Did it develop along one or more highway routes?

b. Is there much traffic through or near your community because of tourists or the trucking of goods? If so, which roads do they usually travel?

c. Circle and label on a community map the places where you live, shop, play, and go to school. Where are the other major areas where people live, work, shop, play, and go to school? How do you travel between these areas? Can you walk? Is it possible to take a bus? Do you have to drive to get where you need to go?

d. Where and when are the major areas of traffic congestion? Do any drivers in your family complain about traffic jams or stop-and-go traffic? How do they avoid driving in traffic?

2. *FAMILY TRAVEL PATTERNS*

a. How do people in your family usually get to school or work? In which directions do people in your family generally commute (e.g., into town or out of town)? Which roads do they take? How far do they travel?

b. Where do members of your household shop or go for recreation? Where else do they normally travel throughout the week? How often do they go to those places? How far away are they?

3. *FUELING AND DISTANCE TRAVELED*

a. What's the average distance your family travels in one week? How many gallons of transportation fuel does your household use per week? How often does your family refuel its car or cars? How much money do members of your family spend each week on transportation fuel?

b. If you wanted to locate a successful gas station in your community, where would you site it? Why is it likely to be successful in that location?

4. *VEHICLE CHARACTERISTICS*

a. When choosing a vehicle, which of these characteristics are important to people in your household: cargo space, power, cost of maintenance and refueling, ability to drive long distances between refueling? How often do members of your household make use of these characteristics?

b. If your family has more than one car, are they used for different purposes? That is, is one used specifically for short trips around town and the other used for long-distance travel? Is one used for single commuters and one used as a family car? Must all cars have the same characteristics that you discussed in 4a?

c. How important is it that all the cars in your household use the same fuel?

OPERATION, MAINTENANCE, AND REFUELING / HANDOUT 3B 54

1) Divide the class into four groups and distribute a map of the community to each group. Refer to the student handout "GETTING AROUND YOUR COMMUNITY: GUIDE TO COMMUNITY RESEARCH." Through this exercise students will better understand the transportation issues in their unique communities. Point out that traffic patterns and service requirements of gasoline-powered cars have influenced the way that many American communities have grown and developed.

Allow 30 minutes for students to discuss the questions on the handout and to mark their maps as requested in the handout. Have the students make a key that describes any symbols they may use on their maps (to designate schools, working areas, traffic, etc.). Note: For questions 2 and 3a students may need to question their family members and report back to the class.

2) Spend 15 minutes having the teams briefly describe and compare their maps to the class. Explain that when alternative-fueled vehicles are more widely used, the community may need to provide additional fueling stations or service stations. Ask them to keep this in mind as they research their alternative fuels.

3) Have students answer questions 2 and 3a with the help of their family members and report back to class the following day. Ask them to keep in mind their family's driving habits when researching and judging the best alternative fuels for local drivers.

WHO'S INTERESTED IN AFVS? WHO CARES ABOUT OPERATION, MAINTENANCE, AND REFUELING?

A wide variety of people have a stake in a change to AFVs. This group is mainly interested in buying and selling AFVs, fueling and maintaining them, and recycling fluids and auto parts.

COMMUTER

I need to get where I'm going when I need to get there with the least amount of trouble. Dependability, easy maintenance, and a comfortable ride are what I want. Will AFVs provide this? How would an AFV change my daily routine? How easy would it be to adjust?

CITY PLANNER

With alternative-fueled vehicles being marketed in the United States, people are going to need places to conveniently refuel their vehicles. Can they refuel in the same place as gasoline-powered cars? If not, where will they do it?

AUTO SALESPEOPLE

With new kinds of cars coming on the market, we've got to learn more about how they perform and what kind of cars people in this area might want to buy. Should we be selling the same kind of car to a salesperson that travels 1,000 miles a week as to someone who just needs a car to get to the grocery store? It's not too early to do some research.

SERVICE SATION MANAGER

Can new fuels be stored in the tanks I now have, or will I need to replace them? Will I need to connect to a pipeline infrastructure, or will fuels be delivered in tanks, as they are today? What are the safety issues related to hydrogen, compressed gas, electricity, or other fuels? Will I need to provide electrical outlets for recharging cars?

AUTO MECHANIC

In 10 years will I be tuning up internal combustion engines or adjusting battery management systems? Maintaining new cars will probably require different equipment. There will probably be new safety certifications to get for the shop and new regulations to meet for recycling parts. What kind of training will I need?

STATE DEPARTMENTS OF ENVIRONMENTAL PROTECTION

In order to protect the environment and human health, we'll need to adjust the regulations (about disposing or recycling various automotive fluids and parts) to take into account the new AFV technologies. Mechanics will need training to meet the new regulations. What kinds of AFVs will be most popular with drivers around here? What kind of additional recycling facilities should we be investigating?

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4) Ask students to identify various types of people who may be interested in driving, maintaining, and refueling cars. What would their chief concerns be? Refer to the student handout "WHO'S INTERESTED IN AFVS? WHO CARES ABOUT OPERATION, MAINTENANCE, AND REFUELING?" Do students identify with any of the people on this list? Who else in their community may have an interest in AFVs, and what might their concerns be?

EXTENSIONS:

- Have students keep a transportation log for the next two weeks that will answer questions 2 and 3a in the handout "GETTING AROUND YOUR COMMUNITY: GUIDE TO COMMUNITY RESEARCH."
- Have students make up a sheet similar to the "WHO'S INTERESTED IN AFVS?" handout that represents actual people in your community.

STEP 3 - Class Discussion
IMAGES THAT SELL CARS

TIME: 30 minutes

1) Ask the class to identify characteristics of cars that appeal to them (and/or to various other people, such as an adventurer, a businessman/woman, a "soccer mom," a single man, or an environmentalist). Their answers may include power, easy handling, body design, mileage, trunk space, ease of maintenance, low mileage, and so on. Write the answers down where the class can see them.

2) Ask students what images car companies use to market their vehicles. Their answers may include personal freedom (an individual driving on an open road), independence (a car parked on a cliff or mountaintop), comfort and luxury (a couple

listening to their favorite music, a passenger sleeping on the reclined seat, a family watching a video in their car), toughness (a man or woman driving a pickup truck on rough terrain), family values (families enjoying a road trip or vacation), friendship (friends eating, talking, laughing, listening to music together), the ability to easily do everyday things (grocery shopping, taking kids to school). Write down these ideas so everyone can see them. What images appeal most to them?

3) Remind students of the list of important issues they analyzed in the section "Getting Oriented," including national self-sufficiency, protecting the health of children or the elderly, and protecting the environment. Ask how the images they identified above relate to the issues that they think are important. (They may find that their issues are not addressed.)

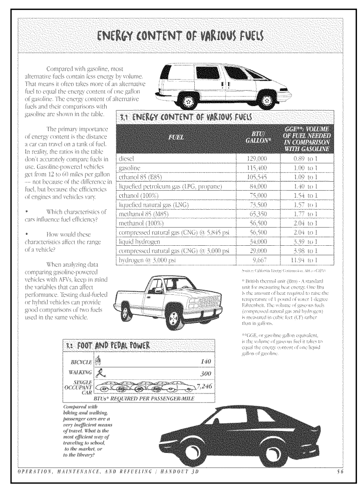
4) Present this issue for discussion: Most Americans think of themselves as environmentalists, yet many Americans drive large, energy-intensive cars. We want to protect our families, yet some of the most popular cars have poor safety records. Are marketing images more powerful than our own values?

5) What images are associated with using mass transit, bicycling, or walking? Do these images appeal to you?

6) How might transportation of the future be marketed to promote its advantages and benefits? Explain that in the next fuel team research activity students will need to identify an image to market their alternative-fueled vehicle to a particular audience.

STEP 4 - Fuel Team Research and Preparation for Presentations

OPERATION, MAINTENANCE, AND REFUELING



ENERGY CONTENT OF VARIOUS FUELS

Compared with gasoline, most alternative fuels contain less energy by volume. That means it often takes more of an alternative fuel to equal the energy content of one gallon of gasoline. The energy content of alternative fuels and their comparisons with gasoline are shown in the table.

The primary importance of energy content is the distance a car can travel on a tank of fuel. In reality, the ratios in the table don't accurately compare fuels in use. Gasoline-powered vehicles get from 12 to 60 miles per gallon — not because of the difference in fuel, but because the efficiencies of engines and vehicles vary.

- Which characteristics of cars influence fuel efficiency?
- How would these characteristics affect the range of a vehicle?

When analyzing data comparing gasoline-powered vehicles with AFVs, keep in mind the variables that can affect performance. Testing dual-fueled or hybrid vehicles can provide good comparisons of two fuels used in the same vehicle.

3.1 ENERGY CONTENT OF VARIOUS FUELS

FUEL	BTU/ GALLON*	GGE**: VOLUME OF FUEL NEEDED IN COMPARISON WITH GASOLINE
diesel	129,000	0.89 to 1
gasoline	115,400	1.00 to 1
ethanol 85 (E85)	105,545	1.09 to 1
liquefied petroleum gas (LPG, propane)	84,000	1.40 to 1
ethanol (100%)	75,000	1.54 to 1
liquefied natural gas (LNG)	73,500	1.57 to 1
methanol 85 (M85)	65,350	1.77 to 1
methanol (100%)	56,500	2.04 to 1
compressed natural gas (CNG) @ 5,845 psi	56,500	2.04 to 1
liquid hydrogen	34,000	3.39 to 1
compressed natural gas (CNG) @ 3,000 psi	29,000	3.98 to 1
hydrogen (@ 3,000 psi	9,667	11.94 to 1

Source: California Energy Commission, ABCs of AFVs

* British thermal unit (Btu) - A standard unit for measuring heat energy. One Btu is the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit. The volume of gaseous fuels (compressed natural gas and hydrogen) is measured in cubic feet (CF) rather than in gallons.

**GGE, or gasoline gallon equivalent, is the volume of gaseous fuel it takes to equal the energy content of one liquid gallon of gasoline.

3.2 FOOT AND PEDAL POWER

BICYCLE	140
WALKING	300
SINGLE OCCUPANT CAR	7,246

BTUs* REQUIRED PER PASSENGER-MILE

Compared with biking and walking, passenger cars are a very inefficient means of travel. What is the most efficient way of traveling to school, to the market, or to the library?

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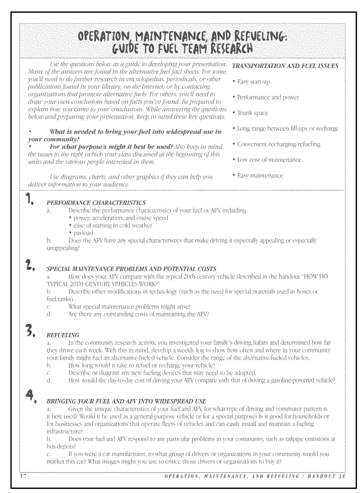
TIME: Three days

1) Distribute the student handouts listed above for fuel research and presentations and refer to student handout "ENERGY CONTENT OF VARIOUS FUELS." Explain that the energy content of a fuel influences how far a car can travel on a tank of fuel, which in turn influences how often a driver has to refuel the car. The efficiency and range of a car are also affected by other characteristics, however. Ask students to identify the characteristics that influence fuel efficiency. (Possible answers: the size and weight of the car and fuel tank, efficiency of the engine, aerodynamic styling, the extras commonly used, such as air conditioning and heat.) How would these characteristics affect the range of a vehicle? (Answer: Large and heavy cars, heavy fuel tanks, inefficient engines, boxy styling, and the use of extras will reduce the range. Large fuel tanks and aerodynamic styling expand the range.)

Help students analyze the chart by asking which fuel has the energy content most similar to gasoline. (Answer: ethanol 85.) Vehicles running on which fuels would need to be refueled most often? (Answer: those at the bottom of the list.)



OPERATION, MAINTENANCE, AND REFUELING: GUIDE TO FUEL TEAM RESEARCH

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 in encyclopedias, periodicals, or other publications found in your library; 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. While answering the questions below and preparing your presentation, keep in mind these key questions:

- ***What is needed to bring your fuel into widespread use in your community?***
- ***For what purpose/s might it best be used?*** *Also 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.*

Use diagrams, charts, and other graphics if they can help you deliver information to your audience.

TRANSPORTATION AND FUEL ISSUES

- Easy start-up
- Performance and power
- Trunk space
- Long range between fill-ups or recharge
- Convenient recharging/refueling
- Low cost of maintenance
- Easy maintenance

1. ***PERFORMANCE CHARACTERISTICS***
   a. Describe the performance characteristics of your fuel or AFV, including
      - power, acceleration, and cruise speed
      - ease of starting in cold weather
      - payload

   b. Does the AFV have any special characteristics that make driving it especially appealing or especially unappealing?
2. ***SPECIAL MAINTENANCE PROBLEMS AND POTENTIAL COSTS***
   a. How does your AFV compare with the typical 20th-century vehicle described in the handout "HOW DO TYPICAL 20TH CENTURY VEHICLES WORK?"
   b. Describe other modifications in technology (such as the need for special materials used in hoses or fuel tanks).
   c. What special maintenance problems might arise?
   d. Are there any outstanding costs of maintaining the AFV?
3. ***REFUELING***
   a. In the community research activity, you investigated your family's driving habits and determined how far they drove each week. With this in mind, develop a weekly log to show how often and where in your community your family might fuel an alternative-fueled vehicle. Consider the range of the alternative-fueled vehicles.
   b. How long would it take to refuel or recharge your vehicle?
   c. Describe or diagram any new fueling devices that may need to be adopted.
   d. How would the day-to-day cost of driving your AFV compare with that of driving a gasoline-powered vehicle?
4. ***BRINGING YOUR FUEL AND AFV INTO WIDESPREAD USE***
   a. Given the unique characteristics of your fuel and AFV, for what type of driving and commuter pattern is it best used? Would it be used as a general-purpose vehicle or for a special purpose? Is it good for households or for businesses and organizations that operate fleets of vehicles and can easily install and maintain a fueling infrastructure?
   b. Does your fuel and AFV respond to any particular problems in your community, such as tailpipe emissions at bus depots?
   c. If you were a car manufacturer, to what group of drivers or organizations in your community would you market this car? What images might you use to entice those drivers or organizations to buy it?

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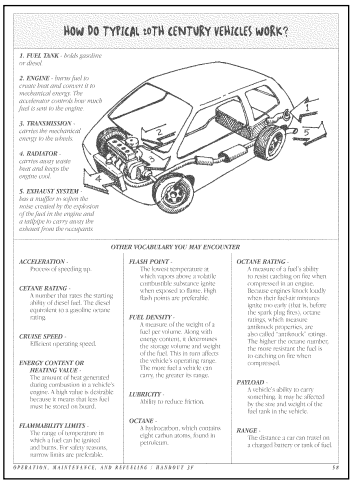
2) Refer to student handout "OPERATION, MAINTENANCE, AND REFUELING: GUIDE TO FUEL TEAM RESEARCH." Explain that in this research activity teams will investigate the performance characteristics of alternative fuels, the design or modifications of the drivetrain, special maintenance and refueling issues, and the special audiences for various AFVs of the future. Students should keep in mind these key questions:

- What is needed to bring your fuel into widespread use in the community?
- For what purpose/s might the alternative fuel or AFV best be used?
- Can it resolve any special problems (such as tailpipe emissions in areas where they are particularly worrisome)?



HOW DO TYPICAL 20TH CENTURY VEHICLES WORK?

1. FUEL TANK - holds gasoline or diesel.

2. ENGINE - burns fuel to create heat and convert it to mechanical energy. The accelerator controls how much fuel is sent to the engine.

3. TRANSMISSION - carries the mechanical energy to the wheels.

4. RADIATOR - carries away waste heat and keeps the engine cool.

5. EXHAUST SYSTEM - has a muffler to soften the noise created by the explosion of the fuel in the engine and a tailpipe to carry away the exhaust from the occupants.

OTHER VOCABULARY YOU MAY ENCOUNTER

ACCELERATION - Process of speeding up.

CETANE RATING - A number that rates the starting ability of diesel fuel. The diesel equivalent to a gasoline octane rating.

CRUISE SPEED - Efficient operating speed.

ENERGY CONTENT OR HEATING VALUE - The amount of heat generated during combustion in a vehicle's engine. A high value is desirable because it means that less fuel must be stored on board.

FLAMMABILITY LIMITS - The range of temperature in which a fuel can be ignited and burns. For safety reasons, narrow limits are preferable.

FLASH POINT - The lowest temperature at which vapors above a volatile combustible substance ignite when exposed to flame. High flash points are preferable.

FUEL DENSITY - A measure of the weight of a fuel per volume. Along with energy content, it determines the storage volume and weight of the fuel. This in turn affects the vehicle's operating range. The more fuel a vehicle can carry, the greater its range.

LUBRICITY - Ability to reduce friction.

OCTANE - A hydrocarbon, which contains eight carbon atoms, found in petroleum.

OCTANE RATING - A measure of a fuel's ability to resist catching on fire when compressed in an engine. Because engines knock loudly when their fuel-air mixtures ignite too early (that is, before the spark plug fires), octane ratings, which measure antiknock properties, are also called "antiknock" ratings. The higher the octane number, the more resistant the fuel is to catching on fire when compressed.

PAYLOAD - A vehicle's ability to carry something. It may be affected by the size and weight of the fuel tank in the vehicle.

RANGE - The distance a car can travel on a charged battery or tank of fuel.

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- Can it be used by individual commuters; or is it best for fleets of vehicles operated by organizations that can install and maintain their own fueling infrastructure? The student handout "HOW DO TYPICAL 20TH CENTURY VEHICLES WORK?" provides a baseline drawing needed to answer question 2a in their guide to fuel team research. It also lists possible new vocabulary students may encounter.

3) As they did for the sections "Availability and Distribution" and "Health, Pollution, and Safety," the fuel teams will use the questions provided in this section to prepare a written report and a mini-presentation lasting about 10 minutes. During that time, other students will be able to ask related questions about the fuel. Refer students to the handout "EVALUATING TEAM REPORTS AND PRESENTATIONS" (page 64), so that students will know in advance what is expected in their presentations.

4) Provide students with the opportunity to meet in their teams, to divide up the research tasks, and to 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.

5) Coach students as they do their research. 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. Especially helpful are publications of the U.S. Department of Energy, the Union of Concerned Scientists, car manufacturers, and organizations that promote alternative fuels (such as NESEA, the American Methanol Institute, and others listed in the Resource Guide) as well as their Internet sites (especially those pages listed in the Resource Guide). It may be helpful for you to investigate some of the recommended web sites to have a better understanding of the information found there.

EXTENSIONS:

- Have each fuel team build a physical model that represents how their fuel is converted into energy. For more information, check out www.howstuffworks.com.
- How do the fuel's physical and chemical characteristics affect its practical use? For example, how well can it be transferred via a pipeline? Can it be compressed? Is it explosive or not? Does it contain or produce toxic materials?

STEP 5 - Team Presentations and Class Discussions

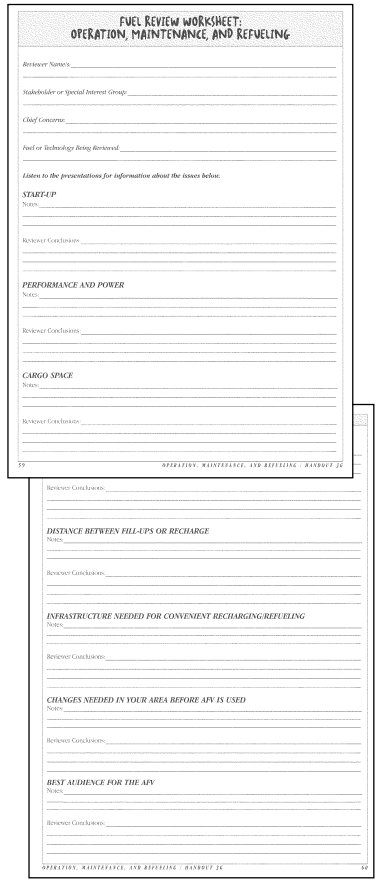
OPERATION, MAINTENANCE, AND REFUELING

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 OPERATION, MAINTENANCE, AND REFUELING?"

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.

3) Refer students to the handout "FUEL REVIEW WORKSHEET: OPERATION, MAINTENANCE, AND REFUELING." 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?


FUEL REVIEW WORKSHEET:
OPERATION, MAINTENANCE, AND REFUELING

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.

START-UP

Notes:

Reviewer Conclusions:

PERFORMANCE AND POWER

Notes:

Reviewer Conclusions:

CARGO SPACE

Notes:

Reviewer Conclusions:

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Reviewer Conclusions:

DISTANCE BETWEEN FILL-UPS OR RECHARGE

Notes:

Reviewer Conclusions:

INFRASTRUCTURE NEEDED FOR CONVENIENT RECHARGING/REFUELING

Notes:

Reviewer Conclusions:

CHANGES NEEDED IN YOUR AREA BEFORE AFV IS USED

Notes:

Reviewer Conclusions:

BEST AUDIENCE FOR THE AFV

Notes:

Reviewer Conclusions:

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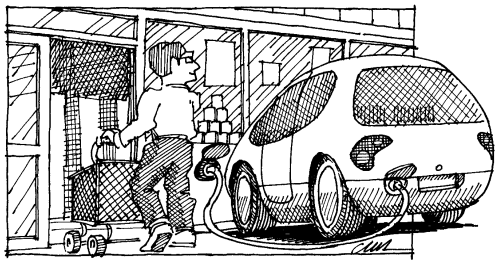
4) Presentations should last 5 to 10 minutes, with additional time for the audience to ask questions. Remind presenters to keep in mind the concerns of the stakeholders in the audience. Encourage students in their audience to ask questions from the points of view of the stakeholders they represent.

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. Taking into account the information gathered in all three sections of this unit, which are the best fuels for their community? Which are the best audiences for each fuel and AFV?

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

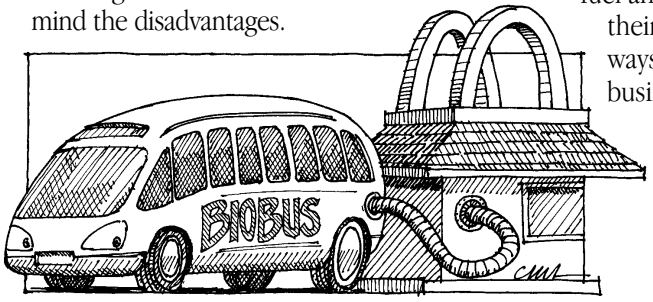
OPERATION, MAINTENANCE, AND REFUELING: THE CHALLENGE

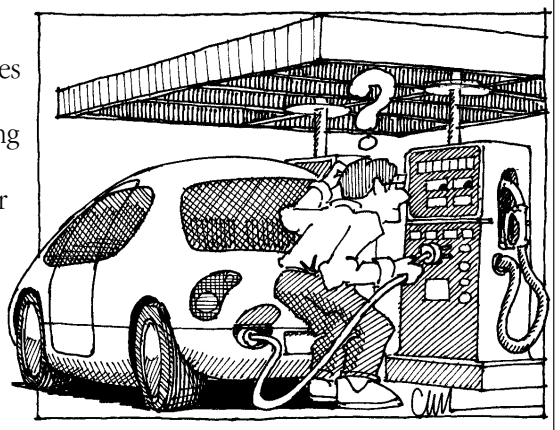
The widespread use of alternative fuels in vehicles requires various types of adaptations—in automobile and fueling technology, consumer use, fueling infrastructure, and even community design.



Many of the problems involved with most liquid and gaseous fuels can easily be addressed using current technology. For example, a limited range of flammability or a high flashpoint can affect the ability of a fuel to start a vehicle, particularly in cold weather. By adding a fuel with a lower flashpoint to methanol or by preheating biodiesel, current technology can resolve these problems. On the other hand, although fuel cells show much promise for powering AFVs, engineers are still working to solve many of the problems they present.

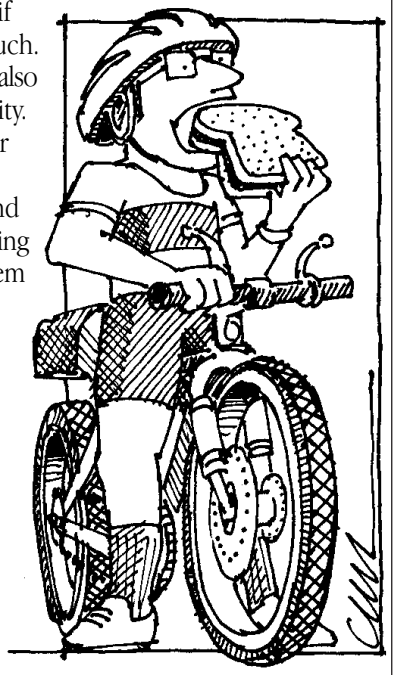
Compared with most alternative fuels, gasoline has a high energy content, which provides gasoline cars with more power and greater driving range than cars that run on other fuels. To many drivers, these characteristics may not matter; to other drivers, a decrease in power or range may be unacceptable. The energy content of fuels ultimately affects the size of the fuel tank and the amount of space left over for trunks or passengers. Drivers of some AFVs may have to make a choice: Do they sacrifice trunk and passenger space to make room for a larger fuel tank? Or do they keep the space they are used to and refuel more often? Because each alternative fuel has its own set of advantages and disadvantages, marketing an AFV means appealing to drivers who appreciate the advantages of the fuel and don't mind the disadvantages.





Adopting alternative-fueled vehicles goes hand in hand with establishing a new fueling infrastructure. After all, few drivers will buy a car that is difficult to refuel. With some adaptations in fueling devices and storage tanks, liquid alternative fuels can be distributed using the same infrastructure now used for gasoline and diesel. Creating an infrastructure for gaseous fuels is a more ambitious project, since they require different kinds of tanks for storage and devices for delivery.

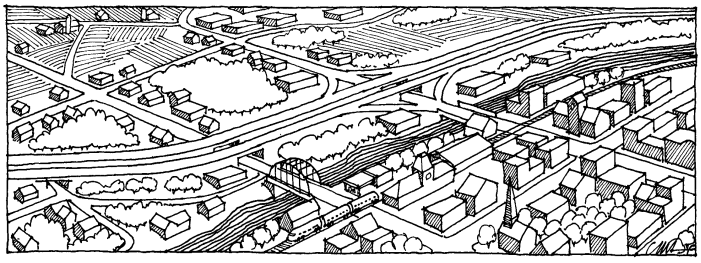
Communities of the future may need to be redesigned to encourage people to walk or bicycle more. Widespread use of mass transit may be difficult in some communities if residential areas are spread out too much. Keeping electric vehicles on the road can also involve major changes in the community. Electricity is already widely available for charging vehicles; but because electric vehicles need to be recharged often and take a long time to fully recharge, choosing the best time and place to recharge them can be a problem. Making recharging convenient means making recharging possible while drivers are doing other things, such as sleeping, working, or doing errands.



In this section, you'll look at what's needed to make AFVs attractive to drivers in your community and to bring alternative fuels into widespread use. Cars of the future may be much more varied than cars of the 20th century. As you think about a particular fuel and the AFV that it powers, think about their unique characteristics and the unique ways that they may appeal to people or to businesses with various transportatio needs.

GETTING AROUND YOUR COMMUNITY: GUIDE TO COMMUNITY RESEARCH

Use the questions below as a guide for learning about getting around your unique community. The answers will be important later as you prepare your presentations about alternative fuels. 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 drivers in your families or other drivers you know.) Mark as much information as you can on a community map.

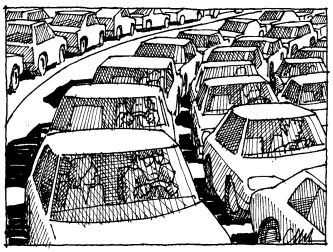


1. *TRANSPORTATION IN YOUR COMMUNITY OR REGION*

a. Describe your community or region. Is it urban, suburban, rural, or a cluster of small towns? Does it have a town center or a cluster of centralized neighborhoods where people can walk or easily bicycle? Did it develop along one or more highway routes?

b. Is there much traffic through or near your community because of tourists or the trucking of goods? If so, which roads do they usually travel?

c. Circle and label on a community map the places where you live, shop, play, and go to school. Where are the other major areas where people live, work, shop, play, and go to school? How do you travel between these areas? Can you walk? Is it possible to take a bus? Do you have to drive to get where you need to go?

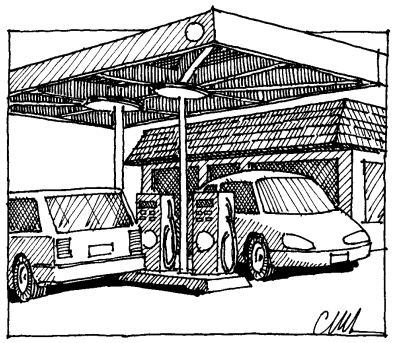


d. Where and when are the major areas of traffic congestion? Do any drivers in your family complain about traffic jams or stop-and-go traffic? How do they avoid driving in traffic?

2. *FAMILY TRAVEL PATTERNS*

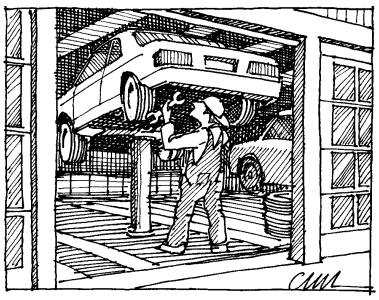
a. How do people in your family usually get to school or work? In which directions do people in your family generally commute (e.g., into town or out of town)? Which roads do they take? How far do they travel?

b. Where do members of your household shop or go for recreation? Where else do they normally travel throughout the week? How often do they go to those places? How far away are they?



3. *FUELING AND DISTANCE TRAVELED*

a. What's the average distance your family travels in one week? How many gallons of transportation fuel does your household use per week? How often does your family refuel its car or cars? How much money do members of your family spend each week on transportation fuel?



b. If you wanted to locate a successful gas station in your community, where would you site it? Why is it likely to be successful in that location?

4. *VEHICLE CHARACTERISTICS*

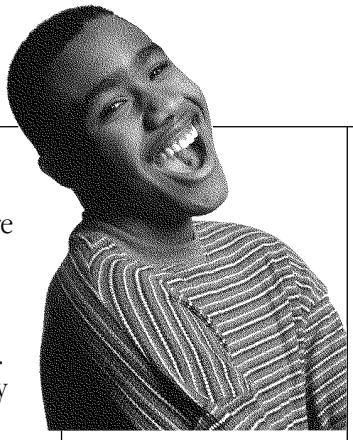
a. When choosing a vehicle, which of these characteristics are important to people in your household: cargo space, power, cost of maintenance and refueling, ability to drive long distances between refueling? How often do members of your household make use of these characteristics?

b. If your family has more than one car, are they used for different purposes? That is, is one used specifically for short trips around town and the other used for long-distance travel? Is one used for single commuters and one used as a family car? Must all cars have the same characteristics that you discussed in 4a?

c. How important is it that all the cars in your household use the same fuel?

WHO'S INTERESTED IN AFVS? WHO CARES ABOUT OPERATION, MAINTENANCE, AND REFUELING?

A wide variety of people have a stake in a change to AFVs. This group is mainly interested in buying and selling AFVs, fueling and maintaining them, and recycling fluids and auto parts.

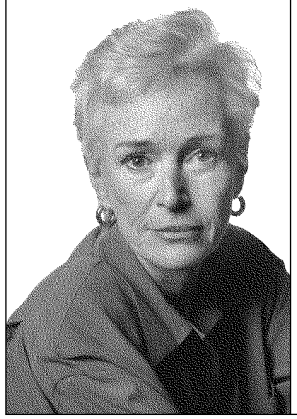


COMMUTER

I need to get where I'm going when I need to get there with the least amount of trouble. Dependability, easy maintenance, and a comfortable ride are what I want. Will AFVs provide this? How would an AFV change my daily routine? How easy would it be to adjust?

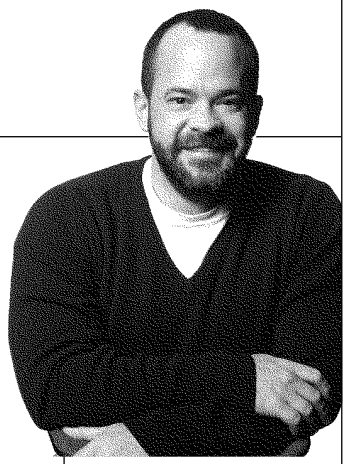
CITY PLANNER

With alternative-fueled vehicles being marketed in the United States, people are going to need places to conveniently refuel their vehicles. Can they refuel in the same place as gasoline-powered cars? If not, where will they do it?



AUTO SALESPEOPLE

With new kinds of cars coming on the market, we've got to learn more about how they perform and what kind of cars people in this area might want to buy. Should we be selling the same kind of car to a salesperson that travels 1,000 miles a week as to someone who just needs a car to get to the grocery store? It's not too early to do some research.



SERVICE SATION MANAGER

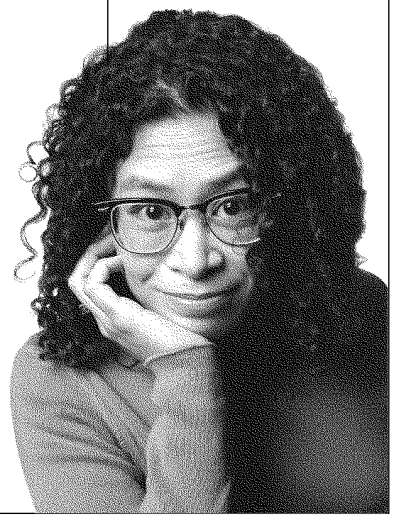
Can new fuels be stored in the tanks I now have, or will I need to replace them? Will I need to connect to a pipeline infrastructure, or will fuels be delivered in tanks, as they are today? What are the safety issues related to hydrogen, compressed gas, electricity, or other fuels? Will I need to provide electrical outlets for recharging cars?

AUTO MECHANIC

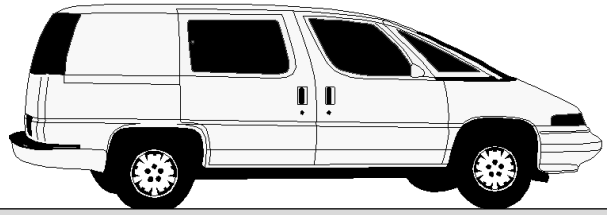
In 10 years will I be tuning up internal combustion engines or adjusting battery management systems? Maintaining new cars will probably require different equipment. There will probably be new safety certifications to get for the shop and new regulations to meet for recycling parts. What kind of training will I need?

STATE DEPARTMENTS OF ENVIRONMENTAL PROTECTION

In order to protect the environment and human health, we'll need to adjust the regulations (about disposing or recycling various automotive fluids and parts) to take into account the new AFV technologies. Mechanics will need training to meet the new regulations. What kinds of AFVs will be most popular with drivers around here? What kind of additional recycling facilities should we be investigating?



ENERGY CONTENT OF VARIOUS FUELS



Compared with gasoline, most alternative fuels contain less energy by volume. That means it often takes more of an alternative fuel to equal the energy content of one gallon of gasoline. The energy content of alternative fuels and their comparisons with gasoline are shown in the table.

The primary importance of energy content is the distance a car can travel on a tank of fuel. In reality, the ratios in the table don't accurately compare fuels in use. Gasoline-powered vehicles get from 12 to 60 miles per gallon — not because of the difference in fuel, but because the efficiencies of engines and vehicles vary.

- Which characteristics of cars influence fuel efficiency?

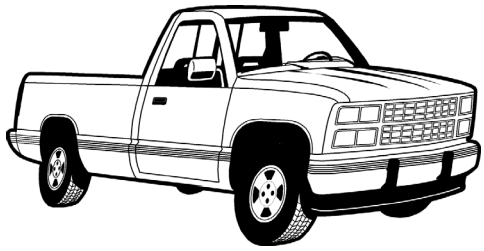
- How would these characteristics affect the range of a vehicle?

When analyzing data comparing gasoline-powered vehicles with AFVs, keep in mind the variables that can affect performance. Testing dual-fueled or hybrid vehicles can provide good comparisons of two fuels used in the same vehicle.

3.1 ENERGY CONTENT OF VARIOUS FUELS

FUEL	*BTU/ GALLON**	*GGE**: VOLUME OF FUEL NEEDED IN COMPARISON WITH GASOLINE*
diesel	129,000	0.89 to 1
gasoline	115,400	1.00 to 1
ethanol 85 (E85)	105,545	1.09 to 1
liquefied petroleum gas (LPG, propane)	84,000	1.40 to 1
ethanol (100%)	75,000	1.54 to 1
liquefied natural gas (LNG)	73,500	1.57 to 1
methanol 85 (M85)	65,350	1.77 to 1
methanol (100%)	56,500	2.04 to 1
compressed natural gas (CNG) @ 5,845 psi	56,500	2.04 to 1
liquid hydrogen	34,000	3.39 to 1
compressed natural gas (CNG) @ 3,000 psi	29,000	3.98 to 1
hydrogen @ 3,000 psi	9,667	11.94 to 1

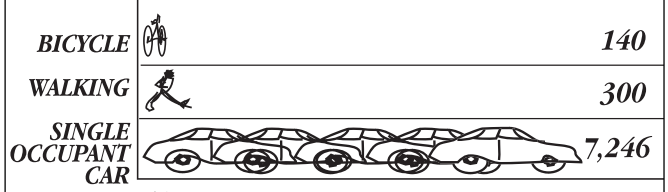
Source: California Energy Commission, ABCs of AFVs.



* British thermal unit (Btu) - A standard unit for measuring heat energy. One Btu is the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit. The volume of gaseous fuels (compressed natural gas and hydrogen) is measured in cubic feet (CF) rather than in gallons.

**GGE, or gasoline gallon equivalent, is the volume of gaseous fuel it takes to equal the energy content of one liquid gallon of gasoline.

3.2 FOOT AND PEDAL POWER



Compared with biking and walking, passenger cars are a very inefficient means of travel. What is the most efficient way of traveling to school, to the market, or to the library?

OPERATION, MAINTENANCE, AND REFUELING: GUIDE TO FUEL TEAM RESEARCH

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 in encyclopedias, periodicals, or other publications found in your library; 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. While answering the questions below and preparing your presentation, keep in mind these key questions:

- ***What is needed to bring your fuel into widespread use in your community?***

- ***For what purpose/s might it best be used?*** *Also 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.*

Use diagrams, charts, and other graphics if they can help you deliver information to your audience.

TRANSPORTATION AND FUEL ISSUES

- Easy start-up
- Performance and power
- Trunk space
- Long range between fill-ups or recharge
- Convenient recharging/refueling
- Low cost of maintenance
- Easy maintenance

1. *PERFORMANCE CHARACTERISTICS*

a. Describe the performance characteristics of your fuel or AFV, including
- power, acceleration, and cruise speed
- ease of starting in cold weather
- payload

b. Does the AFV have any special characteristics that make driving it especially appealing or especially unappealing?

2. *SPECIAL MAINTENANCE PROBLEMS AND POTENTIAL COSTS*

a. How does your AFV compare with the typical 20th-century vehicle described in the handout "HOW DO TYPICAL 20TH CENTURY VEHICLES WORK?"

b. Describe other modifications in technology (such as the need for special materials used in hoses or fuel tanks).

c. What special maintenance problems might arise?

d. Are there any outstanding costs of maintaining the AFV?

3. *REFUELING*

a. In the community research activity, you investigated your family's driving habits and determined how far they drove each week. With this in mind, develop a weekly log to show how often and where in your community your family might fuel an alternative-fueled vehicle. Consider the range of the alternative-fueled vehicles.

b. How long would it take to refuel or recharge your vehicle?

c. Describe or diagram any new fueling devices that may need to be adopted.

d. How would the day-to-day cost of driving your AFV compare with that of driving a gasoline-powered vehicle?

4. *BRINGING YOUR FUEL AND AFV INTO WIDESPREAD USE*

a. Given the unique characteristics of your fuel and AFV, for what type of driving and commuter pattern is it best used? Would it be used as a general-purpose vehicle or for a special purpose? Is it good for households or for businesses and organizations that operate fleets of vehicles and can easily install and maintain a fueling infrastructure?

b. Does your fuel and AFV respond to any particular problems in your community, such as tailpipe emissions at bus depots?

c. If you were a car manufacturer, to what group of drivers or organizations in your community would you market this car? What images might you use to entice those drivers or organizations to buy it?

HOW DO TYPICAL 20TH CENTURY VEHICLES WORK?

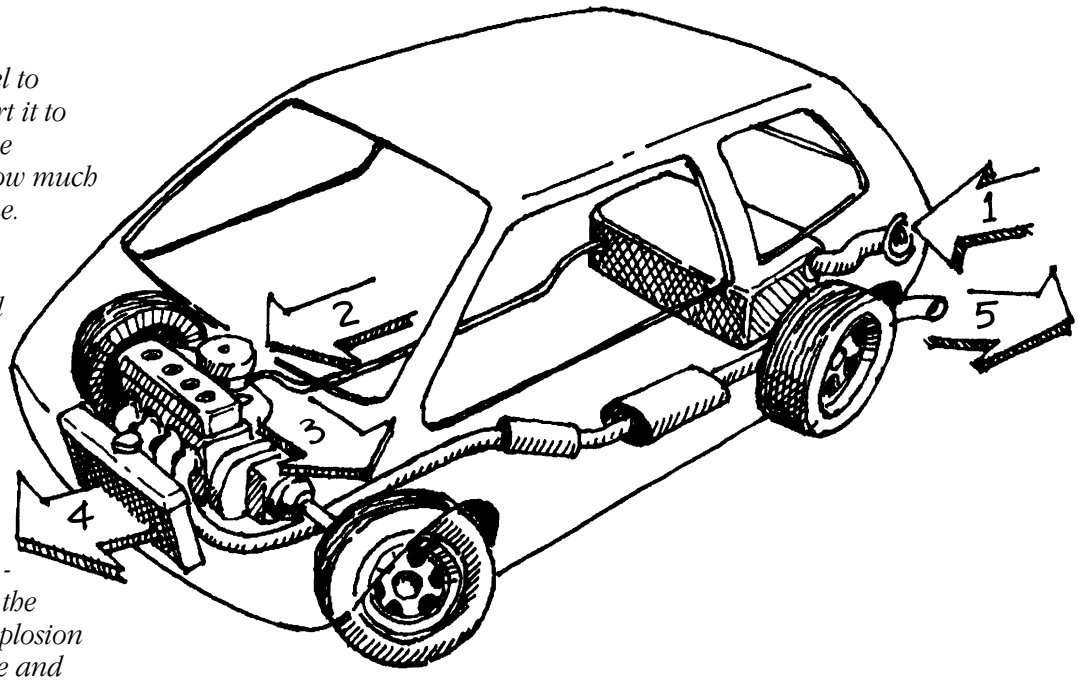
1. FUEL TANK *- holds gasoline or diesel.*

2. ENGINE *- burns fuel to create heat and convert it to mechanical energy. The accelerator controls how much fuel is sent to the engine.*

3. TRANSMISSION *- carries the mechanical energy to the wheels.*

4. RADIATOR *- carries away waste heat and keeps the engine cool.*

5. EXHAUST SYSTEM *- has a muffler to soften the noise created by the explosion of the fuel in the engine and a tailpipe to carry away the exhaust from the occupants.*



OTHER VOCABULARY YOU MAY ENCOUNTER

ACCELERATION *-*
Process of speeding up.

CETANE RATING *-*
A number that rates the starting ability of diesel fuel. The diesel equivalent to a gasoline octane rating.

CRUISE SPEED *-*
Efficient operating speed.

ENERGY CONTENT OR HEATING VALUE *-*
The amount of heat generated during combustion in a vehicle's engine. A high value is desirable because it means that less fuel must be stored on board.

FLAMMABILITY LIMITS *-*
The range of temperature in which a fuel can be ignited and burns. For safety reasons, narrow limits are preferable.

FLASH POINT *-*
The lowest temperature at which vapors above a volatile combustible substance ignite when exposed to flame. High flash points are preferable.

FUEL DENSITY *-*
A measure of the weight of a fuel per volume. Along with energy content, it determines the storage volume and weight of the fuel. This in turn affects the vehicle's operating range. The more fuel a vehicle can carry, the greater its range.

LUBRICITY *-*
Ability to reduce friction.

OCTANE *-*
A hydrocarbon, which contains eight carbon atoms, found in petroleum.

OCTANE RATING *-*
A measure of a fuel's ability to resist catching on fire when compressed in an engine. Because engines knock loudly when their fuel-air mixtures ignite too early (that is, before the spark plug fires), octane ratings, which measure antiknock properties, are also called "antiknock" ratings. The higher the octane number, the more resistant the fuel is to catching on fire when compressed.

PAYLOAD *-*
A vehicle's ability to carry something. It may be affected by the size and weight of the fuel tank in the vehicle.

RANGE *-*
The distance a car can travel on a charged battery or tank of fuel.

FUEL REVIEW WORKSHEET: OPERATION, MAINTENANCE, AND REFUELING

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.

START-UP

Notes: _____

_____

_____

Reviewer Conclusions: _____

_____

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_____

PERFORMANCE AND POWER

Notes: _____

_____

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Reviewer Conclusions: _____

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CARGO SPACE

Notes: _____

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_____

Reviewer Conclusions: _____

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_____

COST AND EASE OF MAINTENANCE

Notes:_____

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Reviewer Conclusions:_____

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DISTANCE BETWEEN FILL-UPS OR RECHARGE

Notes:_____

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Reviewer Conclusions:_____

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INFRASTRUCTURE NEEDED FOR CONVENIENT RECHARGING/REFUELING

Notes:_____

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Reviewer Conclusions:_____

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CHANGES NEEDED IN YOUR AREA BEFORE AFV IS USED

Notes:_____

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Reviewer Conclusions:_____

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BEST AUDIENCE FOR THE AFV

Notes:_____

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Reviewer Conclusions:_____

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