Transportation Fuels: What Car Will You Drive?

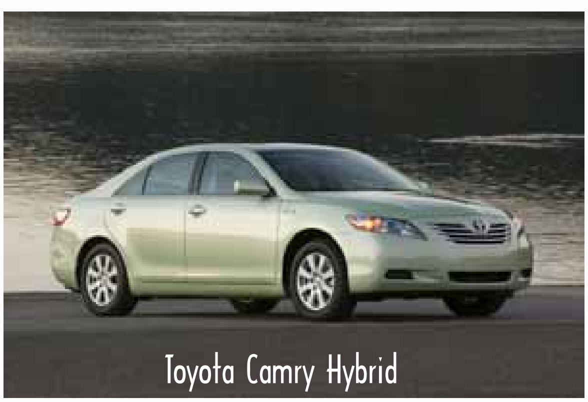
Upper elementary and intermediate students are introduced to traditional and alternative transportation fuels.

TRANSPORTATION FUELS

GRADE LEVEL
4–6

SUBJECT AREAS
Science
Social Studies
Math
Language Arts
Technology


Mercury Mariner Hybrid


Toyota Camry Hybrid


Ford Focus Fuel Cell Vehicle

NEED
2008-2009
Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

Teacher Advisory Board

NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Vision Statement

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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Correlations to National Science Content Standards

(Bolded standards are emphasized in the unit.)

INTERMEDIATE (GRADES 4–8) STANDARD E: SCIENCE AND TECHNOLOGY

1. Abilities of Technological Design

a. Identify appropriate problems for technological design.

b. Design a solution or product.

c. Implement a proposed design.

d. Evaluate completed technological designs or products.

e. Communicate the process of technological design.

2. Understandings about Science and Technology

c. Technological solutions are temporary and have side effects. Technologies cost, carry risks, and have benefits.

f. Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Risk is part of living in a highly technological world. Reducing risk often results in new technology.

INTERMEDIATE–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Natural Hazards

b. Human activities can induce hazards through resource acquisition, urban growth, land-use decisions, and waste disposal.

c. Hazards can present personal and societal challenges because misidentifying the change or incorrectly estimating the rate and scale of change may result in either too little attention and significant human costs or too much cost for unneeded preventive measures.

4. Risks and Benefits

b. Students should understand the risks associated with natural hazards, chemical hazards, biological hazards, social hazards, and personal hazards.

c. Students can use a systematic approach to thinking critically about risks and benefits.

d. Important personal and social decisions are made based on perceptions of benefits and risks.

5. Science and Technology in Society

a. Science influences society through its knowledge and world view. The effect of science on society is neither entirely beneficial nor entirely detrimental.

b. Societal challenges often inspire questions for scientific research, and societal priorities often influence research priorities.

c. Technology influences society through its products and processes. Technological changes are often accompanied by social, political, and economic changes that can be beneficial or detrimental to individuals and to society. Social needs, attitudes, and values influence the direction of technological development.

d. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.

e. Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

Teacher Guide

TO INTRODUCE STUDENTS TO THE ECONOMIC, ENVIRONMENTAL, AND SOCIETAL IMPACTS OF TRADITIONAL AND ALTERNATIVE TRANSPORTATION FUELS.

BACKGROUND

What Car Will You Drive? provides background information and activities in which upper elementary/intermediate students consider the advantages and disadvantages of transportation fuels for themselves and their communities.

CONCEPTS

- All transportation fuels have economic, environmental and societal advantages and disadvantages.
- Economic and environmental impacts are factors in determining the transportation fuels we use.
- Societal needs, personal beliefs, and changes to the quality of life are important considerations in determining the transportation fuels we use.

TIME

- Two–five 45-minute class periods.

SKILL REINFORCEMENT

- Critical thinking
- Math: number manipulation
- Cooperative learning
- Comparison and contrast
- Negotiation and compromise
- Evaluation of multiple factors
- Presentation and persuasion

MATERIALS & PREPARATION

- Familiarize yourself with the materials and activities in this booklet.
- Decide which activities your students will conduct.
- Reproduce materials the students will need to conduct the activities.
- Find experts in the community to supplement the information in this booklet.

SUGGESTED ACTIVITIES

1. Learning about Transportation Fuels

Have your students learn about transportation fuels by reading the background information in this booklet. Brainstorm with students to develop a list of questions they have about transportation fuels and alternative fuel vehicles.

2. Conducting Research on Transportation Fuels

Using the Web Resource List on page 21 and experts in the community, have the students answer the questions they have developed and learn about transportation fuels and vehicles available in their area. Experts might include fuel producers, consumers, distributors, and retailers.

3. Synthesis Activity One

Have the students write one-page papers explaining which alternative fuel vehicle (AFV) they would buy for personal use and why.

4. Synthesis Activity Two

The mayor of a large city in your area has asked your class to develop a plan to reduce emissions from city vehicles—including school buses, public buses, sanitation trucks, police and emergency vehicles, and the city fleet of automobiles. Divide the students into six groups and have each group develop a plan to present to the mayor, listing recommendations for each type of vehicle and the rationale for each recommendation. Invite area experts to visit the classroom to discuss alternative fuel vehicles.

On the board, list the recommendations of each group by vehicle category. Where there are several recommendations, have representative students debate and defend their recommendations until a consensus is reached by the class or by majority vote.

5. Teaching Others about Transportation Fuels—Technology Connection

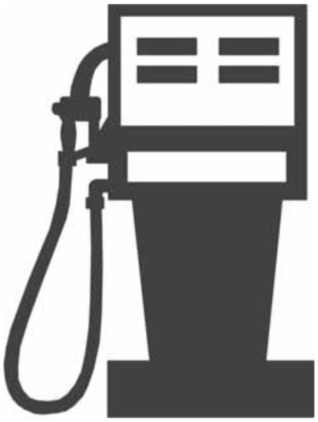
Using the Student Guide on page 22, have students in groups prepare exhibits on transportation fuels to teach others. Have the students develop PowerPoint presentations instead of exhibits.

6. Calculating Fuel Savings

Have your students compare the fuel costs for a Honda Civic Hybrid and a Jeep Wrangler over five years using the following figures:

	2008 Jeep Wrangler	2008 Honda Civic Hybrid
Initial Cost:	$22,529	$22,600
Average Miles per Gallon:	17 mpg	42 mpg
Miles per Year:	15,000	15,000
Cost per Gallon:	$ 4.00	$ 4.00

PETROLEUM—BLACK GOLD



For more than a hundred years, petroleum has fueled our vehicles. In the United States, we use about 13 million barrels of oil each day to keep us on the move. It's no wonder that petroleum is often called "black gold."

The automobile is important to the way we live. Americans drive their personal vehicles about four trillion miles a year. Commercial trucks drive over 180 billion miles and buses drive 6.5 billion miles. There are a lot of vehicles driving those miles—220,000,000 personal vehicles, 7,000,000 commercial trucks and 700,000 buses.

These vehicles all need fuels that we can afford and are easy to find. Today, about 98 percent of our vehicles run on petroleum or diesel fuels. America's whole system of refineries, pipelines, and service stations was designed for oil-based fuels. But there are problems with using petroleum fuels.

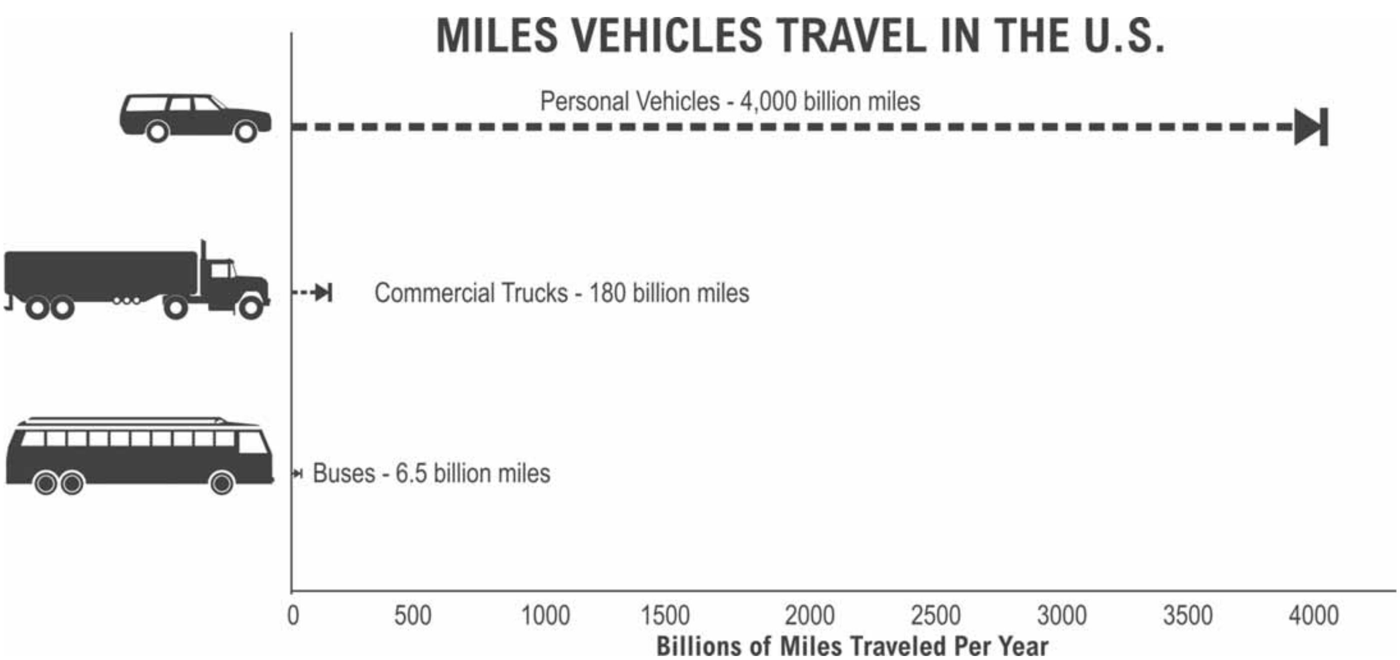
Today, the United States imports about two-thirds of its petroleum from other countries. We need a supply that is reliable. The unrest in the Middle East could cause oil shortages or very high prices at any time. In the spring of 2008, the cost of a barrel of crude oil soared to $120, an all time high.

Auto manufacturers have done a good job of reducing emissions from vehicles. Since the 1960s, emissions have dropped by more than 95 percent. Still, the pollutants cause health and environmental problems, and contribute to global climate change. People keep driving more miles in more vehicles.

The vehicles on the road today cause half of the air pollution in many cities. According to the Environmental Protection Agency, almost half of all Americans live in polluted areas. This has led to an effort to develop alternatives to petroleum fuels.

Taking An Alternative Route

Vehicles can be powered by fuels other than gasoline and diesel. Alternative fuels—such as propane, natural gas, methanol, ethanol, biodiesel and electricity—all can help. Each of these alternative fuels has advantages and disadvantages. Every year, people have the choice of more alternative fuel vehicles.



GASOLINE

Gasoline is a fuel made from petroleum. It is used in most U.S. passenger vehicles with internal combustion engines. Americans use almost 21 million barrels of crude oil, or more than 380 million gallons of gasoline, every day. With 301 million people in the U.S. as of May 2008, that is more than a gallon of gasoline every day for each man, woman, and child.

History of Gasoline

Edwin Drake dug the first oil well in 1859 and distilled the petroleum to produce kerosene for lighting. He had no use for the gasoline or other products, so he discarded them. It wasn't until 1892 with the invention of the automobile that gasoline was recognized as a valuable fuel. By 1920, there were nine million vehicles on the road powered by gasoline and service stations were popping up everywhere.

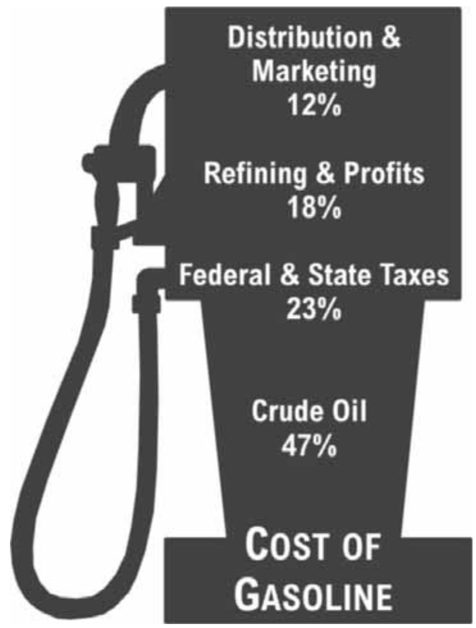
During the 1950s, cars were becoming bigger and faster. Octane levels increased and so did lead levels, as lead was added to gasoline to improve engine performance. Unleaded gasoline was introduced in the 1970s, when the health problems from lead became clear. Leaded gasoline was completely phased out in the 1980s.

Gasoline as a Transportation Fuel

Today, gasoline is the fuel used by most of the passenger vehicles in the U.S. There are about 230 million vehicles that use gasoline to travel an average of 12,000 miles per year. There are 170,000 fueling stations that provide convenient refueling for consumers. Most Americans consider gasoline the most sensible fuel for today, even if it is not an ideal fuel.

Consumers worry about the price of gasoline. During World War I, the cost of gasoline was about $0.25 a gallon. The price of gasoline has averaged about $2.00 a gallon in inflation-adjusted dollars for the last 80 years, until the recent price hikes after Hurricanes Katrina and Rita and unrest in oil-producing countries such as Iran, Iraq, and Nigeria.

In the spring of 2008, prices reached almost $4.00 a gallon and experts don't expect prices to decrease significantly in the future.



Characteristics & Environmental Impacts of Gasoline

Gasoline has a high energy content. It is highly flammable and toxic—gasoline vapors can cause dizziness, vomiting and even death if inhaled in strong concentrations.

Gasoline is a nonrenewable fossil fuel that produces air pollutants when it is burned. Since the 1960s, stricter environmental standards have led to gasolines and vehicle designs that have reduced vehicle exhaust emissions by 95 percent.

The Clean Air Act Amendments of 1990 required that reformulated gasolines be used in areas of the country that do not meet air quality standards, to reduce emissions and improve air quality. In 2002, more than a dozen different types of gasoline were required by law in the U.S.

Even with reductions in emissions, the impact of gasoline on the environment is immense, because there are so many vehicles in the United States driving so many miles. It will take the dedicated efforts of consumers, the transportation industry and federal and state governments to make significant changes to our transportation system.

DIESEL

Diesel is a petroleum fuel that contains energy. At refineries, crude oil is separated into different fuels including gasoline, jet fuel/kerosene, lubricating oil and diesel. Approximately ten gallons of diesel are produced from each 42-gallon barrel of crude oil. Diesel can only be used in a diesel engine, a type of internal combustion engine used in many cars, boats, trucks, trains, buses, and farm and construction vehicles.

History of Diesel

Rudolf Diesel originally designed the diesel engine to use coal dust as fuel, but petroleum proved more effective. The first diesel-engine automobile trip was completed on January 6, 1930. The trip was from Indianapolis to New York City, a distance of nearly 800 miles. This feat helped prove the usefulness of the diesel engine design. It has been used in millions of vehicles since then.

Diesel as a Transportation Fuel

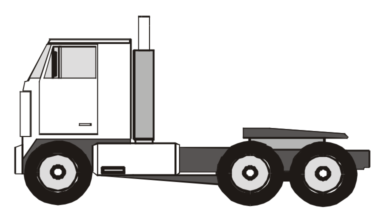
Diesel fuel plays an important role in America's economy, quality of life and national security. As a transportation fuel, it offers a wide range of performance, efficiency and safety features. Diesel fuel contains between 18 and 30 percent more energy per gallon than gasoline. Diesel technology also offers a greater power density than other fuels, so it packs more power per volume.

Diesel fuel is used for many things. In agriculture, diesel powers more than two-thirds of all farm equipment in the U.S. because diesel engines can perform demanding work. In addition, it is the most widely used fuel for public buses and school buses throughout the U.S.

America's construction industry depends on diesel's power. Diesel engines are able to do demanding construction work, like lifting steel beams, digging foundations and trenches, drilling wells, paving roads and moving soil—safely and efficiently. Diesel also powers the movement of America's freight in trucks, trains, boats and barges; 94 percent of our goods are shipped using diesel-powered vehicles. No other fuel can match diesel in its ability to move freight economically.

Diesel automobiles are very popular in Europe, where one of every three cars sold is diesel-powered. Advanced European diesel passenger vehicles exceed today's U.S. gasoline-electric hybrids in fuel efficiency by more than 25 percent. Combining the superior fuel efficiency of diesel engines with the efficiencies of hybrid electric vehicles can provide even greater fuel efficiency. A concept hybrid from Peugeot averages 70 mpg.

Characteristics & Environmental Impacts of Diesel



Diesel-powered cars achieve 20-40 percent better fuel economy than gasoline powered cars, especially in sport utility vehicles (SUVs) and light trucks, which now make up 55 percent of all new vehicle sales. Safety is another advantage of diesel fuel; it is safer than gasoline and other alternatives because it is less flammable.

The major disadvantage of diesel fuel is its harmful emissions. Significant progress has been made in reducing emissions from diesel engines. With new clean diesel technologies, today's trucks and buses are eight times cleaner than those built just a dozen years ago.

New diesel fuels—some of which have lower sulfur content—can also help diesel vehicles achieve lower emissions. Ultra low sulfur diesel (ULSD) fuel is highly refined for clean, complete combustion and low emissions. Using low sulfur diesel fuel and exhaust control systems can reduce particulate emissions by up to 90 percent and nitrogen compounds (NO_x) by 25-50 percent. Beginning in 2006, the legal amount of sulfur allowed in diesel has been reduced to 33 times less than previous standards.

Even with these advances, diesel contributes significantly to air pollution in the United States.

HYBRIDS—A GREAT COMBO

HEVs—Hybrid Electric Vehicles

One of the best kind of new cars is already being manufactured. It is the **hybrid electric vehicle**, or **HEV** (hybrid means combination or mixture). HEVs have a gasoline engine and an electric motor with a battery. HEVs can run on the electric motor for short trips, using the gasoline engine for longer trips and higher speeds. Some HEVs can go 50 percent farther than a regular car on the same amount of fuel. And they have the same power and performance.

When you drive an HEV, it feels the same as driving a regular car—except that there is no noise when the electric motor is running the car. When you stop at a red light, for example, the gasoline engine shuts off. The car is totally quiet. When the light turns green and you step on the accelerator, the electric motor begins to move the car. The gasoline engine kicks in as you need more power and speed.


Honda Civic Hybrid

The battery that powers the electric motor doesn't have to be recharged. The engine recharges the batteries whenever they are low. The braking system captures excess energy when the driver uses the brakes. This energy is also used to recharge the batteries.

Environmental impact

HEVs may be the best kind of new car for the next 10 to 20 years, especially for individuals. They provide the same performance as regular cars, and they are better for the environment, reducing air pollutants by up to one-half.

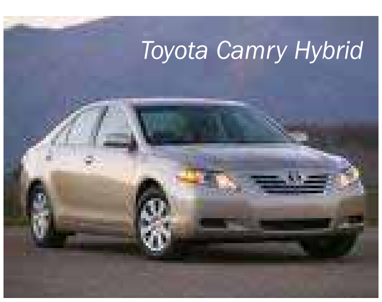
Hydrids Today and Tomorrow

There are several hybrids on the market today. The Toyota Prius is a five-seat sedan that averages 60 mpg in city driving and 51 mpg on the highway driving. It can travel almost 600 miles before refilling. The Honda Civic is also available in a hybrid version that averages 50 miles per gallon. The Ford Escape is the first hybrid SUV on the market. The Escape averages 36 mpg in city driving and 31 mpg on the highway. It can go about 450 miles on a tank of fuel.

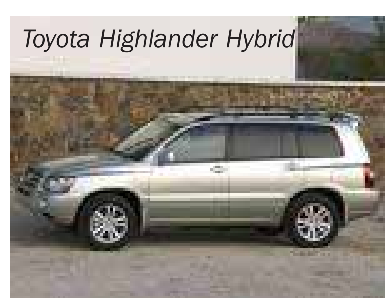
Ford Escape Hybrid


In 2006, there were eight hybrid models available to the general public.In 2008, there were 16 hybrid models, including the Toyota Camry and Highlander, the Saturn Vue and Aura, the Nissan Altima, the GMC Yukon, the Mazda Tribute, the Chevy Malibu, the Mercury Mariner, and three Lexus models.

Chances are, your first car may be a hybrid.

Toyota Camry Hybrid



Lexus Hybrid

Toyota Highlander Hybrid


ETHANOL—FROM FIELD TO FUEL

Ethanol is a clear, colorless **alcohol fuel** made from the sugars found in grains, such as corn, sorghum, and wheat, as well as potato skins, rice, and yard clippings. There are several ways to make ethanol from biomass. The most commonly used processes today use yeast to ferment the sugars and starch in corn. Many cars in Brazil operate on ethanol made from sugar cane.

A new process breaks down woody fibers, so we can make ethanol from trees, grasses, and crop wastes. Trees and grasses need less energy than grains, which must be replanted every year. Scientists have developed fast-growing trees that grow to size in ten years. Many grasses can produce two harvests a year for many years. Soon, you may find yourself driving by huge farms that are not producing food or animal feed, but feedstock for ethanol. **Feedstock** is the raw material used to make a product.

History of Ethanol

Ethanol is not a new fuel. In 1908, Henry Ford designed his Model T to run on a mixture of gasoline and alcohol, calling it the fuel of the future. In 1919, when Prohibition began, ethanol was banned because it was considered a liquor. It could only be sold when it was mixed with petroleum. With the end of Prohibition in 1933, ethanol was used as a fuel again. After World War II, interest in ethanol again decreased because of the low cost of petroleum products.

Ethanol as a Transportation Fuel

Today, many ethanol plants, mostly in the Midwest, produce 7.8 billion gallons of ethanol a year. Gasoline containing ten percent ethanol—E10—is used in many urban areas that don't meet clean air standards. Since ethanol contains oxygen, mixing it with gasoline reduces carbon monoxide emissions up to 25 percent. E10 is not considered an alternative fuel by the Environmental Protection Agency, but a replacement fuel. A **replacement fuel** takes the place of gasoline, but isn't labeled an alternative fuel. Nearly half of the gasoline sold in the U.S. is now E10.

There is also E85, a fuel that is 85 percent ethanol and 15 percent gasoline, used mainly in the Midwest and South. Vehicles are not modified to run on E85; they are specially manufactured as flexible fuel vehicles (FFV). **Flexible Fuel Vehicles** can use any mixture of ethanol and gasoline up to E85. There are about six million cars and trucks using E85. Almost half of these are private vehicles; the rest are fleet vehicles. The cost of E85 is about the same as mid-grade gasoline.

An E85 pump is the same as a gasoline pump. Vehicles that use E85, however, use 15 percent more fuel. Vehicles run as well on E85 as on gasoline and the service is the same.

E85 pump in Lexington, KY

ENVIRONMENTAL IMPACT

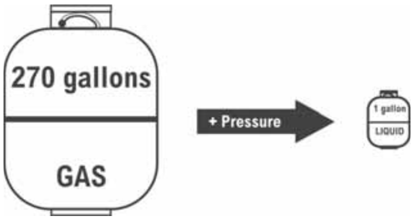
Ethanol is made from crops that absorb carbon dioxide and give off oxygen. This carbon cycle maintains the balance of carbon dioxide in the atmosphere when using ethanol as a fuel.

FUTURE OF ETHANOL

As new technologies develop for making ethanol from all parts of plants and trees, the use of ethanol will increase and more fueling stations will be built. Your first car might run on ethanol.

PROPANE—IT'S NOT JUST FOR GRILLING

Propane is an energy-rich fossil fuel that is sometimes called liquefied petroleum gas (LPG). It is colorless and odorless; a smell is added to serve as a warning. Propane comes from petroleum refining and natural gas processing. Like all fossil fuels, it is nonrenewable.



Under normal conditions, propane is a gas. When propane is put under pressure or cooled to a lower temperature, however, it changes into a liquid and can be stored in tanks. Propane takes up 270 times less space as a liquid than it does as a gas, making it a **portable** fuel. (Portable means easy to move.)

Transportation

Propane has been used as a transportation fuel for more than 75 years. It is the most widely used alternative fuel for fleet vehicles, like taxicabs, government vehicles, and school buses. **Fleets** are groups of vehicles that have their own fuel stations. For fleet vehicles, the cost of using propane is five to 30 percent less than gasoline.

Propane is a good engine fuel. It is cleaner burning than gasoline. The engine stays clean. This means the engine lasts longer and doesn't need as much service. Vehicles can go as fast using propane and carry as much cargo as gasoline-powered cars.

Why is propane not used in more personal vehicles? We can find propane in most areas of the country, but it is not as convenient as gasoline. There are only about 3,000 propane-fueling stations in the U.S. A regular car has to be modified (changed) to use propane, which costs about $2,500.

Propane filling station.

Propane-powered truck making deliveries.

Environmental Impacts

Propane engines produce less air pollution than gasoline. Carbon monoxide emissions from propane vehicles are 50 to 92 percent lower and hydrocarbon emissions are 30 to 62 percent lower than gasoline engines.

FUTURE OF PROPANE

Propane will mostly be used mostly for fleet vehicles in the future. If you get a job at a company that has its own fleet, you may very well be driving a propane vehicle.

CNG—A NATURAL FOR VEHICLES

The natural gas we use for heating, cooking, clothes drying, and water heating can also be a clean burning transportation fuel when **compressed** (put under pressure). Natural gas vehicles burn so cleanly that they are used to carry TV cameras and reporters ahead of the runners in marathons. Natural gas is a nonrenewable fossil fuel with plentiful supplies in the United States.

CNG—Compressed Natural Gas

Natural gas is an energy-rich fossil fuel. It burns cleaner than gasoline, making it a good fuel source for the future. Natural gas is also less expensive than gasoline. To use natural gas in vehicles, it is put in tanks under pressure. Even under pressure, it only has about a third as much energy as gasoline. As a result, natural gas vehicles can't go as far; they have a smaller range. **Range** is the distance a vehicle can go on a tank of fuel. If more tanks are added, the vehicle gets heavy and can't go as far. It also has less space for cargo.

CNG Refueling Pump

Some people worry about using CNG because natural gas is **flammable**—it can catch fire. Manufacturers make CNG tanks stronger than normal gasoline tanks. The fuel tanks are harder to damage in crashes than gasoline tanks. If a fuel line breaks, the natural gas will rise into the air. Gasoline is a liquid that will form puddles. Also, natural gas catches fire at a much higher temperature than gasoline.

Today, there are about 790 natural gas fueling stations in the United States—much fewer than the thousands of gasoline stations. Natural gas vehicles are good as fleet vehicles with their own fueling stations. Many businesses with CNG fleets say their vehicles last longer because the fuel is so clean burning.

Environmental Impacts

Natural gas is a clean-burning fossil fuel. Compressed natural gas (CNG) vehicles produce fewer emissions than gasoline-powered vehicles. They are good to use in areas with air pollution problems.

CNG Vehicles Today and Tomorrow

Today, there are about 144,000 CNG vehicles in the U.S, mostly in the South and West. About half of the vehicles are privately owned and half are owned by government agencies.

Louisville Metropolitan Sewer District Fleet CNG Vehlcle

Several companies make vehicles that run on CNG. A regular vehicle can also be modified to run on CNG at a cost of $2,000 to $3,000.

Right now, CNG is better as a fleet fuel than a personal vehicle fuel. As more CNG stations are built, it will be easier to own a personal vehicle that runs on CNG.

BIODIESEL—FUEL FROM FRENCH FRIES?

Most commercial trucks in the United States use diesel for fuel. So do many buses and boats. **Diesel** is a petroleum-based fuel. It is nonrenewable.

Biodiesel bus used by National Park Service

Biodiesel is a fuel made with vegetable oils, fats, or greases—such as recycled restaurant grease. It is usually used in mixtures of 20 percent biodiesel (B20) and 80 percent regular diesel fuel. Biodiesel can also be used as **neat**, or 100 percent, biodiesel (B100). Biodiesel fuels can be used in diesel engines without changing them. It is the fastest growing alternative fuel in the United States.

Regular diesel fuel contains sulfur. Sulfur can cause damage to the environment when it is burned in fuels. When sulfur is removed from regular diesel fuel, the fuel doesn't work as well. Adding a small amount of biodiesel can fix the problem. Biodiesel has no sulfur, so it can reduce sulfur levels in the nation's diesel fuel supply.

Biodiesel is helpful in diesel storage tanks, too. It acts like a detergent, loosening and dissolving the **sediments** (solids that can stop up pipes). Biodiesel can also improve the smell of diesel fuel—the grease from some restaurants makes the biodiesel smell like french fries.

Biodiesel fuels are sensitive to cold weather and need special anti-freeze, just like petroleum-based diesel fuel does.

Environmental Impacts

Biodiesel is a renewable fuel. It is environmentally safe, biodegradable, and reduces the emission of most air pollutants.

Biodiesel Today and Tomorrow

Today, biodiesel is mainly available through bulk suppliers. There are about 650 public biodiesel refueling stations in the United States. That means biodiesel is more practical for fleets with their own fueling stations. More stations will open as the demand for biodiesel grows.

Today, B20 costs a little more than diesel fuel. The cost will go down as more biodiesel is used. Many states are planning to require that all diesel fuel have a small amount of biodiesel to reduce sulfur emissions.

If you become a truck driver, you may well use biodiesel as a fuel.

Biodiesel ferry at Mammoth Cave, KY

PLUGGING INTO ELECTRIC VEHICLES

In 1891, William Morrison of Des Moines, Iowa, built the first electric car. By the turn of the century, there were twice as many **electric vehicles (EVs)** as gasoline-powered cars. Today, there are about 10,500 EVs in use in the United States, mostly in the West and South. Researchers are still working on the same problem that plagued those early electric vehicles—an efficient battery.

The Battery is the Challenge

Electric vehicles must have batteries that can be recharged over and over again. Since most batteries can't store large amounts of electricity, an EV must carry as many batteries as possible. In some EVs, the batteries make up almost half the weight of the car. The batteries must be replaced every three to six years, which is expensive.

The batteries limit the **range** of an EV—how far it can go on a charge. The more batteries an EV has, the more range it has, to a point. Too many batteries can weigh down a vehicle, causing it to use more energy. The typical EV can only travel 50 to 130 miles between charges. EVs can only go this far with perfect driving conditions. Weather, hills, and air conditioning can reduce the range. Even listening to the radio or turning on the lights can reduce the range.

Electric vehicles are not for people who must drive long distances. They are best as **neighborhood** or **low speed vehicles** for drivers going short distances at speeds of 30 mph or less. Research is being done to develop new batteries that will increase the range. Some of these are like the batteries used in portable computers. These new batteries could double the range of EVs, and last longer before they have to be replaced.

Environmental Impacts

Electric vehicles produce no tailpipe emissions, but making the electricity to charge them can. EVs are really coal, nuclear, hydropower, oil, and natural gas cars, because these fuels produce most of the electricity in the U.S. Coal alone generates more than half of U.S. electricity. When fossil fuels are burned, pollutants are produced like those from the tailpipe of a gasoline-powered car. Power plant pollution, however, is easier to control than tailpipe pollution. Emissions from power plants are controlled and monitored carefully. And power plants are usually located outside major cities.

Maintenance

Many people like the low maintenance of electric vehicles. EVs need no engine tune-ups, oil changes, water pumps, radiators, injectors, or tailpipes. And no more trips to the service station. EVs can be recharged at home at night when electric rates are low, making the fuel cost about the same as gasoline. There are also 602 refueling stations, mostly in California and Arkansas.

The Future of EVs

If you don't need to go far on a single charge, or if better batteries are developed in the near future, your first car might be an EV.

Plugging into an EV Refueling Station.

METHANOL—MADE FOR POWER

Methanol, or wood alcohol, is a colorless, odorless, liquid. Methanol can be produced from natural gas, coal, oil, or biomass. Today, most of the methanol in the United States is produced from natural gas (also called **methane**), a nonrenewable fossil fuel. Most methanol plants are near ammonia plants, since both use the same gas in the production process.

Methanol as a Vehicle Fuel

Although vehicles can operate on pure methanol (M100), methanol blended with 15 percent gasoline—M85—is more practical. Because methanol is a alcohol-based liquid, engines don't need major changes to use it.

There are no car manufacturers that sell vehicles using methanol right now. The cost of M85 is about the same as gasoline. M85 has less energy per gallon, so mileage is lower; but the octane is higher, so cars can go very fast.

Today, there are about 4,600 vehicles that use M85. Most of these vehicles are in California. So are most of the methanol fueling stations. About half of the methanol vehicles are privately owned and half are owned by government agencies.

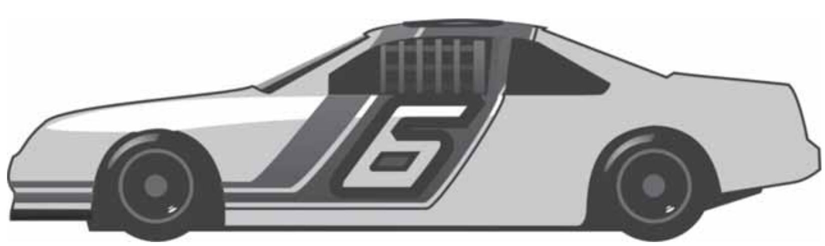
There is no distribution system to get methanol from place to place at this time. In the future, it will probably be moved by barges, trains, or trucks to methanol stations. It cannot be easily moved through the petroleum pipelines we have in place today.

Environmental Impacts

Methanol can be produced from renewable and nonrenewable sources. Methanol is not a perfect fuel. It can help reduce some emissions, but it produces more of others.

Racing Fuel

Since it has a higher octane rating than gasoline, a methanol car can be a clean-burning muscle car. Methanol cars have more horsepower, which gives them faster acceleration than gasoline-powered cars. Methanol is used in drag race vehicles and is the only fuel used in Indianapolis 500 races.



ROAD TO THE FUTURE—HYDROGEN FUEL CELLS

Hydrogen Fuel Cells

Hydrogen may be the answer to our future transportation needs. Hydrogen is the most abundant element in the universe, but it doesn't exist on Earth as a gas. We have to make it from other materials. One way is to split water molecules apart––into hydrogen and oxygen. Another is to break down molecules of natural gas, biomass, or coal.

The space shuttles use hydrogen for fuel. You can't buy a hydrogen car today, but there are research vehicles that are powered by hydrogen fuel cells. **Hydrogen fuel cells** use hydrogen and oxygen to make electricity without harmful emissions; water is the main by-product.

Hydrogen tanks.

Hydrogen is a gas at normal conditions, which makes it harder to move and store than liquid fuels. We have no system today to move and store it.

Today, it costs a lot to make hydrogen fuel, but research is underway to find better ways to produce and use it. The biggest obstacle to widespread use will be storage. The low energy content of hydrogen will require fuel tanks six times larger than gasoline tanks. Its environmental benefits, however, mean that in the future, hydrogen fuel cell vehicles may be a common sight on the roadways of America.The Bush administration is supporting hydrogen fuel cell research because hydrogen is such a clean and abundant fuel.

The Road to the Future

The United States is big; Americans travel more miles than the citizens of any other country. And we use more petroleum than any other country. In many areas, this is causing air pollution problems.

Hydrogen fuel cell vehicles on the road today.

There is no simple answer that can solve the problem, but using alternative fuels can help. Alternative fuels emit fewer air pollutants. Using alternative fuels can also reduce emission of carbon dioxide, a greenhouse gas. Combustion of any carbon-based fuel produces carbon dioxide, but the overall impact of a fuel depends on how the fuel is made. Fuels produced from biomass and from natural gas results in less carbon dioxide than fuels from petroleum.

There are more than 60 alternative fuel vehicles on the market today that can meet the needs of consumers and fleets. Most **dedicated vehicles**—those that use only one fuel—are better suited to fleets with their own fueling stations, since it is sometimes hard to find a fuel station.

Flexible-fuel and hybrid vehicles can meet the needs of most consumers and help the environment. **Flexible fuel vehicles** have engines that can run on either gasoline or a blend of gasoline and ethanol or methanol. **Hybrid vehicles** have two systems so the vehicle can run on either gasoline or an alternative fuel. The gasoline/electric hybrid is available today in several models.

Some alternative fuel vehicles are more expensive to purchase than gasoline-powered cars, but tax incentives make them a good deal for fleet-owners and the general public.

TRANSPORTATION FUEL GLOSSARY

Additives: Chemicals added to fuel to improve and maintain fuel quality. Detergents and corrosion inhibitors are examples of gasoline additives.

Alternative Fuel: As defined by the Energy Policy Act (EPACT) - methanol, denatured ethanol and other alcohols (separately or in mixtures of 85% or more by volume with gasoline or other fuels), CNG, LNG, LPG, hydrogen, "coal-derived liquid fuels", fuels other than alcohols derived from biological materials, electricity, neat biodiesel, and any other fuel "substantially not petroleum" that yields substantial energy security benefits and substantial environmental benefits.

Alternative Fuel Vehicle (AFV): As defined by EPAct, any dedicated, flexible-fueled, or dual-fueled vehicle designed to operate on at least one alternative fuel.

B100: 100 percent biodiesel fuel.

B20: 20 percent biodiesel blended with 80 percent diesel fuel.

Biodiesel: A biodegradable transportation fuel for use in diesel engines that is produced using organically derived oils or fats as feedstock. Biodiesel is used as a component of diesel fuel. In the future, it may be used as a replacement for diesel.

Biomass: Renewable organic matter such as agricultural crops, crop-waste residues, wood, animal and municipal wastes, aquatic plants, fungal growth, etc., used for the production of energy.

British Thermal Unit (Btu): A standard unit for measuring heat energy. One Btu represents the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit (at sea level).

Carbon Dioxide: A product of combustion, a greenhouse gas.

Clean Air Act (CAA): This law set emissions standards for stationary sources, such as factories and power plants. The amendments of 1970 introduced motor vehicle emissions standards. In 1990, reformulated gasoline (RFG) and oxygenated gasoline provisions were added. The RFG provision requires the use of RFG all year in certain areas. The oxygenated gasoline provision requires the use of oxygenated gasoline during certain months, when CO and ozone pollution are most serious. The regulations also require certain fleet operators to use clean-fuel vehicles in certain cities.

Clean Fuel Vehicle (CFV): Any vehicle certified by EPA as meeting federal emissions standards. There are three categories of CFV standards: LEV, ULEV, and ZEV.

Compressed Natural Gas (CNG): Natural gas that has been compressed under high pressures of 2000 to 3600 psi in a pressurized container.

Converted or Conversion Vehicle: A vehicle originally designed to operate on gasoline or diesel that has been modified to run on an alternative fuel.

Corporate Average Fuel Economy (CAFE): A law passed in 1975 that set federal fuel economy standards. The CAFE values are an average of city and highway fuel economy.

Dedicated Vehicle: An alternative fuel vehicle that operates on only one fuel. Usually, dedicated vehicles have lower emissions and better performance than vehicles that can use more than one fuel.

Domestic Fuel: Domestic fuel is derived from resources within the United States, Canada, and Mexico.

Dual-Fuel Vehicle: Vehicle with two separate fuel systems designed to run on either an alternative fuel or conventional gasoline, using only one fuel at a time.

E10 (Gasohol): Ethanol/gasoline mixture containing 10% denatured ethanol and 90% gasoline, by volume.

E85: Ethanol/gasoline mixture containing 85% denatured ethanol and 15% gasoline, by volume.

E95: Ethanol/gasoline mixture containing 95% denatured ethanol and 5% gasoline, by volume.

Electricity: Electric current used as a power source. In electric vehicles, on-board rechargeable batteries power an electric motor.

Electric Vehicle: A vehicle powered by electricity, generally provided by storage batteries, but may also be provided by solar cells or fuel cells.

Ethanol (also known as Ethyl Alcohol, Grain Alcohol, CH_3CH_2OH): An alcohol fuel produced from the fermentation of various sugars from carbohydrates found in agricultural crops and cellulosic residues from crops or wood. When used as a gasoline octane enhancer and oxygenate, it increases octane by 2.5 to 3 numbers at 10% concentration. Ethanol can also be used in higher concentration in AFVs that have been designed or converted for its use.

Feedstock: Any material that is converted to another form of fuel or energy product. Corn, for example, is used as a feedstock for ethanol production.

Fermentation: The transformation of sugars into alcohols. The process by which organic material is converted into ethanol, for example.

Flexible Fuel Vehicles (FFV): Vehicles with a common fuel tank designed to run on varying blends of unleaded gasoline with either ethanol or methanol.

Fuel Cell: An electrochemical engine (no moving parts) that converts the chemical energy of a fuel, such as hydrogen, and an oxidant, such as oxygen, directly into electricity.

Gasification: A chemical or thermal process used to convert a feedstock (such as coal) into a gaseous fuel.

Gasohol (E10): Gasoline that contains 10% ethanol by volume.

Global Warming: The theoretical escalation of global temperatures caused by an increase in greenhouse gas emissions in the lower atmosphere.

Greenhouse Effect: A warming of the earth and its atmosphere as a result of the thermal trapping of incoming solar radiation.

Hybrid Electric Vehicle (HEV): A vehicle that is powered by two or more fuels, one of which is electricity.

Liquefied Natural Gas (LNG): Natural gas that has been condensed to a liquid by cooling.

Liquefied Petroleum Gas (LPG): Gaseous mixture separated from natural gas and petroleum, commonly called propane.

Low Speed Vehicle (LSV): Battery-powered electric vehicle, sometimes referred to as a neighborhood vehicle.

Low Emission Vehicle (LEV): Vehicles that meet federal standards for LEVs.

M85: Fuel with 85% methanol and 15% gasoline by volume, used as a fuel in FFVs.

M100: Neat (100%) methanol.

Methane (CH_4): The simplest hydrocarbon and principal constituent of natural gas.

Methanol (also known as Methyl Alcohol, Wood Alcohol, CH3OH): A liquid fuel usually manufactured from natural gas.

Natural Gas: A mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth and used as a fuel.

Neat Fuel: Fuel that is free from additives or dilution with other fuels. M100, for example, is 100% methanol and is called neat methanol.

Neighborhood Electric Vehicle (NEV): Battery-powered electric vehicle with top speed of 30 mph.

Ozone: Tropospheric ozone, or smog, at ground level is a respiratory irritant and considered a pollutant produced from the interaction of hydrocarbon fuel emissions and sunlight. This is different from the stratospheric ozone in the upper atmosphere that protects the earth from ultraviolet radiation.

Petroleum Fuels: Gasoline and diesel fuels.

Propane: See Liquefied Petroleum Gas.

Reformulated Gasoline (RFG): Gasolines that have been altered to reduce emissions of pollutants.

Smog: A visible haze caused primarily by particulate matter and ozone in the lower atmosphere.

Tax Incentives: A reduction in taxes to encourage people and businesses to invest in socially desirable economic objectives, such as using alternative fuel vehicles.

Toxic Emission: Any pollutant emitted from a source that can negatively affect human health or the environment.

U.S. Department of Energy (DOE): Department of the Federal government that coordinates and manages energy conservation, supply, information dissemination, regulation, research, development and demonstration.

U.S. Department of Transportation (DOT): Department of the Federal government that handles national transportation issues.

U.S. Environmental Protection Agency (EPA): Government agency responsible for protection of the environment and public health, regulating air, water and land pollution, as well as pollution from solid waste, radiation, pesticides and toxic substances. EPA also controls emissions from motor vehicles, fuels, and fuel additives.

Zero Emission Vehicle (ZEV): Vehicle meeting Federal or California standards for ZEVs. ZEVs standards, usually met by electric vehicles, require zero vehicle emissions (though not zero power plant source emissions).

Transportation Fuel Comparison

	GASOLINE	DIESEL	PROPANE	CNG	LNG	ETHANOL	METHANOL	ELECTRICITY	BIODIESEL
Chemical Formula	C_8H_{15-18}	$C_{16}H_{34}$	C_3H_8	CH_4	CH_4	C_2H_5OH	CH_3OH		C_{14} to C_{24}
Energy Content *(Btu/gallon)*	114,000	128,000	84,000	114,000 *gal equiv*	76,000	E85 - 80,460 E100 - 75,000	M85 - 65,000 M100 - 57,000		B20 - 126,000 B100 - 115,000
Octane	86-94	Cetane: 40-55	104	120+		100	100		Cetane: 40-55
Number of Vehicles	220,000,000	800,000	195,000	144,000	3,100	E85-146,000 E10-3,000,000	4,600	55,000	
Number of Fuel Stations	180,000		3,500	1,300	50	E85-200	40	600	
Advantages	Many fuel stations; vehicles designed to use gasoline; familiarity.	Many fuel stations; vehicles designed to use diesel fuel; familiarity.	Inexpensive fuel; most widely available clean fuel; lower emissions of ozone-forming hydrocarbons and toxics, very good for fleets	Very low emissions of ozone-forming hydrocarbons, toxics, and carbon monoxide. Very good fuel for fleets; can be made from renewables.	Very low emissions of ozone-forming hydrocarbons, toxics, and carbon monoxide. Very good fuel for fleets; can be made from renewables.	From renewable feedstocks; very low emissions of ozone-forming hydrocarbons and toxics; can be domestically produced.	Very low emissions of ozone-forming hydrocarbons and toxics; can be made from renewable feedstocks.	Zero vehicle emissions; power plant emissions easier to control; can recharge at night when power cost and demand is low.	Reduces sulfur emissions; increases lubricity; uses renewable waste products; no vehicle changes required.
Disadvantages	Polluting emissions; unpredictable price; nonrenewable; limited and possibly unreliable supply.	Polluting emissions; unpredictable price; nonrenewable; limited and possibly unreliable supply.	Nonrenewable, cost may rise with increasing demand; limited supply; no energy security or trade balance benefits.	Higher vehicle cost, lower vehicle range; limited fueling stations, nonrenewable at present.	Higher vehicle cost, lower vehicle range; limited fueling stations, nonrenewable at present.	Variable fuel cost; somewhat lower vehicle range; not widely available.	Limited supplies; lower range; not widely available; currently made from nonrenewables.	Current technology is limited; higher vehicle cost; lower range and performance; less convenient refueling.	Limited availability; higher cost.

WEB RESOURCES

www.kentuckycleanfuels.org - Kentucky Clean Fuels Coalition

www.afdc.doe.gov - Alternative Fuels Data Center of Department of Energy (DOE)

www.ott.doe.gov - Office of Transportation Technologies of Department of Energy (DOE)

www.eere.energy.gov/hydrogenandfuelcells - Office of Energy Efficiency and Renewable Energy (DOE)

www.ccities.doe.gov - Clean Cities Program of the Department of Energy

www.eia.doe.gov - Energy Information Administration of the Department of Energy

www.epa.gov - U.S. Environmental Protection Agency

www.nrel.gov - National Renewable Energy Laboratory - Department of Energy

www.energy.ky.gov - Kentucky Division of Energy

www.doyourshare.org - Regional Ozone Coalition

www.evaa.org - Electric Electric Drive Transportation Association

www.energy.ca.gov - California Energy Commission

www.biodiesel.org - National Biodiesel Board

www.honda.com - Honda

www.fleet.chrysler.com - DaimlerChrysler

www.fleet.ford.com - Ford

www.gmaltfuel.com - General Motors

www.toyota.com - Toyota

www.parcar.com - Columbia Par Car

www.kypropane.org - Kentucky Propane Council

www.suburbanpropane.com - Suburban Propane

www.biog3000.com - Griffin Industries

www.ridetarc.org - Transit Authority of River City

www.apcd.org - Jefferson County Air Pollution Control District

www.transportation.ky.gov - Ky Transportation Cabinet

www.kysoy.org - Kentucky Soybean Council

www.ethanol-gec.org - Governors' Ethanol Coalition

www.fueleconomy.gov - Fuel Economy U.S. Department of Energy and Environmental Protection Agency

www.dieselforum.org - Diesel Technology Forum

STUDENT GUIDE—FUEL EXHIBIT

Step 1—Learn about your Fuel.

Read about your topic in your backgrounder and in other resources. Underline the main ideas. Put a star (*) by the most important facts. As a group, make a list of the facts you want to teach others.

Make sure you answer these questions:

What is the chemical composition of your fuel?
Is your fuel renewable or nonrenewable?
How is your fuel made?
Is your fuel available in your area?
What types of vehicles can use your fuel?
What are the costs associated with your fuel?
What are the advantages and disadvantages of your fuel?
What are the challenges to developing a widespread market for your fuel?
Would you buy a vehicle that uses your fuel? Why or why not?

Step 2—Plan your Exhibit.

As a group, make a list of the displays you can use to make your exhibit interesting. Here are some suggestions:

Display pictures of vehicles that use your fuel.

Make a diagram listing the advantages and disadvantages of your fuel.

Show a cost analysis of your fuel, including cost of vehicles, fuel, and tax incentives.

Show an environmental analysis of your fuel.

Step 3—Use your Talent.

As a group, decide who will do which jobs. Write down the name of each person in the group. Next to each name, write the person's jobs. You can have more than one person helping on each job.

Who will write the script?

Who will make the displays?

Who will collect the materials we need?

Who will learn the script and teach the others?

Step 4—Create your Exhibit and Write your Script.

Write a two minute script using the list of important facts.

Create an interesting display with posters and hands-on materials. Make sure the display and the script cover the same information.

Practice the script so that you don't have to read it. Use notecards with the important facts listed on them.

Step 5—Teach Others!

Give a presentation of your exhibit to others.

WHAT CAR WILL YOU DRIVE?

Evaluation Form

State: ___________ **Grade Level:** ___________ **Number of Students:** __________

1.	Did you conduct the entire activity?	Yes	No
2.	Were the instructions clear and easy to follow?	Yes	No
3.	Did the activity meet your academic objectives?	Yes	No
4.	Was the activity age appropriate?	Yes	No
5.	Were the allotted times sufficient to conduct the activity?	Yes	No
6.	Was the activity easy to use?	Yes	No
7.	Was the preparation required acceptable for the activity?	Yes	No
8.	Were the students interested and motivated?	Yes	No
9.	Was the energy knowledge content age appropriate?	Yes	No
10.	Would you use the activity again?	Yes	No

How would you rate the activity overall (excellent, good, fair, poor)?

How would your students rate the activity overall (excellent, good, fair, poor)?

What would make the activity more useful to you?

Other Comments:

Please fax or mail to:
NEED Project
PO Box 10101
Manassas, VA 20108
FAX: 1-800-847-1820

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Long Island Power Authority–NY
Maine Energy Education Project
Maine Public Service Company
Marianas Islands Energy Office
Maryland Energy Administration
Massachusetts Division of Energy Resources
Michigan Energy Office
Michigan Oil and Gas Producers Education Foundation
Minerals Management Service–U.S. Department of the Interior
Mississippi Development Authority–Energy Division
Montana Energy Education Council
Narragansett Electric–A National Grid Company
NASA Educator Resource Center–WV
National Alternative Fuels Training Center–West Virginia University
National Association of State Energy Officials
National Association of State Universities and Land Grant Colleges
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
New Jersey Department of Environmental Protection
New York Power Authority
North Carolina Department of Administration–State Energy Office
Nebraska Public Power District
New Mexico Oil Corporation
New Mexico Landman's Association
New York State Energy Research and Development Authority
Offshore Energy Center/Ocean Star/OEC Society
Offshore Technology Conference
Ohio Energy Project
Pacific Gas and Electric Company
Petroleum Equipment Suppliers Association
Poudre School District–CO
Puerto Rico Energy Affairs Administration
Puget Sound Energy
Roswell Desk and Derrick Club
Roswell Geological Society
Rhode Island State Energy Office
Sacramento Municipal Utility District
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