2012-2013

Elementary Transportation Fuels Infobook

Fact sheets and suggested activites to educate students about the economic, environmental, and societal impacts of using conventional and alternative transportation fuels.

TRANSPORTATION

Grade Level:

- Elementary
- Intermediate

Subject Areas:

- Science
- Language Arts
- Technology

NEED
National Energy Education Development Project

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 Statement

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

Permission to Copy

Energy Data Used in NEED Materials

NEED believes in providing the most recently reported energy data available to our teachers and students. Most statistics and data are derived from the U.S. Energy Information Administration's Annual Energy Review that is published in June of each year. Working in partnership with EIA, NEED includes easy to understand data in our curriculum materials. To do further research, visit the EIA web site at www.eia.gov. EIA's Energy Kids site has great lessons and activities for students at www.eia.gov/kids.

NEED
National Energy
Education Development

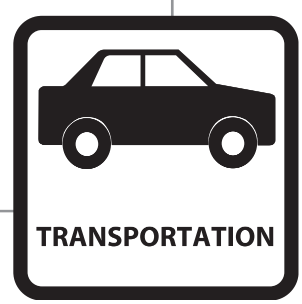
1.800.875.5029
www.NEED.org

Elementary Transportation Fuels Infobook

Table of Contents

Data For This Guide is From:

- **U.S. Department of Energy Office of Energy Efficiency and Renewable Energy**
  - Alternative Fuels and Advanced Vehicles Data Center
  - Clean Cities Program
- ***U.S. Department of Energy Transportation Energy Data Book,* 30th Edition**
- **Fueleconomy.gov**
- **U.S. Energy Information Administration**



Correlations to National Science Education Standards: Grades 1-4

This book has been correlated to National Science Education Content Standards.
For correlations to individual state standards, visit **www.NEED.org**.

Content Standard B | *PHYSICAL SCIENCE*

- **Properties of Objects and Materials**
  - Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.
  - Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort a group of objects or materials.
  - Materials can exist in different states—solid, liquid, and gas. Some common materials, such as water, can be changed from one state to another by heating or cooling.

Content Standard D | *EARTH AND SPACE SCIENCE*

- **Properties of Earth Materials**
  - Earth materials are solid rocks and soils, water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.

Content Standard F | *SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES*

- **Types of Resources**
  - Resources are things that we get from the living and nonliving environment to meet the needs and wants of a population.
  - Some resources are basic materials, such as air, water, and soil; some are produced from basic resources, such as food, fuel, and building materials; and some resources are nonmaterial, such as quiet places, beauty, security, and safety.
  - The supply of many resources is limited. If used, resources can be extended through recycling and decreased use.
- **Changes in Environments**
  - Changes in environments can be natural or influenced by humans. Some changes are good, some are bad, and some are neither good nor bad. Pollution is a change in the environment that can influence the health, survival, or activities of organisms, including humans.
- **Science and Technology in Local Challenges**
  - People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people.
  - Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world.

Correlations to National Science Education Standards: Grades 5-8

This book has been correlated to National Science Education Content Standards.
For correlations to individual state standards, visit **www.NEED.org**.

Content Standard B | *PHYSICAL SCIENCE*

- **Properties and Changes of Properties in Matter**
  - A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample. A mixture of substances often can be separated into the original substances using one or more of the characteristic properties.
  - Chemical elements do not break down during normal laboratory reactions involving such treatments as heating, exposure to electric current, or reaction with acids. There are more than 100 known elements that combine in a multitude of ways to produce compounds, which account for the living and nonliving substances that we encounter.
- **Transfer of Energy**
  - Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.
  - In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light mechanical motion, or electricity might all be involved in such transfers.

Content Standard E | *SCIENCE AND TECHNOLOGY*

- **Understandings about Science and Technology**
  - Scientific inquiry and technological design have similarities and differences. Scientists propose explanations for questions about the natural world, and engineers propose solutions relating to human problems, needs, and aspirations. Technological solutions are temporary; technologies exist within nature and so they cannot contravene physical or biological principles; technological solutions have side effects; and technologies cost, carry risks, and provide benefits.
  - Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in back-up systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.
  - Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.
  - Technological solutions have intended benefits and unintended consequences. Some consequences can be predicted, others cannot.

Content Standard F | *SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES*

- **Risks and Benefits**
  - Students should understand the risks associated with natural hazards (fires, floods, tornadoes, hurricanes, earthquakes, and volcanic eruptions), with chemical hazards (pollutants in air, water, soil, and food), with biological hazards (pollen, viruses, bacterial, and parasites), social hazards (occupational safety and transportation), and with personal hazards (smoking, dieting, and drinking).
  - Important personal and social decisions are made based on perceptions of benefits and risks.
- **Science and Technology in Society**
  - Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.
  - Technology influences society through its products and processes. Technology influences the quality of life and the ways people act and interact. 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.

TRANSPORTATION

Teacher Guide

Fact sheets and suggested activites to educate students about the economic, environmental, and societal impacts of using conventional and alternative transportation fuels.

Grade Level

- Elementary and Intermediate Grades 3-6

Time

- Two-five 45-minute class periods

NEED Resources

NEED has many guides available to expand and extend your unit on transportation fuels. All guides are available to download free of charge from www.NEED.org:

- *Energy Expos*
- *Fossil Fuels to Products*
- *H_2 Educate*
- *Transportation Fuels Debate*
- *Transportation Fuels Enigma*
- *Transportation Fuels Rock Performances*

Background

The *Elementary Transportation Fuels Infobook* provides the foundation for NEED's transportation curriculum of cooperative learning activities in which students evaluate the advantages and disadvantages of conventional and alternative 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.

Skill Reinforcement

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

Preparation

1. Familiarize yourself with the materials and activities in this booklet.
2. Project or copy the *Alternative Fuel Vehicles in Use Since 1992* Graph on page 26 to share with your class.
3. Decide which activities your students will conduct.
4. Reproduce materials the students will need to conduct the activities. There are several items in the Teacher Guide that may be helpful for students while reading and researching. These include: *Glossary*, *Web Resources*, and the *Transportation Fuel Acronyms* list. Some of the items on these materials have not been discussed in-depth within the guide, but may show up during student research and questioning.
5. Find experts in the community to supplement the information in this booklet.

Suggested Activities

1. ***LEARNING ABOUT TRANSPORTATION FUELS***

   Share the *Alternative Fuel Vehicles in Use Since 1992* graph with the class. Discuss trends seen in the graph.

   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 alternative fuels and alternative fuel vehicles.

2. ***CONDUCTING RESEARCH ON TRANSPORTATION FUELS***

   Using the *Web Resources* listed on page 30 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, or create a display, 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 groups and have each group develop a plan to present to the mayor, listing recommendations and costs 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 Guides in *Energy Expos,* have students in groups prepare exhibits or multimedia presentations on transportation fuels to teach others. *Energy Expos* is available to download at www.NEED.org.

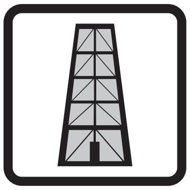
6. ***CALCULATING FUEL SAVINGS***

   Have your students compare the fuel costs for a Ford Fusion and Ford Fusion Hybrid over five years using the following figures:

	2011 FORD FUSION	**2011 FORD FUSION HYBRID**
Initial Cost:	$25,300	$28,600
Average Miles per Gallon:	26 mpg	39 mpg
Miles per Year:	15,000	15,000
Cost per Gallon:	$ 3.31	$ 3.31

7. ***PRETZEL POWER***

   The students will recognize the energy efficiency of different kinds of transportation and the benefits of carpooling.



Petroleum

For more than a hundred years, petroleum has fueled our vehicles. In the United States, we use almost 13.5 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 2.5 trillion miles a year. Commercial trucks drive over 288 billion miles, public transit buses drive 2.3 billion miles, and school buses drive nearly six billion miles. There are a lot of vehicles driving those miles—246,000,000 personal vehicles, 11 million commercial trucks, 65,400 public transit buses, and 683,700 school buses.

These vehicles all need fuels that we can afford and are easy to find. Today, over 99 percent of our vehicles run on gasoline 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 half 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 summer of 2008, the cost of a barrel of crude oil soared to $133, 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.

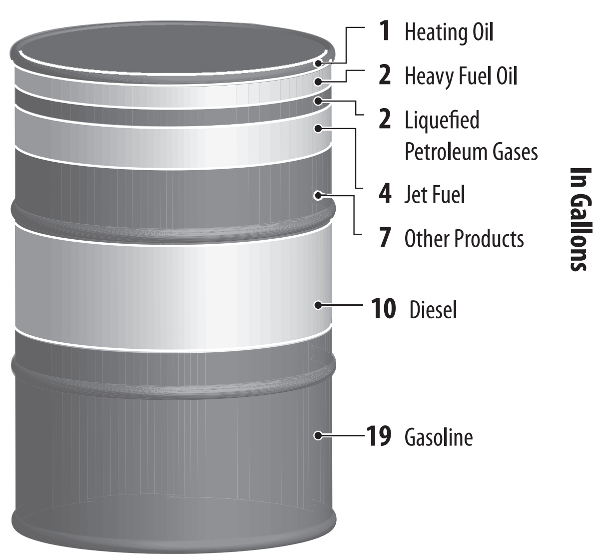
The vehicles on the road today cause half of the air pollution in many cities. According to the **U.S. Environmental Protection Agency**, almost half of all Americans live in polluted areas. This has led to an effort to develop alternatives to petroleum fuels.

Taking an Alternative Route

Vehicles can be powered by fuels other than gasoline and diesel. **Alternative fuels**—such as propane, natural gas, 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**.

OIL PUMP JACK

Products Produced From a Barrel of Oil, 2010



Note: A 42-U.S. gallon barrel of crude oil yields about 45 gallons of petroleum products.

Data: Energy Information Administration

Gasoline

Gasoline is a fuel made from petroleum. It is used in most U.S. passenger vehicles with **internal combustion engines**. To meet our transportation needs, Americans use 13.4 million barrels of crude oil, or 256.5 million gallons of gasoline, every day. With over 309 million people in the U.S., that is almost one gallon of gasoline every day for each man, woman, and child.

History of Gasoline

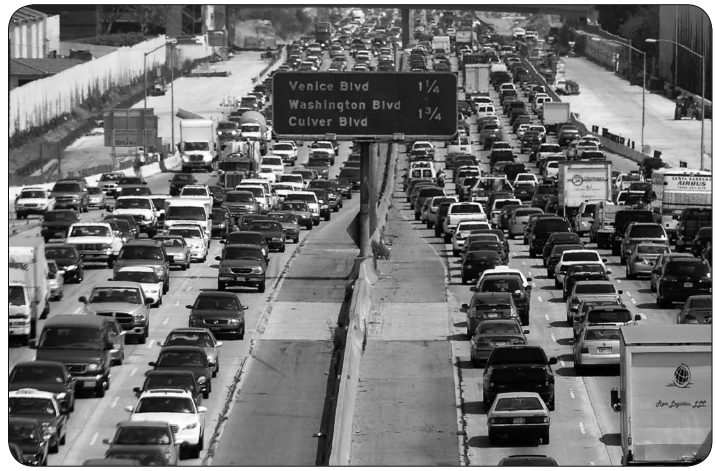
Edwin Drake dug the first oil well in 1859 and distilled the petroleum to produce kerosene for lighting. He had no use for the gasoline or other products, so he discarded them. It wasn't until 1892 with the invention of the automobile that gasoline was recognized as a valuable fuel. By 1920, there were 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 ratings** 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 246 million vehicles that use gasoline to travel an average of 12,000 miles per year. There are 159,000 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 shortages after Hurricanes Katrina and Rita and unrest in oil-producing countries such as Iran, Iraq, and Nigeria. In 2008, the average price for a gallon of gasoline was the highest ever at $3.27. However, in 2010, the average price for a gallon of gasoline was only $2.79.



More than 246 million passenger vehicles take to the roads every day in the United States. Gasoline fuels 99 percent of these vehicles.

Characteristics and Environmental Impacts of Gasoline

Gasoline has 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 gasoline and vehicle designs that have reduced vehicle exhaust emissions by 95 percent.

The **Clean Air Act** Amendments of 1990 required that **reformulated gasoline** 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 was 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 achievement 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, because it provides more power per volume.

Diesel fuel is used for many things. 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 commonly used fuel for public buses and school buses throughout the U.S.

America's construction industry depends on the power of diesel fuel. 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.

Several auto manufacturers are in the process of releasing new models of light-duty diesels and passenger cars. Within the next few years, demand for diesel vehicles is expected to increase greatly in the U.S.

DIESEL TRUCK

Characteristics and Environmental Impacts of Diesel

Diesel-powered cars achieve 30-35 percent better fuel economy than gasoline powered cars, especially in sport utility vehicles (SUVs) and light trucks, which now make up more than half 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. Major progress has been made in reducing emissions from diesel engines. New diesel fuels—some of which have lower sulfur content—can also help diesel vehicles achieve lower emissions. As of 2010, new trucks and buses have near zero emission levels. 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.

Biodiesel

Biodiesel is a fuel made from vegetable oils or animal fats. It is usually made from soybean oil, but it can also be made from corn oil or even used restaurant grease and fryer oil. If it is made from restaurant oil, it can sometimes smell like french fries. Since biodiesel is made from plant and animal oils, it is a renewable fuel. We can grow more plants in a short time to make more biodiesel.

Biodiesel as a Transportation Fuel

Biodiesel works as well in engines as diesel fuel. In many ways, it is a better fuel, though it is more expensive. Burning biodiesel does not produce as much air pollution as burning petroleum fuels. This means the air is cleaner and healthier to breathe when biodiesel is used. Biodiesel is also nontoxic—it is not dangerous to people or the environment, and is safe to handle. If biodiesel spills, it is biodegradable—it breaks down quickly into harmless substances.

Biodiesel can be used instead of diesel fuel or it can be mixed with diesel fuel. It is usually mixed with diesel fuel as a two percent (B2), five percent (B5), or 20 percent (B20) biodiesel blend. Pure biodiesel is called B100. That means it is 100 percent biodiesel. The B stands for biodiesel and the number stands for the percent of biodiesel in the mixture or blend.

Most biodiesel used today is B20, which is 20 percent biodiesel and 80 percent diesel. Many school districts have begun using B20 in their school buses. In Arizona's Deer Valley Unified School District, school buses have been running on B20 since 1999. These buses drove over 2.5 million miles per year on B20. Everyone involved is pleased with the way the buses operate and believe using biodiesel improves the environment and the health of the students and drivers.

Many cities, as well as the U.S. Army, Air Force, and Department of Agriculture, are using biodiesel to run their buses, garbage trucks, snowplows, and other vehicles. These fleets have their own fueling stations. Biodiesel fuels are also becoming more available at public stations, as consumer demand grows.

Environmental Impacts

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

BIODIESEL SCHOOL BUS

Image courtesy of NREL

Used vegetable oil can be used in modified diesel engines, making the exhaust smell like the food that was fried in the oil.

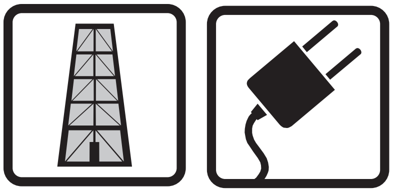
SOYBEANS

Soybean oil is often used to make biodiesel.

Biodiesel Today and Tomorrow

Today, biodiesel is mainly available through bulk suppliers. There are 618 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 fuels have a small amount of biodiesel to reduce sulfur emissions.



Hybrid Electric Vehicles

The **hybrid electric vehicle**, or HEV (hybrid means combination, or mixture), has a growing presence in the automotive market. 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. HEVs on the market today have the same power and performance but can travel farther on one gallon of gas than gasoline-only vehicles.

When you drive an HEV, it feels the same as driving a regular car—except that there is very little 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.

The battery that powers the electric motor is continually recharged by an on-board generator. The engine recharges the batteries whenever they are low. The **regenerative braking** system captures excess energy when the driver uses the brakes. This energy is also used to recharge the batteries.

Environmental Impacts

HEVs have significant environmental benefits. They reduce pollutants by one-third to one-half compared to conventional vehicles, because they use less fuel.

Hybrids Today and Tomorrow

In 2006, there were eight hybrid models available to the general public. Today, there are over 30 hybrid models available from almost every manufacturer, and they range from passenger cars to SUVs and pickup trucks.

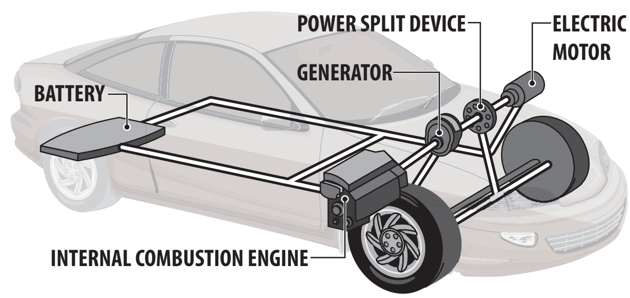
PHEV RECHARGING STATION

Image courtesy of NREL

TOYOTA PRIUS

Image courtesy of NREL

How a Hybrid Electric Vehicle Works



Hybrid electric vehicles combine the benefits of gasoline engines and electric motors. Typically, the wheels are powered by an electric motor, and in some cases, the internal combustion engine assists. Hybrid electric vehicles do not need to be plugged in to charge the battery because they are charged by an onboard generator.

Plug-In Hybrid Electric Vehicles (PHEVs)

PHEVs are very similar to HEVs. They have an internal combustion engine, an electric motor, and a large battery pack. The larger battery pack in the PHEV gives it a range of 10-40 miles on an electric only range. When the battery is depleted the car continues to operate as a hybrid or gasoline vehicle.

The battery pack in a PHEV can be recharged by plugging it into a regular 120-volt electric outlet. People using a PHEV in an urban setting may be able to make their daily commute using all-electric power and then recharge the battery overnight to be ready for the next day's commute.

In 2012, there are only a few PHEV models available on the market, but more are expected to be available soon.

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 more than 57,500 EVs in use in the United States. Researchers are still working on the same problem experienced by those early electric vehicles—an efficient battery.

The Battery is the Challenge

Electric vehicles must have batteries that can be charged 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.

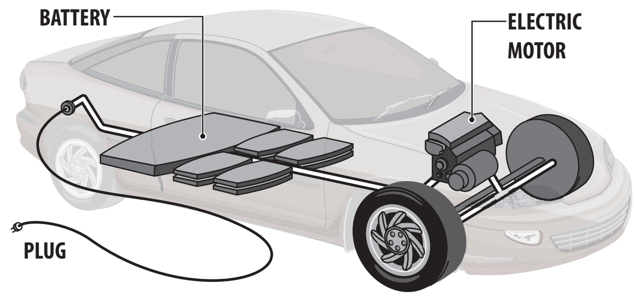
The batteries limit the range of an EV—how far it can go on a charge. The more batteries an EV has, the more range it has, to a point. Too many batteries can weigh down a vehicle, causing it to use more energy. The typical EV can only travel 50 to 130 miles between charges. EVs can only go this far with 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 35 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 produce emissions. EVs are really coal, natural gas, nuclear, hydropower, and wind cars, because these fuels produce most of the electricity in the U.S. Coal alone generates almost 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.

How an Electric Vehicle Works



Electric vehicles store electricity in large battery banks. They are plugged into a wall outlet (either a 240-volt or standard 120-volt) for several hours to charge. An electric motor powers the wheels, and acts as a generator when the brakes are applied, recharging the battery.

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 9,980 electric charging units at public refueling stations, allowing you to recharge at the airport, in a parking garage, or even while shopping at the mall.

The Future of EVs

Today there are not too many options if you want to drive a dedicated EV. However, more and more car manufacturers are manufacturing EVs. By 2015, Nissan, Ford, Honda, Toyota, Chrysler, and Chevrolet all expect to have EVs available to consumers.

Ethanol

Ethanol is a clear, colorless fuel made from the sugars found in plants. Ethanol can be blended with gasoline to reduce pollution from the tailpipes of vehicles. In the U.S., ethanol is usually made from corn. Today, many ethanol plants, mostly in the Midwest, produce over nine billion gallons of ethanol a year.

There are several processes that can produce alcohol (ethanol) from **biomass**. The most commonly used processes today use yeast to **ferment** the sugars and starch in the **feedstock** to produce ethanol. 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.

Ethanol as a Transportation Fuel

Most of the ethanol fuel used today is **E10**. The letter E stands for ethanol and the number stands for the percent of ethanol that is mixed with gasoline. E10 is 10 percent ethanol and 90 percent gasoline. There are fueling stations all over the country that offer E10 in their pumps. All vehicles that run on gasoline can use E10 without making any changes to their engines. You will often see stickers at the gas pump telling you that the gas may contain up to 10 percent ethanol.

When we add small amounts of ethanol to gasoline (up to 10 percent) there are many advantages. It reduces the pollution from the tailpipes of vehicles, making the air cleaner. It keeps engines running smoothly without the need for lead or other dangerous chemicals. Ethanol is produced from crops grown in the United States; it is a **domestic fuel**. Over ninety percent (90%) of the ethanol produced in the United States today is mixed with gasoline to make E10.

There are also cars that are designed to run on higher ethanol blends. These cars are called **flexible fuel vehicles (FFVs)**. They can use any blend of ethanol fuel from E10 to E85. Gasoline that contains 85 percent ethanol or more is considered an alternative fuel. While there are an estimated eight million FFVs in the United States today, only 618,500 of these vehicles use **E85**. Many FFVs don't have access to E85. There are 2,500 fueling stations with E85 pumps in 46 states. This number is expected to keep rising in the next few years.

ETHANOL

Image courtesy of NREL

The city of Boulder, CO has set a goal to make 90 percent of its fleet vehicles run on some kind of alternative fuel. Many of them run on E85.

Ethanol can be mixed with diesel as a fuel for trucks and buses that usually run on diesel. It can also be used instead of leaded gasoline in small planes. In addition, ethanol is being tested as a fuel to produce hydrogen for **fuel cell** vehicles.

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

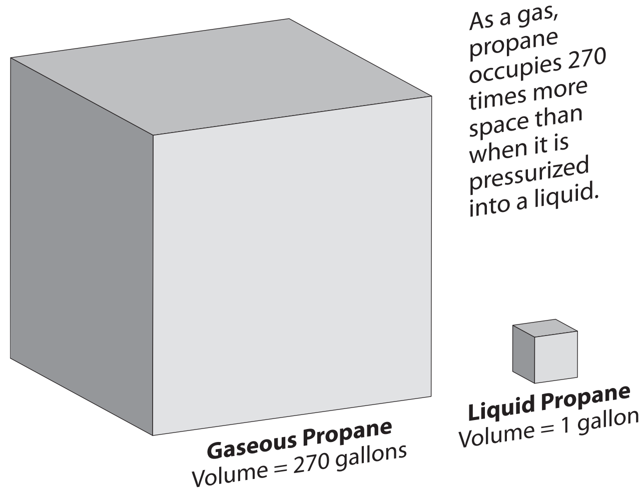
Using ethanol as a fuel helps farmers by providing additional uses for their crops. Ethanol is a cleaner fuel than gasoline; it makes the air healthier to breathe. Using ethanol also means we don't have to import as much petroleum from other countries.

Propane

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 agent. 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.)

Liquefied Propane



Propane as a Transportation Fuel

Propane has been used as a transportation fuel for more than 80 years. It is commonly used as an 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 less than gasoline.

Propane is a good engine fuel. It is cleaner burning than gasoline. The engine stays clean, 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 2,660 propane-fueling stations in the U.S. A regular car has to be modified (changed) to use propane, which can cost between $4,000 to $12,000.

PROPANE-FUELED VAN

Image courtesy of NREL

Many fleet vehicles have been converted to run on propane.

Environmental Impacts

Propane engines produce less air pollution than gasoline. Carbon monoxide emissions from propane vehicles are 20 to 90 percent lower and hydrocarbon emissions are 40 to 80 percent lower than gasoline engines.

Future of Propane

Propane will mostly be used 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.

Natural Gas

The **natural gas** we use for heating, cooking, clothes drying, and water heating can also be a cleaner 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.

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, making it a little more difficult to catch fire.

Today, there are only 1,014 natural gas fueling stations in the United States—much fewer than the 159,000 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 cleaner-burning fossil fuel. Compressed natural gas 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 116,000 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. Nearly 10,000 public transit buses around the country are using CNG as fuel.

Honda manufactures a Civic that runs on CNG. It costs over $10,000 more than a gasoline-powered Civic. A regular vehicle can also be modified to run on CNG at a cost of $12,000 to $18,000.

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.

LNG—Liquefied Natural Gas

There are about 3,400 vehicles in the U.S. that run on LNG—natural gas that is turned into a liquid by cooling it to –259°F. Most LNG vehicles are government-owned. There are 53 LNG-fueling stations at this time. The advantage of LNG is that natural gas takes up much less space as a liquid than as a gas, so the tanks can be much smaller. The disadvantage is that the fuel tanks must be kept cold, which uses more fuel.

NATURAL GAS BUS

Image courtesy of the United States Environmental Protection Agency

Many public buses are fueled by natural gas.

Hydrogen and the Road to the Future

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.

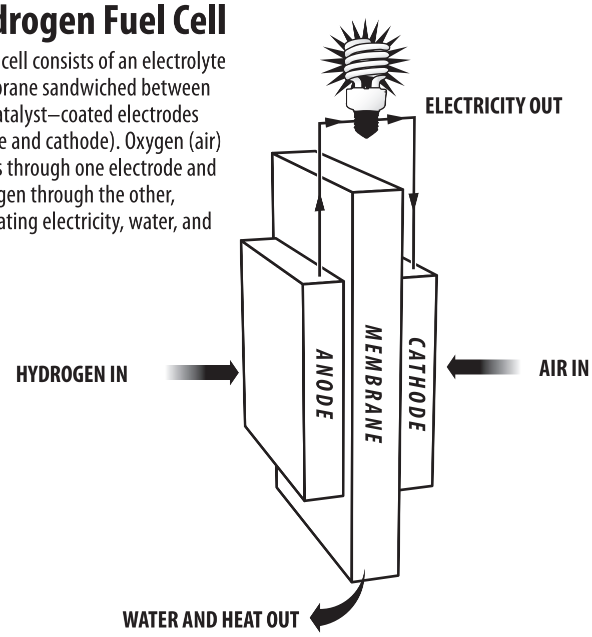
You can't buy a hydrogen car today, but there are research vehicles that are powered by hydrogen fuel cells. Hydrogen fuel cells use hydrogen and oxygen to make electricity without harmful emissions; water is the main by-product.

CAR FUELED BY A HYDROGEN FUEL CELL

Image courtesy of DOE-NREL, Keith Wipke

Hydrogen Fuel Cell

A fuel cell consists of an electrolyte membrane sandwiched between two catalyst–coated electrodes (anode and cathode). Oxygen (air) passes through one electrode and hydrogen through the other, generating electricity, water, and heat.



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 **U.S. Department of Energy** 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.

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 result in less carbon dioxide than fuels from petroleum.

There are about one million alternative fuel vehicles on the road today meeting the needs of individuals, families, and fleets. Most **dedicated alternative fuel vehicles**—those that use only one fuel (hydrogen, LNG, electric, CNG, LPG, or E85)—are better suited to fleets with their own fueling stations, since it is sometimes hard to find a fuel station.

With rising gasoline prices and concern for the environment, more and more people are looking at using alternative fuels to fuel their vehicles.

TRANSPORTATION

Selected Light Duty Vehicles, 2012

MODEL	FUEL	VEHICLE	EMISSION CLASS	FUEL ECONOMY
Buick LaCrosse FFV	Flex Fuel E85	Sedan	Tier 2 Bin 4	13 mpg city, 19 mpg highway
Cadillac Escalade ESV	Flex Fuel E85	SUV	Tier 2 Bin 5	10 mpg city, 15 mpg highway
Cadillac Escalade Hybrid	Hybrid Electric	SUV	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Chevrolet Equinox	Flex Fuel E85	SUV	Tier 2 Bin 4	15 mpg city, 22 mpg highway
Chevrolet Malibu	Flex Fuel E85	Sedan	Tier 2 Bin 4	15 mpg city, 23 mpg highway
Chevrolet Silverado 1500 Hybrid	Hybrid Electric	Pickup Truck	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Chevrolet Tahoe 1500 Hybrid	Hybrid Electric	SUV	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Chevrolet Volt	Plug-in Hybrid Electric	Sedan	SULEV	95 mpgge city, 93 mpgge highway
Chrysler Town & Country	Flex Fuel E85	Minivan	Tier 2 Bin 4	12 mpg city, 18 mpg highway
Dodge Grand Caravan	Flex Fuel E85	Minivan	Tier 2 Bin 4	12 mpg city, 18 mpg highway
Ford Escape FFV	Flex Fuel E85	SUV	Tier 2 Bin 4	13 mpg city, 17 mpg highway
Ford Escape Hybrid	Hybrid Electric	SUV	SULEV, Tier 2 Bin 3	34 mpg city, 31 mpg highway
Ford F150	Flex Fuel E85	Pickup Truck	Tier 2 Bin 4	12 mpg city, 17 mpg highway
Ford Focus EV	Electric (Dedicated)	Sedan	ZEV, Tier 2 Bin 1	100 mile range city
Ford Fusion Hybrid	Hybrid Electric	Sedan	SULEV, Tier 2 Bin 3	41 mpg city, 36 mpg highway
GMC Yukon 1500 Hybrid	Hybrid Electric	SUV	Tier 2 Bin 5	20 mpg city, 23 mpg highway
Honda Civic NGV	Natural Gas (Dedicated)	Sedan	LEV II AT-PZEV, Tier 2 Bin 2	24 mpgge city/ 36 mpgge highway
Honda Fit EV	Electric (Dedicated)	Two-Seater	CARB ZEV, Tier 2 Bin 1	100 mile range city
Honda Insight	Hybrid Electric	Two-Seater	LEV II AT-PZEV, Tier 2 Bin 2	40 mpg city, 43 mpg highway
Jeep Grand Cherokee	Flex Fuel E85	SUV	Tier 2 Bin 4	13 mpg city, 17 mpg highway
Kia Optima Hybrid	Hybrid Electric	Sedan	LEV II SULEV	35 mpg city, 40 mpg highway
Lexus CT 200h	Hybrid Electric	Sedan	LEV II SULEV, Tier 2 Bin 3	43 mpg city, 40 mpg highway
Nissan Altima Hybrid	Hybrid Electric	Sedan	LEV II SULEV, Tier 2 Bin 5	33 mpg city, 33 mpg highway
Nissan Leaf	Electric (Dedicated)	Sedan	CARB ZEV, Tier 2 Bin 1	100 mile range city
Porsche Cayenne S Hybrid	Hybrid Electric	SUV	LEV II ULEV, Tier 2 Bin 5	20 mpg city, 24 mpg highway
Tesla Motors Model S	Electric (Dedicated)	Sedan	CARB ZEV, Tier 2 Bin 1	300 mile range city
Toyota Highlander Hybrid	Hybrid Electric Flexible Fuel	SUV	LEV II SULEV, Tier 2 Bin 3	28 mpg city, 28 mpg highway
Toyota Prius Hybrid	Hybrid Electric	Sedan	LEV II AT-PZEV, Tier 2 Bin 3	51 mpg city, 48 mpg highway
Toyota Prius Plug-in Hybrid	Plug-in Hybrid Electric	Sedan	LEV II AT-PZEV, Tier 2 Bin 3	95 mpgge city
Toyota RAV4 EV	Electric (Dedicated)	SUV	CARB ZEV, Tier 2 Bin 1	100 mile range city

mpgge = miles per gallon gasoline equivalent

For a complete list, visit www.fueleconomy.gov.

TRANSPORTATION

Transportation Fuel Comparison

	GASOLINE	DIESEL	PROPANE	CNG	LNG	ETHANOL	ELECTRICITY	BIODIESEL	HYDROGEN
Chemical Formula	C_4 to C_{12}	C_8 to C_{25}	C_3H_8	CH_4	CH_4	C_2H_5OH	N/A	C_{12} TO C_{22}	H_2
Energy Content (Btu/gallon)	116,090	128,450	84,950	20,268 Btu/lb	74,720	E85 – 80,460 E100 – 76,330	3,414 Btu/kWh	B20 – 126,000 B100 – 119,550	51,585 Btu/lb
Octane	84-93	Cetane 40-55	105	120+	120+	110	N/A	Cetane 48-65	130+
Number of Vehicles (2010)	239,700,000	4,800,000	143,037	115,863	3,354	618,506	57,462	N/A	421
Number of Fuel Stations	159,000	68,880	2,661	1,014	52	2,499	9,980 electric changing units	618	56
Advantages	Many fuel stations; vehicles designed to use gasoline; familiarity.	Many fuel stations; vehicles designed to use diesel fuel; familiarity; more fuel-efficient than gasoline; near zero emissions.	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.	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.	Near zero emissions; can be produced domestically from renewable sources.
Challenges	Polluting emissions; unpredictable price; nonrenewable; limited and possibly unreliable supply.	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.	Current technology is limited; higher vehicle cost; lower range and performance; less convenient refueling.	Limited availability; higher cost.	Production is still in research stage; distribution infrastructure is not in place.

TRANSPORTATION FUELS

Pretzel Power

Objective

The students will recognize the energy efficiency of different kinds of transportation and the benefits of carpooling.

Materials

- 3" x 5" Cards
- Internet access for students (see Note below)
- Bag of pretzels
- Plastic sandwich bags
- Three signs (Home, Near Town, Far Town)

Preparation

1. Prepare a plastic bag with ten pretzels for each student.
2. Make three signs: one labeled "Home," one labeled "Near Town," and one labeled "Far Town." The signs should be large enough to see from across the room.
3. Select a large area and place the Home, Near Town, and Far Town signs on poles or walls. The distance to Near Town should be 50 steps. The distance to Far Town should be 100 steps. (Do not give these distances to students.)

Procedure

1. Have students look up a car they would like to drive on www.fueleconomy.gov. On 3" x 5" cards, students should record the car's name, model year, combined miles per gallon, and the number of passengers the car holds.

   NOTE: If you would prefer you can use the pre-made automobile cards on page 26-30. If you would like to print the cards on labels use Avery 5392.
2. Distribute a bag of pretzels to each student. Tell students not to eat the pretzels until they are told to.
3. Explain to the students that each pretzel represents one gallon of gasoline, and each step (heel-to-toe) the student takes represents one mile traveled.
4. Students eat a pretzel and take the appropriate number of steps before eating the next pretzel. All steps are heel-to-toe.

❶ Round One

- Using only 5 pretzels for this round. Each person will drive his/her car. Students will go to work in "Near Town" and return "Home." If anyone runs out of fuel (pretzels), he/she must stay at that point until round one is over. Line up at "Home" and start stepping!

DISCUSS Which cars got you to work and home? Which didn't?

- Did anyone have extra fuel remaining?
- What alternatives to driving your own car are there?

❷ Round Two

- Using the remaining five pretzels, try some of the suggestions discussed above. Expect "negotiations." Suggest students carpool to work. Drivers may combine each passenger's pretzels for fuel. Everyone will travel to "Far Town" and return "Home." Line up at "Home" and start stepping!

DISCUSS Who made it to "Far Town" and back? How did you do this?

- Who did not make it to "Far Town" and back? Why not?

2012 Audi A3

FUEL	Diesel
CLASS	Small Station Wagon
NUMBER OF PASSENGERS	5
COMBINED MPG	34

2012 Bentley Continental GT

FUEL	Flex Fuel E85
CLASS	Compact
NUMBER OF PASSENGERS	4
COMBINED MPG	10

2012 BMW Gran Turismo

FUEL	Gas
CLASS	Large
NUMBER OF PASSENGERS	5
COMBINED MPG	18

2012 Bugatti Veyron

FUEL	Gas
CLASS	Two-Seater
NUMBER OF PASSENGERS	2
COMBINED MPG	10

2012 Buick LaCrrosse eAssist

FUEL	Hybrid Electric
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	29

2012 Buick Verano

FUEL	Gas
CLASS	Compact
NUMBER OF PASSENGERS	5
COMBINED MPG	25

2012 Cadillac Escalade ESV

FUEL	Flex Fuel E85
CLASS	SUV
NUMBER OF PASSENGERS	8
COMBINED MPG	12

2012 Chevrolet Camaro

FUEL	Gas
CLASS	Compact
NUMBER OF PASSENGERS	4
COMBINED MPG	22

2012 Chevrolet Equinox

FUEL	Gas
CLASS	SUV
NUMBER OF PASSENGERS	5
COMBINED MPG	26

2012 Chevrolet Malibu

FUEL	Flex Fuel E85
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	18

2012 Chevrolet Suburban

FUEL	Gas
CLASS	SUV
NUMBER OF PASSENGERS	8
COMBINED MPG	17

2012 Chevrolet Volt

FUEL	Plug-In Hybrid Electric
CLASS	Small Station Wagon
NUMBER OF PASSENGERS	4
COMBINED MPG	94 MPGGE

2012 Chrysler 200

FUEL	Flex Fuel E85
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	16

2012 Chrysler Town & Country

FUEL	Flex Fuel E85
CLASS	Minivan
NUMBER OF PASSENGERS	7
COMBINED MPG	14

2012 Dodge Ram 1500

FUEL	Gas
CLASS	Pickup Truck
NUMBER OF PASSENGERS	3
COMBINED MPG	15

2012 Ferrari FF

FUEL	Gas
CLASS	Midsize
NUMBER OF PASSENGERS	4
COMBINED MPG	13

2012 Ford E350 Wagon

FUEL	Gas
CLASS	Passenger Van
NUMBER OF PASSENGERS	11
COMBINED MPG	11

2012 Ford Escape Hybrid

FUEL	Hybrid Electric
CLASS	SUV
NUMBER OF PASSENGERS	5
COMBINED MPG	32

2012 Ford F150

FUEL	Gas
CLASS	Pickup Truck
NUMBER OF PASSENGERS	3
COMBINED MPG	17

2012 Ford Feista

FUEL	Gas
CLASS	SubCompact
NUMBER OF PASSENGERS	5
COMBINED MPG	33

2012 Ford Focus EV

FUEL	Electric (Dedicated)
CLASS	Compact
NUMBER OF PASSENGERS	5
COMBINED MPG	105 MPGGE

2012 Ford Fusion FFV

FUEL	Flex Fuel E85
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	16

2012 GMC Sierra 15 Hybrid

FUEL	Hybrid Electric
CLASS	Pickup Truck
NUMBER OF PASSENGERS	6
COMBINED MPG	21

2012 Honda Civic Hybrid

FUEL	Hybrid Electric
CLASS	Compact
NUMBER OF PASSENGERS	5
COMBINED MPG	44

2012 Honda Civic NGV

FUEL	Natural Gas (Dedicated)
CLASS	Compact
NUMBER OF PASSENGERS	5
COMBINED MPG	31

2012 Honda Insight

FUEL	Hybrid Electric
CLASS	Compact
NUMBER OF PASSENGERS	5
COMBINED MPG	42

2012 Jeep Grand Cherokee

FUEL	Flex Fuel E85
CLASS	SUV
NUMBER OF PASSENGERS	5
COMBINED MPG	14

2012 Kia Optima Hybrid

FUEL	Hybrid Electric
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	37

2012 Lexus LS 460

FUEL	Gas
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	19

2012 Lexus RX 450H

FUEL	Gas
CLASS	SUV
NUMBER OF PASSENGERS	5
COMBINED MPG	30

2012 Lincoln Navigator

FUEL	Gas
CLASS	SUV
NUMBER OF PASSENGERS	7
COMBINED MPG	16

2012 Maybach 57

FUEL	Gas
CLASS	Large
NUMBER OF PASSENGERS	4
COMBINED MPG	12

2012 Mazda 5

FUEL	Gas
CLASS	Minivan
NUMBER OF PASSENGERS	6
COMBINED MPG	24

2012 Nissan Leaf

FUEL	Electric (Dedicated)
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	99 MPGe

2012 Smart Fortwo Coupe

FUEL	Gas
CLASS	Two-Seater
NUMBER OF PASSENGERS	2
COMBINED MPG	36

2012 Toyota Camry

FUEL	Gas
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	28

2012 Toyota Highlander Hybrid

FUEL	Hybrid Electric
CLASS	SUV
NUMBER OF PASSENGERS	7
COMBINED MPG	28

2012 Toyota Prius

FUEL	Hybrid Electric
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	50

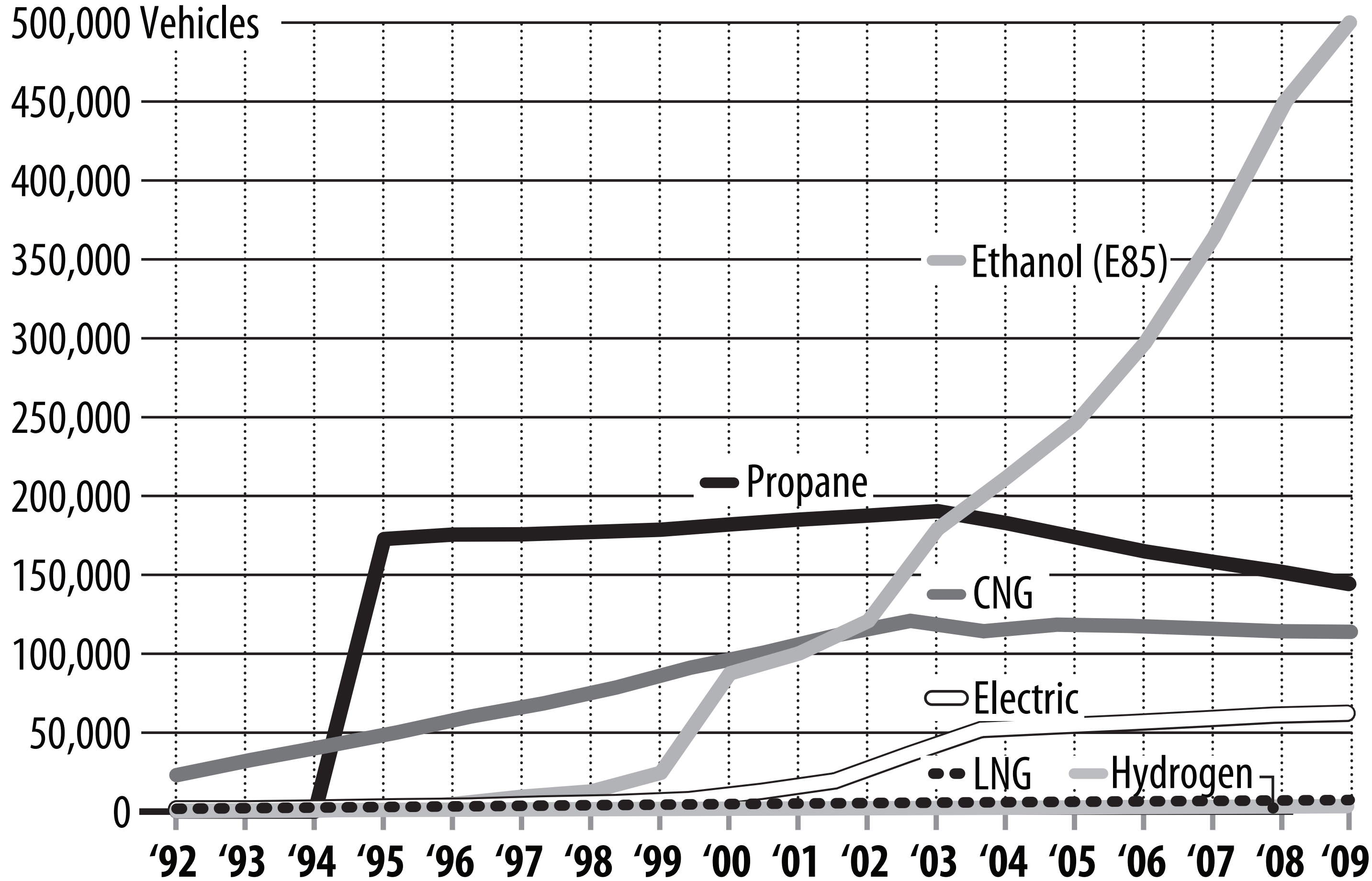
2012 Volkswagen Passat

FUEL	Diesel
CLASS	Midsize
NUMBER OF PASSENGERS	5
COMBINED MPG	34

2012 Volkswagen Touareg

FUEL	Diesel
CLASS	SUV
NUMBER OF PASSENGERS	5
COMBINED MPG	22

Alternative Fuel Vehicles in Use Since 1992



Data: Energy Information Administration

TRANSPORTATION

Glossary

alternative fuel	as defined by the Energy Policy Act of 1992 (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
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, and in the future it may be used as a replacement for diesel; B100 is 100 percent biodiesel, B20 is 20 percent biodiesel blended with 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
Clean Air Act (CAA)	originally enacted in 1963, the 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
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
E85	ethanol/gasoline mixture containing 85% denatured ethanol and 15% 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 photovoltaic cells or fuel cells
emissions	gaseous products of combustion, some are pollutants
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 enzymatic transformation by microorganisms of organic compounds such as 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
gasoline	a petroleum product that powers many vehicles
global warming	the 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
internal combustion engine	an engine in which a fuel is burned within the chamber to create motion
liquefied natural gas (LNG)	natural gas that has been condensed to a liquid by cooling

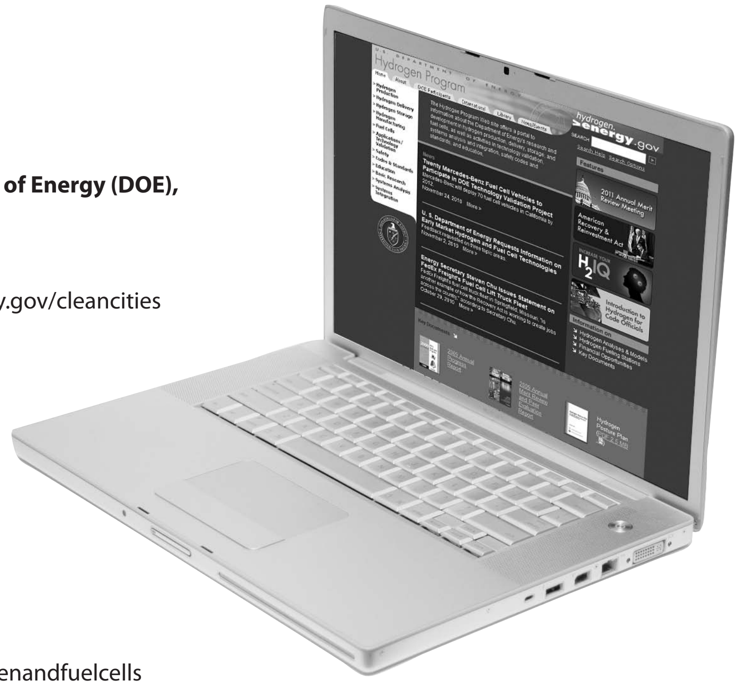
liquefied petroleum gas (LPG)	gaseous hydrocarbon mixture separated from natural gas and petroleum, commonly called propane
natural gas	a mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth and used as a fuel
nitrogen oxides (NO_x)	regulated air pollutants, primarily NO and NO_2, which are precursors of smog and acid rain
octane rating (octane number)	a measure of a fuel's resistance to self-ignition; a measure of the antiknock properties of the fuel
petroleum fuels	gasoline and diesel fuels
propane	see Liquefied Petroleum Gas
reformulated gasoline (RFG)	gasolines that have been altered to reduce emissions of pollutants
regenerative braking	converts wasted energy from braking into electricity that can be stored in a battery
smog	a visible haze caused primarily by particulate matter and ozone in the lower atmosphere
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. 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

Transportation Fuel Acronyms

AFV	alternative fuel vehicle
B20	20% biodiesel/diesel blend
Btu	British thermal unit
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CAFE	corporate average fuel economy
CFV	clean fuel vehicle
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
E85	85% ethanol/gasoline blend
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act of 1992
FFV	flexible fuel vehicle
HEV	hybrid electric vehicle
HC	hydrocarbon
ILEV	inherently low emission vehicle
LEV	low emission vehicle
LNG	liquefied natural gas
LPG	liquefied petroleum gas (propane)
LSV	low speed vehicle
MSW	municipal solid waste
MTBE	methyl tertiary butyl ether
NAAQS	National Ambient Air Quality Standards
NEV	neighborhood electric vehicle
PM	particulate matter
PPM	parts per million
PSI	pounds per square inch
RFG	reformulated gasoline
SULEV	super ultra low emission vehicle
TLEV	transitional low emission vehicle
ULEV	ultra low emission vehicle
ULSD	ultra low sulfur diesel
VOC	volatile organic compound
VFV	variable fuel vehicle
ZEV	zero emission vehicle

TRANSPORTATION

Web Resources



Alternative Fuels and Advanced Vehicles Data Center of Department of Energy (DOE), www.afdc.energy.gov/afdc

California Energy Commission, www.energy.ca.gov

Clean Cities Program of the Department of Energy, www1.eere.energy.gov/cleancities

Columbia Par Car, www.parcar.com

DaimlerChrysler, www.fleet.chrysler.com

Diesel Technology Forum, www.dieselforum.org

Electric Drive Transportation Association, www.electricdrive.org

Energy Information Administration of the Department of Energy, www.eia.gov

Ford, www.fleet.ford.com

Fuel Cell Technologies Program (DOE), www1.eere.energy.gov/hydrogenandfuelcells

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

General Motors, www.gmaltfuel.com

Governors' Biofuels Coalition, www.governorsbiofuelscoalition.org

Griffin Industries, www.biog3000.com

Honda, www.honda.com

Kentucky Clean Fuels Coalition, www.kentuckycleanfuels.org

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

Kentucky Propane Gas Association, www.kypropane.org

Kentucky Soybean Board, www.kysoy.org

Kentucky Transportation Cabinet, www.transportation.ky.gov

Louisville Metro Air Pollution Control District, www.apcd.org

National Biodiesel Board, www.biodiesel.org

National Renewable Energy Laboratory, www.nrel.gov

Regional Ozone Coalition, www.oki.org/cleanair

Suburban Propane, www.suburbanpropane.com

Toyota, www.toyota.com

Transit Authority of River City, www.ridetarc.org

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

Vehicle Technologies Program (DOE), www1.eere.energy.gov/vehiclesandfuels

Elementary Transportation Fuels Infobook Evaluation Form

TRANSPORTATION

State ____________ **Grade Level** ____________ **Number of Students** ____________

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

Please explain any 'no' statement below.

How would you rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the unit more useful to you?

Other Comments:

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

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National Fuel
National Grid
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
Nebraska Public Power District
New Mexico Oil Corporation
New Mexico Landman's Association
New Orleans Solar Schools Initiative
New York Power Authority
NSTAR
OCI Enterprises
Offshore Energy Center
Offshore Technology Conference
Ohio Energy Project
Pacific Gas and Electric Company
PECO
Petroleum Equipment Suppliers Association
Phillips 66
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Puget Sound Energy
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Tennessee Department of Economic and Community Development–Energy Division
Tennessee Valley Authority
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U.S. Department of Energy
U.S. Department of Energy–Hydrogen Program
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U.S. Department of Energy–Office of Fossil Energy
U.S. Department of Energy–Wind for Schools
U.S. Department of Energy–Wind Powering America
U.S. Department of the Interior–Bureau of Land Management
U.S. Department of the Interior–Bureau of Ocean Energy Management, Regulation and Enforcement
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