Instructional Packet
Energy Conservation in Transportation

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Description:

This instructional packet is designed to educate secondary students about the important goal of conserving energy and power in transportation, while stressing the economic, environmental, and societal impacts that make conserving energy and power so difficult. It contains design and cooperative learning activities in which these students evaluate the advantages and disadvantages of alternative fuels and technologies for themselves and their communities.

(audience intended for students in grades 9-12)

Concepts:

All transportation fuels have physical, economic, environmental, and societal advantages and disadvantages.

Energy conservation, financial costs, resource usage, societal demand, and changes in the quality of life are factors in determining the transportation methods we choose.

Skills:

- Critical thinking
- Math
- Cooperative Learning
- Comparison and contrast
- Negotiation and compromise
- Evaluation
- Presentation and persuasion

Activities:

- Laboratory Packet- Rubber Band Powered Vehicle
- Class Interaction- Brainstorm with students to develop a list of questions they have about alternative fuels and technologies; split into teams to research the questions.
- Synthesis- Have the students write a one-page papers explaining which alternative fuel vehicle they would buy for personal use and why.
- Presentation- Have students in groups prepare Power Point Presentations which describe the advantages and disadvantages of one alternative means of transportation vs. another.
- Math Work- Have the students calculate a payback period, which is the length of time you must own an energy-efficient vehicle before the decreased operational costs make up for the difference in initial purchase price.

Time:
5 to 8 class periods.

Objectives:

- Students will demonstrate knowledge and skills in designing a transportation system that optimizes speed, power, distance, and energy;
- Students will be able to identify an energy conservation problem involving transportation, propose designs, make ethical choices among alternative transportation solutions, implement a solution, evaluate the solution, and communicate the problem, process, and solution.
- Students will be able to describe how human populations use resources in the environment to maintain and improve their existence.
- Students will be able to describe how the earth has limited resources with resources that cannot be renewed.
- Students will be able to describe the positive and negative attributes of different alternative fuel options.
- Students will be able to explain that natural systems can change so rapidly that organisms can't adapt naturally and humans can't adapt technologically.
- Students will be able to explain that population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth can influence environmental quality.
- Students will be able to debate economics, policies, politics, and ethics of various science and technology related challenges; however, make a point that science alone will not resolve local, national, and global challenges.

Scope and Sequence

I. Energy Conservation in Transportation Givens:

A. Driving has become an important part of our daily lives.

B. These vehicles require fuels that are economical and convenient.

C. Because people keep driving more miles in more vehicles, scientists and engineers have been making a concerted effort to develop alternatives to petroleum fuels:

1. Propane
2. Natural gas
3. Methanol
4. Ethanol
5. Biodiesel
6. Electricity
7. Hydrogen Fuel Cells
8. Solar Power

D. It will take the concerted efforts of consumers, industry and government to make significant changes to our transportation system.

II Petroleum:

(For more than a century, petroleum has been the lifeblood of our transportation system.)

A. Facts and statistics

1. In the United States alone, we use almost 13 million barrels of oil each day to keep us on the move.
2. Today, about 98 percent of the vehicles in the U.S. are powered by petroleum or diesel fuels.
3. Americans drive their personal vehicles about 2.3 trillion miles a year.
4. Commercial trucks drive 183 billion miles and buses drive 6.5 billion.
5. Approx. 203,000,000 personal vehicles, 7,000,000 commercial trucks and 700,000 buses are racking up mileage in America and those numbers are climbing.
6. Today, the United States imports about two-thirds of its petroleum from other countries, about twice as much as during the oil embargoes of the 1970s

B. Problems with using petroleum.

1. Even though pollutants represent less than one percent of the fuel consumed, the large number of cars and growing quantities of fuel they use result in emissions that constitute major health and environmental concerns.
2. Our oil supply might seem stable today, the unrest in the Middle East could cause shortages or much higher prices at any time.
3. The millions of cars, trucks, and buses on the road today contribute half or more of the air pollution in many metropolitan areas. According to the
4. Environmental Protection Agency, almost one-half of all people in the
5. U.S. live in areas that are not in compliance with federal air quality standards (non-attainment areas).

C. Accomplishments

1. Auto manufacturers have done a good job of reducing emissions from vehicles.
2. Since the 1960s, when controls were first introduced, emissions from vehicles have been reduced by more than 95 percent.

III.Gasoline:

(Gasoline is a petroleum-based fuel made of different hydrocarbons that contain energy. It is used as a fuel in most U.S. passenger vehicles with internal combustion engines. Today, 47 percent of the crude oil in the U.S. is refined into gasoline.)

A. History of Gasoline(Optional)

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.

The early distillation process converted only a small percentage of crude oil into gasoline. As the demand for gasoline increased, processes *were developed to increase the yield. Heavy hydrocarbon molecules were cracked using heat and pressure. In the 1960s, catalytic cracking began being used to produce much higher yields. A typical U.S. refinery may produce twice as much gasoline from each barrel of crude oil as a European refinery.*

During the 1950s, cars were becoming bigger and faster. Octane levels increased and so did lead levels, as lead compounds were added to gasoline to reduce knocking and improve engine performance. Unleaded gasoline was introduced in the 1970s, when the health implications of lead became clear. Leaded gasoline was completely phased out in the 1980s with the introduction of catalytic converters to enhance fuel combustion.

B. Gasoline as a transportation fuel.

1. Today, gasoline is the fuel used by a vast majority of passenger vehicles in the U.S.
2. There are fueling stations that provide convenient accessibility for consumers.
3. The production and distribution infrastructures are in place.
4. Most Americans consider gasoline the most sensible transportation fuel for today, even if it is not an ideal fuel.
5. If the price of gasoline had increased at the same rate as inflation, gasoline would cost about $3.00 a gallon today.

C. Characteristics and environmental impacts of gasoline.

1. Gasoline has a high energy content of about 114,000 Btu/gallon.
2. It is highly flammable and toxic gasoline vapors can cause dizziness, vomiting and even death if inhaled in strong concentrations.
3. Gasoline is a nonrenewable fossil fuel that produces air pollutants when it is burned.
4. Stricter environmental standards have led to gasoline formulations and vehicle designs that have reduced vehicle exhaust emissions.
5. The Clean Air Act Amendments of 1990 mandated that reformulated gasoline be used in areas of the country that do not meet air quality standards, as well as reductions in nitrogen compounds (No_x) and volatile organic compounds (VOCs). In 2002, more than a dozen different types of gasoline were required by law in the U.S.

IV. Diesel:

(Diesel is a petroleum-based fuel made of hydrogen and carbon molecules (hydrocarbons) that contain energy. At refineries, crude oil is separated into different fuels including gasoline, jet fuel/kerosene, lubricating oil and diesel. Approximately 9.2 gallons of diesel are produced from each 42-gallon barrel of crude oil. Diesel can only be used in a specifically designed diesel engine, a type of internal combustion engine used in many cars, boats, trucks, trains, buses, and farm and construction vehicles.)

A. History of Diesel (Optional)

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 that time.

B. Diesel as a transportation fuel

1. Diesel fuel plays a vital role in America's economy, quality of life and national security.
2. As a transportation fuel, it offers a wide range of performance, efficiency and safety features.
3. Diesel fuel contains between 18 and 30 percent more energy per gallon than gasoline.
4. Diesel technology also offers a greater power density than other fuels, so it packs more power per volume.
5. Diesel fuel has a wide range of applications.
    - a. In agriculture, diesel powers more than two-thirds of all farm equipment in the U.S. because diesel engines are uniquely qualified to perform demanding work.
    - b. It is the predominant fuel for public transit buses, school buses and intercity buses throughout the U.S.
    - c. Diesel engines are able to do demanding construction work, like lifting steel beams, digging foundations, drilling wells, digging trenches for utilities, grading and paving new roads and moving soil safely and efficiently.
    - d. Diesel power dominates the movement of America's freight in trucks, trains, boats and barges.
    - e. Diesel automobiles are very popular in Europe, where one of every three cars sold is diesel-powered.
6. Advanced European diesel passenger vehicles exceed today.s U.S. gasoline-electric hybrids in fuel efficiency by more than 60 percent.
7. Combining the superior fuel efficiency of diesel engines with the efficiencies of hybrid electric vehicles can provide even greater fuel efficiency.

C. Characteristics and Environmental Impacts of Diesel

1. It is safer than gasoline and other alternatives because it is less flammable.
2. Diesel-powered cars achieve better fuel economy than gasoline powered equivalents.
3. The major disadvantage of diesel fuel is its harmful emissions.
4. Pollutants associated with the burning of diesel fuel are gaseous emissions, including sulfur dioxide (SO_2) and nitrogen oxide (NO_x), and particulate matter.
5. Clean diesel technologies, today.s trucks and buses are eight times cleaner than those built just a dozen years ago.

V. Hybrids:

(Hybrid Electric Vehicles may be the best alternative vehicle for the near future, especially for the individual consumer. HEV's offer many of the energy and environmental advantages of the dedicated electric vehicle without the drawbacks.

Hybrids are powered by two energy sources an energy conversion unit (such as a combustion engine or fuel cell) and an energy storage device (such as battery, flywheel, or ultracapacitor.))

A. Hybrids as a transportation technology

1. The energy conversion unit can be powered by gasoline, methanol, compressed natural gas, hydrogen, or other alternative fuels.
2. HEVs have the potential to be two to three times more fuel-efficient than conventional vehicles.
3. HEVs can have either a parallel or series design.
   a. Parallel design- the energy conversion unit and electric propulsion system are connected directly to the vehicle's wheels. The primary engine is used for highway driving; the electric motor provides added power during hill climbs, acceleration, and other periods of high demand.
   b. Series design- the primary engine is connected to a generator that produces electricity. The electricity charges the batteries and drives an electric motor that powers the wheels.
4. Because batteries can only supply power for short trips, a generator powered by an internal combustion engine was added to increase range. A
5. HEV can function as a purely electric vehicle for short trips, only using the internal combustion engine when longer range is required.
6. HEVs have twice the fuel economy of conventional vehicles.
7. Depending on driving conditions, one or both are used to maximize fuel efficiency and minimize emissions, without sacrificing performance.
8. An HEV battery doesn.t have to be recharged.

B. Environmental impacts- the HEV provides extended range and rapid refueling, as well as significant environmental benefits, reducing pollutants by one-third to one half.

C. Hybrids today and tomorrow- (There are several hybrids on the market today. The Honda Insight is a two-seat hybrid that averages over 60 mpg and can travel 700 miles on a tank of gasoline. The Honda Civic is also available in a hybrid version that averages up to fifty miles per gallon. The Toyota Prius is a five-seat sedan that averages over 50 mpg and can travel 500 miles before refilling. The Ford Escape is the first hybrid SUV on the market. The Escape averages over 30 mpg and can go 500 miles on a tank of fuel. By 2006, there will be at least seven hybrid models available to the general public. Chrysler and Toyota have hybrid SUVs in the works. In the long term, Toyota plans to offer hybrids in most of its models, including its trucks. By 2006, there will also be Dodge Ram and GM hybrid trucks, as well as the possibility of other hybrid models.)

VI. Propane:

(Propane is an energy-rich fossil fuel often called liquefied petroleum gas (LPG). It is colorless and odorless; an odorant called mercaptan is added to serve as a warning agent. Propane is a by-product of petroleum refining and natural gas processing. And, like all fossil fuels, it is nonrenewable. The chemical formula for propane is CH_8.3 Under normal atmospheric pressure and temperature, propane is a gas. Under moderate pressure and/or lower temperature, however, propane can easily be changed into a liquid and stored in pressurized tanks. Propane is 270 times more compact in its liquid state than it is as a gas, making it a portable fuel.)

A. Transporting Propane

1. Propane is moved from refineries through underground pipelines to distribution terminals across the nation.
2. It is then transported by railroad tank cars, transport trucks, barges, and tanker ships to bulk plants.
3. A bulk plant is where local propane dealers fill their small tank trucks.
4. People who use very little propane backyard barbecuers; for example, must bring their propane cylinders to a dealer to be filled. There are about 165,000 propane dealers in the U.S. today.

B. Transportation

1. Propane has been used as a transportation fuel for more than half a century and is the most widely used and most accessible alternative fuel.
2. Taxicab companies, government agencies, and school districts often use propane instead of gasoline to fuel their fleets.
3. For fleet vehicles, the cost of using propane is 5 to 30 percent less than for gasoline.
4. Propane is cleaner burning than gasoline- leaves no lead, varnish, or carbon deposits that cause the premature wearing of pistons, rings, valves, and spark plugs. The engine stays clean, free of carbon and sludge.
5. Some fleets report 2-3 years longer service life and extended maintenance intervals.
6. Propane doesn.t require the additives that are usually blended into gasoline.
7. Propane contains 91,000 Btu/gallon and provides slightly less range than gasoline.

C. Environmental Impacts

1. Carbon monoxide emissions from engines using propane are 50 to 92 percent lower than emissions from gasoline-fueled engines.
2. Hydrocarbon emissions are 30 to 62 percent lower.
3. In 2004, there were about 3,500 LPG vehicle-fueling stations in the U.S., which cost about the same to build as gasoline stations.
4. A conventional automobile engine has to be converted to use propane fuel, at a cost of approximately $2,500.

VII. Ethanol:

(Ethanol is a clear, colorless alcohol fuel made by fermenting the sugars found in grains, such as corn, grain sorghum and wheat, as well as potato wastes, cheese whey, corn fiber, rice straw, urban wastes, and yard clippings. 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 uses enzymes to break down the cellulose in woody fibers, making it possible to produce ethanol from trees, grasses, and crop residues. Trees and grasses require less energy than grain crops, which must be replanted every year. Scientists have developed fast-growing, hybrid trees that can be harvested in ten years or less. Many perennial grasses can be established in one year and 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 fuel for ethanol.)

A. History of ethanol (Optional)

Ethanol is not a new product. It was widely used before the Civil War. 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, the ethanol industry received a blow when Prohibition began. Since ethanol was considered a liquor, it could only be sold when it was denatured.rendered poisonous by the addition of petroleum components. With the end of Prohibition in 1933, interest in the use of ethanol increased.

B. Ethanol as a transportation fuel

Oil embargoes revived interest in ethanol as an alternative fuel. Today, more than fifty ethanol plants, mostly in the Midwest, produce over a billion gallons of ethanol.

Gasoline containing ten percent ethanol is widely used in urban areas that fail to meet standards for carbon monoxide and ozone.

Ethanol is not considered an alternative fuel under EPACT, but a replacement fuel.

With an octane rating of 100, power acceleration, payload capacity, and cruise speed are comparable to gasoline.

There are about 150,000 light-duty vehicles using this fuel, serviced by ethanol fueling stations. Nearly half of these are private vehicles; the rest are federal, state and local government fleet vehicles.

C. Environmental impacts

Ethanol is made from crops that absorb carbon dioxide and give off oxygen.

Since ethanol contains oxygen, using it as a fuel additive results in up to 25 percent fewer carbon monoxide emissions than conventional gasoline.

Ethanol is made from domestic, renewable feedstocks.

VIII. Biodiesel:

(Biodiesel is a fuel made by chemically reacting alcohol with vegetable oils, fats, or greases, such as recycled restaurant greases. It is most often used in blends of two percent or 20 percent (B20) biodiesel. It can also be used as neat biodiesel (B100). Biodiesel fuels are compatible with and can be used in unmodified diesel engines with the existing fueling infrastructure. It is the fastest growing alternative transportation fuel in the U.S.)

A. Biodiesel as a transportation fuel

1. Today, Biodiesel costs between $1.25 and $2.25 a gallon.
2. Biodiesel contains virtually no sulfur, so it can reduce sulfur levels in the nation.s diesel fuel supply. Removing sulfur from petroleum-based

diesel results in poor lubrication.
3. Biodiesel is a superior lubricant and can restore the lubricity of diesel fuel in blends of only one or two percent.
4. Biodiesel can also improve the smell of diesel fuel, sometimes smelling like french fries.
5. B100 and biodiesel blends are sensitive to cold weather and may require special anti-freeze, as petroleum-based diesel fuel does.
6. Biodiesel acts like a detergent additive, loosening and dissolving sediments in storage tanks. Because biodiesel is a solvent, B100 may cause rubber and other components to fail in vehicles manufactured before 1994. Using B20 minimizes these problems.

B. Environmental Impacts
1. Biodiesel is renewable, safe, and biodegradable, and reduces serious air pollutants such as particulates, carbon monoxide, hydrocarbons, and air toxics. Emissions of nitrogen oxides, however, increase slightly with the concentration of biodiesel in the blend.
2. Biodiesel.s fuel characteristics exceed those of petroleum-based diesel in cetane number, resulting in superior ignition. Therefore, biodiesel has a higher flash point, making it more versatile where safety is concerned.
3. Horsepower, torque, and fuel economy are comparable to diesel.
4. Many states are considering mandates that will require the addition of two percent biodiesel in every gallon of diesel fuel in an effort to reduce harmful emissions.

C. Distribution of Biodiesel
1. Currently, biodiesel is available only through bulk suppliers; there are a growing number of public biodiesel refueling stations in the United States, but they are not widespread. Biodiesel, therefore, is more practical for fleets with their own fueling facilities.
2. Biodiesel is delivered by distributors directly to fleet operators.
3. Availability is increasing as the market expands.

IX. Electric Vehicles

A. History of Electric Vehicles
In 1891, William Morrison of Des Moines, Iowa, developed the first electric car. By the turn of the century, dedicated electric vehicles (EVs) outnumbered their gasoline-powered counterparts by two-to-one. Today there are about 10,500 dedicated 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 dedicated EVs..an efficient battery.

B. Battery Limitations
1. Dedicated electric vehicles must have batteries that can be discharged and recharged repeatedly. Since most batteries can.t store large amounts of energy, a dedicated electric vehicle must carry as many batteries as possible. In some dedicated EVs, the batteries constitute almost half the weight of the car.
2. The typical dedicated EV battery pack must be replaced every 20,000 to

30,000 miles, a big expense in itself. Tax incentives can offset some of these costs.

3. The batteries limit the range of a dedicated EV, which is determined by the amount of energy stored in its battery pack. The more batteries a dedicated EV can carry, the more range it can attain, to a point.

4. Too many batteries can weigh down a vehicle, reducing its load-carrying capacity and range, and causing it to use more energy. The typical dedicated EV can only travel 50 to 130 miles between charges.

5. This driving range assumes perfect driving conditions and vehicle maintenance. Weather conditions, terrain, and some accessory use can significantly reduce the range.

6. The batteries used in EVs today include lead-acid, NiCad, NiMH, nickel iron, and nickel zinc. Extensive research is being conducted on advanced batteries that will increase electric vehicle range. Some of these batteries are scaled-up versions of the batteries used in portable computers. Such advanced batteries could double the current range of electric vehicles, and hold promise for being longer lived.

C. Electric Vehicles as a transportation technology-

Dedicated EVs, therefore, have found a niche market as neighborhood or low speed vehicles for consumers going short distances at speeds of 30 mph or less.

D. Environmental Impacts

1. Dedicated electric vehicles produce no tailpipe emissions, but producing the electricity to charge them can.

2. EVs are really coal, nuclear, hydropower, oil, and natural gas cars, because these fuels produce most of the electricity in the U.S.

3. Coal alone generates more than half of our electricity. When fossil fuels are burned, pollutants are produced like those emitted from the tailpipe of a gasoline-powered automobile. Power plant emissions, however, are easier to control than tailpipe emissions. Emissions from power plants are strictly regulated, controlled with sophisticated technology, and monitored continuously. In addition, power plants are usually located outside major centers of urban air pollution.

E. Maintenence

1. The low maintenance of dedicated electric vehicles is appealing to many consumers.

2. Dedicated EVs require no tune-ups, oil changes, water pumps, radiators, injectors, or tailpipes. And no more trips to the service station.

3. Dedicated EVs can be refueled at home at night, when electric rates are low, making the fuel cost comparable to or lower than gasoline.

X. CNG/LNG

(The natural gas we use for heating, cooking, clothes drying, and water heating can also be a clean burning transportation fuel when compressed or liquefied.)

A. Natural Gas as a transportation fuel

1. Natural gas vehicles burn so cleanly that they are used to carry TV

cameras and reporters ahead of the runners in marathons.

2. Natural gas is usually placed in pressurized tanks when used as a transportation fuel.

3. Even compressed to 2,400-3,600 pounds per square inch (psi), it still has only about one-third as much energy per gallon as gasoline.

4. Natural gas vehicles typically have a shorter range, unless additional fuel tanks are added, which can reduce payload capacity.

5. With an octane rating of 120+, power, acceleration and cruise speed are comparable.

B. Environmental impacts

1. Natural gas is a nonrenewable fossil fuel with plentiful supplies in the United States. Its chemical formula is CH_4.

2. A gasoline engine can also be converted to run on CNG at a cost of $2,000-3,000, depending on the number of fuel tanks installed.

3. CNG tanks are designed for high pressures; they are many times stronger than normal gasoline tanks. It is much less likely that CNG fuel tanks will be damaged in vehicle crashes than the typical gasoline tank.

4. If a fuel line is accidentally severed, the natural gas that is released rises and disperses, unlike gasoline, which forms puddles. Natural gas also ignites at a much higher temperature than gasoline (1,200^{o}Fahrenheit compared to 800^{o}Fahrenheit), making accidental combustion of natural gas less likely.

5. Compressed natural gas (CNG) vehicles emit 8590 percent less carbon monoxide, 10-20 percent less carbon dioxide, and 90 percent fewer reactive non-methane hydrocarbons than gasoline-powered vehicles. (Reactive hydrocarbon emissions produce ozone, one of the components of smog that causes respiratory problems.) These favorable emission characteristics result because natural gas is 25 percent hydrogen by weight.

6. 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.

7. The disadvantage of LNG is that the fuel tanks must be kept cold, which uses fuel.

XI. Methanol:

(Methanol, or wood alcohol, is a colorless, odorless, toxic liquid. Methanol is the simplest alcohol (CH_3OH), produced by replacing one hydrogen atom of methane with a hydroxyl radical (OH). Methanol can be produced from natural gas, coal, residual oil, or biomass. Today, most of the methanol in the United States is produced by the steam reforming of natural gas (methane), a nonrenewable fossil fuel. Most methanol plants are located adjacent to ammonia plants, since both use the same synthesis gas in the production process.)

A.Uses of Methanol

1. A gasoline additive used to reduce emissions of carbon monoxide.

2. The use of MTBE as an oxygenate is declining because of concerns that

it can pollute ground water.

B. Methanol as a vehicle fuel

1. Because methanol is a liquid fuel, it does not require major changes in the distribution system or in car engines, but no major auto manufacturers offer M85 compatible vehicles at this time. The cost of M85 is equal to or slightly higher than premium blends.
2. M85 has a lower energy content per gallon, so mileage is lower; but power, acceleration and payload capacity are comparable to gasoline.
3. Vehicles using methanol, however, must use a special, expensive lubricant.
4. About half of the methanol vehicles are privately owned and half are owned by government agencies.
5. There is no distribution system for methanol in place at this time. In the future, it will probably be transferred from production facilities by barge, rail, or truck to reach retail outlets. It cannot easily be moved through the existing petroleum pipeline network.

C. Environmental impacts

1. Methanol is not a perfect fuel. It can help reduce hydrocarbon emissions in nonattainment areas, but it produces more formaldehyde emissions than gasoline engines.
2. Formaldehyde.besides being an eye and respiratory system irritant.contributes to ozone formation and is toxic.

D. Racing Fuel

1. Since it has a higher octane rating than gasoline (about 105), a methanol car can be a clean-burning muscle car.
2. Methanol.s exhaust contains 35 percent less smog-producing hydrocarbons that are less reactive (they produce less ozone in the atmosphere) and 30 to 40 percent less airborne toxics than gasoline.
3. The fuel's superior combustion means that engines designed for methanol typically develop more horsepower, which gives methanol cars faster acceleration than comparable gasoline-powered cars.

XII. Hydrogen Fuel Cells:
(In the future, hydrogen may provide a significant contribution to the alternative fuel mix.)

A. Hydrogen fuel cells as the space shuttles use hydrogen for fuel.
B. Fuel cells use hydrogen and oxygen to produce electricity without harmful emissions.
C. Water is the main by-product.
D. Hydrogen is a gas at normal temperatures and pressures, which presents greater transportation and storage hurdles than liquid fuels. No distribution system currently exists.
E. Hydrogen is the most abundant element in the universe, but it doesn't exist on
F. Earth as a gas; it is produced by two methods- electrolysis and synthesis gas production from steam reforming or partial oxidation. Electrolysis uses electricity to split water molecules into hydrogen and oxygen. The Department of Energy does not expect electrolysis to be the predominant method of producing large

quantities of hydrogen fuel.
G. Today, the predominant method of producing hydrogen is steam reforming of natural gas, although biomass and coal can also be used as feedstocks.
H. High production costs have limited hydrogen as a fuel to date except in research vehicles, but research is progressing on more efficient ways to produce and use it. The largest drawback to widespread vehicle use will be storage.. the lower energy content of hydrogen requires fuel tanks six times larger than gasoline tanks. Its environmental benefits, however, mean that in 20 years, hydrogen fuel cell vehicles may be a common sight on the roadways of America.
I. The Bush administration has launched a hydrogen fuel cell initiative to further research and development of this promising technology.

Student Guide for a Power Point Presentation:

Step 1. Learn about an alternative 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 alternative fuel?
Is your alternative fuel renewable or nonrenewable?
How is your alternative fuel made?
Is your alternative fuel available in your area?
What types of vehicles can use your alternative fuel?
What are the costs associated with your alternative fuel?
What are the advantages and disadvantages of your alternative fuel?
What are the challenges to developing a widespread market for your fuel?
Would you buy a vehicle that uses your alternative fuel? Why or why not?

Step 2. Plan your Presentation

As a group, make a list of the displays you can use to make your presentation 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 presentation and write your report

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 note cards with the important facts listed on them.
Give a presentation of your exhibit to others.

Step 5. Teach the class
Alternative Transportation Fuels
Evaluation Form

Calculating Payback Periods

Payback period is the length of time you must own an energy-efficient vehicle before the decreased operational costs make up for the difference in initial purchase price. Have your students calculate the payback period for a Honda Civic Hybrid vs. a Jeep Wrangler using the following figures:

JEEP WRANGLER		HONDA CIVIC HYBRID
Initial Cost:	$17,500	$20,000
Tax Incentive:	0	$ 1,500
Miles per Gallon:	16 mpg	50 mpg
Miles per Year:	15,000	15,000
Cost per Gallon:	$ 2.00	$ 2.00

Laboratory- Rubber Band Powered Vehicle

Overview:

In this lab activity, given specified materials and design constraints, high school level students will use their creative and logical thinking skills to design and construct a transportation device powered by rubber bands that will compete for speed, distance, and power. Students will also turn in a written report with drawings detailing the project and their design.

The length of the activity will require both in-class and out-of-class time. The students should have enough time to generate ideas and test their solutions prior to competition.

This activity may be done in teams to develop cooperation, communication, and collaboration with other group members, but is also easy enough to be done individually. If done in teams, peer evaluations may be used to ensure individual accountability.

Objectives:

Upon completion of this activity, students will be able to:

1) design a rubber band powered vehicle, given specifications that must be met;

2) design a vehicle that takes into consideration speed, distance, and power;
3) produce a vehicle that is in working condition;
4) complete a team written report detailing the project;

Materials:

1) Corrugated Cardboard
2) Smooth Round Surfaced Pencils
3) Metal Clothes Hanger
4) 21 rubber bands (7 each of 3 different sizes)
5) **Fastening** Material (glue, tape, staples)

Purpose:

Engineers are often times faced with a challenge of making a transportation device that meets specific and desirable needs, such as speed, power, size, environment, and/or a limited budget while also taking into consideration the energy that is needed to complete the task. In order to simulate this scenario, the students will be provided with a bill of materials, which is sufficient to construct a rubber band powered vehicle. The vehicle should be designed for optimal performance in speed, distance, and power. In order to test the final designs, the vehicles presented will compete against all other vehicles in the class. The result of this competition will determine a portion of the students' grades for the activity.

Design Requirements:

1) The materials provided, with the exception of fasteners previously stated, are the only materials that may be used in the construction of the vehicle.
2) The vehicle must have a minimum of three wheels to support both the vehicle and its cargo.
3) The vehicle must be powered by rubber bands.
4) The vehicle must start from a resting position and may not otherwise be catapulted or slung into motion. Once released, the vehicle must operate without intervention.
5) The vehicle must have a cargo area capable of supporting an unopened 12 oz soda can.
6) Geometric Constraints
    a) Vehicle Length (less than 24 in.)
    b) Vehicle Width including wheels (less than 12 in.)
    c) Vehicle Height including cargo (less than 12 in.)

Performance:

1) Vehicle speed will be measured by a distance/time relationship where the distance is some predetermined length from the start line;
2) Maximum distance will be measured with the use of a tape measure, and pieces of tape to mark distances that exceed the length of the tape;
3) Vehicle power must be able to transport a 12 oz can of soda
4) Time will always be measured when the vehicle comes to a complete stop;

Report Instructions and Requirements:

1) The report should be written on a level that an educated, but non-technical audience can understand;
2) The report should include car development, testing, and conclusions;
3) Definitions should be used where possible;
4) General terms should be used instead of technical terms where possible;
5) Drawings and sketches should be included to convey possible ideas;

Design Content:

The report should address the following areas:

- Problem identification
- Preliminary Ideas
- Scaled Sketches
- Analysis and Implementation
- Experimentally obtain distance/time data
- Plot Experimental Data
- Estimate Acceleration
- Include a final description of your design that includes a single prototype, results of the project, functionality of the design, and any trials faced

English Requirements:

The report should adhere to the following qualifications:

- Well-organized, logical, ordered, aesthetically pleasing
- Demonstrates knowledge of the conservation of energy
- Begins with a clear introductory problem statement
- Outlines the product development
- Lists strengths and weaknesses
- Includes any conclusions or implications
- Uses clear sentences
- Uses well structured sentences
- Consistent in style
- Avoids errors in grammar, spelling, and punctuation
- Graphics are titled and labeled
- Graphics are referenced
- Includes a cover page and report cover
- Includes a bibliography if any resources were used as research in the report

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Book Resources:

Transportation Fourth edition, John J. Coyle, Edward J. Bardi, Robert A. Novack , West Publishing Co., 1994.

Energy Technology Sources of Power, Schaller & Gilberti, Thomason Learning Tools, 1996.

Energy Its Use and the Enviroment, Roger A. Hinrichs, Saunders College Publishing, 1996.

Transportation Energy and Power Technology, Anthony E. Schwaller, Delmar Publisher, IMC, 1989.

Tchnology, R. Thomas Wright Goodhart/Willcox Co., IMC, 2000.

Foundation Coalition *Rubber Band Powered Car,* P. K. Imbrie, 2002

Curriculum Guide Resources:

Energy Systems, Larry R. Hughes, Ed.D Center for Occupational Curriculum Development, 1983

Exploring Energy, Power, and Transportation Technology, John D. Joerschke The Multistate Academic and Vocational Curriculum Consortium, 1997.

The Need Project, 2004

Web Resources:

www.kentuckycleanfuels.org -Kentucky Clean Fuels Coalition

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

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

www.eere.energy.gov/hydrogenandfuelcells

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.doe.gov - National Renewable Energy Laboratory - Department of Energy

www.nr.state.ky.us/nrepc/dnr/energy/dnrdoe.html -Kentucky Division of Energy

www.doyourshare.org - Cincinnati Clean Cities

www.evaa.org - Electric Vehicle Association of the Americas

www.energy.ca.gov/afvs> -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.cunninghamgolfcar.com - Cunningham Golf Car/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.kytc.state.ky.us/multimodal/index.html -Ky Transportation Cabinet

www.kysoy.org - Kentucky Soybean Council

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