



Drexel-SDP GK-12 LESSON

Lesson: Alternative Fuels

Subject Area(s) Science and Technology

Associated Unit Environments, module 4

Lesson Title Lesson: Alternative Fuels

Grade Level 6 (4-8)

Lesson # 2 of 5

Lesson Dependency None.

Time Required 60 minutes

Heading



Image 1

ADA Description: Picture shows a bus powered by biodiesel

Caption: A bus powered by biodiesel

Image file name: biodiesel3.jpg

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Summary

In this lesson, students will practice thinking like an engineer to analyze existing alternative fuel vehicle technologies and identify two areas that they would need to improve to make the vehicle competitive with traditional gasoline powered cars.

This lesson will begin with a presentation by the instructor on six different existing types of alternative fuels. Students are asked to take notes on the vocabulary definitions and the pros and cons of each alternative fuel technology as it is explained.

Engineering Connection

Mechanical engineers are hard at work to make alternative fuel vehicles both efficient and affordable for the average consumer. Auto manufacturers are in heated competition to be the first to market with affordable alternative fuel vehicles that can be practically operated on a day-to-day basis. For example, an engineer may design an affordable car that runs on bird guano, but without access to a supply of the bird guano, who will buy the car? Alternative fuel-powered automobiles are an excellent example of the challenges that engineers face – to design creatively, but within the constraints of what current supply-and-demand can support.

Keywords

Alternative fuels, biodiesel, fuel, automobile pollution, fossil fuels, zero-emission vehicles.

Educational Standards (PA)

- Environments and Ecology: Renewable and nonrenewable resources 4.2.A. Uses, 4.2.B. Availability, 4.2.C. Management, 4.2.D. Influential factors
Environmental Health 4.3.A. Environmental health issues, 4.3.B. Human actions, 4.3.C. Societal needs, 4.8.B. Sustainability, 4.8.C. Human impacts, 4.8.D. Supply and demand
- Science: Earth Sciences, Resources 3.5.B – Technology Education – Biotechnology 3.6.A, Physical Technologies 3.6.C., Science, Technology and Human Endeavors – Physical Science, Chemistry and Physics, Energy 3.4.C – Inquiry and Design, Problem Solving in Technology 3.2.D.
- Math: Computation and Estimation 2.2

Pre-Requisite Knowledge

Be familiar with the concept that gasoline-powered automobiles burn the fuels in a combustion engine to generate mechanical energy.

Learning Objectives

After this lesson, students should be able to:

- **Describe existing alternative fuels and understand some of the pros and cons of each one**
- **Summarize the pros and cons of one alternative fuel car, explaining what aspects they, as an engineer, would target to improve the fuel technology.**

Introduction / Motivation

How do we give energy to make our cars go? By going to a gas station and filling them up with fuel, right? What if there were different ways to power our cars? For example, what if we just let them soak up the sunshine on a sunny day and store that energy? Or, what if we plugged them into an electrical wall socket, along with our cell phones? In this activity, we will challenge you to get creative in thinking about all the different sources of energy that we might

use to power our cars and trucks and move away from the gas stations. Engineers have been hard at work at developing many of these so-called alternative fuel sources, and we will ask you to evaluate each one of them, just like an engineer would.

(In this activity, students will practice thinking like an engineer to analyze existing alternative fuel vehicle technologies and identify two areas that they would need to improve to make the vehicle competitive with traditional gasoline powered cars)

Lesson Background & Concepts for Teachers

This lesson will begin with a presentation by the instructor on six different existing types of alternative fuels. Students are asked to take notes on the vocabulary definitions and the pros and cons of each alternative fuel technology as it is explained. A handout of illustrating some costs and benefits of alternative fuels is attached.

Students are free to ask questions through the presentation. Then, after the students have completed a one page analysis of an alternative fuel technology of their choice and what they would improve, the instructor will ask for volunteers to read what they have written and we, as a class, will talk about their ideas.

Motivation:

Currently today more than 99% of all fuel consumed is petroleum (3). In the year 2025 the world's reserves of petroleum will be a dry source (7). Other than the shortage of petroleum, the burning of petroleum also causes many problems such as global warming. In this case, engineers and scientists need to come up with an alternative energy source for gasoline not only because of the shortage, but because of the environmental problems gasoline and other fossil fuels cause for the environment. Out of all forms of alternative fuels for vehicles bio-diesel seems to be the next alternative source of fuel, but more research needs to prove this assumption.

However, most of us know that transportation, though necessary, is also causing harm to the environment and to our health. The problem is that automobiles, buses, and trucks - the most commonly used forms of transportation - require gasoline for fuel. Gasoline is a refined by-product of oil, a fossil fuel. Diesel fuel, mainly used for heavy duty vehicles such as buses and trucks, is the cheapest and crudest form of gasoline, and is the most hazardous fuel because it emits a tremendously higher level of pollutants per mile than conventional gasoline. The danger in gasoline and diesel and other fossil fuels (except natural gas) is that they contain certain gases that, when released into the air, negatively affect air quality and damage the environment. These particular gases are not compatible with the respiratory systems and processes of life on Earth. As well, these gases are an unnatural addition to the delicate atmospheric balance of gases that work together to sustain and protect life on Earth. As a result, gases from fossil fuel emissions have caused and are continuing to cause great damage to the atmosphere (such as the greenhouse effect and acid rain).

Another problem with gasoline is that its source product - oil - is found in countries other than the United States. This means that we depend on other countries for one of our most vital necessities. Our transportation system is over 90 per cent dependent on oil with over 50 per cent of our supply coming from overseas. Since 1999, the price of oil has risen dramatically. The use of alternative fuels to power our cars, buses, and trucks would significantly reduce our dependence on foreign oil. This would also benefit our economy since alternative fuels can be produced in the U.S.

The other pressing issue with our use of oil is that it is a finite resource. This means that it cannot be regenerated and once we have depleted all known reserves that will be the end of our ability to use gasoline. It is predicted that, at this time, we have approximately 35 to 40 years left of oil, based on current usage figures.

Alternative Fuel - A popular term for "non-conventional" transportation fuels made from natural gas (propane, compressed natural gas, methanol, etc.) or biomass materials (ethanol, methanol).

Alternative-Fuel Vehicle (AFV) - A vehicle designed to operate on an alternative fuel (e.g., compressed natural gas, methane blend, electricity). The vehicle could be either a vehicle designed to operate exclusively on alternative fuel or a vehicle designed to operate on alternative fuel and/or a traditional fuel.

Types of alternative fuels

Biodiesel: Waste vegetable oil can be converted to biodiesel in a chemical reaction with lye and methanol for about 70 per gallon. The chemical reaction changes the vegetable oil into a fluid diesel fuel that won't gum up the fuel lines, plus a waste product, which can be converted into soap. The resulting biodiesel can be used interchangeably with ordinary diesel fuel, without the need to modify the vehicle.

Straight Vegetable Oil: Diesel vehicles can be modified with an extra fuel tank and special heating systems to run on straight vegetable oil, without the need to process the oil with lye and methanol to make biodiesel. Instead, the fuel is filtered and dumped into the extra fuel tank. The car or truck is started on ordinary diesel (or biodiesel) fuel. As the engine is warmed up, the hot radiator fluid is piped around the secondary fuel tank and fuel lines to warm and thin the waste vegetable oil. When the oil is properly thinned, then it will flow and burn properly in the diesel engine. A switch is used to change over to the secondary fuel tank. Flipping the switch back prior to your destination causes diesel fuel to run through the vegetable oil lines, purging them before oil cools and congeals in the lines. Kits to convert a vehicle over to straight vegetable oil cost about \$1,000, but once installed, the fuel itself is free.

Pros: Diesel cars can run off biodiesel with little or no modifications
Fewer emissions than gasoline

Cons: may lead to slash and burn agriculture in tropics
Can cause premature damage to cars due to high operating pressure

Ethanol (E85) - Ethanol can be mass-produced by fermentation of sugar or by hydration of ethylene from petroleum and other sources. Current interest in ethanol lies in production derived from crops (bio-ethanol), and there's discussion about whether it is a sustainable energy resource that may offer environmental and long-term economic advantages over fossil fuels, like gasoline or diesel. It is readily obtained from the starch or sugar in a wide variety of crops. Ethanol fuel production depends on availability of land area, soil, water, and sunlight.

Pros: made from renewable resources
Burns with few emissions

Cons: Invisible flame may cause safety issues
Requires lots of agricultural space

Methanol - Ethanol is easily manufactured from methane (the chief constituent of natural gas) as well as by pyrolysis (burning in an absence of oxygen) of many organic materials. A problem with pyrolysis is that it is only economically feasible on an industrial scale, so it is not advisable to try to produce methanol from renewable resources like wood on a small (personal use) scale.

Pros: made from renewable resources
Few emissions

Cons: Cannot be made on a small scale
Is corrosive to rubber and can decrease the life of car parts
Methanol production creates CO₂ greenhouse gases

Compressed Natural Gas (CNG) is a compressed form of what you may be familiar with as cooking and home heating gas. It is made by compressing methane (CH₄) extracted from natural gas. It is stored and distributed in hard containers, usually cylinders.

Argentina and Brazil, in the Southern Cone of Latin America, are the two countries with the largest fleets of CNG vehicles.

Pros: Extends the life of cars
Fuel is relatively inexpensive

Burns cleaner than gasoline

Technology is mature and requires few modifications

Cons: Made from a non-renewable fossil fuel

A great percent of our domestic supply resides in the Alaskan wildlife preserves

Emits a significant amount of nitrous oxide (laughing gas)

Electric battery power - A battery electric vehicle (BEV) is an electric vehicle that utilizes chemical energy stored in rechargeable battery packs. Electric vehicles use electric motors instead of, or in addition to, internal combustion engines (ICEs). Vehicles using both, electric motors and ICEs, are examples of a hybrid vehicles, and are usually not considered pure BEVs. Hybrid vehicles with batteries that can be charged and used without their ICE are called plug-in hybrid electric vehicles, and are pure BEVs while they are not burning fuel. BEVs are usually automobiles, light trucks, motorized bicycles, electric scooters, golf carts, forklifts and similar vehicles, because batteries are less appropriate for larger long-range applications.

Pros: the more electricity a car runs on, the less emissions it produces

Excellent gas mileage

Cons

Frequent recharging (100-200 miles before recharge)

Batteries are expensive

Repairs are expensive

Hydrogen Fuel Cell - A fuel cell is an electrochemical energy conversion device. It produces electricity from external supplies of fuel (on the anode side) and oxidant (on the cathode side). These react in the presence of an electrolyte. Generally, the reactants flow in and reaction products flow out while the electrolyte remains in the cell. Fuel cells can operate virtually continuously as long as the necessary flows are maintained.

Fuel cells differ from batteries in that they consume reactants, which must be replenished, while batteries store electrical energy chemically in a closed system. Additionally, while the electrodes within a battery react and change as a battery is charged or discharged, a fuel cell's electrodes are catalytic and relatively stable.

Many combinations of fuel and oxidant are possible. A hydrogen cell uses hydrogen as fuel and oxygen as oxidant.

Pros: cars have zero emission,

Hydrogen is a virtually inexhaustible resource

Cars can get up to 100 mpg

Cons: expensive to purchase the hydrogen
 Making the hydrogen produces 9:1 amounts of CO₂
 Expensive and potentially dangerous to store and transport

Vocabulary / Definitions

Word	Definition
Alternative Fuel	A popular term for "non-conventional" transportation fuels made from natural gas (propane, compressed natural gas, methanol, etc.) or biomass materials (ethanol, methanol).
Alternative Fuel Vehicle (AFV)	A vehicle designed to operate on an alternative fuel.
Fossil Fuel	Oil, coal and natural gas that originates from decayed plants and animals.
Zero Emissions Vehicle (ZEV)	Has no tailpipe emissions and is 98 percent cleaner than the average 2003 car.
Biodiesel	A type of biofuel made by combining animal fat or vegetable oil.
Fuel Cell	An electrochemical device which converts chemical energy to electrical energy without combustion. Unlike a battery, a fuel cell will continuously produce electricity as long as fuel is supplied to it.
Ethanol	An alternative fuel; a liquid alcohol fuel with vapor heavier than air; produced distilled agricultural products such as corn, grain and sugar cane. The type of alcohol found in alcoholic beverages.
Methanol	A colorless, odorless, poisonous volatile inflammable liquid obtained by the distillation of wood.

Attachments

See the attached handout and distribute to students for discussion.

Associated Activities

Energy facts and activities for children:

<http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/gasoline.html>

Lesson Extension Activities

Energy facts and activities for children:

<http://www.eia.doe.gov/kids/energyfacts/sources/renewable/ethanol.html>

<http://www.eia.doe.gov/kids/energyfacts/sources/renewable/biomass.html>

References

<http://www.eia.doe.gov/kids/history/timelines/ethanol.html>

<http://magma.nationalgeographic.com/ngexplorer/0801/articles/mainarticle.html>

Lesson Closure

Follow with the Activity: Visit the EIA's website hosted by the DOE

Assessment

Lesson Summary Assessment

If you require note-taking during lessons, ask to see the students' notebooks to ensure they have recorded the lesson notes. Design a short quiz of 5-6 questions to see if the students were listening. In addition, you may use the rubric below for classroom observation and evaluation of written work.

Students will be evaluated on a scale from 0 to 4 on:

	_____	_____	_____
None.	Attentiveness	Assignment Completion	Comprehension

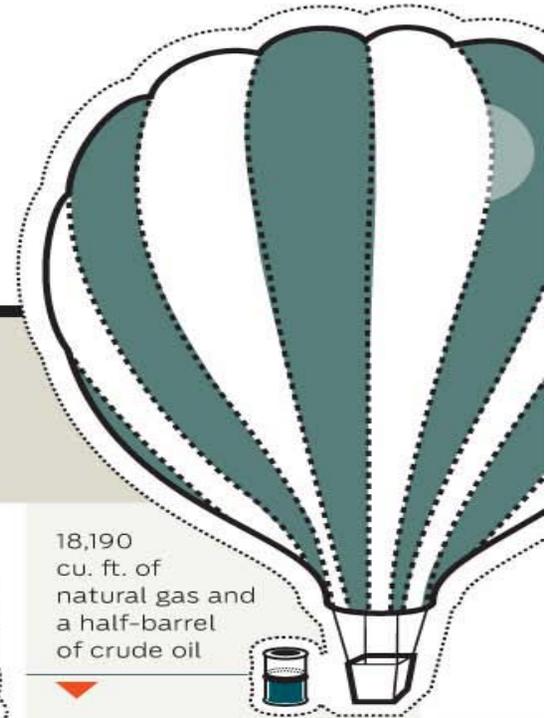
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Popular Mechanics



THE GREAT ALT-FUEL RALLY

It takes five barrels of crude oil to produce enough gasoline (nearly 97 gal.) to power a Honda Civic from New York to California. So how do the alternative fuels that may gradually reduce America's dependence on foreign oil stack up against the mileage and convenience of the filling-station stalwart? Here's a reality check.

	Gasoline	E85/Ethanol	M85/Methanol
RAW MATERIALS CONSUMED	4.5 barrels of crude oil 	53 bushels of corn and a half-barrel of crude oil 	18,190 cu. ft. of natural gas and a half-barrel of crude oil 
FUEL NEEDED	90.9 GAL	176 GAL	214 GAL
FUEL COST	\$212.70	\$425	\$619
PRICE ECONOMY	\$2.34/GAL 33 MPG 	\$2.41/GAL 17 MPG 	\$2.89/GAL 14 MPG 
	<p>Gasoline</p> <p>HONDA CIVIC Is the benchmark for all the vehicles in our virtual comparison. It burns regular 87-octane gasoline (available on every corner)—even if it's not always cheap.</p>  <p>2006 HONDA CIVIC</p>	<p>E85/Ethanol</p> <p>CURRENT TAURUS FFV burns 85% ethanol and 15% gasoline. (The gas gets the engine started on cold days.) This mix provides about 15% less mileage than straight gasoline, but burns cleanly and reduces pollution.</p>  <p>2005 TAURUS FFV</p>	<p>M85/Methanol</p> <p>MID-'90s TAURUS FFV ran on M85 sold in California in a limited number of stations, and also to some dedicated fleets. Low BTU content of methanol means 35% fewer miles per gallon. Made from natural gas, methanol burns cleanly.</p>  <p>1998 TAURUS M85 FFV</p>

* Gallon of Gasoline Equivalent

We picked cars for this virtual cross-country trip to be as close in size and weight as possible. To compare the alternative fuels, we measured their energy content in gallon of gas equivalents (GGE)—the amount of fuel with the same energy content as a gallon of gasoline.

INFORMATION DESIGN BY AGUSTIN CHUNG
ILLUSTRATIONS BY JIXEL QUEEN



16 5-gal. jugs of used vegetable oil



68.2 GAL

\$231

\$3.40/GAL

44 MPG

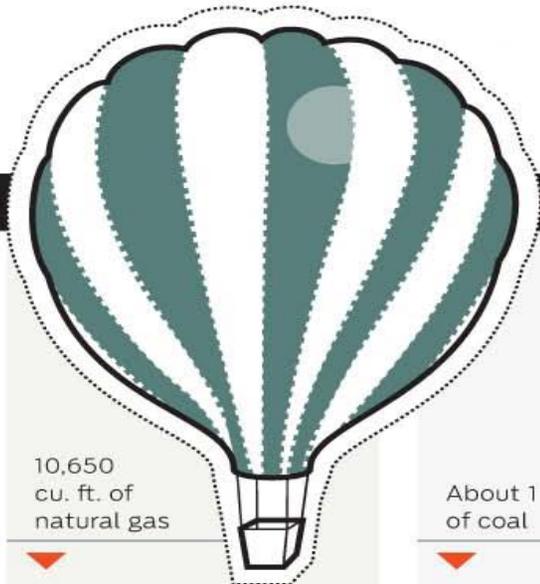


B100 Biodiesel

VW GOLF AND NEW BEETLE TDI are the mileage champs of all conventional cars, sipping diesel fuel at a miserly rate. (And they can burn B100, although VW only recommends B5.) B20 would lower the cost of the trip to less than \$183.



2006 GOLF TDI



10,650 cu. ft. of natural gas

88 GGE*

\$110

\$1.25/GGE

34 MPGGE



Compressed Natural Gas

HONDA CIVIC GX can be refueled at home—as could any CNG vehicle—with a home compressor. But crossing the country in a dedicated CNG car would be tough: There aren't a lot of CNG stations, and many are for fleet use only.



2005 CIVIC GX

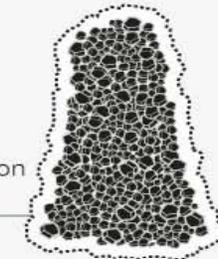
About 1 ton of coal

16.4 GGE

\$60

\$3.66/GGE

202 MPGGE

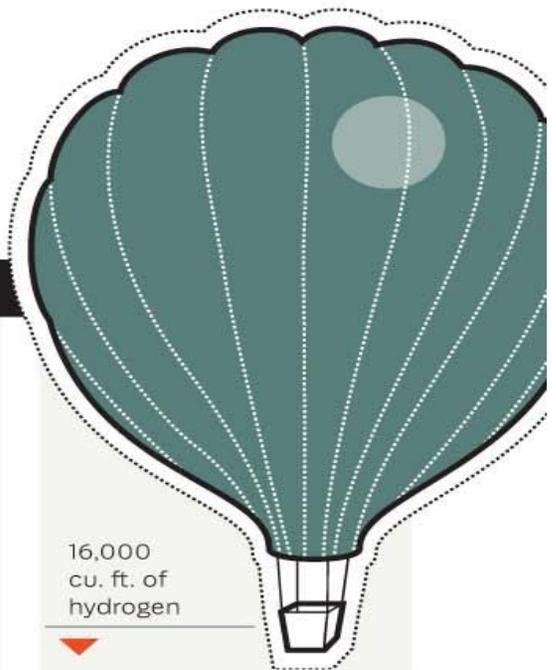


Electricity

LATE-'90s HONDA EV PLUS got about 100 highway miles on a nearly full charge of 20 kilowatt-hours (kwh). The vehicle's NiMH battery pack had a total capacity of 26.5 kwh. Electricians do better in traffic, thanks to regenerative braking.



1997 HONDA EV PLUS



16,000 cu. ft. of hydrogen

73 GGE

\$804

\$11/GGE

41 MPGGE



Hydrogen Fuel Cell

HY-WIRE CONCEPT uses compressed hydrogen, which costs about four times as much as gasoline, although the DOE projects prices below \$2/GGE by 2012. New technology will double vehicle range by raising tank pressure to 10,000 psi.



GM HY-WIRE