

Alternative Fuels

Activity 6

Students compare the potential impact various alternative fuels may have on greenhouse gas emissions and then discuss with alternative-fuel vehicle owners what it's like to own and operate these vehicles. There are several options available for facilitating conversations between students and vehicle owner/operators. These include: (1) a field trip to an alternative-fuel vehicle event, (2) communication with members of a web-based alternative-fuel vehicle owners club, and (3) organizing a transportation technology fair at your school.

Objectives

To investigate and describe human uses of renewable and nonrenewable resources, describe how alternative fuel technology can contribute to the solution of a global problem, recognize that issues related to science, technology, and society often are complex and involve risk/benefit trade-offs, identify technological advances that are reported in the media, and understand that engineers and others use scientific knowledge to solve practical problems.

Standards

Students will develop the ability to ask good questions and apply experimental procedures to collect and analyze data. Students will develop interest in global issues and the ability to collect, analyze and use data to explore and explain related science concepts. Students will address standards 6.1, 7.1, 9.3, 9.5, 9.8, 9.9, scientific inquiry, scientific literacy, and scientific numeracy from Connecticut's Core Science Curriculum Framework.

Time

One class period of pre-event preparation
One class period for the event

Materials

- Alternative Fuels and Global Climate Change handout with fact sheets on plant-based fuels, electricity, and hydrogen
- Video news clip
- Magazines or clip art where students could find graphics and photographs to clip

Method

For assistance in locating alternative-fuel or alternative-technology vehicle(s) with accompanying speaker(s) to visit your school contact:

Planet Connecticut Program Manager
1-800-FIND-RIDE
info@planetconnecticut.org

Visit Planet Connecticut at www.planetconnecticut.org to find out about any alternative vehicle events in your area such as the Northeast Sustainable Energy Association's annual Tour de Sol: The Great American Green Transportation Festival, www.tourdesol.org – as seen in the enclosed video.

You can also ask your students to post questions they may have on alternative fuels and alternative vehicle technologies with the Green Car Club. Go to www.greencarclub.org and look for the appropriate discussion group.

Pre-event preparation

To help students prepare for a visiting speaker, a field trip to an alternative-vehicle event, or to ask questions on the Green Car Club web site, distribute the Alternative Fuels and Global Climate Change handout with fact sheets and show the news clip video. Then divide the class into groups and ask each group to choose two of the following categories:

- plant-based fuels
- electricity from non-fossil-fuel-powered power plants
- electricity from fossil-fuel-powered power plants
- hydrogen from fossil fuels
- hydrogen from water

Give each group 10 minutes to make a list of what they know about their topics. Then ask them to write down what they want to know. Tell them that this will help them prepare to ask questions of the speaker, on the field trip, or to be posted to the discussion group.

Alternative Activities

Show the news clip video. Then divide the class into groups and assign each group one of the following categories.

- plant-based fuels
- electricity from non-fossil-fuel-powered power plants
- electricity from fossil-fuel-powered power plants
- hydrogen from fossil fuels
- hydrogen from water

Give the students time to read the fact sheets that pertain to their fuel type and to plan out a display. The display should show the movement of carbon (if any), and energy transformations for their category. Let them know that they will have some more class time over the coming week to conduct further research and produce the display. Encourage them to use representative graphics, such as pictures clipped from magazines, clip art, charts, graphs, and flowcharts.

Have each group give a five-minute presentation on their topic using their display.

Alternative Fuels and Global Climate Change

For several reasons, scientists and engineers are researching and testing alternatives to gasoline and diesel fuels for use in cars and trucks. Since the United States has greatly depleted our own supplies of oil, forcing us to import increasing amounts of oil from overseas, the federal government would like to develop alternatives that are still available here in the US. The federal government would also like to develop fuels that produce less air pollution.

As of 2003, the federal government had not yet set a goal of finding alternative fuels that produce less greenhouse gases. But some of the locally produced and cleaner fuels that are being tested for other reasons do just that. Let's take a look at the types of alternatives to gasoline and diesel that are being looked at and see which ones will help reduce greenhouse gas emissions. We will look at:

Alternative petroleum products – Fuels made from petroleum products (fossil fuels) that either produce less pollution than gasoline and diesel or are produced in the US.

Plant-based fuels – Fuels made from plants. Most of the plants used to produce fuels used in the US are grown in the US.

Electricity – Most electricity in the US is made from sources of energy found in the US. Electricity can be used to power automobiles and trucks.

Hydrogen – Hydrogen can be made from sources of energy found in the US. Hydrogen can be used to power automobiles and trucks

Alternative Petroleum Products

Alternative petroleum products that can be used to run an automobile include propane and natural gas. Propane is a colorless, non-toxic gaseous hydrocarbon extracted from natural gas or crude oil. You may be familiar with propane as the fuel often used for gas-powered barbeque grills.

Natural gas is a gaseous mixture of simple hydrocarbon compounds, usually found in deep underground reservoirs. Natural gas is composed almost entirely of methane, but does contain small amounts of other gases.

Most of the natural gas and propane used in the US are produced in North America. Both burn much cleaner than gasoline or diesel and so could help reduce air pollution in our cities.

Although natural gas produces slightly less CO₂ emissions than gasoline or diesel when used, it still moves a considerable amount of CO₂ from deep in our earth into the atmosphere.

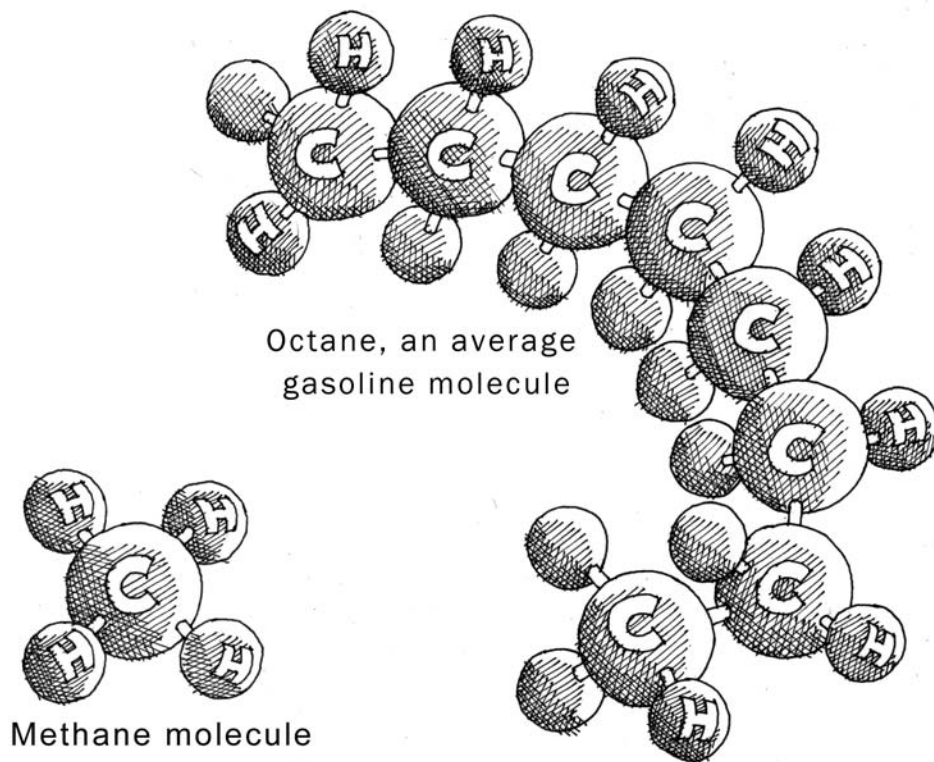


Fig 6a: Methane, the primary gas in natural gas, produces slightly more energy than gasoline or diesel for the same amount of CO₂ emissions. Burning octane, a typical gasoline molecule, releases energy from 25 molecular bonds (count them in the above graphic) and produces eight CO₂ molecules from the eight carbon atoms. Burning eight methane molecules also produces eight CO₂ molecules but releases energy from 32 molecular bonds.

Plant-based Fuels

Plant-based fuels include biodiesel (a diesel fuel made from vegetable oil instead of petroleum) and alcohols (such as methanol or ethanol that can be made by fermenting substances found in plants such as starch, sugar, and cellulose). Plant-based fuels can reduce CO₂ build-up in our atmosphere because their carbon content comes from plants, which took CO₂ out of the air in order to grow.

How much these fuels reduce CO₂ build-up depends on how much energy is needed to grow the plants, process them into fuel, and transport the fuel. This is because fossil fuels are still used to plant, harvest, process, and ship these fuels. Using fossil fuels means that there will still be some carbon moved from deep in the ground into our atmosphere.

Growing and processing plants to make biodiesel uses a relatively small amount of fossil fuel energy, so replacing diesel with biodiesel can greatly reduce CO₂ build-up in our atmosphere. Ethanol, on the other hand, frequently uses almost as much energy (from fossil fuels) to grow and process plants into fuel as is provided by the fuel. So replacing gasoline with ethanol reduces the amount of CO₂ build-up in our atmosphere by only a modest amount. Scientists are experimenting with new techniques to process cellulose and whole plants into ethanol that will use far less fossil fuel energy. If successful, the use of ethanol could be even more helpful in reducing CO₂ build-up in our atmosphere.

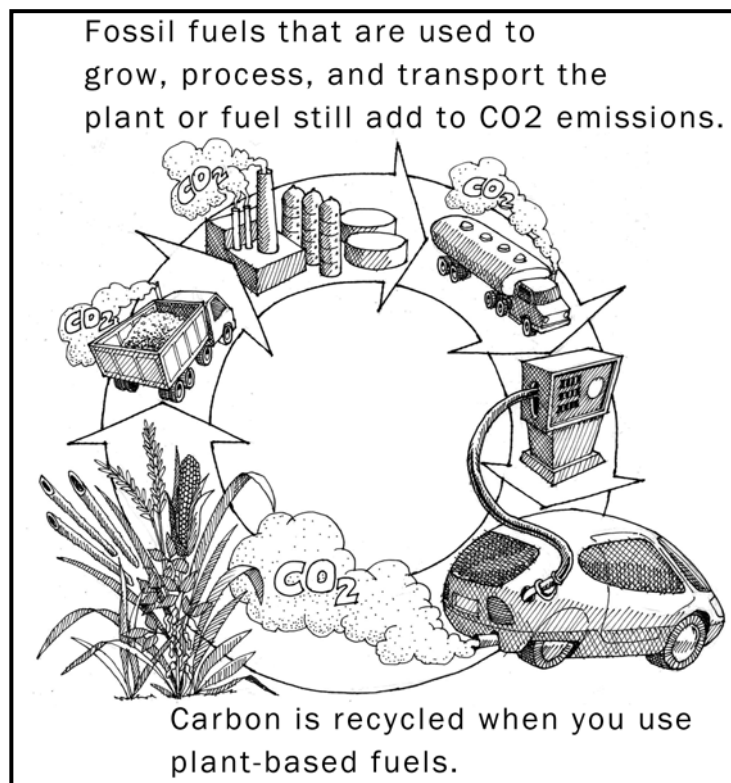


Fig. 6b. Carbon is recycled when you use plant-based fuels. Plants use carbon from the air to make oils, sugars, and cellulose that humans turn into fuels. When these fuels are burned, the carbon goes back into the air as carbon dioxide that other plants then absorb to make oils, sugars, and cellulose.

Fossil fuels that are used to grow, process, and transport the plant or fuel don't recycle carbon. Instead, the CO₂ emissions they produce when burned came from carbon that had been stored underground.

Electricity

Although electricity can be used to run a car, electricity isn't even truly a fuel. Instead, it provides a way to carry or transport energy to your car.

Battery-electric cars produce no exhaust (there isn't even a tailpipe) and so they could greatly help in reducing air pollution in our cities. Whether they help reduce CO₂ emissions or not depends on how the electricity is produced.

Some ways of producing electricity generate no CO₂ emissions. These include solar-electric, wind power, hydroelectric, geothermal, and nuclear power. Each of these may have other environmental impacts that should be considered, such as the effects on ecosystems of large dams, the visual impact of wind turbines, or the long-term storage of nuclear waste.

Even when oil or natural gas are used to generate electricity to power an electric car they still produce less CO₂ emissions per mile than running the same size car on gasoline or diesel.

Using coal to generate electricity to power an electric car produces more CO₂ emissions per mile than running the same size car on gasoline or diesel. There are also many health and environmental concerns related to using coal to produce electricity.

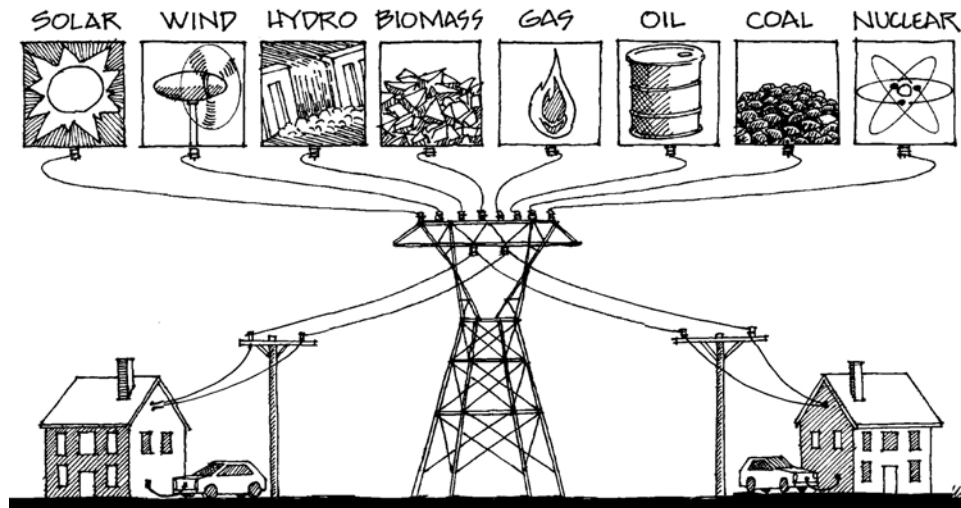


Fig 6c. Source of electricity that could be used to power a battery-electric car

Hydrogen

Hydrogen can be burned in an engine (similar to, but not the same as, your car's engine) or used by a fuel cell to produce electricity. Either can be used to power a car. Like a battery, fuel cells provide electricity that can be used to run an electric car. Unlike a battery, fuel cells are never recharged. Instead, they use hydrogen as a fuel to produce electricity. You don't recharge a fuel cell electric car – you fill it up with hydrogen fuel.

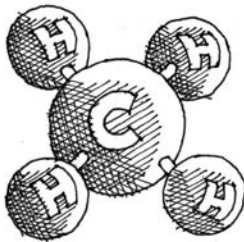
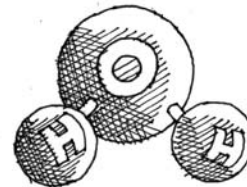
Simple hydrogen molecules (H_2) are never found in nature. Hydrogen atoms must be pulled off of other molecules such as water (H_2O) or methane (CH_4 , the primary gas in natural gas) – and that takes energy.

Whether using hydrogen as a fuel can reduce CO_2 emissions or not depends on what source of energy was used to create the hydrogen molecules (H_2). For instance, electricity can be used to extract hydrogen from water. If the electricity comes from non-fossil fuel sources (such as solar or wind) it would produce no CO_2 emissions but, so far, this is very expensive. On the other hand, chemists can extract hydrogen molecules from gasoline and feed these to a fuel cell. (The carbon atoms are discarded as CO_2 .) But the car will go about the same distance as if you fed the gasoline to a gas-powered car of the same size. So you are releasing as much carbon into the atmosphere as before. These show two extremes. Scientists and engineers are working on several other techniques that will reduce CO_2 emissions, but probably won't eliminate them altogether – at least not right away.

Fuel cell electric cars do have a tailpipe. But all that comes out is water, in the form of steam. So these cars could greatly help in reducing air pollution in our cities.

Hydrogen atoms can be found in many places.

Each water molecule (H_2O) has two hydrogen atoms attached to an oxygen atom.



The primary gas in natural gas, methane (CH_4), has four hydrogen atoms attached to one carbon atom.

Hydrogen molecules (H_2) are never found in nature. They have to be made by pulling two hydrogen atoms off of other molecules such as water or methane.

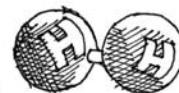


Fig. 6d: Hydrogen can be found in many places. Making it into a fuel takes energy.