HYBRID AUTOMOBILES

Background, Activities and Critical Analysis

By Ed Linz, a Physics teacher at West Springfield High School in Springfield, VA

Subject(s): Physics, Engineering, Environmental Science, Social Studies

Grade Level: Middle - High School

Time: 2 class periods

Lesson Objectives: Students will:

- Understand the basic principles of gasoline engines as propulsion for vehicles
- Be able to list pro's and con's associated with gasoline engines
- Cite reasons why alternatives for gasoline engines are being considered
- Understand differences between a motor and an engine
- Understand relationship between a motor and a generator
- Understand basic principles of operation of hybrid vehicles
- Be able to discuss different types of hybrid vehicles
- Understand pros and cons associated with hybrid vehicles

Overview:
Hybrid automobiles have been increasingly in the news as state and federal governments struggle to find ways to reduce consumption of fossil fuels and to lessen exhaust pollutants into the atmosphere. One method of accomplishing both objectives is to produce vehicles that use electricity for propulsion because no fossil fuels are directly involved and there are essentially no emissions. However, purely electric vehicles have met with little success in the marketplace due to lack of a national network for re-charging automobile batteries and the relatively limited range which these electric vehicles can achieve without recharging As a result of these shortcomings, automobile manufacturers began to develop "hybrid" vehicles, that is, automobiles that retain the range and re-fueling advantages of internal combustion engines with the environmentally desirable characteristics of electric motors. Sales of such hybrid vehicles have been rising almost geometrically in the past few years as consumers switch (often partially due to government incentives) to these types of cars. But is this good science, or is it simply an interim measure to delay the inevitable exhaustion of fossil fuel resources? And to what extent do hybrid vehicles improve the environment?

Materials:

1. A classroom set of 12 hand-held generators (Genecon Hand-Operated Generator is recommended - available from most science education catalogs, approximate cost $48 each).
2. Twelve 9-volt batteries (available anywhere)
3. Twelve miniature screw sockets with 6.3 volt incandescent lamps (available from all science supply catalogs)
4. Computers with Internet access, either one teacher station with overhead projection capability, or classroom set of 12 computers with Internet access.
5. Online NewsHour articles as background reading:

Clean Cars: http://www.pbs.org/newshour/bb/environment/jan-june00/cars_5-3.html
Emissions Decisions: http://www.pbs.org/newshour/bb/transportation/jan-june98/cars_1-27.html
All Charged Up: http://www.pbs.org/newshour/bb/environment/electric_9-9.html

Procedure

1. **Understanding internal combustion engines (ICE) in automobiles, the pros and cons, and why alternatives are being sought.**

Have students work in pairs at a computer terminal or observe teacher's projection of Internet on screen. Go to www.howstuffworks.com and select button titled "Auto Stuff." Then select section titled "Car Engines" and proceed through menu on site from "How Engines Work" to the excellent moving graphic (Figure 1) under "Understanding the Cycles." Emphasize the text which explains why most cars today use reciprocating internal combustion engines: [These are some of the "pro's" associated with gasoline engines.]

- Relatively efficient (compared to an external combustion engine)
- Relatively inexpensive (compared to a gas turbine)
- Relatively easy to refuel (compared to an electric car)

Cons for these engines include:

- Rapidly decreasing availability of gasoline worldwide
- Harmful exhaust emissions into atmosphere (CO, CO2, hydrocarbons, etc.)

2. Engines, Motors, and Generators

Engines are internal combustion devices as explained above. Motors are electrical and turn other forms of energy (usually motion) into electricity using magnets. Generators are electrical devices and use magnets to turn electricity into other forms of energy (usually motion).

Have pairs of students hook up the leads from a Genecon handheld generator to a miniature screw socket holding a 6.3 volt lamp (any small voltage lamp will work, but smaller voltage bulbs can be burnt out with the voltage produced by the generator).

Have students take turns turning the handle on the generator to produce electricity to light the lamp. Note that the faster the handle is turned, the brighter the bulb is lit. Note also that the light goes out when the student stops turning the handle. (Mention to students that every car has a generator which is turned by a belt on a pulley attached to the engine. As the engine turns, it creates electricity for the car so long as the engine is running).

Now disconnect the generator from the socket and bulb and have one student hold the handle on the generator while another touches the two leads from the generator to the terminals of the 9-volt battery. Observe that the same generator has now become a motor because, instead of it being turned to produce electricity, it is using electricity to make it turn!

3. Hybrid Vehicles; principles, types, and pros and cons

In order to meet the demands for less exhaust emissions and improved mileage by vehicles, "hybrid" automobiles are now being produced. These vehicles are not purely electric or internal combustion, but an attempt to create an efficient combination of the two in what is referred to as an "Integrated Electric Engine", often simply called a "hybrid." These automobiles, initially developed about 10 years ago, have different designs, depending on the manufacturer, but all have the common theme of using both an internal combustion engine (ICE) and an electric motor to power the car. It is important to note that the only source of external energy put into the vehicle

is gasoline or diesel fuel (as opposed to purely electric cars which are literally plugged into electrical outlets for overnight charging). All hybrids, regardless of design or manufacturer, use the ICE for the majority of propulsion and use the electric motor for limited use situations (such as stop-and-go commuting on a congested highway).

Have students return to computer terminals with Internet access (or use teacher station computer with overhead projection capability) and return to www.howstuffworks.com. Select "Auto Stuff," then "Hybrid Cars," then "What Makes It a Hybrid." In this section and the one which follows, have students use the interactive Figures (1) through (4) to understand the basic components of hybrid cars and the principle differences between series and parallel designs.

Direct the students to take notes in the following section, "Hybrid Components", listing the six major parts (and functions) of any hybrid vehicle [gasoline engine, fuel tank, electric motor, generator, batteries, and transmission].

Ask students to work in pairs to develop lists of pros and cons of hybrid automobiles. They may search the Internet for information, but should be able to list at least 4 pros and 4 cons. Use the blackboard or an overhead projector to develop a combined list from class input once everyone has completed the assignment.

Divide the class into four groups. Each group should create a poster on one of the following topics following online research.

a. How a Series Hybrid Car Works
b. How a Parallel Hybrid Car Works
c. Typical Fuel Savings of Hybrid Cars vs. Conventional Cars
d. Exhaust Emission Results of Hybrid vs. Conventional Cars

As a supplemental activity, consider using the batteries, screw sockets and lamps with standard classroom insulated wiring to set up and discuss series and parallel electric circuits so that students reinforce understanding of the terms "series" and "parallel."

Extension Activities

1. Create a long-term assignment for students to gather and bring to class brochures on each of the different models of cars by manufacturer and function (e.g. the Toyota Prius, Lexus SUV, Dodge Ram Truck, etc.). Form discussion groups to evaluate manufacturer claims compared to independent analysis (e.g., Consumer Reports, Motor Trend magazine, etc.) on such issues as fuel economy, emission results, long-term cost.

2. Ask one or more local car dealerships to bring a hybrid automobile to your school for inspection and demonstration. (I have found most car dealers are very willing to do this.)

Correlation to National Science Education Standards:

Content Standard A:
As a result of their activities, students should develop understandings about scientific inquiry.

Content Standard B:
As a result of their activities, students should develop an understanding of motions and forces.

Content Standard E:

As a result of activities, students should develop understandings about science and technology.

***About the Author**: Ed Linz teaches four levels of Physics at West Springfield High School in Springfield, VA. He is a retired nuclear submarine commander, and has been teaching and coaching in public schools in Virginia since 1985. He is an author [Life Row, 1997] and a weekly newspaper columnist for Exchange Publishing in Spokane, WA. He also is a consultant on education assessment for the American Institutes for Research in Washington, DC.*