

# A Basic Understanding of Battery Electric & Hybrid Electric Vehicles

## **Instructor's Manual**



National Alternative  
Fuels Training Consortium

A Program of

 West Virginia University

# Chapter 1: Why Do We Need Alternative Fuels?

Battery-Electric and Hybrid-Electric Vehicles

## Notes

Energy security is of great importance to the United States. Dependence on foreign oil weakens the country's energy security and puts the nation at risk. Instability in the Middle East can disrupt the importation of oil and cause market prices to skyrocket. Another threat to U.S. energy security is the use of oil as a weapon. The only way for the United States to overcome these issues and to strengthen the nation's energy security is to become less reliant on foreign oil supplies.

### **Alternative Fuels and Vehicles That Use Them**

Now that we have discussed the emissions released by conventional vehicles and the impact of dependence on foreign oil sources on U.S. security and the economy, we will propose a possible solution: the adoption of alternative fuels for transportation and other purposes. In this section, we will simply introduce each fuel and offer a brief description. Additional information about each fuel is available elsewhere, in this and other courses and manuals.

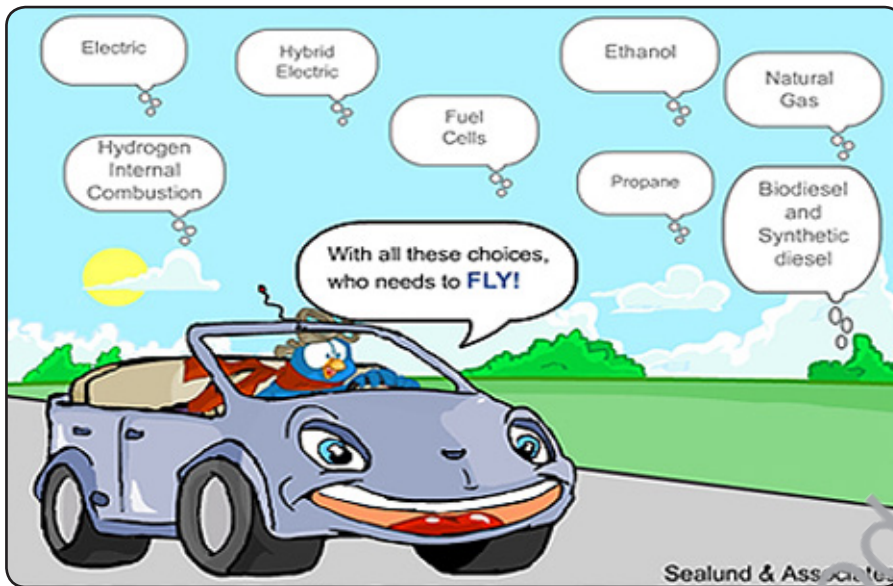
The following list of fuels does not imply any preference or belief that one fuel is better than another or more likely to succeed. It is very unlikely that any one fuel can ever replace gasoline or that the same fuel will be available in every service station in the country. This fact alone raises serious challenges regarding infrastructure (the network of support services and functions that must be available in order for a fuel to be adopted).

One additional note is in order. It is important to make a distinction between a "fuel" and a "vehicle that uses a fuel." In the list that follows, some of the entries are actually **fuels** (in which case we can assume that conventional vehicles can use them, with or without some kind of conversion), while other entries are actually new kinds of **vehicles**—and one is neither!

### **What Are Alternative Fuels?**

The Energy Policy Act of 1992 (EPAAct) was passed by Congress to reduce our nation's dependence on imported petroleum. It required certain fleets of vehicles (operated by the government or large private enterprises) to acquire "alternative fuel vehicles," which are defined in the law as those capable of operating on *non-petroleum fuels*.

EPAAct listed eight alternative fuels: ethanol, natural gas, propane, hydrogen, biodiesel, electricity, methanol, and "P-series fuels" (a mixture of ethanol, natural gas, and a chemical solvent). Of these fuels, methanol and P-series fuels never became very widespread. The other six named in EPAAct, however, remain viable alternatives under consideration (see Figure 1-8).



**Figure 1-8:** *Alternative fuels.*

For purposes of this lesson (and this course), we have chosen to separate the two types of electric vehicles and to consider biodiesel and synthetic (non-biological) diesel fuels together.

- Battery-powered electric vehicles—Cars with electric motors and rechargeable batteries that are recharged by plugging them into an external electricity supply.
- Hybrid electric vehicles—Cars that use an internal combustion engine or a fuel cell (see below) in conjunction with one or more electric motors and a rechargeable battery. The battery is recharged internally by the engine or fuel cell. Another approach is a vehicle that combines both technologies—a high-capacity rechargeable battery with a plug-in charger. These are known as plug-in hybrid electric vehicles.
- Hydrogen—Fuel that can be burned in an internal combustion engine or in a fuel cell, although the vehicle must be able to accommodate a high-pressure storage tank or other means of hydrogen storage. Hydrogen is usually created in a gas-manufacturing facility, but can be generated onboard the vehicle in a process known as “reforming.”
- Fuel cells—Neither a fuel nor a vehicle, a fuel cell is a device that generates electrical power. Fuel cells use hydrogen as their fuel and can power a hybrid electric vehicle.
- Ethanol—Alcohol fuel made from crops (generally corn). It can be used alone or blended with gasoline. Conventional vehicles can run on 10% ethanol, while flexible-fuel vehicles can run on higher concentrations, such as 85% ethanol.



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## Battery-Electric and Hybrid-Electric Vehicles

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- Biodiesel and synthetic diesel—Two fuels that can be burned only in diesel vehicles. Biodiesel is made from plant oils (such as soybeans), while synthetic diesel is produced from chemicals.
- Natural gas—A fuel that comes in two forms: compressed at high pressures or liquefied into a cryogenic liquid. Conventional vehicles can be converted to run on either form of natural gas. Compressed natural gas is distributed by a nationwide pipeline system. Liquefied natural gas must be obtained at a special fueling facility.
- Liquefied petroleum gas—A form of petroleum commonly called “LPG” or propane. Conventional vehicles can be converted to run on propane, which is sold commercially almost everywhere.

### Benefits of Using Alternative Fuels

Regardless of which fuel or combination of fuels may be used, there are definite advantages in dealing with the problems of pollution and dependence on foreign energy supplies.

For example, ethanol can be made from corn that is grown in the United States; biodiesel can be made from soybeans, also domestically produced. The United States has vast supplies of natural gas. The only fuel in this list that still depends on foreign sources of petroleum is propane.

Carbon monoxide, carbon dioxide, and oxides of nitrogen remain problems, but to a smaller extent, when the fuel is ethanol, natural gas, propane, biodiesel, or synthetic diesel. Use of these fuels can help cities attain their air-quality goals much more easily than can controls on gasoline and other petroleum-based fuels.

The cleanest fuel is hydrogen, either burned in an internal combustion engine or as a fuel source for a fuel cell. In fact, the only waste product from a fuel cell is  $H_2O$ —water! Electricity is also a clean fuel, but we have to pay attention to how that electricity was generated—what other fuels were burned to make it, either onboard the vehicle or at the power plant. The cleanest vehicle on the road today burns compressed natural gas.

Will alternative fuels ever completely replace gasoline and diesel? It is not likely any time soon. General Motors Corporation coined the phrase “the hydrogen economy” during the fuel crisis of the 1970s. Its proposition was to move to hydrogen as an all-around fuel for transportation, heating, industry, and other purposes. This bold vision is now more than thirty years old, and we still have virtually no infrastructure and little chance that we will see hydrogen vehicles commercially available in our lifetimes.

Nevertheless, if we acknowledge that pollution caused by vehicle emissions and the dangers of reliance on foreign energy sources are serious problems faced by the United States and other countries today, it only makes sense to explore alternatives and pursue those that make sense now and in the near future. A world in which alternative fuels are available to most and used by many would be a cleaner, more secure place to live.

### Conclusion

### Notes

No one is seriously suggesting that the United States or other industrialized countries could give up petroleum products overnight—nor even that it can ever happen entirely. However, a cleaner environment and a more secure energy supply could make everyone breathe easier and sleep more soundly.

The challenges of environmental pollution and energy security are real and growing. Governments have taken and will continue to take action to address these problems.

Alternative fuels offer great promise as solutions to these problems, as well as significant challenges. As civilization has evolved on earth, humankind has followed a natural progression from the use of fuels with intensive carbon content toward fuels with less and less carbon. Early societies used wood as their energy source. As societies evolved and developed industries, coal replaced wood. Within the last hundred years, we have seen petroleum products replace a great deal of coal usage. Gaseous fuels contain even less carbon. The end point of this progression would be a hydrogen economy. Using only hydrogen, our societies would be carbon free! Of course, people tend to resist change. Oftentimes new technologies are met with stiff resistance! In any case, we are still decades from achieving the goal of a hydrogen economy.

Because the problems are so great and the urgency so immediate, alternative fuels are being looked at closely today as a possible solution to the problems of pollution and instability of the energy supply—the promise of **clean air and energy independence** is real and exciting!

You should now have a better understanding of the importance of the use of alternative fuels as the provider of our future energy needs.