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Transportation and Air Quality Transportation and Regional Programs Division
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Clean Alternative Fuels: Fuel Cells

One in a series of fact sheets

SUCCESS STORY

Georgetown University in Washington, DC, has successfully developed a fuel cell that uses methanol—a fuel derived from renewable sources and readily available at a reasonable price. Granted money in 1991 from the U.S. Federal Transit Administration, Georgetown has actively researched using fuel cells in transit buses. The university has proposed building eight fuel cell-powered transit buses for research and testing.

Through this program, Georgetown has learned valuable information about fuel cell technology's performance and promise. The university's research will play an important role in the future commercialization of fuel cell technology for vehicles.

For more information, contact James Larkins, Georgetown's program manager, at (202) 687-7361.

From midsize passenger vehicles to large transit bus fleets, fuel cells offer a promising new source of clean power for electric vehicles. This innovative technology uses chemical energy rather than combustion to generate electric power, resulting in far fewer emissions. In addition, fuel cell vehicles can utilize renewable fuel and are expected to provide a wider driving range than today's battery-powered electric vehicles. At least seven types of fuel cells are currently being researched (see box).

Fuel cells generate power through an electrochemical process, much like a battery. They convert chemical energy to electrical energy by combining hydrogen from fuel with oxygen from the air. Hydrogen fuel can be supplied in two ways—either directly as pure hydrogen gas or through a "fuel reformer" that converts hydrocarbon fuels such as methanol, natural gas, or gasoline into hydrogen-rich gas.

Providing fuel to power these vehicles presents several challenges. Large investments are required to establish hydrogen production facilities and a convenient hydrogen distribution system to serve the general public. As an alternative, manufacturers are working to improve fuel reformers to allow fuel cell vehicles to use conventional fuels, which would encourage consumer acceptance of this technology.

AVAILABILITY

Three major U.S. manufacturers and several European and Japanese manufacturers are actively researching fuel cell transportation technologies and testing prototype passenger vehicles. Several North American cities are also testing fuel cell-powered transit buses. There are no fuel cell vehicles currently available for sale in the United States, but one major U.S. automaker has announced plans to make 40,000 fuel cell vehicles available for purchase by the general public by 2004. At least four other manufacturers also plan to market fuel cell vehicles that year.

EMISSIONS CHARACTERISTICS*

Actual emissions will vary with engine design.

- Fuel cell vehicles operating on hydrogen or methanol can achieve zero emission vehicle levels.
- Fuel cells operating with a fuel reformer emit water vapor, carbon dioxide, and hydrocarbon emissions.

* Estimates based on fuel cell's inherently "cleaner" properties.

AFFORDABILITY

There is no data currently available on fuel cell vehicle costs because the vehicles are not yet commercially available. Vehicle costs are expected to vary depending on the fuel cell technology used and the scale of vehicle production. Fuel prices also will vary. Though hydrogen derived from natural gas is more expensive than conventional fuels, vehicles fueled by hydrogen achieve greater fuel economy. Keys to making these vehicles cost-competitive include providing low-cost, high-volume manufacturing processes, as well as lightweight, compact, and affordable hydrogen storage systems.

PERFORMANCE

Because the technology is still under development, fuel cell vehicles' performance has not been well-studied or documented. Based on available research, fuel cell vehicles are expected to offer an extremely quiet ride with little vibration. Compared with conventional vehicles, fuel cell vehicles are also expected to provide improved fuel economy, increased engine efficiency, lower smog-forming emissions, and reduced greenhouse gas emissions.

SAFETY

Safety issues vary depending on the specific fuel source used. Although most fuel cells, fuel reformers, and fuel storage systems are not heavier than conventional systems, some may be. For such systems, the added weight can make stopping the vehicle more difficult. The onboard fuel reformers also present unique safety concerns—some reformers can generate internal temperatures up to 1,000°C and produce steam or steam fuel mixtures at very high pressures.

For More Information

EPA Alternative Fuels Web Site
www.epa.gov/otaq/consumer/fuels/altfuels/altfuels.htm

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Alternative Fuels Data Center
Web site: www.afdc.nrel.gov

National Alternative Fuels Hotline
Phone: 800 423-1DOE

Types of Fuel Cells

All fuel cells contain two electrodes—one positively and one negatively charged—with a substance that conducts electricity (electrolyte) sandwiched between them. Fuel cells can achieve 40 to 70 percent efficiency, which is substantially greater than the 30 percent efficiency of the most efficient internal combustion engines. The following are different types of fuel cells:

- **Phosphoric Acid**—The most commercially developed fuel cell, generates electricity at more than 40 percent efficiency.
- **Proton Exchange Membrane**—Considered the leading fuel cell type for passenger car applications, operates at relatively low temperatures and a high power density.
- **Molten Carbonate**—Promises high fuel-to-electricity efficiencies and the ability to utilize coal-based fuels.
- **Solid Oxide**—Can reach 60 percent power-generating efficiencies and be employed for large, high-powered applications such as industrial generating stations.
- **Alkaline**—Used extensively by the space program, can achieve 70 percent power-generating efficiencies, but is considered too costly for transportation applications.
- **Direct Methanol**—Expected efficiencies of 40 percent with low operating temperatures; able to use hydrogen from methanol without a reformer.
- **Regenerative**—Currently being researched by NASA; closed loop form of power generation that uses solar energy to separate water into hydrogen and oxygen.

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