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## Hydrogen Refueling Stations

My January column focused on fuel cell vehicles as the ultimate hybrid for the 21st century and beyond. But hydrogen-powered vehicles can only usher in a future hydrogen economy if roadside hydrogen refilling stations become as plentiful as your neighborhood gas station. This column will look at the production and future distribution of hydrogen.

To place all readers on equal footing, let's start with some basic facts about hydrogen. First, it is the most abundant element on our planet. Every drop of water contains two parts hydrogen and one part oxygen. As a gas, hydrogen is extremely volatile—think *Hindenburg*. Hydrogen is the lightest gas ever discovered, and it contains about 3 times as much energy as natural gas.

The electrolysis process produces hydrogen by passing an electric current through water. Although electrolysis is the best-known process for producing hydrogen, it is only used to produce about 4 percent of our current hydrogen needs. About 95 percent of the hydrogen that our society currently consumes is produced by a steam reformation process that converts natural gas into hydrogen and carbon dioxide.

Without refueling fuel cell vehicles, the United States already uses 10 million tons of hydrogen annually in industrial processes at facilities around the country. Perhaps the most interesting fact of all is that each of us personally uses hydrogen as a power source all the time. Most

electronic devices currently run on nickel metal hydride (NiMH) batteries, which store and release hydrogen in the electrochemical reaction that powers the devices.

The Shell service station pictured below dispenses liquid hydrogen, compressed hydrogen and good old-fashioned gasoline to meet the varying needs of customers in the Washington, DC, area, one of the major initial testing zones for fuel cell vehicles. Royal Dutch/Shell Group established Shell Hydrogen to focus on hydrogen as an energy source.



Together with its partners, it is building hydrogen-refueling networks of four to six stations in every large metropolitan area where fuel cell vehicles are currently undergoing testing.

If a commercial hydrogen production facility is nearby, the hydrogen that is sold at a gas station is trucked in and stored in special pressurized tanks at the station. As I write this column, 18 U.S. operating hydrogen-vehicle-refueling stations produce their hydrogen on site us-

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ing electrolysis or the reformation of natural gas.

The nozzle illustrated at right creates a positive sealed link between the refueling storage tank and the vehicle's onboard storage tank. The connection is supposed to be childproof, and it prevents outside air and hydrogen from entering each other's domain. Before refueling begins, the nozzle grounds the car to bleed off any static electricity present, and the design of the fuel door shuts off the vehicle's electric motors so the car can't be accidentally driven during refueling. The system makes it safer to refuel a hydrogen-powered vehicle than a gasoline-powered vehicle.

How quickly will hydrogen-refueling stations spread across the industrialized world is anyone's guess. The experts see this as a "which came first, the chicken or the egg" conundrum—demand for hydrogen refueling will drive the construction of future infrastructure, and at the same time the construction of the future infrastructure will drive the demand

Photo Credit Shell Hydrogen



for hydrogen-powered vehicles. A future hydrogen-based economy also depends on major research breakthroughs that will ramp up fuel cell vehicle efficiency, as well as new methods of producing, storing, transporting and using hydrogen as an alternative energy source.

Breakthroughs are being made. For example, a December 12, 2006, news release heralded a major hy-

drogen production technology breakthrough in Switzerland, where researchers demonstrated a solar-powered system that produces hydrogen very inexpensively from water using lab-grown cobalt and silicon nanostructures.

The \$6 million question is how much will a hydrogen equivalent to a gallon of gas cost you in the future? Some experts predict prices as low as \$3 per gallon, with windfall profits once the infrastructure is built and the demand for hydrogen becomes significant. At this point in time, a fuel cell vehicle fill-up is highly subsidized to keep the price competitive with gasoline.

### Recalling the Facts

1. Do you think hydrogen powered vehicles will eventually replace gasoline powered vehicles? Why?
2. Describe four basic properties of hydrogen and two methods that are used to produce it.
3. Do you personally use hydrogen to power electronic devices that you own? If yes, which devices? ☺

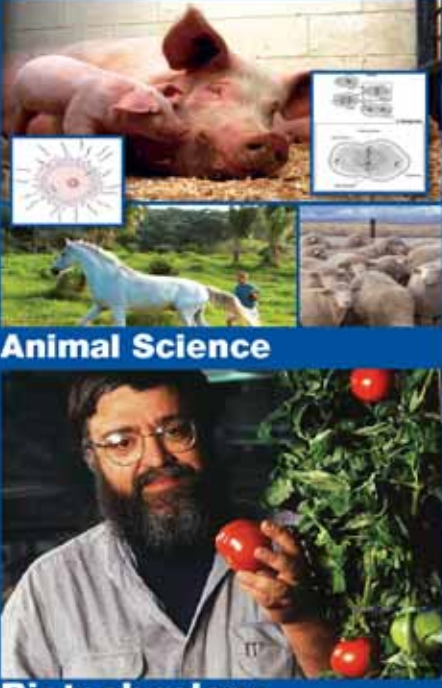
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