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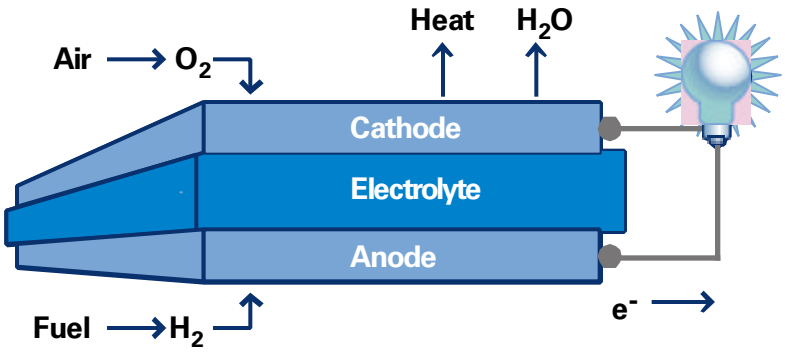
Are Hydrogen Fuel Cells the Future of the Energy Industry?

Cheap and readily available energy drives our modern information age. Whether it's electricity to run our homes and businesses or petroleum to fuel our cars, busses and planes, we are completely dependent on a complex and global energy infrastructure. Yet the side effects of this addiction to fossil fuels are beginning to threaten the very society which they enable. Most scientists now agree that combustion of hydrocarbons, including coal, oil, and natural gas is leading to an unprecedented concentration of carbon dioxide (CO^2) and other greenhouse gasses in our atmosphere. And while the debate continues on how and when this impacts our climate and lifestyles, it appears that consensus is building for the need to migrate our energy consumption to more environmentally benign energy sources. At the same time, the political and social costs of depending on the MidEast for petroleum fuels (63% of the world's oil resources are held within the five countries of Saudi Arabia, Iran, Iraq, Kuwait, and the United Arab Emirates) are becoming all too apparent.

This leads us to our current interest in hydrogen fuel cells. And recently there have been significant signs that this interest is more than a passing fad. The Bush Administration has allocated $1.7 billion to research hydrogen fuel cells, the Chairman of Ford Motor Company has stated that fuel cells will end the reign of the internal combustion engine, and you can even go to your local bookstore and pick up a book by popular futurist Jeremy Rifkin titled *The Hydrogen Economy: The Creation of the Worldwide Energy Web and the Redistribution of Power on Earth*. So what is the reality? Are hydrogen fuel cells poised to take over the power generation and automobile markets? Read on for an explanation of what hydrogen fuel cells are, how real the hype is, what the timing of any changes may be, and why you will care as a participant in the energy industry.

How a Fuel Cell Works



Oxygen from the air and hydrogen fuel are applied to the cathode and anode respectively. The hydrogen migrates through the anode and reacts with the elctrolyte to create free electrons as well as positively charged hydrogen ions. The hydrogen ions combine with the oxygen to create water, the electrons flow to create electricity, and heat is released as a by-product

Hydrogen and Fuel Cells

First, it is important to understand that hydrogen and fuel cells are two separate and distinct things that do not need to be linked. Hydrogen is simply a flammable, colorless, odorless, gaseous chemical element. Hydrogen is not a primary energy source like coal and gas, but is an energy carrier. We say this because hydrogen cannot be mined or

pumped from the ground like coal, oil or natural gas. Rather, it is manufactured from other sources such as water or hydrocarbons. The two most common methods for manufacturing hydrogen are electrolysis of water (which requires large amounts of electric energy) and reformulation (refining) of natural gas, coal, or biomass fuels. The advantage to hydrogen as a fuel is that when hydrogen combusts, we get only water and heat as a by-product — no carbon, no greenhouse gases and no air pollutants.[1]

A fuel cell is a means of generating electricity. By definition, a fuel cell is an electrochemical device that converts a fuel's chemical energy directly to electric energy. Fuel cells have no moving parts and are like a battery except that batteries only store energy while fuel cells can produce electricity continuously given an ongoing supply of fuel and air. So think of a fuel cell as a battery that you can continually recharge by inputting fuel. Fuel cells can run on various fuels including natural gas, gasoline, biogas, methanol, ethanol, and hydrogen.

The reason we often hear talk about a hydrogen fuel cell future is that such a vision combines the best of two worlds from an environmental standpoint. Hydrogen as a fuel is non-polluting and fuel cells as a source of energy are highly efficient.

Where Fuel Cells Are Today

In the long run, use of fuel cells to either directly power vehicles (mobile propulsion) or as a source of onsite generation (stationary power) may become common. Initially, however, we will see fuel cells marketed as battery replacements. Small fuel cells are already making the leap from lab to market, and appear poised to be one of the hot technologies introduced in 2004. Laptop manufacturers including NEC and Toshiba will be offering laptop PCs powered by methanol fuel cells next year. Initial models will have a run-time of five hours and will be similarly sized but lighter than your current laptop battery. And in two years, NEC expects to expand fuel cell life to a stunning 40 hours. If the batteries run out, simply add some liquid methanol and keep on computing!

The next widespread use for fuel cells will most likely be stationary power. Fuel cells as an onsite source of electricity are already commercially available in sizes ranging from 1 kW to as large as 2 MW. Companies such as UTC, Plug Power, Ballard, and Fuel Cell Energy have installed fuel cells at a total of a few hundred sites. These run off natural gas, provide digital quality power, and are expected to be reliable once the inevitable initial bugs are ironed out. What currently holds back more rapid market penetration is cost. Current costs are in the $4000/kW range costs and need to be in the $750-1000/kW range to be competitive with utility power for most uses. However, fuel cells are more reliable and provide higher power quality than other current alternatives. So in places where critical or premium power is required, fuel cells are already an attractive alternative. Meanwhile, in Japan and Europe interesting market tests are being done with home sized cogeneration units that have the potential to provide a home's total electrical and hot water needs. Some analysts believe that within this decade stationary fuel cells may become a valid option for widespread use in distributed electric production.

The last implementation may or may not be for mobile propulsion. Car companies including General Motors, Daimler-Chrysler, Ford, and Toyota have begun to devote very real research and development dollars towards the creation of viable fuel cells cars. But all agree that substantial penetration of fuel cells cars is probably more than a decade away. Penetration for large vehicles like busses may be sooner. But at least initially, these will be powered by gasoline, methanol, or natural gas, not hydrogen.

The replacement of natural gas or methanol with hydrogen as a fuel for fuel cells is even further off, perhaps four-to-five decades. Questions including how to economically create large

[1]Of course, the environmental benefits are less attractive if you cause negative environmental impacts in creating hydrogen. If electrolysis is to be used, one must first ask how will we generate the electricity necessary to create hydrogen. Visions for generation sources include gasified coal, nuclear and large banks of wind power or other renewable sources. The debate has already begun about which vision makes the most sense.

amounts of hydrogen, how to safely and economically transport hydrogen, and how to create and fund a new infrastructure are still areas for research to solve.

What Does This Mean to The Energy Industry?
So why — as a participant in the natural gas or electricity industry — should you care? And when should you care? Certainly hydrogen fuel cells are not going to take over the world tomorrow. And not likely even in the next decade. But many believe that the companies that get involved now will be the market leaders in years to come. Two U.S. utilities currently active in fuel cells with the future in mind are Avista and DTE.

In the meantime, natural gas fuel cells appear poised to become an increasingly viable new technology. If costs are brought down and reliability in the field proven, fuel cells may be the answer for bridging our current distribution system with an increasing digital world unable to tolerate sags, surges, transients, and outages. Such a development would mean a new set of options for electric consumers, a new growth market for natural gas companies, and a new design paradigm for electric distribution systems.