

## Fuel Cells

Talk by Charles O. Adams for Barn Gang of Engineers Club of Dayton

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NOTE: Image numbers are preserved for archival purposes. However, the images are missing. If they are found in the future, they will be added to this page.

### Introduction:

This first transparency shows something many of you may not have seen before. It is the web home page of our Engineers Club. I thought it might be of interest, and a way to start this program. ( Pic. 1)

Most of you know my primary interests for many years have been The Reduction of Pollution and The Elimination of the Need for Foreign Oil. Fuel Cells offer the first major opportunity to accomplish both goals. This now has the attention of our national government, particularly the Department of Energy, Office of Transportation. This message from Tom Gross, Deputy Assistant Secretary, Office of Transportation, even states 'our goal is to lower the demand for imported petroleum and reduce pollutant emissions and greenhouse gases.' (Pic.2)

In (Pic.3) the D.O.E. national laboratories are working closely with industry partners to overcome critical barriers to automotive fuel cell development. The Los Alamos National Laboratory has developed fabrication processes with reduced platinum loading that decreases the cost of the catalyst by 90%. This LANL has developed carbon monoxide cleanup technology that was recently integrated with a gasoline fuel processor that generated electrical power for the first time in a proton-exchange-membrane fuel cell. Argonne National Laboratory has developed fuel cell processing technology for ethanol-powered fuel cell systems.

### Fuel Cells 2000 - What Is A Fuel Cell.

A fuel Cell consists of two electrodes sandwiched around an electrolyte. Oxygen passes over one electrode and hydrogen over the other, generating electricity, water and heat. In (Pic.4) this is shown schematically. Hydrogen fuel is fed into the anode of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. Encouraged by a catalyst, the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water.

A fuel cell system which includes a 'fuel reformer' can utilize the hydrogen from any hydrocarbon fuel — from natural gas to methanol, and even gasoline. Since the fuel cell relies on chemistry and not combustion, emissions from this type of a system would still be much smaller than emissions from the cleanest fuel combustion processes.

### Overview of a Fuel Cell.

In (Pic.5) is another picture illustrating a hydrogen-oxygen fuel cell. This is simply to repeat how hydrogen atoms are separated into electrons and protons at the catalyst surface. The protons pass through the membrane, while the electrons take the external path through the load, and return from the load to the other side of the membrane. There, the oxygen combines with the hydrogen protons and the hydrogen electrons to form the water discharge from the fuel cell, and generate by-product heat.

#### National Energy Policy:

The first National Energy Policy drafted by Vice President Dick Cheney's committee stressed reliance on Big Oil. It created a ruckus. As finally released, the National Energy Policy includes tax incentives for hybrid and fuel cell vehicles. In addition to focusing on increases in oil drilling and energy production, the report recommends measures designed to promote energy efficiency, conservation, and increasing use of renewable and alternative energy sources. Three of these are shown on (Pic.6): Tax Credits for HEVs and FCEVs, Commitment to IT Transportation Systems, Clean buses, FC Bus Technologies, and Clean Trucks, and Develop Next Generation Technology. The latter also directs the Secretary of Energy to focus research and development efforts on integrating current programs regarding hydrogen, fuel cells, and distributed generation of energy, or DG.

Congress is recognizing the need to push non-combustible power for automobiles. (Pic.7) and (Pic.8) show a Summary of BEV, FCEV, HEV and Infrastructure Provisions in the Clean Efficient Automobiles Resulting From Advanced Car Technologies, the Clear Act - Senate 760. Shown are Battery Electric Vehicle Provisions, Fuel Cell Electric Vehicle Provisions, Hybrid Electric Vehicle Provisions, and Infrastructure Provisions. I recommend we all contact our Senators to push for early passage of this bill.

The Office of Power Technologies, of the Department of Energy, pushing for Fuel Cells, issued the FUEL CELL Summit listing Calendar of Events. This lists by months the various meetings, conferences, and symposiums covering fuel cell and energy issues. This is shown in (Pic.9).

A National Fuel Cell Research Center was established in 1997 on the campus of the University of California, Irvin. It hosts a two-day workshop that addresses the basics of fuel cell technology. (Pic.10) calls attention to this workshop held July 16-17, 2001. I intend to see what I can find out about what was accomplished.

#### Fuel Cell Companies and Products:

There are a multiplicity of companies now making fuel cell products, some for stationary power generation, some for transportation vehicles. International Fuel Cells is one of the largest making units for Distributed Generation. Examples are shown in (Pic.11), (Pic.12) and (Pic.13). Four IFC fuel cells now serve as the primary source of power for the First National Bank of Omaha, (Pic.11). In Anchorage, Alaska, the U.S. Postal Service Has five fuel cells, connected in parallel, producing one megawatt of electricity, 24 hours a day. This is used in conjunction with the power grid of Chugach Electric Utility. It kicks in whenever there is a power outage. 30 outages have been experienced since the IFC

installation in July 2000. Each time, the fuel cells have kept the Mail Processing Center operational. This is seen in (Pic.12). In the center of New York City's Times Square, two IFC fuel cell units provide the Durst Organization with 'green,' reliable power in the Conde Nast Building, (Pic.13). These all are hydrogen-oxygen fuel cells.

Metal Fuel Cells are being made by several companies. (Pic.14) shows an electric scooter powered by a zinc-air fuel cell from Evonyx. Evonyx feels their zinc-air fuel cell has the potential to outperform, at lower cost, all advanced batteries and hydrogen fuel cell systems, and to ultimately supplant the internal combustion engine. Their announcement of what they call the Revco Power Cell is shown in (Pic.15). A schematic drawing of the Evonyx fuel cell is shown in (Pic.16). The Zinc can be in the form of replaceable RPC PowerCard, or a zinc-tape, used as a moving zinc tape anode. This concept has a discharging cathode and separate recharge cathode, allowing rapid recharging.

Metallic Power, Inc. makes a zinc-air fuel cell, using a hopper full of tiny zinc pellets immersed in concentrated potassium hydroxide (KOH) in contact with a current collector.. The zinc/air fuel cell, showing electrodes, is pictured in (Pic.17), and the fuel cell and electrolyte management system is shown on (Pic.18). On these two sheets are shown the chemical expressions explaining the reactions. On (Pic.19), some frequently asked questions are answered.

#### Nanostructure Science and Technology:

This is another subject the Barn Gang should look into. Using carbon nanotubes, hydrogen can be adsorbed and released in much greater volume than any other method of storage or transport. (Pic.20) Carbon nanotubes are a single layer of the hexagonal lattice graphite, wrapped into a single-walled, cylindrical tube of about 1 nanometer diameter (with about 20 atoms around the cylinder), but up to several microns long.

#### Videos to help explain Fuel Cells:

We will now show two short videos and a short video CD to help clarify this talk on Fuel Cells.

Thank you.

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