



Fuel Cells and Biomass

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presented by
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 - Colorado School of Mines
 - Gas Technology Institute
 - National Renewable Energy Laboratory
 - Versa Power Systems, Inc.



Located on the CSM Campus



The CFCC is located in the General Research Lab (GRL) on the Colorado School of Mines Campus.

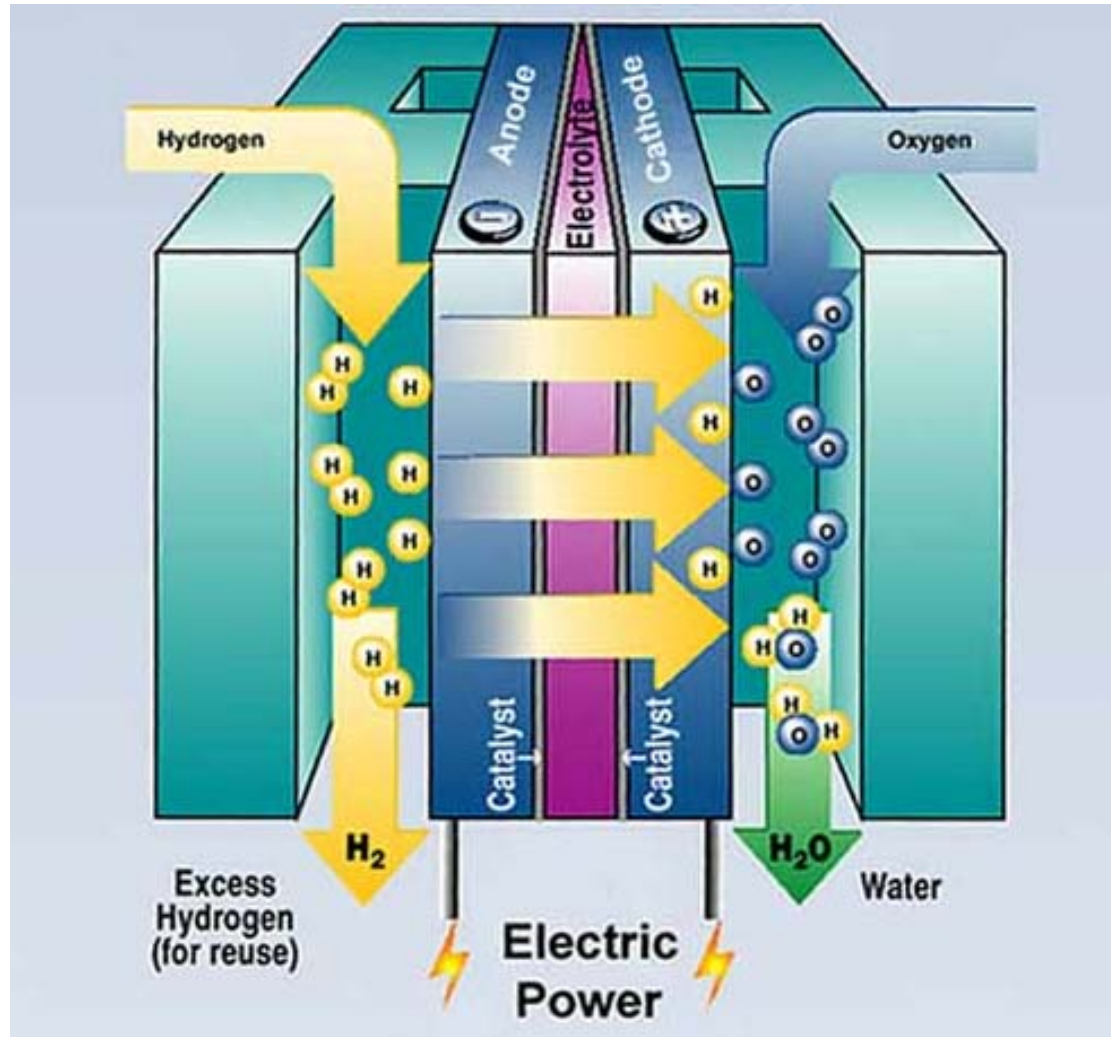


Our Three-Fold Mission

- Research and Development
- Education and Outreach
- Support for Commercialization

What's a Fuel Cell?

Diagram
courtesy of
the US DOE





Different kinds of fuel cells operate at different temperatures

- Low temperature PEM (-20° to 200°F)
 - Operate on hydrogen or methanol
 - Power plants for fuel cell vehicles and a wide range of consumer electronics
- High temperature (350° to 1800°F)
 - Operate on natural gas, propane, diesel, kerosene, coal gas, biogas, ethanol, and logistic fuels used by the military

Fuel Cells come in all sizes

75-Watt Fuel Cell
Fabricated by:

Mesoscopic Devices,
Broomfield, CO



Prototype Residential Fuel Cell

2-kilowatt net AC
Natural Gas Fueled

Fabricated by:
Versa Power Systems
Littleton, CO and
Calgary, Alberta



The PowerCell 200™ is available from UTC Fuel Cells

Uses:

2100 SCF/hr

Produces:

200 kW (37%)

925,000 Btu/hr
water at 60°C



DFC 300 from FuelCell Energy

Uses

1920 SCF/hr

Produces

250 kW (47%)*

& Steam at
360°C



*When combined with a 50 kW steam turbine achieves 56% electrical efficiency



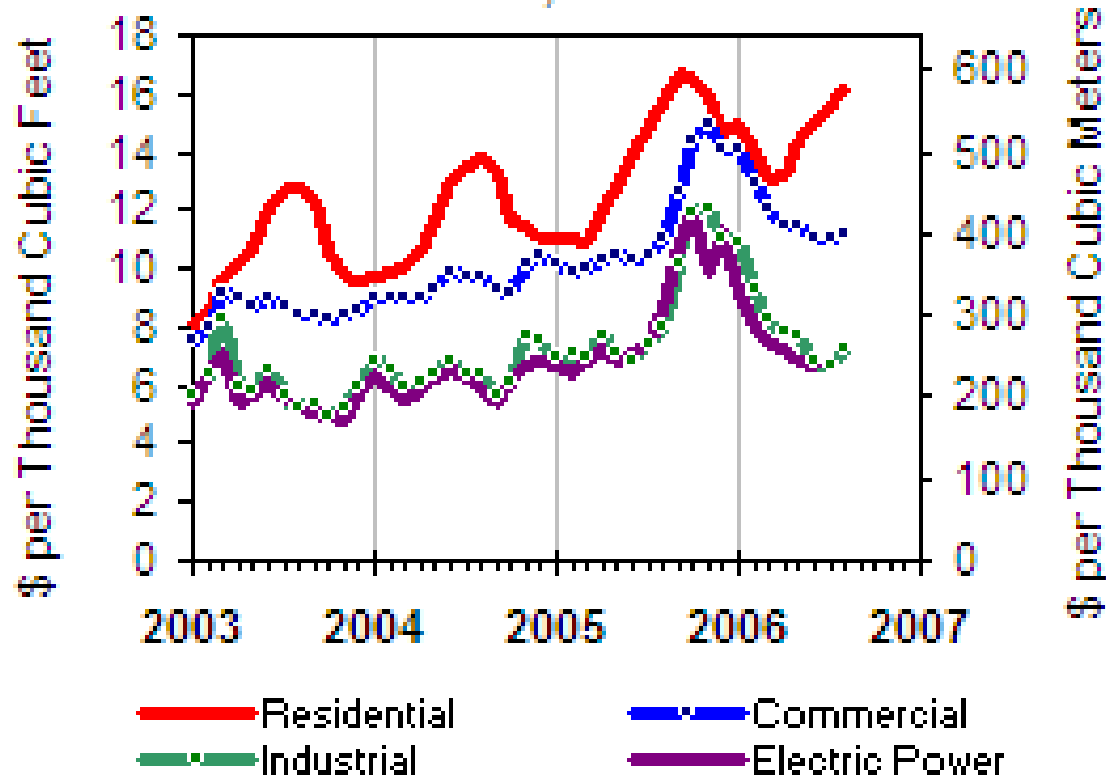
Realities of high fuel prices

- Natural Gas Costs as ¢/kW-hr*
 - 3.1 ¢/kW-hr at \$4 MMBtu
 - 4.6 ¢/kW-hr at \$6 MMBtu
 - 6.1 ¢/kW-hr at \$8 MMBtu
 - 7.7 ¢/kW-hr at \$10 MMBtu
 - 9.2 ¢/kW-hr at \$12 MMBtu

** Based on specifications for DFC 300 at 47% electrical conversion efficiency*

The problem isn't likely to change anytime soon.

Average Consumer Price of Natural Gas
in the U.S., 2003-2006





But, what if the fuel is Free?



Fuel Cells are Efficient for On-site Generation using Waste Methane

FuelCellEnergy 1-megawatt power plant



Waste is Power

- Fuel Cells are operating on:
 - Methane from landfills
 - Methane from sewage treatment plants
 - Methane from food-processing waste (onions)
- Other alternatives for consideration
 - Ethanol from corn, beets, or potatoes
 - Methane from digestion of agricultural wastes
 - Organic waste from production of biofuels
 - Fuel from wood chip gasification





R&D Challenges



- Identify economically viable waste streams
- Develop processing methods for maximizing fuel gas production from agricultural, forestry, and food processing wastes
- Reduce manufacturing costs
 - Current installed costs of \$6 million for the 1-megawatt power plant is too high
 - Projected costs for 2.4-megawatt power plant (DFC-3000™) is about \$8 million by 2008.

THANK YOU



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