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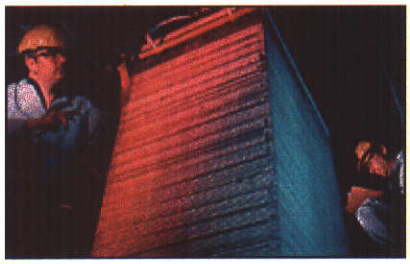
Future Fuel Cells R&D



"So we're creating the National Climate Change Technology Initiative...to fund demonstration projects for cutting-edge technologies, such as fuel cells."
President George W. Bush
June 11, 2001

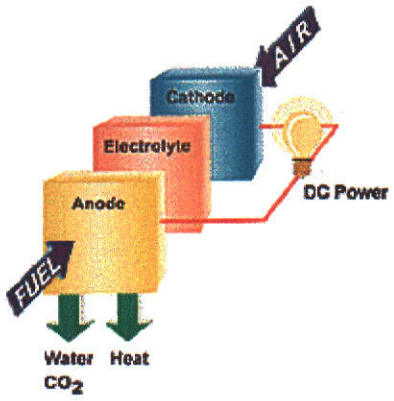
MORE INFO
- Phosphoric Acid Fuel Cells
- Molten Carbonate Fuel Cells
- Solid Oxide Fuel Cells
- Solid State Energy Conversion Alliance

Fuel cells are an energy user's dream: an efficient, combustion-less, virtually pollution-free power source, capable of being sited in downtown urban areas or in remote regions, that runs almost silently, and has few moving parts.

Using an electrochemical process discovered more than 150 years ago, fuel cells began supplying electric power for spacecraft in the 1960s. Today they are being used in more down-to-earth distributed generation applications: to provide on-site power (and waste heat in some cases) for military bases, banks, police stations, and office buildings from natural gas. In their most successful commercial applications, fuel cells convert the energy in waste gases from water treatment plants to electricity.

In the near future, fuel cells could be propelling automobiles and allowing homeowners to generate electricity in their basements or backyards.

Fuel cells operate much like a battery, using electrodes in an electrolyte to generate electricity. Unlike a battery, however, fuel cells never lose their charge. As long as there is a constant source of fuel – usually hydrogen produced from natural gas, and air as the source for oxygen – fuel cells will generate electricity.



DOE's Stationary Power Fuel Cell Program

The U.S. Department of Energy's Office of Fossil Energy is partnering with several fuel cell developers to develop the technology for the stationary power generation sector - that is, for power units that can be connected into the electricity grid primarily as distributed generation units. Industry participation is extensive, with more than 40 percent of the program funded by the private sector. If the joint government-industry fuel cell program is successful, the world's power industry will have a revolutionary new option for generating electricity with efficiencies, reliabilities, and environmental performance unmatched by conventional electricity generating approaches.

For most of the 1970s and early 1980s, the Federal program included development of the phosphoric acid fuel cell system, considered the "first generation" of modern-day fuel cell technologies. Largely because of the R&D support provided by the Federal program, United Technologies Corporation and its subsidiaries manufactured and sold phosphoric acid fuel cells around the world.

In the late 1980s, the department shifted its emphasis to development of advanced

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generations of higher temperature fuel cell technologies, specifically the molten carbonate and solid oxide fuel cell systems. Federal funding for these technologies have concluded. Private commercial manufacturing facilities have been built and commercial sales have been achieved.

While first generation fuel cells continue to spur interest in fuel cell technologies, the focus of the Department of Energy's Fossil Energy fuel cell program is to develop a much lower cost fuel cell. The target is $400 per kilowatt or less, which is significantly lower (by about a factor of ten) than current fuel cell products. It is expected that lower cost fuel cells will lead to widespread utilization (see below).

Fuel Cell Benefits

Fuel cells are the cleanest and most efficient technologies for generating electricity from fossil fuels. Since there is no combustion, fuel cells do not produce any of the pollutants commonly emitted by boilers and furnaces. For systems designed to consume hydrogen directly, the only products are electricity, water and heat.

When a fuel cell consumes natural gas or other hydrocarbons, it produces some carbon dioxide, though much less than burned fuel. Advanced fuel cells using natural gas, for example, could potentially reduce carbon dioxide emissions by 60% compared to a conventional coal plant and by 25% compared to modern natural gas plants. Moreover, the carbon dioxide is emitted in concentrated form which makes its capture and storage, or sequestration, much easier.

Fuel cells are so clean that, in the United States, 26 states have financial incentives to support their installation. In fact, the South Coast Air Quality Management District in southern California and regulatory authorities in both Massachusetts and Connecticut have exempted fuel cells from air quality permitting requirements. Some 16 states have portfolio standards or set asides for fuel cells. Additionally, there are major fuel cell programs in New York (NYSERDA), Connecticut (Connecticut Clean Energy Fund), Ohio (Ohio Development Department), and California (California Energy Commission). Certain states have favorable policies that improve the economics of fuel cell projects. For example, 39 states and the District of Columbia have net metering, and 19 of those have net metering for fuel cells which obligates utilities to deduct any excess power produced by fuel cells from the customer's bill.

Fuel cells are also inherently flexible. Like batteries in a flashlight, the cells can be stacked to produce voltage levels that match specific power needs; from a few watts for certain appliances to multiple megawatt power stations that can light a community.

Cost - the Major Hurdle

So why aren't fuel cells being installed everywhere there is a need for more power?

The primary reason is cost. Fuel cells developed for the space program in the 1960s and 1970s were extremely expensive ($600,000/kW) and impractical for terrestrial power applications. During the past three decades, significant efforts have been made to develop more practical and affordable designs for stationary power applications. But progress has been slow. Today, the most widely deployed fuel cells cost about $4,500 per kilowatt; by contrast, a diesel generator costs $800 to $1,500 per kilowatt, and a natural gas turbine can be even less.

Recent technological advances, however, have significantly improved the economic outlook for fuel cells.

The U.S. Department of Energy has launched a major initiative - the Solid State Energy Conversion Alliance (www.seca.doe.gov) - to bring about dramatic reductions in fuel cell costs. The goal is to cut costs to as low as $400 per kilowatt by the end of this decade, which would make fuel cells competitive for virtually every type of power application. The initiative signifies the Department's objective of developing a modular, all-solid-state fuel cell that could be mass-produced for different uses much the way electronic components are manufactured and sold today.

Advanced Fuel Cell Research

The High Temperature Electrochemistry Center (HiTEC) Advanced Research Program was created in 2002 to provide crosscutting, multidisciplinary research supporting FutureGen. HiTEC is centered at Pacific Northwest National Laboratory (PNNL) with satellite centers at Montana State University and the University of Florida. Research includes the development of low-loss electrodes for reversible solid oxide fuel cells, the development of high temperature membranes for hydrogen separation, and the study of fundamental electrochemical processes at interfaces. HiTEC is also pursuing the development of high temperature electrochemical power generation and storage technologies and advanced fuel feedstock. Financial assistance will be provided to organizations capable of performing basic, fundamental and applied research to advance scientific understanding and devise concepts that apply new scientific insights toward advancement of novel electrochemical based power generation and energy storage technologies for use at large coal power plants.

Fuel Cells for Near Zero Emissions Coal-Based Systems

The SECA Program is currently focused on small, 3-10 kW scale fuel cell systems for distributed generation applications. These relatively small fuel cells can be scaled up to larger megawatt class systems for use as power modules in coal based applications, including FutureGen. Large fuel cell systems will then be combined with other power generation modules (e.g., a gas turbine as a fuel cell-turbine hybrid), into hybrid power systems.

Beginning in FY 2005, new work will focus on building larger cells that will be combined into stacks and the stacks will be combined into fuel cell modules that can be used as building blocks for multi-megawatt class power systems. The ultimate goal of this new initiative is the development of large (> 100 MWe) fuel cell power systems that will produce affordable, efficient and environmentally-friendly electrical power at greater than fifty percent (50% HHV) overall efficiency from coal to AC power, in systems that include CO2 separation for sequestration.

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