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FUEL CELLS

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The Environmental and Energy Study Institute hosted two Congressional briefings to discuss the potential of fuel cell technologies in today's market as well as future energy markets. The U.S. Department of Energy, with the support of Sen. Murkowski (R-AK), Sen. Bingaman (D-NM), and Rep. Regula (R-OH), co-sponsored the first briefing to look at the opportunities and challenges facing the fuel cell industry. Global Legislators Organization for a Balanced Environment USA (GLOBE USA), along with GLOBE USA Members Reps. Nancy Johnson (R-CT) and Mark Udall (D-CO) and Sen. Jim Jeffords (I-VT), co-sponsored the second briefing to discuss hydrogen and fuel cell technology as a part of the solution to the energy crisis.

The United States is faced with many energy challenges, ranging from regional power supply crises and sharply escalating energy prices to oil extraction. According to the *Wall Street Journal*, Americans are more concerned about energy now than they have been for decades. The time is ripe for renewable and sustainable energy technologies to play a much larger role in our energy future, and one of the key elements of this new energy economy is hydrogen and fuel cells. Fuel cells are electrochemical engines that convert the energy of a fuel directly into electricity. This simple process involves no combustion, and thus no pollution. The by-products are water and heat.

BENEFITS OF FUEL CELLS

Dan Reicher, assistant secretary (2000) of the Energy Efficiency and Renewable Energy Office at the Department of Energy (DOE), stated that alternative power sources are the future, and fuel cells offer a "gold medal technology with a variety of applications." He emphasized that fuel cells "can revolutionize transportation as it exists today by increasing fuel economy by a factor of two or more" compared to a conventional gasoline-powered internal-combustion engine. This is important since petroleum fuels 97 percent of the transportation sector and shows no signs of decreasing as population continues to increase in the United States. DOE expects to see a number of new technologies over the next 20 years, but they believe fuel cell technology has the potential to take the lead.

One reason fuel cells have been brought to the alternative energy forefront is their ability to conform to different applications and provide multiple benefits including energy security, reduced air

PANELISTS

Panel I: Opportunities and Challenges, September 2000

Dan Reicher
Assistant Secretary, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy

John Wallace
Executive Director, TH!NK Group, Ford Motor Company; Chairman, California Fuel Cell Partnership

Steve Chalk
Energy Conversion Team Leader, Office of Transportation Technologies, U.S. Department of Energy

Bill Miller
President, International Fuel Cells

Rita Bajura
Director, National Energy Technology Laboratory

Dr. Alan Lloyd
Chairman, California Air Resources Board

George Rudins
Deputy Assistant Secretary, Office of Fossil Energy, U.S. Department of Energy

Panel II: Energy for the Future, March 2001

Representative Mark Udall (D-CO)
Co-chair, House Energy Efficiency and Renewable Energy Caucus

William Parks
Associate Deputy Assistant Secretary, Office of Power Technologies, U.S. Department of Energy

Robert Rose
Executive Director, Breakthrough Technologies Institute and the U.S. Fuel Cell Council

Bill Miller
President, International Fuel Cells

pollution and economic growth. Fuel cells provide energy security benefits by reducing our dependence on imported oil, thereby reducing the trade deficit and increasing economic, political and military security. Fuel cells also reduce air pollution since they produce near zero emissions, whereas much air and water pollution comes from the combustion of fossil fuels. By reducing carbon dioxide (CO2) emissions, fuel cells can be a significant technology in climate change mitigation. These emission reductions also help to improve public health and reduce the risk of lung disease, asthma and other respiratory ailments. Fuel cells offer economic benefits including increased international competitiveness, reduced expenditures on fuel, uninterrupted and high quality power, and the generation of jobs through growth in this new industry.

In addition to the benefits mentioned above, fuel cells have specific functional advantages over conventional fossil fuel energy sources. Fuel cells have the ability to use a variety of fuels to power their system including natural gas and alcohols, such as ethanol and methanol. They are a very reliable source of power with no spikes or surges. Fuel cells are versatile and can be used in multiple applications such as transportation (automobiles and buses), buildings, distributed power, military, and portable and premium power (laptops, video cameras and cell phones). They are compact, modular systems allowing them to be installed almost anywhere, and have few rotating parts making them extremely quiet.

EXAMPLES OF FUEL CELL APPLICATIONS

According to **Bob Rose, executive director of Breakthrough Technologies Institute and the U.S. Fuel Cell Council,** several fuel cell technologies are being developed for the commercial power market, with fuel cell systems ranging from 200 kilowatt (kW) to 2-4 megawatts (MW). Hundreds of fuel cell power units are already operating in the United States, European Union and Japan. The current cost for commercial fuel cell systems is between $3,000 and $4,500 per kilowatt. Costs are expected to drop to $800 to $1,200 per kilowatt.

Bill Miller, president of International Fuel Cells (IFC), discussed some of the examples of fuel cell applications that IFC has implemented. The first installation of fuel cells, developed by IFC, was by the U.S. space program in the 1960's powering the Apollo, Apollo-Soyuz and Skylab programs. The cost of these fuel cells was $600,000/kW. Today, a PC-25 fuel cell costs about $4,500/kW and they have become an important source of reliable energy for many institutions. The Condé Nast building in New York's Times Square uses two PC-25 fuel cells providing 400kW, five percent of the building's power while using the heat from the operation of the fuel cells for the building's perimeter heating.

Other institutions utilize fuel cells for power assurance. The First National Bank of Omaha, a credit card processing company, must have power at all times to service retailers across the country. If their power went down, it would cost their retailers $6 million in revenue in an hour. First National installed four fuel cells to serve as their primary source of energy while the heat from the fuel cells is used for space heating. South County Hospital, in Wakefield, Rhode Island, installed a PC-25 power plant system on site to assure the constant operation of their emergency medical equipment.

OPPORTUNITIES AND CHALLENGES

Even though fuel cells have great benefits and multiple applications, there remain significant barriers to their widespread commercialization. **John Wallace, executive director of Ford Motor Company's TH!NK Group and chairman of the California Fuel Cell Partnership,** identified costs, fuel storage and fuel supply infrastructure as the main challenges for the fuel cell industry. Fuel cell units can operate using a variety of fuels that are converted into hydrogen power to operate the fuel cell unit. The fuel cell processors used for this conversion are very expensive and bulky. Also, when fossil fuels are used, pollutants result from the conversion process. Fuel cells powered solely by hydrogen do not require a special fuel processor and produce near zero emissions, however hydrogen is a very diffuse energy source, and it is difficult to store enough during one refueling to provide consumers with the kind of range they are used to in their current vehicles.

Addressing fuel supply infrastructure is instrumental in bringing fuel cell vehicles to consumers. Gasoline is the only fuel source with a major infrastructure. Ultimately, maintains Miller of IFC, the vision is to produce hydrogen for diverse fuel cell applications through the use of renewable energy such as hydroelectric, solar and wind power. Lack of a mature, national hydrogen infrastructure requires today's fuel cells to derive hydrogen from hydrogen-rich fuel sources, such as natural gas. According to Miller, since transit buses return to a central location each day, they are viewed as a near term opportunity to create the hydrogen infrastructure (production, distribution and storage capability) that will be required to make hydrogen available and affordable for future cars, homes and businesses.

Wallace acknowledged other barriers that relate to the "functional requirements" of a fuel cell, which are necessary to compete with internal-combustion engine vehicles and meet consumer satisfaction. These requirements include: near ambient operating temperature, high power density, compatibility with processed fuel and air, quick start-up, rapid response to frequent load changes, hydrogen storage, resistance to shock and vibration, and relatively easy control and maintenance of equipment.

Wallace described Ford Motor Company's dedication to resolving these issues and said Ford has made a strong commitment to research and development through large investments in Ecostar Electric Drive and Dbb Fuel Cell Engines. Ford Motor Company also partnered with the California Fuel Cell Partnership (CAFCP). The CAFCP was formed in 1999 and includes auto manufacturers, energy providers, fuel cell companies, hydrogen gas suppliers, hydrogen fueling station developers, bus transit companies, and the government. The environmental community also plays an active role in this initiative. The CAFCP's plan is to place about 70 fuel cell passenger cars and fuel cell buses on the road between 2000 and 2003. In addition to testing the fuel cell vehicles, the CAFCP will also identify fuel infrastructure issues and prepare the California market for this new technology.

In order to move fuel cell technology forward, greater demand is needed. Miller discussed the importance of the federal government in taking the lead

role in helping to commercialize the technology and providing the needed volume. The U.S. government is the single largest user of energy in the world, and uses 30 percent of U.S. commercial building energy consumption. Miller believes that the government needs to devise a life-cycle cost model that will take into account the best, clean reliable energy that can be provided to government buildings across the country. "It just seems surprising to me that if we have fuel cells powering buildings in Tokyo, Japan; Anchorage, Alaska; Houston, Texas; New York City; Hamburg, Germany; and around the world, we should have fuel cells in buildings in Washington DC, the head of our country, as soon as possible."

In addition, Miller stated that the U.S. government can help make commercially available hydrogen fuel cells a reality by:

- Approving financial incentives, such as a fuel cell tax credit and a buydown grant program for the U.S. Department of Defense (DOD) and DOE to accelerate commercialization.
- Funding a zero emission hydrogen bus demonstration program.
- Reauthorizing the Hydrogen Future Act that will provide funding for government fuel cell purchases, as well as R&D for production, distribution and storage of hydrogen.

Another area of contention regarding fuel cell commercialization involves what Miller described as the "Catch 22" of utility deregulation. In some states, deregulation has been implemented and the utility sector has been split into generation, transmission and distribution entities. The power generators focus on operating large power plants that are centrally located and produce electricity at the lowest possible cost to maximize their profits. However, if all the power is in centralized stations and the grid has a problem, the entire system is affected. Fuel cells could help alleviate this problem since they provide reliable power with no spikes or surges. But power generators generally are not interested in fuel cell technology because it is distributed generation that will cost them somewhat more than conventional fuels and they do not want to worry about the cost of distribution.

Many customers in these deregulated markets would like to have reliable power through distributed generation. The "Catch 22" is that many deregulation programs make it difficult for customers to own distributed power generating assets like fuel cells. In those states where customers can purchase distributed power, they often have to pay a high exit fee to the local utility to leave the grid. Such situations slow down the deployment of fuel cells around the country. According to Miller, the federal government can help improve the situation by getting involved in deregulation, encouraging the incorporation of distributed technologies like fuel cells in deregulation legislation, and requiring the removal of exit fees. Federal implementation of tax credits for homeowners and businesses that install fuel cells is another important component to build volume in this industry and drive the cost down.

GOVERNMENT PROGRAMS & ACTIVITIES

Federal Government

Steven Chalk, Energy Conversion team leader from the U.S. Department of Energy, explained that the DOE Hydrogen program is trying to address issues regarding hydrogen storage, infrastructure, as well as the size and weight of the fuel cell systems. Progress has been made in reducing the cost of these systems through reductions in the amount of platinum used in the fuel cell unit and mass production of the electrodes used as the hydrogen catalysts. The system cost has been decreasing, but it may be a major challenge to reach their goal of $50/kW by 2004. DOE will continue to focus on research and development to improve the manufacturing process, fuel processors, auxiliary components, etc.

Rita Bajura, director of the National Energy Technology Laboratory, discussed how her lab has implemented much of the Department of Defense's (DOD) Climate Change Program by providing grants to potential fuel cell buyers, covering one-third of the buyer's cost. The program has cost-shared in the installation of more than two hundred 200kW fuel cell units worldwide. One example is the Anchorage Mail Processing Center of the U.S. Postal Service. The Anchorage Mail Processing Center experienced major problems every time there was a disruption with the grid. Their mail sorting machines would clog up with mail and shut down when there was a blackout. It would take them about eight hours to pull all the mail out of the machines. To resolve these problems, they worked with the local utility and received funding from DOD to install five 200 kW units, which produce one megawatt of electricity and are the primary source of power. This is the largest commercial fuel cell system in the United States and the first system to be part of an electric utility's grid.

In 1995, DOE started to fund proton exchange membrane (PEM) fuel cells, primarily for transportation applications. Over the past three years, DOE has spent around $2-3 million per year on PEM research and development for residential building applications and to resolve issues regarding their acceptance. Through the DOD Climate Change Program, they have provided almost $1 million in funding for 139 PEM fuel cell units to be installed in various single and multi-family dwellings.

Since 1977, DOE has invested about $400 million developing molten carbonate fuel cell (MCFC) systems, which can operate at about 50-60 percent electrical efficiency. This year, DOE chose to fund an MCFC developer, Fuel Cell Energy, in excess of $10 million per year. Fuel Cell Energy has operated a grid-connected 250 kW unit for almost 12,000 hours without repairs to the fuel cell stack. This is the longest operating MCFC unit in the world in its size range. Bajura also mentioned that there are cost-shared demonstrations planned with a 250 kW unit near the Los Angeles airport; a 500 kW unit in Carderock, Pennsylvania; a unit at the Daimler-Benz SUV-manufacturing plant in Alabama; and a unit in King's County, Washington, that will run on digester gas (methane produced when bacteria digest biomass).

Since 1977, DOE has invested more than $210 million to develop solid oxide fuel cells (SOFC). Currently, they are funding Siemens-Westinghouse, the leader in SOFC, in excess of $10 million per year. A two-cell system has successfully operated more than 70,000 hours (about nine years) with virtually no degradation. This kind of reliability means lower operating and maintenance costs. There have been a large number of successful cost-shared demonstrations, and eight additional ones are planned.

In order for MCFC and SOFC units to be

economically viable in the mass market, deep cost reductions are needed. Improvements are needed in both technology and manufacturing. One way to obtain deep cost reductions is through "mass customization," mass-producing common modules for a variety of applications. Mass customization is the goal of a new national program called the Solid State Energy Conversion Alliance (SECA). This alliance includes industrial teams, research and development organizations, universities, and government agencies to develop solid-state, high power-density fuel cells with a core module of 5-10kW. Fuel cells built from core modules will have wide market applicability – from military, to transportation, to stationary power generation applications. The prototype has a target cost of $800/kW and is expected to be ready by 2005, and by 2010, the cost is projected to be $400/kW, which should bring wide market acceptance. Bajura emphasized that "investing in research now will help develop the mature fuel cell market of the future."

California's Alternative Fuel Vehicle Mandates

Dr. Alan Lloyd, Chairman of the California Air Resources Board (CARB), discussed the evolution of California's air emissions plan for the transportation sector. CARB was primarily driven by the health concerns attributable to poor air quality. More than 95 percent of Californians live in areas that do not meet health-based federal or state air quality standards. Approximately 50 percent of smog-forming pollutants come from gasoline and diesel-powered vehicles. The University of Southern California completed a 10-year study on the long-term effects of smog on children, which showed how common air pollutants slow children's lung development over time. Based on these facts, CARB wanted to implement a policy that would maintain a robust economy, address health and environmental concerns, diversify the energy mix and provide clean, reliable, efficient power.

In 1998, CARB amended their Zero Emissions Vehicles (ZEV) mandate, which required 10 percent of the new cars for sale in California in 2003 and beyond to be ZEVs. They allowed major automakers to satisfy up to six percent of the ZEV requirement with automobiles that are not pure zero emission vehicles, but clean enough to qualify for partial ZEV credits. Vehicles that qualify for partial ZEV credits include specific gasoline-powered vehicles rated by CARB as super-ultra-low-emission vehicles (SULEVs). Fuel cell vehicles and some hybrid vehicles qualify for partial ZEV credits.

SUMMARY

As many of the panelists mentioned, fuel cell technology is an important part of our future power system providing multiple benefits in a wide variety of applications for both stationary and mobile sources. Fuel cells can respond to our increasing energy demands while contributing to electric reliability, pollution prevention and greenhouse gas reductions, and reducing our dependence on foreign oil. This industry could obtain billions of dollars in sales and generate hundreds of thousands of U.S. jobs. We can achieve this success by positioning the U.S. fuel industry to export this technology in rapidly growing world energy markets. Increasing global demand for power generation technology could create a $1 trillion market by 2020. Fuel cells provide an excellent opportunity abroad with the growing number of individuals in remote locations with no distribution lines, or in roaming areas where the current system is too overloaded to allow additional connection. But, we must act now, cautioned Reicher. There is a "worldwide race to build fuel cells" with Japan, the European Union countries and Canada actively involved. It is estimated that the Japanese are spending twice as much as DOE on fuel cell research and development.

The speakers emphasized that this industry could revolutionize the marketplace if it is properly developed and deployed. Government and industry must continue working together to overcome the remaining barriers and establish the United States as a leading supplier of fuel cell technologies.

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