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**HEARING ON THE USE OF HYDROGEN FUEL CELL
TECHNOLOGY IN THE NATIONAL PARK SERVICE**

***TESTIMONY BEFORE THE SUBCOMMITTEE ON NATIONAL PARKS,
RECREATION AND PUBLIC LANDS
UNITED STATES HOUSE OF REPRESENTATIVES
MAY 15, 2004***

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by

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MAY 15TH, 2004

Mr. Chairman and Members of the Committee, thank you for the opportunity to provide testimony on hydrogen and hydrogen fuel cell vehicle technologies and the opportunities and challenges for using these technologies in our national parks.

I am a research director for the Institute of Transportation Studies at the University of California, Davis (ITS-Davis). I manage our Institute's Hydrogen Pathways Research Program. Previous to this position, I was a program manager for Ford Motor Company, working on the hydrogen fuel cell vehicle and infrastructure demonstration program along with the California Fuel Cell Partnership in West Sacramento, California. In December of 2002, ITS-Davis established the Hydrogen Pathways Research Program to address the very issues before your committee here today – to develop an understanding of the key technological, economic and market challenges associated with bringing hydrogen and hydrogen vehicle technologies to the market. This program receives financial support from nearly every – 17 in total – major energy and automotive company in the world as well as from the US Departments of Energy and Transportation. Additionally, we are actively participating in many of the recent federal and state initiatives surrounding hydrogen and fuel cell vehicle research, development, demonstration and public education. These initiatives include the US Department of Energy's *Hydrogen Fuel Cell and Infrastructure Technology* research program and *Controlled Hydrogen Fleet and Infrastructure Demonstration*, and the California Hydrogen Highway initiative announced by California Governor Arnold Schwarzenegger at our UC Davis hydrogen station just a few weeks ago. UC Davis is one of the world's leading university research centers for the study of advanced environmental vehicles and fuels including hybrids, fuel cells and hydrogen. Our university has a distinguished record of over 20 years of valuable research in these areas. We are happy to provide testimony on this very important subject.

I will emphasize the following key points in my testimony:

1. National Parks as Demonstration Sites. Our national parks are highly visible to visitors from around the country and around the world. As such, they offer a great opportunity to

demonstrate a strong public commitment to new types of clean and efficient energy technologies such as renewable power, hydrogen and fuel cells. Further, the greatest value of high visibility demonstration projects may be to educate park visitors about the benefits and challenges associated with the technology and about the connections between the parks and the larger world in which they exist. Specifically, hydrogen and fuel cell vehicle demonstrations in National Parks may be valuable in educating visitors how their support for such initiatives outside the parks may help to protect America's great natural and historic places.

2. Park Demonstrations Must Provide Real Benefits. We must make sure that hydrogen and fuel cell deployment projects in our National Parks add value with respect to key environmental, technology development and educational goals. Our parks offer up a unique set of challenges and opportunities when it comes to implementing and demonstrating hydrogen and fuel cell technologies. Availability, pricing, and logistics of hydrogen energy feedstocks, together with unique power requirements, must be considered in the design of projects.
3. Design Demonstrations to Guide the Future. Hydrogen fuel cell vehicles and the associated hydrogen infrastructure technologies are currently entering into a 'demonstration' phase of development. Technology demonstrations provide important feedback for the research and development of the participating organizations. But such demonstrations also are characterized by low volume, high cost, rapid learning and the associated potential for rapid obsolescence. The Government can play a significant and helpful role in this phase by providing funding, acting as an early and technically proficient 'customer', and participating in education and outreach activities surrounding the new technology.
4. Key Considerations for National Park Demonstrations. Depending on the characteristics of any given park, the National Park Service might consider deploying hydrogen and fuel cells for the following applications:
 - a. Hydrogen fuel cell fleet vehicles for applications where clean, quiet operations are highly valued and the vehicles can be used for a public education and outreach campaign;
 - b. Stationary power and/or 'Energy stations' for the joint production of electric power (either back-up or continuous) for buildings and fuel for vehicles when the application provides real environmental benefits;
 - c. Fuel cells for off-road vehicle applications.
5. Education and Research Essential for National Park Demonstrations. The heart of any hydrogen and fuel cell projects in the National Parks Service must be education and research. The nation's universities, with their growing expertise in the area of clean energy technologies, and their knowledgeable and objective researchers and students, will make a key partner in this effort. The committee should consider increasing support for the joint Department of Interior and Department of Energy's successful University National Park Energy Partnership Project and the National Park Transportation Scholars Program which has the dual advantage of educating our future engineers and scientists while demonstrating

efficient clean energy technology within our parks. I have included expanded descriptions of these two projects in my written testimony.

Why fuel cells and hydrogen?

Industry, academia, and governments from around the world are showing rapidly growing interest in hydrogen and fuel cell technology. President Bush highlighted the technology in his 2003 State of the Union address, California Governor Schwarzenegger included it in his environmental platform and in a recent Executive Order signed at UC Davis. Why? Because hydrogen and fuel cells have the long-term potential for hydrogen and fuel cells to address some of society's most vexing energy problems including air and water pollution, global warming, and dependency on foreign sources of energy.

There are many types of fuel cells and fuel cell systems for a wide variety of applications, all with different technological readiness, cost, and performance attributes. I will focus my comments today on fuel cells and related infrastructure for transportation applications. In as much as these same types of fuel cells and infrastructure technologies can be used for stationary applications, I will briefly touch on this in my testimony and am happy to answer questions.

The future of fuel cells and hydrogen for transportation is directly linked to the automotive industry's embrace of the technology. The industry, or at least a significant part of it, sees fuel cells as an inevitable and desired future. Fuel cells provide the opportunity to reduce transportation's environmental impact by eliminating criteria pollutants and greenhouse gas emissions from the tailpipe for the life of the vehicle. In addition, hydrogen fuel cell vehicles may provide extra value to customers. This has not been true of any other non-petroleum vehicle technology. Fuel cell vehicles are quiet, quick to refuel, have smooth, rapid acceleration and potentially lower maintenance requirements. Their electric drive and by-wire systems allow for radically different vehicle designs and give automakers the opportunity to reduce the number of vehicle platforms they must produce to meet the diversity of vehicle needs that today's automotive consumer demands. Fuel cells are a logical extension of the technological pathway automakers are already following with hybrid vehicles. And if fuel cell costs become competitive and if hydrogen fuel can be made widely available at a reasonable cost, two very big "ifs," fuel cells vehicles could become superior consumer products.

However, we still have a ways to go before fuel cell vehicles can offer these value-added amenities at an affordable cost, and with sufficient reliability. Substantial research and development will be needed to reduce fuel cell stack and system materials costs, increase durability in all weather conditions, and improve hydrogen storage technology before fuel cell vehicle become commercially viable. And while automakers are making rapid and substantial progress on these challenges, even the most optimistic say that the decision about whether to move into high-volume series production will not occur until 2010 at the earliest. This commercial reality, coupled with the temporal realities of vehicle product development and market adoption, suggests that hydrogen fuel cell vehicles will not likely begin to gain significant market share until 2015 or later. A recent report by the National Academies (2004) concurs, citing 2015 as the beginning of significant market penetration of hydrogen vehicles in its optimistic scenario.

Such a timescale is not to suggest that real actions cannot be taken today. In fact, if hydrogen and fuel cells are ever to be successful we must take action now in the key areas of research, development and demonstration. There are also some key early markets that could be exploited to accelerate the adoption of hydrogen and fuel cells into the transportation market.

State of fuel cells and fuel cell vehicle technology

A fuel cell is an electrochemical device that converts the chemical energy of a fuel, such as hydrogen, along with oxygen from air, directly into electrical energy. Fuel cells have existed for over 150 years, but it is only in the last ten years that substantial attention and effort has been expended to develop this technology for automotive applications.

The progress made in the development of fuel cell technology for automobiles has been remarkable. Costs have come down by a factor of ten or more, and manufacturers are coming closer to their targets of reliability, all-weather performance, weight, and packaging with every new generation of technology.

This progress is very encouraging. But for fuel cells to be successful in the commercial vehicle market, the following must occur:

1. Costs will need to continue to come down by almost another factor of ten;
2. Reliability should be increased by a factor of four;
3. Hydrogen storage will have to be improved substantially to provide adequate vehicle range at reasonable cost.

Despite these remaining challenges, applications exist where fuel cells are currently attractive, at least for demonstration purposes. These applications are generally where quiet, zero emissions operation is highly valued and/or the opportunity exists to make the project highly visible for the purpose of education and outreach. The following is a list of some (but not all) of the potential applications in national parks.

1. **Fuel cell fleet vehicles**
Fuel cell fleet vehicles such as light-duty cars and trucks as well as buses will become increasingly available for demonstration purposes over the next five years. Demonstration vehicles offer the opportunity to provide experience with the technology to park staff, and when used in a public application (i.e. park buses), can be part of a highly visible educational campaign.
2. **Fuel cells for backup and remote power**
Fuel cells are currently providing backup power for cell phone towers and some office buildings – to protect against outages. Fuel cells could also provide power in remote applications that are off the grid (but with a readily available hydrogen supply). These stationary applications could also be upgraded to ‘energy stations’ that are capable of producing and delivering hydrogen for vehicles.
3. **Fuel cells for non-automobile transport applications**
In locations where quiet, zero-emission motorized transport is very important, such as indoor material handling or in sensitive wilderness environments, fuel cell vehicles can offer significant value. Current demonstrations include hydrogen fuel cells for forklifts, small off-road vehicles (e.g. E-Gator by John Deere), and marine applications.

Hydrogen Production

While hydrogen is the most abundant element in the universe it does not exist readily in its elemental form on earth. It must be either reformed from a hydrocarbon such as natural gas, petroleum, or coal, or produced from electrolysis using electricity and water. In fact, one cannot talk about hydrogen fuel cell vehicles without addressing the question “where does the hydrogen come from?” The method by which hydrogen is produced can have substantial implications on its cost and on the amount of smog-forming and greenhouse gas emissions released into the surrounding atmosphere.

Hydrogen produced from hydrocarbons, like natural gas, can provide significant emissions and greenhouse gas benefits, especially if the carbon dioxide is captured and stored. Hydrogen produced from renewable fuels like wind and solar power may have even greater environmental benefits. While some production technologies are competitive today, substantial research is still needed to reduce the capital and operating cost of most renewable and electrolyzer technologies, and to manage their penetration into the electric power generation market. In fact, it is very likely that the production of hydrogen fuel and the production of electricity will continue to become increasingly intertwined. For the purposes of deciding an optimal hydrogen production pathway the choice will be highly influenced by the geographic location, cost of the local feedstock and characteristic of the hydrogen demand (e.g. size, distribution, growth rate).

Demonstrations

Virtually every major automotive manufacturer, energy company, and fuel cell component supplier will be participating in major demonstration projects over the next several years. Demonstration projects are characterized by very low volume, high cost and limited deployment of technology into “protected” real-world applications. Demonstrations provide real-world systems engineering experience, feedback into research and development programs, and public exposure and education. Public sector financing of technology demonstrations provides valuable signals to industry that the technology itself, as well as the goals the technology is designed to achieve, have strong public support. Public financing also helps justify internal private programmatic funding for future programs.

On the other hand, demonstrations can pose substantial challenges. In demonstrations, much of the technology is often immature, making it subject to reliability problems, high construction, operation, and maintenance costs, and rapid obsolescence.

The following are criteria for good public/private demonstrations and some of the potential benefits and challenges of demonstrating hydrogen and fuel cell technology within the National Park Service.

Criteria for good public/private demonstrations

- Consistent with future market potential of the technology.
- Maximize education and exposure to the general public of public policy goals and technology tools to achieve those goals.

- Evaluate demonstrations (economic, technical, environmental) and maximize learning and knowledge transfer from the evaluations through public reports/publications, technical workshops for other demonstration leaders, conferences, etc.
- Provide for institutional learning by non-hydrogen entities (permitting agencies, government officials, etc.). Facilitate learning for codes and standards development, dissemination, and adoption.
- Ensure interoperability between vehicles and stations.

Benefits of Demonstrating Hydrogen and Fuel Cell Technology with the National Park Service

- Due to their high visibility to visitors from around the country and around the world, our National Parks offer a great opportunity to demonstrate a strong commitment to new types of clean and efficient energy technology such as renewable power and fuel cells. High visibility demonstration projects also offer the opportunity to educate visitors about the benefits and challenges associated with the technology.
- The National Parks management structure, purchasing process, and highly-trained and educated workforce make technology demonstrations attractive.
- Current use in some parks of older diesel generators for back-up power offers an opportunity to replace such units with fuel cells that have substantially lower pollutant emissions.
- Parks near a viable hydrogen supply (such as the Presidio in San Francisco) offer greater opportunities for near-term demonstration of H₂ and FCV transportation applications than park units more remote from such supply (i.e. Yosemite).

Challenges of Demonstrating Hydrogen and Fuel Cell Technology with the NPS

- Due to the lack of natural gas pipelines into many parks, the availability of an inexpensive hydrogen feedstock could make hydrogen powered fuel cells for base load (continuous) power supply challenging.
- Due to strict controls on new construction, siting and permitting, developing hydrogen infrastructure within some parks could offer a challenging learning opportunity.

Education, Research, and the Role of Universities

The heart of any near-term National Parks hydrogen and fuel cell initiative must be education and research. While hydrogen and fuel cells are compelling, much is still uncertain and unknown. The best method of producing, distributing and using hydrogen is still uncertain, and will be based on the unique characteristics of the project location. Most importantly, the most promising means of producing, distributing, and using hydrogen in fuel cells still require major improvements that can only be obtained with additional research. Major advances are needed to develop renewable resources, store hydrogen efficiently, and develop reliable cost-competitive fuel cells.

Education and outreach to park visitors is another benefit from high visibility demonstrations. Many public policy issues and problems that affect the parks have their root causes outside the parks. Whether or not hydrogen and fuel cell vehicles provide long-term solutions to energy, environmental, and transport problems in the parks will depend in large measure on whether these technologies effectively address these same problems outside the parks. Education and outreach around hydrogen and fuel cell vehicle demonstration in the National Parks can connect

people's everyday choices as consumers and citizens to decisions they make that effect America's treasured parks.

The principal role and value of government-funded research is to:

- Conduct exploratory and basic research;
- Build a public knowledge base for policy-makers to make informed decisions;
- Educate and train the next generation of engineers, scientists, and policy makers;
- Support public education;
- Incubate new industries.

To maximize the value of demonstration projects within the national parks, these projects should contain a research component. Additionally, the National Parks Service should draw upon the resources of our nations' universities. Our universities contain a large number of highly motivated students and researchers interested in 'real world' projects. They are also the training ground for the next generation of engineers, scientists, business leaders and policy makers. There are several current collaborations between the parks service and universities that I would like to highlight.

University National Park Energy Partnership Project

(<http://www.energypartnerships.org/pandp02.htm>)

With funding from the University National Park Energy Partnership Program (UNPEPP) James Madison University and Shenandoah National Park are collaborating on the design, development, testing and installation of fuel cell systems for remote power, auxiliary power and emergency power applications. UNPEPP is part of the Green Energy Parks Program, a joint initiative between the Department of Interior and the Department of Energy. UNPEPP links universities and national parks across the United States to explore and develop energy-related projects in the parks, strengthening the tradition of stewardship at the National Park Service. These partnerships cut energy costs, implement renewable energy systems and educate the public about energy use and conservation while offering significant opportunities for students to learn about energy systems in unique and interesting natural environments.

FFY2003 UNPEPP Projects

1. Redwood and Humboldt State University

Title: Solar Hot Water Installation.

Participants will install solar hot water heating in Redwood Information Center (RIC), which serves as the main visitor center within the Park. This is a 3800-square-foot building located among sand dunes just a few hundred feet from the ocean. The facility currently includes public and staff restrooms served with hot water heated by an electric water heater. The hot water system functions poorly and is expensive to operate. A solar water heating system will be added to the building to supplement or replace the existing system.

2. James Madison University and the National Park Service

Title: Alternative Fuel Vehicles for NPS Activities.

This partnership involves research, development, and demonstration of alternative fuel vehicles that would be useful for park personnel. One of several projects being investigated includes work to produce a quiet, efficient vehicle for park use that operates in all climates on waste vegetable oil and

has less harmful exhaust products than either internal combustion or regular diesel engines. JMU will be working with Shenandoah National Park to determine whether waste vegetable oil from food services can be used to power equipment at the park. In addition, this project will conduct a feasibility and design study to examine the costs and benefits of developing a fuel cell powered back-up system for the air quality monitoring station at SHEN. In addition to monetary costs, JMU will assess energy, emissions and maintenance issues related to fuel cell use.

3. Yellowstone National Park and South Dakota State University

Title: Assessing the Potential for a PV Power System at the North Entrance Station, Yellowstone.

This project is focused on designing a PV system for the North Entrance of YNP. To design this system, the project will conduct data collection activities on energy loads and solar power availability using a sophisticated instrumentation package, which includes data logging capabilities. This is an addendum to the existing project and will allow full implementation of the panels at the park.

4. Hawaii Volcanoes NP and University of Washington

Title: Evaluating Energy Efficiency Options for Hawaii Volcanoes.

Participants will conduct an energy load assessment and design and develop several renewable energy and energy efficiency projects for Hawaii Volcanoes National Park. This project is strongly supported by the NPS regional personnel.

5. Independence National Historic Park and University of Pennsylvania

Title: Saving Measures at Independence National Historic Park.

This project will identify and implement energy saving measures at Independence National Historic Park. The project will include an energy audit and analysis to identify conservation measures that satisfy thermal comfort and lighting criteria, and the design of a PV system to be visibly integrated on the park visitor center.

6. North Carolina Solar Center/NC State University and Wright Brothers National Memorial

Title: Public Education Campaign for Solar Power

This project involves development of kiosk designed to educate visitors about solar power and renewable energy. This educational project is linked to several solar power and wind power projects in development at the Memorial

National Park Transportation Scholars Program

The National Park Transportation Scholars Program pairs transportation professionals and graduate students with National Parks seeking expert assistance on projects involving transportation planning, analysis, coordination with local communities, environmental and traffic studies, and other transportation-related tasks. The program placed 8 scholars last year. The program could easily be expanded to emphasize fuel cell and hydrogen studies in several parks. The National Park Transportation Scholars Program is made possible through the generous support of the Ford Motor Company, a Proud Partner of America's National Parks. The program is managed as a partnership between Ford, the National Park Foundation, the National Park Service, and the Eno Transportation Foundation. UC Davis has one transportation Scholar this year and one for the upcoming year. <http://www.enotrans.com/News/2004NPTSbrochure.pdf>

Background on How UC Davis Is Contributing to the National Effort to Develop Hydrogen and Fuel Cell Technologies

I want to share with you the ways that UC Davis is making a difference in developing the technology, infrastructure and people to advance the state of the art of hydrogen for transportation. Due to the long transition time associated with vehicle turnover and fuel infrastructure introduction, business and policy decisions like those being considered here are being made today. These near-term decisions will affect the transportation sector for many years to come. It is very important that federal and state policy be shaped by the best available current knowledge and that future policy be shaped by objective research.

Brief Descriptions of Related ITS-Davis Research

About 35 graduate students and ten faculty members are involved in advanced environmental vehicle and fuels research on the UC Davis campus. Graduates of our interdisciplinary Transportation Technology and Policy (TTP) program have obtained positions within the automotive and energy industries, academia, environmental NGOs, and government. The following is a sampling of our larger programs:

Hydrogen Pathways Research Program

The Hydrogen Pathways Research Program is a multi-year program designed to look at the near to mid-term introduction of hydrogen as a transportation fuel from a technical, economic, market, and policy perspective. Bringing together people already working on these issues, the ITS-Davis Hydrogen Pathways Research Program has engaged a broad consortium of leading industry partners, federal stakeholders and state agencies.

Fuel Cell APUs: A \$3 million project is developing and testing fuel cell auxiliary power units (APUs) that power truck-trailer refrigeration and other auxiliary systems. The new APUs could eliminate the need for idling big-rig diesel engines, which is inefficient, expensive, noisy, and polluting. APUs could also power electric systems in aircraft, leading to fuel savings in the nation's future commercial aircraft fleet.

Advanced Vehicle Modeling: ITS-Davis researchers conduct extensive computer modeling of vehicle and heavy-duty truck emissions, fuel economy and performance. ITS-Davis is completing a five-year, \$3 million fuel cell vehicle modeling program that was sponsored by 20 companies and three government agencies.

Hybrid Vehicle Prototypes and Component Evaluations: The UC Davis Hybrid Vehicle Driveline Research and Design Center designs and builds vehicles that demonstrate improved overall efficiency, high fuel economy and low emissions. The HEV Center's current efforts focus on plug-in hybrid-electric vehicles (HEVs) and continuously variable transmissions (CVTs). Researchers at ITS-Davis study energy storage and conversion technologies (including ultracapacitors) for electric, hybrid-electric and fuel cell vehicle applications for a variety of government and industry sponsors.

New Advanced Environmental Vehicle Laboratories: The UC Davis College of Engineering and ITS-Davis are planning to build a new advanced environmental vehicle facility. This project would create large synergies by clustering UC Davis clean-vehicle research and education programs. The facility would include high-bay vehicle laboratory space, a distributed computing facility and a hydrogen refueling station. Co-funding from public and private sources is currently being sought.

SHEN-JMU Fuel Cell Project. [The following information is provided at the request of Dr. CJ Brodrick of James Madison University/UC Davis, and C.S. Oglesby, Director, JMU Fuel Diversification Program]

The JMU/SHEN Fuel Cell Partnership, sponsored by JMU's Fuel Diversification Program, is directed by Dr. CJ Brodrick, also of the UC Davis Institute for Transportation Studies. This multi-phase project demonstrates the use of hydrogen-fueled PEM fuel cells to power tools in remote locations both for short-term and quasi-stationary applications. With additional funding from SHEN, Dr. Brodrick and her students will design and demonstrate an emergency power system for the air quality monitoring station. The station will replace the current diesel back-up power, which generates emissions that can interfere with the air monitoring station's background levels. Investigations are under way to determine how this work can best achieve UNPEPP's goal of educating the public about wise energy use and future energy systems. The long-term objective of this project is to incorporate the fuel cell and hydrogen technologies into the educational outreach projects conducted by the Park.

Graduate Education

We are especially proud of the success of our expanding graduate education and research program much of which involved advanced fuels such as hydrogen and advanced electric-drive vehicles. The National Science Foundation awarded ITS-Davis a \$2.6 million Integrative Graduate Education and Research Traineeship (IGERT) grant for our innovative Transportation Technology and Policy graduate program, the only transportation institute in the country to be funded. In addition, the U.S. Department of Energy awarded UC Davis two (of ten nationally) Graduate Automotive Technology Education (GATE) Centers – to ITS-Davis for fuel cell vehicles and to the Department of Mechanical and Aeronautical Engineering for Hybrid Electric Vehicles. UC Davis won the first two (1998 and 2001) FutureCar and FutureTruck competitions sponsored by the U.S. Department of Energy and the USCAR program of the U.S. auto makers, and placed second overall in the 2003 FutureTruck competition.

Recommended readings:

National Research Council and National Academy of Engineering, The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs. (Washington, D.C.: The National Academies Press, 2004) (online at www.nap.edu).

Daniel Sperling and James S. Cannon, The Hydrogen Energy Transition: Moving Toward the Post-Petroleum Age in Transportation. (St. Louis: Elsevier, 2004).

Daniel Sperling and Joan Ogden, *The Hope For Hydrogen*, Issues in Science and Technology. (Washington, D.C.: National Science Foundation, April 2004). (ITS-Davis Research Report UCD-ITS-RP-04-19 online <http://www.its.ucdavis.edu/pubs/pub2004.htm>)

Department of Energy, *Hydrogen Posture Plan: An Integrated Research, Development, and Demonstration Plan*, February, 2004

Lipman, et al, *Hydrogen Production Technologies* (2004), ITS-Research Report (forthcoming)

*The ITS reports and articles, along with additional information on our programs are available at:
Our website: www.its.ucdavis.edu AND www.its.ucdavis.edu/hydrogen*