Mr. Brian Castelli

Chief of Staff to the Assistant Secretary of the Office of Energy Efficiency and Renewable Energy

to

The Attendees of the Coal to Hydrogen Workshop

September 19, 2000

Introduction

Hello, my name is Brian Castelli. I am the Chief of Staff to the Assistant Secretary of the Energy Efficiency and Renewable Energy Office at the U.S. Department of Energy. It is a pleasure to be here with you today.

These are exciting times for the Hydrogen community. Hydrogen presents a potentially low-cost option for reducing greenhouse gases levels and providing greater energy security. This is perhaps particularly true as we see the cost of gasoline, heating oil, and natural gas sky-rocket as the Asian, European, and American economies continue to expand. We view the Hydrogen Program activities as relevant for mid- and long-term solutions to greenhouse gas mitigation, eventually leading to an environmentally sound and energy-secure future where renewable and fossil fuels are utilized for hydrogen production. Ultimately, the Hydrogen community shares a vision of a future where hydrogen and electricity are the pro eminent energy carriers.

Strategic Directions Slide

(the first 4 bullets below pertain to the first two bullets on the presentation slide)
One of the distinctive attributes of the Hydrogen Program is that there is significant industry investment in the development of Proton Exchange Membrane (or PEM) Fuel Cells for both transportation and stationary applications. The financial pages have documented the IPO actions and stock prices of these new "energy" companies. The Hydrogen Program does not duplicate the current industry efforts associated with their commercialization strategies, but concentrates in the development of technologies that seek to increase the performance of these elements to enhance power generation for commercial and industrial transportation systems. Industry has invested hundreds of millions of dollars in these technologies. Since industry is focusing on developing residential systems at 5-7 kW, the Hydrogen Program, along with Distributed Energy Resources and the Office of Transportation Technologies, is collaborating with industry to develop 50-75 kW fuel cell and reformer modules which are compatible with both stationary generation for buildings and transportation applications.

As part of the Hydrogen Program Strategic Plan, technologies are currently being developed in three thrusts. One key thrust is to develop advanced, highly efficient, reformation processes for producing hydrogen-rich streams from natural gas to be utilized by Proton Exchange Membrane (PEM) Fuel Cells. In addition, the Hydrogen

Program is focusing on developing biomass to hydrogen technologies and electrolysis systems for wind systems that could permit the Great Plains States to become a major supplier of hydrogen fuel.

In addition, as part of the necessary hydrogen infrastructure development and to permit off-board reforming of hydrogen, the Program is sponsoring industry and university efforts to provide the storage necessary to supply fuel for hydrogen vehicles and buses.

Finally, the Hydrogen Program, Industry, and International Associations are all supporting the introduction of safe and dependable hydrogen-based energy systems, including the development of codes and standards, which will permit the successful introduction of these hydrogen systems.

(pertaining to the Coal to Hydrogen with Sequestration bullet)
The new Coal to Hydrogen with Sequestration project is the subject of the workshop, and is the very reason we are here today. Industry and laboratory studies, that you will hear more about today in some detail, have been performed on the coal to hydrogen technology, and I will discuss some results a little later. Carbon sequestration represents an immediate strategy for hydrogen production from coal that further reduces greenhouse gases and expands the domestic resource base. As an

example of one of these potential strategies, both the Fossil Energy and Energy Efficiency and Renewable Energy Offices are supporting the development of membranes that separate O_2 from air. These membranes have the potential to reduce capital and operating costs associated with producing high-purity hydrogen. They could be installed in future power plants that utilize coal gasification to produce a clean fuel for combustion turbines to generate electricity as well as hydrogen for transportation systems.

In addition, we have an on-going effort to develop technologies that utilize biomass, wind, and electrolyzers for hydrogen production. We feel that there a continuum of natural gas to hydrogen with coal to hydrogen, and renewable production of hydrogen can lead to a 30-year program, enabling us to achieve a sustainable and infinitely clean hydrogen economy.

Program Metrics Slide

In looking at technology developments to achieve the vision that I mentioned while discussing the strategic directions, three important elements are required for moving hydrogen to the marketplace.

We need to decrease the cost of hydrogen production to levels that won't be inflationary. We are working with industry to develop the reformation technology and to consider the impact of being able to mass-produce these systems. In regards to the reformer and 50-75 kW module sizes, requirements are being advanced as they become applicable for both stationary and distributed refueling stations.

We need to devise and develop safe, high-pressure storage systems that demonstrate, by weight and volume, feasible and reasonable solutions to integrate systems into vehicles, light-duty vehicles, and trucks. Industry is developing 5,000 psi tanks which exceeds the 5.5 wt% DOE goal with DOE support, but it is important that we decrease the volumetric limits for high-pressure storage tanks (5000 psi) in order to make major inroads in the transportation sector. To do this, we are also developing metal hydride and carbon storage systems. Currently existing low temperature hydrides suffer from low gravimetric energy densities and add significant weight to the vehicle. Researchers are developing low-temperature metal hydrides systems that can store 3-5.5 wt% hydrogen. In addition, researchers have discovered special pretreatments that maximize hydrogen adsorption on single-walled carbon nanotubes at approximately 7 wt%. Metal hydrides and carbon nanotubes are both safe hydrogen storage systems.

We are actively pursuing the development of electrolyzers and reversible fuel cells for integration with wind and solar energy technologies for hydrogen production. We are working with industry to reduce the cost of electrolyzers to less than $300/kw.

Considering today's prices for natural gas and gasoline, some of the hydrogen production technologies via coal and renewable options can become more relevant today.

Cost of Delivered Hydrogen Slide

We have compared studies on systems for distributed generation via natural gas, coal with sequestration, and renewable technologies. We compared these technologies on the basis of anticipated mass production and technology advancement. The target cost for delivered, pressurized hydrogen produced via these technologies is $12-15/MMBtu.

For stationary applications, we anticipate that hydrogen produced by distributed generation via natural gas, which includes biomass where high-value co-products are produced can attain the target cost goal of $12-$15/MMBtu by 2010. We would like to hear from the workshop, as to what development steps are required to achieve the target cost for coal to hydrogen and by what date would such technology be available. We have presented a representative date of 2015.

In the long term, we expect renewable hydrogen production technologies to achieve, within a factor of two, the cost target for hydrogen production by 2020 for both stationary and transportation applications. These studies were done prior to the energy price increase we see today. So, the overall competition between these resources are no doubt “more equal.”

In the transportation sector, market penetration is dependent upon the price hydrogen compared to gasoline. On an untaxed energy basis, the dollar amount for a gallon of gasoline equivalent for the delivered cost of hydrogen is projected to range from $1.30 to $2.50 per gallon of gasoline for the respected technologies if the DOE goals are attained. However, if fuel cell vehicles are 2.2 times more efficient than internal combustion engines, we are talking about $.50-$.60 to $1.20 on a cents per mile basis to even more efficient ICE gas mileage vehicles (30 mpg).

Historical Funding Slide

The potential use of hydrogen as an energy carrier has been under consideration since the early 1970s when the oil embargo sent energy awareness shocks throughout the the United States. In 1978, the Program transferred from the NSF to the Department of Energy.

In the 1980s, as the shocks from the oil embargo were reduced and fossil fuel prices declined, interests in alternative fuel sources began to diminish. Funding for the Program in the 1980s was at its all time low.

In a time where global warming and greenhouse gas emissions became everyday terms, the 1990s saw a rebirth of interest in alternative fuel sources. In 1990, the Matsunaga Act was authorized. This act was implemented to accelerate efforts to develop a domestic capability to economically produce hydrogen in quantities for making a significant contribution toward reducing the Nation's dependence on conventional fuels. Increased debate over global warming sparked the development of the Hydrogen Futures Act. In 1994, the Hydrogen R&D Program became budget line. The Program would finally begin to experience significant funding levels. Funding levels have been increasing annually since 1994, and as you can see, we are lagging the Hydrogen Futures Act authorization levels by about two years, but still the budget has been increasing significantly. Future budgets will depend on how convincing a prospectus can be generated on the ability of industry to proceed to make a reality of the Hydrogen Program vision. This workshop will be a major contribution to that process.

Key Events for Next Year Slide

We are making progress in all of the areas mentioned.

Fueling stations – We are constructing 2 hydrogen fueling stations, one in Las Vegas, Nevada, that will supply hydrogen to a 50 kW fuel cell system by reforming natural gas to hydrogen. The station will provide fuel to fleet vehicles and buses. The buses at the Sunline Transit Agency will be part of the California Fuel Cell Partnership.

Light-weight pressurized tanks – IMPCO and Thiokol are producing 5,000 and 10,000 psi storage tanks which will exceed the goal of 5.5 wt% hydrogen. Actually, they will be producing tanks that achieve 7.5 and 8.5 wt% hydrogen in two phases. With industry, we will be producing tanks that achieve 5.5 and 7.5 wt% hydrogen.

The University of Hawaii has developed an Alanate hydride concept that we believe can meet the goal of 5.5 wt% hydrogen with a dehydriding temperature around 100^{o} C.

In the upcoming year, we also expect the carbon nanotube technology to be able to demonstrate on sample sizes and achieve the goal of 5.5 – 7.5 wt% hydrogen.

Conclusion

We are very interested in the outcome of this workshop. This is an exciting new area that we feel fits directly with the strategic direction of the Hydrogen Program. We believe that distributed generation via natural gas and renewable hydrogen production technologies will lead to a clean, sustainable environment with a greater utilization of domestic resources. We are pleased to enter into a collaboration with the National

Energy Technology Laboratory, and plan to participate with them on the Coal to Hydrogen with Sequestration project. Our role in this collaboration will be concerned with the technology in the back end and utilization areas associated with separation, purification, compression (5,000 psi), storage, and hydrogen infrastructure development for vehicles.

This workshop presents us with several excellent opportunities. I appreciate your attention and thank you for your time. Have a nice day and enjoy the proceedings.