The President's Hydrogen Initiative: US DOE's Approach

A Paper for the Biennial Asilomar Conference on Energy and Transportation on "The Hydrogen Transition"

July-August 2003

By

Steve Chalk
Program Manager, Hydrogen, Fuel Cells and Infrastructure Technologies Program

And

Lauren Inouye
Sentech Inc.

Introduction

Since the President's 2003 State of the Union address, the media and general public have voiced their interest in the potential of hydrogen to meet America's energy needs. It is encouraging to see popular interest in energy issues, and to see enthusiasm from the private sector and the American public regarding the potential of hydrogen and fuel cell technologies. At the same time, it is important that coverage of hydrogen and fuel cells be balanced, and that people also be aware of the full spectrum of Department of Energy activities.

The President's Hydrogen Initiative should be viewed in terms of what the program is, rather than what it is not. Together, the President's Hydrogen Initiative and FreedomCAR programs are a well-planned $1.7 billion effort to develop a more sustainable energy and transport system. However, the program has been mislabeled as a panacea to the world's sustainable development challenges, and this is not the case. Hydrogen is not the solution to suburban sprawl, to inadequate transportation in the developing world, or to all pollution in the United States. It is, however, one of the most viable energy options for transportation that allows for energy independence and has the ability to virtually eliminate greenhouse gases and air pollutants.

It is important that hydrogen not be "over-sold" to the public, leading to unrealistic expectations about either the timeframe of hydrogen fuel cell vehicles (FCVs) or the scope of problems they can help address. Such misunderstandings may result in disappointment when technologies are not available or backlash from individuals who expect more than any individual technology can promise. Hydrogen FCVs are a promising technology, and one that has tremendous potential to address transportation

and energy problems, but they are only one element in our nation's larger strategy to secure a healthy environment and sound economy for future generations.

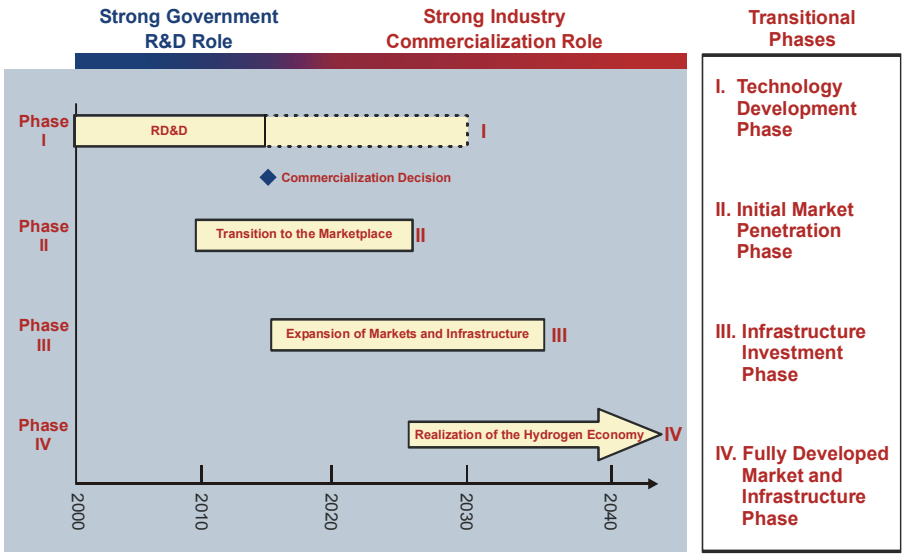
Overview

Hydrogen has the potential to be an important component of the long-term solution to US energy needs. The DOE research timeframe aims to achieve enough significant technological progress to allow the private sector to make a commercialization decision in 2015. To achieve this goal, the DOE has developed a Hydrogen Posture Plan which envisions long-term goals and technology milestones over the next 12 years. In addition, the Office of Energy Efficiency and Renewable Energy has laid out a more detailed Multi-year Research, Development and Demonstration Plan with specific technology targets and evaluation points over the next seven years. As the technology develops, we will consider our options, evaluating the costs and benefits of various methods of hydrogen production, delivery and storage. The program will evolve and adapt as we complete research activities, and weigh our technological options, environmental impacts, and economic trade-offs. We anticipate a transition period of several decades as technologies mature and conventional internal combustion engine cars are phased out in favor of superior low-emissions gasoline or diesel vehicles[1], high-efficiency hybrid vehicles and then hydrogen vehicles.

Timing: Complexity requires systems integration: Customers require superior performance

[1] Such as vehicles conforming to the Environmental Protection Agency's Tier 2 standards.

Some have argued for a more rapid transition to a hydrogen economy. However, the Department of Energy does not mandate what individual consumers drive; individual buyers will make that decision themselves. Unlike the Apollo Program, with which the President's Hydrogen Fuel Initiative has sometimes been compared, the government is not the ultimate customer of the technology we are helping to develop. In order for hydrogen vehicles to be widely adopted, businesses must offer vehicles which meet consumer requirements. However, financial risks involved in the development of hydrogen technologies and infrastructure are significant. Without additional research demonstrating their promise, the business case for investment in the hydrogen economy is uncertain. Therefore, DOE will support R&D to help establish a business case and to enable a commercialization decision. Given the tremendous technical hurdles that must be overcome today to meet customer requirements, 2015 is an ambitious but achievable timeframe.



Wide adoption of fuel cell vehicles will most likely not take place until 2020, and a minimum of 20 years will be required for the majority of petroleum-based ICEs to be effectively replaced. DOE's timeline takes technological unpredictability into account, but aggressively seeks to make a commercialization decision on fuel cell vehicles possible by 2015.

Our timeframe and budget allow us to support the exploration of multiple production, delivery and storage pathways, and to re-evaluate the feasibility of different options with phased "Go/No-Go" decision points. Systems integration is crucial. Hydrogen production, storage, and delivery methods must complement each other, and the feasibility of one method will depend upon its compatibility with other parts of the system. This is why we have established a Systems Integration Plan to analyze all models & pathways and to appropriately integrate individual efforts with overall objectives at the macro-system level.

Our timeframe balances a desire to begin work on fundamental technical barriers to the hydrogen economy with a measured plan and methodology for systems analysis. Compressing our research schedule would not allow for the necessary learning and experimentation cycles required in R&D programs. Over-aggressively funding research that is not well thought-out could result in wasted taxpayer money. For example, DOE is currently funding research into 10,000 psi storage tanks. Storage and delivery are particularly challenging aspects of the hydrogen system, and clearly need further research. However, if further research determines that low-pressure, solid state storage is a better technical option, it would change our thinking about delivery and refueling infrastructure. Careful coordination of the development of all components of hydrogen production, delivery, storage, end-use conversion and infrastructure is needed.

In particular, the DOE Hydrogen program emphasizes co-developing hydrogen infrastructure in parallel with hydrogen fuel cell-powered vehicle technologies. If one element of the hydrogen system is not able to meet customer requirements, it is unlikely that the system as a whole will be able to function. For example, having the infrastructure to enable every driver to refuel their hydrogen fuel cell vehicle near their home or place of business is crucial to the success of the hydrogen transition. There is a need to coordinate elements of the hydrogen value chain, so one component does not delay progress on another.

Countering those who push for a faster hydrogen transition, others argue that DOE is "rushing" the hydrogen transition, and want to postpone hydrogen-related research. Often, their proposed alternatives focus on near-term policies and regulations to address pollutants, greenhouse gas emissions, and oil dependency. However, substantial efforts to improve near-term energy efficiency and environmental impact do already exist. The Department of Energy supports a broad and robust portfolio of activities in energy efficiency, renewable energy, nuclear energy, fossil fuels, carbon sequestration, and other research at the same time we support research on hydrogen and fuel cells. The two approaches are not mutually exclusive. Many short-term, immediate actions supported by DOE will make a greater near-term difference to current fuel consumption and air quality than the hydrogen program will, because FCVs will probably not be widely available until 2020. While resource constraints make it impossible to support every project, DOE's work recognizes that it is important that both long-term and short-term solutions be supported.

Far from being mutually exclusive, near-term efforts can actually support long-term solutions. This is the case with hybrid vehicles. Hybrids can meet customer requirements on performance, design, and durability, and hybrids are commercially available today. More hybrids on the road mean greater fleet efficiency and cleaner air. The Administration supports an efficiency-based income tax credit for the purchase of new hybrid vehicles. In addition, through the FreedomCAR Partnership, DOE continues to support development of advanced hybrid vehicle components and research on electric powertrain technologies. This research, which today helps improve battery-internal-combustion engine (ICE) hybrids, will be used in the future on the electric drive systems in FCVs. Other research sponsors work in improved energy storage and advanced lightweight materials. These technologies improve the efficiency, cost and durability of hybrids while also contributing to FCVs.

Distributed production of hydrogen from natural gas is another example of a "near-term" solution that helps reduce pollution while building the infrastructure for renewable hydrogen production methods which are still in development.

It is also important to recognize that short-term measures, while essential, will not bring a total solution. While the current Administration is supporting measures such as hybrid vehicle tax credits, ethanol production and revisions in fuel-efficiency standards, these interim strategies will not ultimately reverse our dependence on foreign oil or address environmental problems as hydrogen can.

Thus far, hydrogen is the one of few fuel options which gives us the option of a domestically-based zero-emissions energy economy.[2] It would be foolish not to begin

[2] Battery electric vehicles show similar potential, but without a significant break-through in battery technologies, are unable to meet customer requirements. DOE continues to support battery research, which

exploring its potential. By investing critical funding in R & D today, wide-spread, commercial adoption of hydrogen fuel cell vehicles could be near completion in 2040 or 2050. Without the commitment and funding of the President's Hydrogen Initiative, it is unlikely that hydrogen and fuel cells will be viable technology options when the interim measures we can take today are no longer sufficient.

Other near-term policies may also be part of the solution to energy security and environmental concerns. However, many policies in this arena are quite contentious, and may have consequences on the economy and American competitiveness. It is risky to call for legislation requiring technical solutions when the needed technologies do not yet exist. In addition, it can take years for consensus to emerge around a sound policy, and even then, it is often difficult to implement the laws to ensure it is effective. Given the tremendous uncertainty of overcoming all the technical hurdles to a hydrogen economy, it is best to focus today's efforts on research, development, and technology validation. In reaching our technical performance and cost targets, DOE will enable tomorrow's policy makers to debate about a more proven technology. In the interim, DOE will help support the further development and adoption of existing technologies, such as advanced combustion engines, hybrid vehicles and renewable energy.

DOE Program Approach: Our Strategy is R&D

The DOE role is to stimulate and support early, high-risk research with the most significant potential payback. DOE, with its partners, will also test these technologies in real-world conditions through learning demonstration projects, and the information we

---

may also be important components of commercially viable FCVs, but hydrogen fuel cells appear to be a more attractive option at this time.

gather will be fed back into our research programs, to help us determine where problems and priorities lie. We have identified the three greatest challenges to a hydrogen transition as: improving hydrogen storage, reducing the cost of hydrogen production and delivery, and making fuel cells less expensive and more durable.

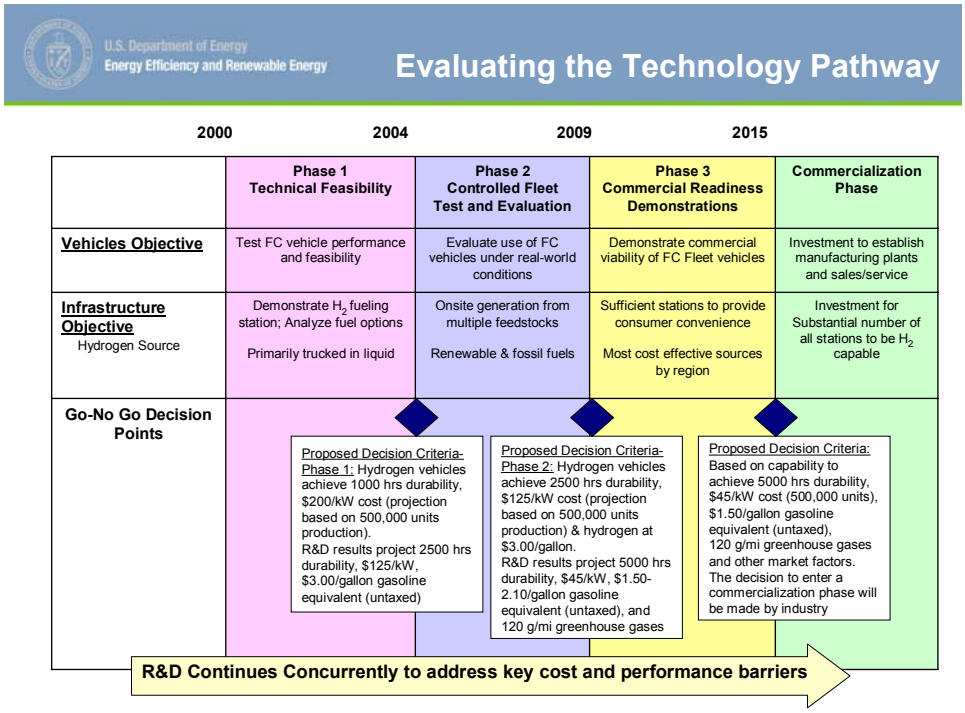
Some FCV enthusiasts advocate policies and incentive programs to encourage widespread adoption of hydrogen fuel cell vehicles today, either among fleets or individuals. It is true that economies of scale in the automotive industry make it possible to produce technologies in mass-production at a lower cost than the same product made in smaller quantities. However, while this is an appropriate strategy for some technologies, such as hybrid -electric vehicles, it is premature for hydrogen FCVs. It is far too early to bring hydrogen technologies and fuel cells down the cost-curve with such policies. Today, FCVs do not meet customer needs and are not close to the cost targets for broad commercialization. It would be a waste of taxpayer funds to promote technology that did not meet customer needs, and could even back-fire by popularizing negative perceptions about FCV performance or durability. In addition, we lack the infrastructure and codes and standards necessary to make any vehicle early adopter program involving the general public a feasible scenario.

When the hydrogen and FCV technologies are close to meeting customer requirements, and the business case is nearly established, policies and programs with incentives for early adopters will be considered. Until that point, we will lower costs through materials R&D and improving performance, not through premature volume production. DOE will only encourage wide-spread adoption of FCVs when the

technology meets customer needs and expectations and when industry can establish a business case for large scale production and investment in hydrogen infrastructure.

However, DOE will support small-scale learning demonstrations. These projects will allow us to collect data on technology operating in real-world conditions, identify areas for improvement, and feed information back into our R&D program. This information is important for us to validate different technology options. However, large-scale demonstrations are not necessary, and would be costly.

Hydrogen fuel cells may become commercially competitive in some stationary, mobile, and auxiliary applications earlier than fuel cells for transportation. The experience gained in development and use of fuel cells for these markets will help speed and encourage fuel cell research for vehicles. DOE also supports development of fuel cells for these applications, while focusing our activities and long-term goals on the light-duty transportation sector, among the most challenging, but also most important energy sectors we must address to meet our energy security and environmental goals.



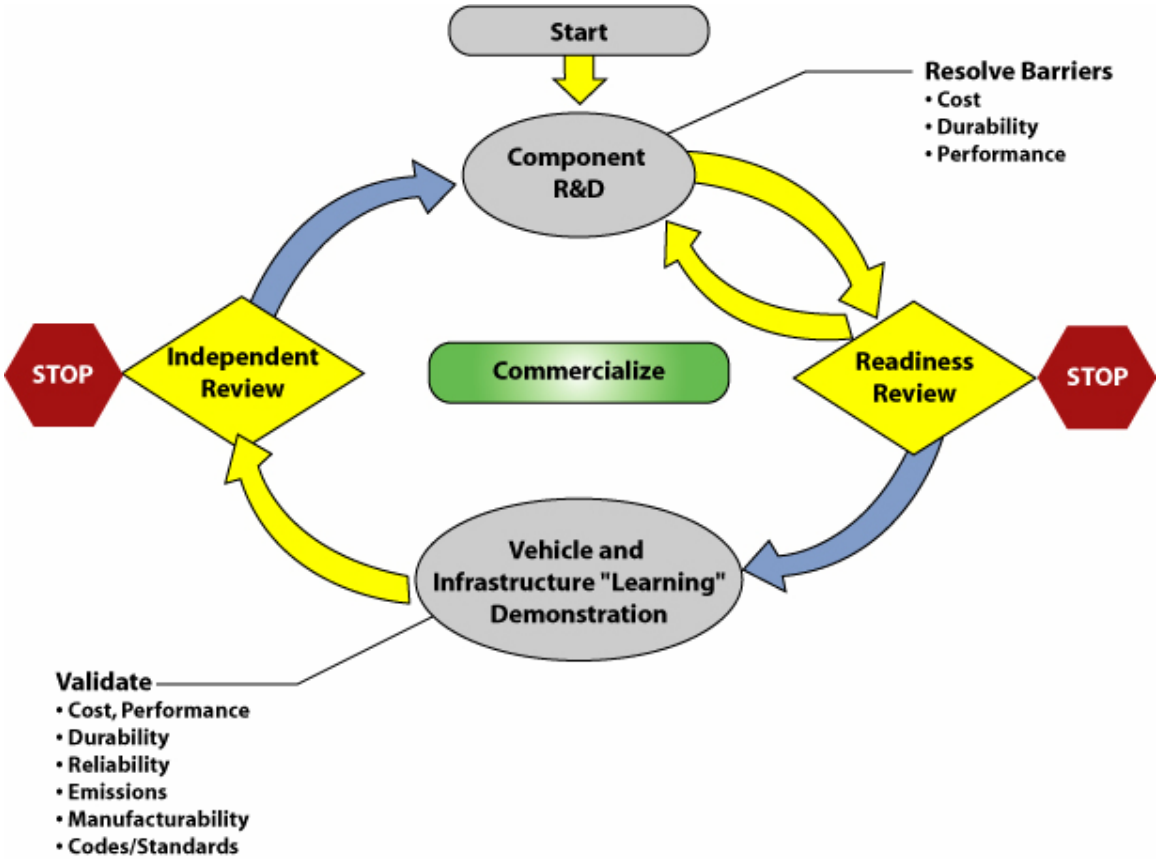
Learning Demonstration and Technology Validation projects play different roles in different phases of development of the hydrogen fuel cell pathway.

Some members of the auto industry indicate they plan to produce a commercial fuel cell vehicle before 2015, perhaps as early as 2010. This is an admirable goal, one which we hope the automakers will reach, and one which we are working to achieve as well. However, DOE's 2015 commercialization decision is not based solely on the ability to build a vehicle. Hydrogen FCVs prototypes exist today; the challenge lies in establishing them as feasible commercial vehicles for a mass audience. It may be possible to introduce fuel cell vehicles to a small community of "early adopters," or controlled fleets whose needs are different than those of the general population. Today, controlled fleet demonstration projects allow FCV manufacturers to demonstrate their technology for customers like the military and companies like FedEx and UPS.

However, for widespread commercial acceptance, the full range of our technical and commercial targets must be attained, a goal that we anticipate reaching in 2015.

Our 2015 date also takes into account progress in overcoming economic and institutional barriers, including;

1. The high investment risk of developing a hydrogen delivery infrastructure, given technology status and current demand.
2. The lack of uniform codes and standards to ensure safety, insurability, and fair global competition.
3. The low level of education regarding hydrogen safety and benefits among local code officials, policy makers, and the general public.



Technology validation confirms that component technologies can be incorporated into a complete system solution, and that system performance and operation are met under anticipated operating scenarios. The Technology Validation Element of the Hydrogen Fuel Cells and Infrastructure Program will collect data to determine whether technical

targets have been met under realistic operating conditions. The results of the validations will be used to provide feedback on progress, and to efficiently manage the research elements of the program and provide redirection as needed.

Why is Hydrogen a Viable Alternative Fuel for the Future?

Hydrogen has the potential for both significant displacement of petroleum based-fuels and zero or near zero emission vehicle operation. While most current alternative fuels provide these same benefits, the potential benefits to both are greater with hydrogen. Historically, issues concerning fuel supply infrastructure, cost, and vehicle performance have slowed the growth of alternative fuels in the marketplace. The Department of Energy has focused its efforts on addressing each of these issues through concerted research efforts with the fuels and automotive industries. These previous and ongoing efforts will directly benefit hydrogen as a future viable alternative fuel. For example, the Department's support of natural gas fuel infrastructure (both compressed gas and cryogenic) development will directly support the development of future hydrogen fuel supply infrastructure. Further, many of the domestically-produced alternative fuels like natural gas and ethanol can be "hydrogen carrier" feedstocks from which vehicle fuel grade hydrogen can be produced.

As pressure to reduce vehicle emissions has increased, industry has continued to seek solutions, including the use of alternative fuels. Partnering with Federal agencies to develop alternative fuels was a logical and necessary step for industry to meet shared national and regional goals of a low-emission transportation system. The Department of Energy recognizes this important role of supporting industry efforts through basic research and demonstration of those fuels and technologies that could achieve these air quality goals while at the same time reducing foreign energy dependence. The

Department's previous and ongoing support of alternative fuel technologies has created a bridge for the viable and sustainable "hydrogen economy" envisioned by President Bush.

While technical, institutional and political issues remain to be addressed, the combination of previous Department of Energy programmatic and research support of alternative fuel technology, the fuels and automotive industry commitment to commercialization, and projected widescale U.S. market acceptance ensures hydrogen's place in the future transportation fuels market.

Industry Support for Hydrogen and Fuel Cell Technology

The automotive and energy companies, two very important industry sectors, have shown sustained interest in hydrogen and fuel cell technologies. Without such a commitment from the private sector, no program aimed at commercialization can be successful. This need for industry participation is why the Department of Energy has worked closely with these industries to cooperate on research, development, and demonstration of key technologies.

Many of hydrogen's public benefits are also private benefits. Hydrogen, potentially a zero-emissions fuel, is attractive because it frees automakers from many concerns about vehicle emissions and pollution. Repeatedly readjusting production to meet stricter standards can be expensive. Rather than continued redesign of vehicle product lines to meet mandated incremental emission reductions, the industry sees the use of hydrogen and fuel cells as eliminating this costly cycle from the vehicle production process. It is desirable to preempt regulation, and, in the words of Larry Burns, Senior Vice-President of General Motors "remove the automobile from the environmental

equation." The industry views hydrogen and fuel cell technologies as viable long-term solutions to the vehicle emissions problem.

In addition, unlike some alternative fuels which have limited applications due to feedstock supply, geographic or other technical reasons, hydrogen FCVs have the potential to replace light-duty gasoline ICEs. It is more attractive for both for the government and the private sector to invest in a technology with a large commercial audience, rather than one with a small niche market.

Another advantage is that hydrogen can be produced from a variety of feedstocks, including renewable sources, nuclear energy, natural gas, coal and other fossil fuels. This diversity of feedstocks allows hydrogen to be produced with fewer concerns about price shocks, foreign disturbances, or other disruptions to supply. Hydrogen unifies our nation's many energy resources into one fuel.

Hydrogen produced through electrolysis is also a uniform fuel, allowing automakers to produce standard "engines" or fuel cells, unlike gasoline and some alternative fuel mixes whose formulation can differ from nation to nation, and even state to state. This is an advantage for automobile and energy companies which increasingly must consider the demands of the global market. Hydrogen produced from fossil fuels could also be purified to meet international standards to ensure maximum performance of PEM fuel cells and global compatibility.

Commercial appeal is arguably the single most important factor in the success of hydrogen fuel cell vehicles. Many important business partners from the energy and automobile industries have already demonstrated a committed interest in hydrogen and fuel cells, and launched hydrogen research programs. Major energy companies have

worked to redefine themselves as providers of energy services, unlimited to the sale of any particular commodity; as BP, or British Petroleum says, "Beyond Petroleum." The energy companies have experience managing large financial resources and capital, skills important for a long-term research program like the development of a global hydrogen infrastructure. ChevronTexaco cites their company's long history in developing large scale infrastructure as experience which will help them to succeed in the hydrogen economy as they have in hydro-carbon economy.

The automobile industry has also shown interest in the business opportunities a hydrogen fuel cell economy may someday offer. Auto executives are optimistic about their abilities to manufacture fuel cell vehicles which meet or exceed their customer requirements, with features like sensitive electric drive systems, auxiliary power options, greater flexibility of design, and more convenient refueling options, such as home-based hydrogen appliances. FCV designs may also allow manufacturers to reduce the number of parts in a car, thereby lowering costs and possibly increasing durability. While still acknowledging that a number of tough technical barriers (hydrogen storage, for example) must be overcome, many car companies have shown considerable enthusiasm for hydrogen and fuel cell technology, and are voluntarily supporting initiatives to develop and demonstrate such technologies, in collaboration with the FreedomCAR Partnership and the California Fuel Cell Partnership. General Motors has publicly stated that they plan to be the first company to sell one million fuel cell cars, and say they hope to begin offering fuel cell vehicles in the next decade[3]. Ford expects to have its vehicles on the

3 "Hybrids And Hydrogen Are The Stars Of General Motors' Sacramento Tech Tour." By Poul Erik Bak, based on Press Release from GM. Feb 10, 2003, http://www.h2cars.biz/artman/publish/printer_92.shtml.

road by 2020, and expects half of the vehicles they sell in 2040 to run on hydrogen[4]. The enthusiasm of the private sector will also help DOE educate the American public about hydrogen and fuel cells.

The International Partnership for a Hydrogen Economy

Energy security and the environment, the two main drivers for the hydrogen economy, are both global problems, calling for global solutions. The interest in hydrogen from around the world is yet another reason to be optimistic about its potential. Japan's fuel cell and hydrogen technology research, development, and demonstration program has tripled in size since 1995. The European Commission recently announced a program of € 2.1 billion on hydrogen, fuel cells, and other related renewable energy activities. Iceland has committed itself to becoming the world's first total hydrogen economy. Developing countries, including China and India, have also expressed interest in hydrogen, and have initiated research programs themselves.[5]

Recognizing that international cooperation and collaboration will be important to efficiently achieve hydrogen and fuel cell technology goals, Secretary Abraham has called for an "International Partnership for the Hydrogen Economy" to establish cooperative R&D efforts, common codes and standards, and the sharing of information necessary to develop a hydrogen economy. The international partnership will promote common codes and standards that will avoid trade barriers and promote global harmonization while minimizing duplication of R&D efforts. Because the United States

[4] "Ford Sees Future with Hydrogen." By Dee-Ann Durbin, Fuel Cells Today. June 10, 2003. http://www.fuelcelltoday.com/FuelCellToday/IndustryInformation/IndustryInformationExternal/NewsDisplayArticle/0,1602,3007,00.html

[5] "Toward Hydrogen", IEA Workshop, March 3, 2003. http://www.iea.org/workshop/2003/hydrogen/

is the world's largest economy, we are in an excellent position to lead the way to a global hydrogen economy, and to encourage other nations to work with us in achieving this transition. Demonstrating U.S. leadership, Secretary Abraham will host the first IPHE Ministerial in Washington D.C. November 19-21, 2003.

Conclusion

While energy efficiency and adoption of alternative fuels can and are being encouraged by the Department as interim measures, they are only partial solutions. Together, they don't come close to completely solving our dependency on foreign oil, which is expected to grow from 50% today to 68% by 2025. This dependence, and the related challenges of air pollution and greenhouse gas emissions, will not go away. Energy independence has been a goal for decades, but without a truly viable means of replacing the tremendous quantities of oil we import, political will can only go so far. Ultimately, businesses and consumers will opt for the cheapest, most reliable fuel, which for decades has been petroleum. Hydrogen is a fuel with the potential to be a real replacement for petroleum. Additional policies beyond R&D can then be implemented when a stronger political and scientific consensus exists to move forward.

The DOE research program is needed to more firmly establish the technical and economic feasibility of hydrogen and fuel cells, specifically their ability to function with performance and cost comparable to conventional vehicles. Without this assurance, the private sector will be unwilling to invest in the hydrogen infrastructure necessary to make the hydrogen transition possible. In addition, the government can act to develop important codes and standards, and help to build the human infrastructure necessary to ensure hydrogen safety.

With cooperation and enthusiasm from the private sector, we will develop technologies capable of eliminating our dependency on foreign oil and protecting the environment, but also turning profits. With collaboration and eagerness from our international partners, we will reach our technology goals faster, and foster a fair and open technology transfer and trading system, coordinate integrated codes and standards, and build a supportive policy framework. Hydrogen is not a panacea for all the world's energy ills, but it is a promising technology, and with the interest shown by businesses, scientists, educators and policy makers from around the world, we believe it is a feasible solution to our energy security and environmental goals. Working together, we can make it possible, in the words of President Bush, for "the first car driven by a child born today to be fueled by hydrogen, and pollution-free."