PPI | Policy Report | January 22, 2003

FreedomCAR and Fuel Cells: Toward the Hydrogen Economy?

By Daniel Sperling

FreedomCAR is the Bush administration's bid to reduce our reliance on oil. A successor to the Clinton administration's Partnership for a New Generation of Vehicles (PNGV), FreedomCAR is a research initiative designed to promote greater coordination between federal agencies and U.S. carmakers. In marked contrast to its predecessor, FreedomCAR shifts the research focus away from technologies close at hand to fuel cells, a family of products further down the road with far greater promise to reduce petroleum use and the air pollution that results from its combustion.

Unlike today's engines, fuel cells use chemical reactions to create a continuous stream of electricity from hydrogen. They are two-to-three times as efficient as gasoline-powered engines and have the potential to produce no harmful air emissions. In addition to reducing oil use, fuel cell vehicles also have the potential to return electric power to the grid when they are idle.

FreedomCAR's emphasis on fuel cells and hydrogen is auspicious. But to reduce oil consumption and pollution, much more must be done than simply promote fuel cell research and development (R&D).

Although the technology is highly promising, two large challenges remain: fuel cell costs must come down; and a network of hydrogen fuel stations must be constructed. Moreover, if consumers are to have sufficient incentive to buy vehicles powered by fuel cells, the vehicle technology and infrastructure must be commercially available at the same time.

FreedomCAR's goal is to fund research that brings the cost of today's fuel cells down from their present level of $3,000-to-$4,000 per kilowatt hour to about $45, a level roughly comparable to the cost of mass-manufactured cars on the road today.[1] There is no apparent reason why these cost reductions cannot be accomplished -- though it will require an enormous engineering effort. It is widely believed that by 2008 to 2010, a concerted engineering effort can help to put fuel cell vehicles where hybrid electric cars are today, selling a few thousand per month in the United States. Sales in the hundreds of thousands are expected to start several years later.

The fuel supply issue will prove even more stubborn because its solution will require more than just technical innovation and engineering. It will require the engagement of a broader array of companies and government agencies in this effort in the near term, and the development of a new set of energy resources in the longer term.

Although it is the most abundant substance in the universe, hydrogen does not exist in a free state. It must be extracted from other substances in which it occurs -- water and hydrocarbons (e.g., natural gas, methanol, and gasoline).

Today, most hydrogen is produced from natural gas for use as a specialty chemical, but current supplies are inadequate to run our transportation system. In order to use hydrogen as a transportation fuel, it will be necessary in the near term to create a nationwide network to produce, distribute, and store it. In the longer term it will be necessary to import natural gas and/or develop entirely new resources and production processes in order to provide a sufficient supply of hydrogen. Already, the U.S. Department of Energy (DOE) and large energy companies are exploring the use of biomass, sunlight, coal, and nuclear energy to supply much-expanded quantities of hydrogen for the future.

The most pressing supply problem at this initial stage is how best to deliver hydrogen to the fuel cell on the vehicle. Hydrogen is the lightest molecule on earth. To provide enough energy to power a vehicle a few hundred miles is daunting. One approach, pursued by General Motors and several oil companies, is to extract hydrogen from gasoline -- an approach that would help employ the existing infrastructure as a step toward a hydrogen economy. DaimlerChysler, in

turn, is looking to extract hydrogen instead from methanol, which produces fewer harmful emissions than gasoline. Other options would entail converting natural gas directly into hydrogen at fuel stations and then compressing or liquefying it and perhaps even storing it on board in molecular carbon formations known as "nanotubes." Until automakers resolve these questions, energy companies will remain reluctant to invest in fuel stations and fuel distribution systems. It is a classic "chicken and egg" problem.

It is doubtful that the private sector will solve this problem on its own. Owing to their enormous potential to slash emissions implicated in smog and global warming, as well as enhance energy security, there is a clear role for the federal government to play in the acceleration of fuel cell vehicle technologies. To successfully accelerate the hydrogen transportation future, the Progressive Policy Institute (PPI) supports the following seven-point plan:

1. Fund efforts to reduce fuel cell vehicle cost;

2. Build the infrastructure to supply and deliver hydrogen;

3. Expand FreedomCAR to include energy companies;

4. Train future engineers, autoworkers, and technicians;

5. Keep FreedomCAR focused on technologies down the road;

6. Link FreedomCAR with policies to promote a clean energy future; and

7. Increase FreedomCAR's funding.

To the extent that it refocuses federal efforts away from near-term technologies toward fuel vehicles powered by hydrogen, FreedomCAR is a small but positive shift over its predecessor, PNGV. But like PNGV, FreedomCAR's scope and scale are simply too narrow. A national effort to produce, distribute, and supply hydrogen as a transportation fuel must engage more than U.S. automakers. Its focus must be expanded to include energy companies; small, innovative technology firms; and universities. To ensure FreedomCAR's resources are invested wisely, the initiative must avoid duplicating efforts already underway in the private sector and focus on technologies further from commercialization. To give producers and consumers the incentive to build and buy fuel cell vehicles powered by hydrogen, FreedomCAR must be aligned with policies to promote a clean energy future. To achieve these goals, the initiative will require a far greater commitment of resources than FreedomCAR's architects have contemplated.

Fund Efforts to Reduce Fuel Cell Vehicle Cost

In several important respects, the hydrogen transportation economy has already arrived. The challenge for FreedomCAR is to avoid funneling scarce federal research dollars to private sector efforts already underway. Daimler Benz in 1997 announced plans to mass-produce fuel cell vehicles by 2004. Today, DaimlerChrysler is putting hydrogen-powered buses on the road in Europe. California, as part of the public-private California Fuel Cell Partnership, (inspired, but not mandated by the state's zero emission vehicle (ZEV) requirements) plans to put hydrogen buses on the road by 2004.

A variety of automakers plan to place increasing numbers of fuel cell cars in test fleets in the United States over the next couple of years, mostly in California (as part of the fuel cell partnership). In December 2002, Honda and Toyota leased fuel cell sport utility vehicles (SUVs) to the City of Los Angeles and the University of California (Davis and Irvine), as well to the Japanese government. Given these ongoing efforts, FreedomCAR must endeavor to target those important challenges that the industry is unlikely to adequately address. Perhaps the most important challenge in this regard is the lingering question of how hydrogen should be stored on vehicles.

To build a vehicle that looks and performs like today's conventional cars, automakers must find a way to reduce the amount of space hydrogen consumes. A few possibilities include compression, converting it to liquid form, or squeezing it into solid storage materials. The other option is to simply deliver hydrogen to a fuel cell via another type of easily transportable liquid fuel that contains hydrogen (for example methanol or gasoline).

In order to address these challenges, one of the highest priorities for FreedomCAR must be to provide funding to support research and development of safe, onboard storage of hydrogen in sufficient quantity to provide a vehicle driving range comparable to that of gasoline-powered engines. One of the most promising methods is to store hydrogen as a solid, rather than a gas or liquid. FreedomCAR research should support efforts to advance methods to effectively store solid hydrogen.

Another priority should be to develop methods and technologies to tap the electric power produced by fuel cell vehicles when they are idle. Like today's electric and hybrid vehicles, fuel cell vehicles are propelled by electricity. When they are not in use, electric propulsion vehicles have enough electricity to power several homes. Soon, such cars will be able to supply auxiliary power to homes and to offices. With a few minor modifications, these cars have the potential to "sell" their electricity back to the power grid. Such cars would be outfitted with special meters that allow grid operators to know how much power to draw down from the cars during the day, leaving enough for the vehicle's owner to be able to drive them home at night.

Today, such vehicle-to-grid or "V2G" systems have the potential to supplement regional grids during periods of peak demand. Down the road, electricity from fleets of such vehicles has the potential to be a vital input to a locally distributed energy grid. In the short run, V2G systems may help to accelerate the adoption of fuel cell and other electric vehicles by helping to offset the sticker price of these vehicles. A V2G system could net the typical car owner up to $3,000 per year for power sold back to the grid.[2]

Given this potential to supplement and back up our electricity supply in the near term and serve as a source of local distributed power in the future, FreedomCAR should support research to advance our understanding of how electricity from vehicles can be generated while they idle. Specifically, research should examine how to link vehicles to electricity grids -- both small, locally distributed energy grids and larger regional grids. Research that examines how to return power generated by hydrogen vehicles back to the electricity grid is largely ignored by the automotive industry, yet such research might prove pivotal in making fuel cell vehicles not only less costly but also more attractive to consumers by reducing their utility bills and assuring emergency backup power for their homes.

Until such uncertainties are resolved, fuel cell vehicles will have a tough time displacing internal combustion engines. After a century of development, vehicles powered by conventional fuels still receive billions of dollars per year in industry R&D (far more, even today, than the industry is investing in the development of fuel cell vehicles). If FreedomCAR is to succeed, it must fund research that will make fuel cell cars competitive with today's internal combustion engine.

Build the Infrastructure to Supply and Deliver Hydrogen

Even if the cost of fuel cell cars decreases, consumers will not buy them in significant numbers until hydrogen filling stations are as accessible as gas stations are today. The lack of adequate infrastructure to support consumers who would buy and drive hydrogen vehicles, in turn, discourages energy suppliers and automakers from investing in the development of this new technology.

Owing to such chicken-and-egg problems, FreedomCAR must do more than support research to build a better fuel cell vehicle. FreedomCAR must also support research to develop an entirely new infrastructure to support fuel cell cars powered by hydrogen. In particular, FreedomCAR should promote efforts to supply and to distribute hydrogen.

A hydrogen transportation economy demands that hydrogen be available when and where it is needed. In the United States, hydrogen primarily is produced as a specialty chemical, rather than as energy fuel to power the transportation sector.[3] Most commercially usable hydrogen currently is extracted from conventional fuels such as oil and natural gas. Adding an electric charge to water also generates hydrogen. This process, known as electrolysis, separates hydrogen from oxygen, allowing it to be used to power fuel cells.

Extracting hydrogen from conventional fuels can help defray the need to invest in the construction of an entirely new infrastructure to supply hydrogen and get hydrogen-powered cars on the road faster. But producing hydrogen from oil does little to promote energy independence and still generates harmful emissions. If the electricity needed to extract hydrogen is generated from renewable sources of energy, such as wind, hydroelectric, photovoltaic, geothermal, or biomass, the environmental impact of its production will be close to zero.

Due in part to this lingering debate, efforts to build fuel cell vehicles and the infrastructure to support them have stalled. In order to accelerate the transition to a hydrogen economy, FreedomCAR must not only fund research to reduce the cost of fuel cell cars, but also help energy producers identify the best method to safely produce, transport, and store hydrogen.

Engage Energy Companies, Future Engineers, and Future Auto Assemblers

FreedomCAR's most important targets are the companies that will supply, store, and distribute fuels to generate hydrogen -- activities that largely are outside the capabilities and historic activities of the Big Three automakers, Ford, General Motors, and DaimlerChrysler.[4] But like PNGV before it, FreedomCAR largely excludes energy companies. If it is to successfully speed the hydrogen transportation future, FreedomCAR must include energy companies in the partnership. To do so, PPI supports the creation of a linked FreedomFUEL partnership.

Because they are the ultimate end users of the technology that will be developed though a federal program, FreedomCAR program should also expand the scope of participation beyond the Big Three to include other automakers such as Toyota, Honda, and Nissan, which arguably are as "American" as DaimlerChrysler. Consider that Toyota is about equal to Chrysler in U.S. sales, DaimlerChrysler is a German company, and Honda sells more than half its cars in the United States.

FreedomCAR also must target funds to companies that are most likely to achieve significant new breakthroughs. It is a well-established fact that government R&D is most effective when it is targeted at industries that are not concentrated and have low R&D budgets. The auto industry does not fit this profile. The world's 10 major auto manufacturers are highly concentrated (they account for most auto sales) and each spends billions each year on R&D, an increasing proportion of which is going toward fuel cells and other alternative vehicle technologies. To maximize the federal government's return on R&D investment dollars, FreedomCAR should not only engage organizations that are already investing tens and hundreds of millions in R&D, but also those with low R&D budgets, especially small, innovative technology companies and larger ones that do not yet supply major automotive companies.

Train Future Engineers, Autoworkers, and Technicians

In addition to engaging the companies that ultimately will build, market, and sell fuel cell vehicles, federal efforts to promote a hydrogen future must help to train the engineers and scientists who will develop fuel cell cars, as well as initiate training programs for technicians who will service them. The Clinton administration, as part of its bid to build a cleaner, more fuel efficient car, funded several advanced vehicle university centers and student vehicle projects in its latter years, but it amounted to less than 2 percent of the program's $150 million dollar annual budget.

To create the next generation of fuel cell engineers and scientists, PPI supports the creation of a FreedomEDUCATION partnership that builds on existing DOE programs such as the small

Graduate Automotive Technology Education centers program.[5] Funding for university education and centers should be ratcheted to over $30 million eventually (still considerably less than is given to university transportation centers).

Training scientists and engineers is important. But to reduce the cost to manufacture and assemble fuel cell cars, it will be necessary to train autoworkers in their manufacture and assembly. To help create a highly skilled, highly trained fuel cell vehicle workforce, PPI supports the creation of a FreedomTRAINING partnership. The partnership would fund high school and trade school vocational programs to create the next generation of high skilled, highly paid automobile assemblers.

Keep FreedomCAR Focused on Technologies Down the Road

Not everyone is sold on fuel cells. Fuel cell critics favor more near-term technologies such as high-tech diesel because it is available today, is far less costly to the consumer than fuel cells, and continues to use our existing infrastructure to supply and deliver petroleum. Such arguments ultimately won the day under the Clinton administration's PNGV program, which settled eventually on the goal of building an 80 mile per gallon prototype for a family sedan fueled by diesel. But diesel, which contributes to lung cancer and other respiratory problems, is far less clean than fuel cell technology, which has the potential to emit only water vapor. Moreover, while a high-tech diesel engine could help put a dent in petroleum consumption and harness existing infrastructure, it does virtually nothing to accelerate research breakthroughs essential to achieving a hydrogen-based transportation economy in the long term.

Focusing public research dollars on technologies close at hand does little to disseminate new ideas. As a rule, businesses with technologies close to commercialization have little incentive to make their discoveries public. But not so for basic research still far from commercial application. FreedomCAR's focus on fuel cell technologies further down the road stands a better chance of leading to technical breakthroughs that can be rapidly disseminated to the R&D community and industry.

As discussed in a companion paper to this report, a number of observers believe that fuel cells will become the dominant energy technology in the 21st century.[6] To tap their potential, FreedomCAR's scope must be extended beyond its current focus on automotive fuel cells to other products that have the potential to be powered by them, including laptop computers, camcorders, and power tools.

Link FreedomCAR with Policies to Promote a Clean Energy Future

If FreedomCAR is to succeed, it must be aligned with other policies to promote a clean energy future. Among the most notable are standards to advance vehicle fuel economy. FreedomCAR's critics claim that the Bush administration merely is using the initiative to forestall efforts in Congress to tighten standards to promote fuel economy. Indeed, at the same time that Detroit was promoting its latest line of fuel cell concept cars in December 2001, industry lobbyists successfully blocked efforts in the Senate to raise corporate average fuel economy (CAFE) standards.[7] FreedomCAR cannot merely serve as a smokescreen to maintain status quo fuel efficiency standards.

Because FreedomCAR essentially seeks to move away from conventional carbon-based fuels to hydrogen, the adoption of environmental laws to limit emissions of carbon dioxide and other global warming gases can also help to ensure FreedomCAR's success. However, the Bush administration is unlikely to support mandatory limits on carbon dioxide any time soon, though mandatory caps on carbon dioxide and other greenhouse gases are essential to promoting the shift away from hydrocarbons toward a hydrogen economy.

To spur demand for fuel cell vehicles, FreedomCAR must be aligned with federal energy policies that reward companies for selling fuel cell vehicles and hydrogen, and consumers for buying them. A good start is found in the energy legislation that failed to move last year in Congress.

Various legislative proposals sought to provide up to $4,000 in consumer tax credits for advanced vehicles and also contained requirements that federal fleets include fuel-cell powered and other advanced technology vehicles, when available. When it returns to debate the energy bill this year, Congress should adopt these provisions.

Federal, state, and local governments also can promote the use of fuel cells by adopting procurement standards for government fleets and policies to promote their use in public transportation. Using fuel cells to power buses and other forms of public transportation is appealing because hydrogen storage does not pose as much of a problem as it does on passenger cars, where space is limited. California's Fuel Cell Partnership, which plans to put hydrogen buses on the road there by 2004, is one promising model.

Increase FreedomCAR's Funding

It is imperative that FreedomCAR become aligned with policies to promote clean energy. But adequate program funding also is crucial to FreedomCAR's success. The U.S. Department of Energy, which is charged with FreedomCAR's administration, has requested $150.3 million to operate FreedomCAR in 2003.[8] If FreedomCAR is administered correctly, this funding level falls far short of what is required to accelerate a hydrogen transportation future. To put this number in perspective, consider that the cost to build facilities capable of producing 1.6 million barrels of hydrogen a day have been estimated to be $400 billion for production and another $175 billion for hydrogen distribution.[9]

If the nation is serious about accelerating the development of a hydrogen transportation economy, then Congress must commit far more money to FreedomCAR than its current annual appropriation. However, should FreedomCAR, like its predecessor PNGV, direct scarce public dollars toward the wrong types of research and researchers, then the initiative's $150 million in annual research funding will prove to be far too costly.

Conclusion

As PNGV was pushing efforts to build a prototype for a high-tech diesel sedan, Toyota and Honda (who were not part of the initiative) raced far ahead of the U.S. companies in commercializing hybrid electric vehicles. Indeed, Ford even bought much of the advanced technology for its first hybrid vehicle, the Escape, from Toyota. FreedomCAR faces a far greater, more daunting challenge than its predecessor: to accelerate a hydrogen economy. In its present form, FreedomCAR, like PNGV before it, is only a *research* initiative. But to accelerate the hydrogen economy, the federal government must fund products that result in the commercialization of new technologies.

FreedomCAR is a step in the right direction. But it is a small step. As presently conceived, FreedomCAR will do little to reduce our oil dependence or clear the air of tailpipe exhaust for at least the next decade, and may even divert attention away from the pressing need for energy conservation and efficiency. In order to accelerate the hydrogen transportation economy, FreedomCAR must be aligned with other policies that can promote a clean energy future. At a minimum, the White House must not misuse FreedomCAR simply as a way to forestall more rigorous fuel economy requirements. Policies to promote a clean energy future are particularly critical, not just to assure a timely transition to fuel cells and hydrogen, but also to accelerate the commercialization and adoption of cleaner, more efficient technologies on the road today, including hybrid electric vehicle technologies.

If we take to heart these recommendations, however, FreedomCAR could be the first step toward transforming our automotive and energy industries, and creating a more sustainable transportation and energy system.

Suggested reading

Sperling, Daniel, "Updating Automotive Research," *Issues in Science and Technology,* Spring

2002. Adapted from testimony before the U.S. Congress, House Science Committee, on February 7, 2002.

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Endnotes

1. Nance, S., "Fuel-Cell Vehicles Hold Promise, Big Questions," *The Energy Daily,* April 24, 2002.

2. Kempton, Willet, Jasna Tomic, Steven Letendre, Alec Brooks, and Timothy Lipman, "Vehicle-to-Grid Power: Battery, Hybrid, and Fuel Cell Vehicles as Resources for Distributed Electric Power in California," A report to the California Air Resources Board, 2001. Available at: **http://www.acpropulsion.com/Veh_Grid_Power/V2G-Cal-ExecSum.pdf**.

3. Roan, D.L., "DOE's FreedomCAR: Hurdles, Benchmarks for Progress and Role in Energy Policy," Testimony by the Vice President and Chief Technology Officer, Chevron-Texaco, before the Committee on Energy and Commerce Subcommittee on Oversight and Investigations, U.S. House of Representatives, June 6, 2002.

4. Chapman, Rob, "The Machine That Could: PNGV, A Government-Industry Partnership," RAND, Santa Monica, CA, 1998.

5. Universities are now only educating and training students by the handful to design and engineer fuel cells and related technologies. Automakers are obligated to recruit engineers with no experience in fuel cells and train them in-house. That is highly inefficient, and will not allow for a rapid ramping up of fuel cell vehicle production. Universities need funding and support to develop new programs, especially when they are interdisciplinary, as these must be. PNGV (via DOE) provided only about $1 million to $2 million per year to universities, about half that for 10 university centers of advanced vehicle technology.

6. Hoffmann, Peter and Robert Rose. "Toward Tomorrow's Energy: Speeding the Commercial Use of Fuel Cells and Hydrogen." *Progressive Policy Institute,* Washington, D.C. 2002, **www.ppionline.org/ppi_ci.cfm?contentid=251177&knlgAreaID=144&subsecid=304**.

7. Stoffer, Harry, "Unmoved by hydrogen, critics seek higher CAFE," *Automotive News,* January 21, 2002.

8. Garman, D.K., Testimony by the Assistant Secretary for Energy Efficiency and Renewable Energy before the Committee on Energy and Commerce Subcommittee on Oversight and Investigations. U.S. House of Representatives, June 6, 2002.

9. Study by Argonne National Laboratory (ANL/ESD/TM-140) as cited by Roan, D.L., "DOE's FreedomCAR: Hurdles, Benchmarks for Progress and Role in Energy Policy." Additional comments attached to testimony by the Vice President and Chief Technology Officer, Chevron-Texaco, before the Committee on Energy and Commerce Subcommittee on Oversight and Investigations. U.S. House of Representatives, June 6, 2002, p. 6.

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