

Defining the Future: Potential Enhancements to the FreedomCAR Program

With a new national commitment, our scientists and engineers will overcome obstacles to taking these cars from laboratory to showroom, so that the first car driven by a child born today could be powered by hydrogen, and pollution-free. Join me in this important innovation to make our air significantly cleaner, and our country much less dependent on foreign sources of energy. State of the Union Address, January 28, 2003

Introduction

In committing to the advancement of hydrogen fuel technologies, this administration has made a significant departure from the previous administration's Partnership for a New Generation of Vehicles (PNGV), which focused on the relatively near-term advancements in gasoline Internal Combustion Engine (ICE) hybrids. However, we must remember that our predecessors' program can provide valuable lessons as we refine our approach. By examining the specific strengths and weaknesses of PNGV, we can identify strategies to improve the quality of the current program. There are also major issues beyond the scope of PNGV that, due to innovative nature of FreedomCAR, are now central to the execution of the program. The following represents a first step toward the development of real, implementable interventions that will make FreedomCAR's legacy at least as great, if not greater, as that of PNGV. In moving forward with this initiative, we must ask ourselves: Are our efforts bringing us closer to our original goals? If not, should we refocus our efforts to better reflect the spirit of the program?

This memo has been written under the assumption that the Bush administration has made a firm commitment to hydrogen. Despite a variety of critiques, it would be politically risky to turn back on this very public choice. The enormity of the challenges necessitates our full attention. Any signs that this is waning will reduce our chance of a lasting impact.

A. PNGV Lessons

Design Goals and Evaluation Process

PNGV had a series of specific goals, all leading to the ultimate target of developing a market-ready prototype that could achieve fuel efficiency of at least 80 mpg (80 miles per 114, 132 BTUs if based on alternative fuels). A selection of target vehicle was to be made by 1997, the development of a concept prototype would occur by 2000, and production prototype would be ready by 2004. This could not be just any vehicle; the final product would have the equivalent safety, performance, cost, and comfort characteristics of a contemporary mid-size, family sedan. The emphasis was on a vehicle that could enter the market as a true option for consumers. The first two goals were met within the time-scale, with the announcement of three concept vehicles in 2000: Daimler-Chrysler's ESX3, Ford's Prodigy, and GM's Precept. All of these cars were originally expected to have fuel efficiencies between 70-80 mpg.¹

However, four years later, a US-manufactured car with 80 mpg fuel efficiency has yet to reach the market. According to ACEEEEE figures for the 2004 model year, both Honda and Toyota have led the way in producing marketable, high fuel efficiency hybrid vehicles with the Insight (57 mpg city/56 mpg highway) and the Prius (60 city/51 highway), respectively.² It appears that Ford will be the first of the Big Three to enter the retail market with its Escape hybrid, planned for release later this year. This vehicle is expected to achieve 35-40 mpg in the city and around 30 mpg for highway driving and represents a trend toward the development of hybrid SUVs.

¹ Standing Committee to Review the Research Program of the Partnership for a New Generation of Vehicles, National Research Council, Review of the Research Program of the Partnership for a New Generation of Vehicles: Sixth Report (2000)

<http://books.nap.edu/books/0309070945/html/2.html#pagetop>

² American Council for a Fuel Efficient Economy, Greenest Vehicles of 2004 Highlights
<http://www.greencars.com/12green.html>

It has been contended that the PNGV goals may have actually been *too* restrictive and not ambitious enough. Could even greater technology advances have resulted if developers were allowed greater latitude? For instance, the final production designs have tended to deviate from the original target of a mid-size vehicle. Automakers have argued that this departure from the original PNGV scheme is justified by the fact that hybrid small cars do not have the same cost recovery as larger, more expensive vehicles. If SUVs are truly a more effective option (still a questionable assertion), would an emphasis on even larger, more industrial vehicles have been appropriate? After all, approximately 40% of all transportation related emissions in the US come from heavy trucks, construction equipment, ships, and aircraft.³ Such tangents could not be as easily explored under the PNGV framework.

The idea that the program would produce cleaner cars that are “just as good” as the standard American vehicle may have also been misguided. If marketability was a major condition, then the features of the production cars should have been markedly better than the standard mid-size sedan.⁴ The public typically assigns a relatively low value to both fuel efficiency and emissions benefits. A survey conducted in 2003 indicated that only 5% of respondents would “immediately” purchase a more fuel efficient vehicle if fuel prices remained above \$2.75 for at least six months.⁵ Rather, it is argued that most would be much more willing to buy if the vehicle offered greater comfort, more power, and was more aesthetically pleasing than the average mid-size automobile.

³ Moore, Bill. “FreedomFuel or Folly?,” EV World, February 8, 2003, <http://evworld.com/view.cfm?section=article&storyid=489>

⁴ Lovins, Amory B. and Timothy C. Moore. Vehicle Design Strategies to Meet and Exceed PNGV Goals,” The Hypercar Center, Rocky Mountain Institute, August 1995, p. 1

Lesson for FreedomCAR: We are all aware of the criticism that FreedomCAR lacks concrete goals. Since we are still in the very early stages of exploring the technology, it would be unreasonable to establish market-oriented milestones similar to PNGV's. Additionally, PNGV has taught us that it is possible for goals to stifle potential innovation. However, without true aims it is very likely that the current program will be no more than a costly academic exercise with little to show for our efforts. Although the hydrogen economy is a distant prospect, there are sub-components of the hydrogen systems in which measurable, near-term achievements can be made. Potential areas of focus will be discussed throughout this document and a set of realistic recommendations will be made in the closing. During the PNGV era, frequent progress reviews were conducted by an Independent Oversight Committee within the National Research Council. If more concrete targets can be developed, such a review process should be useful for our program, which currently lacks such a defined structure.

We should not be discouraged by the fact that US automakers were surpassed by the Japanese in efforts to mass produce the highest-efficiency vehicles. There is some consolation in the theory of the PNGV boomerang effect. It has been observed that the US initiative inspired similar efforts in competing countries, which in turn spurred US companies to upgrade their research efforts to an even higher level. Although costly for competing firms, such a phenomenon should be viewed as a positive by a government that is officially more interested in the environmental and fuel security benefits. The stated goal is to overhaul the national vehicle fleet as swiftly and effectively as possible. It would be delusional to expect that this will occur solely through domestic innovation.

⁵ CNW Marketing Research, as quoted in Salem (OR) Statesman Journal article, Some drivers unfazed as gasoline prices ratchet up, Toby Manthy, April 8, 2004,

Technology Focus, But with a Degree of Balance

Although PNGV began in 1993 without a specific target technology, a general focus on gasoline ICE hybrid vehicles emerged in 1997. However, this did not mean that other, complementary technology efforts were completely ignored. Manufacturers realized that a variety of platforms could use similar components such as motors, electronics, battery technologies, and body design. For example, at the same time that General Motors engineers was developing a feasible hybrid system, they were also contributing to research that would make the hydrogen-fueled Precept a more realistic option. To develop the Fine-N concept car, Toyota (not a PNGV participant, but in pursuit of similar goals) combined electric and fuel cell technologies into one system. In the later years of PNGV, there was an increasing shift of program funding toward the hydrogen technologies that we are considering now.

Lesson for FreedomCAR: Although a target technology is declared, that does not have to mean that resources are being overly concentrated. It is best to prioritize major projects that could potentially have an impact beyond the hydrogen fueled transport sector. This concept has been a part of the FreedomCAR program from the very beginning, but our detractors still accuse us of putting all of our eggs in one basket. It would be our best interest to craft a public relations campaign that highlights the potentially widespread impact of our research.

Partnerships

PNGV has been praised for restricting itself to a manageable partnership network, which was primarily comprised of relationships with Ford, General Motors, and Daimler-Chrysler. FreedomCAR has followed closely by maintaining these as the fundamental private partnerships. This significantly reduces the complexities of the program and contributes to more effective implementation. In order to achieve even greater efficiencies, the FreedomCar has cut the multi-agency component of PNGV and placed most administrative responsibility within the Department of Energy.

However, it is important to recognize that this limited number of large partners could also be a liability. Conflict of interest is certainly a concern; the large automobile manufacturers are not necessarily in favor of more sustainable energy technologies. For instance, the Big Three's aversion to efficiency and emissions standards are well-known and it is safe to assume that they would be quite displeased if major technological leaps resulted in even more stringent policies. Additionally, federal funding, both under PNGV and the current program, is very small in comparison with the overall research budget for each partner. Federal funding is typically on the order of \$100-200 million per year, while combined Big Three "PNGV-related" investments have approached \$1 billion each year. Under such conditions, the main benefit to corporate partners is access to information and communications networks. However, communication and cooperation between partners declined as each of the Big Three approached the production stage. Proprietary information became much more of an issue in the later years of the PNGV program, thus eliminating many of the benefits of a partnership.

Lesson for FreedomCAR: Federal funding could be better spent by leveraging smaller research budgets, especially those that are more likely to be the real centers of

technological innovation. There is a great deal of outsourcing in the industry, meaning that the Big Three are not necessarily experts in many of the technologies that government is trying to promote. Also, a more encompassing definition of “hydrogen innovator” is necessary. As discussed in greater detail below, there must be less of an obsession with the vehicle technology and more attention paid to the supporting fuel production and infrastructure. Ultimately, stronger relationships, accompanied by a greater share of the funding pie, should be formed with smaller suppliers, academic institutes, and research firms. During PNGV, only 2% of the annual budget was directed toward education efforts. When encouraging a technology with as many “unknowns” as ours does, it is imperative that we invest a great deal more in training the engineers and auto workers of the future.⁶

Political Issues

It is impossible to avoid the political aspects of a project this large in scope. One of the major strengths of the PNGV program was that it had clear support at the very highest levels of both the Clinton administration and the automobile industry. In fact, it was regarded as a pet-project of the Vice President, therefore elevating it to a position of high priority. However, the project did not fare as well with other branches of government, specifically the US Congress. There was substantial hostility toward the program and frequent accusations that it was little more than “corporate welfare.” This limited the amount of funding directed toward PNGV research each year. Despite a number of National Academy of Science recommendations in favor of a centrally-

⁶ Sperling, Daniel. “FreedomCAR and Fuel Cells: Toward the Hydrogen Economy?” PPI Policy Report, January 22, 2003, http://www.ppionline.org/ppi_ci.cfm?cp=1&knlgAreaID=144&subsecid=304&contentid=251176

controlled budget, the program was never able to obtain a line-item in the federal allocations. This added a layer of financial uncertainty and limited the opportunities available to program administrators. There is no indication that this situation has changed with the new program.

The major goals of PNGV were well suited for publicity efforts. Each time a milestone was reached, it provided the administration with tangible proof that progress was indeed being made. Of course, this backfired when the final production goals were not reached by 2004. However, this does not discount the need for a strong public affairs effort.

Lessons for FreedomCAR: It is important that we gain the level of Congressional approval that PNGV never quite achieved. If it has not already been accomplished, a more centralized and dependable budget is needed to insulate the program from ebbs and flows in the political system. Finally, we need to give the public a greater sense that FreedomCAR is more than just a grand statement with few real world applications. Again, the establishment and effective promotion of more short-term, tangible goals would be a step in the right direction.

Accusations of Regulation Avoidance

The PNGV program has been portrayed as a convenient, politically-correct way for the Big Three to avoid more stringent fuel efficiency and emissions standards. The FreedomCar Program has also been subject to this type of criticism. It is important that we dispel this myth.

Although very risky from a political perspective, enhanced standards (both for efficiency and emissions) would demonstrate a true commitment to the principles of

FreedomCar. Leading the way on this front is the state of California, which implemented the CA ZEV mandate (1990 mandate stating that 2% of vehicles sold in 1998 should be zero-emissions emitting, 2001 should be 5%, 2003 should be 10%, etc.) However, national CAFÉ standards for both passenger vehicles and light trucks have not changed since the 1980s, with values at 27.5 mpg and 20.7, respectively.⁷ At the same time, the popularity of SUVs in recent years has pushed national efficiency averages down to approximately 20 mpg from a late-eighties peak of about 22 mpg.⁸

An administration that desires to make a significant impact, especially in the relatively short run, should reconsider current standards and the questionable practice of categorizing retail vehicles into two separate fleets (passenger vehicles and light trucks). PNGV initiated the first step toward creating production vehicles that could increase average fuel efficiency, now it is our role to spur actual market change. We cannot continue to ignore standards as we wait for hydrogen to work its “magic.” We will most certainly be waiting for a very long time.

There is a strong argument for enhanced standards. Comparisons with other countries show that the US lags far behind in average fuel efficiency⁹.

Country	Mpg
Austria	34
Belgium	35.3
Denmark	32.8
France	36.4
Germany	32
Ireland	34.7
Italy	34.1

⁷ Bureau of Transportation Statistics, Average Fuel Efficiency of US Passenger Cars and Light Trucks, http://www.bts.gov/publications/national_transportation_statistics/2003/html/table_04_23.html

⁸ <http://www.commondreams.org/headlines02/1030-03.htm>

⁹ Based upon data from European Conference of Ministers of Transport Council of Ministers, “Monitoring of CO2 Emissions from New Cars,” April 19, 1999.

Luxembourg	32.2
Netherlands	33.2
Norway	31.4
Portugal	35.9
Spain	35.8
Sweden	27.9
Switzerland	28.6
United Kingdom	32.7

Even China is joining the fuel efficiency bandwagon with standards planned for 2005 that will beat the US by 2 mpg and for 2008 that will raise that to 5 mpg.¹⁰ Notably, the tradition for clean technology research that has propelled Toyota ahead of its competitors was largely in response to early US regulations.¹¹ Greater regulation could ensure that the entire fleet becomes cleaner, not just US-produced vehicles. Otherwise, there are few incentives for carmakers to make significant progress – research investment can only bring the program so far.

Lessons for FreedomCAR: In order to demonstrate genuine commitment to the guiding principles of the program, an administration would be wise to bolster efforts with enhanced regulation measures. The proper “carrot and stick” combination could provide the extra push needed to create a real shift in the automobile market. Of course, this is at the risk of alienating long term partners. Furthermore, it is debatable whether regulation is really more effective than higher fuel prices at creating proper supply and demand for more fuel efficient vehicles. Regardless of these uncertainties, we should not believe that R&D funding is enough incentive to create lasting changes in the auto industry.

¹⁰ Mieszkowski Katharine. “Green China?”, November 20, 2003, Salon,
http://archive.salon.com/tech/feature/2003/11/20/china_pollution/

¹¹ Fairley, Peter. “Fill 'er Up With Hydrogen,” MIT Technology Review, Nov/Dec 2000
<http://www.technologyreview.com/articles/fairley0404.asp?p=4>

II. FreedomCAR Potential Points of Weakness

In addition to the issues raised above, FreedomCAR is also subject to a number of criticisms that were not relevant during the PNGV years. These include the choice of hydrogen as the primary technology, the means by which hydrogen is currently produced, and the fueling infrastructure required to make the hydrogen economy a reality.

Technology Choice

There are some that argue that pursuit of a hydrogen economy is not a worthwhile use of government funds. Moderate critiques accept the possibility of a hydrogen economy in the more distant future, while more extreme views dismiss it as unrealistic for any era. Some of the more common arguments include:

1) Cost: The technology is still much too expensive for universal deployment and prices are not expected to reach a reasonable level for many years. Current rates ensure that the hydrogen driver of today would pay 30% more per mile than for an average gasoline vehicle.¹² Opponents often point out that investment in near-term fuel efficiency improvements would be a more effective option.

2) Lifecycle Inefficiencies: The specific properties of hydrogen mean that the infrastructure for a hydrogen-based would be very energy-intensive. According to Bossel and Eliasson, “the input of electrical energy to make, to package, to transport, to store and to transfer hydrogen may easily exceed the hydrogen energy delivered to the end user - implying an well-to-tank efficiency of less than 50 per cent.”¹³ Just the production of 1

¹² Asaravala, Amit. “Pricey Pumps Hinder Hydrogen Cars,” Wired Magazine, October 22, 2003, <http://www.wired.com/news/autotech/0,2554,60926,00.html>

¹³ Bossel, Ulf and Baldur Eliasson. “Hydrogen Economy: Bright or Bleak?” Version distributed at the 2003 Fuel Cell Seminar (Nov. 2003)

unit of hydrogen would require 1.2 – 1.4 units of energy. A counter argument by Friedman suggests that the vehicle efficiencies gained from fuel-cell usage can make up for many of these losses.¹⁴ Such fundamental issues are still hotly debated in the scientific community and further research is needed to determine the true restrictions of hydrogen.

3) Potential Side-Effects of Hydrogen Economy: Some researchers suspect that our efforts to reduce fossil fuel emissions will simply lead to higher concentrations of hydrogen in the atmosphere, perhaps with an equally serious impact on the environment. Scientists at CalTech estimate that a full-scale hydrogen economy would result in leakages on the scale of 60-120 trillion grams of hydrogen released into air each year. This would be equivalent to 4 -8 times the current atmospheric concentrations.¹⁵ The potential impact is still largely unknown, but there must be funding for investigations of this and similar phenomenon. If mitigation measures are not in place from the outset, the shift to a hydrogen focus may be ultimately perceived as a great mistake.

These points, although valid, do not mean that we should immediately abandon our hydrogen efforts. However, they do mean that we must be more careful in selecting particular projects for federal investment. Projects that seek to lower overall costs, address system-wide inefficiencies, and more accurately determine the environmental impact of a hydrogen economy deserve priority.

Reliance on Fossil Fuels for Production

¹⁴ Mieszkowski, Katharine. "Not-so-clean cars," February 25, 2003, http://www.salon.com/tech/feature/2003/02/25/hydrogen_source/

¹⁵ "Does Hydrogen Fuel Pose Environmental Problems?," October 20, 2003. <http://www.pbs.org/newshour/science/hydrogen/environment.html>

Currently, we are acting as if hydrogen is a fuel with zero environmental impact. This is untrue, since fossil fuels used to produce most hydrogen today. According to the US Department of Energy, the breakdown is as follows¹⁶:

Source	Global Share
Natural Gas	48%
Oil	30%
Coal	18%
Water Electrolysis	4%
Total	100%

Regardless of whether the production method relies on natural gas, oil, or coal, certain levels of carbon dioxide are still produced as byproducts. Even the seemingly innocuous water electrolysis process is impossible without some form of electricity, typically from the grid which, again, is heavily reliant upon fossil fuels. However, the efficiencies of fuel cells mean that steam-reforming (methane based) process does result in significantly less carbon dioxide than does burning fossil fuels for the same amount of energy.¹⁷ (Muller, 2003)

The current policies show few signs of attempts to alter this situation. In the 2004 federal budget, there were reductions in renewable-related hydrogen research to \$17.3 million. Research for fossil fuel based technologies receive an equal amount (combined coal and natural gas funding is approximately \$17 million). The original 2002 National Hydrogen Energy Roadmap indicated that up to 90% of hydrogen was to be refined from non-renewables. Consequently, the stated goals for the hydrogen fuel program are currently at

¹⁶ Data gathered from US Department of Energy website.
<http://www.eere.energy.gov/hydrogenandfuelcells/hydrogen/production.html>

¹⁷ Muller, Richard A. "A Pollution-Free Hydrogen Economy? Not So Soon..." MIT Technology Review, July 11, 2003, http://www.technologyreview.com/articles/print_version/wo_muller071103.asp

odds with the production methods. In order to bring the program in line with our ideals, greater investment in renewable energy technology is required. The options are available and it is the responsibility of the government to ensure that research in this area is occurring. As an important side benefit, any progress made in renewable energy research will have implications for the entire US energy economy.

Fueling Infrastructure

PNGV's technology goals were so safe and achievable largely because the necessary fuel production and distribution infrastructure was well established. This allowed PNGV innovators to focus solely on the vehicle design. However, in order to create a true hydrogen economy, we must initiate a restructuring of the national fueling infrastructure. FreedomCAR has been widely criticized for underestimating the massive costs of such an undertaking. For instance, a recently installed station designed to service 8 vehicles per day at UC Davis cost \$600,000. This is a minuscule portion of the funds needed for a fully functional fueling network.¹⁸ The Department of Energy estimates that it would cost at least \$1 trillion to convert all infrastructure for a hydrogen economy. This makes the official commitment of \$1.2 billion seem woefully inadequate. This is not simply a matter of replacing every gas station with a hydrogen station. As mentioned earlier, researchers such as Bossel and Eliasson contend that the conversion, movement, and storage of hydrogen consume so much energy that the current costs outweigh the benefits.

However, we should not be intimidated by the scope of these problems or, even worse, simply ignore them in the hopes that someone else will take care of the

¹⁸ Asaravala, Amit. "Pricey Pumps Hinder Hydrogen Cars," Wired Magazine, October 22, 2003, <http://www.wired.com/news/autotech/0,2554,60926,00.html>

infrastructure issue. If the government does not take the lead in this area, the hydrogen program will come to a standstill. A more feasible alternative to a full restructuring is the establishment of concentrated nodes of hydrogen fuel activity. Hydrogen car lease programs can be created for companies that have already invested in stationary fuel cell sources.¹⁹ Such a scheme would still be expensive and the early efforts primitive, but it would at least give us a starting point for real advancement. A targeted federal program for early versions of this system will encourage innovators to create better, more effective designs. It would also contribute to advancements in the realm of stationary hydrogen fuel power, a technology that brings us even closer to our environmental and energy security goals.

III. Conclusion

If the goal is to leave a legacy of lower air pollution and petroleum dependence, the current hydrogen car path will never get us there. There is more to the success of FreedomCAR than just the vehicle technology. Even a focus on the fueling infrastructure, a major issue by itself, will not be addressing the whole problem. We do not want to be remembered as the administration that merely made a few interesting car prototypes – we want to create a better system. Whereas auto manufactures are very willing to share the cost and time needed for vehicle developments (as demonstrated by hybrid car and early fuel cell efforts) investment in the broader system will be a much less popular option. Keeping this in mind, we recommend that the following principles be added to the

¹⁹ Scheme attributed to Amory Lovins in Hydrogen Cars May Hit Showrooms by 2005, Janet Ginsburg for National Geographic Today January 29, 2003 (Originally published on October 16, 2001)
http://news.nationalgeographic.com/news/2001/10/1016_TVhypercar.html

program goals. Within each area, there should be as many tangible technology deployments as possible. The FreedomCAR program is our opportunity to:

Demonstrate a commitment to tangible progress

Explicitly focus on technologies that have benefits for propulsion systems other than hydrogen fuel cell. Set specific goals that ensure the implementation of these measures long before mass production of hydrogen vehicles. Although the entire vehicle prototype may not be immediately ready for mass-production, energy saving components may be easily incorporated into existing vehicle technologies. When this occurs, it is necessary to ensure that there is widespread media coverage. People need to know that they have the opportunity to “test out” innovative hydrogen car-related technologies by simply purchasing the latest hybrid ICE model.

Demonstrate a commitment to change

Show that we are not afraid of more strict regulations, both for fuel efficiency and emissions. This will not be popular, but the current system has too many weak carrots and too few sticks for any real progress to be made. Our corporate partners and the public will definitely protest such actions, but our current standards are increasingly unacceptable.

Demonstrate a commitment to innovation and learning

Increase funding to smaller partners including educational institutes, technology development firms, component suppliers, and labor organizations. Ensure that each dollar truly has an impact on the future of this technology and does not just get lost in the piles of Big Three R&D funds.

Demonstrate a commitment to infrastructure

Aim for a certain number of prototype placements that build on the Lovins nodal concept. Focus on federal departments initially, but also provide incentives for private companies (tax breaks, coverage of capital costs, etc.) to adopt this model.

Demonstrate a commitment to renewable energy

To ensure that a renewable framework gets started, we must set a very specific goal that the public can easily understand. For instance, we must say that we will develop a certain number of fully functional, entirely renewable, hydrogen energy production centers by a particular date. An ambitious (yet achievable) number of facilities and date of completion should be determined by a panel of energy experts. The facilities should be varied in both size and type of technology to ensure that we are exploring the greatest variety of options. This will obviously require an increase in funding for renewables.

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