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Lessons Learned from the Alternative Fuels Experience and How They Apply to the Development of a Hydrogen-Fueled Transportation System

M. Melendez, K. Theis, and C. Johnson

Technical Report

NREL/TP-560-40753

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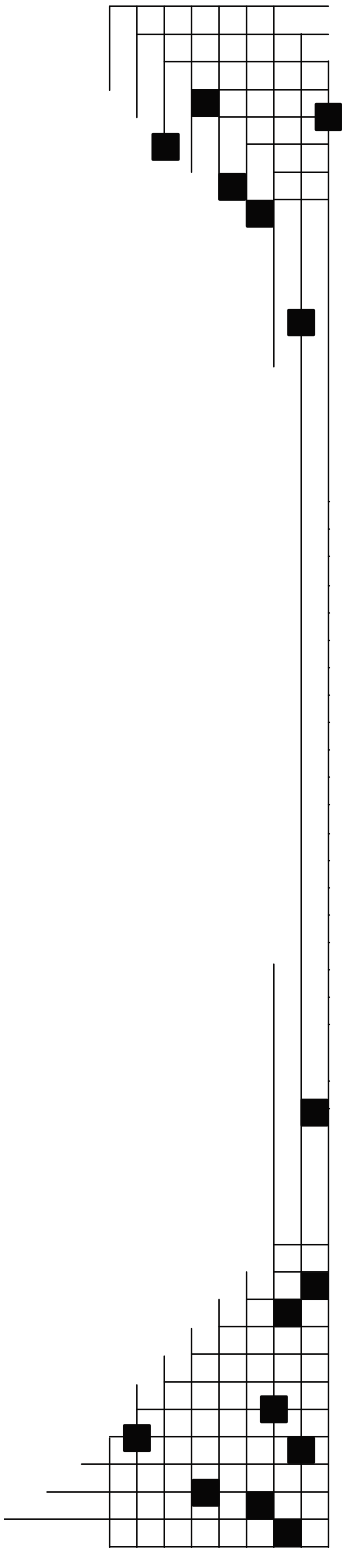

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Background

> *A simple chemical reaction between hydrogen and oxygen generates energy, which can be used to power a car producing only water, not exhaust fumes. 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.*
>
> – President George W. Bush, State of the Union Address, January 28, 2003

On January 13, 2006, the National Academy of Sciences released its recommendations on how best to develop the hydrogen future outlined by President George W. Bush in his 2002 Hydrogen Fuel Initiative and in his January 2003 State of the Union Address. The National Academy of Sciences' recommendations included direction to the U.S. Department of Energy (DOE) to sponsor an independent study of lessons learned in the efforts to deploy alternative transportation fuels and alternative fuel vehicles (AFVs) into the U.S. market. Specifically, the National Academy of Sciences directed DOE to research what it considered the lack of success and widespread market acceptance of previous alternative fuel technologies. The study would allow stakeholders in the development of a hydrogen future to:

- Assess the role of government policy and its stability as it affects industry and consumer behaviors
- Optimize strategies related to the introduction of hydrogen in the end-use sectors
- Avoid repeating mistakes of previous transportation technology introduction programs.

In response to the National Academy of Sciences' recommendations, DOE's Office of Energy Efficiency and Renewable Energy (EERE) sponsored a broad two-phased study of 1) the success/failure of alternative-fuel vehicle programs and corresponding legislative policies, and 2) how well alternative fuels and vehicles met customer requirements and achieved economic viability.

This report, *Lessons Learned from the Alternative Fuels Experience and How They Apply to the Development of a Hydrogen-Fueled Transportation System,* describes the results of the study and uses them to provide policy recommendations.

Research Methodology

Since 1994, the National Renewable Energy Laboratory (NREL) has worked on behalf of EERE to develop and evaluate advanced transportation technologies including alternative fuels and alternative fuel vehicles (AFVs). This work has been supported by activities within EERE's FreedomCAR and Vehicle Technologies Program. NREL's work with

alternative fuels activities such as Clean Cities, the Alternative Fuels Data Center, and the Advanced Vehicle Testing Activity, has resulted in extensive knowledge of the implementation of alternative fuels. In addition, NREL supports the DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program to develop viable hydrogen fuel cells and hydrogen fueling infrastructure. These combined bodies of work provided a solid foundation from which NREL researched the alternative fuels experience and recommended strategies for integrating hydrogen fuel cell vehicles into the U.S. transportation infrastructure.

Resources that NREL used in this project include several recently produced documents evaluating the deployment of AFVs and the development of a hydrogen infrastructure. Those documents are listed in the References.

NREL also tapped expert experience through a meeting of program and industry experts on July 20, 2006. Meeting attendees are listed in the Appendix. In addition, several industry experts, technology experts, and Clean Cities stakeholders provided input outside of the meeting.

We (NREL) have broken our contributors down into key stakeholder categories. These categories are:

- Policy makers
- Fuel producers and providers
- Fuel station owners
- Vehicle manufacturers and dealers
- Fleet decision makers
- Consumers.

We divided our study to capture the successes attained and challenges faced by each of these stakeholder groups as they attempted to integrate alternative transportation fuels and AFVs into the U.S. transportation market.

Each of these stakeholders plays a critical role individually, but is just one piece of the community necessary to implement the sea change that an entirely new transportation system requires. All the stakeholders are needed, so all must benefit from the change. Coordination among these groups is key because a transportation system cannot stand without the support of those creating infrastructure and manufacturing, purchasing, and driving vehicles.

Policy Makers

Regulations and Laws

Policy makers in state, local, and federal government have enacted a variety of regulations and laws to encourage the use of alternative fuels and advanced technology vehicles. According to DOE's Alternative Fuels Data Center, as of November 2006, there were 283 laws and regulations on the books with state and the federal governments that are designed to advance reduced-petroleum alternatives in transportation [1]. The Alternative Fuels Data Center considers regulations and laws that may impact the deployment of alternative fuels, AFVs, and advanced transportation technologies to include:

- Acquisition requirements
- Fuel taxes
- Idling restrictions
- Registration requirements
- Fuel production standards
- Vehicle driving restrictions
- Energy-based economic development plans
- Vehicle emissions inspections
- Renewable fuel standards
- Renewable fuel mandates
- Fuel use requirements.

Many of these regulations and laws were seen as effective by attendees of the July 2006 Lessons Learned Meeting. For example, Energy Policy Act (EPAct) state and fuel provider rules had a positive impact in some states.

> *"EPAct worked well for the state of New York. Adequate enforcement would cause it to be taken seriously in other states as well. EPAct done well, worked well; EPAct done wrong, didn't work.*" – Steve Ellis, Honda

Regulations mandating the use of ethanol and biodiesel in some markets and for some state fleets were considered effective and allowed the fuels to overcome a price disadvantage. For example, the success of E85 in Minnesota (which has more than 300 E85 stations) is due in part to that state's aggressive policy toward E10. More is possible.

> "*Half of Minnesota's "20% renewable" content mandate could be filled by E85. The 3 billion gallon market projected for 2010 would require 60% of all outlets or roughly 1,800 stations selling an average of 14,000 gallons/month."* – Tim Gerlach, American Lung Association of the Upper Midwest

Other regulations and laws were seen as less effective, often due to a mismatch between alternative fuel vehicle availability and the type of vehicle needed for a particular function, as well as budget constraints. The DOE's EPAct federal fleets program is one example and, according to meeting attendees, may be having limited success because government fleets are very budget driven. Additionally, the government procurement process—its complexity and the time required—has also limited the number of AFVs that have been purchased to fulfill government mandates.

Furthermore, there is also a mismatch between the mandates and the availability of alternative fuels, infrastructure, and vehicles.

Incentives

Incentive programs were generally seen as being more successful than mandates in increasing the number of alternative fuel and hybrid electric vehicles purchased. The Alternative Fuels Data Center lists 345 state and federal incentives that have been implemented to increase AFVs and advanced transportation technologies. Incentive programs include:

- Grants
- Tax incentives
- Loans and leases
- Rebates
- High-occupancy vehicle lane access
- Exemptions from requirements and restrictions
- Fuel discounts
- Technical assistance.

Of those, the hybrid electric vehicle tax credit is well used, according to meeting attendees, although there is some question as to whether the tax incentive is influential or if these drivers are already committed to making a "green" purchase. Other incentives, such as high-occupancy vehicle lane access, may also account for some of the popularity of hybrid electric vehicles.

Among loan and lease programs, many meeting attendees consider the California Air Resources Board's zero emissions vehicle program a success because of its broad approach. The program ran from 1998 – 2000 and under its specifications the board established memoranda of agreement with original equipment manufacturers (OEMs) who were producing zero emission vehicles. The OEMs placed more than 1,300 vehicles with fleets and consumers. The California Air Resources Board provided the manufacturers with entrée to fleets, assistance with infrastructure development, and an emergency respondents training program. It also offered consumer incentives including buy-downs for up to $5,000/vehicle and assistance with the installation costs of home rechargers...

Grant programs are popular for covering incremental vehicle and infrastructure costs in a fleet environment. A measure of their success is the amount of cost sharing provided by project partners. For example, in 2006 Clean Cities provided $8.6 million for 16 projects covering three topic areas—E85 infrastructure, incremental costs for AFVs, and idle reduction training and awareness for school districts. Project partners invested another $16 million in the projects.

Not all incentive programs met with success, according to meeting attendees. There was criticism that consumer and fleet incentive programs don't change the market price of vehicles, but only offset the OEM's costs. High-occupancy vehicle lane access for AFVs was criticized as an incentive because the more numerous and convenient hybrid electric vehicles often had this same access.

Overall, inconsistent public policy is seen as a fundamental barrier to the acceptance of alternative transportation fuels [2]. A disjointed and random collection of mandates and incentives, along with shifting priorities and short incentive terms, have led to confusion and the dilution of resources. Focusing resources on one alternative fuel, its vehicles and infrastructure, may be a more effective approach. Or, at a minimum, it's critical to not shift from fuel to fuel, but to maintain support for the same fuels and technologies over time.

> "*Consistent policy and economics are the only two factors that matter…DOE, DOT, and EPA need to coordinate.*" – Bob Myers, Propane Education and Research Council

Fuel Producers and Providers

Success for alternative fuel producers and providers is measured by net profits at the pump. Both volume and pricing are important. Sales at alternative refueling stations are greatly impacted by cost and how that cost compares to that of conventional fuels. In 2006, when the cost of petroleum-based fuels surpassed the cost of ethanol and biodiesel in some areas of the country, alternative fuel sales greatly increased. According to NREL senior scientist Robert McCormick, biodiesel sales grew more than 100% in 2005 and nearly that in 2006, and it's a market worth pursuing.

> "*It's a 60 billion gallon diesel market, and some producers are now* [July 2006] *selling B20 for less than petroleum diesel.*" – Robert McCormick, NREL

Despite some success in sales volume when pricing was optimum, alternative fuel producers and providers still face barriers. Competition against the economies of scale available to conventional fuels was seen as a key barrier to the use of alternative fuels [2]. It was suggested at the Lessons Learned Meeting that if the producers and providers of different alternative fuels worked together, they could enjoy some of those same economies of scale.

Different fuel delivery systems also impacted the market. Diesel, for example, is transported by pipeline, but biodiesel is transported by rail—an option that is 10-20 times more expensive, according to meeting attendees.

There have been isolated cases in which the biofuels industry has not been able to keep up with demand for ethanol and biodiesel in all areas of the country. These shortages and corresponding business opportunities have resulted in an increase in the number of biodiesel and ethanol plants under construction. The National Biodiesel Board reported in September 2006 that 65 biodiesel plants were under construction and 13 plants were being expanded at that time. That represents another 1.4 billion gallons per year in biodiesel production capacity [3]. And the Renewable Fuels Association's Ethanol Industry Outlook reported that ethanol production increased by more than 20% in 2006. In addition to the 106 refineries nationwide that have a capacity to produce more than 5 billion gallons annually, there are 48 ethanol refineries and seven expansions under construction with a combined annual capacity of more than 3.5 billion gallons of ethanol [4]. These supply and demand corrections are a common pattern in emerging industries.

> "*New industries tend to go through periods of rapid growth followed by correction where those businesses that are well-managed survive and those that are uncompetitive will fail. We don't expect that biodiesel will be any different. It will not be long before the rapid expansion of the biodiesel industry produces a shortage of feedstocks causing price increases that will challenge the profitability of biodiesel production.*" – J. Van Gerpen et al., Building a Successful Biodiesel Business, Second Edition [3]

Fuel quality was another issue discussed at the July 2006 Lessons Learned Meeting. Attendees agreed that fuel quality and high standards are necessary to win and keep consumers. B20 has recently faced quality issues. An NREL study sponsored by DOE and the National Biodiesel Board found that half of the B20 samples they tested between November 2005 and July 2006 did not meet current standard ASTM D-6751. The most serious concern was that about one-third of the samples failed to meet specifications for total glycerin. Total glycerin levels above the specification can cause operational problems in cold weather by clogging fuel filters. Additionally, some of the fuel samples failed sodium level and flash-point specification tests.

> "*The government needs to set quality standards for fuels. This is especially important for hydrogen because fuel cells can be completely ruined by contaminants.*" – Richard Parish, WestStart-CALSTART

Some Lessons Learned Meeting attendees suggested that emissions problems could be better solved during fuel production than with vehicle-based emissions remedies. Emissions have become less of an issue in the alternative fuels discussion, because new conventional vehicles are running so clean that alternative fuels do not significantly reduce regulated pollutant emissions. There are, however, substantial reductions in greenhouse gases when alternative fuels are used. Fuel producers and providers are marketing alternative fuels for both their emissions reductions and their contribution to the nation's energy security. The impact this promotion has had on sales is unknown.

Fuel Station Owners

Midwestern refueling stations that offer E85 were the big winners in 2006. According to Tim Gerlach, coordinator of the Minnesota Clean Cities Coalition and a vice president of the American Lung Association of the Upper Midwest, 2006 E85 sales in Minnesota increased 125% over sales in 2005 and 600% over sales in 2004. Today, more than 300 Minnesota refueling stations offer E85. Some stations (those in which mid-grade and premium sales were dropping and the stations had no franchise restrictions), replaced their mid-grade gasoline pumps with E85 at a relatively low conversion expense. In addition, a few retailers have begun installing E85 equipment with little or no financial assistance. However, retailers still face a lower return on investment with E85 compared to overall gasoline sales and many must seek grant assistance and other incentives.

The success of E85 in Minnesota is partially attributable to gasoline price spikes. At one point in the summer of 2006, E85 was averaging $0.43/gallon less than gasoline in Minnesota. Furthermore, infrastructure investment is minimized by the fact that the equipment required is very similar to that required for gasoline.

The most significant barrier to AFV integration, according to current literature, NREL engineers, and Clean Cities coordinators, is the availability of alternative refueling infrastructure for drivers [2]. As of November 2006, there were 737 compressed natural gas (CNG) stations and 1,167 E85 stations in the United States [1]. (See Figure 1 for a breakdown of fuel offerings from 1998 – 2006.) Comparatively, there were more than 167,000 gasoline stations [5]. That means that consumers who purchase CNG vehicles or flexible-fuel vehicles (FFVs) have to make a greater effort to fuel their vehicles with alternative fuels. To make matters worse, some of these fueling stations are private and provide alternative fuels to fleets only. While these fleets can present an attractive market for an individual station owner, they do not aid in the distribution of alternative fuel beyond fleets – to the public. Making these stations public would slightly increase the availability of alternative fueling stations, but security and liability are issues that discourage the station owners.

Additional barriers for fueling stations and the customers who use them include key card access limitations, misunderstood safety and fire codes, and lack of reliable information on station locations and hours of operation. This is especially true of stations that offer gaseous fuels because these require driver training before drivers can operate the pumps. However, progress has been made in California, New York, Arizona, and Texas where some CNG stations have been converted to accept major credit cards and provide video training for instant pump activation.

The introduction of FuelMaker's Phill provides consumers with home CNG refueling and also works to diminish the barrier of fueling station availability. Some meeting attendees felt that Phill may pave the way for a similar model to be used with hydrogen fuel.

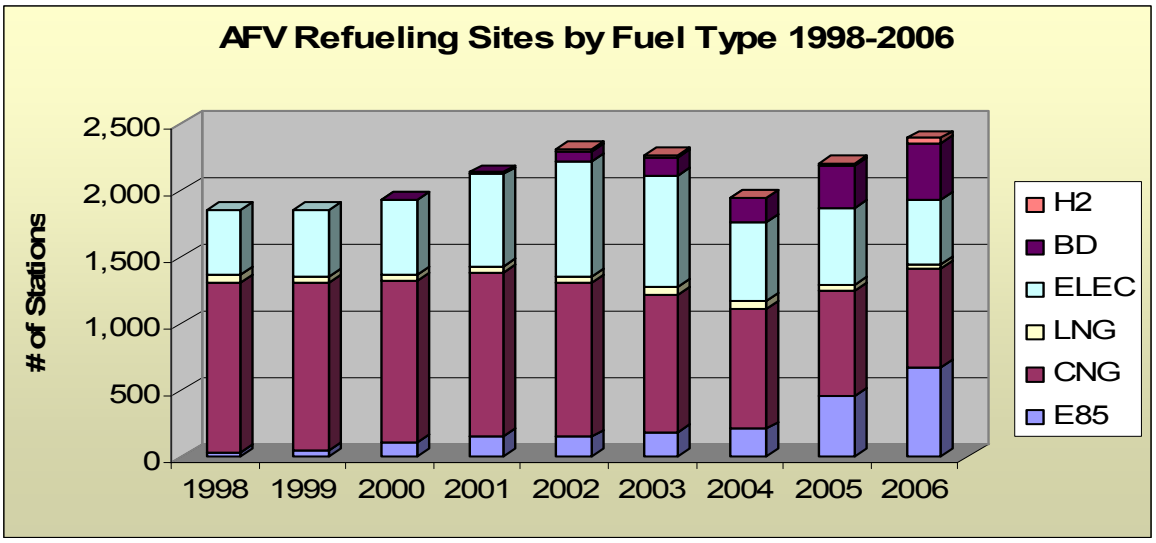

Figure 1. Refueling stations by fuel offered, November 2006

Vehicle Manufacturers and Dealers

Another key barrier to alternative fuels and vehicle proliferation is the availability of AFVs [2]. Approximately 15 million passenger cars and light trucks are sold annually in the United States. According to the Energy Information Administration, only 4,940 dedicated AFVs were made available to consumers in 2005 [6]. There are nearly 1,000 models that operate on conventional fuels and only about 30 models of AFVs available from OEMs, some in limited quantities. Given this lack of consumer choice, it is extremely difficult for AFVs to break into the conventional vehicle market.

OEMs at the Lessons Learned Meeting believed that some AFVs were still quite marketable, particularly FFVs and CNG vehicles. Initially, Honda thought that CNG was a good new and long-term investment because of its reduced emissions and 100% displacement of gasoline. Honda's first year fleet sales of 1,000 vehicles were twice what it expected. Among its targets were federal, state, and utility customers mandated by EPAct. Other targets included parking enforcement, local governments, cab companies, and rental fleets. But, according to Honda, it was eventually faced with lack of demand due to the fact that EPAct fleet rules were not expanded, there were few dedicated vehicles purchased by federal government agencies, GSA procurement was often difficult, and there was a lack of refueling infrastructure. These can be critical issues related to launching a new vehicle technology. Honda sees sales of CNG vehicles as providing critical experience and information to the hydrogen industry.

> "*CNG vehicle customers today are apprentices for hydrogen fuel cell vehicles tomorrow. Target them.*"– Steve Ellis, Honda

OEMs are offering 31 FFVs in model year 2007. Some industry experts believe that marketing the vehicles and E85 has been key to the growing success of FFVs. General Motors' "Live Green, Go Yellow" campaign is cited as an example. Of course, it's acknowledged that the majority of FFVs aren't fueling with E85. Consumers can wait to

use E85 whenever it becomes cost-effective and convenient. This flexibility has been the key to the growth in FFV manufacture and sales.

When hybrids are added to the advanced vehicle mix, incentives and early adopters are credited with some of the OEMs' successes. Other cited causes of success are ease of use and available infrastructure.

Existing markets, emissions standards, and fuel tank size and cost have influenced and limited the vehicle models available for alternative fuels. Biodiesel is prevalent in heavy-duty vehicles, but not in light-duty vehicles because there are very few light-duty diesel vehicles. A variety of models are offered as FFVs, including many sport-utility vehicles, and they help the manufacturers receive corporate average fuel economy credits without making extensive changes to the vehicles. The CNG light-duty market is restricted because of the CNG tank size and cost requirements—many CNG vehicles use trunk space for the large tanks, which limits the storage available in the car. The tanks can also be expensive, which adds to the vehicle price and cannot be offset, at this time, by fuel costs savings alone.

Dealers are independent from OEMs and, as such, need to hire or train their own experts to sell, maintain, and repair AFVs. Many of the dealers feel no incentive to develop expertise in AFVs because often they are bought by fleets, in bulk, and from a distant dealership. Furthermore, it doesn't make sense to invest in an AFV expert when the dealership sells and repairs so few of them. One possible solution for this is for free-lance AFV experts to hire out to multiple dealerships.

Fleets

AFV deployment efforts have targeted fleets. Regulations affecting federal, state, and alternative fuel provider fleets have spurred AFV sales, however they still represent less than 1% of the vehicles on the road today [2]. Notably, while this is a small number of vehicles, it can represent a significant amount of fuel sales to station owners.

High-volume fleets can become good AFV customers. South Coast Air Quality Management District rules are credited with building a strong network of interdependent fleets and fueling stations. Fleets are also seen as important markets for fuel suppliers because an anchor fleet guarantees a base level of fuel use for a station owner, helping to make that station economically viable.

Education of and assistance to fleets have been provided by the Clean Cities program, which has helped develop more than 85 community-based coalitions across the country. These coalitions provide testing grounds for market readiness for alternative fuels. Clean Cities and its stakeholders are seen as a strong network of alternative and advanced transportation experts that could be key in advancing hydrogen infrastructure and vehicles.

Additionally, DOE's Advanced Vehicle Testing Activity has evaluated alternative fuel and advanced vehicles operating in fleets. These evaluations of both light- and heavy-duty vehicles operating in real-word service have provided unbiased information about maintenance and operating costs so that fleets can make informed decisions.

While fleet efforts have been valuable, they have not moved AFVs into the hands of individual consumers. These consumers are seen as more demanding in terms of convenience, cost, performance, and range for their vehicles. Those same demanding drivers don't typically have the authority to dictate the vehicles used by a fleet. Those decisions are often mandated.

> "*Fleet versus retail are two totally different paradigms.*" – Matt Miyasato, South Coast Air Quality Management District

Consumers

Individual consumers who purchased AFVs did so because of their perceived environmental benefits, technological novelty, tax incentives, and, more recently, reduced fuel costs, according to meeting attendees.

With the exception of recent campaigns for E85 and FFVs and ongoing work by Honda in promoting its CNG Civic, individual consumers have not been targeted by OEMs or fuel providers attempting to sell AFVs or alternative fuels. Additionally, they have not been educated about AFVs or other advanced technology vehicles. Lessons Learned Meeting attendees thought this might be a valuable role for Clean Cities or similar locally based coalitions to fill. In fact, it may be critical in transitioning from a fleet strategy to a consumer focus.

> *"Why would we (as consumers) buy a vehicle that's unproven, has unknown resale value, limited fueling, and possible safety issues?"* – Bob Myers, Propane Education and Research Council

Conclusion: Lessons Learned

The effort to deploy alternative fuels and AFVs has uncovered pitfalls that could be of value to the hydrogen deployment effort.

Chief among the findings is that changing infrastructure is more complex than early AFV advocates may have realized. A coordinated deployment of vehicles and fueling infrastructure is difficult, yet essential. All players, notably those represented in this report—policy makers, fuel producers and providers, fuel station owners, vehicle manufacturers and dealers, fleet decision makers, and consumers—must work together to change a system that has been entrenched in the United States since the first half of the 1900s. Making sure that all stakeholders benefit from the change is key to getting them to do their part.

Costs, of course, make a difference. According to meeting attendees, the success of biofuels in the Midwest in 2006 showed that alternative fuels prosper when they cost less than conventional fuels.

Fleet use does not equate to consumer use. Fleets that are regulated have no choice but to purchase AFVs, if not alternative fuels. The strategies used to implement regulation are not the same as free market strategies. Additionally, fleets have more access to incentive programs and other resources than do individual consumers. Grants and other awards can

assist with a fleet's costs, and fleets often have access to vehicle and fuel experts. Individual consumers, on the other hand, don't know where to go for information and have not been the target of significant AFV marketing and promotional plans. They are looking for convenience, reliability, and low costs. The AFV market has not been able to provide that in all cases. Changing consumer behavior is a complex proposition.

Recommendations for Hydrogen Deployment

Hydrogen faces many of the same barriers that have been confounding the alternative fuel industry. There is very little developed hydrogen infrastructure, and there is a lack of knowledge among consumers, OEMs, and policy makers.

Added to that, hydrogen has issues of its own. It's early in the research and development stage and has some perceived additional safety concerns.

So, what recommendations do alternative fuel and advanced technology vehicle experts have for the nascent hydrogen fuel and vehicle industry?

- **Set realistic deployment goals. Don't let deployment get out ahead of research and development.** Currently DOE's Hydrogen Fuel Initiative is slated to receive $1.2 billion over the period FY 2004 - FY 2008. The initiative is a five-year commitment to develop the fundamental science and technologies to produce, store, and distribute hydrogen for use in fuel-cell vehicles, electricity generation, and other applications. Clearly the emphasis for the near term will be on R&D. In October 2006, for example, $100 million was awarded to 25 fuel cell R&D projects that will benefit both power production and transportation.

  According to the DOE plan, fuel cell vehicles will be available by 2020, and the "lighthouse model" will be key to their deployment.

  > "*Hydrogen will not be easy and may look like a failure if we don't set realistic expectations.*" – Steve Ellis, Honda

- **Educate policy makers, OEMs, vehicle dealers, fleets, and consumers.** There is confusion about hydrogen production, and hydrogen vehicle and fueling safety. Universities and colleges, technician training programs, trade press, Clean Cities, other local agencies, industry associations, and well-informed media can play key roles in education. The technology is not yet completely developed—there are many options for producing hydrogen. This leaves it particularly vulnerable to criticism, so timing of any outreach efforts is important and should take cues from the research and development timetable. Additionally, policy should be formed by educated stakeholders who can determine the most effective incentive programs.

- **Address both vehicle and infrastructure costs.** According to Britta Gross, General Motors, there will be a long and complicated transition period to economies of scale in deploying hydrogen vehicles and developing hydrogen infrastructure. This transition period will take government support to endure. One possible form of support could be a fuel subsidy. If another form, regulatory pressure, is used to move hydrogen into the market, incentives should be used to soften the costs to consumers.

Additionally, OEMs will need a significant commitment from government to offset incremental costs. Incentives should be sustained over a useful period.

- **Create and maintain a cohesive, consistent national policy.** Efforts like the "lighthouse model," organizations like Clean Cities, and government-backed incentives, regulations, and messages are all seen as valuable in the effort to deploy an advanced transportation system. But government efforts should be well thought out and coordinated. National policies for hydrogen fuel cell vehicles should be crafted only after alternative fuel and AFV data are gathered, so the impact of incentives and mandates can be analyzed and carried over to deployment efforts for hydrogen fuel and vehicles.

  In addition, a national policy should be long lasting and not susceptible to political whims. For example, financial incentives, such as those made to fuel station owners, should reflect a long-term commitment in order to see the business owner through the unprofitable start-up period.

- **Use local efforts for deployment.** Champions of hydrogen fuel cell vehicles will come from state and local governments, air quality entities, and environmental and health organizations. They can all play a very effective role in deploying vehicles, establishing infrastructure, and educating end users. Clean Cities coalitions provide the added benefit of access to federally funded resources, tools, and experts in advanced transportation technologies.

- **Use fleets for initial deployment, but create a strategy to leap to the individual consumer market.** While fleets are an important first step for hydrogen vehicle deployment and provide a valuable learning tool, they do not provide an automatic entrée into the consumer market. Strategies addressing consumer lifestyle (particularly sensitivity to cost and convenience) must be developed. Educational and marketing campaigns by automotive sales organizations should specifically target consumers. And, government or private sector programs to help manage incremental costs or encourage early adopters should be considered.

The Value of Lessons Learned

With more than 15 years of experience, the alternative fuels community is a treasure trove of information on how to implement change in the U.S. transportation system. While not all efforts have met with success, others, such as the growth of Clean Cities from one coalition in 1993 to nearly 90 today, provide a successful model for fuel and vehicle introduction. Additionally, all efforts, whether deemed successful or not, provide valuable insight.

The lessons learned by our stakeholders—policy makers, fuel producers and providers, fuel station owners, vehicles manufacturers and dealers, fleet decision makers, and consumers—are documented in this report. These lessons will be used to jump start the development of a hydrogen transportation system, accelerating the debut of the hydrogen future outlined in President George W. Bush's Hydrogen Fuel Initiative.

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Appendix. Lessons Learned Meeting Attendees

NREL, July 20, 2006

Participant	Association
Jesse Adams	DOE, Golden Field Office, Hydrogen Program
John Ashworth	NREL, National Bioenergy Center
Jill Banaszynski	General Motors
Analisa Bevan	California Air Resources Board
Linda Bluestein	DOE, EPAct Fleet Program
Todd Cambell	Clean Energy
Wendy Dafoe	NREL, Clean Cities
Carolyn Elam	DOE, Golden Field Office, Project Management
Stephen Ellis	Honda
Leslie Eudy	NREL, Advanced Vehicle Testing Activity
Karl Fiegenschuh	Ford
Henry Fowler	DOE, Golden Field Office, Project Management
Cliff Gladstein	Gladstein, Neandross and Associates
John Garbak	DOE, Hydrogen Program
Dale Gardner	NREL, Renewable Fuels Director
Tim Gerlach	American Lung Association; Clean Cities – Minnesota
Lee Grannis	Clean Cities – Connecticut
Sig Gronich	DOE, Hydrogen Program
Britta Gross	General Motors
Jill Gruber	DOE, Golden Field Office, Project Management
Terry Henry	Denver International Airport
Nina Hoffert	Lakewood (Colorado) Public Schools
Doug Hooker	DOE, Golden Field Office, Project Management
Fred Joseck	DOE, Hydrogen Program
Lynn Kaemmerer	Facilitator
John Lapetz	Ford
Maggie Mann	NREL, Hydrogen Program
Margo Melendez	NREL, Clean Cities
Bob McCormick	NREL, Non-Petroleum-Based Fuels
Shawna McQueen	Energetics
Matt Miyasota	South Coast Air Quality Management District
Bob Myers	PERC Consultant
Ernie Oakes	DOE, Golden Field Office, Intergovernmental Projects
Richard Parish	WestStart-CALSTART
David Peterson	DOE, Golden Field Office, Project Management
Vicky Putsche	NREL, Clean Cities
Stephanie Sung	DOE, Golden Field Office, Intergovernmental Projects
Keith Wipke	NREL, Energy Analysis
Lea Yancey	DOE, Golden Field Office, Project Management

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14. ABSTRACT *(Maximum 200 Words)*
The report discusses the successes and failures of alternative-fuel vehicle programs and how those lessons might be applied to the developing hydrogen-fueled transportation system.

15. SUBJECT TERMS
alternative fuels; alternative transportation fuels; aternative fuels experience; AFVs; hydrogen; hydrogen fuel cells; lessons learned meeting july 2006;

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