# IX.6 Policies to Promote Alternative Fuel Vehicles

David L. Greene
Howard H. Baker, Jr. Center for Public Policy
The University of Tennessee
1640 Cumberland Avenue
Knoxville, TN 37996-3340
Phone: (865) 974-3839
Email: dlgreene@utk.edu

DOE Manager: Fred Joseck
Phone: (202) 586-7932
Email: Fred.Joseck@ee.doe.gov

Project Start Date: October 1, 2013
Project End Date: September 30, 2016

## Overall Objectives

- By means of quantitative analysis, research, and synthesis of the literature, advance the understanding of how policies have and could affect the market success of hydrogen and fuel cell technologies.
- Assist in the development and use of models and analytical tools that are useful for predicting the effects of policies on the deployment of hydrogen infrastructure and consumers' purchases of fuel cell vehicles.
- Assist DOE and Argonne National Laboratory with planning and analysis of the transition to hydrogen fuel cell vehicles in the United States.

## Fiscal Year (FY) 2016 Objectives

- Conduct a thorough review of the past 15 years of peer-reviewed literature addressing policies to promote alternative fuel vehicles and summarize lessons learned in a published report.
- Develop a level playing field analysis of the refueling infrastructure costs of alternative fuels, with special focus on battery electric and hydrogen fuel cell electric vehicles.
- Provide analytical support to DOE's participation in H2USA, as requested by DOE.

## Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

(A) Future Market Behavior

(C) Inconsistent Data Assumptions and Guidelines

(D) Insufficient Suite of Models and Tools

(E) Unplanned Studies and Analysis

## Contribution to Achievement of DOE Systems Analysis Milestones

This project will contribute to achievement of the following DOE milestones from the Systems Analysis section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Milestone 1.16: Complete analysis of program performance, cost status, and potential use of fuel cells for a portfolio of commercial applications. (4Q, 2018)
- Milestone 1.19: Complete analysis of the potential for hydrogen, stationary fuel cells, fuel cell vehicles, and other fuel cell applications such as material handling equipment including resources, infrastructure and system effects resulting from the growth in hydrogen market shares in various economic sectors. (4Q, 2020)

## FY 2016 Accomplishments

- Completed a critical review of the past 15 years of peer-reviewed and gray literature that sheds light on the effectiveness of policies to promote alternative fuel vehicles. The review has been published as a Baker Center report and is available on the website of the Howard H. Baker, Jr. Center for Public Policy [1].
- Presented results of the literature review to DOE's Hydrogen and Fuel Cells Technical Advisory Committee, Hydrogen and Fuel Cells Program Annual Merit Review, and other venues.
- Completed a level playing field analysis of the costs of alternative fuel refueling infrastructure using the best available current information on costs and technology status.

## INTRODUCTION

Since the energy crises of the 1970s, the United States has tried to substitute alternative energy sources for petroleum use by motor vehicles. Achieving reductions in light-duty vehicle greenhouse gas emissions of 50% to 100% by 2050 would likely require that a majority of new vehicles sold in 2050 are battery electric or hydrogen fuel cell electric

vehicles [3,6]. Accomplishing such a large-scale energy transition for the public good poses new challenges for public policy [2].

More than a decade ago, McNutt and Rodgers [4] published a seminal assessment of alternative fuels policies from the enactment of the Alternative Motor Fuels Act of 1988 until 2003. This report updates and expands on their analysis.

## APPROACH

More than 90 recent studies covering a wide range of policies to promote alternative fuels and vehicles were analyzed to glean insights about the effectiveness of policies addressing the natural barriers faced by alternative fuel vehicles (AFVs).

- Lack of scale economies in the vehicle and fuel supply chains
- The need for further technological progress and learning by doing
- Consumers' lack of familiarity with and aversion to the risk of novel products
- Lack of diversity of AFV choices in vehicle markets (e.g., make, model, vehicle class)
- Lack of refueling infrastructure
- Lack of a market for alternative fuel
- Inappropriate administrative and regulatory infrastructure (e.g., codes, standards, ordinances)

Policies were grouped into six areas and findings were summarized.

- Reducing the cost of AFVs to consumers
- Increasing consumer awareness and reducing perceived risk
- Increasing the availability of alternative fuel refueling infrastructure
- Reducing the cost of alternative fuels
- Establishing supportive institutional and regulatory infrastructure
- Advantages of a systemic policy strategy

Cost estimates from 25 recent studies were analyzed to estimate current refueling infrastructure costs per mile and cost per gallon of gasoline equivalent (GGE) for light-duty vehicles. A spreadsheet was created to document all calculations. The estimates account for the energy content of fuels and relative efficiencies based on current vehicle technology. Various sizes of refueling stations were considered.

## RESULTS

The importance of providing substantial and sustained financial incentives to reduce the costs of AFVs to consumers is the most consistent finding in the literature. Financial incentives given at the time of purchase have two to ten times the impact of income tax credits or deductions and subsidies should be large relative to the incremental cost of an alternative fuel vehicle to insure salience in consumers' vehicle choice decisions. Financial incentives should be designed to be readily understandable by consumers and their availability should be well publicized. California's zero emission vehicle mandates have played a critical role in early market transformation by inducing manufacturers not only to research, design and offer zero emission vehicles, but also to subsidize their sale and the deployment of supporting recharging and refueling infrastructure.

Lack of awareness, unfamiliarity, and the perceived risk of purchasing a novel technology appear to be the most important non-financial barriers to AFV adoption. Most consumers' knowledge of AFVs is minimal and often inaccurate and many are waiting to see large numbers of AFVs on the road before they will consider purchasing one. Early adopters therefore play a critical role in the diffusion process. Maximizing the opportunities for consumers to experience an AFV first hand can accelerate early market development. Individuals concerned about climate change and energy security are far more likely to be early adopters than others, yet don't expect to pay more for vehicles that help achieve the same societal goals. Non-financial policies such as high occupancy vehicle lane access, free parking, and free plug-in electric vehicle (PEV) charging have value in their own right when local circumstances are favorable and serve as positive reinforcement for early adopters.

Findings about the importance of recharging and refueling infrastructure to AFV sales come chiefly from stated preference surveys and model simulations. Statistical analyses of PEV sales generally indicate that charging infrastructure promotes PEV sales. While public recharging infrastructure is beneficial to adoption of battery electric vehicles, it is not absolutely critical and is somewhat less important to potential plug-in hybrid electric vehicle than battery electric vehicle customers. For hydrogen fuel cell vehicles, refueling infrastructure is essential. The literature has not yet satisfactorily measured the importance of policies to increase fuel availability at low levels of availability. Underutilization of infrastructure in the early transition appears to be inevitable, yet excess infrastructure is almost certainly necessary to encourage the growth of the stock of AFVs. How much infrastructure should be provided, of what kind, where, and when continues to be a conundrum.

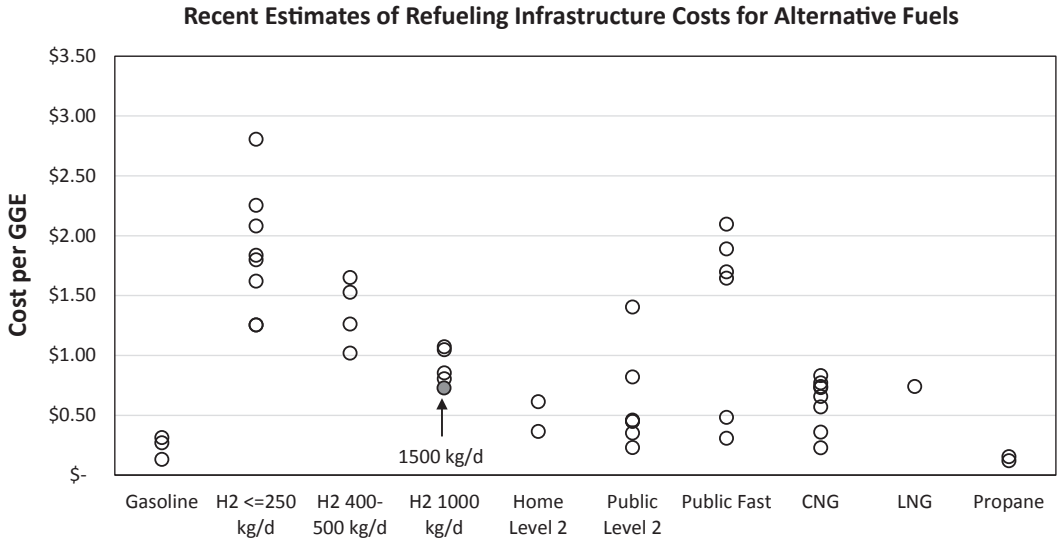
Reducing the price of alternative fuels is also critically important. Consumers expect alternative fuels to be competitive with the price of gasoline. Insuring competitive

pricing is challenging because the early stages of transition require excess investment in refueling infrastructure and therefore low utilization rates for AFV refueling stations. Direct public subsidies, investment tax credits, and public–private partnerships (driven by regulatory mandates) have all been tried with some degree of success.

Policy makers at local levels emphasize the importance of developing appropriate regulatory and institutional infrastructure for alternative fuels and increasing public awareness (e.g., through public information but also standardized signage), issues that are taken for granted with conventional fuels but that are critically important during the early stages of transition.

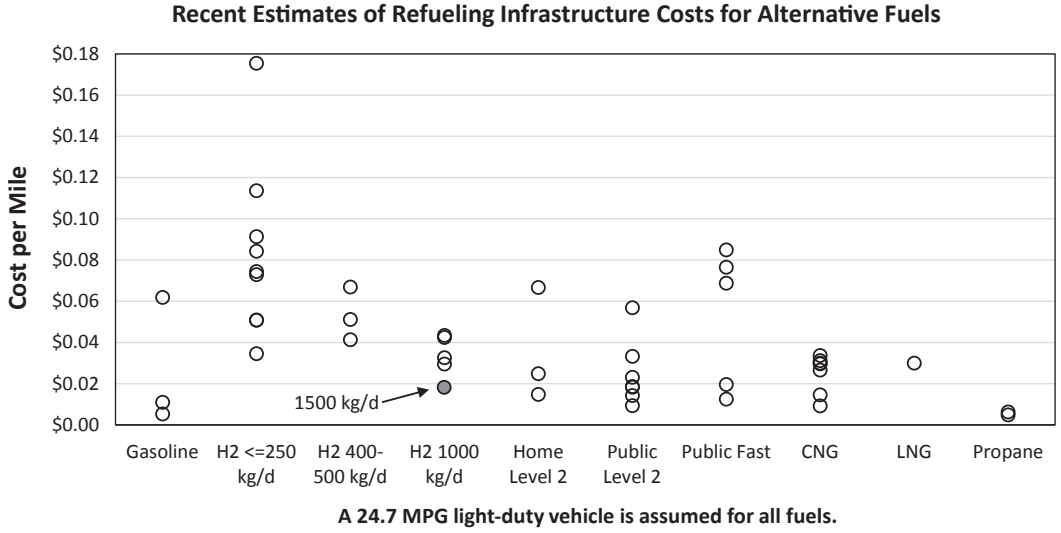
Because of the complexity and variety of market barriers to a transition to alternative fuels, comprehensive policy strategies that systemically address all barriers are more likely to be effective and economically efficient. Cross-national and regional analyses tend to support this conclusion, as well.

Graphs of refueling infrastructure costs per GGE and per vehicle mile were developed, based on current vehicle and refueling technologies. Figures 1 and 2 summarize the results.




CNG – Compressed natural gas; LNG – Liquefied natural gas

**FIGURE 1.** Estimates of refueling infrastructure costs per gallon of gasoline equivalent




MPG – Miles per gallon

**FIGURE 2.** Recent estimates of refueling infrastructure costs per mile for alternative fuels

## CONCLUSIONS AND FUTURE DIRECTIONS

Transitioning to low-greenhouse gas energy for motor vehicles will take several decades and the success of any one alternative is uncertain. Because of this, public policy must be persistent and flexible [5].

Accomplishing a large-scale energy transition for the public good is a new challenge for public policy. As more experience is gained from the ongoing market transformation process, future research will provide additional insights that will enable policy makers to refine and improve policies to promote the transition to sustainable energy for motor vehicles.

Future research should address accurately quantifying the interdependence of fuel availability and alternative fuel vehicle choice and developing effective means of modeling the coevolution of alternative vehicles and fuels. Further analysis of the benefits and costs of systemic policy strategies is needed.

## FY 2016 PUBLICATIONS/PRESENTATIONS

**1.** Greene, D.L. and S. Ji, 2016. "Policies for Promoting Low-Emission Vehicles and Fuels: Lessons from Recent Analyses," Baker Center Report 4:16, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, Knoxville, available at: http://bakercenter.utk.edu/policies-promoting-low-emission-vehicles-fuels-report-released.

**2.** Greene, D.L., 2016. "Analysis of Incentives and Policy Impacts on the Market for Alternative Fuels and Vehicles," presentation SA058, DOE Annual Merit Review and Peer Evaluation Meeting, Washington, D.C., June 8.

**3.** Greene, D.L., 2016. "PEV Charging Infrastructure: What can we learn from the literature?" STEPS Workshop, Critical Barriers and Opportunities for PEV Commercialization in California, University of California, Davis, CA, April 26.

**4.** Greene, D.L., 2016. "Policies to Promote Alternative Fuel Vehicles: What can we learn from the literature?" Hydrogen and Fuel Cell Technical Advisory Committee, Livermore, California, April 6.

**5.** Greene, D.L., 2016. "Why Hydrogen Fuel Cell Vehicles?" Pollution Probe Pathways Initiative Workshop, Toronto, Ontario, Canada, March 22.

**6.** Greene, D.L., 2016. "Accelerating Change: Towards Low Carbon Transportation," Center for Climate and Energy Solutions Webinar, February 18.

## REFERENCES

**1.** Greene, D.L. and S. Ji, 2016. "Policies for Promoting Low-Emission Vehicles and Fuels: Lessons from Recent Analyses," Baker Center Report 4:16, Howard H. Baker, Jr. Center for Public Policy, The University of Tennessee, Knoxville, available at: http://bakercenter.utk.edu/policies-promoting-low-emission-vehicles-fuels-report-released.

**2.** Greene, D.L., S. Park and C. Liu, 2014b. "Public policy and the transition to electric drive vehicles in the U.S.: The role of the zero emission vehicles mandates," *Energy Strategy Reviews*, vol. 5, pp. 66–77.

**3.** McCollum, D. and C. Yang, 2009. "Achieving deep reductions in US transport greenhouse gas emissions: Scenario analysis and policy implications," *Energy Policy*, vol. 37, pp. 5580–5596.

**4.** McNutt, B.D. and D. Rodgers, 2004. "Lessons Learned from 15 Years of Alternative Fuels Experience – 1988 to 2003", in D. Sperling and J.S. Cannon, eds., *The Hydrogen Energy Transition*, Elsevier Academic Press, San Diego, CA.

**5.** Melton, N., J. Axsen and D. Sperling, 2016. "Moving beyond alternative fuel hype to decarbonize transportation," *Nature energy*, article no. 16013, 2/22/2016, www.nature.com/natureenergy .

**6.** National Research Council (NRC), 2013a. *Transitions to Alternative Vehicles and Fuels*, National Academies Press, Washington, D.C.