X.3 Discrete Choice Analysis of Consumer Preferences for Refueling Availability

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Objectives

- Quantify the value of refueling availability to household consumers when considering the purchase of a new alternative fuel vehicle (AFV) with social and environmental benefits but some degree of limited refueling availability.
- Quantify cost penalties for three distinct geographic scales: (1) metropolitan: (2) regional (within 150 miles of the metropolitan center): and (3) national (along interstates).
- Express the cost penalties associated with different degrees of limited refueling availability on an equivalent basis as the purchase price of a new vehicle.

Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section (4.5) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Future Market Behavior

(D) Suite of Models and Tools

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 Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 3:** Begin a coordinated study of market transformation analysis with H2A and Delivery Models. (1Q, 2006)

Accomplishments

- Fielded a discrete choice survey tool in three major urban areas and attained responses from 1,486 respondents.
- Analyzed survey results and determined cost penalties associated with limited refueling availability on an equivalent basis as the purchase price of a new vehicle.
- Quantified cost penalties associated with limited refueling availability on three geographic scales: (1) metropolitan; (2) regional (within 150 miles of the metropolitan center); and (3) national (along interstates connecting major urban areas).

Introduction

A lack of convenient refueling availability can be a significant deterrent to household consumers considering the purchase of a hydrogen vehicle. Several studies have developed estimates of the number of stations that may be needed to satisfy the refueling availability requirements of early adopters, but only a limited number of studies have attempted to quantify the consumer value, or disincentive, associated with limited refueling availability. This study involves an analysis of consumer responses to a hypothetical vehicle purchase decision posed through a detailed survey tool. The focus of this analysis was to develop representative cost penalties associated with different levels and geographic scales (metropolitan, regional, and national) of limited refueling availability.

The coordination of station and vehicle introductions over time (and space) determines the degree of infrastructure utilization, and therefore significantly influences fuel costs. Understanding the role of consumer preferences for refueling availability in the decision to purchase a hydrogen vehicle can therefore help to inform DOE technical targets related to the cost of hydrogen fuel.

Approach

Discrete choice analysis methods are commonly employed to quantify consumer preferences for similar products with distinct attributes (i.e., cost, performance, appearance). In this study, a discrete choice survey tool was used to present a representative panel of households with a hypothetical choice to purchase one of two vehicles: a conventional vehicle and an AFV. In choosing which vehicle they would prefer, the respondents took into consideration quantitative descriptions of vehicle attributes such as cost and range, as well as quantitative and visual representations of different levels of refueling availability. The discrete choice methodology involves an algorithm that alternates vehicle attributes as respondents make choices in order to isolate the influence of different attributes on consumer preferences. In the survey, the AFV was described as being identical to the conventional gasoline vehicle in all aspects except two: 1) refueled availability might be more limited, and 2) the AFV would offer significant social and environmental benefits. The AFV was not associated with any particular alternative fuel.

A series of initial screening questions collected information about participants' driving behavior and acquainted them with the setup of the survey, the definitions used to describe vehicle attributes, and the maps used to represent refueling availability on three geographic scales: metropolitan, regional, and nationwide along interstate highways connecting major cities. An example map for the Los Angeles metropolitan area is shown in Figure 1. Similar maps were used to indicate levels of refueling availability on regional and nationwide geographic scales. Consumer responsiveness to vehicle purchase price was used to normalize responsiveness to other attributes, allowing preferences for different attributes to be expressed in equivalent vehicle purchase price dollars. Limited refueling availability could then be expressed as an equivalent cost penalty against the purchase price of a new vehicle.

Results

The survey was completed by 1,486 respondents, and statistically relevant coefficients were identified to quantify consumer preferences for refueling availability. In general, survey responses followed anticipated trends, with higher cost penalties being associated with more limited levels of refueling availability. Cost penalties associated with metropolitan area coverage were comparable to, but somewhat higher than, those found in other discrete choice studies, and were significantly higher than results from analytic studies based upon "rational" economic models of consumer behavior. Additional analysis and survey work will be required to refine this model, but preliminary results are summarized below.

Cost penalties associated with limited coverage on a metropolitan scale are indicated in Figure 2, where the horizontal axis indicates coverage in terms of an equivalent percentage of existing gasoline stations. Error bars indicate two standard deviations. Cost penalties drop with higher percentages, and are ranked by city

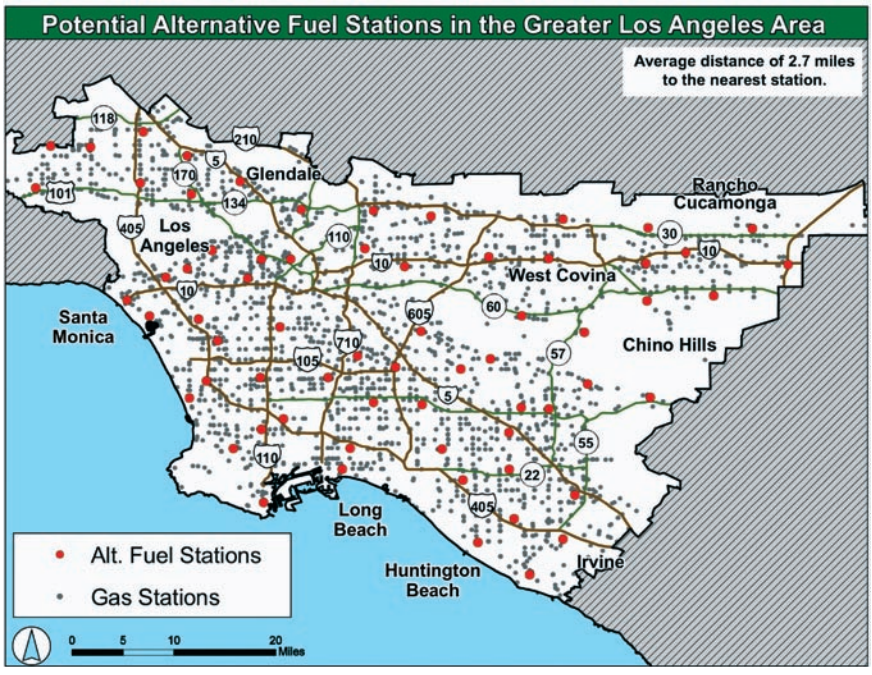

FIGURE 1. Example Map of Metropolitan Coverage in Los Angeles, California

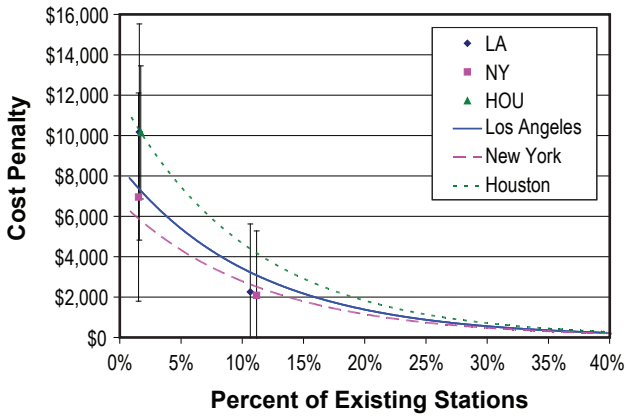

FIGURE 2. Cost Penalties for Metropolitan Coverage

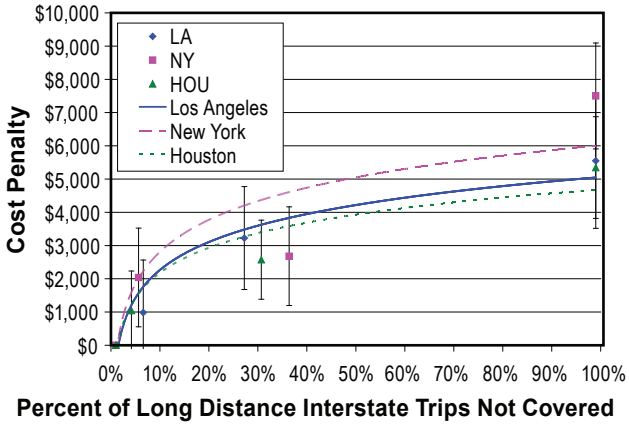

FIGURE 3. Cost Penalties for Interstate Coverage

population density: Houston is less dense than Los Angeles, which is less dense than New York. Generally, a very large cost penalty, roughly $20,000 to $30,000, was associated with no regional coverage, but additional trends in regional penalties are difficult to characterize. Figure 3 indicates cost penalties for limited coverage along interstates connecting major urban areas. In this graph, the horizontal axis is determined based upon the number of long-distance vehicle trips made from major urban areas to destinations across the country (using American Travel Survey data). The units are the percent of long-distance trips that would not be possible due to limited refueling availability, with no interstate coverage having the highest cost penalties on the right-hand side of the figure. Interestingly, significant cost penalties (roughly $1,000 to $3,000) are associated with the last 5-10% of long-distance trips not covered.

Conclusions and Future Directions

Significant cost penalties are associated with limited refueling availability. The results of the present study are based upon stated preferences, and are not as reliable as revealed preferences, but they do provide insights into the relative value of different types and levels of penalties for limited refueling availability. Preliminary results suggest that coverage on a regional scale (within 150 miles of the city center) and on a national scale (along interstates) are as influential as metropolitan coverage in the decision to purchase a vehicle. Additional analysis will be needed to improve the interpretation of these results, and a second survey will be fielded in 2008 in four additional cities with a more precise representation of metropolitan and regional coverage. This choice model will continue to be developed into 2009, and future work will involve integrating the model with "rational" representations of refueling availability preferences. A refined version of this choice model will eventually prove useful for a broad range of analysis applications, especially where the dynamic interaction of infrastructure development and vehicle deployment is modeled explicitly.

FY 2008 Publications/Presentations

1. Welch, C.; Melaina, M. *Using HyDIVE™ to Analyze Hydrogen Scenarios.* Golden, CO: National Renewable Energy Laboratory, 2008 Forthcoming.

2. Melaina, M.; Bremson, J. "The Cost of Refueling Availability to Urban Vehicle Purchasers." Prepared for the National Hydrogen Association (poster presentation). Sacramento, CA. March 30 - April 5, 2008.

3. Melaina, M.; Welch, C.; Baumgartner, R.; Rambo, E. "Consumer preferences for refueling availability: results of a household survey." Prepared for the Annual Conference of the National Hydrogen Association. Sacramento, CA. March 30 to April 3, 2008.

4. Melaina, M. W. *Discrete Choice Modeling of Consumer Preferences for Vehicle Refueling Availability: Interim Report for Phase I.* NREL/TP-560-43413. Golden, CO: National Renewable Energy Laboratory, 2008. Forthcoming.