Discrete Choice Analysis of Consumer Preferences for Refueling Availability

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Project ID #: AN15

This presentation does not contain any proprietary, confidential, or otherwise restricted information
Overview

Timeline

Project start date: September 2007
Project end date: July 2008
Percent complete: 60% (phase I complete)

Budget

Total project funding
- $510 K (DOE)
Funding received in FY07
- $190 K (DOE)
Funding for FY08
- $320 K (DOE)

Barriers

Systems Analysis
A. Future Market Behavior: “…hydrogen supply, vehicle supply, and the demand for vehicles and hydrogen are all dependent and linked.”

Hydrogen Production
Reduce the cost of hydrogen to $2.00-$3.00/gge (delivered) at the pump.
- Depends upon size and number of early stations required.

Partners

Subcontractor: PA Consulting (with Knowledge Networks)
Project lead: Marc Melaina, NREL
Objectives

• Quantify consumer reluctance to purchase an alternative fuel vehicle due to a lack of refueling availability.
  – Based upon survey results
  – Reluctance is expressed as a cost penalty against the purchase price of a vehicle

• Compare survey results to comparable results derived from analytic models
  – Assuming a certain “cost of time” associated with the additional distance traveled to a station

• Develop a general discrete choice model for major urban areas
Milestones

System Analysis MYPP Milestone
• “Begin a coordinated study of market transformation analysis with H2A and Delivery models” (2007 MYPP, p. 4-14)

Project Milestones
Survey Work
• Design and field survey in 3 urban areas Nov. 2007
• Complete subcontractor report (phase I) Feb. 2008
• Design and field survey in 4 additional urban areas May 2008
• Complete final subcontractor report (phase II) Aug. 2008

Other Work
• Compare results to analytic derivations July 2008
• Complete final synthesis report Sept. 2008
Approach: Discrete Choice Methodology

- Discrete choice methods are commonly applied in decision analyses of preferences for products with similar attributes.

**Hypothetical Example:**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Product A</th>
<th>Product B</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Color</td>
<td>A1</td>
<td>B1</td>
</tr>
<tr>
<td>B - Speed</td>
<td>A2</td>
<td>B2</td>
</tr>
<tr>
<td>C - Cost</td>
<td>A3</td>
<td>B3</td>
</tr>
</tbody>
</table>

- Previous studies of vehicle choice have included refueling availability as an attribute, but none have treated this attribute with a sufficient level of detail.
- Attributes included in survey:
  - Vehicle Purchase Price
  - Fuel Costs ($/mo)
  - Vehicle range (miles)
  - Refueling availability
    - Various types (see below)
Approach: Choosing between two hypothetical vehicles

What we asked:

- Respondents were asked to choose between two vehicles:
  - Conventional Vehicle
  - Alternative Fuel Vehicle
- Both vehicles were described as being identical to the respondent’s most recently purchased vehicle (with 3-4 years)

The Alternative Fuel Vehicle (AFV)
Described as identical to the Conventional Vehicle (CV) in all respects, except two:

1) Social and Environmental Benefits
   - Virtually no oil use, no smog-forming pollutants, and reduction in greenhouse gas emissions by 30%-70%
2) Limited refueling availability
   - Metropolitan, Regional and National geographic scales
Approach: Ensuring Clarity and Consistent Responses

• A series of preliminary questions were used to familiarize the respondents with:
  – Concepts used in the survey (e.g., AFV; percent of stations)
  – Maps used for each geographic scale
    • e.g., asked them if they could locate their homes on map
  – Types of choices they would be making in the discrete choice portion of the survey

• Follow-up questions and one-on-one interviews inquired about the difficulty of the survey
  – Only a small fraction of respondents found the survey very difficult
  – Map sizes were increased after the first round of beta testing
### Approach: Discrete Choice Survey Format (L.A. example)

Each refueling availability attribute has 4 levels.

<table>
<thead>
<tr>
<th>Vehicle Attributes</th>
<th>Gasoline Vehicle Similar to YOUR VEHICLE</th>
<th>Alternative Fuel Vehicle Similar to YOUR VEHICLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving Range</td>
<td>Same as YOUR VEHICLE</td>
<td>X miles</td>
</tr>
<tr>
<td>Average Distance to the nearest Metro Area Refueling Station</td>
<td>0.4 miles</td>
<td>Virtually NO oil used or imported No smog emissions 30%-70% fewer Greenhouse Gas emissions</td>
</tr>
<tr>
<td>Number of stations within 150 miles of the metro area</td>
<td>3,000</td>
<td>3,000 stations within 150 miles of the metro region. Same as conventional vehicles.</td>
</tr>
<tr>
<td>Long Distance Trips that are Possible</td>
<td>All destinations are possible</td>
<td></td>
</tr>
<tr>
<td>Distance Between Highway Stations Varies</td>
<td>Varies</td>
<td>X miles</td>
</tr>
<tr>
<td>Fuel Cost ($/month)</td>
<td>$ X</td>
<td>$ X</td>
</tr>
<tr>
<td>Purchase Price</td>
<td>$ X</td>
<td>$ X</td>
</tr>
<tr>
<td>Vehicle you are MOST likely to purchase</td>
<td>☐</td>
<td>☑</td>
</tr>
</tbody>
</table>
Approach: Metropolitan Maps (L.A., Level 1)
Approach: Metro Area Maps (L.A., Level 2)
Approach: Metro Area Maps (L.A., Level 3)
Approach: Metro Area Maps (L.A., Level 4)
Approach: Metro Region Maps (L.A., Level 1)

No stations beyond the metro area.
Approach: Metro Region Maps (L.A., Level 2)
Approach: Metro Region Maps (L.A., Level 3)
Approach: Metro Region Maps (L.A., Level 4)

3,000 stations within 150 miles of the metro region. Same as conventional vehicles.
Approach: Interstate Maps (L.A., Level 1)

No stations beyond the metro area.
Approach: Interstate Maps (L.A., Level 2)
Approach: Interstate Maps (L.A., Level 3)
Approach: Interstate Maps (L.A., Level 4)

All destinations are possible.
Approach: Equivalent Dollar Values

- Cost penalty results can be expressed on the same dollar value basis as the purchase price of the vehicle.
- Each attribute is included in a utility function, and parameters result from fitting the function to the survey responses.
- The utility function includes attributes ($X$) and corresponding coefficients ($\beta$):
  \[ U_i = \beta_i X_i \]
  Values for $i$ represent distinct attributes.
- The value of any attribute level can be expressed in terms of equivalent dollars values using the vehicle purchase price coefficient as a basis:
  \[ V_i = \frac{X_i \beta_i}{\beta_{VPP}} \]
Results: Overview

• Fielded survey in households in 3 major urban areas
  – Los Angeles, Houston and New York
  – Total of 1486 completed surveys

• Cost penalty results were consistent with expectations
  – Penalties increase at lower levels of availability
  – Lower penalties found for higher density cities (e.g., NY)
  – Exception was regional result for L.A.
  – Additional survey work will help clarify regional results

• Found statistically significant results for most of the geographic levels of refueling availability
  – Some levels were not distinguishable for some cities
  – Additional survey work will make levels more visually distinct
Results: Cost Penalties for Metro Area Coverage follow an Exponential Trend

- Lower costs for higher population density: NY < LA < HOU
- Basis is percent of sufficient stations (less than existing stations).

Note: HOU only has 2 data points
Results: Regional Cost Penalties Follow Exponential (LA) and Power (NY, HOU) Trends

Higher cost penalties for LA warrant additional survey work to understand preferences for regional availability.
Results: Significant cost penalties ($1000-$2000) remain even for long, infrequent trips

Note the inverted basis: long distance trips not covered
Results: Metro cost penalties are high relative to comparable studies

At 10% of existing stations, cost penalty is $3000 - $4000
Future Work

Motivation for analysis of additional urban areas:

• We would like to have a general cost penalty function that can be extrapolated to a large number of major urban areas.
• Penalties may vary between different city sizes and densities.
• Some geographic levels could not be valued with statistical significance

Analysis of preferences in four additional urban areas:

– Seattle, WA
– Minneapolis – St. Paul, MN
– Atlanta, GA
– Washington, DC

These four cities were chosen based upon their range of sizes and population densities.

• Expect results of additional surveys within 4 months of signing new subcontract with PA Consulting
Summary

• Consumer cost penalties for limited refueling availability are higher than those reported in most other studies
  ▪ $3000-$4000 for 10% coverage of existing urban stations

• The penalties for limited coverage at regional and interstate/national scales are comparable to those at the metropolitan area scale

• Cost penalties are probably exaggerated because they are based upon stated preference survey results

• Additional research is required to reconcile penalties based upon stated preferences and analytic derivations

• High cost penalties associated with limited refueling availability would provide a strong justification for financial support of more extensive hydrogen station networks for early vehicle markets