Fuel Choice for Fuel Cell Vehicles: Stakeholder Risk Analysis

Stephen Lasher (Primary Contact), Peter Teagan, Stefan Unnasch
TIAX, LLC
Acorn Park
Cambridge MA, 02140
Phone: (617) 498-6108; Fax: (617) 498-7054; E-mail: lasher.stephen@tiax.biz

DOE Technology Development Manager: Peter Devlin
Phone: (202) 586-4905; Fax: (202) 586-9811, E-mail: Peter.Devlin@ee.doe.gov

Objectives

- Assess opportunities and risks of various fuel cell vehicle (FCV) and fuel pathways, with specific focus on a transtion to a hydrogen infrastructure options.
- Assess impact on the various stakeholders (e.g. car manufacturers, energy companies, government, etc.) and how risks could be shared and minimized.
- Determine what range of factors might trigger the introduction of FCVs (e.g. oil price increase, carbon taxes, FCV cost reduction).

Technical Barriers

This project addresses the following technical barriers from the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

Hydrogen Production

- AD.Market and Delivery

Hydrogen Delivery

- A. Lack of Hydrogen/Carrier and Infrastructure Options Analysis

Hydrogen Storage

- V. Life Cycle and Efficiency Analysis

Approach

- Develop a net present worth (NPW) analysis of both the fuel and vehicle aspects, but with the focus on the transitional risks of a hydrogen fuel infrastructure.
- Generate a "straw-person" scenario of the hydrogen infrastructure introduction based on results from previous work, literature sources, and additional analysis.
- Present the straw-person scenario assumptions and NPW results to a quorum of FCV developers, fuel distributors, and fuel producers.
- Refine the analysis and rank the fuel pathways with respect to a set of performance criteria, in particular to overall financial risk.

Accomplishments

- Constructed a NPW analysis for hydrogen.
- Generated a straw-person scenario focusing on two hydrogen fuel chains: forecourt (i.e. on-site, distributed) natural gas-based production and central natural gas-based production with liquid hydrogen delivery.

- Presented the straw-person results to a limited number of stakeholders.
- Updated the NPW analysis assumptions based on stakeholder input to date.

Future Directions

- Define "lowest-cost" and "most likely" hydrogen infrastructure scenarios and present NPW results to a larger stakeholder audience.
- Define a straw-person FCV scenario and present NPW results to a limited number of stakeholders.
- Evaluate feedback and update model as appropriate based on stakeholder input.
- Evaluate the technology risk, financial exposure, and safety and regulatory risks associated with the various fueling options for each respective stakeholder.
- Generate final report for DOE vetted by key stakeholders.

Introduction

In the previous phase of work, TIAX assessed the well-to-wheel energy use, greenhouse gas emissions and ownership costs of various fuel choices for fuel cell vehicles (FCVs) at a future point in time assuming high capacity factors and high manufacturing production volumes for equipment (Lasher, et al 2001). However, alternative fuels, especially hydrogen, will require significant up-front investment during a transition period, representing a risk to both vehicle manufacturer and fuel provider. The financial risks involved in each of the fuel options vary, and the risk may shift from one player in the value chain to another. Dealing with this risk represents a formidable barrier to the use of alternative fuels, especially hydrogen, for FCVs. In the current phase of work, the DOE has commissioned TIAX to assess the relative risks of various fuel pathways for use in FCVs.

Approach

In order to evaluate financial risks and the effect that potential triggers may have on the various stakeholders, we will develop a net present worth (NPW) analysis. The NPW analysis will take into account the time value of money so that early investments are weighted more heavily than future profits. We will start with an assumed number of FCVs on the road and estimate how the alternative fuel infrastructure (i.e. hydrogen) will be introduced over time. Other inputs will include capital costs as a function of production volume, operating costs, fuel prices (e.g. gasoline, hydrogen), and fuel savings. The NPW analysis will include both the fuel and vehicle aspects, but with the focus on the transitional risks of a new fuel infrastructure.

We will generate a "straw-person" scenario of the hydrogen infrastructure introduction based on results from previous work, literature sources, and additional analysis. We will present the straw-person scenario assumptions and results to a quorum of FCV developers, fuel distributors, and fuel producers, to verify and refine the assumptions and the analysis and discuss the risk aspects for each stakeholder. Based on the feedback from these presentations, we will refine our analysis and rank the fuel chains with respect to a set of performance criteria, in particular to overall financial risk.

Results

We have developed a straw-person scenario with preliminary input assumptions. The assumed hydrogen FCV introduction is based on the conservative scenario results from DOE's Vision Model. Hydrogen infrastructure introduction is assumed to be built up regionally with 10% regional coverage achieved in the 3rd year (10% coverage means one in ten existing fueling stations would have hydrogen capacity). Hydrogen infrastructure proceeds from region to region so that local coverage can be achieved while maintaining reasonable capacity factors. In a single region, hydrogen fueling stations are carefully constructed to coincide with appropriate FCV introduction over a 15-year period. A single region is assumed to be similar in size and make-up to the South Coast Air Quality Management

District (SCAQMD). The 50-year infrastructure introduction for the whole U.S. is presented in Figure 1. Note that we have assumed installations will favor smaller stations (30 FCV/day capacity) with their higher capacity factors in the early years (0-20 years) compared to larger stations. However, larger stations (300 FCV/day capacity) are favored overall when demand increases due to their lower capital costs per unit hydrogen capacity. Capital costs for the fueling station equipment are reduced using progress ratios as production volumes (i.e. number of fueling stations) increase.

A NPW model was constructed for forecourt and central plant hydrogen generation for use in direct hydrogen FCVs. The model can be used to track the NPW results for various input assumptions, such as FCV and hydrogen infrastructure introduction scenarios, central plant size, hydrogen selling price, fueling station capital and energy costs, and many others. Figure 2 is an example of the sensitivity of the hydrogen infrastructure NPW to various input parameters. The straw-person baseline scenario assumes hydrogen is sold for $2.80/kg (excluding tax), which would result in cost parity with a conventional vehicle on a $/mi basis assuming 30 mpg and $1.07/gal for a conventional vehicle and 80 mpeg for a hydrogen FCV. The model is also set up to track cash flow and capital investment over time for the various stakeholders. Figure 3 is an example of the cash flow and capital investment of the entire hydrogen infrastructure.

It should be noted that the straw-person assumptions are based on projections of the future cost of a high efficiency hydrogen infrastructure. We did not use DOE targets, and there is on-going work at DOE and various industries to improve costs and performance beyond those projected here. In addition to refining the straw-person analysis, incorporating the potential improvements from the following could improve the straw-person NPW and cash flow results:

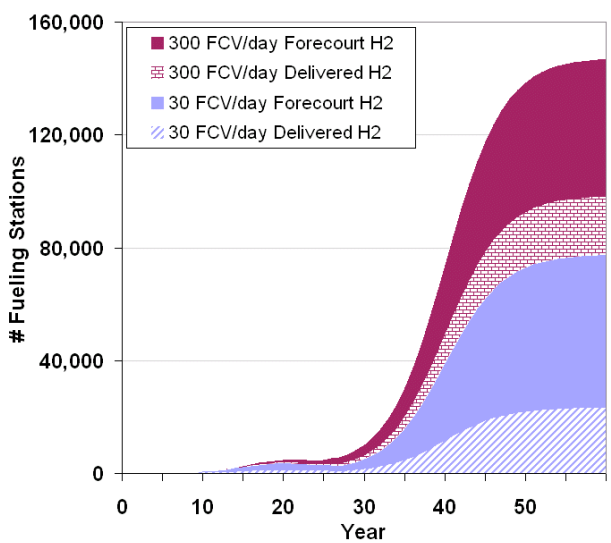

Figure 1. National Hydrogen Stations Buildup - Straw-person Scenario

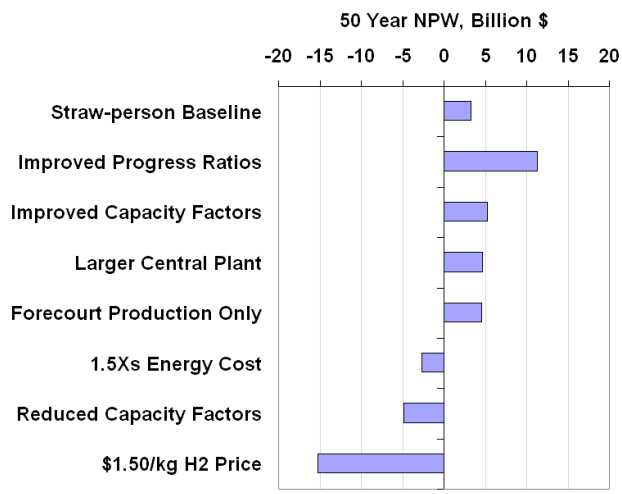

Figure 2. Hydrogen Infrastructure 50-Year NPW Sensitivity - Straw-person Scenario

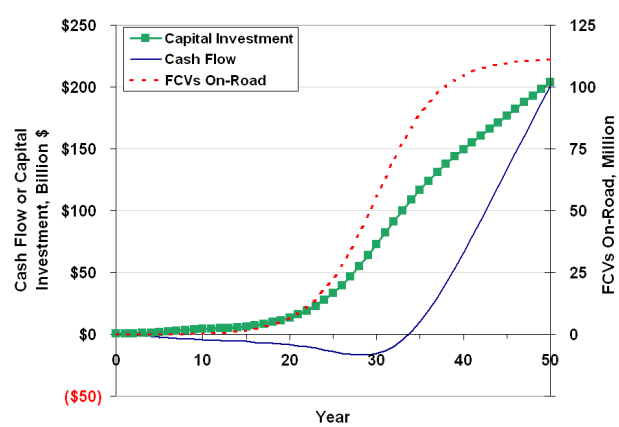

Figure 3. Cash Flow and Capital Investment for Hydrogen Infrastructure - Straw-person Scenario

- Utilize existing excess hydrogen capacity (e.g. methanol and ammonia plants)
- FCV demonstrations and fleets (e.g. buses, government vehicles, etc.)
- Hydrogen internal combustion engine vehicles
- Energy stations (i.e. hydrogen forvehicle fueling and stationary power)

Conclusion

Using the straw-person scenario for hydrogen infrastructure introduction, a few general conclusions can be drawn:

- Hydrogen production costs could ultimately be low (<$2/kg), but initial costs are high due to high capital cost and low capacity factors in the early years (see Figure 4).

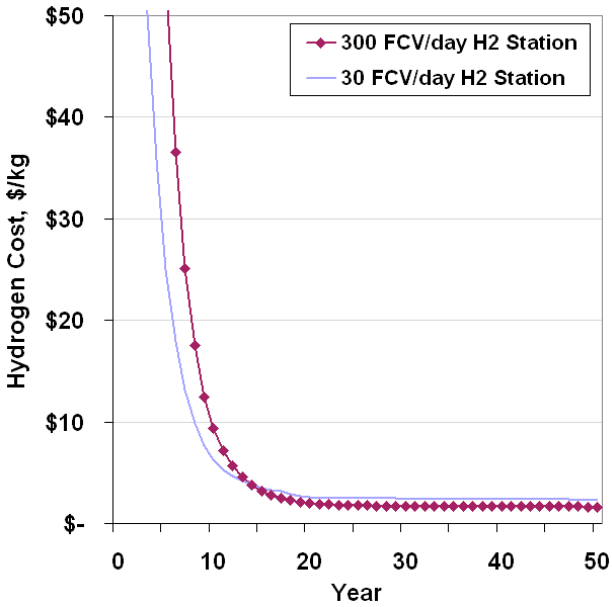

Figure 4. Projected Hydrogen Costs from Forecourt Stations - Straw-person Scenario

- If hydrogen were priced to provide cost-parity with conventional vehicles, the hydrogen infrastructure stakeholders could turn a profit in the long-run, but break-even would not be achieved for many years.
- Near-term pathways are needed to improve capacity factors and reduce capital cost of the hydrogen infrastructure.

References

1. Lasher, S., J. Thijssen, S. Unnasch, "Guidance for Transportation Technologies: Fuel Choice for Fuel Cell Vehicles", 2001 Annual Progress Report - Fuels for Advanced CIDI Engines and Fuel Cells, EERE OTT, November 2001

FY 2003 Publications/Presentations

1. Lasher, S., "Guidance for Transportation Technologies: Fuel Choice for Fuel Cell Vehicles", presented at 2002 American Chemical Society Meeting, Boston MA, August 18-22, 2002

2 Thijssen, J., "Fuel Choice for Fuel Cell Vehicles: Near-Term and Long-Term Perspectives", poster at 2002 Fuel Cell Seminar, Palm Springs CA, November 18-21, 2002