IX.11 National FCEV and Hydrogen Refueling Station Scenarios

Marc Melaina (Primary Contact), Brian Bush
National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
Phone: (303) 275-3836
Email: marc.melaina@nrel.gov

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

Subcontractor:
Lexidyne, LLC, Colorado Springs, CO

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Overall Objectives

- Develop and analyze self-consistent national scenarios of fuel cell electric vehicle (FCEV) market growth and hydrogen refueling station (HRS) deployment.
- Work with industry and other stakeholders.
- Accurately represent early market trends.
- Explore long-term possibilities for FCEV adoption.

Fiscal Year (FY) 2016 Objectives

- Develop and analyze national FCEV scenarios with respect to financing and station locations.
- Work with industry and other stakeholders to develop financial metrics for HRSs.
- Accurately represent early market trends for specific regions.
- Explore long-term possibilities for HRS financing with respect to assumed FCEV market adoption trends.

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

(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 1.19: 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)
- Milestone 2.2: Annual model update and validation. (4Q, 2011 through 4Q, 2020)

FY 2016 Accomplishments

- Developed and analyzed three distinct scenarios with detailed geographic, temporal, and financial information for vehicles, stations, and networks.
- Completed sensitivity analysis of the aforementioned scenarios.
- Delivered an interactive scenario design and browsing tool to stakeholders and demonstrated the tool in workshops.
- Prototyped the Business Case Scenario tool for exploring the full range of scenario outputs geographically over time.

INTRODUCTION

Integrated scenario analysis assesses interactions among FCEV adoption, infrastructure requirements, and investment. This project examines market and financial implications of strategies to support vehicle and infrastructure expansion nationally.

APPROACH

The scenarios developed in this project embody high levels of self-consistency and quantify key variabilities in the evolution of FCEV adoption. They match published regional early market plans and forecasts and coordinate changes in number of vehicles, number of stations, and station finances. The staging of states with and without zero-emission vehicle mandates (ZEV and non-ZEV states), the market penetration

for FCEVs, the station utilization, and the financial metrics vary among the scenarios. The scenarios' inputs and algorithms capture historical experience and near-term regional plans.

In particular, the three scenarios frame emphases and time periods relevant to different stakeholder audiences. The near-term (2015–2025) period emphasizes early adopter markets and a California ramp-up period along with coordination, planning, and coverage in other ZEV states. The mid-term (2025–2035) period focuses on early adopter markets beyond California and provides significant national coverage, based on broad state coalitions where the ZEV mandate is a major influence. The long-term (2035+) period extends beyond early markets so that many states are onboard and the transition is complete in some markets.

RESULTS

In the *Urban Green Tech* scenario, national FCEV adoption rates are relatively modest, and growth is restricted to the most promising urban markets with high concentrations of early adopters. Early adopters are consumers willing to pay a premium for green vehicles or high-tech vehicles. These consumers tend to be concentrated in large urban areas along the West Coast and East Coast and in a select number of additional urban markets. The clustering effects are strong in this scenario, and the development of station networks in response to early adopter demand results in an increase in local market share across other consumer segments, including fast followers and mainstream consumers. The result is relatively deep pockets of FCEV adoption in major urban areas, with station coverage along highway corridors linking clusters of cities.

In the *State Success* scenario, strong national market growth is achieved due to the influence of state policies such as vehicle rebates and ZEV mandates. Early station networks tend to be limited to urban areas in these states, and they only expand to other states after FCEVs have become a mainstream consumer product. Early adopters are still important in this scenario, but less so than in the Urban Green Tech scenario, and the neighbor effect has a modest influence on the expansion of markets geographically.

In the *National Expansion* scenario, California continues to be a key early market for FCEVs, but additional growth is distributed across a broad range of markets due to both the successful market adoption of FCEVs and aggressive investments in hydrogen station networks. Concentrations of early adopters help guide the placement of early-coverage stations but otherwise have little influence on larger market growth trends. Barriers to hydrogen infrastructure development are removed and overcome quickly, and rapid adoption of FCEVs occurs due to removal of information barriers in general rather than due to the neighbor effect. FCEV technology and cost improves quickly, and consumers purchase FCEVs as replacements for conventional vehicles with little concern over availability of stations, due to rapid network expansion.

The early market portion of the *State Success* scenario matches published forecasts for California and ZEV states. The three scenarios achieve different overall FCEV market shares, but all three scenarios show substantial FCEV

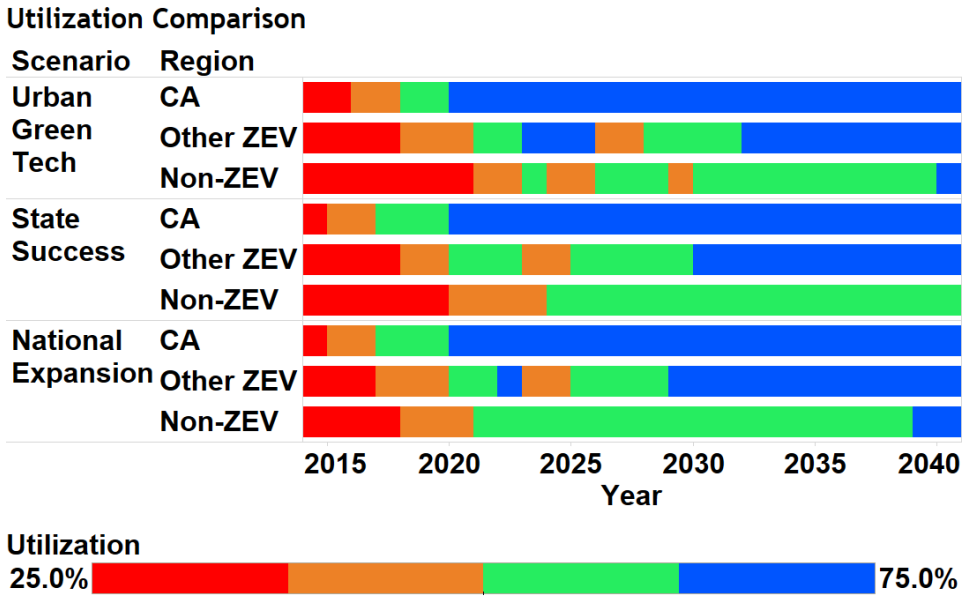

FIGURE 1. Overall average station utilization becomes favorable in stages over time and geographically, varying by scenario

market growth by 2035. The more aggressive scenarios have substantially greater numbers of hydrogen refueling stations, and all scenarios embody different geographic emphases on sales of FCEVs (see Figure 1).

An interactive scenario design and browsing tool has been delivered to stakeholders and demonstrated in workshops (see Figure 2). Furthermore, the prototype Business Case Scenario tool explores the full range of scenario outputs geographically over time. Financial metrics for different stakeholders (funding organizations, investors, lenders, consumers) summarize the business case for hydrogen refueling stations in each of the scenarios.

CONCLUSIONS AND FUTURE DIRECTIONS

In FY 2016, this project developed and analyzed three self-consistent national FCEV scenarios that accurately represent early market trends but also explore long-term possibilities for FCEV adoption. It directly addresses DOE objectives for stakeholder-engaged scenario development and analysis. The three scenarios are grounded in empirical data, early market plans, and technical analysis. Results indicate how many hydrogen refueling stations are required, and where and when they would be installed, in response to variations in the scale and regional distribution of market demand for FCEVs.

The project will continue to provide direct support for H2USA working group activities, engaging with stakeholders to improve analyses; update scenarios to adjust to updated input data and market trends; and disseminate results to H2USA members and the general public. Future work will integrate the national scenarios with explicit representations of finance strategies, incentives, and hydrogen prices. The scenario results will be published as a report and an interactive website.

FY 2016 PUBLICATIONS/PRESENTATIONS

1. Brian Bush and Marc Melaina, "National FCEV and Hydrogen Fueling Station Scenarios." Presented at the DOE Hydrogen and Fuel Cells Program Annual Merit Review and Peer Evaluation Meeting, Washington, D.C., June 6–10, 2016.

2. Marc Melaina, Brian Bush, Michael Penev, Dana Stright, Jarett Zuboy, "National Hydrogen Scenarios for the United States: How many Stations, Where and When?" Presented at the 21st World Hydrogen Energy Conference, Zaragoza, Spain, June 13–16, 2016.

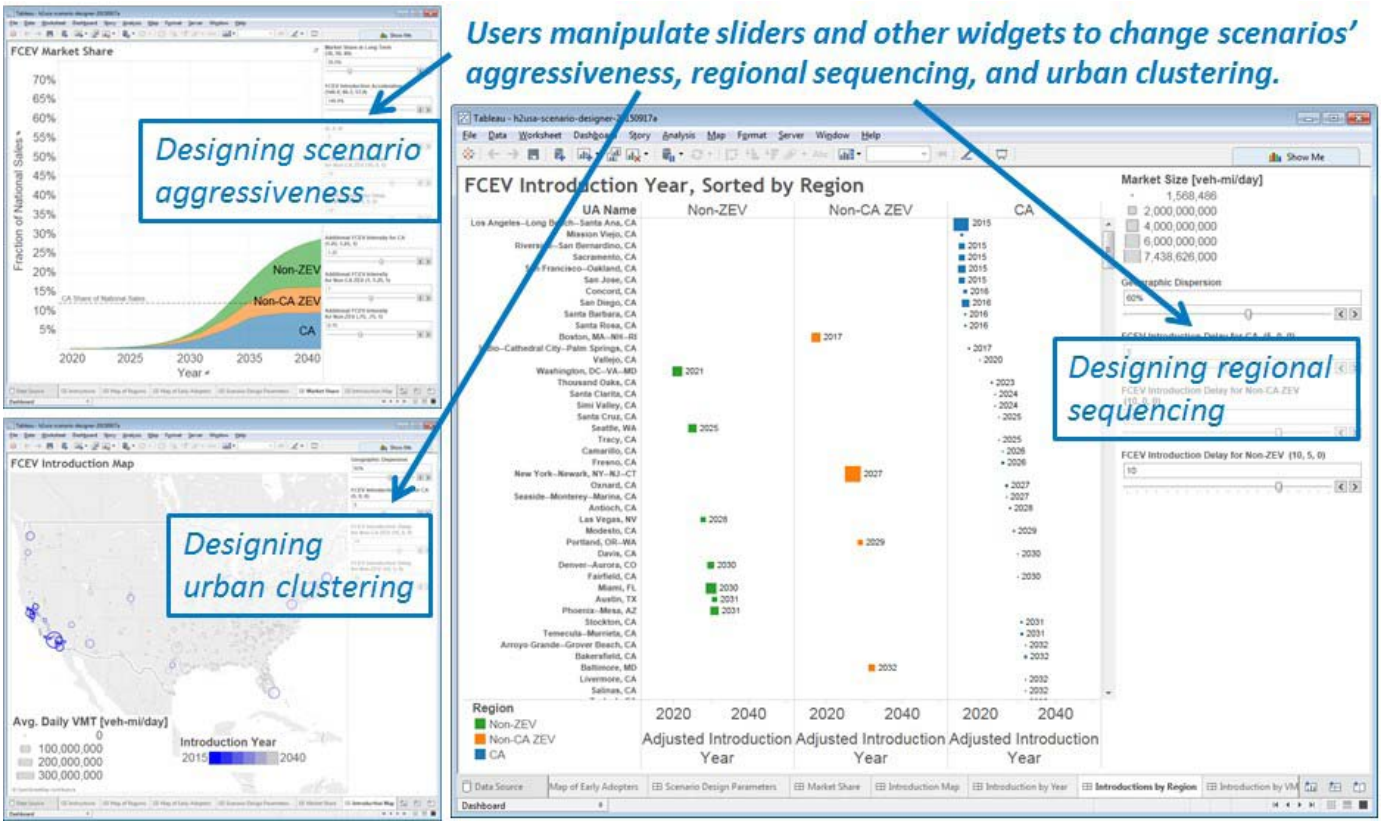

FIGURE 2. Screen captures from the interactive scenario design and browsing tool that has been delivered to stakeholders and demonstrated in workshops