# V.C System Analysis

## V.C.1 Controlled Hydrogen Fleet & Infrastructure Analysis

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### Objectives

- By 2008, validate hydrogen vehicles with greater than 300-mile range, greater than 2,000-hour fuel cell durability, and lower than $3/kg hydrogen production cost.
- Assist DOE in demonstrating use of fuel cell vehicles and hydrogen infrastructure under real-world conditions, using multiple sites, varying climates, and a variety of sources for hydrogen.
- Analyze data from vehicles and infrastructure to obtain maximum value for DOE and industry from this "learning demonstration."
- Provide feedback and recommendations for further hydrogen and fuel cell R&D.
- Identify near-term strategies for developing hydrogen infrastructure.

### Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- A. Vehicles
- B. Storage
- C. Hydrogen Refueling Infrastructure
- E. Codes and Standards
- F. Centralized Hydrogen Production from Fossil Resources
- H. Hydrogen from Renewable Resources

### Approach

- Provide technical support for DOE's solicitation process for "Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project" and prepare for post-award work.
- Plan NREL/DOE data analysis activities.
- Investigate hydrogen infrastructure transition pathways through geographic information systems (GIS) analysis.

- Based on analysis results from this project, identify technology gaps and research opportunities within the HFCIT program.

### Accomplishments

- Assisted DOE in formulating plans for "learning demonstration" solicitation.
- Contributed technical details of solicitation RFP statement of Objectives (Appendix C).
- Performed technical review of solicitation proposals.
- Completed draft validation project technical "Data Analysis Plan" and sample data flows.
- Performed preliminary infrastructure transition analysis using spreadsheet techniques and GIS analysis.

### Future Directions

- Actively participate in industry team kick-off meetings, discussions on data collection methods, and early applications/analyses of data.
- Begin producing quarterly Validation Assessment Reports.
- Complete first generation vehicle & infrastructure analysis.
- Wrap-up infrastructure transition analysis work and document findings.
- Compare technical progress to program objectives.
- Implement second-generation vehicle systems to meet 2008 targets.
- Actively feed findings from project back into HFCIT program R&D activities to make this an active "learning demonstration."

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## Introduction

Hydrogen fuel cell vehicles (FCVs) are currently in the pre-production stage of development, and the infrastructure to refuel them has not yet been made broadly available. Because there are currently so few hydrogen FCVs on the road, there is lack of sufficient hydrogen vehicle data available to draw definitive conclusions about the potential fuel cell durability, range, and performance of these vehicles under real-world conditions. The current on-board storage technique employed is primarily compressed hydrogen tanks, which does not meet consumer-driven vehicle range requirements of 300 miles without intruding on passenger or cargo volumes. The high cost and insufficient availability of the hydrogen refueling infrastructure does not allow a natural market introduction of the vehicles at this time, even if the vehicle issues of cost, range, and life were solved. Finally, there is a lack of adoption of standards for hydrogen vehicles and the associated refueling infrastructure, and the current cost to produce a kilogram of hydrogen is too high to compete with gasoline.

By testing complete system solutions, DOE's Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project offers the opportunity to conduct an integrated field validation project that creatively addresses the impact of introducing both fuel cell vehicles and the hydrogen infrastructure simultaneously. Through this project we seek to gain knowledge about the progress toward the technical targets, and provide insight into how the HFCIT program research could be refocused to more quickly move toward cost-effective, reliable hydrogen fuel cell vehicles and supporting refueling infrastructure.

## Approach

In its first full-year since inception, NREL's approach to achieving the 5-year objectives of this project was to first assist DOE in launching and achieving a successful competitive process to attract auto industry and energy company interest in participating in the project. This involved helping to formulate the RFP, holding discussions with key industry stakeholders, reviewing proposals, and planning the post-award analysis activities. NREL's

approach to add value to the project is to use its unique, objective modeling and analysis capabilities to provide valuable technical recommendations based on the in-use experiences from the vehicles and the infrastructure being introduced simultaneously under controlled conditions. These recommendations will be made while protecting the sensitive FCV and infrastructure technologies data generated from the project. Since there will be a significant volume of data collected by the industry teams, a high priority is placed on planning the data processing and analysis activities, and a data analysis plan is an effective way to communicate this with others.

The small number of vehicle models and refueling stations involved in this project and the others underway, will be far short of that necessary to induce consumers to choose hydrogen vehicles over gasoline vehicles. Therefore, logical pathways to transition to a hydrogen infrastructure were also investigated. The approach taken by NREL to achieve this investigation was to identify the number and optimal locations for stations using GIS data and analysis techniques.

## Results

NREL has assisted DOE in initiation of a successful competitive process to attract auto industry and energy company participation in the project. This was accomplished through discussions with major auto manufacturers, energy companies, collaborative partnerships such as the California Fuel Cell Partnership, fuel cell and fuel storage suppliers, the military, and educational institutions. NREL assisted in the preparation of some of the technical details in the RFP Statement of Objectives, which included eight tables of data that DOE required project participants to include in their proposals. The tables included footnotes to clarify and provide context for the data being requested from the industry participants. Other national labs and agencies such as EPA were also involved in the preparation of these tables.

Once the RFP was launched by DOE, NREL was involved in reviewing the proposals and providing recommendations on modifications to the statements of work. After DOE announced the awardees

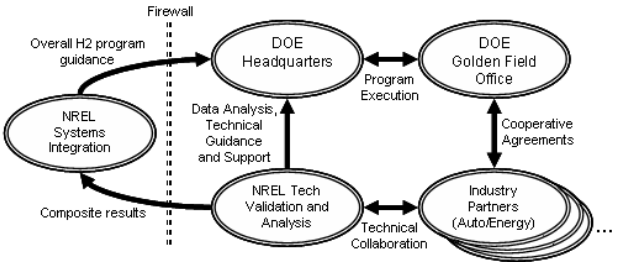


**Figure 1.** The Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project Involves Collaboration Among Multiple Organizations

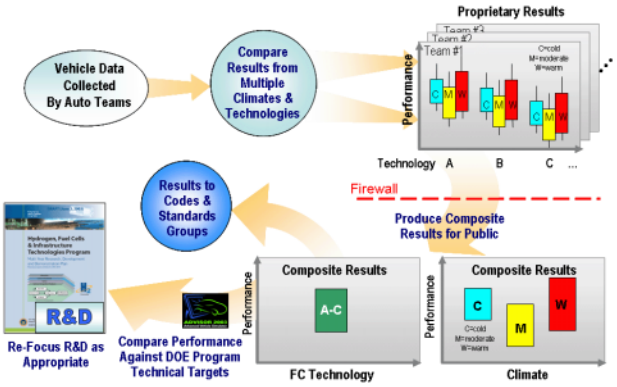


**Figure 2.** Overview of Technology Validation Hydrogen Fuel Cell Vehicle Performance Analysis

publicly, NREL participated in the kick-off meetings with industry to discuss and refine the statements of work. In parallel with the solicitation activity, NREL also completed the first draft of a Data Analysis Plan that details the types of analyses possible with the data collected, and the types of technical questions that could be answered based on the anticipated results from the project. The objective of the document was to facilitate discussion with DOE and industry, and it has accomplished this objective. (See Figure 1 for a diagram showing the participants in this project, and their primary roles.) The plan is now being refined to include a section that lays out the plans for the composite data that will be shared with the public and not contain any proprietary or sensitive data. Figures 2 and 3 illustrate high-level examples from this plan showing the flow of data from the industry teams and the types of data products that will be produced.

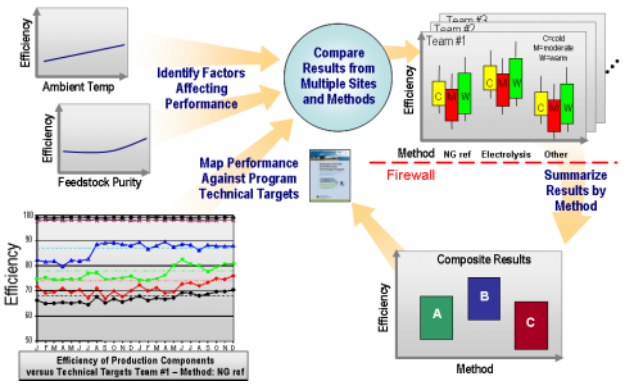


**Figure 3.** Overview of Technology Validation Hydrogen Production Analysis

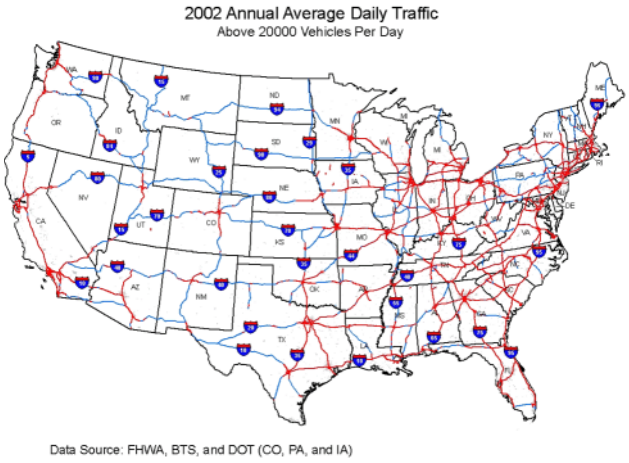


**Figure 4.** Sample of GIS Data Being Used to Evaluate Optimal $H_2$ Refueling Station Placement at a National Level

Significant accomplishments have been made in examining the possible pathways to transition to a national network of hydrogen refueling stations. Initial results were obtained with simplifying assumptions and spreadsheet models. Subsequent studies used sophisticated GIS tools and analysis techniques to look deeper at where people live, which routes they take to travel across country, and where stations should be placed in the early states of a refueling station network to service the public. Figure 4 shows an example of the type of GIS data used, in this case highlighting the stretches of interstate having more than 20,000 vehicles per day.

## Conclusions

NREL has been actively involved in helping DOE launch the Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project and plan for the subsequent analytical activities that will take place using industry-collected data. NREL is using its unique, objective modeling and analysis capabilities to provide valuable technical recommendations based on the in-use experiences from the vehicles and the infrastructure being introduced simultaneously under controlled conditions. Through this project we seek to gain knowledge about the progress toward the technical targets, and provide insight into how the HFCIT program research could be refocused to more quickly move toward cost-effective, reliable hydrogen fuel cell vehicles and supporting refueling infrastructure.

## FY 2004 Publications/Presentations

1. K. Wipke, S. Gronich, D. Hooker, “Hydrogen Technology Validation as a Learning Demonstration that Feeds the R&D Process,” 2004 National Hydrogen Association Annual Meeting, Hollywood, CA (2004).