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## VII.3 Agent-Based Model of the Transition to Hydrogen-Based Personal Transportation: Consumer Adoption and Infrastructure Development Including Combined Hydrogen, Heat, and Power

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- (A) Future Market Behavior
- (B) Stove-piped/Siloed Analytical Capability
- (C) Inconsistent Data, Assumptions and Guidelines

### Technical Targets

This project addresses the following Systems Analysis objectives:

- Develop and utilize a macro-system model of the hydrogen fuel infrastructure to support transportation systems.
- Identify and evaluate early market transformation scenarios consistent with infrastructure and hydrogen resources.



### Objectives

- Explore the chicken-or-egg problem: co-development of the hydrogen production and delivery infrastructure and the user base which supports it.
- Understand how the system works rather than provide one forecast of system development.
  - How do different policies affect the transition?
  - How sensitive is growth to factors beyond the control of policy makers?
  - What role do consumer attitudes and behavioral characteristics play?
- Consider in a complex adaptive system the interactions between:
  - Hydrogen fuel producers and suppliers.
  - Consumers of hydrogen fuel and fuel cell vehicles (FCVs).
  - Manufacturers of FCVs.
- Extend the current agent-based model to include limited-service combined hydrogen, heat and power (CHHP) facilities as well as the regular distributed production hydrogen fueling stations (HFSs) currently modeled.

### Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

### Approach

We develop a computer simulation of the transition from petroleum-based to hydrogen-based personal transportation, focused on the Los Angeles, California metropolitan area. The technique we employ is Agent-Based Modeling and Simulation (ABMS), one in which the overall system behavior emerges from the simulation of the decisions, actions, and interactions of individual players, or “agents.” Driver agents represent consumers of vehicles and fuel. They are characterized by attributes such as home location and income level, and take simulated trips around the roadway network purchasing fuel when necessary. Drivers’ vehicle purchase decisions are based on cost, the availability of fuel, their attitudes towards new technology, and interactions with other drivers. Investor agents represent the builders of the hydrogen fueling infrastructure. They assess the suitability of various sites to locate HFSs based on traffic past the site and their estimates of competition and future growth in hydrogen sales, and build HFSs accordingly. A manufacturer agent controls the supply and selling price of FCVs.

The existing model must undergo modifications and enhancements in order to be able to examine questions dealing with CHHP facilities. After implementing the necessary changes we will use the model to analyze various scenarios under the premise that owners of CHHP plants may sell limited amounts of hydrogen to consumers via hydrogen dispensing facilities (HDFs). We will explore how owners of CHHP facilities might expand the hydrogen refueling infrastructure by adding

HDFs, and how the presence of HDFs might affect the overall transition.

### Accomplishments

The project was initiated in March 2010. At the time of the 2010 Annual Merit Review Meeting, the following model enhancements had been completed:

- Increased the granularity of the roadway network topology to allow more refueling locations and more realistic trip routing.
- Added a simple manufacturer agent to limit the supply of vehicles during the early phase of the transition.
- Based on literature estimates and discussions with an automotive market research firm, improved the calibration of driver “personalities” (attitudes towards new technology and “greenness”) to the actual distribution in the population and stated willingness to pay.
- Provided driver agents with multiple personalities to help the agents better reflect the diversity in a modeled population 1,000 times larger.
- Calibrated driver trip distances to latest National Household Travel Survey data.
- Improved investor agents’ method of estimating and projecting hydrogen sales.

### Future Directions

- Identify candidate locations for CHHP facilities.
- Develop simplified cost structure for CHHP facilities.
- Develop algorithms for driver agents to register/purchase from HDFs based on their proximity to home/work, the agent’s mileage driven, and perhaps other factors.
- Extend driver personalities to incorporate attitudes towards FCVs influenced by the inconvenience of purchasing fuel at HDFs (e.g., lack of full-service amenities, possible registration requirement).
- Develop algorithms for driver actions in the event of a HDF running out of fuel, and the resulting costs to the driver in inconvenience.
- Conduct scenario analyses and summarize findings in a report.

### FY 2010 Publications/Presentations

1. Presentation at 2010 Hydrogen Program Annual Merit Review Meeting, M. Mahalik and C. Stephan.