III.13 Analysis of the Hydrogen Production and Delivery Infrastructure as a Complex Adaptive System

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Objectives

- Leverage the experience and expertise of team members in economic analysis, energy systems studies, large-scale infrastructure analysis, hydrogen production and merchant market experience, and complex adaptive systems analysis to develop an agent-based model that simulates the evolution of a national hydrogen infrastructure that spans the entire hydrogen supply chain, that is, from resource (feedstock) production to hydrogen consumption.

Technical Barriers

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

- E. Lack of Understanding of the Transition of a Hydrocarbon-Based Economy to a Hydrogen-Based Economy
- D. Stove-Piped/Siloed Analytical Capabilities
- C. Lack of a Macro-System Model

Approach

The work proposed here is to analyze the hydrogen infrastructure's development as a complex adaptive system using an agent-based modeling and simulation (ABMS) technique. ABMS has been used successfully in other domains to develop insight not available from traditional techniques. Unlike other modeling

frameworks, ABMS does not assume systems to be in equilibrium, nor does it postulate a single overall objective function, perfect foresight or unbounded rationality. Rather, it is designed to address the various transition states that the hydrogen infrastructure might go through during the ups and downs of system development, as well as the end or equilibrium state. ABMS can help determine the magnitude of the fluctuations in the system and to identify areas of stability, oscillation, or instability in the various parameters that affect hydrogen infrastructure development. Its ability to treat the non-linearities in this type of complex adaptive system is ideal.

Another key feature is that ABMS allows agent heterogeneity to be represented in the form of differing objectives, strategies, and capabilities, and by permitting different types and levels of interactions. In addition, ABMS allows agents to adjust their preferences and adapt their decision rules as they learn which behaviors enhance the achievement of their objectives and which result in undesirable outcomes. This learning and adaptation process allows the agents to "find" solutions that cannot be determined by traditional modeling and simulation techniques and permits identification of stable, periodic, and chaotic portions of the solution space as the agents explore different approaches. The analysis can then be used to identify how the hydrogen infrastructure might evolve, what factors might contribute to the rate and stability of market development, and how technological or cost-reducing innovations might aid or detract from market growth.

A project kick-off meeting was held in Chicago on June 29-30, 2005, to lay the groundwork for the project, coordinate partners' roles and responsibilities, and identify activities required for the rest of FY 2005. This activity focused on developing the initial scope and resolution of the model, coordinating the efforts of the six partners, and defining model outputs. Due to funding limitations, these activities were initiated in FY 2005 but will not be completed until the middle of FY 2006.