Hydrogen System Assessment: Recent Trends and Insights

J.M. Ogden

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Joan M. Ogden

Abstract

The potential role of hydrogen in the world's future energy system has been analyzed in many assessments and remains a topic of vigorous, ongoing debate. A hydrogen economy involves not only new types of vehicles, but a new fuel infrastructure and development of low carbon primary resources. Given the number of possible configurations for a future hydrogen economy, systems analysis plays a key role in informing decision-makers in government and industry about the best hydrogen strategies and the prospects for hydrogen as compared to alternatives such as electricity, biofuels or fossil-derived liquid fuels.

While early assessments presented a vision of an "end-state" hydrogen economy, recent analyses have focused more on transitions: what is required to move toward widespread use of hydrogen energy starting from today's energy system. To understand the dynamics of transitions, analysts are using increasingly sophisticated tools: models of consumer choice and decision-making, infrastructure design models including spatial optimization and regional geographic data, and energy system modeling including interactions with the rest of the energy system. Lifecycle assessment is an important method for comparing the societal benefits of hydrogen to other fuels, considering the entire system, across multiple dimensions.

In this paper, I present an overview of recent trends in hydrogen system modeling and results from hydrogen systems assessments. In the last section, I propose a multi-attribute framework for evaluating hydrogen and other future fuels with respect to technical performance, cost, energy use, infrastructure development and greenhouse gas (GHG) emissions, while considering air pollution, energy security and reliability, water use, land use, and materials requirements. The goal is to illuminate hydrogen transition pathways that are viable across a wide range of economic and sustainability constraints, and to compare to other energy pathways.