VIII.10 Hydrogen Technology Analysis: H2A Production Model Update

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Objectives

- Improve the transparency and consistency of the analysis of hydrogen production systems.
- Reflect the best understanding of hydrogen production technologies for system cost and performance.
- Simplify model structure and user interface.
- Develop new modeling tools for well-to-wheels emissions, carbon sequestration, and sensitivity analyses.

Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section (4.5) of the Hydrogen, Fuel Cells, and Infrastructure Technologies (HFCIT) Program Multi-Year Research, Development and Demonstration Plan:

(B) Stove-Piped/Siloed Analytical Capability

(C) Inconsistent Data, Assumptions, and Guidelines

(D) Suite of Models and Tools

(E) Unplanned Studies and Analysis

Contribution to Achievement of DOE Systems Analysis Milestones

This project contributes to the achievement of the following DOE milestone from the Systems Analysis section of the Hydrogen, Fuel Cells, and Infrastructure Technologies Program Multi-Year Research, Development, and Demonstration Plan:

- **Milestone 19:** Complete update of the H2A production models to include scaling factors for production size and mid-scale capital costs for the natural gas and biomass production cases.

Accomplishments

- Maintained DOE H2A Analysis Web site, which provides the latest information about program activities as well as the production models and case studies.
- Developed H2A production models and current technology case studies and released them for public use, providing an assessment of a variety of hydrogen production pathways, including biomass, coal, natural gas, nuclear, wind/electrolysis, ethanol, and methanol. The H2A production models and associated case studies were used in the development of several key DOE documents, including the Hydrogen Posture Plan and the HFCIT Multi-Year Research, Development, and Demonstration Plan.

Introduction

As discussed in the HFCIT Multi-Year Research, Development, and Demonstration Plan, systems analysis is needed to determine the economic viability of various hydrogen production processes and technologies and to identify technologies that have the greatest likelihood of success. To make the appropriate recommendations to decision-makers, analysis of hydrogen technologies and systems must be carried out using consistent and transparent methodologies.

In 2003, the H2A Program began to develop a transparent and consistent framework for the analysis of hydrogen production and delivery systems (only H2A production efforts covered in this report). The H2A production models offer a means of reporting financial parameters and methodological assumptions as well as calculating minimum hydrogen selling price. The

current update of the H2A production models focuses on simplifying the model structure, developing new model features, and insuring that accurate performance and cost assumptions are used in the available production case studies.

Approach

The H2A production models are Excel-based. They use a discounted cash flow analysis to determine the levelized selling price of hydrogen required to attain a specified internal rate-of-return (that is, the minimum hydrogen selling price or profited cost). There are two distinct H2A production models for centralized hydrogen production and forecourt production, utilizing different sets of financial and performance assumptions. The models allow users to enter their own inputs or default to standard H2A inputs. Building on the existing models, the current update will simplify the user interface and add new model features.

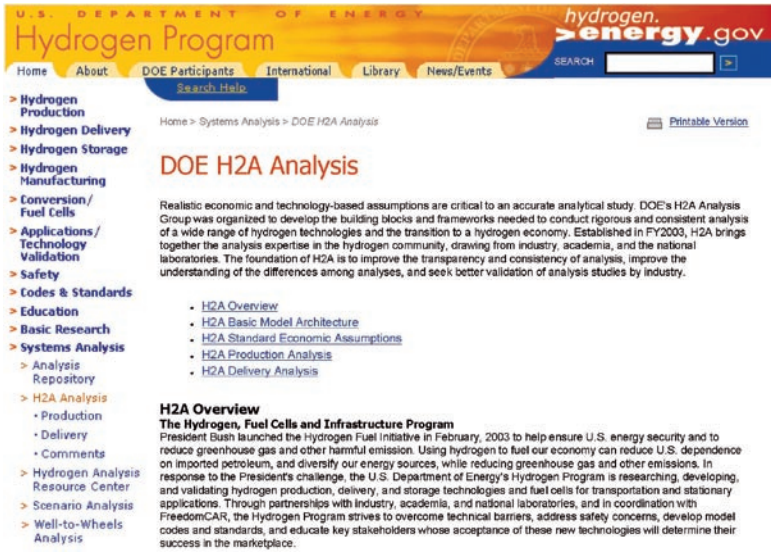

FIGURE 1. DOE Hydrogen Analysis Web Site

Results

In October 2005, DOE launched the H2A Analysis Web site, making available the H2A production and delivery models and associated case studies (see Figure 1). Web site statistics reveal significant interest in these modeling tools, with thousands of unique users downloading the generic H2A centralized and forecourt production models and the specific production case studies. The H2A production models and associated production case studies provide a transparent and consistent means of assessing the cost of producing hydrogen through a variety of technology pathways. Using either standard or user-defined inputs on costs and performance, together with financial inputs, feedstock and utility prices, and physical property data, the H2A production models report the minimum selling price of hydrogen, including the cost contributions of capital, operation (fixed), maintenance, feedstock, and raw materials (see Figure 2).

To insure that the H2A production models and case studies continue to be a useful suite of tools, the H2A production models are being revised to improve the user interface and provide additional functionality. Once the update is completed, the H2A production models will have:

- a simplified underlying spreadsheet structure;
- improved model inputs and outputs;
- improved sensitivity analysis capabilities, including automated graphing of results;
- plant-size scaling, allowing analysis of a wider range of hydrogen output levels;
- more thorough accounting of carbon sequestration costs and amounts; and
- well-to-wheels emissions calculations.

Using the H2A production models, members of the H2A team developed case studies of key technologies, assessing the production of hydrogen through both centralized and distributed (forecourt) production pathways. Current case studies investigate production technologies that could be installed today. Advanced case studies assess production technologies that might be installed between 2010 and 2020, while longer-term case studies consider technologies that might be employed between 2020 and 2030.

Current production case studies are available online via the DOE H2A Analysis Web site. To insure that the case studies remain accurate, the existing case studies are being revised and new case studies are being developed. As part of this process, case studies will be updated to:

- reflect up-to-date technology assumptions regarding cost and performance;
- provide consistent assumptions, levels of detail, and analytic approaches across cases; and
- improve transparency with more detailed breakdown of costs, components, and subsystems.

Current, advanced, and longer-term case studies are being revised and developed for a variety of production pathways, as outlined in Table 1. Once these case studies are complete, they will be posted online and made available to the public.

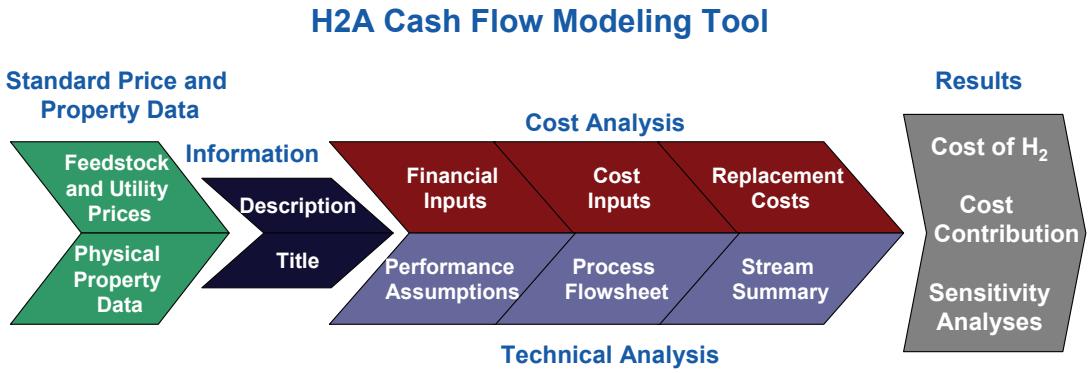

FIGURE 2. H2A Production Analysis Tool

TABLE 1. H2A Production Case Studies

Hydrogen Production Pathways	
Central Technologies	**Forecourt Technologies**
Coal Gasification • With and without carbon sequestration	Natural Gas Reforming
Natural Gas Reforming • With and without carbon sequestration	Ethanol Reforming
Biomass Gasification	Methanol Reforming
Nuclear • High Temperature Electrolysis • Sulfur-Iodine Thermo-chemical	Water Electrolysis
Water Electrolysis	

Conclusions and Future Directions

The H2A effort has successfully provided a platform for transparent and consistent analysis of hydrogen production technologies. The H2A update will insure that the models and case studies are consistent with the latest R&D and DOE program direction. The revisions underway will make the models more user-friendly and provide additional functionality allowing for more thorough analysis of production technologies.

Future directions:

- Revise model to address hydrogen quality.
- Address other environmental concerns (e.g., water quality and water treatment needs).
- Develop city-gate/semi-central production cases for existing technologies.
- Expand available production cases (including coal to Fischer-Tropsch liquids, forecourt aqueous-phase reactor, and advanced bio-derived liquids).

Special Recognitions & Awards/Patents Issued

1. 2005 DOE Hydrogen Program R&D Award for H2A Production model.

FY 2007 Publications/Presentations

1. "Hydrogen Technology Analysis: H2A Production," Johanna Levene, presentation, American Institute of Chemical Engineers Annual Meeting, November, 2006.

2. "Hydrogen Technology Analysis: H2A Production Model Update," Todd Ramsden, poster presentation, DOE Hydrogen Program Annual Merit Review, May, 2007.