X.6 Updates to the H2A Hydrogen Production Discounted Cash Flow Model (H2A Version 2.0)

Darlene M. Steward
National Renewable Energy Laboratory (NREL)
1617 Cole Blvd.
Golden, CO 80401-3393
Phone: (303) 275-3837; Fax: (303) 275-2905
E-mail: darlene_steward@nrel.gov

DOE Technology Development Manager:
Fred Joseck
Phone: (202) 586-7932; Fax: (202) 586-9811
E-mail: Fred.Joseck.ee.doe.gov

Subcontractor:
Directed Technologies, Inc., Arlington, VA

Project Start Date: December 1, 2006
Project End Date: H2A Version 2.0 updates - April 30, 2008

Objectives

- Update the H2A model to improve its applicability and flexibility for addressing Hydrogen Program barriers.
- Provide a consistent approach for tabulating the primary cost elements for hydrogen production over the lifetime of the facility.
- Provide a template for reporting analysis assumptions.
- Calculate the annualized cost of hydrogen produced to create a benchmark for comparing technologies and measuring progress.

Technical Barriers

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

(B) Stove-piped/Siloed Analytical Capabilities
(C) Inconsistent Data, Assumptions, and Guidelines
(D) Suite of Models and Tools
(E) Unplanned Studies and Analysis

Achievement of DOE Systems Analysis Milestones

This project will help achieve the following DOE milestones from the Systems Analysis section of the Hydrogen, Fuel Cells, and Infrastructure Technologies Program Multi-Year Research, Development, and Demonstration Plan:

- **Milestone 23:** Complete the first version of the Macro-System Model for the analysis of the hydrogen fuel infrastructure to support the transportation systems. (4Q, 2008) – Update of the H2A production model will be incorporated into the Macro-System Model interface architecture.
- **Milestone 26:** Annual model update and validation (4Q, 2008).

Accomplishments

- Completed all modifications and additional functionality identified in the scope of work.
- Published Version 2.0 of the H2A Forecourt and Central models and 19 hydrogen production case studies in June of 2008.

✧ ✧ ✧ ✧ ✧

Introduction

The H2A discounted cash flow model was developed to help standardize cost analyses and assess progress for hydrogen production technology development projects funded by the DOE. The model was created in Microsoft Excel to facilitate rapid development and maintain flexibility and transparency for users (see Figure 1). Work on the equations and model structure was begun in 2003 and cost analyses for a suite of technologies were published in 2005. H2A has since become the primary cost analysis tool for evaluating hydrogen production costs for the DOE Hydrogen Program.

A variety of model enhancements and updates have been identified over the course of its use, resulting in the current project. Many members of the original team of researchers and Key Industrial Collaborators (KIC) gathered in February of 2007 to develop a scope of work for updating the H2A model. This report outlines the enhancements and changes that were made to the H2A production model in response to the consensus scope of work developed by the team.

Approach

The approach taken to update the H2A production model reflects the desire of the DOE and KIC to maintain the flexibility and transparency of the H2A

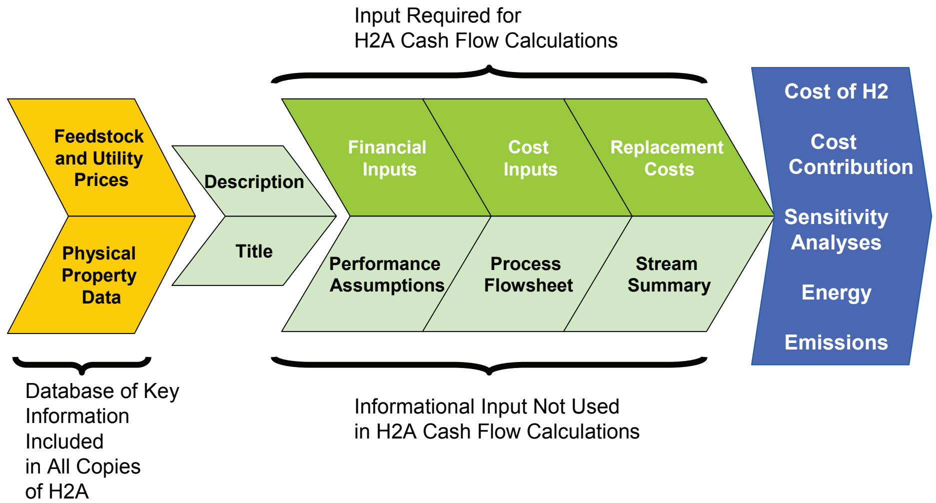

FIGURE 1. H2A Model Schematic

model while enhancing its usability and adding key new features. Therefore, the detailed yearly cash flow analysis and extensive financial and cost inputs to the model were retained essentially in their original form. Changes to the existing model focused on eliminating redundant or unused data, clarifying definitions and default values, and streamlining data entry and analysis functions. New features and calculations were incorporated into the model, with care to retain transparency and avoid obscuring the primary cost calculations.

Results

The improvements to the H2A model structure can be grouped into four primary categories: addition of new functionality; addition of calculations for important auxiliary processes (forecourt compression, storage and dispensing, and carbon sequestration); elimination of extraneous information; and streamlining and clarification of input.

Several new user functions were added to the model to facilitate analyses. These include:

- Addition of a plant-scaling function, which scales capital and operating costs with changes in plant capacity, measured in kilograms of hydrogen per day (kg H_2/day), according to equations selected by the user (see Figure 2).
- Addition of an automated method for performing sensitivity analyses and generating a tornado plot.
- Addition of functions for importing and exporting data from the model.

Two auxiliary processes were modeled. Forecourt compression, storage, and dispensing calculations taken from the Hydrogen Delivery Scenario Analysis Model (HDSAM) were incorporated into the forecourt version of the H2A production model, and carbon sequestration calculations were added to the central production version of H2A.

In addition to the new functions and calculations added to H2A, a wide variety of changes were made to the format, navigation, and user interface of the model to clarify model input and operation. A users' guide was developed for the model to further aid accessibility.

The following updates, modifications, and new functionality have been added to the H2A model:

- Modified forecourt compression storage and dispensing calculations from the hydrogen delivery model and incorporated them into H2A.
- Adapted upstream Greenhouse Gas Emissions tables from the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model and incorporated them into H2A for estimated calculations of GHG emissions.
- Developed flat file output to communicate with other models (e.g., Macro-System Model).
- Clarified input and output definitions to enhance consistency between models.
- Incorporated Excel variable naming to identify and locate critical input and output.
- Provided default values and clarified their use.
- Provided additional detail for critical input (e.g., capital costs).
- Provided calculations for complex nonproduction system components (e.g., carbon sequestration).
- Eliminated redundant or unused tables and data.
- Provided detailed written documentation of methods and assumptions.

The scaling utility sets the H2A case up so that when the capacity is changed, the capital costs and other values are scaled according to equations selected by the user.

- Keeps track of the baseline (original) values
- Provides a range of plant capacities for which scaling is valid
- Gives scaling factor exponents for individual or aggregate capital equipment
- Furnishes user-selected scaling equations for indirect capital and non feed operating costs
- Reverts to the original values by turning plant scaling off

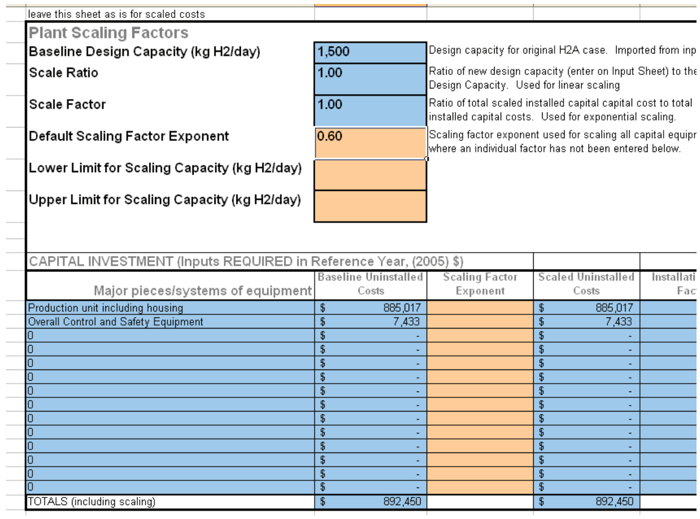

FIGURE 2. H2A Plant Scaling Function

- Streamlined input by layering input detail; Summary values are shown on the primary input sheet with links to additional detail.
- Provided usability tools such as color coding, keys, hyperlinks, and cell notes.
- Developed the "Toolkit" pop-up form to localize special functions and tools "out of the way" of standard use of the model.
- Clarified use of feeds, utilities, and byproducts and facilitated the addition of "user-defined" feeds.
- Added a formalized plant scaling method.
- Developed a users' guide to aid accessibility and provide guidance for analysis using the model.
- Published the forecourt and central model templates and 19 case studies.

Conclusions and Future Directions

In Fiscal Year 2007 and FY 2008 the H2A hydrogen production discounted cash flow model was extensively revised and updated. The model was divided into separate forecourt and central versions, and major new functionalities were added to the model. These functionalities included plant scaling, carbon sequestration, and new forecourt calculations. The model templates and 19 updated case studies were published in June of 2008.

The H2A production models (forecourt and central versions) will require periodic maintenance and updating. The forecourt model compression, storage, and dispensing calculations are based on another model, HDSAM, which continues to undergo revision and updating. The forecourt H2A hydrogen production model will need to be updated to remain current with the HDSAM model. Similarly, the upstream greenhouse gas emissions calculations in both the forecourt and central model are based on tables of emissions factors that are derived from the GREET model. These tables will require periodic revision and updating to remain current with that model.

Future analysis activities and support for the model include:

- Analysis of a variety of new cases (e.g., hybrid feed systems).
- Analysis of systems economics (e.g., cost of carbon policy).
- Support for model users and maintenance of the model.

FY 2008 Publications/Presentations

1. H2A Hydrogen Production Forecourt and Central Model Version 2.0 templates and 19 hydrogen production case studies published at http://www.hydrogen.energy.gov/h2a_production.html, June 6, 2008.

2. Oral Presentation, DOE Hydrogen Program Annual Merit Review and Peer Evaluation, June 9–13, 2008.