II.I.1 H2A Production Model Updates

Darlene Steward (Primary Contact), Olga Antonia
National Renewable Energy Laboratory (NREL)
1617 Cole Blvd.
Golden, CO 80401
Phone: (303) 275-3837
E-mail: Darlene.Steward@nrel.gov

DOE Manager
HQ: Sara Dillich
Phone: (202) 586-7925
E-mail: Sara.Dillich@ee.doe.gov

Subcontractor:
Directed Technologies, Inc., Arlington, VA

Project Start Date: 2010
Project End Date: Project continuation and direction determined annually by DOE

Fiscal Year (FY) 2011 Objectives

Update the H2A central and forecourt models to:

- Incorporate new knowledge.
- Incorporate new Annual Energy Outlook (AEO) fuel cost projections.
- Update baseline year.
- Re-evaluate assumptions.

Technical Barriers

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

(B) Stove-piped/Siloed Analytical Capability

(D) Suite of Models and Tools

(E) Unplanned Studies and Analysis

Technical Targets

The update of the H2A models directly supports the following milestones from the Systems Analysis function from FY 2004 through FY 2016.

Milestone 26	Annual model update and validation. (4Q, 2008; 4Q, 2009; 4Q, 2010; 4Q, 2011; 4Q, 2012; 4Q, 2013; 4Q, 2014; 4Q, 2015)
Milestone 39	Annual update of Analysis Portfolio. (4Q, 2007; 4Q, 2008; 4Q, 2009; 4Q, 2010; 4Q, 2011; 4Q, 2012; 4Q, 2013; 4Q, 2014; 4Q, 2015

FY 2011 Accomplishments

Three primary tasks were completed to update the H2A central and distributed case studies:

- Primary assumptions and values were reviewed and updated as needed.
  - Cost of land increased from $5,000 to $50,000 per acre.
  - Construction period increased from two to three years with little expenditure during the first year.
  - Compression, storage, and dispensing calculations were updated to reflect a new baseline of 10,000 psi onboard storage pressure.
- The reference year was updated to 2007.
  - Startup year changed from 2005 to 2010 current, 2020 future.
  - Feedstock prices were updated using the AEO 2009 reference case and program values.
  - Capital costs were updated to 2007 dollars using Chemical Engineering Progress Cost Indexes (CEPCI).
  - Operating and other material costs were updated using appropriate indexes (consumer price indexes, labor indexes, SRI chemical price indexes).
- Templates were developed for central and distributed case studies.

Introduction

In FY 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 functionality including plant scaling, carbon sequestration, and new forecourt calculations were added. The model templates and 19 updated case studies were published in FY 2008. Version 2.1 of the H2A Hydrogen Production Model was uploaded to the H2A website on December 5, 2008. Version 2.1 incorporated minor fixes and improvements to the model. NREL, in consultation with researchers, is currently developing version 3 of the H2A hydrogen production models.

In Version 3, the reference year and costs have been updated to 2007 and major assumptions have been reviewed and updated as appropriate. Four new technologies have been added: solar thermo-chemical, photo-electrochemical and biological hydrogen production and reforming of bio-derived liquids.

Approach

Version 3 templates were developed for the H2A distributed and central hydrogen production models. The templates were reviewed for accuracy and completeness and the existing published H2A case studies were ported into the new templates. New case studies based on the templates, were developed for the four new technologies. All the completed case studies were reviewed for accuracy and completeness. The version 3 H2A case studies will be published on the DOE website (https://apps1.hydrogen.energy.gov/h2a_analysis.html). Case study reports outlining the changes to each technology case study were developed.

Results

The H2A production model central and forecourt primary assumptions were reviewed, and default values adjusted as necessary. New feedstock price tables were added to the model: AEO 2009 reference case, AEO 2009 high price case, and AEO 2010 reference case. CEPCI, consumer price index, labor index, and chemical price index tables were updated or added.

N^{th} plant assumptions were reviewed for the forecourt H2A models. The N^{th} plant assumption provides a context for estimating the effect of prior experience on capital and indirect costs for forecourt stations. At the technology readiness date, N^{th} plant assumptions apply; costs have decreased substantially because of learning, production economies, and modularization. Figure 1 presents a hypothetical hydrogen production cost reduction plot for a technology with a technology readiness date of 2015. N^{th} plant also applies to stations. Station design is assumed to be modular, but each site also has unique features that affect layout and design and increase costs for some aspects of the facility.

N^{th} plant assumptions include:

- Moderate annual system production rate: 50–150 systems per year.
- Substantial reduction in system cost but not full automation.
- Corresponding markups: could be ~50% gross margin.

Several new calculations were added to the forecourt model to provide more flexibility in specifying the facility's operating characteristics and to more accurately size equipment. New compression, storage, and dispensing calculations were added to model a new default refueling pressure of 700 bar (10,000 psi). The new calculations are based on the NREL H2A Delivery Components Model (NREL 2010, http://www.hydrogen.energy.gov/h2a_delivery.html). New calculations were also added to more accurately define the amount of onsite storage required to supply hydrogen during fluctuations in daily and weekly demand and during outages (see Figure 2) and to enable the user to define the weekly dispensing profile (Figure 3).

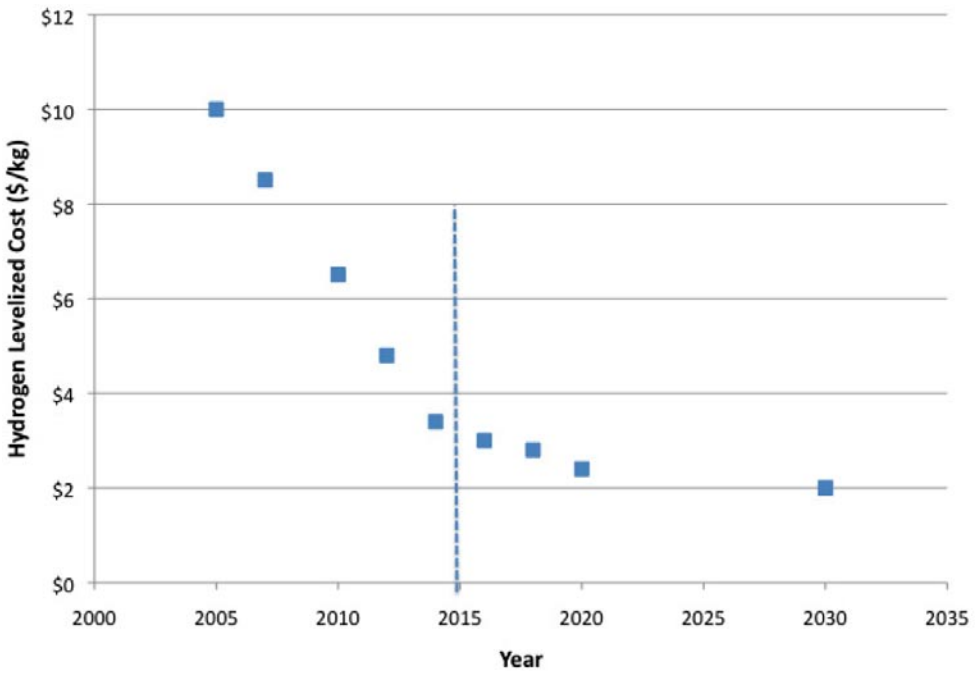

FIGURE 1. Hypothetical Hydrogen Cost Reduction Plot for a Technology with a Technology Readiness Date of 2015

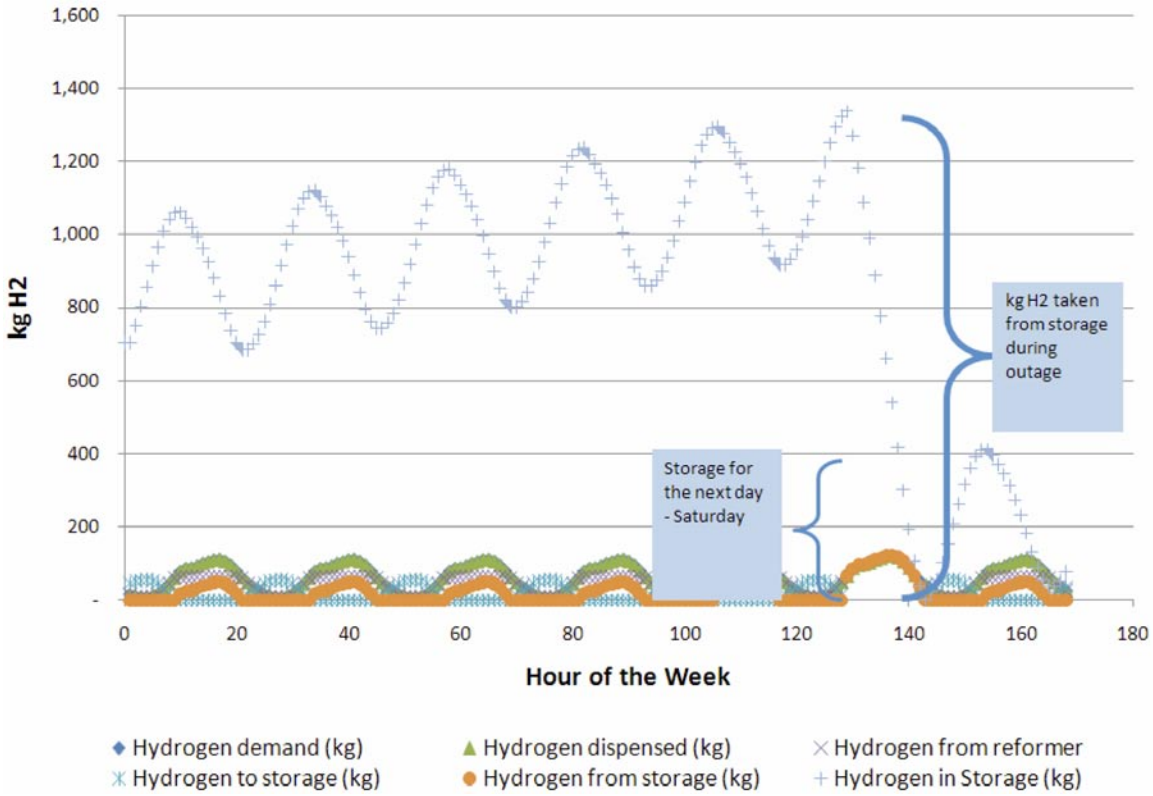

FIGURE 2. Hydrogen Dispensing and Storage Profile for a Week in the Summer – Worst Case Scenario Reformer Outage

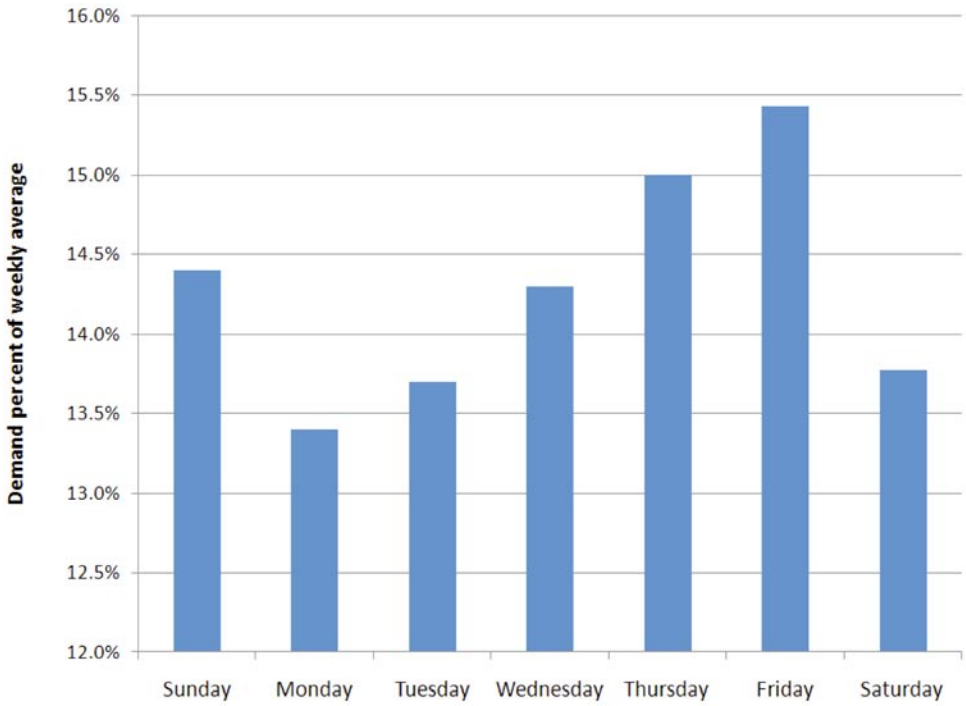

FIGURE 3. User-Defined Weekly Dispensing Profile

Conclusions and Future Directions

Development of Version 3 of the H2A hydrogen production models was necessary to maintain accuracy in the model and consistency with other DOE models. Updating to 2007 dollars and re-evaluation of N^{th} plant assumptions increased costs for all technologies. However, both top-down and bottom-up cost targets for all technologies are also being updated and will be using consistent assumptions.

FY 2011 Publications/Presentations

The following hydrogen production technology case studies will be published on the DOE website (https://apps1.hydrogen.energy.gov/h2a_analysis.html):

1. Current and Future Central Hydrogen Production via Biomass Gasification

2. Current and Future Central Hydrogen Production from Grid Electrolysis

3. Current and Future Central Hydrogen Production from Coal without CO_2 Sequestration

4. Current and Future Central Hydrogen Production from Coal with CO_2 Sequestration

5. Current and Future Central Hydrogen Production from Natural Gas without CO_2 Sequestration

6. Current and Future Central Hydrogen Production from Natural Gas with CO_2 Sequestration

7. Future Central Hydrogen Production from Nuclear Energy via High Temperature

8. Current and Future Forecourt Hydrogen Production from Grid Electrolysis (1,500 kg per day)

9. Current and Future Forecourt Hydrogen Production from Natural Gas (1,500 kg per day)

10. Current and Future Forecourt Hydrogen Production from Ethanol (1,500 kg per day)