II.B.7 Cost Analysis of Distributed Bio-Derived Liquids Reforming

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Objectives

- Assess the capital cost, performance and resulting total hydrogen cost for three different configurations of 1,500 kgH_2/day distributed hydrogen production systems:
  - A current technology ethanol reformer system.
  - An advanced technology ethanol reformer system.
  - An aqueous phase reformer glycerol reformer system.
- Conduct basic sensitivity analysis on the above reformation systems to assess the impact on hydrogen cost ($/kg).

Technical Barriers

This project addresses the following technical barriers from the "Hydrogen Production: Distributed Hydrogen Production from Natural Gas or Renewable Liquid Feedstocks" section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Reformer Capital Costs

(B) Reformer Manufacturing

Technical Targets

This project is conducting configuration and cost analysis of current and future technology distributed bio-derived liquids reforming systems for the on-site production of hydrogen. Insights gained from these studies may be applied toward future system development that can meet the DOE 2012 hydrogen production from bio-derived liquids targets:

- Production Unit Energy Efficiency: 72%
- Production Unit Capital Cost (uninstalled): $1M
- Total Hydrogen Cost: <$3.80/gge

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Approach

This project seeks to quantitatively assess the projected cost of hydrogen produced by advanced configuration bio-derived liquids reformer systems. To achieve this objective, several bio-derived liquids (ethanol and glycerol) reformation system configurations will be defined and evaluated for expected performance and capital cost. All systems will be sized to produce 1,500 kg/day of purified hydrogen. While the focus of the work will be determination of the capital cost and performance of the production system, the results will be combined with the standard DOE assumptions for hydrogen compression, storage and dispensing to arrive at the total delivered hydrogen cost for comparison with DOE targets.

A baseline ethanol gas-phase reformation system using current technology catalysts and configuration will be examined to serve as a benchmark. The baseline will utilize steam reforming and employ discrete unit reactors (reformation, water-gas shift, pressure swing adsorption, etc.). Catalyst beds will be sized by experimental data and/or kinetics modeling to the extent possible. System performance will be evaluated using HYSYS® simulations and system cost estimated by a combination of scaling factors, previous estimates, and additional Design for Manufacture and Assembly-style calculation. The expected total delivered cost of hydrogen will be evaluated using DOE's H2A cost model which provides a discounted cash flow methodology and standard assumptions regarding H_2 compression, storage, and dispensing at the forecourt dispensing station.

Advanced technology on-site ethanol reforming systems will next be examined. Emphasis will be placed on unitized operations to achieve tighter heat integration, smaller reactor volume, enhanced efficiency, and lower capital cost. Integrated reformer/shift beds and integrated reformer/shift/membrane purification beds will be examined. Advanced catalysts for lower temperature operation will be considered. Like the baseline configuration, performance will be evaluated in

HYSYS®, capital costs by a variety of methods, and total hydrogen cost by the H2A model. Sensitivity analysis will be conducted on all configurations to assess the impact on hydrogen cost. The impact of ethanol with water dilution and ethanol/gasoline mixtures will be assessed.

A low temperature aqueous phase reformer system utilizing glycerol as the bio-derived liquid feedstock will next be configured. Reactor sizing will be based on a combination of published developer data and first principles reaction rates. Capital costs will be estimated based on a variety of methods as described above. Production systems performance and capital costs will be entered into the H2A model to obtain estimated delivered hydrogen cost for the total dispensing station.

Accomplishments

- Defined the baseline ethanol system to consist of pre-reformer, steam reformer, water-gas shift, and pressure swing adsorption.
- Initiated capital cost analysis of the baseline configuration.
- Conducted literature reviews and preliminary configuration analysis of several advanced configuration systems.