DOE Hydrogen and Fuel Cells Program Record	
Record #: 12021	**Date:** May 14, 2012
Title: Cost Projections for Delivery Operations at a Distributed H_2 Production/Refueling Site	
Originator: Scott Weil, Mark Ruth, Sara Dillich, and Erika Sutherland	
Approved by: Sunita Satyapal and Rick Farmer	**Date:** November 28, 2012

Item:

Delivery costs associated with distributed production refueling station functions, Compression, Storage and Dispensing (CSD), were projected to be \$2.45/kg and \$1.65/kg, for 2010 and 2020, respectively. Calculations were made in \$2007 using the Hydrogen Delivery Scenario Analysis Model (HDSAM).

Data and Assumptions:

In fiscal year 2011, the Hydrogen Analysis Model (H2A) V3 was used to define a set of centralized and distributed hydrogen production cost targets for the Hydrogen Production sub-program. Because distributed production combines unit operations attributable to both hydrogen production (e.g. hydrogen gas generation via small-scale steam methane reformation or on-site electrolysis) and delivery (e.g. subsequent gas compression, storage, and dispensing), it was necessary for the purposes of future R&D planning to separate the corresponding costs and define targets for each set of technologies. Technical and cost targets for the delivery operations were defined using HDSAM V 2.3, as described in Record #12022 [1].

As a first step, CSD costs were isolated from a 2020 pipeline gas HDSAM delivery scenario developed to meet the 2020, \$2.1/gge central delivery cost.[a] The pipeline delivery scenario was chosen because it represents the closest analog to distributed production with respect to the incoming conditions of the hydrogen (e.g. 300 – 600 psi pressure, ambient temperature gas, etc.). The CSD costs associated with the 2020 HDSAM pipeline delivery scenario developed were < \$1.30/gge [2]. This figure must be adjusted to account for differences in seasonal H_2 storage between a central pipeline scenario (where variations in summer and winter needs are met via geologically stored H_2) and an on-site, distributed production scenario, in which all storage is assumed to be located at the station.

The magnitude of the adjustment depends on the extent to which the on-site H_2 production unit and/or on-site low-pressure storage are scaled (or sized) to accommodate hydrogen demand at the station under peak conditions. Station demand varies due to the following: a summer surge that is 10% higher than the daily average for the year; a Friday peak at 8% higher than the average for that week; and a demand profile indicating an afternoon peak [3]. An analysis conducted by Argonne National Laboratory (ANL)

[a] Assumptions included: (1) Indianapolis as the target city (population 1.2 M), (2) a mature fuel cell vehicle market penetration of 15%, (3) all costs expressed in \$2007, (4) an average refueling station capacity of 1000 kg of H_2/day at 95+% utilization, (5) mature economies of scale with respect to component manufacture for various unit operations, (6) the H_2 production plant is sited 100 km from the city gate, and (7) they H_2 pressure on-board the vehicle is 700 bar.

and the National Renewable Energy Laboratory (NREL)[b] concluded that the combined production and delivery costs for this type of station are minimized when the production unit is designed to supply a sufficient amount of hydrogen to meet the summer surge and the on-site storage is designed to cover weekly variation (i.e., the Friday peak) and unplanned outages [4]. However no extra storage capacity was built into the cost models to accommodate on-site planned production outages. The costs of "up-sizing" storage and/or the H_2 production unit were deemed excessive. Instead, it was assumed that customers would seek an alternative, available station for refueling.

The total 2020 projected CSD cost of a station where H_2 is generated on-site is \$1.65/kg. To establish a 2010/11 baseline, a similar analysis was conducted assuming 2010 distributed production and delivery technologies. Final results yield a projected 2010 CSD cost of \$2.46/gge [5, 6]. Costs for 2011 and 2020 were rounded to \$2.50/gge and < \$1.70/gge, respectively, in The Fuel Cell Technology Program 2012 MYRD&D.

References

1. Program Record #12022, November, 2012. "H_2 Delivery Cost Projections – 2011," S. Weil, S. Dillich, and E. Sutherland.
2. Fuel Cell Technologies Program Multi-Year Research, Development and Deployment Plan (MYRD&D), Section 3.2, Hydrogen Delivery, 2012, http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/delivery.pdf
3. T-P. Chen, Nexant: "Hydrogen Delivery Infrastructure Options Analysis," DOE Award #DE-FG36-05GO15032, Appendix B, May 2008.
4. Internal Communication, analysis of distributed production station sizing, Mark Ruth, Darlene Steward, and Amgad Elgowainy, February, 8, 2012.
5. Current Distributed Hydrogen Production from Natural Gas without CO_2 Sequestration version 3.0; http://www.hydrogen.energy.gov/h2a_prod_studies.html
6. Future Distributed Hydrogen Production from Natural Gas without CO_2 Sequestration version 3.0; http://www.hydrogen.energy.gov/h2a_prod_studies.html

[b] Amgad Elgowainy (ANL), Mark Ruth (NREL) and Darlene Steward (NREL)