IX.8 Status and Prospects of the N.A. Non-Automotive Fuel Cell Industry: 2014 Update

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Overall Objectives

- Quantify the North American (N.A.) non-automotive fuel cell industry's progress in terms of reduction in costs of products and improvements in performance
- Quantify the impact of the American Recovery and Reinvestment Act (ARRA) and Investment Tax Credit (ITC) on the N.A. non-automotive fuel cell industry
- Estimate the timing and conditions under which the industry is likely to become self-sustaining without further policy support
- Assist DOE and Argonne National Laboratory (ANL) with planning and analysis of the transition to hydrogen fuel cell vehicles in the United States

Fiscal Year (FY) 2015 Objectives

- Estimate the total costs of nationwide, vehicle refueling or recharging infrastructure for (1) gasoline and diesel, (2) hydrogen, (3) electricity, (4) natural gas, (5) propane and (6) E85
- Prepare a draft report reviewing the literature on how consumers' evaluate novel vehicle technologies, quantifying key factors as the literature permits
- Provide analytical support to DOE's participation in H_2USA, as requested by DOE

Technical Barriers

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

(A) Future Market Behavior

(C) Inconsistent Data Assumptions and Guidelines

(D) Insufficient Suite of Models and Tools

(E) Unplanned Studies and Analysis

Contribution to Achievement of DOE Systems Analysis Milestones

This project contributes to achievement of the following DOE milestones from the Systems Analysis section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Milestone 3.3: Complete review of status and outlook of non-automotive fuel cell industry. (biennially from 4Q, 2011 through 4Q, 2019)
- Milestone 1.15: Complete analysis of program milestones and technology readiness goals—including risk analysis, independent reviews, financial evaluations, and environmental analysis—to identify technology and risk mitigation strategies. (4Q, 2015)
- Milestone 1.16: Complete analysis of program performance, cost status, and potential use of fuel cells for a portfolio of commercial applications. (4Q, 2018)
- Milestone 1.19: Complete analysis of the potential for hydrogen, stationary fuel cells, fuel cell vehicles, and other fuel cell applications such as material handling equipment including resources, infrastructure and system effects resulting from the growth in hydrogen market shares in various economic sectors. (4Q, 2020)

FY 2015 Accomplishments

- Through interviews with original equipment manufacturers (OEMs) and analysis of financial reports and published literature, developed updated estimates of scale economies, rates of learning-by-doing, annual technological progress, and costs of fuel cell material handling equipment (MHE) and backup power (BuP) systems manufactured in North America

- Updated the N.A. Non-Automotive Fuel Cell Market Model to reflect 2014 industry restructuring, technological advances and market conditions, including deployments under ARRA
- Completed an evaluation of the additional impacts of the ARRA and ITC on the domestic fuel cell industry and estimated the impacts of ending or phasing out the ITC after 2016

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INTRODUCTION

North American firms have been producing fuel cell BuP and MHE systems for demonstration and commercial sales for about a decade. Fuel cell technologies typically compete with battery and diesel generator systems in the BuP market, and battery-powered forklifts in indoor, warehousing MHE applications where emission-free operation is a priority. Over the past five years, the industry has made enormous progress improving the performance of its products and reducing their costs. The industry has benefited from government policies that provide tax credits and other subsidies, as well as direct purchases.

This project estimates the impact of government subsidies provided by ARRA and ITC on the sales of fuel cell BuP and MHE (i.e., forklifts) by North American firms. The objective is to estimate the additional impact of those policies and their effects on the outlook for the industry in the future.

APPROACH

The N.A. Non-Automotive Fuel Cell Market Model [2] was updated and revised based on information obtained via confidential interviews with hydrogen fuel cell OEMs, as well as from published sources and the internet. Past sales and cost projections of the model were compared with data collected during 2014 to evaluate its performance and identify parameters in need of recalibration. The updated model was then used to estimate the impacts of ARRA and ITC on the North American fuel cell industry and to develop conditional projections of its prospects.

DOE reports that the ARRA partially funded sales of 524 MHE units and 824 BuP units (see Table 1) [5,6]. The ARRA expenditures for fuel cell MHE support was $9.7 million, while the industry cost share was $11.8 million. The corresponding numbers for ARRA funded BuP sales were $18.5 million from DOE and $30.8 million from industry. In addition, DOE has subsidized 83 BuP units and 189 MHE units out of its departmental appropriations. Thus, total DOE-subsidized fuel cell sales amount to 907 BuP units and 713 MHE units. Since 2009, firms have purchased 5,568 BuP units and 8,340 MHE units without DOE support.

TABLE 1. Fuel Cell Unit Sales (Delivered and Planned) by North American OEMs since 2009

Equipment Type	DOE ARRA	DOE Budget	DOE Total	Industry	Total
Backup Power	824	83	907	5,568	6,475
Material Handling	524	189	713	8,340	9,053

Source: Devlin and Kiuru [5,6].

However, these sales also benefitted from ITC and possibly state subsidies.

The customer choice model of the Market Model was recalibrated to exactly predict the sales of fuel cell MHE and BuP units not supported by ARRA for the period 2005 to 2014. Purchases directly supported by ARRA were added making the sum of the two exactly equal to total sales for the period. ARRA sales thereby influenced scale economies and learning in the model. Sales were predicted through 2025. Purchases directly supported by ARRA were then subtracted from the actual purchases and the model was rerun, providing an estimate of what sales would have been in the absence of the ARRA program during the 2009 to 2013 period, as well as the impact on projected sales through 2025. The additional impact of ARRA was estimated by the difference between non-ARRA supported sales given ARRA and the predicted sales without ARRA. Sensitivity analysis was used to explore the effect of assuming that none of the ARRA sales would have occurred in the absence of the program.

RESULTS

Sales predictions made by the 2011 study were compared with estimated actual sales for MHE and BuP. Given the many factors, including ARRA and industry consolidation, influencing sales from 2010 to 2014, the MHE projections are satisfactory but generally underestimate estimated actual sales. BuP sales projections, on the other hand, generally overestimated estimated actual sales, although the data for 2013 and 2014 are incomplete due to the absence of data for one firm in 2013 and two firms in 2014. In both cases the model's predictions are of the correct order of magnitude but the accuracy in any given year is not much better than +/- 50%

Cost analyses published since 2011 and discussions with OEMs in 2014 suggest scale economies for fuel cell stack production in the range of -0.07 to -0.1 [3]. For fuel cell stacks for material handling equipment, cost estimates by Contini et al. imply scale elasticities of -0.04 to -0.07 [1]. Scale elasticities inferred from their cost estimates for the balance of plant are -0.11 for 100 to 1,000 units per year and -0.07 for 1,000 to 10,000. Recent data is consistent with progress ratios for learning by doing of approximately 0.95. Rates of cost reduction due to technological progress are averaging about 2% per year.

The recalibrated market model predicts a price of $33,000–$34,000 for the MHE stack and balance of plant in 2010 but with a wide range of uncertainty (Figure 1). Prices and uncertainty decline sharply in 2011 and continued progress is predicted through 2014. The prediction for 2013 ($17,000) is close to HD Systems' estimate of $15,000–$16,000 for that year, based on manufacturer interviews, company annual reports, and other public sources [3]. The model's cost estimates for BuP also show that 2014 costs are approximately half of the 2010 level (Figure 2). In contrast to Contini et al., HD Systems assumes that the markup over direct manufacturing cost for a fuel cell OEM unit was only 10–15% because market conditions in 2013 did not allow full cost recovery [1,3].

The 504 ARRA MHE deployments were estimated to induce an additional 1,500 MHE sales through 2025 (Figure 3). The 852 ARRA BuP deployments were estimated to produce 3,000 additional BuP unit sales through 2025. Sensitivity analysis predicted that even if as many as 50% of the ARRA deployments would have occurred in the absence of ARRA support, the ARRA-supported deployments would induce 1,000 additional sales of fuel cell MHE and 1,500 additional sales of BuP fuel cell units.

Ending ITC abruptly after 2016 was estimated to have a disruptive effect on the N.A. non-automotive fuel cell market, reducing sales in 2017 to approximately half the 2016 level. Sales could be sustained at approximately the 2016 level through 2020 by a linear phase-out of ITC.

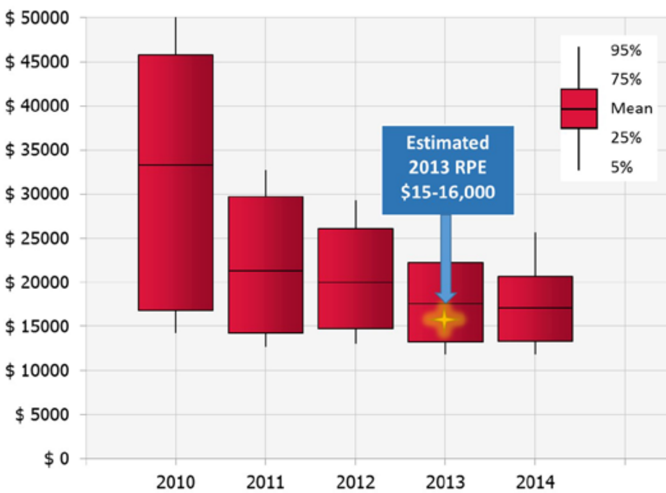

FIGURE 1. Predicted retail price equivalent (RPE) of fuel cell stack and balance of plant for a representative 5 kW forklift

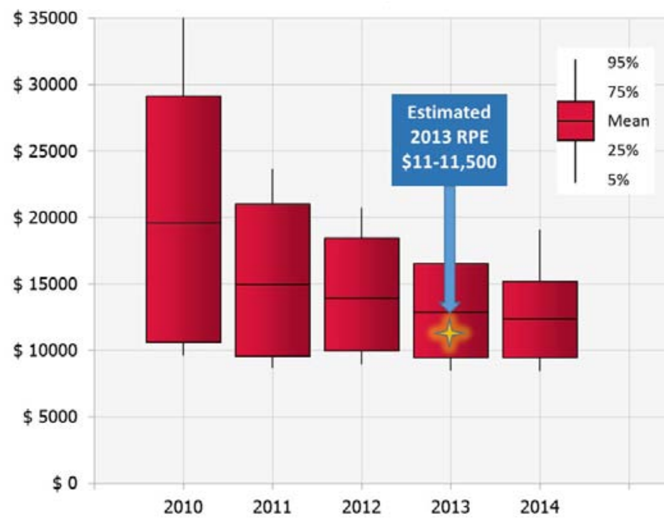

FIGURE 2. Predicted retail price of fuel cell stack and balance of plant for a representative 5 kW backup power unit

FIGURE 3. Estimated additional impact of ARRA on sales of fuel cell (FC) MHE and BuP in North America through 2020

CONCLUSIONS AND FUTURE DIRECTIONS

- The N.A. non-automotive fuel cell industry made substantial progress between 2010 and 2014, cutting costs by approximately half while improving durability and performance.
- Deployment of fuel cell MHE and BuP systems directly supported by ARRA will induce approximately three times as many additional sales of fuel cell systems by N.A. manufacturers through 2025.
- Throughscale economies and learning by doing, the ARRA deployments reduced the cost of fuel cells systems manufactured in N.A. by several hundred dollars per unit.
- Terminating ITC abruptly after 2016 will likely have a disruptive effect on N.A. fuel cell manufacturers. The negative impact could likely be eliminated by gradually phasing out the tax credit by 2020.
- Previous model predictions for the N.A. non-automotive fuel cell industry appear to have underestimated rates of technological progress while overestimating scale economies and learning by doing. Substantial future progress is likely to make the industry self-sustaining without public policy support before 2025.

Future model development should improve the representation of domestic and international markets and increase the level detail in representing fuel cell products. Another review of industry status and prospects, to obtain updated information and continue validation of the industry model should be carried out in 2016–17.

FY 2015 PUBLICATIONS/PRESENTATIONS

1. Greene, D.L., 2015. "Potential Applications of Scale Economies and Learning Curves in Modeling the Transition to Hydrogen Fuel Cell Technologies," Joint FPITT-HDTT-PHTT Meeting, National Renewable Energy Laboratory, Golden, CO, July 14, 2015.

2. Greene, D.L., "Status and Prospects of the N.A. Non-Automotive Fuel Cell Industry: 2014 Update," Project SA056, 2015 U.S. DOE Hydrogen and Fuel Cells Program and Vehicle Technologies Office Annual Merit Review and Peer Evaluation Meeting, Arlington, VA, June 9, 2015.

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1. Contini, V., K. Mahadevan, F. Eubanks, J. Smith, G. Stout, and M. Jansen, 2013. "Manufacturing Cost Analysis of Fuel Cells for Material Handling Applications," Battelle, 5/14/2013, http://www.hydrogen.energy.gov/pdfs/review13/fc097_mahadevan_2013_o.pdf .

2. Greene, D.L., K.G. Duleep, and G. Upreti, 2011. "Status and Outlook for the U.S. Non-Automotive Fuel Cell Industry: Impacts of Government Policies and Assessment of Future Opportunities," ORNL/TM-2011/101, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

3. H-D Systems, 2015. "Non Automotive Fuel Cell Applications: Analysis of Technology, Cost and Markets," Draft Final Report to Oak Ridge National Laboratory, Washington, D.C., January 15.

4. Upreti, G., D.L. Greene, K.G. Duleep, and R. Sawhney, 2012. "Fuel cells for non-automotive uses: status and prospects," International Journal of Hydrogen Energy, Volume 37, Issue 8, pp. 6339–6348, 2012.

5. P. Devlin and K. Kiuru, 2015a. "Industry Deployed Fuel Cell Backup Power (BuP)," DOE Hydrogen and Fuel Cells Program Record 15004, U.S. Department of Energy, Washington, DC.

6. P. Devlin and K. Kiuru, 2015b. "Industry Deployed Fuel Cell Powered Lift Trucks," DOE Hydrogen and Fuel Cells Program Record 15003, U.S. Department of Energy, Washington, DC.