VI.0 Manufacturing R&D Sub-Program Overview

INTRODUCTION

The Manufacturing Research and Development (R&D) sub-program supports activities needed to reduce the cost of manufacturing hydrogen and fuel cell systems and components. Manufacturing R&D will enable the mass production of components in parallel with technology development and will foster a strong domestic supplier base. The sub-program's R&D activities address the challenges of moving today's technologies from the laboratory to high-volume, pre-commercial manufacturing to drive down the cost of hydrogen and fuel cell systems. The sub-program focuses on early-stage commercialization needs for the manufacturing of hydrogen and fuel cells, along with necessary components and systems. Reducing cost for components being used now and in the future remains the research investment focus, as well as reducing overall processing times. Progress toward targets is measured in terms of reductions in the cost of producing fuel cells, increased manufacturing processing rates, and growth of manufacturing capacity.

In Fiscal Year (FY) 2017, manufacturing projects continued in the use of rolled goods quality control to detect defects in membrane electrode assembly materials and modeling of the effect of defects on fuel cell material performance. In addition, the sub-program significantly expanded hfcnexus.com, the U.S. Hydrogen and Fuel Cell Directory, showcasing commercial hydrogen and fuel cell products.

GOAL

The sub-program's goal is to reduce the cost of manufacturing hydrogen production, delivery, storage, and fuel cell component systems through research, development, and demonstration.

OBJECTIVES[1]

Key objectives for Manufacturing R&D include:

- Develop manufacturing techniques to reduce the cost of automotive fuel cell stacks at high volume (500,000 units/yr) from the 2008 value of $38/kW[2] to $20/kW by 2020.
- Develop fabrication and assembly processes to produce compressed hydrogen pressure vessels to enable a total onboard storage system cost of $10/kWh for widespread commercialization of hydrogen fuel cell vehicles across most light-duty platforms by 2020, with an ultimate target of $8/kWh.
- Support efforts to reduce the cost of manufacturing components and systems to produce hydrogen at <$4/gge (2007 dollars) (untaxed, delivered, and dispensed) by 2020, compared with the baseline[3] cost estimates for producing, delivering, and dispensing (untaxed) hydrogen in the near-term market of $13/kg–$16/kg (i.e., $13/gge–$16/gge) without incentives.

FY 2017 TECHNOLOGY STATUS AND ACCOMPLISHMENTS

Presently, fuel cell systems are fabricated in small quantities. The cost of a 10-kW, low-temperature polymer electrolyte membrane (PEM) fuel cell system for combined heat and power (CHP) is projected to be ~$1,170/kW at a volume of 50,000 systems/yr.[4] For automotive applications, the cost of an 80-kW PEM fuel cell system is projected to be $50/kW for low-volume manufacturing (100,000 systems/yr) and $45/kW for high-volume manufacturing (500,000 systems/yr). Projected costs include labor, materials, and related expenditures, but do not account for manufacturing R&D investment.

[1] Note: Targets and milestones were recently revised; therefore, individual project progress reports may reference prior targets.
[2] *Mass Production Cost Estimation for Direct H2 PEM Fuel Cell Systems for Automotive Applications: 2008 Update*, Brian D. James and Jeffrey A. Kalinoski, 2009. http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/mass_production_cost_estimation_report.pdf
[3] *Low Volume Production and Delivery Cost*, Program Record (Hydrogen and Fuel Cells Program) 15011, U.S. Department of Energy, 2015. https://www.hydrogen.energy.gov/pdfs/15011_low_volume_production_delivery_cost.pdf
[4] *A Total Cost of Ownership Model for Design and Manufacturing Optimization of Fuel Cells in Stationary and Emerging Market Applications*, Max Wei, 2016. https://www.hydrogen.energy.gov/pdfs/review16/fc098_wei_2016_o.pdf

Accomplishments in the manufacture of fuel cells and hydrogen storage systems in FY 2017 include the following:

- The Ohio Fuel Cell Coalition held a series of fuel cell supply chain exchanges in conjunction with workshops to facilitate socializing of U.S. fuel cell supply chain companies through regional technical exchange centers and began efforts to organize national standardization efforts.
- Virginia Clean Cities completed significant expansion of the www.hfcnexus.com website (Figure 1), adding a total of 352 companies with a variety of hydrogen and fuel cell components and products to provide supplier information for hydrogen and fuel cell technologies, as well as matchmaking capabilities to introduce suppliers and integrators to each other and advertising capabilities to create a self-sustaining site.

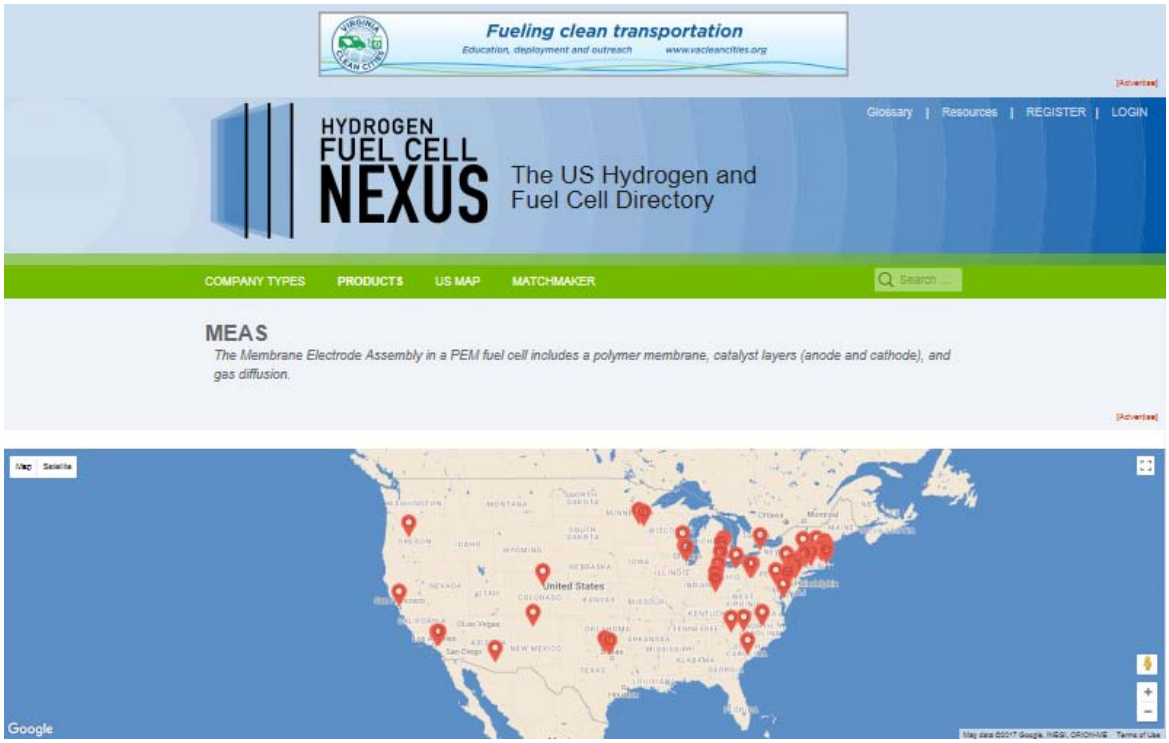

FIGURE 1. www.hfcnexus.com homepage

- GLWN developed a final report and in-depth analysis for five key components (bipolar plates, membranes, gas diffusion layers, catalysts, and hydrogen storage vessels). The drawings were sent to suppliers to obtain price quotations at four vehicle volume levels (1,000; 10,000; 100,000; and 500,000 units/yr). GLWN also completed an analysis of the global fuel cell and hydrogen supply chain to determine opportunities for U.S. competition and expansion.
- Automated Dynamics developed an innovative metal/polymer composite hydrogen pipeline coupler and is now developing and refining the design specification with some metal parts to reduce the possibility of hydrogen embrittlement. The design included mechanical loading, environmental effects, and leak rates. It is passing pressure and leak rate tests and will be subject to testing and analysis to pass fatigue requirements.
- Mainstream developed a small-scale (6-in web width) winder/unwinder to run at 100 ft/min for quality control in roll-to-roll processing of fuel cell membranes. Mainstream also demonstrated an optical system that detected 40 out of 40 100-µm pinhole defects in real time on National Renewable Energy Laboratory's continuous roll-to-roll web line with Nafion211 membrane material at speeds of up to 30 ft/min. With post processing, all defects were successfully identified at web line speeds up to 100 ft/min.
- National Renewable Energy Laboratory identified and tested defective samples, and preliminary results indicated that defects less than 10 µm have no immediate effect on performance, and defects larger than 300 µm decrease performance. National Renewable Energy Laboratory also demonstrated real-time imaging of membrane

thickness as seen in Figure 2, which shows the thickness map of a nominally 25-µm membrane taken at a scanning speed of 5 ft/min.

- The Manufacturing R&D sub-program joined the DOE Office of Energy Efficiency and Renewable Energy's Roll-to-Roll Consortium (R2R) focused on batteries, fuel cells, and membranes for water purification and issued a cooperative research and development agreement (CRADA) call soliciting projects.

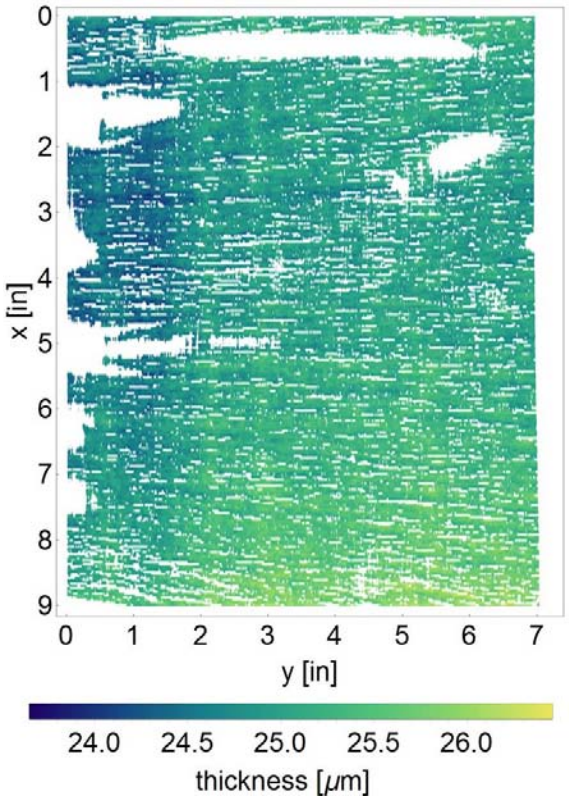

FIGURE 2. Thickness image of 25-µm membrane taken at 5 ft/min

BUDGET

The FY 2017 budget allocated $1 million to the Manufacturing R&D sub-program (Figure 3).

UPCOMING ACTIVITIES AND PLANS

Using funding from prior year appropriations, in FY 2018, the Manufacturing R&D sub-program will:

- Continue projects on supply chain development, report on fuel cell shipments and revenues, and conduct global manufacturing competitive analysis.
- Use the four-laboratory consortium to solicit projects for a CRADA call on fuel cell roll-to-roll processing in collaboration with, and leveraging investment by, the Advanced Manufacturing Office in the Office of Energy Efficiency and Renewable Energy.
- Complete the project to manufacture reliable joints (with very low leak rates) that connect fiber-reinforced pipeline for hydrogen delivery at 100 bar with a final design and physical fatigue tests.

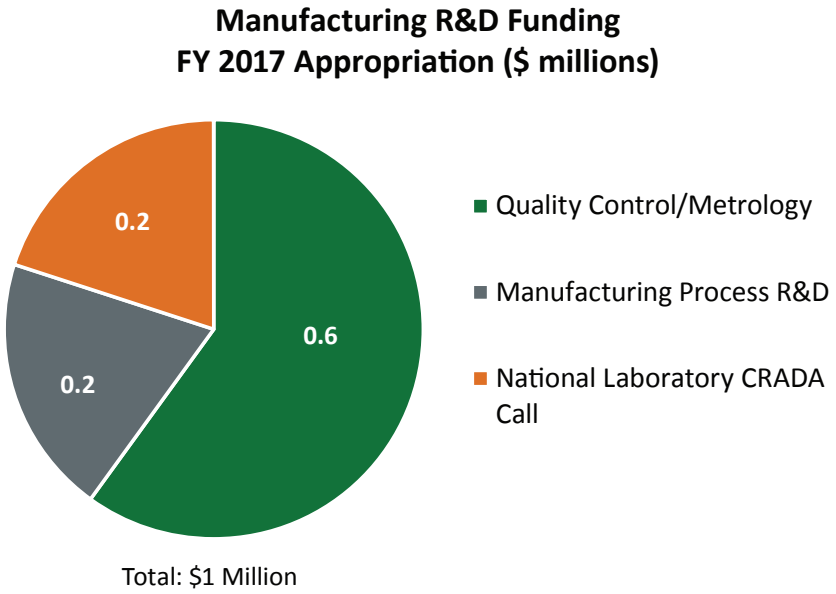

FIGURE 3. FY 2017 Appropriations

- Correlate size of defects generated during membrane, membrane electrode assembly, and gas diffusion electrode fabrication to loss in fuel cell performance.
- Continue to use predictive modeling and single and segmented cell test methods to assist diagnostic development.
- Expand implementation of defect diagnostic techniques on industry production lines to original equipment manufacturers.

The Fuel Cell Technologies Office will continue to coordinate with other agencies (including the National Institute of Standards and Technology and the U.S. Department of Defense) and with other technology offices within DOE's Office of Energy Efficiency and Renewable Energy to identify synergies and leverage efforts.

Future activities are subject to appropriations.

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