VI.0 Manufacturing R&D Sub-Program Overview

The Manufacturing R&D sub-program supports research and development needed to reduce the cost of manufacturing hydrogen and fuel cell systems and components. The manufacturing research and development (R&D) effort will enable the mass production of components (in parallel with technology development) and will foster a strong domestic supplier base. Activities will address the challenges of moving today's laboratory-produced technologies to high-volume, pre-commercial manufacturing to drive down the cost of hydrogen and fuel cell systems. This sub-program focuses on the manufacture of components and systems that will be needed in the early stages of commercialization. Research investments are focused on reducing the cost of components currently used (or planned for use) in existing technologies, as well as reducing the cycle times of the processes being developed. Progress toward goals 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) 2011, manufacturing projects continued in the following areas: novel electrode deposition processes for membrane electrode assembly (MEA) fabrication, high-volume fuel cell leak-test processes, novel assembly processes for low cost MEAs, gas diffusion layer cost reductions, flow field plate manufacturing variability and its impact on performance, and fabrication technologies for high-pressure composite storage tanks.

Goal

Research and develop innovative technologies and processes that reduce the cost of manufacturing fuel cells and related systems–providing critical support to industry and helping to spur the growth of a strong domestic supplier base.

Objectives[1]

Currently, the sub-program is focused on technologies and processes for manufacturing polymer electrolyte membrane (PEM) fuel cells and tanks for high-pressure hydrogen storage.

Key objectives for fuel cell manufacturing include:

- By 2012, develop continuous in-line measurement for MEA fabrication.
- By 2013, reduce the cost of manufacturing MEAs by 25%, relative to 2008 baseline of $\$63/kW_e$ (at 1,000 units/year).
- By 2015, reduce the cost of PEM fuel cell stack assembly and testing by 50%, relative to the 2008 baseline of $\$0.84/kW_e$ (at 1,000 units/year).
- By 2017, develop improved fabrication and assembly processes for polymer electrolyte membranes that will enable an automotive fuel cell system cost of $30/kW (projected to high-volume).

Cost targets for hydrogen storage tanks are currently being re-evaluated.

FY 2011 Technology Status

Presently, fuel cell systems are fabricated in small quantities. The cost of 5-kW, low-temperature PEM fuel cell systems for stationary applications is projected to be ~$\$3,100/kW_{net}$ at a volume of 1,000 systems per year.[2] There were almost 2,000 stationary fuel cell systems shipped by North American manufacturers in 2010.[3] For automotive applications using today's technology, the cost of an 80-kW PEM fuel cell system is projected to be $49/kW for high-volume manufacturing (500,000 systems/year) and about $220/kW at manufacturing

[1] Note: Targets and milestones are under revision; therefore, individual progress reports may reference prior targets.
[2] James, B. D., et al., "Low Temperature PEM Stationary Fuel Cell System Cost Analysis: Preliminary Results", NREL Subcontract Report, Subcontract number AGB-0-40628-01, May 2011.
[3] *2010 Fuel Cell Technologies Market Report*, U.S. Department of Energy, June 2011. www1.eere.energy.gov/hydrogenandfuelcells/pdfs/2010_market_report.pdf.

volumes of 1,000 systems/year.[4] The projected high-volume cost includes labor, materials, and related expenditures, but does not account for manufacturing R&D investment.

FY 2011 Accomplishments

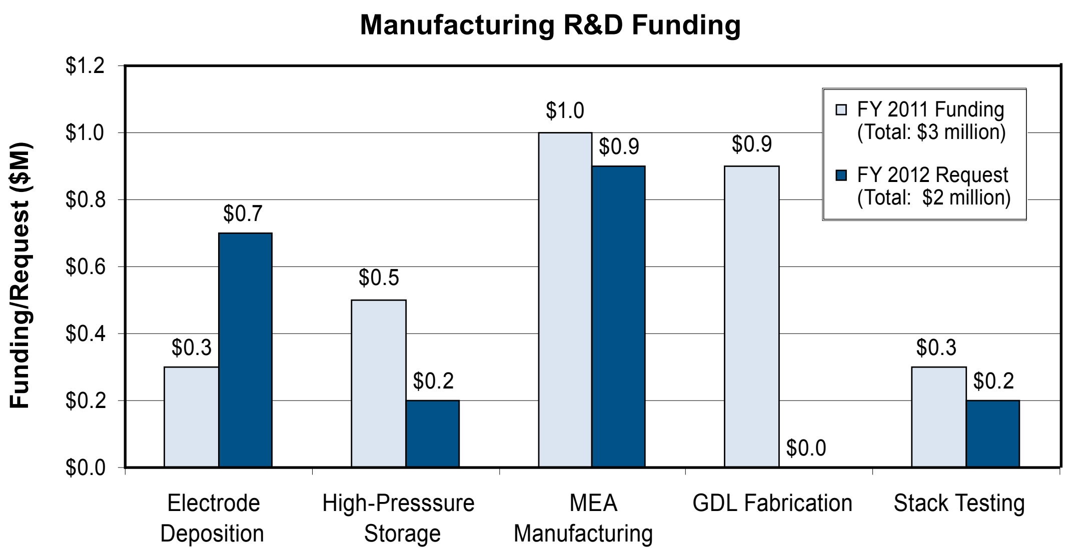
FY 2011 saw a number of advancements in the manufacture of fuel cells and storage systems, including:

- **Gas Diffusion Layer (GDL) Fabrication:** Ballard improved thickness and basis-weight uniformity of GDLs by adding mass flow meters to the "Many-at-a-Time" coating equipment, resulting in GDL cost reduction of over 60% since 2008, while increasing manufacturing capacity nearly four-fold.
- **Electrode Deposition:** W.L. Gore reduced membrane thickness, eliminated membrane backers, reduced scrap with better coating process, and eliminated finishing operations such as electrode and membrane edge trim. Gore previously demonstrated, using their cost model, that a new three-layer MEA process has the potential to reduce MEA cost by 25%.
- **High-Pressure Storage:** Quantum saved 17.4 kg of composite from the baseline (all fiber wound) vessel (23% savings).
- **MEA Manufacturing:** BASF reduced ink preparation time and the number of coating applications by >50%, and improved fuel cell performance by 20 mV over the baseline of 0.67 V at 0.2 A/cm^2. BASF also demonstrated a microporous layer on a production coater with full-width cloth.
- **Component and Stack Measurement:** The National Renewable Energy Laboratory demonstrated the ability to detect defects ≥6.25 mm^2 (e.g., pinholes, electrical shorts, and electrode thickness variations) and catalyst loading variations ≥10% (at nominal 0.45 mg Pt/cm^2) in MEAs using their internal resistance/direct current diagnostic.
- **Bipolar Plate Flow Field Uniformity:** Using their non-contact sensor apparatus for vertical and lateral measurement of flow field dimensions, the National Institute for Science and Technology showed that there was very little accuracy degradation as the scan rate was increased from 30 mm/s to 500 mm/s–allowing high-speed, fully-automated inspection.
- **Hydrogen and Fuel Cells Manufacturing R&D Workshop:** In August 2011, the National Renewable Energy Laboratory and DOE hosted a workshop to identify strategies and R&D needs for lowering the cost of manufacturing hydrogen production, delivery, and storage systems and fuel cell systems and components. The input from the workshop will be used to identify key barriers and needs for future Program activities as well as funding opportunities.

Budget

The President's FY 2012 budget request for the Fuel Cell Technologies Program includes $2 million for Manufacturing R&D. The FY 2011 appropriation for Manufacturing R&D was $3 million.

[4] James, B.D., et al., "Manufacturing Cost Analysis of Fuel Cell Systems," 2011DOE Hydrogen and Fuel Cells Program Annual Merit Review Proceedings, May 2011, www.hydrogen.energy.gov/pdfs/review11/fc018_james_2011_o.pdf, May 2011.



FY 2012 Plans

In FY 2012, activities in the Manufacturing R&D sub-program will: scale up production of low-cost MEAs; update the cost model of hydrogen pressure vessels to include the consideration of lower-performance carbon fiber; demonstrate a 2x reduction in the cost of MEAs by reducing labor involved in ink preparation and reducing the number of coating applications; and further develop the National Renewable Energy Laboratory's continuous in-line measurement of MEA fabrication.

Participants at the Hydrogen/Fuel Cell Manufacturing Workshop suggested a number of follow-on activities for DOE, including:

1. Hosting a meeting of manufacturers to initiate efforts to:
   - Establish a consensus on standard specifications for hydrogen and fuel cell systems and components.
   - Facilitate leveraging the buying power of multiple customers to reduce costs.
   - Facilitate development and expansion of the supply chain.
2. As an output of the first meeting, defining sub-groups to discuss and make plans to address (if possible) individual issues. Each sub-group can involve different supply chain vendors as necessary for their tasks/issues.
3. Hosting a meeting in which the sub-groups report back to the full working group for prioritization, decisions, etc.

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