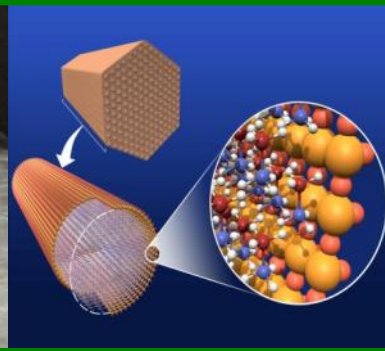




U.S. DEPARTMENT OF
ENERGY



Manufacturing R&D

- Session Introduction -

Nancy Garland

2013 Annual Merit Review and Peer Evaluation
May 15, 2013

- Goals
 - Research and develop technologies and processes that will:
 - Reduce the cost of producing components and systems for fuel cells, storage, and hydrogen production
 - Grow the domestic supplier base
- Objectives
 - Develop manufacturing techniques to reduce the cost of automotive fuel cell stacks at high volume (500,000 units/year) from the 2008 value of \$38/kW to \$21/kW by 2017.
 - Develop process to produce & [{] ! ^ • • ^ a Á @ a ! [* ^ } Á d | æ * ^ Á • ^ • c ^ { • d Á @] Á ^ ^ Á @ Á F G D Y @ Á [• c æ * ^ Á ^ Á G E F I È Á G E F € status - \$19/kWh)

Move the manufacture of hydrogen and fuel cell components and systems from the laboratory into low-cost, high-volume production

Key Examples

Fuel Cell Needs

- High-Volume Processes to manufacture Membrane Electrode Assemblies (MEAs), Bipolar Plates, and Balance-of-Plant
- High-Speed Sealing Techniques
- Automated Stack Assembly

Hydrogen Storage Needs

- Fabrication Processes to attach Carbon Fiber to Conformable Tanks

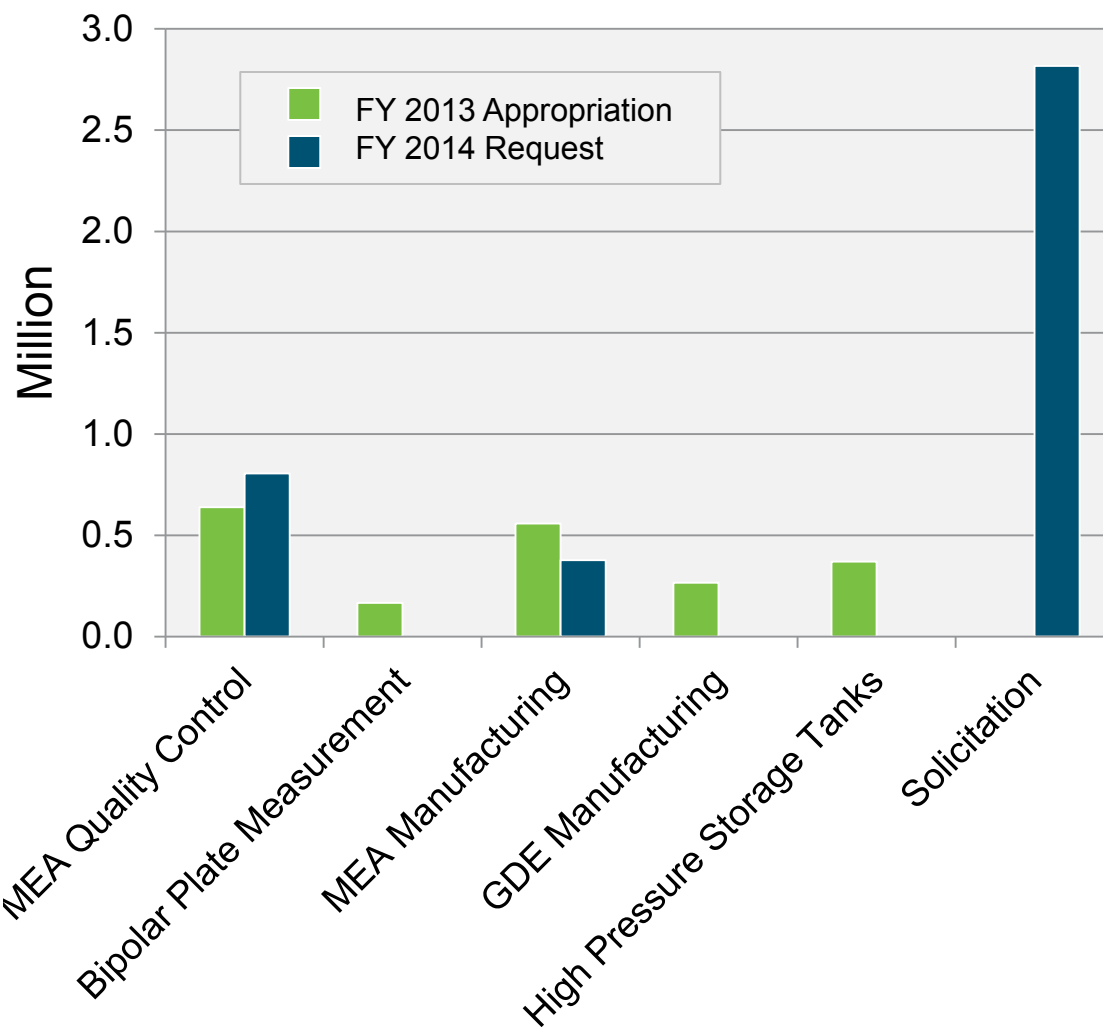
Hydrogen Production Needs

- Reliable Compressors, dispensers and other components



FY 2013 Appropriation = \$1.9 M

FY 2014 Request = \$4 M



EMPHASIS

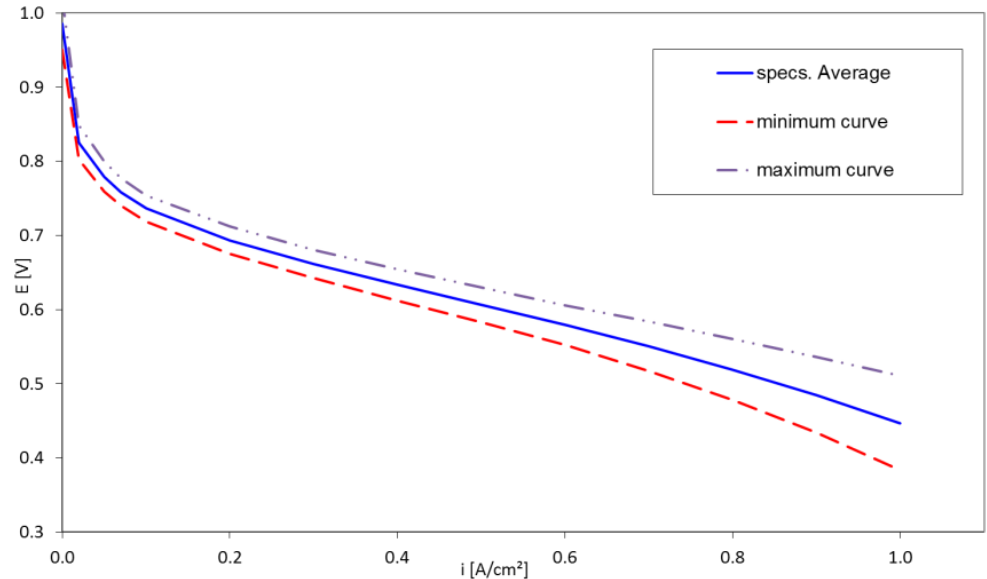
- Continue core efforts on PEM fuel cells
 - Simplify roll-to-roll processing of MEAs by reducing the number of coating passes and direct coating of catalyst onto ionomer

Projects

- **MEA Manufacturing**
 - Gore, LBNL
 - **Effective Measurement of Fuel Cell Stacks**
 - NREL
- Fund new projects (from FY 2013 funding opportunity announcement) based on results from hydrogen and fuel cell Manufacturing R&D workshop (subject to appropriations)

BASF's new Celtec® P1100W product based on DOE project

- **Status:** 2012 AMR demonstrated production scale multi-step MPL fabrication. 2012/13 focus was on single application steps for MPL and catalyst layer
- **Approach:** Increase solids content (and thus viscosity) of ink without loss of stability. Investigate alternative application process to handle higher viscosity inks
- **Results:** Scaled single-pass MPL to production coating machine. Pilot scale single-pass with catalyst. All at 1/2 width.



Improvement vs. best cloth

Cost (hrs. or material)	% reduction
Coating Time (1/2 width)	28
Coating Time (full width)	64
Base Material Cost*	44
Ink Time	pilot scale

* 3,000 5-kW systems

Project Accomplishments

- Reduced total GDE labor costs ~75%
- Exceeded 3x throughput project goal to 4x
- Launched new product based on this work
 - Transitioned from selectively picking high performers to “six sigma” product

FY13 Focus: exploratory diagnostic studies

Progress: Ion Power to demonstrate NREL's (in-plane) IR/DC technique on their own coating line (transfer from lab to industry)

Approach

Understand quality control needs from industry partners and forums

Develop diagnostics

Use modeling to guide development

Use *in situ* testing to understand the effects of defects

Validate diagnostics in-line

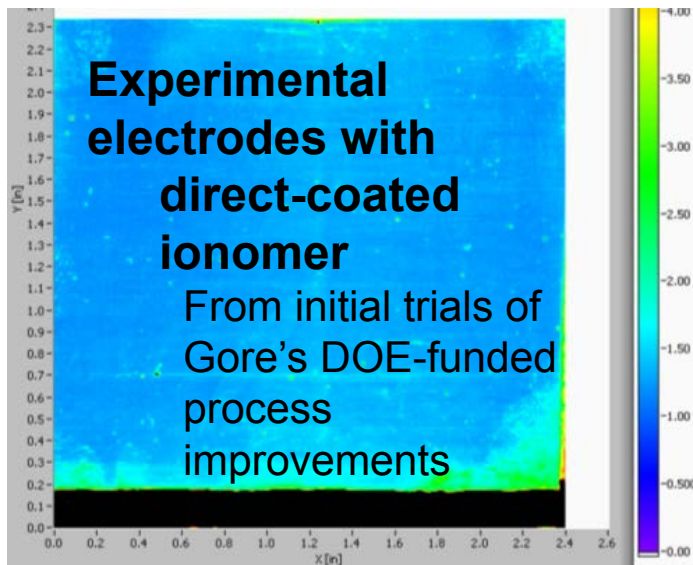
Transfer technology



Optical diagnostic on CCMs

Experimental electrodes with direct-coated ionomer

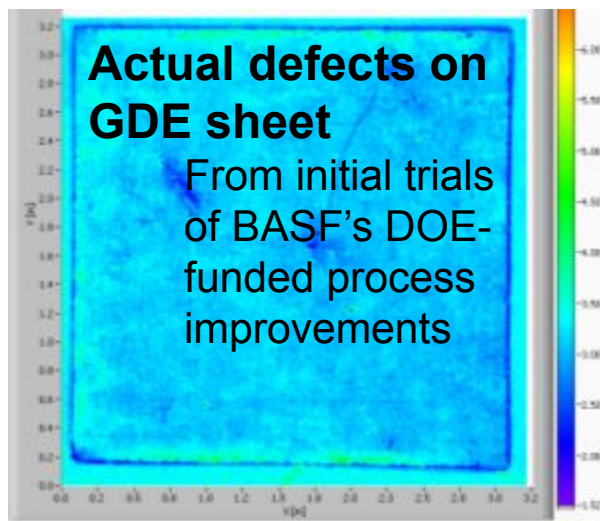
From initial trials of Gore's DOE-funded process improvements



Optical diagnostic on GDEs

Actual defects on GDE sheet

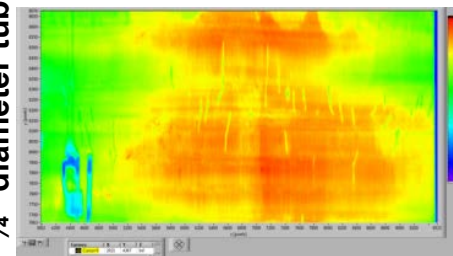
From initial trials of BASF's DOE-funded process improvements



Optical diagnostic on tubes



1/4" diameter tube



- Fired tubes (anode + electrolyte)
- Detected defects of ~1 mm dimension

Workshop Held to Inform Potential Focus Areas for Future FOA

NREL convened industry and stakeholders with expertise in hydrogen and fuel cell technologies, manufacturing, and automation to solicit input on barriers to the manufacture of hydrogen and fuel cell systems and components, and high-priority needs and R&D activities that government can support to overcome those barriers.

Issue	Votes
PEM Fuel Cells/Electrolyzers BOP: Facilitate a manufacturing group for DOE to expand supply chain.	21
Electrodes: How to apply ink directly to membrane; dual direct coating of CCM; <i>membrane dimensional change with deposition of current inks (Fuel cell R&D)</i>	20
PEM Fuel Cells/Electrolyzers BOP: <i>Develop low cost manufacturing of natural gas reformers (Fuel cell R&D)</i>	18
Stack Assembly: High volume stack assembly processes: reduced labor, improved automation	15
Quality/Inspection/Process Control: Develop methods of identifying coating defects on a moving web, then rejecting single pieces downstream; defect detection after MEA assembly when defect may no longer be visible; ability to separate materials with defects from rolled goods with minimum production of scrap	15
SOFC: Multi-layer/component sintering	14

Organized by the National Renewable Energy Laboratory for the U.S. Department of Energy
Minutes posted at: http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_h2_fc_manufacturing.html

PEM Fuel Cells

Current MEA

- Large batch mixing
- Roll-to-roll processes for membrane, electrode, and GDL fabrication
- Decal transfer of electrode to membrane
- Manual assembly of MEA with seals
- Hot pressing

Advancements

- Continuous mixing
- Robotic or roll-to-roll assembly of MEAs with seals
- Direct coating of electrode on membrane
- Hot-roll lamination or improved pressing

Current Stack

- Manual assembly
- Manual leak/performance test

Advancements

- Automated assembly
- Automatic leak/performance test

Current BOP

- Lean manufacturing cells and flow
- Unique components

Advancements

- Standardized designs
- Robotic BOP/system assembly line

Solid Oxide Fuel Cells

Current Cell

- Large batch mixing of powders and slurries
- Single layer tape casting with lamination of layers (planar)
- Batch pressing or extrusion of tubes (tubular)
- Semi-automated coating of electrolyte and cathode (tubular)
- Batch heat treatment and sintering
- Manual assembly of cells with seals
- Manual winding of interconnect wire (tubular)

Advancements

- Continuous mixing
- Multi-layer tape casting (planar)
- Continuous pressing or extrusion of tubes (tubular)
- Continuous firing and sintering
- Robotic assembly of cells with seals
- Automated winding of interconnect wire (tubular)

Current Stack

- Manual assembly
- Manual shaping of insulation
- Manual leak/performance test

Advancements

- Automated assembly
- Net-shape or other methods for insulation
- Automatic leak/performance test

Current BOP

- Manual assembly
- Unique components

- Lean manufacturing cells and flow

Advancements

- Standardized designs
- Robotic BOP/system assembly line

Cross-cutting EERE Initiative launched by Assistant Secretary Danielson in March 2013

- **Objectives:**

- Increase U.S. competitiveness in the production of clean energy products
- Increase U.S. manufacturing competitiveness across the board by increasing energy productivity.

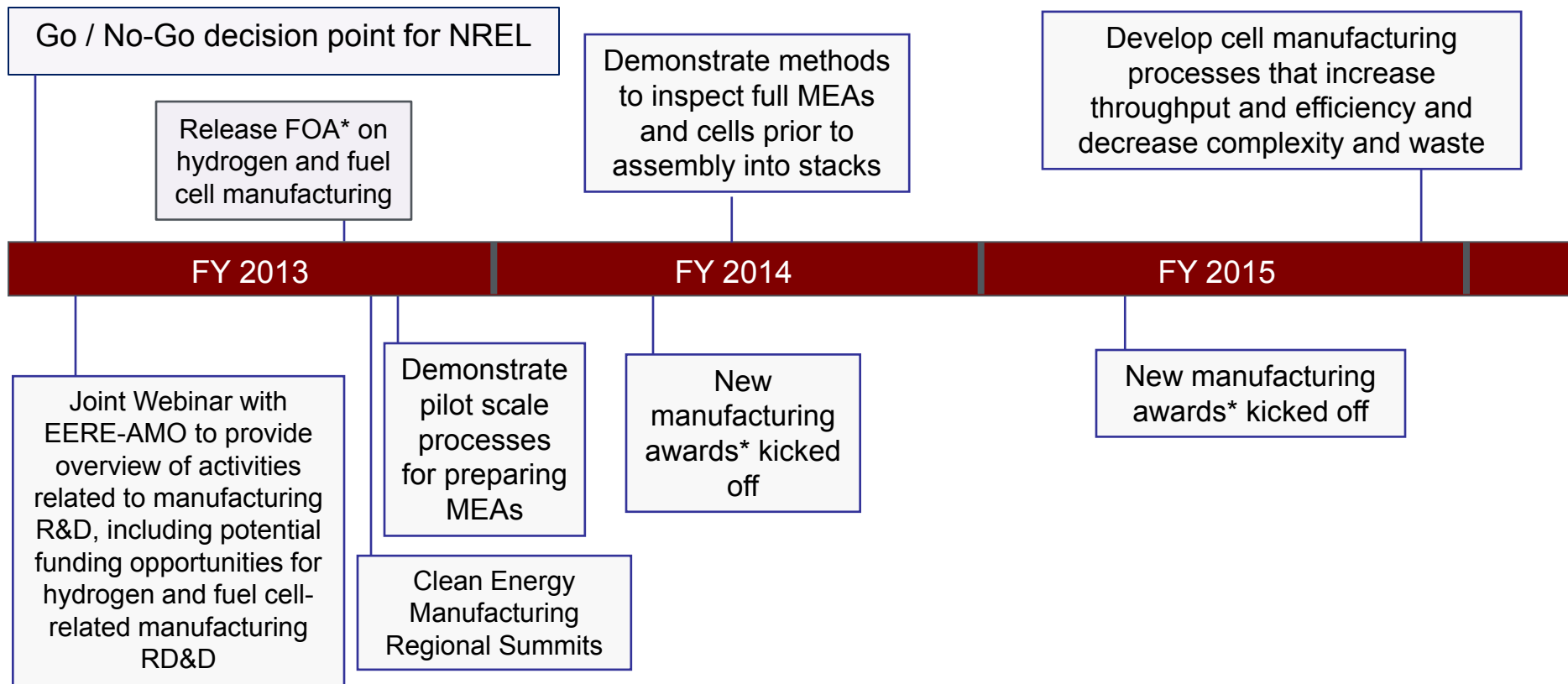


- **Highlights:**

- Increased funding for manufacturing R&D across the board
- Increased EERE focus on energy productivity resources for manufacturers
- Development of competitiveness analysis and strategies
- A clean energy manufacturing portal
- Regional and national summits
- New partnerships and engagement opportunities

eere.energy.gov/energymanufacturing

Key milestones and future plans



*Subject to appropriations

- **Electrode Deposition**
 - BASF
- **High Pressure Storage**
 - Quantum
 - PNNL
- **MEA Manufacturing**
 - RPI
 - Gore
 - NIST
- **Measurement of MEA Defects**
 - NREL
 - LBNL

Manufacturing

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- This is a review, not a conference.
- Presentations will begin precisely at scheduled times.
- Talks will be 20 minutes and Q&A 10 minutes.
- Reviewers have priority for questions over the general audience.
- Reviewers should be seated in front of the room for convenient access by the microphone attendants during the Q&A.
- Please mute all cell phones and other portable devices.
- Photography and audio and video recording are not permitted.

- Deadline to submit your reviews is Friday, **May 24th at 5:00 pm EDT.**
- ORISE personnel are available on-site for assistance.
 - **Reviewer Lab Hours:**
 - Monday, 5:00 pm – 8:00 pm (Gateway ONLY)
 - Tuesday – Wednesday, 7:00 am – 8:00 pm (Gateway)
 - Thursday, 7:00 am – 6:00 pm (Gateway)
 - Tuesday – Thursday, 7:00 am – 6:00 pm (City)
 - **Reviewer Lab Locations:**
 - Crystal Gateway Hotel—*Rosslyn Room* (downstairs, on Lobby level)
 - Crystal City Hotel—*Roosevelt Boardroom* (next to Salon A)