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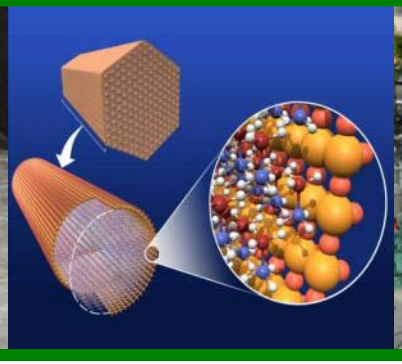

Manufacturing Sub-program
- Session Introduction -

Nancy Garland

2011 Annual Merit Review and Peer Evaluation

May 12, 2011

Goals & Objectives

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- Goals
  - Develop and demonstrate technologies and processes that will:
    - Reduce the cost of components and systems for fuel cells, storage, and hydrogen production
    - Grow the domestic supplier base
- Objectives
  - Enable the reduction in cost of fuel cell stacks from $1500/kW to $15/kW by 2015
  - Enable the reduction in cost of forecourt compression from $4/kg/hr to $3/kg/hr by 2015

Challenges

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Move hydrogen and fuel cells from laboratory-scale production into high-volume, low-cost manufacturing

Fuel Cells

Lack of: High-Volume Membrane Electrode Assembly (MEA), Bipolar Plate, and Balance-of-Plant Manufacturing Processes
High-Speed Sealing Techniques
Automated Stack Assembly

Storage

High Cost of Carbon Fiber
Lack of Carbon Fiber Fabrication Techniques for Conformable Tanks

Hydrogen Production

Lack of: Automated Joining, Coating, Stamping, and Extrusion Processes
Continuous Manufacturing and Modularization Processes

Budget

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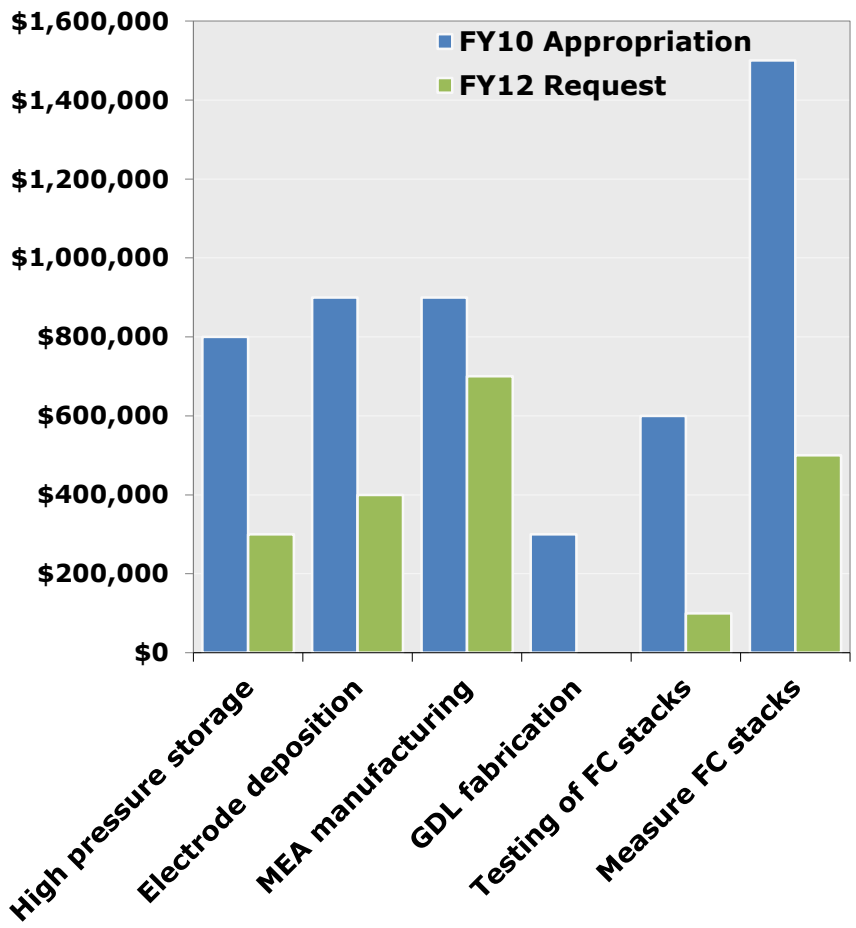
FY 2010 Appropriation = $5 M*

FY 2012 Request = $2 M



*FY11 appropriation to be determined.

EMPHASIS

- Develop novel, robust, ultrasonic bonding processes for MEAs to reduce MEA-pressing cycle time
- Develop real-time, online measurement tools to reduce/eliminate ex situ characterization, sampling, and testing
- Develop and demonstrate innovative precision fiber placement and commercial filament winding for high-pressure carbon composite tanks
- Conclude efforts on streamlining GDL fabrication techniques

Progress: GDL Fabrication Cost Reduction

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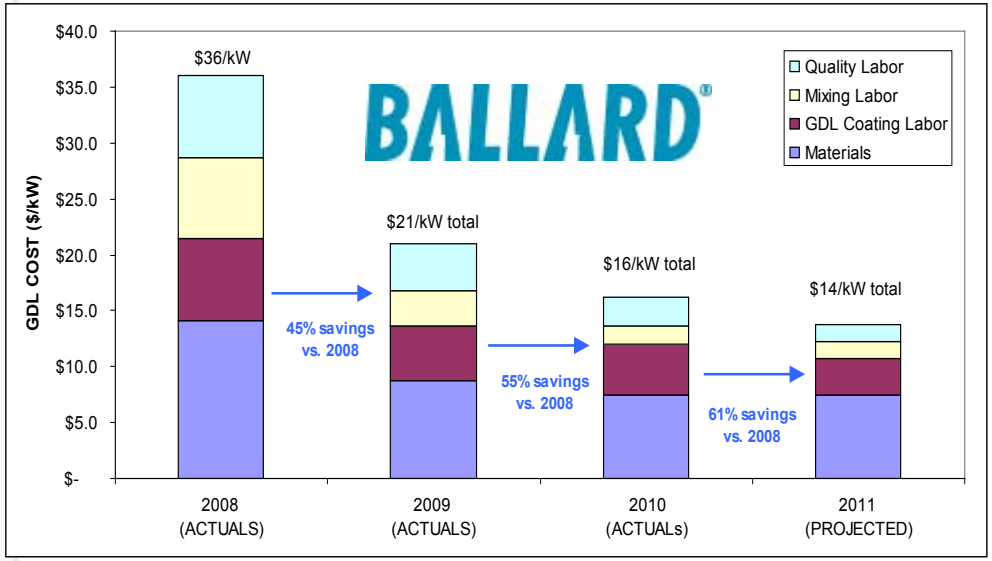
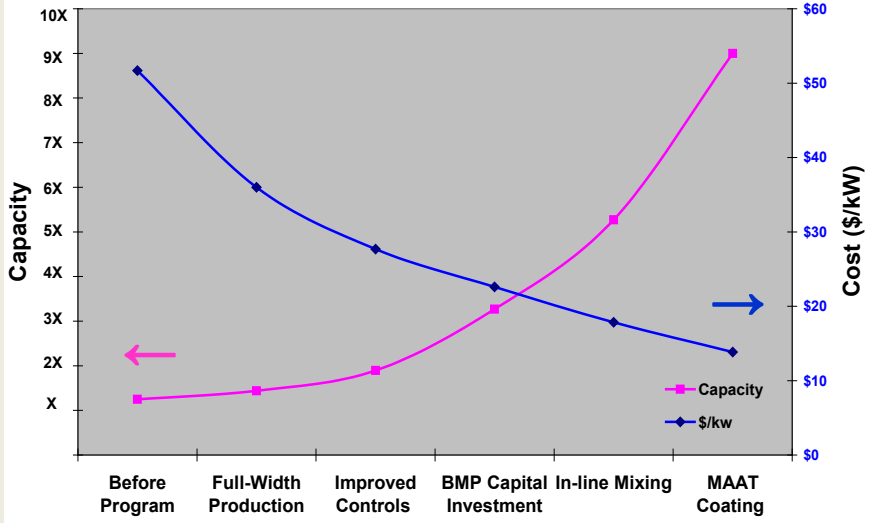
Reduced cost of GDLs by more than 50% and increased manufacturing capacity more than 4x since 2008

Project Approach:

- **Reduce high material & manufacturing costs:**
  - Eliminate process steps, improve production yields, reduce scrap and increase production efficiency
- **Develop high-volume MEA (GDL) processes:**
  - Process modifications introduced in this project have increased production volumes nearly 4-fold
- **Improve low levels of quality control and inflexible processes:**
  - Introduce new quality control technologies such as mass flow meters to control MPL loadings, provide more uniform properties and reduce the amount of ex situ testing required
  - Add an in-line visual inspection station as a final quality tool to improve processing efficiency and accuracy





Progress: Low-cost, durable MEAs

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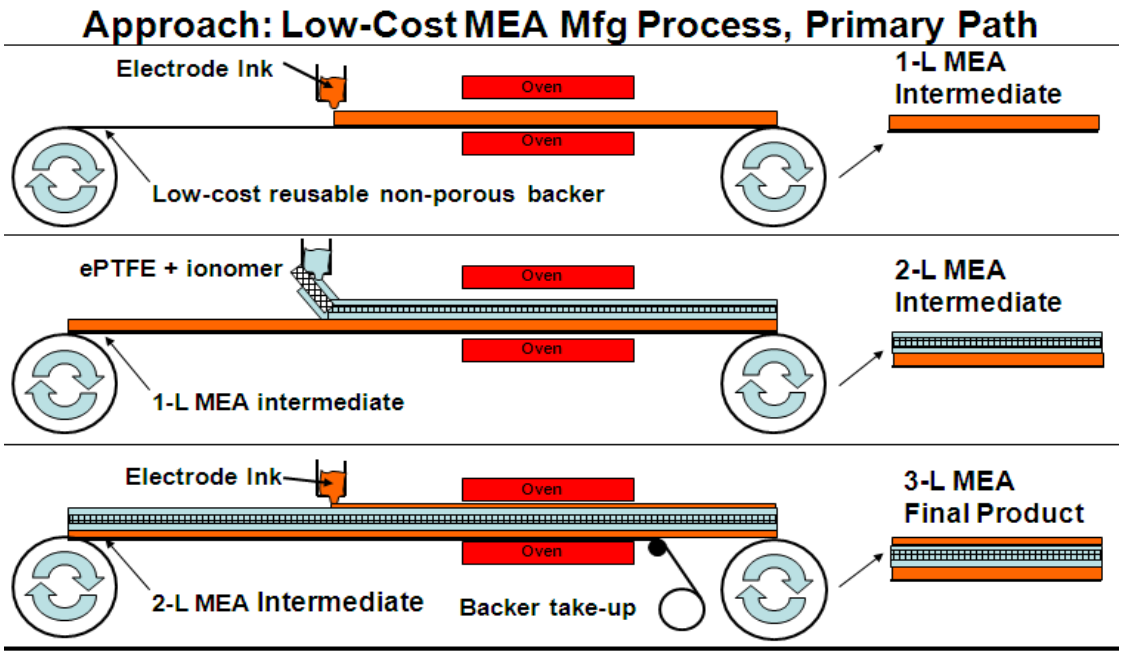
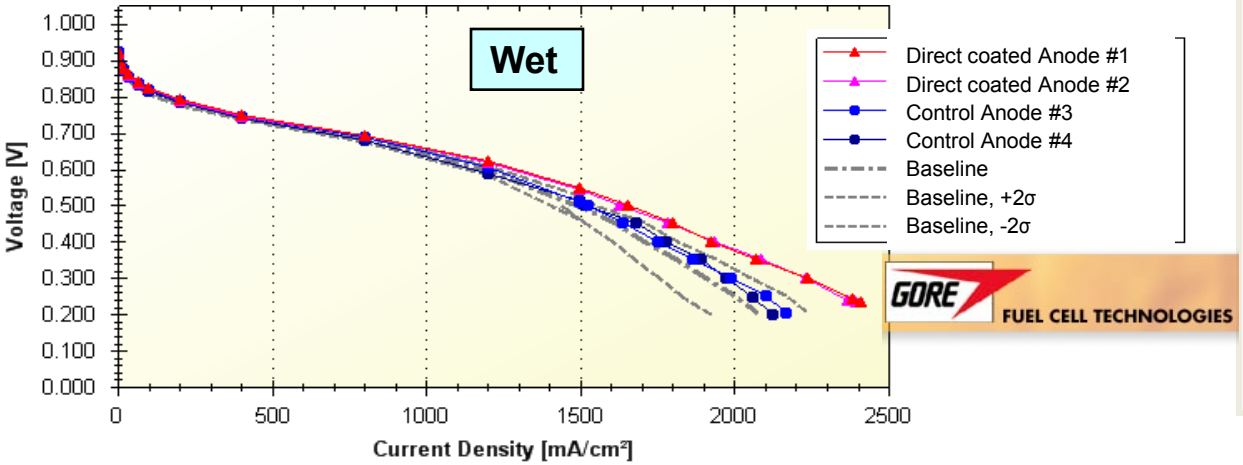
Increased performance by 200 mA/cm² at 0.4 V by improving the membrane/anode interface through direct coating





Reduce MEA & Stack Costs

- Eliminate intermediate backer materials
- Reduce number & cost of coating passes
- Minimize use of solvents
- Reduce conditioning time & cost

Enabling Technologies:

- Direct coating: Use coating to form at least one membrane–electrode interface
- Gore's advanced ePTFE membrane reinforcement & advanced PFSA ionomers enable durable, high-performance MEAs
- Model mechanical stress and heat / water management to accelerate low-cost MEA optimization
- Advanced fuel cell testing & diagnostics

Explore new 3-Layer MEA Process

- Investigate equipment configuration for MEA production
- Investigate raw material formulations
- Map process windows for each layer of the MEA

Progress: Developing diagnostics for MEA manufacture

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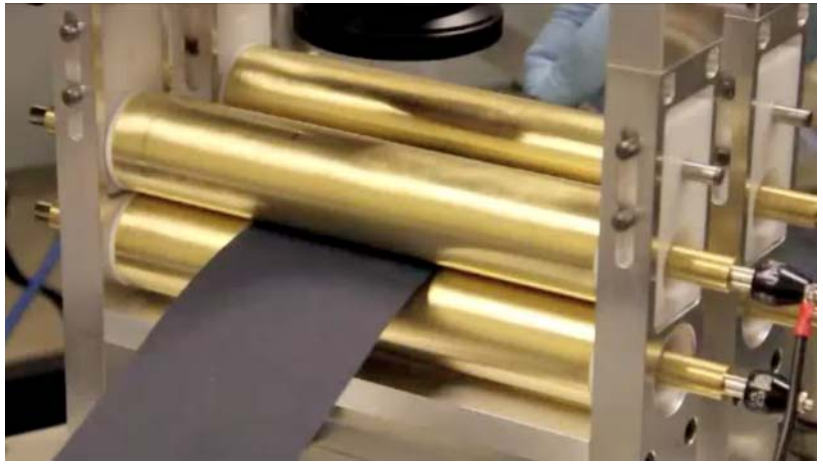
Achieved areal image of catalyst layer uniformity, technique can be scaled up for in-line testing

Project Approach:

Evaluate and develop in-line diagnostics for MEA component quality control, and validate in-line

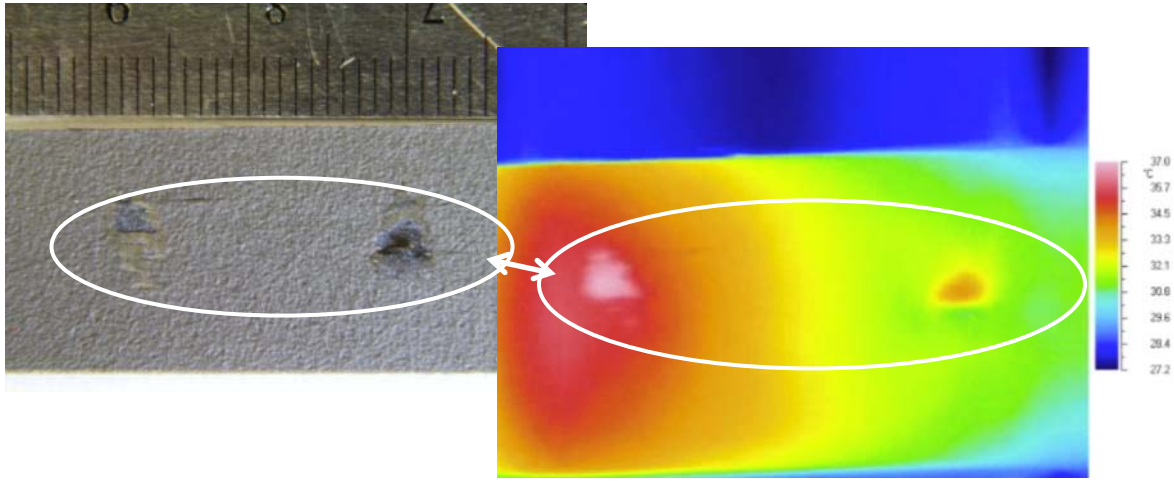
Investigate the effects of manufacturing defects on MEA performance and durability to understand the accuracy requirements for diagnostics

Integrate modeling to support diagnostic development and implementation



Example:

- **DC excitation of catalyst-coated membrane causes thermal response**
- **Defects change catalyst layer resistance, thus altering the thermal response**
- **IR camera provides rapid, quantifiable 2D data**



NREL NATIONAL RENEWABLE ENERGY LABORATORY

BERKELEY LAB

Summary

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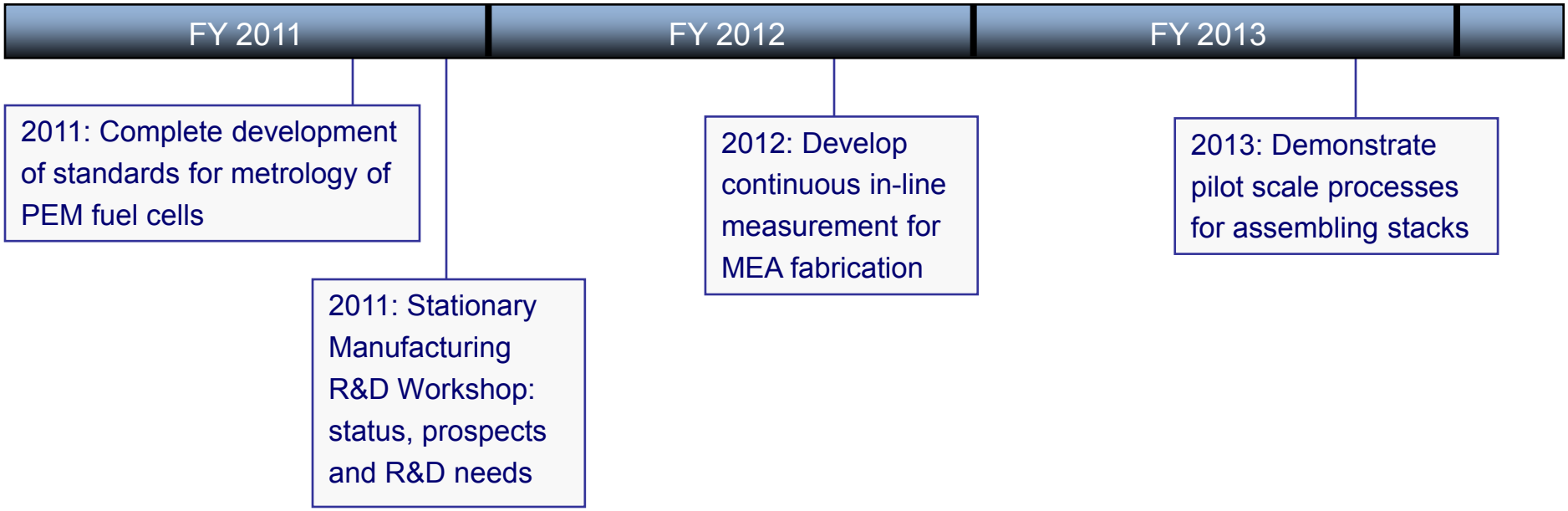
Major Milestones and Workshops

Go / No-Go decision point for Modular, High-Volume Fuel Cell Leak-Test Suite and Process:
6/30/2011 Achieve 5 pph capacity, 50 pph throughput design



Session Instructions

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- This is a review, not a conference.
- Presentations will begin precisely at the 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 turn off all cell phones, BlackBerries, etc.
- Photography and audio and video recording are not permitted.

Reviewer Reminders

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- Deadline for submitting final review form is May 20th at 5:00 PM EDT.
- ORISE personnel are available on-site for assistance. A reviewer-ready room is set up in *The Boardroom* (next to Salon A) and it will be open Tuesday – Thursday from 7:30 AM to 6:00 PM and Friday 7:30 AM to 2:00 PM.
- Reviewers are invited to a brief feedback session at 12:30 PM today, in this room.

For More Information

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Manufacturing

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EERE Postdoctoral Fellowship Program

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- Fuel Cell Technologies Program Opportunities Available
  - Conduct applied research at universities, National Laboratories, or other research facilities
  - Up to five positions are available in the areas of hydrogen production, hydrogen delivery, hydrogen storage, and fuel cells

- ❑ Applications are due June 30, 2011
- ❑ Winners will be announced mid-August
- ❑ Fellowships begin in mid-November 2011

www.eere.energy.gov/education/postdoctoral_fellowships/

Participating Organizations

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- **Electrode Deposition**
  - BASF
- **High Pressure Storage**
  - Quantum
  - PNNL
- **MEA Manufacturing**
  - ORNL
  - RPI
  - Gore
- **GDL Fabrication**
  - Ballard Material Products
- **Testing of FC Stacks**
  - UltraCell
  - PNNL
  - LLNL
- **Measurement of FC Stacks**
  - NIST
  - NREL
  - LBNL