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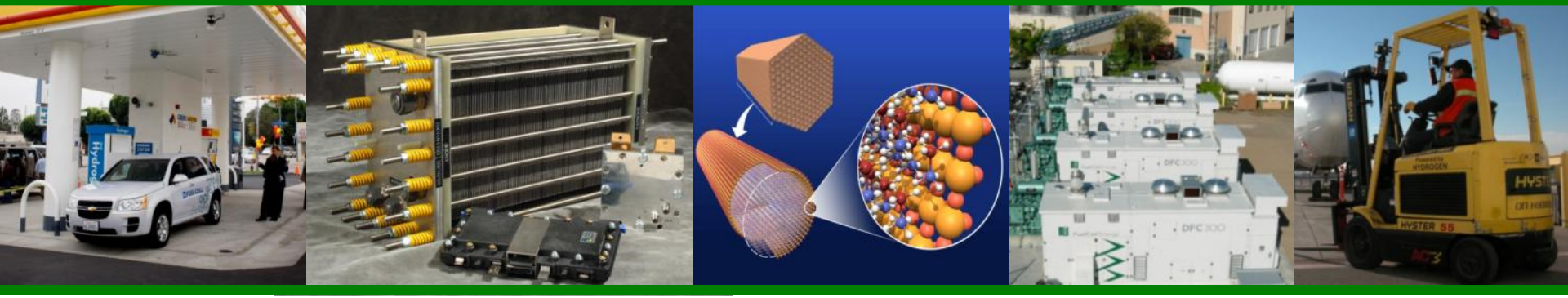

Manufacturing R&D
- Session Introduction -

Nancy Garland

2012 Annual Merit Review and Peer Evaluation
May 16, 2012

Goals & Objectives

- 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
  - Enable the reduction in cost of fuel cell stacks from $22/kW to $15/kW by 2017 (production at 500,000 units/year)
  - Develop fabrication and assembly processes for high pressure hydrogen storage technologies that can achieve a reduction of 10% off the baseline cost of $18/kWh for Type IV, 700 bar tanks. (4Q, 2015)

Challenges

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

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

Budget

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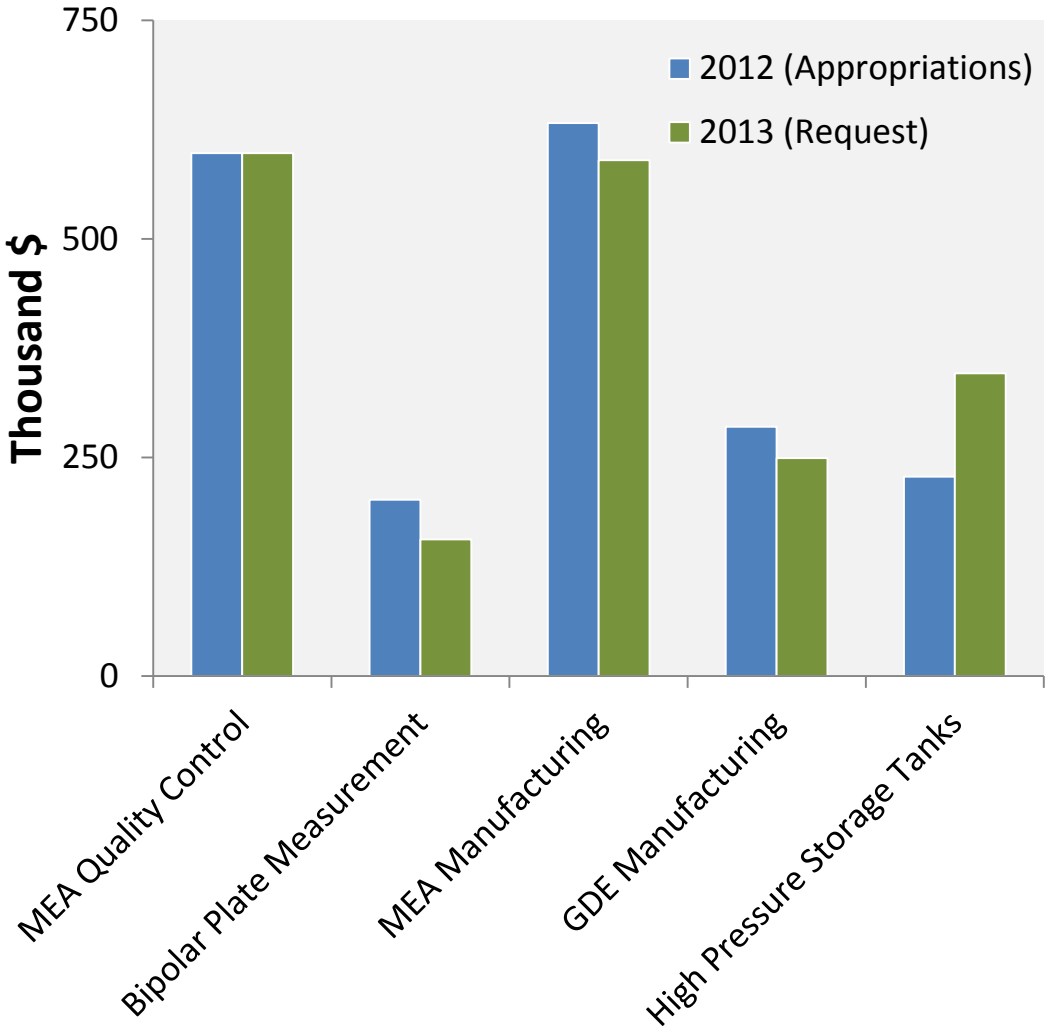
FY 2012 Appropriation = $1.9 M

FY 2013 Request = $1.9 M



EMPHASIS

- Develop novel, robust ultrasonic bonding processes for MEAs to reduce MEA-pressing cycle time
- Develop real-time online tools for defect detection to reduce/eliminate ex situ characterization, sampling, and testing
- Develop and demonstrate innovative precision fiber placement and filament winding for high-pressure carbon composite tanks

Progress: Low-cost, durable MEAs

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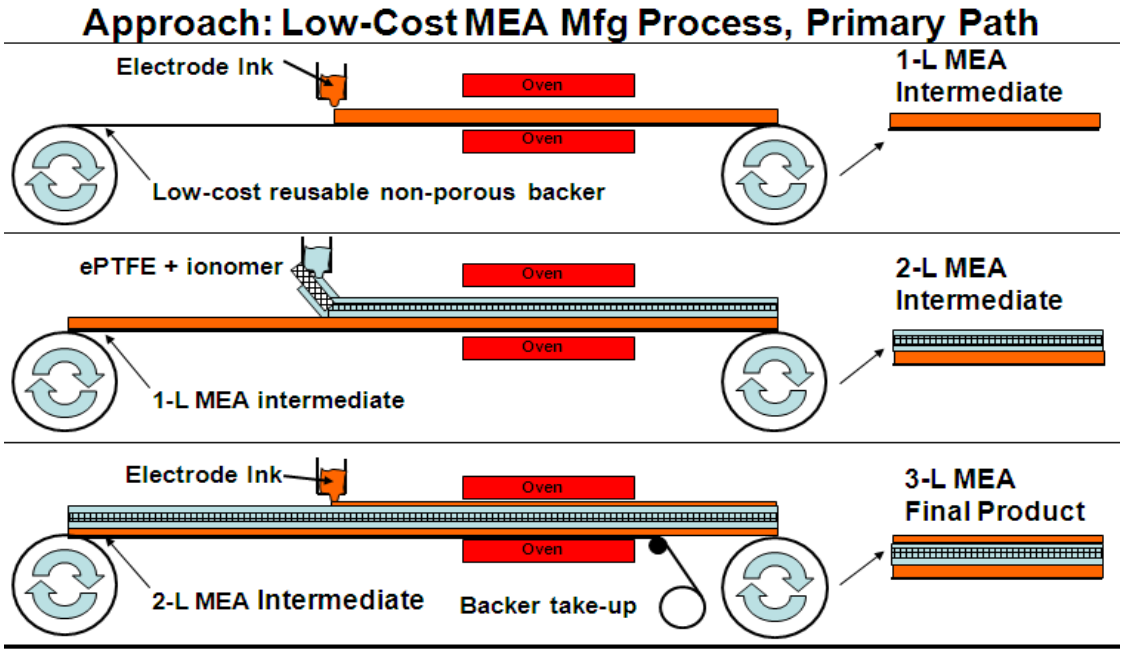
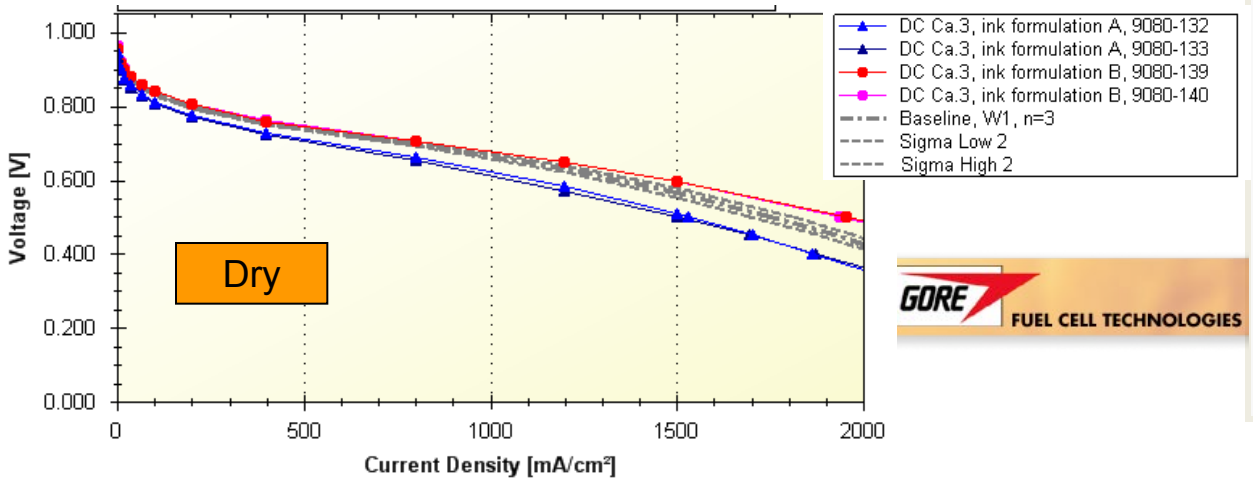
Increased performance by ~200 mA/cm² at 0.6 V under dry conditions by improving the cathode through direct coating





GORE FUEL CELL TECHNOLOGIES

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

Enabling Technologies:
- Use direct coating to form at least one membrane–electrode interface
- Gore's ePTFE membrane reinforcement & PFSA ionomers enable durable, high-performance MEAs
- Model mechanical stress and heat / water management to accelerate MEA optimization

Explore new 3-Layer MEA Process
- Investigate equipment configuration for MEA production
- Investigate raw material formulations

Progress: Developing diagnostics for MEA manufacture

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IR/DC technique yields areal image of catalyst layer uniformity, is scaled up for in-line testing. IR/RFT technique validates model prediction of temperature rise as a function of catalyst loading.

Approach:

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

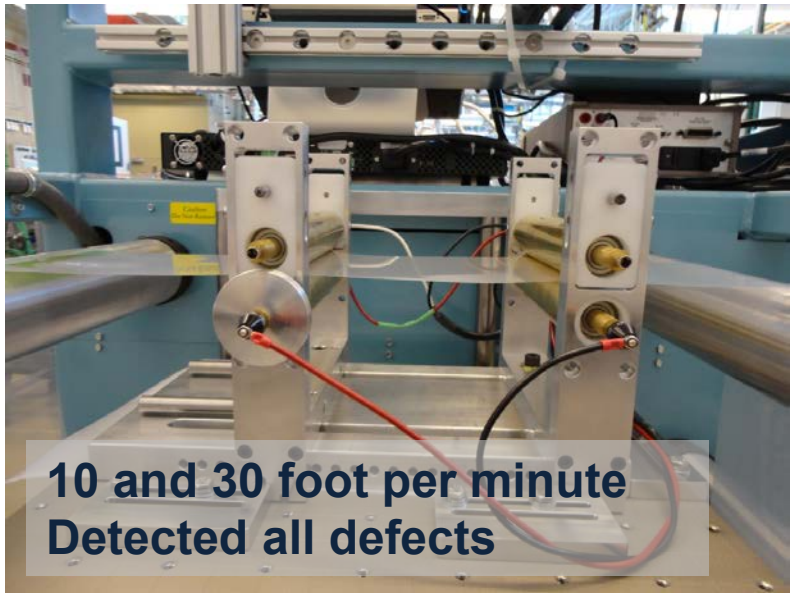
Investigate the effects of manufacturing defects on MEA performance and durability to understand the accuracy requirements for diagnostics

Integrate modeling to support diagnostic development and implementation

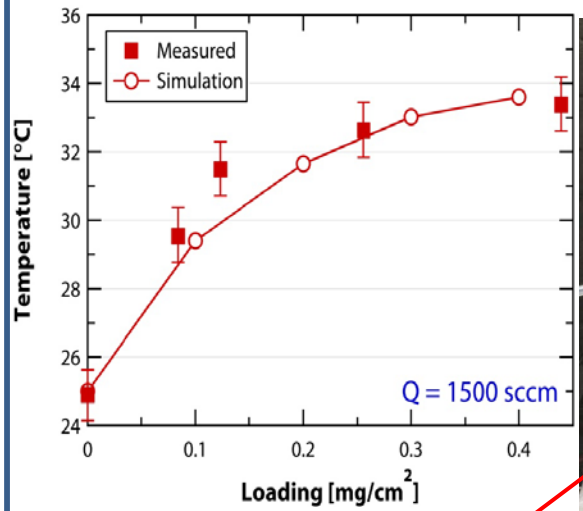
NREL NATIONAL RENEWABLE ENERGY LABORATORY

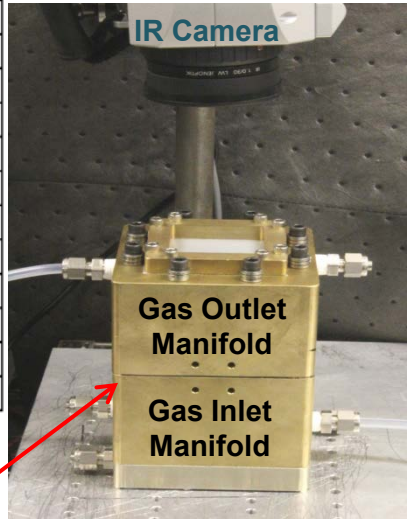
BERKELEY LAB

IR/Direct Current



IR/Reactive Flow Through





NREL Hydrogen and Fuel Cells Manufacturing R&D Workshop

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Output from the workshop was used to update the MYRD&D plan and will inform a future funding opportunity* in FY13.

- Held 8/11 in Washington, D.C. with reps from industry, academia, lab, and government (including DOE-AMO)
- Identified and prioritized needs and barriers to manufacturing
- Outputs support potential FY13 FOA* for H_2 & FC Manufacturing R&D

Issue
PEM Fuel Cells/Electrolyzers BOP: Facilitate a manufacturing group for DOE to expand supply chain.
Electrodes: How to apply ink directly to membrane; dual direct coating of CCM; *membrane dimensional change with deposition of current inks (Fuel cell R&D)*
PEM Fuel Cells/Electrolyzers BOP: *Develop low cost manufacturing of natural gas reformers (Fuel cell R&D)*
Stack Assembly: High volume stack assembly processes: reduced labor, improved automation
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
SOFC: Multi-layer/component sintering

***subject to appropriations**

http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_h2_fc_manufacturing.html

Defense Production Act Committee/Title III

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RFI on fuel cells released by DOD; possible RFP to follow

- In 9/11, 3 DPAC Study Groups were established to focus DPAC work:
  - Metal Fabrication
  - Power and Energy
  - Telecommunications

- On 3/7/12, the Metal Fabrication Study Group released an RFI on "Addressing the Availability of Forged-Quality Parts“.

- On 4/13/12, the Fuel Cell Study Group released an RFI, crafted with DOE support (including DOE-AMO), for three topic areas:
  - Standardization, improved manufacturing, and improved design/performance of fuel cell balance-of-plant equipment.
  - Stack and Stack Component Standardization and Improved Manufacturing.
  - Acquisition and Deployment of tactical fuel cell systems. https://www.fbo.gov/index?s=opportunity&mode=form&id=c0edaf3ff2f5eecc35309ad0f016ad33&tab=core&_cview=0
  - Responses were due 5/14/12. Late responses may be considered.

- Based on responses to the RFIs, RFPs may be issued. DPAC has pledged $5M against fuel cell RFP but is looking for match from civilian agencies, other DOD

Input to DPAC: PEMFC Manufacturing

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Status of current PEMFC manufacturing technology and potential effect of technology injection through DPAC

Current	Advancements
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	• Continuous mixing • Robotic or roll-to-roll assembly of MEAs with seals • Direct coating of electrode on membrane • Hot-roll lamination or improved pressing
Stack: • Manual assembly • Manual leak/performance test	• Automated assembly • Automatic leak/performance test
BOP: • Lean manufacturing cells and flow • Unique components	• Standardized designs • Robotic BOP/system assembly line

Summary

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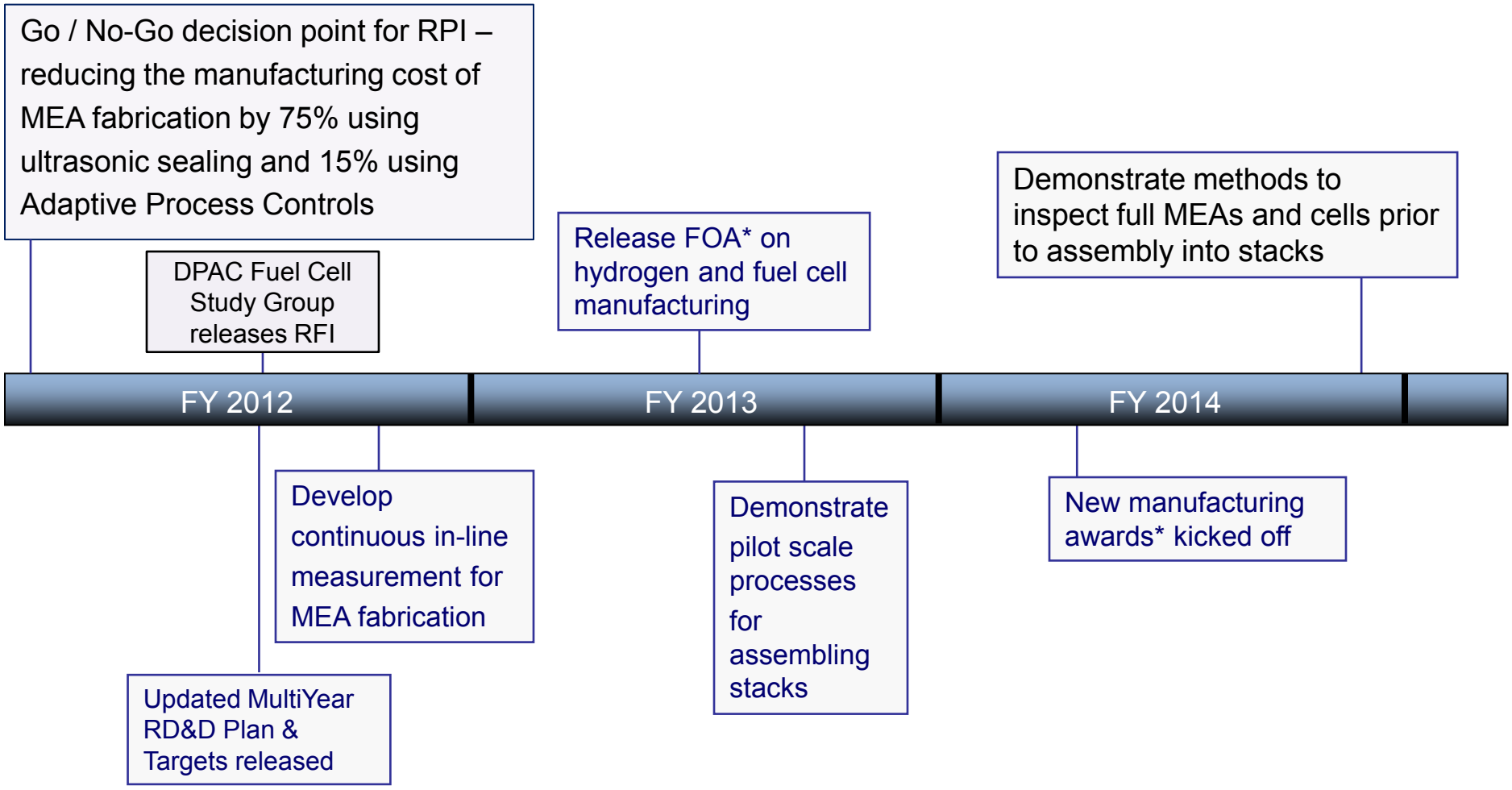
Major Milestones and Workshops



*Subject to appropriations

Session Instructions

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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.

Reviewer Reminders

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- Deadline to submit your reviews is **May 25th at 5:00 pm EDT.**
- ORISE personnel are available on-site for assistance.
  - **Reviewer Lab Hours:** Tuesday – Thursday, 7:30 am – 8:30 pm; Friday 7:30 am – 1:00 pm.
  - **Reviewer Lab Locations:**
    - Crystal Gateway Hotel—Rosslyn Room (downstairs, on Lobby level)
    - Crystal City Hotel—the Roosevelt Boardroom (next to Salon A)
- Reviewers are invited to a brief feedback session – at 5:15 pm today, in this room.

For More Information

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Cassidy Houchins (SRA)

Participating Organizations

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