Adaptive Stack With Subdivided Cells for Improved Stability, Reliability, and Durability Under Automotive Load Cycle

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Plug Power Inc.
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Project ID: FCP18
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## Overview

### Timeline
- Start – May 2007
- End – April 2009
- 0% Complete

### Barriers
- Barriers addressed
  - Durability with load cycling
  - Transient response
  - Stack materials cost

### Budget
- Total project funding
  - DOE $999,404
  - Contractor $249,855
- Funding received in FY06
  - N/A
- Funding for FY07
  - $505,918

### Partners
- 3M Corporation
Objectives

**Topic 5A. Innovative Fuel Cell Concept:** To develop a 1-kW prototype PEMFC stack that will lead to *increased reliability and lifetime* and enable the realization of DOE targets specified in its *Multi-Year Research, Development and Demonstration Plan*

- Increase stack life and provide stable performance under simulated automotive load cycling conditions
- Offer smooth power transitions over the entire power range
- Reduce degradation associated with high cell voltage operation
- Improve system efficiency and reliability during low power operation
- Reduce cost and parts count for auxiliary units
TEAM

- **Plug Power**
  - Design, model, and test stack components
  - Evaluate materials compatibility
  - Design and modify a test station for load cycling
  - Demonstrate the adaptive stack concept
  - Build and test a 1-kW prototype stack

- **3M**
  - Design and fabricate sub-divided MEAs
  - Modify 3M universal gasket technology for rapid MEA production
  - Optimize gasket design and fabrication process

- **Plate Supplier**
  - Machine by bipolar plates
Approach

- Minimize changes in voltage and current density
- Allow variable active area
- Maintain constant flow velocity
- Eliminate “fuel-air” fronts
PHASE I

- **Task 1: Cell/stack configuration selection and optimization**
  - Evaluate design options using CFD Modeling
  - Pre-screen MEA fabrication process
  - Pre-screen bipolar plate fabrication process
  - Modify test station for load cycling
  - Select best cell/stack design

- **Task 2: Component development/fabrication**
  - Make subdivided MEAs
  - Make subdivided bipolar plates
  - Evaluate materials compatibility
  - Design and build test rigs

**Milestones:**
- Stack architecture
- Sample MEAs
- Sample plates
- Test station
- DMC estimation

**Milestones:**
- Module/stack MEAs
- Module/stack plates
- Material selection
- Test hardware
- Control scheme
PHASE II

Task 3: Module testing

- Build test modules
- Evaluate module designs
- Improve stack/control scheme via CFD iterations
- Build and test new modules (if necessary)
- Progress report and go/no-go recommendation

Go/no-go decision criteria:

- Design concept validated
- Module test successful
- Control scheme practical

Milestones:
- ✔ Module testing
- ✔ Load cycling data
- ✔ Stack DMC
PHASE III

❖ Task 4: Stack assembly and testing
  • Fabricate stack components
  • Build a prototype 1 kW stack
  • Test prototype stack
  • Evaluate stack control scheme
  • Optimize overall stack design and operation
  • Progress Report

PHASE IV

❖ Task 5: DOE evaluation
  • Set up a 1-kW demo stack at a designated DOE site
  • Assist DOE stack evaluation
  • Final report

Milestones:
✓ Stack testing
✓ Load cycling data
✓ Final design
✓ Cost analysis

Deliverables:
1. Prototype stack
2. Final report
RELEVANT PRE-AWARD ACCOMPLISHMENTS

- Quadrant stack design (Plug Power: US Patent 5,945,232)
  - Quadrant MEAs
  - Interconnected

- Universal gasket design (3M)
  - Seal suitable for any MEA shape
# DOE TECHNICAL TARGETS

- **Automotive-scale stack:**

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<tr>
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<th>2005 status</th>
<th>2010</th>
<th>2015</th>
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<tr>
<td>Cost ($/kW)</td>
<td>110</td>
<td>45</td>
<td>30</td>
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<tr>
<td>Durability with cycling (hr)</td>
<td>~ 2,000</td>
<td>5,000</td>
<td>5,000</td>
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<tr>
<td>Transient response (s)</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
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- **Stationary stack:**

<table>
<thead>
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<th>2011</th>
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<tbody>
<tr>
<td>Cost ($/kW)</td>
<td>1,500</td>
<td>530</td>
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<tr>
<td>Steady state durability (hr)</td>
<td>~ 20,000</td>
<td>40,000</td>
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<tr>
<td>Transient response (s)</td>
<td>&lt; 3</td>
<td>1</td>
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</table>
SCHEDULE

Task 1. Stack design selection & optimization
  Options  Selection  Optimization

Task 2. MEA and plate design and fabrication
  Samples  Modules  Stack DMC

Task 3. Module testing
  Modules  Go/No-go

Task 4. Stack testing
  1-kW Stack  Report

Task 5. Demo

Final report

Q2/07  Q3/07  Q4/07  Q1/08  Q2/08  Q3/08  Q4/08  Q1/09
Phase I → Phase II → Phase III → Phase IV
Current Status

- Completed contract negotiation w/ DOE (starting date: May 1)
- Initiated stack design selection process
- Started modifying module test station
- Discussed the path forward w/ component suppliers
Future Work

• Down-select stack design
• Complete module station modification
• Build module stack
• Simulate load cycling operation