DOE Hydrogen Program

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

Bin Du

Plug Power Inc.

May 16, 2007

Project ID: FCP18

SAFE HARBOR STATEMENT

This presentation contains forward-looking statements, including statements regarding the company's future plans and expectations regarding the development and commercialization of fuel cell technology. All forward-looking statements are subject to risks, uncertainties and assumptions that could cause actual results to differ materially from those projected. The forward-looking statements speak only as of the date of this presentation. The company expressly disclaims any obligation or undertaking to release publicly any updates or revisions to any such statements to reflect any change in the company's expectations or any change in the events, conditions or circumstances on which such statement is based.

Overview

Timeline

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

Budget

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

Barriers

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

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*

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

❖ Task 2: Component development/fabrication

- *Make subdivided MEAs*
- *Make subdivided bipolar plates*
- *Evaluate materials compatibility*
- *Design and build test rigs*

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*

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

PHASE IV

❖ Task 5: DOE evaluation

- *Set up a 1-kW demo stack at a designated DOE site*
- *Assist DOE stack evaluation*
- *Final report*

Deliverables:
1. Prototype stack
2. Final report

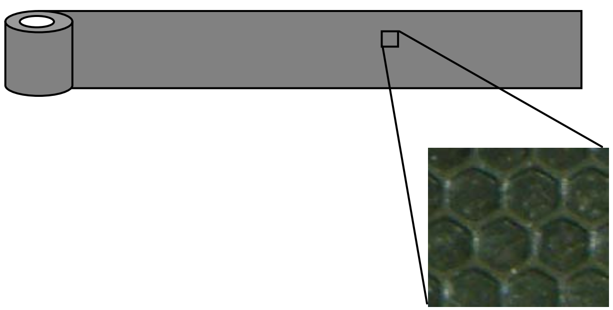
RELEVANT PRE-AWARD ACCOMPLISHMENTS

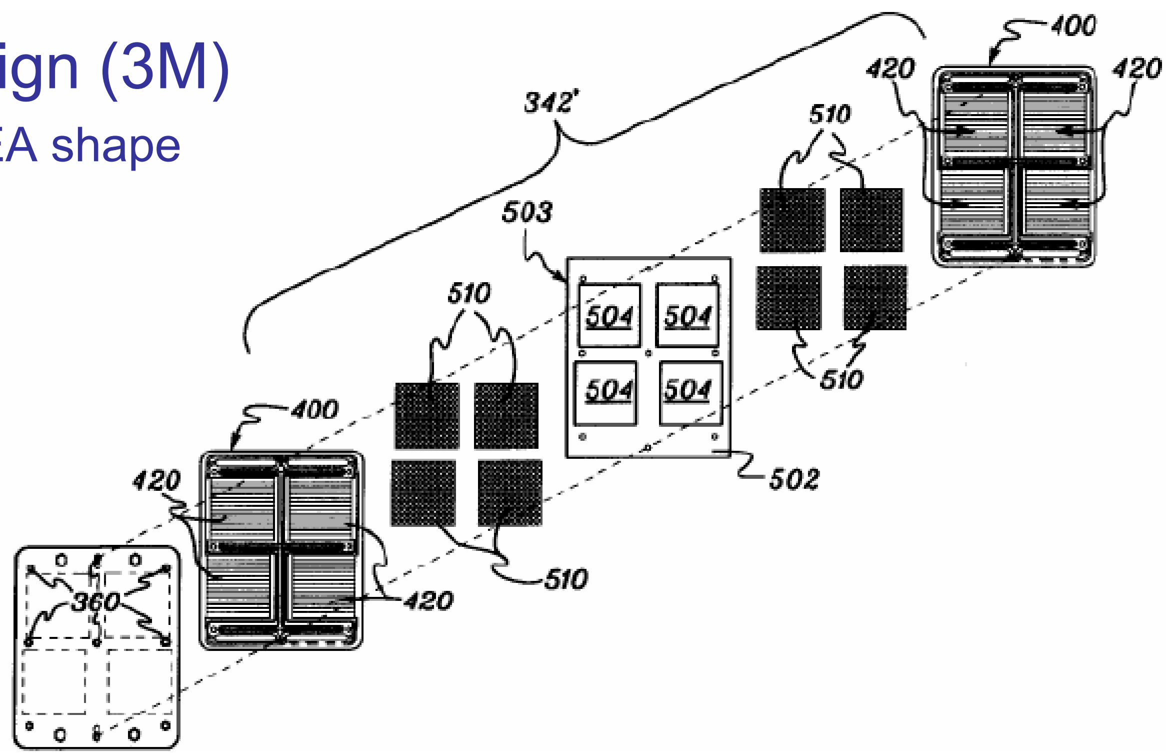
❖ Quadrant stack design (Plug Power: US Patent 5,945,232)

- Quadrant MEAs
- Interconnected

❖ Universal gasket design (3M)

- Seal suitable for any MEA shape





DOE TECHNICAL TARGETS

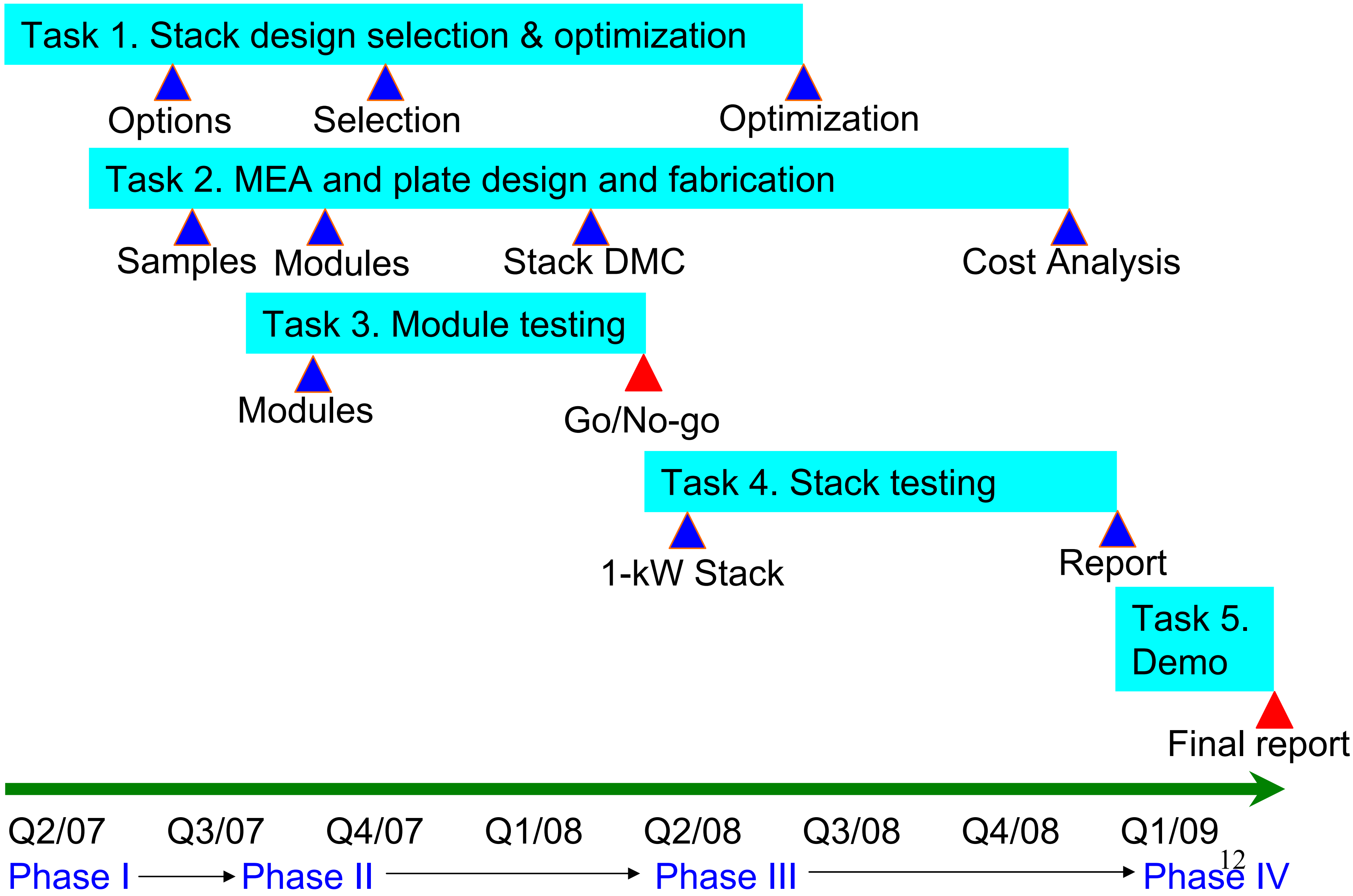
❖ Automotive-scale stack:

	2005 status	2010	2015
Cost ($/kW)	110	45	30
Durability with cycling (hr)	~ 2,000	5,000	5,000
Transient response (s)	1.5	1	1

❖ Stationary stack:

	2005 status	2011
Cost ($/kW)	1,500	530
Steady state durability (hr)	~ 20,000	40,000
Transient response (s)	< 3	1

SCHEDULE


Task 1. Stack design selection & optimization
Options
Selection
Optimization
Task 2. MEA and plate design and fabrication
Samples
Modules
Stack DMC
Cost Analysis
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