

# Novel Manufacturing Process for PEM Fuel Cell Stacks Low Cost Integrated 250W Balance of Plant

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Project ID # MFP2



# Project Overview

## Timeline

- Start September 2005
- Finish June 2008
- 95% Complete

## Budget

- Total project funding
  - NCMS Share – \$550K
  - Protonex/Parker Share – \$550K
- Funding Received in FY06
  - \$350K
- Funding Received in FY08
  - \$200K

## Barriers

- Conventional stack manufacturing methodologies not cost effective
- High Parts Count
- Limited availability of adequate BOP components

## Partners

- Protonex – Project Lead
  - Fuel cell stack design & test
  - System design & test
- Parker Hannifin
  - Fuel cell stack volume manufacturing scale-up
  - Balance-of plant (BOP) component development & test



# Project Objective

## Phase I

- Design and develop mass-producible stack architecture, stack components and optimize the stack assembly
- Develop and optimize one-step integral casing/sealing of stack assembly
- Establish technical and cost benefits of one-step injection molding process

## Phase II

- Develop concept of modular assembly and BOP component integration
- Design/develop and assemble sub-modules of BOP components with appropriate interfacing of sub-modules with fuel cell stack
- Integrate a fuel cell system prototype using modularized BOP components
- Evaluate and demonstrate the system benefits of the modular BOP

“Enhance manufacturing capabilities for fuel cells. Techniques are needed for handling high fuel cell production volumes and achieving better consistency and quality control. Advancements in this area are one of the surest means to achieving the large cost reductions needed to move fuel cells from niche to mass markets. Improvements are also needed in the cost and integration of balance-of-plant components, such as power conditioning, thermal storage and management, water management, and fuel processing equipment.” – National Hydrogen Energy Roadmap – November 2002



# Milestones

## FY06

- Stack architecture & manifold design - **Complete**
- Optimization - **Complete**
- Stack test & verification - **Complete**

## FY07

- Stack test & verification - **Complete**
- Transition to mid/high volume techniques - **Complete**
- Qualification of volume manufacturing process - **Complete**

## FY08

- Integrated modular BOP design - **Complete**
- Optimized fuel cell compatible air pump - **May 2008**
- Fuel cell system testing - **June 2008**



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**Parker**

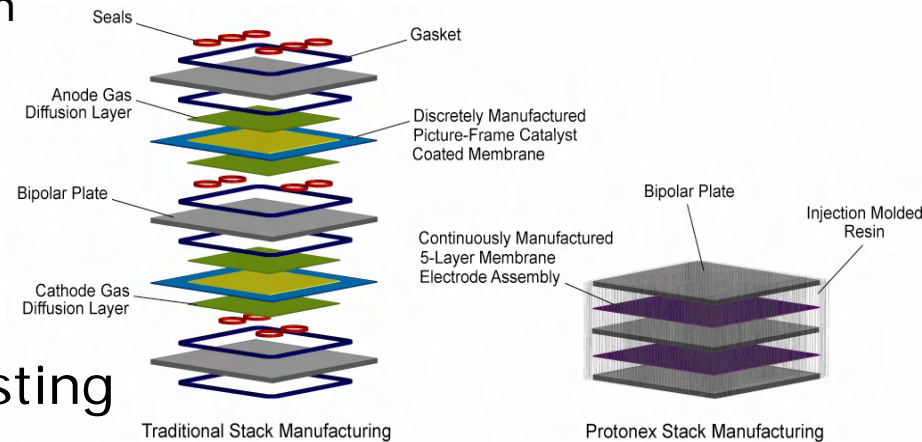
# Approach – Phase 1

Developed cost-effective, adhesion molded fuel cell stack design

- Design enables simple, low tolerance parts
- Significant part count reduction
- Fast & easy build cycles
- Easily automated
- Low Cost Roll MEA
- No compression set issues
- Component vendor flexibility

Verify design by extensive testing

Validated at commercial scale



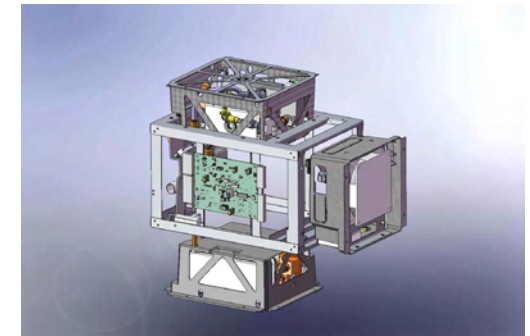
## Approach – Phase 2

Developed cost effective, modular BOP design to support injection molded fuel cell stack

- Design based on multiple modules
- Module testability
- Simple interconnects
- Fast build cycles

Initial 2 units built by development technician for process validation

Next 15 systems built by low cost production personnel



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# Accomplishments - Phase 1

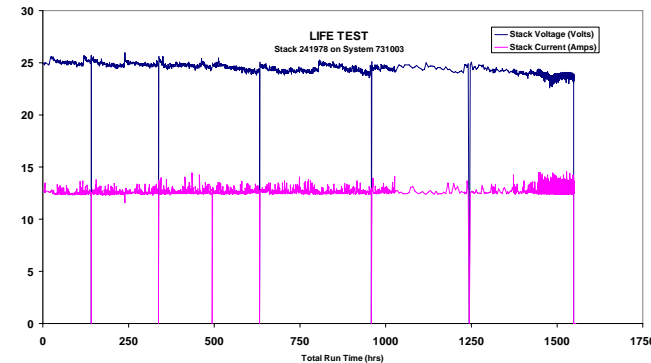
Exceeded Stack Power Density Targets

- Target 368 W/kg - Actual 500 W/kg
- Stacks Life Test Continues

Demonstrated one-step injection molding process for fuel cell stacks - demonstrated repeatable at Parker's manufacturing facility

Over 250 optimized fuel cell stacks manufactured to date

Assembled fuel cell stacks are to be demonstrated for multiple DoD and Commercial programs



**LOW COST MANUFACTURING PROCESS DEMONSTRATED AS VIABLE**



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# Accomplishments - Phase 2

Significantly reduced system build times

- Tech 16 Std Hrs. > Production 4 Std Hrs.

Large build costs reductions made by utilizing production labor vs. technician labor for assembly of system

Over 30 systems manufactured to date

Over 50,000 hours of test on systems performed to date



***INTEGRATED BOP SIGNIFICANTLY REDUCES MANUFACTURING COSTS***



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# Future Work

Scale up to higher power levels

Expand life testing to include environments

Reduction of BOP parasitic losses

Expand to fueling systems

Demonstration in portable systems

Alternate configurations

Optimize next level interconnection designs

Improve operational envelope

- Current -20C ~ 50C
- Target -40C ~ 60C



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# Summary

One-step injection molding process successfully demonstrated for 250W fuel cell stacks; results were repeatable at Parker's scaled-up manufacturing facility

Throughput and yield of the manufacturing process demonstrated and adopted into production

Modular BOP significantly reduced labor costs and improved reliability

Multiple systems based on this technology are in development for both DoD and commercial markets

Commercial success in initial fuel cell markets will drive market investments in technology

