Advanced Direct Methanol Fuel Cell for Mobile Computing

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May 16, 2012

Project ID
H2RA004

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Overview

Timeline

- Start date: January 1, 2010
- End date: June 30, 2012
- Percent complete: 100%
- Passed Go-NoGo milestone in January, 2011

Barriers

Characteristic	Requirement -2013
Specific Power	30 W/kg
Energy Density	500 Wh/L
Cost	< $10/W at system level
Durability	3000 hours

Budget

- Total project budget $3,054,464
  - DOE share $2,443,441
  - Contractor share $611,023
- Project was completed on-time and on-budget.

Partners

- University of Florida (UF)

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Relevance: Objective

- The project objective was to develop a DMFC power supply for mobile computing using the novel passive water recycling technology acquired by UNF from PolyFuel, Inc. which enables significant simplification of DMFC systems.

- The objective of the 2011 effort was to perform system engineering and extensive brassboard (unpackaged) to achieve the 2011 Technical Targets.

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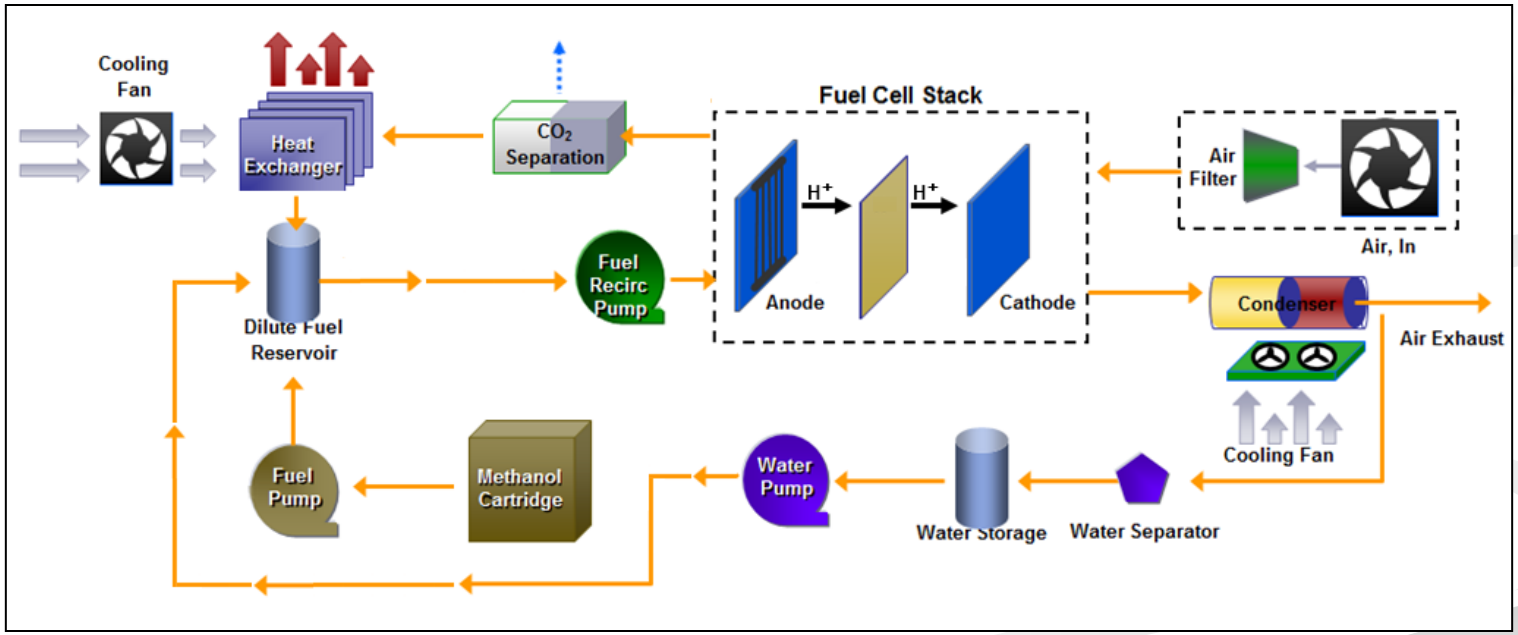
Relevance: Conventional DMFC System

- The typical DMFC balance of plant require heavy, bulky components for water recovery (condenser, water storage, cooling fans, pumps, etc.)
- These components do not scale with size or miniaturize, therefore they are not practical in the 10-50 W power range.



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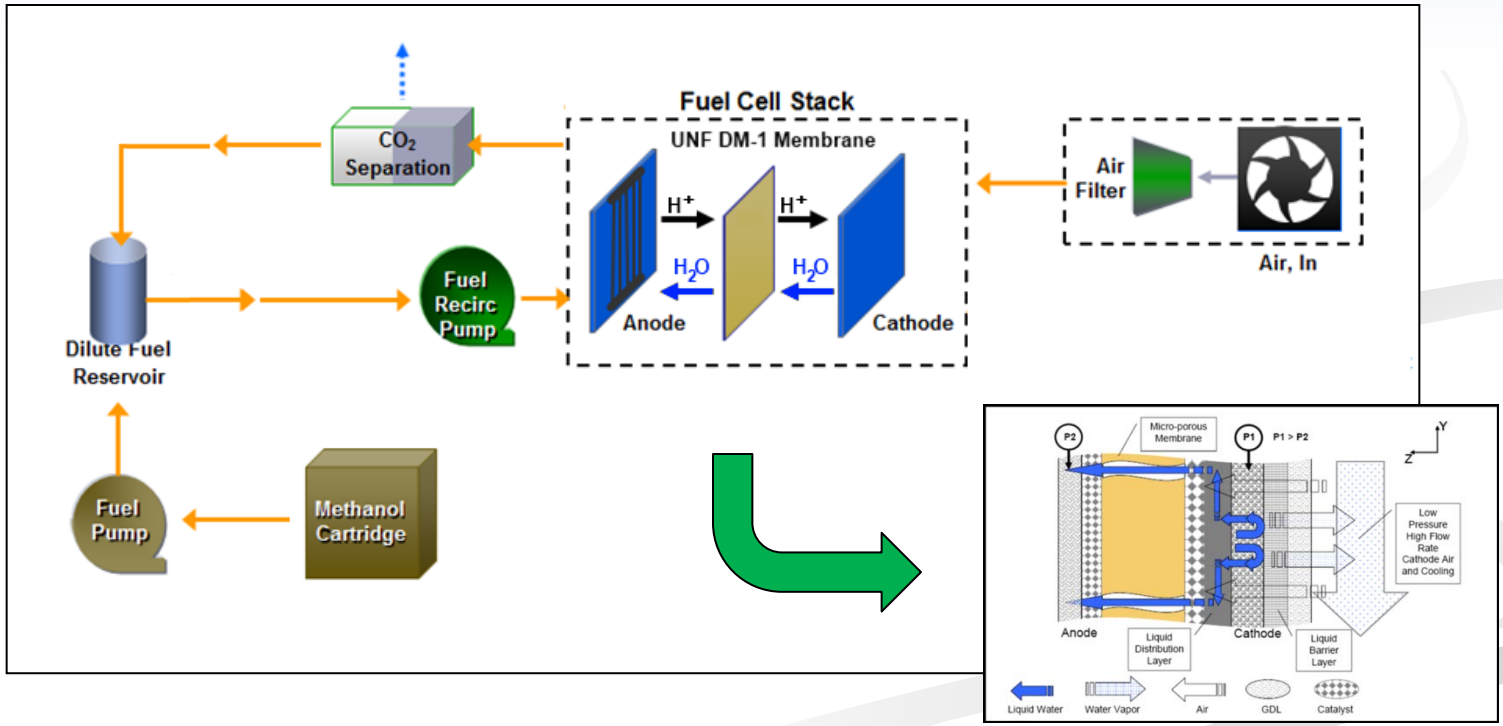
Relevance: Conventional DMFC System

- Using UNF's innovative passive water recovery MEA, the heavy, bulky components used for water recovery are eliminated, resulting in a simplified, compact, lightweight balance of plant.



Relevance: Impact

Characteristic	DOE 2011 Status	DP4 with ISSYS Methanol Sensor	DP4 without ISSYS Methanol Sensor
Operation Duration (hrs)		10	10
Specific Power (W/kg)[3]	15	26.3	29.2
Specific Energy (Whr/kg)[3]	150	263	292
Power Density (W/L)[3]	20	28.0	31.4
Energy Density (Whr/L)[3]	200	280	314

3 Power section including battery and fuel weight, 25 W rated power.

UNF Baseline Membrane Electrode Assembly (MEA) provides path to system simplification and increased power and energy density, with lower system cost.

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Approach: Project Integration

- This project focused on the balance of plant (pumps, blowers, sensors, etc.) development and overall system integration.
- This effort is highly integrated with the UNF-led Topic 5A: *New MEA Materials for Improved DMFC Performance, Durability, and Cost* project (DOE funded) which focuses on optimizing the passive water recovery MEA
  - Reducing off-state degradation.
  - Industry partner Johnson Matthey is applying commercial processes to the MEA production
  - Research partner Northeastern University is developing ultra-stable catalyst.
  - Critical to achieving cost, robustness, and lifetime goals for the DMFC power supply

Integrating the commercially produced MEA into the improved balance of plant is an important step towards commercialization.

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Approach: Milestones

100% Complete

➢Component Engineering
- CDRs Revised
- Component DFMEAs
- Key Subsystems – Prototypes
- Shell Body and Interface Prototypes
- Fuel Cartridge Prototype

100% Complete

➢Component/Subassembly Testing
- Component Performance & Durability
- Integrated Subsystem Testing

100% Complete

➢System Engineering
- Concept Design
- DFMEA, DFMA of System
- Brassboard Assembly & Testing
- System Assembly & Testing

100% Complete

➢Control System Development
- Rest /Rejuvenation Protocol Optimization
- Start-up & Shut-down Protocol
- Operating Protocol Tuning Revised System

100% Complete

➢System Validation Testing
- Test Plan Released
- Operating and Storage Durability Testing
- Ex-Situ System Testing
- In-Situ System Testing

➢Program Management
- Quarterly & Annual Report
- **Go /No-Go Decision**

The project was completed on schedule.

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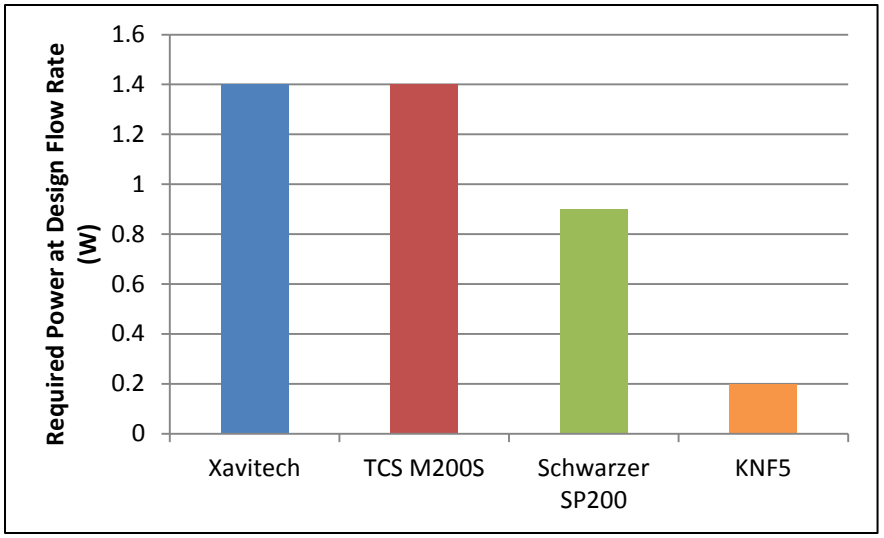
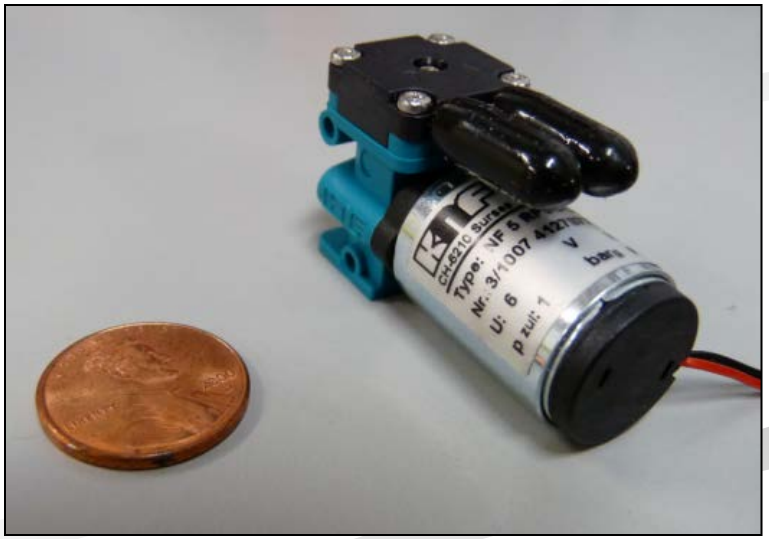
Technical Accomplishments:

Anode Recirculation Pump

- Six different recirculation pumps were selected and tested based on the component design requirements (CDRs).
- The KNF5 was selected as the recirculation pump which offers a significant reduction in parasitic power.





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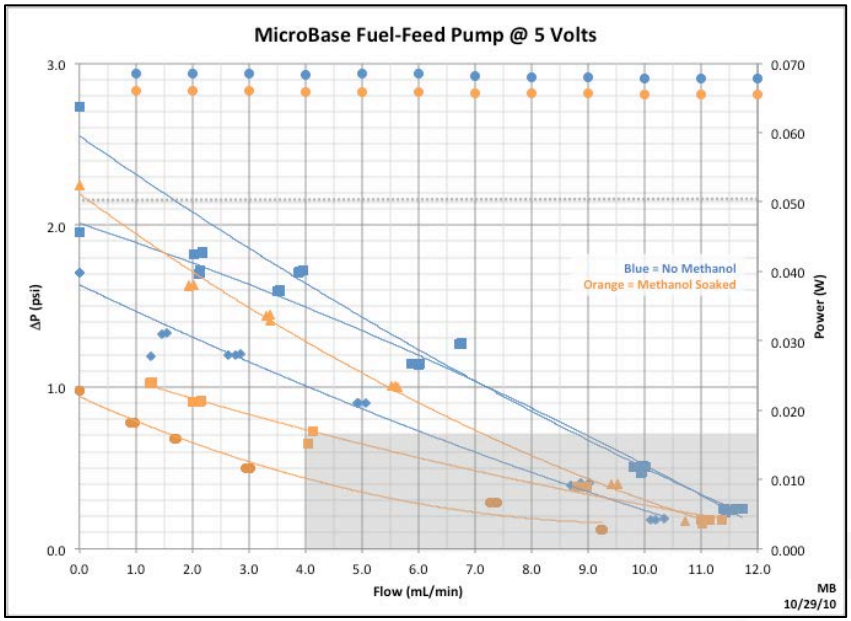
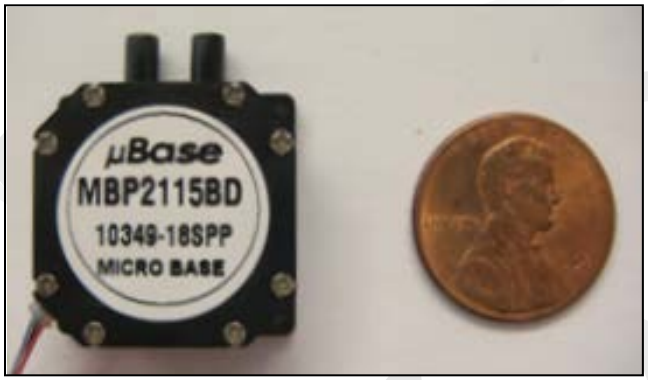
Technical Accomplishments

Methanol Injection Pump

- The Microbase MBP2115BD is one of the few methanol injection pumps that meet the system requirements.
- The Microbase pump passed methanol durability and manufacturing repeatability testing.



Grey area indicates system load curve.



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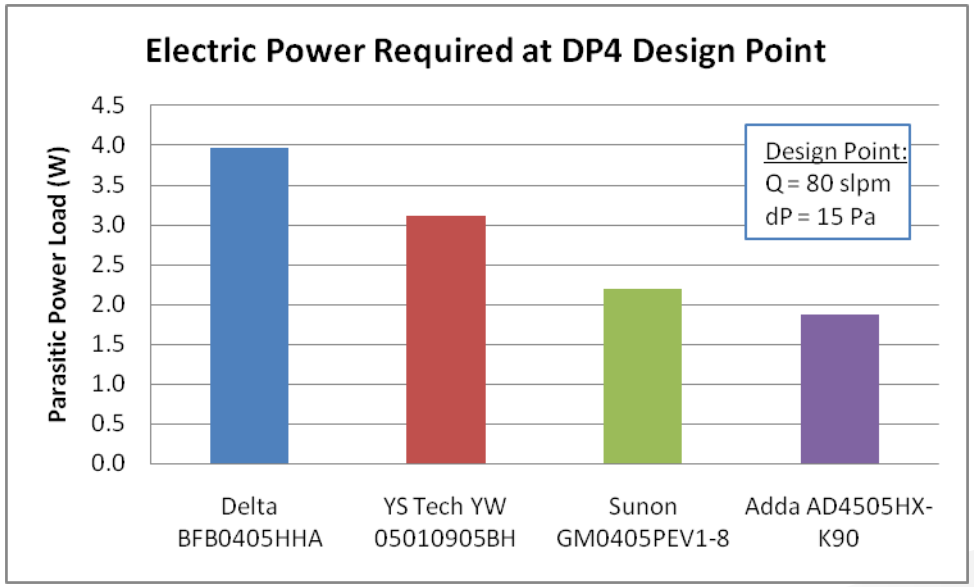
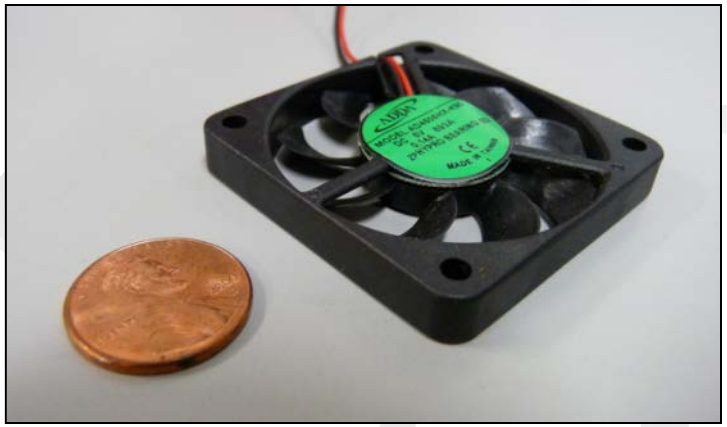
Technical Accomplishments:

Cathode Reactant/Cooling Fan

- The ADDA AD4505HX-K90 was selected as the cathode supply fan from dozens of fans tested and evaluated.
- The ADDA fans have completed over 2000 hours of operation and still meet design point requirements.





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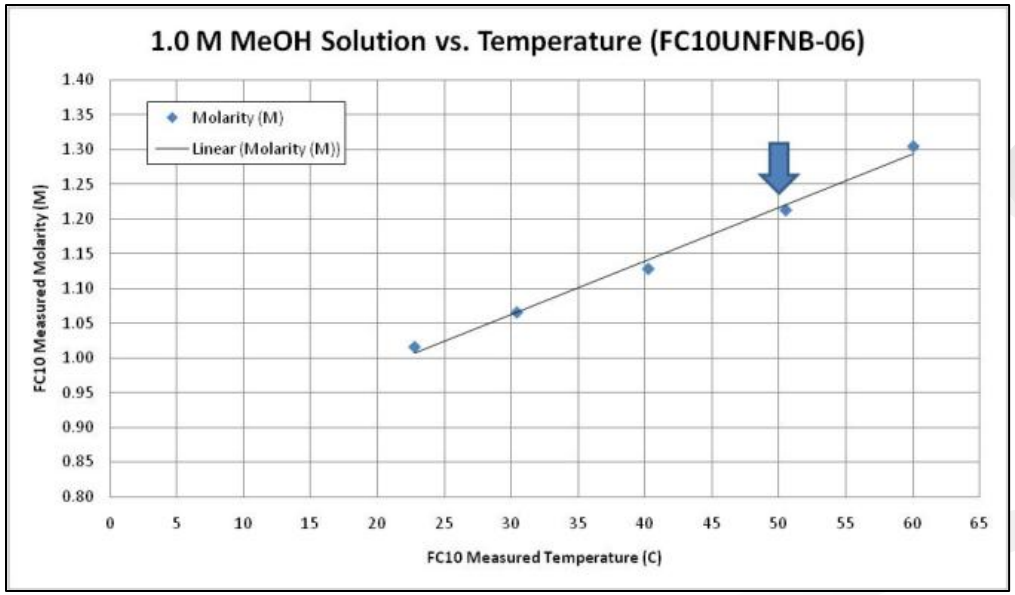
Technical Accomplishments:

Methanol Sensor

- The ISSYS FC-10 density meter was selected as the methanol sensor for the DP4.
- Temperature compensation was added to the DP4 control code to reduce the chances of fuel starvation.
- ISSYS FC-10 sensor is not optimized for the portable fuel cell application (size, weight, and cost).



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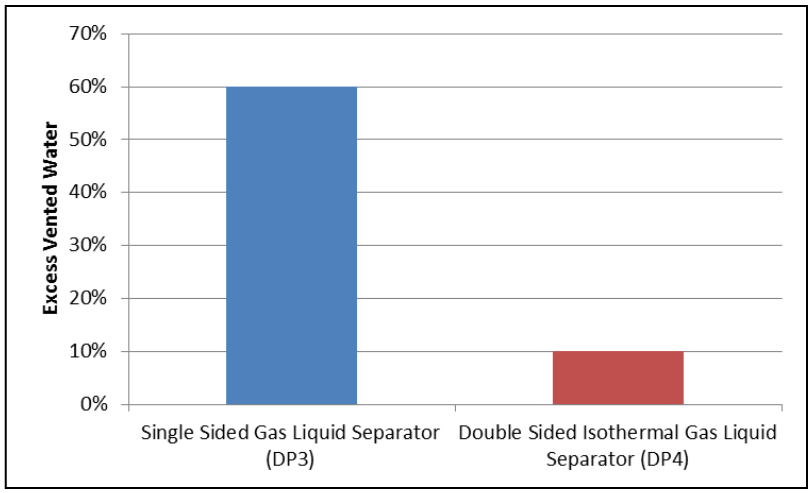
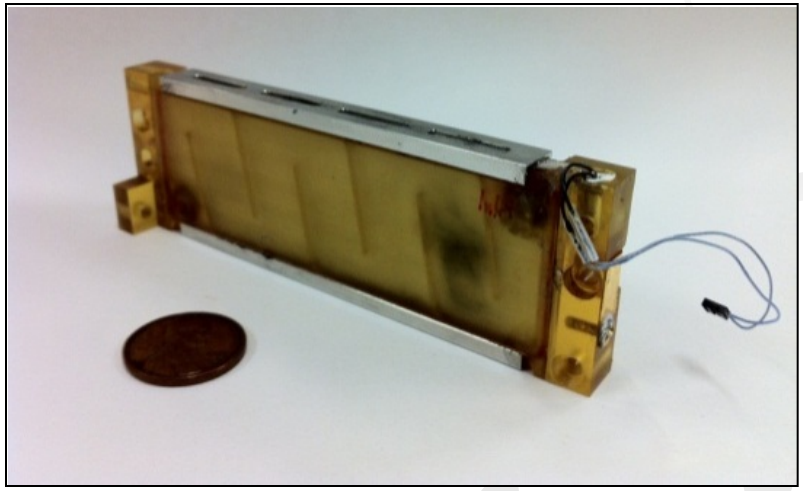
Technical Accomplishments:

Gas Liquid Separator

- Isothermal design has proven to be vastly superior to the single sided design from the previous DP3 design for minimizing water loss.





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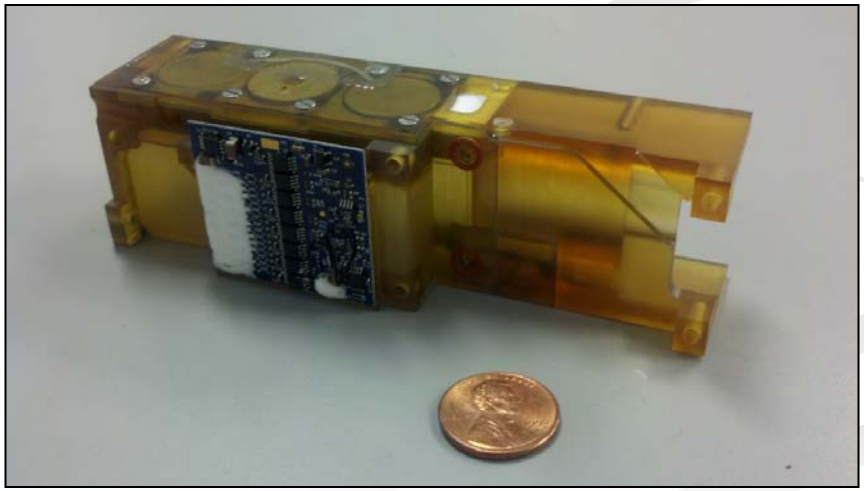
Technical Accomplishments:

System Engineering

- The integrated reservoir tank assembly holds the anode solution for the fuel cell stack and retains the solution through valving when the DP4 is not in operation.
- In addition, the tank is designed to incorporate the majority of the balance of plant components into a tightly integrated system package.



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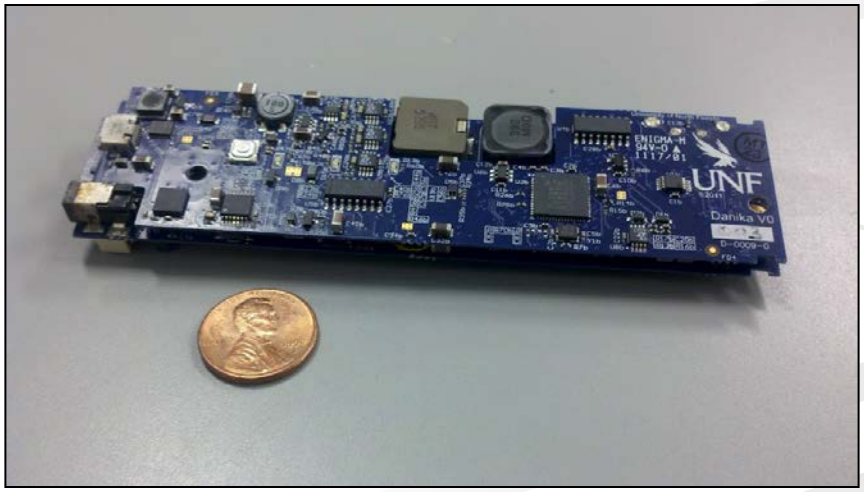
Technical Accomplishments:

System Engineering

- Once the system components were selected, the DP4 control board was designed and fabricated to meet the measurement and power requirements for each subsystem.
- The control board logic is powered by an ATMEL ATmega128 microprocessor.



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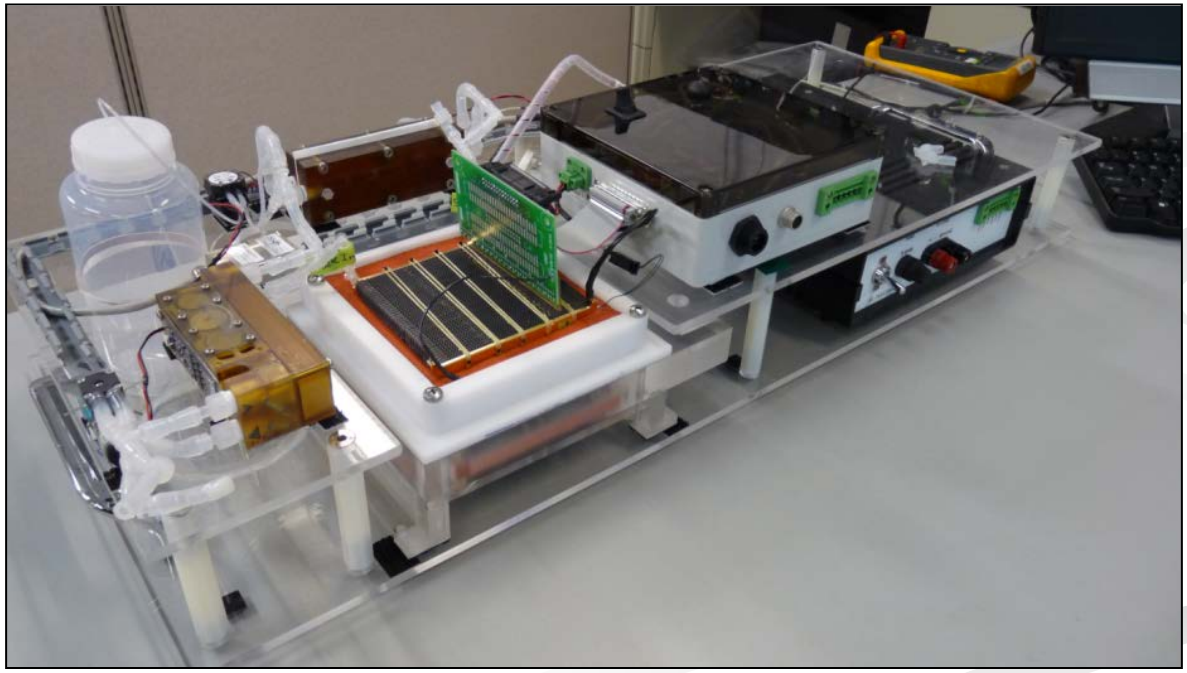
Technical Accomplishments:

System Engineering: Brassboard (Unpackaged System)

- Three DP4 brassboards were developed for in-situ component testing and control strategy development.
- Over 1,500 hours of combined testing was conducted with the DP4 brassboards.



Each brassboard has over 500 hours of operation.

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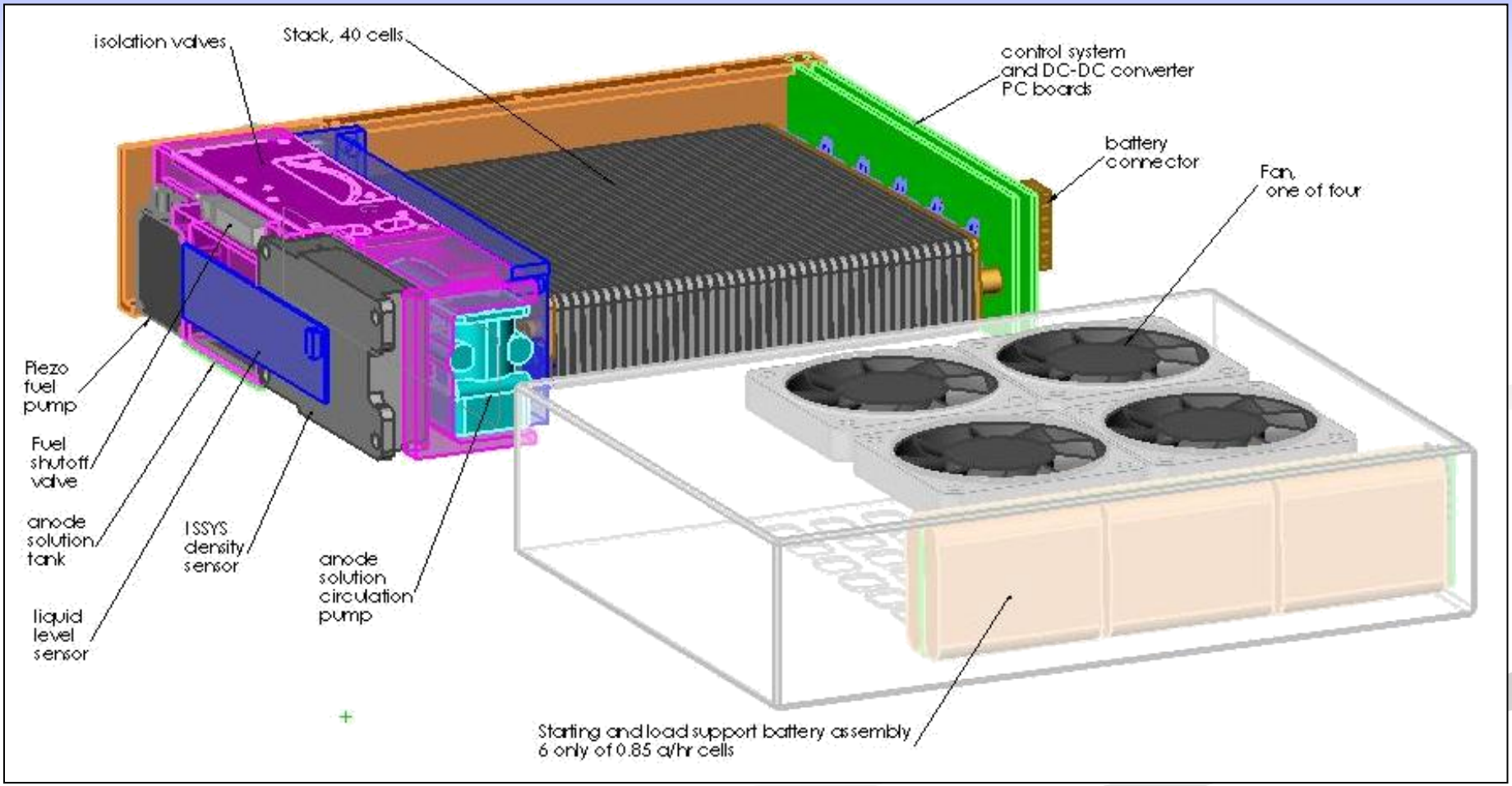
Technical Accomplishments:

System Engineering: Packaged System



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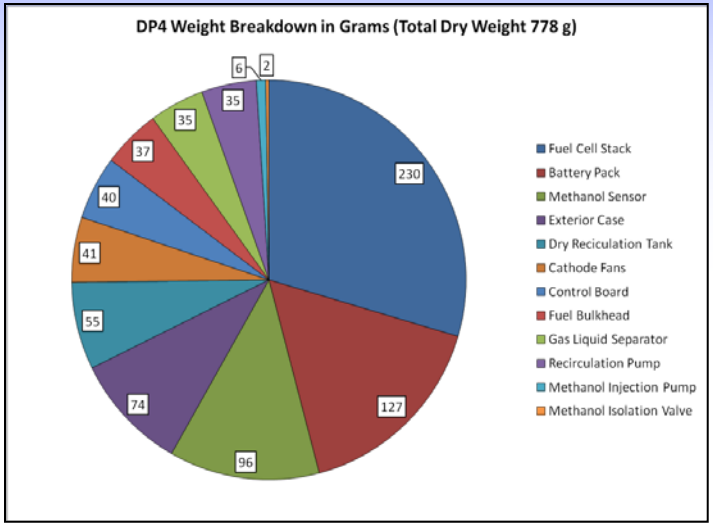
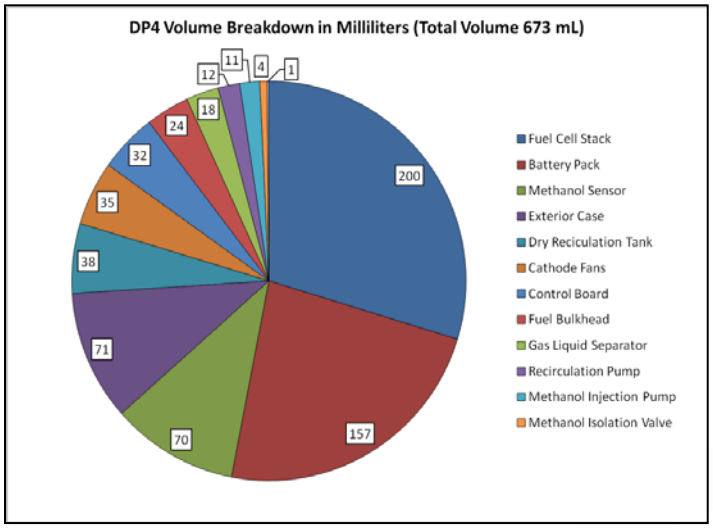
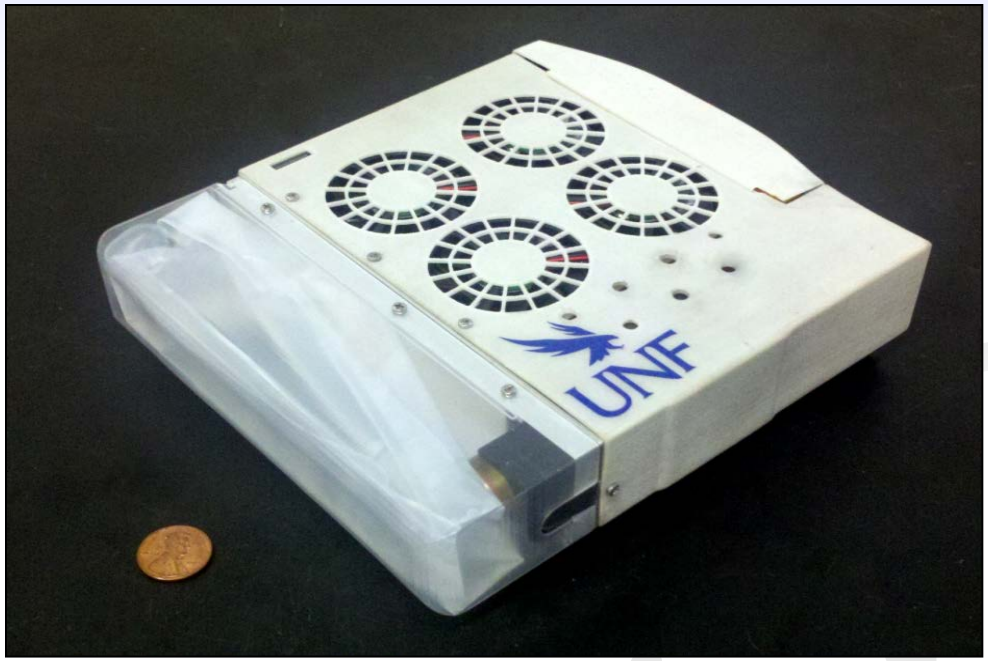
Technical Accomplishments:

System Engineering: DP4 Packaged System







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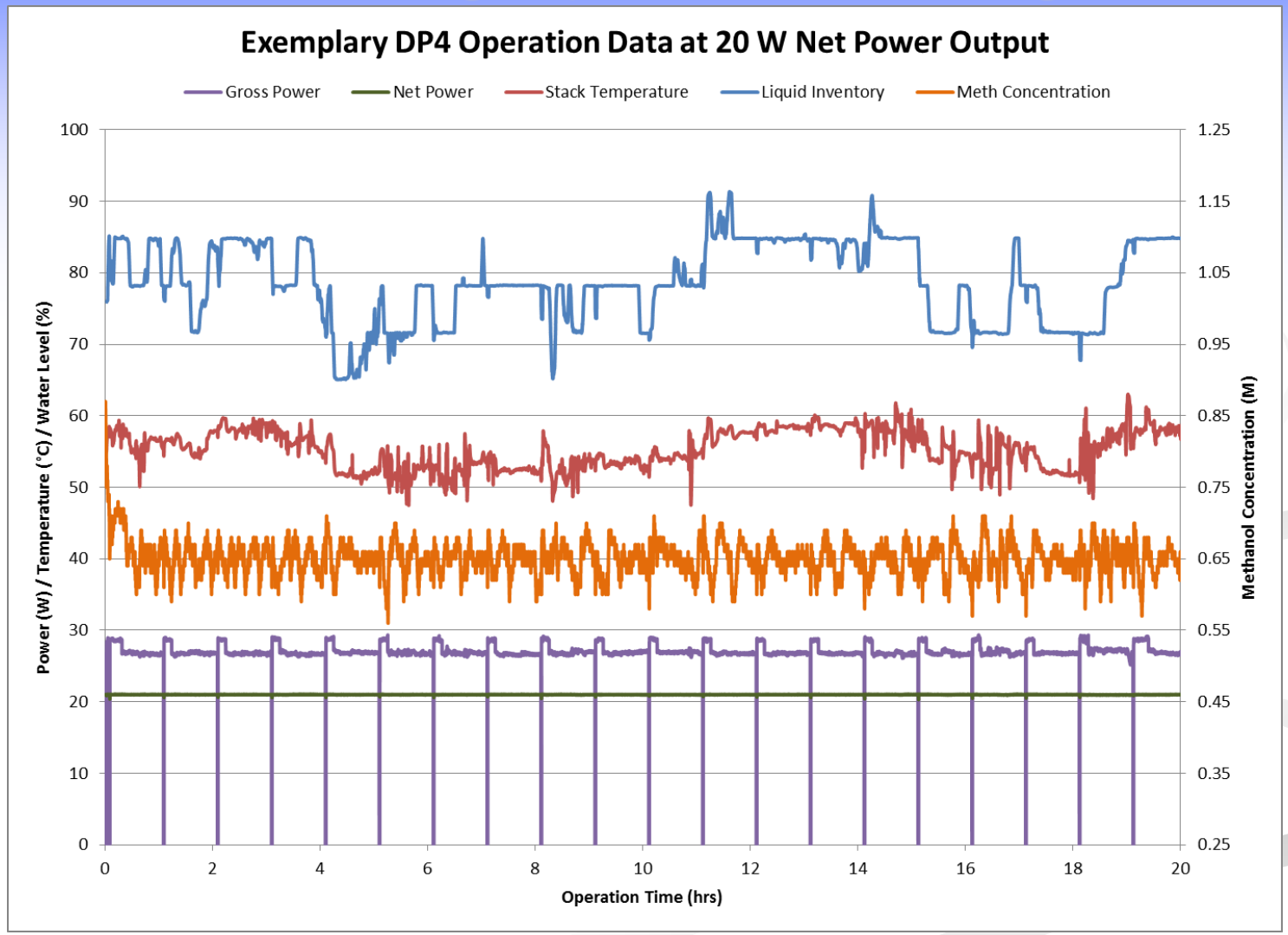
Technical Accomplishments:

DP4 Packaged System Validation Testing



Stable operation achieved in multiple, packaged systems .

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Collaborations

- University of Florida (Academic)
  - Dr. Bill Lear leads the effort to develop critical components including the fuel pump, the recirculation pump, and the CO_2 removal membrane
  - Dr. Oscar Crissale leads the effort to develop the overall control strategy
- The DOE funded project (UNF Prime) *New MEA Materials for Improved DMFC Performance, Durability, and Cost* includes the following collaborators:
  - University of Florida (Academic): Focus on manufacturability and advanced catalysis
  - Johnson Matthey (Industry): Integration of commercial processes into the MEA manufacturing
  - Northeastern University (Academic): Advanced catalysis focused on ultra-stable ruthenium catalyst

The University of North Florida (Prime) and the University of Florida also collaborate on a U.S. Army CERDEC funded project to develop a militarized version of the DMFC laptop power supply

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Proposed Future Work

- The project was completed in December of 2012 and met all milestones.
- The evolution and optimization of the portable power supply continues with focus on reducing weight and volume to meet the DOE 2013 Technical Targets.

Characteristic	DOE 2013 Targets	DP4 without ISSYS Methanol Sensor	Modified DP4 without ISSYS Methanol Sensor[5]
Operation Duration (hrs)		14.3	14.3
Specific Power (W/kg)[4]	30	26.9	32.9
Specific Energy (Whr/kg)[4]	430	385	471
Power Density (W/L)[4]	35	28.1	33.5
Energy Density (Whr/L)[4]	500	402	480

4 Power section including battery and fuel weight, 25 W rated power.
5 Modified DP4 with 25% reduction in weight and volume.

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Project Summary

- **Project Relevance:** The novel passive water recovery MEA technology allows for simplified balance-of-plant which results in a DMFC power supply approaching the DOE Technical targets.
- **Approach:** Cascade-down design requirements to each component resulting in a robust design. Integrate the balance-of plant with the optimized passive water recovery MEA.
- **Technical Accomplishments:** Component testing completed. Brassboard testing used to develop control strategies and in-situ testing. Packaged system completed and fully functional.
- **Collaborations:** Technical expertise at UF focused on component development and robust control system.
- **Proposed Future Work:** Reduction of system weight and volume to meet DOE 2013 Technical Targets.

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