Commercialization Effort for 1 Watt Consumer Electronics Power pack

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Project ID:
ARRAH2001

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Overview

Timeline

• Start date: July 15, 2009
• End date: November 30, 2010
• 75% complete

Budget

• Total project funding: $6,003,092
  – DOE share: $2.99M
  – Contractor share: $3.01M

Barriers

• Manufacturability
• Cost
• Performance & degradation
• Market acceptance

Partners

• Methanol Foundation
• Component suppliers
• Project lead: MTI Micro Fuel Cells
Relevance: Project Objectives

Demonstrate and field test a commercially viable one Watt Direct Methanol Fuel Cell (DMFC) charger for consumer electronic devices

- Reduce cost to attain a competitively priced product
- Design for manufacture & ease of assembly
- Demonstrate performance across range of environmental conditions
- User field test of 75 fuel cell powered chargers
Project Application
DMFC powered charger for consumer electronics

Current mobile power source:

1. Bring all your chargers
2. Find a wall outlet
3. Wait for battery charging

The new DMFC mobile power source:

All you need is one DMFC charger to power all your devices
And a Methanol cartridge for instant power

Carry with you and charge on the go
Relevance to ARRA

• Alignment with ARRA goals of saving and creating jobs:
  • Directly created/ retained 14 FTE jobs in NY state
  • The leverage DOE funds offered enabled MTI to obtain private investment.
  • DOE funds used by MTI for labor – no direct materials or capital

• Alignment with FCT ARRA project goals of accelerating the commercialization and deployment of fuel cells:
  • Fuel cell charger will be commercial ready at end of program
  • Components have been redesigned for low cost, high volume manufacturing.
  • 75 fuel cell systems to be deployed in 2010 during field test
Approach
Development followed by deployment

- Developed and submitted environmental and safety plans in 2009

- **Phase I: Redesign for low cost manufacturing**
  - Redesigned all components to be produced using processes capable of low cost and high volume.
  - Test stacks/engines for improved performance & degradation
  - Build and test Alpha level systems for performance and robustness

◊ **Go/No-Go PHASE GATE:** Must meet predetermined performance, cost, and manufacturing metrics.

- **Phase II: Complete tooling for all components**
  - Build and test Beta systems with components from hard tooling

- **Phase III: Deploy 75 units in the field and execute field test**
  - Build and test all units to quantify performance prior to shipping
  - Test all units when they return to quantify loss in performance
  - Analyze any field failures to determine root cause
Approach Development detail

• Redesign components for reduced cost and high volume manufacturing:
  • Plastic components went from machined to injection molded
  • Sheet metal components went from machined to formings and stampings
  • Laser cut free-standing gaskets were replaced with profiled gaskets over-molded onto components they seal

• Subsystem performance/ life improvements

• System Integration and testing
  • Algorithm development
  • Performance & qualification testing
  • Life testing
    – Steady state
    – User profile
Approach: Go/No-Go metrics & results

- To pass phase gate system had to achieve predetermined levels of
  - Continuous run power (Achieved 1.04W net, Target was 1W net)
  - Energy from 1st cartridge (Achieved 28.9Whr, Target was 26Whr)
  - Life time (Target of 2000 hrs)
    - Achieved over 6000hrs at 5% loss per 1000 hrs on Stack/Engine
    - Achieved over 2000 hrs of run time on complete system
  - High volume unit production cost projection ($ MSRP target achieved but confidential)
  - Total labor content reduction (Achieved 74% reduction, Target was 50%)

- Demonstrate robust operation for consumer electronics application:
  - 0-40C temperature operation with 10%-90% relative humidity
  - 0-8K Feet altitude operation
  - Orientation Independence

Achieved metrics and passed Phase gate on-schedule (November 2009)
Technical Accomplishments:
Achieving high stack/ engine performance

Performance
Higher Fuel Feed Rate
Lower Fuel Feed Rate
Power Density
100mW/cm²
84mW/cm²
Energy Efficiency
1.28Wh/cc
1.4Wh/cc

2007 = 50mW/cm²
2008 = 62mW/cm²
Today = 100mW/cm²
Technical Accomplishments:
Variable fuel flow to adjust power level
Technical Accomplishments:
High power density & efficiency of stack/engine

![Graph showing Neat Methanol Pump Rate (mL/hr) vs Power density (mW/cm²) and Energy Conversion Efficiency (Wh/cc)](Image)

- **Power density (mW/cm²)**
- **Energy Conversion Efficiency (Wh/cc)**

Legend:
- **Power**
- **Efficiency**
Technical Accomplishments:
Over 90% fuel utilization of stack/engine
Demonstrated Low Decay
Normalized stack/engine power

\[ y = -0.0025x + 100 \]

<table>
<thead>
<tr>
<th>Year</th>
<th>Test Time (h)</th>
<th>Decay Rate</th>
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<tbody>
<tr>
<td>2008</td>
<td>2,700</td>
<td>15%</td>
</tr>
<tr>
<td>2009</td>
<td>6,000</td>
<td>5%</td>
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</tbody>
</table>

- 2008 = 2,700 hours at 15% decay per 1000 hours
- 2009 = 6,000 hours at 5% decay per 1000 hours
Technical Accomplishments
Stable Open Circuit Voltages over 6000 hr run

![Graph showing stable open circuit voltages over 6000 hours of run time.](image-url)
Technical Accomplishments

System Level Testing

System level testing completed:

- Environmental latitude
  - 0C-40C
  - 0-90% RH
- Cold and hot ambient start-up
- Completed sound testing
- Surface temperature measurement
- Drop testing
- Orientation independence
- Altitude testing
MTI system provides stable power and more than twice the power density within the Consumer Electronics temperature range of 0 to 40°C.
Demonstrated Performance over Ambient Temperature & Humidity

MTI system operates across consumer electronics temperature and humidity range

Limited temperature and humidity range may not work:
- In hot and wet Summer
- In cold and dry Winter

Psychrometric Chart
Normal Temperatures

MTI Micro DMFC

Other Micro DMFC

Mobion

Reproduced courtesy of Carrier Corporation
Collaboration

• Methanol Foundation:
  • Consumer and environmental safety & associated regulatory standards development and compliance
  • Working with key states EPA on cartridge & system end-of-life disposal and recycling

• Fuel cell component suppliers:
  • MEA, membranes, plate and seal materials
  • Share performance and life test results with partners
  • Qualified multiple sources of supply for key components
Future Work

• Execute Field Test:
  – Procure and qualify components and subsystems for field test units
  – Build & test all systems
  – Identify target end users
  – Deploy and support systems during field test
    – Methanol cartridge supply
    – Address/ resolve fields issues
• Evaluate system performance and degradation in field conditions
• Analyze user feedback from field test and prepare comprehensive report
• Test fuel cell systems and Methanol cartridges for IEC compliance
Summary

- Relevance:
  - Project is in direct alignment with ARRA and FCT ARRA goals
    - 14 FTE jobs retained in NY state
    - Improved manufacturability to accelerating commercialization
    - Deploying 75 fuel cell systems into field for critical user feedback

- Approach:
  - All technical performance targets/metrics have been achieved
  - Passed Go/No-Go phase gate in November 2009

- Technical Accomplishments:
  - Reduced cost and improved manufacturing
    - Machined components to plastic injection molding or metal stamping
    - Over 50% reduction in labor content to build a system
  - Demonstrated high performance, fuel efficiency, and low degradation
  - Demonstrated system temperature & humidity latitude (0C-40C, 0-90%RH)

- Collaborations
  - Methanol Foundation:
    - Cartridge and system regulatory standards development & compliance
    - End of life disposal and recycling
  - Component suppliers/ commercialization partners

- Future work
  - Deploy and support 75 field test systems during 2010
  - Evaluate system performance and degradation in field conditions
Thank You!

A power generator that fits in your hand!