# XI.1 Commercialization Effort for 1 W Consumer Electronics Power Pack


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### Objectives

Demonstrate and field test a commercially viable 1 Watt direct methanol fuel cell (DMFC) charger for consumer electronic devices:

- Design for low-cost, high-volume manufacturing processes and ease of assembly.
- Demonstrate performance across temperature and humidity range of consumer electronic devices.
- Deploy 75 units into the field to obtain real world usage feedback.

### Relevance to the American Recovery and Reinvestment Act (ARRA) goals of saving and creating jobs:

- Project funding created/retained 14 full-time equivalent jobs in Albany, NY.
- The leverage DOE funds offered enabled MTI to obtain private investment.

### Relevance to the U.S. DOE Fuel Cell Technologies (FCT) ARRA goals of accelerating the commercialization and deployment of fuel cells:

- Fuel cell charger will be ready for commercialization at the end of this project.
- Components have been redesigned for low-cost, high-volume manufacturing.
- Seventy-five fuel cell systems will be deployed in 2010 during the field test.

### Technical Barriers

Progress against the barriers listed below is discussed in the following sections.

- Cost and manufacturability
- Performance and degradation
- Market acceptance

### Accomplishments

- Reduced cost and improved manufacturability and assembly:
  - Previously machined components are now being produced using injection molding for plastic parts and metal stamping for metallic parts.
  - Over 50% reduction in labor content achieved in system assembly.
- Achieved over 6,000 hours of stack operation with less than 5% decay per 1,000 hours.
- Demonstrated high performance, high fuel efficiency, and low degradation.
- Demonstrated system temperature and humidity latitude (0-40°C, 0-90% relative humidty, RH).
- Achieved all technical metrics and passed the Go/No-Go phase gate on-schedule.

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## Introduction

The objective of this project is to demonstrate and field test a commercially viable 1 Watt DMFC charger for consumer electronic devices. The fuel cell system and replaceable methanol cartridge will meet all requirements for commercialization. The system will achieve targets of cost, performance, and design reliability at a level compatible to the standards and requirements of the consumer electronics market.

## Approach

The project's environmental and safety plans had been developed and submitted during 2009. The project has been organized into three phases. Phase 1 demonstrates alpha level of capability and readiness for a consumer product, Phase 2 demonstrates beta level of capability and readiness for a consumer product, and Phase 3 demonstrates usability in the hands of the customer by conducting a field test with 75 units.

The tasks in Phase 1 include component cost reduction, redesign for manufacturability, performance and reliability testing, and system integration. Phase 2 tasks include tool fabrication, debugging, and tooled component prove-out in working systems. Phase 3 tasks include demonstrating the DMFC charger's functionality in the hands of real users while also providing feedback for potential design improvements. This field test will be the first time a significant number of MTI units will be put into the field to test usability and functionality. This field test will generate user feedback on product viability as well as identify potential improvements. The fuel cell charger will be ready for commercialization at the completion of this project.

## Results

A major focus of this project was to reduce the cost of MTI's DMFC-powered charger to attain a competitively priced product when in production. To achieve a low-cost system many of the components had to be redesigned so that they could be produced using low-cost, high-volume, manufacturing processes. The system also had to be redesigned for ease of assembly to increase build yield and reduce the amount of labor content needed. In addition, the assembly process had to be simplified so that technicians and assemblers could perform the assembly rather than engineers and scientists.

During Phase 1 of this project many parts and process steps were completely eliminated or were significantly simplified. In one instance a complete subassembly, with all associated cost and reliability issues, was eliminated. Phase 1 of the project was completed during the fall of 2009 and there was a successful Go/No-Go review meeting that occurred on November 5, 2009 at MTI's facility in Albany, NY. At the completion of Phase 1 almost all components were redesigned for reduced cost and high-volume manufacturing. The following are examples of component redesigns implemented to reduce cost and make the components capable of being manufactured using common, low-cost, high-volume manufacturing processes:

- Plastic components previously machined were designed to be injection moldable.
- Sheet metal components previously machined were redesigned to be stamped and coined.
- Laser cut free-standing gaskets were redesigned to be profiled gaskets, either over-molded onto components they seal or otherwise easily placed.
- Many adhesives and small bridge plates were completely eliminated by integrating their function in other interfacing components.

There were several performance improvements achieved at the engine/stack subsystem level. Figure 1 demonstrates an engine/stack completing over 6,000 hours of operation with a decay rate of only 5% per 1,000 hours. This decay rate was achieved on multiple engine/stack subsystems.

The engine stack subsystem also demonstrated increased performance for membrane electrode assembly (MEA) power density. Figure 2 shows the power density of 85 $mw/cm^2$ and 100 $mw/cm^2$ corresponding to two different fuel feed rates. Part of this achievement was due to engine/stack design changes that enable the engine to efficiently consume methanol at higher fuel feed rates. In past engine/stack designs there was a substantial efficiency fall off at higher fuel feed rates. Figure 3 shows the stack/engine life test obtaining both high power density and relatively high fuel efficiency at increased fuel feed rates.

During Phase 2 of the project, tools were fabricated and parts were produced for evaluation of the design intent. This required several iterations of part, tool and process changes until the parts produced off of the tooling met the design requirements. Comprehensive

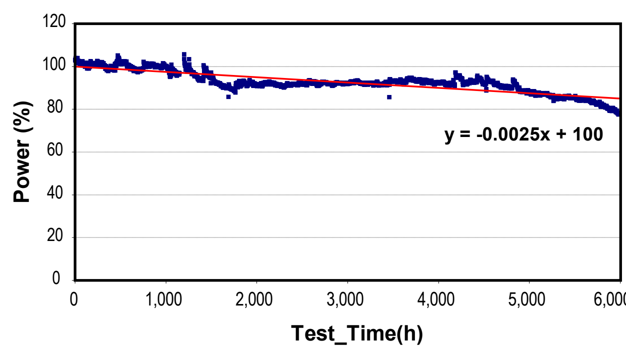


**FIGURE 1.** Stack/Engine Life Test Demonstrating 6,000 Hours at 5% Decay per 1,000 Hours

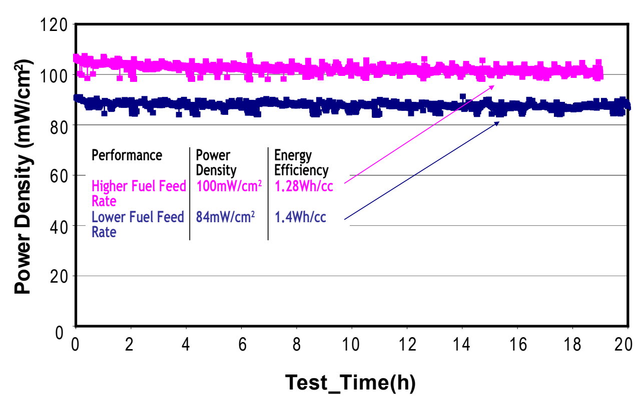


**FIGURE 2.** MEA Power Density

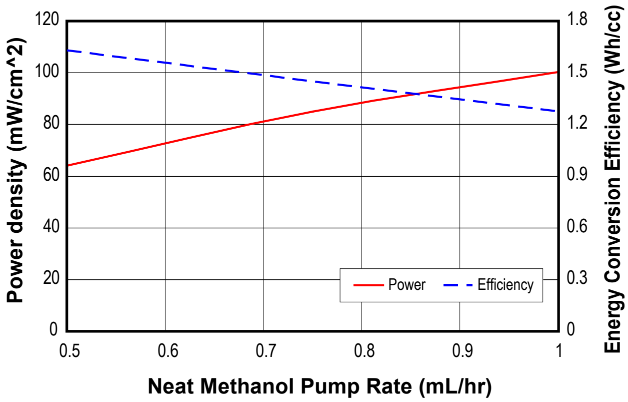


**FIGURE 3.** Stack/Engine Power Density and Efficiency vs. Pump Rate

subsystem level testing was carried out to quantify the impact the redesigned subsystems had on durability and performance. There was also a significant amount of system integration work done to bring the new lower cost subsystems together. Testing at the system level was used to verify that the system is capable of operating well during transients such as start-up and shut-down and at all specified temperatures, humidity, and orientations.

At the system level there were several configuration changes that required system integration activities followed by complete system characterization testing. Testing at the system level included:

- Algorithm development
- Performance and qualification testing:
  - Sound testing
  - Cold and hot ambient start-up
  - Surface temperature measurement
  - Drop testing
  - Temperature and humidity latitude (0-40°C, 0-90% RH)
  - Altitude testing
  - Orientation independence
- Life testing
  - Steady-state decay rate
  - Start-stop decay rate

## Conclusions and Future Directions

- High power density and high fuel efficiency has been achieved simultaneously.
- Low stack degradation rate exceeding product requirements has been demonstrated.
- Performance of system at temperature and humidity latitude (C-40°C, 0-90% RH) has been demonstrated.
- Phase 3 field test underway:
  - First units shipped in June.
  - Participants identified for the field trail.
  - Field trial feedback forms designed.

The main area of future work for this project is to complete the field test successfully. Support for the fuel cell units in the field with additional cartridges and quickly addressing any issues that arise is important to obtaining the maximum amount of useful information from the field test. Areas of particular interest in the evaluation are the user interface, field reliability and performance, and determining new user preferences.

## FY 2010 Publications/Presentations

**1.** Lim, P, 2010, "MTI Micro's latest development of fuel cells system for mobile use," FC Expo, Tokyo, Japan.

**2.** Prueitt, J., 2010, "MTI Micro's latest development of fuel cells system for mobile use," Small Fuel Cells 2010, Cambridge, MA