XII.1 Commercialization of 1 Watt 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 11 full-time equivalent jobs in Albany, NY.
- The DOE funds 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:

- Components have been redesigned for low-cost, high-volume manufacturing.
- Seventy-five fuel cell systems have been deployed during 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

- Deployed 75 fuel cell systems into the field for real world evaluation.
- Reduced cost and improved manufacturability and assembly.
- Demonstrated high performance, high fuel efficiency, and low degradation.
- Demonstrated system temperature and humidity latitude (0-40°C, 0-90% relative humidity).
- Achieved or exceeded all technical metrics.

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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.

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 is the first time a significant number of MTI units (shown in Figure 1) are put into the field to test usability and functionality. The objective of the field test is to generate user feedback on product viability as well as identify potential product improvements.

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. 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.
- Many adhesives and small bridge plates were completely eliminated by integrating their function in other interfacing components.

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

During phase 3 of the project 75 user evaluation kits were sent out which contained the contents shown in Figure 2. The kit included a mobion handheld generator, two cartridges filled with methanol, quick start guides, and a cable that had interchangeable tips enabling use with all of the common connections for handheld electronic devices. Although only two cartridges were sent with the units there were more available upon request.

The fuel cell systems were deployed to the groups specified in the statement of work including individual users,

FIGURE 1. MTI Mobion DMFC Charger

FIGURE 2. Contents of Box Field Trial Participant Received

original equipment manufacturers (OEMs), various military groups and government agencies. The allocation of the units is shown in Figure 3.

Feedback from the field test has been very positive overall. Below are some verbatim comments from the participants within the larger groups that have participated in the field trial:

- *"Just finished off my first cartridge today. I charged my (iPhone) phone approx 10x from ~25% to 100% battery before it needed replacement" – OEM*
- *"We were impressed with the form factor and with the chemical conversion technology. It repeatedly charged our iPhones in a timeframe similar to that from a standard electrical outlet." - OEM*
- *"The device works excellently and has not provided many inconsistencies. Mostly, not being able to have the fuel cell in an enclosed space (i.e., laptop bag) while it is generating power was an inconvenience though not a major problem." – Individual user*
- *"Alternative energy on the battlefield is evolving into one of the most salient issues of the day. We believe that despite initial concerns, Mobion should continue advancement of this unique technology to potentially meet some of the existing and future tactical energy requirements." - Military*

An online post-test survey was used to capture user feedback. Figure 4 shows results from one of the questions on the survey that captured the attributes users liked.

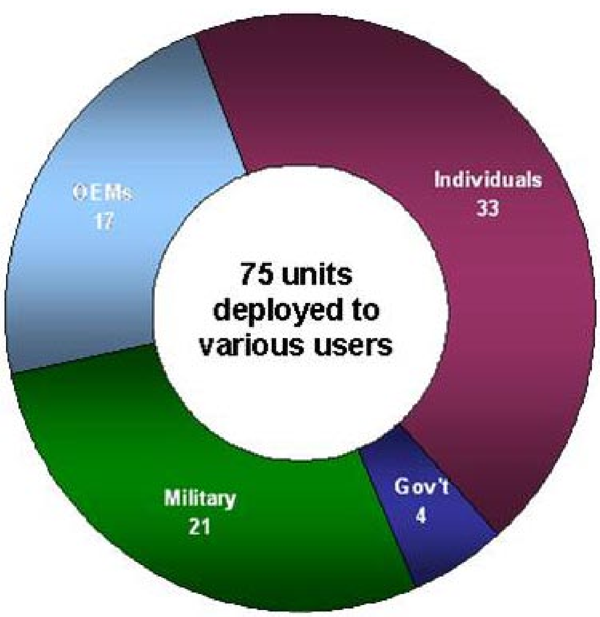

FIGURE 3. Allocation of the 75 Units Deployed for Field Trial

This field trial accomplished the objective of obtaining real world usage feedback and identifying areas of product

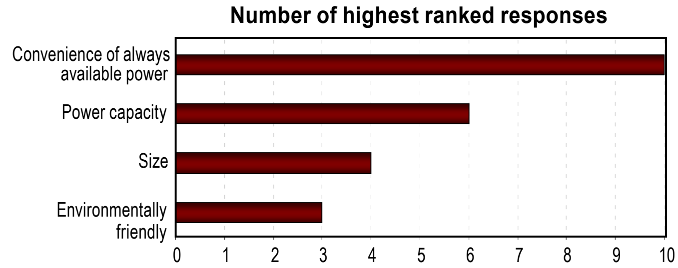

FIGURE 4. Results from Feedback Form - What Users Liked

improvement. Valuable feedback was coming in just days after the initial units were being shipped. For example, there was a compatibility issue the fuel cell had when connected to one of the newer smart phones. The issue was quickly resolved and did not reappear throughout the duration of the trail. This issue exemplifies the enormous value the field trial added to the product development process. There are some issues, such as the one described, that will not show up in the lab and that will only be uncovered when units are deployed into the field in significant numbers. The user interface was another area that benefited greatly from this user field test. The user interface functioned well but was confusing to some users because it had two buttons. The feedback on the user interface from this field trial led to the development of a new single switch user interface and other features to make the device more intuitive.

A secondary benefit of the filed trial was that it enabled the participant and the organizations they represent to become aware of the commercial readiness of this product. In general, the participants that have evaluated fuel cell offerings from other companies in the past were most impressed with the Mobion charger during the field trial. Sending units for evaluation gave credibility to the product claims, specifications, and commercial readiness. Several business relationships initiated or strengthened by the field trial will further impact the commercialization of this product and technology in the coming months.

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 (0-40°C, 0-90% relative humidity) has been demonstrated.
- Seventy-five unit field test has been completed:
  - Seventy-five units built, tested, and shipped
  - Product improvements identified

Although this project is complete several product improvements have been identified that will continue to guide our product development in the coming months.

FY 2011 Publications/Presentations

1. Carlstrom, C, 2011, "Commercialization of 1 Watt Consumer Electronics Power Pack ," DOE Annual Merit Review, Arlington, Virginia, USA.

2. Prueitt, J., 2010, "Portable Fuel Cell Panel," Clean Energy Conference, Boston, MA.