XII.4 Solid Oxide Fuel Cell Diesel Auxiliary Power Unit Demonstration

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Subcontractors:
- Electricore, Inc., Valencia, CA
- PACCAR, Inc., Bellevue, WA
- TDA Research, Inc., Wheat Ridge, CO

Project Start Date: August 1, 2011
Project End Date: January 31, 2012

Objectives

- Design, develop, and demonstrate a 3-5 kW solid oxide fuel cell (SOFC) auxiliary power unit (APU) for heavy-duty commercial Class 8 Trucks (Figure 1).
- Utilize Delphi's next generation SOFC system as the core power plant and prove the viability of the market opportunity for a 3-5 kW diesel SOFC APU system.
- Test and demonstrate the diesel SOFC APU system in a high visibility fleet customer vehicle application that will support hotel loads and other real world operating conditions.

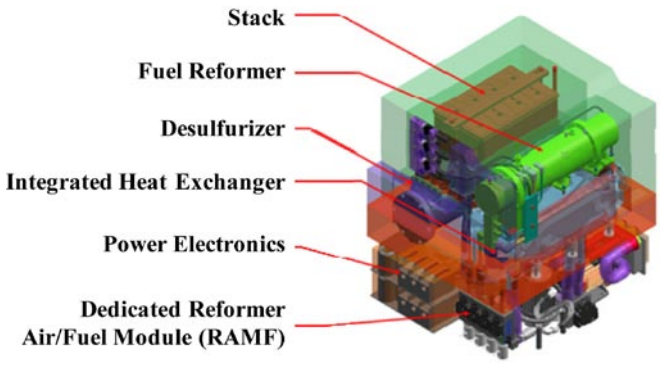

FIGURE 1. Delphi Solid Oxide Fuel Cell Auxiliary Power Unit (A-Level Prototype) Schematic

Relevance to the American Recovery and Reinvestment Act (ARRA) of 2009 Goals

- During this phase of the project, a total of 21 jobs were created/maintained:
  - Delphi 18 jobs
  - Electricore 1 job
  - PACCAR 1 job
  - TDA 1 job
- As a result of this project, Delphi will be able to install its SOFC APU on a high visibility fleet truck. This will provide Delphi, and its fleet customer, with real world use experience as well as the associated fuel consumption and emission data. This demonstration should increase the overall awareness of SOFC APUs and provide positive momentum in preparing to commercialize this product.

Technical Barriers

- As a result of the successful execution of this project, Delphi will have addressed:
  - System vibration robustness
  - Overall system packaging
  - System weight
  - System cost
  - System manufacturability
  - System durability/reliability
- During a recent SOFC APU system test, we discovered an issue with the desulfurizer during repeated thermal cycles. This issue needs to be resolved before the unit could begin fleet testing.

Technical Targets and Milestones

- Build next generation prototype (B-Level) SOFC APU for installation on fleet customer truck during the fourth quarter of 2011. Begin on-road, real-world application demonstration.
- Provide 3-5 kW of power during idle periods allowing for reduced fuel consumption and harmful emissions.
- Specific power ≥15 w/kg.
- Power density ≥10 w/l.
- Net system efficiency ≥35%.
- ≥2,000 hours of operation.

Accomplishments

- A-Level SOFC APU mounted on Peterbilt Class 8 truck and driven >3,000 miles (Figure 2):
  - SOFC APU air inlet was modified based upon data from road-test.
- A-Level SOFC APU completed >50 thermal cycles of 250 planned.
- System and Subsystem vibration analysis initiated:
  - System tested to the equivalent of 17,000 highway miles on a vibration table.
  - Stack tested to the equivalent of 3.5-million miles on a vibration table.
- Integrated next generation stack into B-Level build. Addresses improved system efficiency and packaging barriers listed above.
- Integrated a sorbent bed for removal of hydrogen sulfide (H_2S) from the reformate. Abovementioned issue needs to be addressed:
  - Able to remove H_2S to <0.010 ppm.
- Enhanced the heat exchanger subsystems using a common footprint for each. Provides a more robust and cost-effective design.
- Launched the next generation endothermic reformer. Provides improved heat transfer and an improved cost due to reduced manufacturing complexity.

Introduction

Delphi's SOFC power system, installed on heavy-duty commercial trucks as an APU, addresses the growing concerns about emissions, fuel consumption, and noise. In the United States today, there are more than one million long-haul heavy-duty commercial trucks with sleeper cabs on the road. When drivers stop for their mandatory rest periods or loading/unloading, they often leave their engines idling in order to heat/cool their sleeping areas and operate other vehicle systems. This idling practice is costly to the driver, the fleet owner, and harmful to the environment. The Environmental Protection Agency's SmartWay Transport Partnership estimates that each year, long duration idling of truck engines consumes approximately 960-million gallons of diesel fuel and emits 11 million tons of carbon dioxide, 180,000 tons of nitrogen oxide, and 5,000 tons of particulate matter into the air. In addition to the consumed fuel and emissions, idling trucks create elevated noise levels. The SOFC APU has the potential to decrease idling fuel consumption by up to 85%, reduce exhaust emissions below federal regulation emission standards, and decrease radiated noise levels to less than 60 dBA when compared to the truck's main engine.

FIGURE 2. Delphi Solid Oxide Fuel Cell Auxiliary Power Unit (A-Level Prototype) Installed on PACCAR Truck

As a result of the on-road demonstration under this project, Delphi will be able to present user profile data from its fleet customer. This data will reinforce the lab-generated data showing that use of a SOFC APU as an anti-idling solution will provide drivers and fleets with reduced fuel consumption as well as reduced emissions and noise. This demonstration should increase the overall awareness of SOFC APUs and provide positive momentum in preparing to commercialize this product.

Approach

Under this project, Delphi is pursuing a 3-phased approach to conduct its research. During Phase 1, Delphi, working with its truck manufacturer partner PACCAR, will establish the applications specifications and commercial requirements for a SOFC APU. Phase 2 work will focus on design verification and system testing (bench-top and on-vehicle). Phase 3 will include the demonstration of the SOFC APU on a heavy-duty Class 8 vehicle. The data collected during this phase will be analyzed and reported will respect to fuel consumption, emissions, and noise.

All Delphi facilities involved with this project are required to meet Delphi's stringent safety requirements which are aligned with the Safety Planning Guidance documentation specified by DOE.

Results

During this report period, Delphi has completed several of the tasks necessary to provide a road-ready SOFC APU to our fleet customer.

- Completed requirements document.
- Completed SOFC APU B-Level system design release.
- Completed SOFC APU system integration.
- Completed in-house subcomponent and system testing.
- Started SOFC APU system build. Scheduled to be delivered and installed on fleet customer truck during the third quarter of 2011.

Specific subcomponent and system development achievements are described in the Accomplishment section above.

Conclusions and Future Directions

Delphi continues to make significant progress towards introducing a production-intent SOFC APU for use by heavy-duty truck manufacturers, fleets, and drivers. This leading edge technology will provide users with the ability to run their hotel electrical loads during idling without the need to run their main truck engine or a diesel generator. As a result of using a SOFC APU, they will see reduced fuel consumption, reduced harmful emissions, and reduced noise.

Under this specific project, Delphi will next complete assembly and deliver its B-Level prototype SOFC APU to its fleet customer. After vehicle installation and fleet/driver user training, the unit will be deployed in a real-world application. During this demonstration period, Delphi will be able to monitor the SOFC APU performance real time through a dedicated telematic connection.

Patents Issued

1. Patent Filing Number 12/964806; Filing Date 10 Dec 2010.

FY 2011 Publications/Presentations

1. Jan 2011 21st Century Truck Partnership and National Academy Sciences Review Committee Presentation: "Solid Oxide Fuel Cell Development at Delphi", Rick Kerr.

2. May 2011 DOE Hydrogen Program Peer Review Presentation: "Solid Oxide Fuel Cell Diesel Auxiliary Power Unit Demonstration," Dan Hennessy.