XI.2 Solid Oxide Fuel Cell Diesel Auxiliary Power Unit Demonstration

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Contract Number: DE-EE0000478

Subcontractors:
- PACCAR, Inc., Bellevue, WA
- TDA Research, Inc., Wheat Ridge, CO
- Electricore, Inc., Suite 105, Valencia, CA

Project Start Date: August 1, 2009
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.
- 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 system.
- Test and demonstrate the diesel APU system in a high visibility fleet customer vehicle application that will support hotel loads and other real-world operating conditions.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section (3.4) of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability
(B) Cost
(C) Performance
(G) Start-up and Shut-down Time and Energy/Transient Operation

This project also is key to the development of the SOFC technology specific to the transportation industry which will have the opportunity to create new high tech jobs while maintaining and growing existing technical and non-technical jobs. The long-term economic impact can be very significant and will enable America's dominance in this area.

This project in conjunction with other efforts is assisting in enabling the acceleration of Delphi's commercialization goals for SOFCs which are in line with the DOE Fuel Cell Team's ARRA project goals of accelerating the commercialization and deployment of fuel cells and fuel cell manufacturing, installation, maintenance, and support services.

TABLE 1. APU (3-5 kW rated, 5-10 kW peak) Actuals

Technical Targets : 1-10 kW SOFC Auxiliary Power Units [1]						
	Units	2010 Targets [2]	2010 Actuals	(Production)	2015	2020
Specific Power	W/kg	120	7	17	22	25
Power Density	W/L	120	4	10	15	20
Efficiency @ Rated Power [3]	%	35	25	30	35	35
Cost	$/kW	400	[4] See below	[4] See below	[4] See below	[4] See below
Cycle Capability (from cold start) over operating lifetime	Number of cycles	500	[5] See below	416	416	416
Operating Life	hours	5,000	2500	30,000	30,000	30,000
Start-up time	minutes	15-30	180	90	60	60

[1] Operating on Standard Ultra-Low Sulfur Diesel
[2] Initial targets for program as defined in 2003 SOPO
[3] Regulated DC Net/Lower heating value of fuel
[4]. Heavy duty truck market is highly price sensitive.
[5] < 50 System Cycles but >200 stack Cycles

Accomplishments

- Completion and submission of Delphi's Hydrogen Safety Plan and National Environmental Policy Act documentation.
- Completed initial system specifications and commercial requirements.
- Completed system design and layout.
- Initiated component fabrication.
- Completed initial on-vehicle testing/demonstration.
- Completed initial system (Level A) and subsystem vibration testing and analysis.
- Onsite project review with DOE.

Introduction

Based on previous APU work with DOE Topic 2 contract DE-FC36-04GO14319, Delphi has teamed with heavy-duty truck manufacturer PACCAR Incorporated (PACCAR), and catalysts and advanced materials firm TDA Research, Inc. to develop, test and demonstrate a diesel APU that will meet or exceed the 2010 development targets for APUs.

In addition, Delphi has identified the following barriers that must be addressed:

- System Vibration Robustness
- Packaging/Size (Form factor)
- System Weight
- System Cost
- System Manufacturability
- System Durability/Reliability

The project will test and demonstrate the diesel APU in a high visibility fleet vehicle that will provide power for vehicle hotel loads and other needs under "real world" operating conditions. There will also be a series of in-house tests, including on-vehicle testing, to validate the "road worthiness" of the diesel APU prior to installation on the demonstration truck. The primary focus will be the acceleration of the development and acceptance of the diesel APU by the Class 8 heavy-duty truck market. The project will also focus on meeting the 2015 technical targets specified within this project. Delphi will demonstrate an integrated SOFC APU system on an in-service long-haul Class 8 commercial truck. The project will include:

- Operating data from at least one field unit at a customer site.
- Degradation analysis including failure mode analysis.
- Projection of system lifetime.

Approach

Based on manufacturer, market and DOE requirements, Delphi will develop, test and demonstrate a next generation diesel APU (Gen5 APU) that will meet or exceed current development targets. Working with PACCAR, Delphi will create a detailed application and commercial requirements list for the diesel Gen5 APU for on-board auxiliary power. These along with DOE requirements will become part of a comprehensive system specification. The specifications include:

- Application requirements and metrics formalization;
- Defining of real-world, on-road operating conditions for the APU;
- Defining electrical load duty cycles for testing the APU; and
- Obtaining load cycles from PACCAR for system electrical testing.

Delphi will focus on several key enabling developments in order to implement the new APU. The new Gen5 APU that will be developed as part of this project will then be deployed as the demonstration unit. Data from this unit will be collected, analyzed, and reported in the final report.

Results

Delphi has updated the customer requirements using Peterbilt as the primary point of contact. The document was updated for size; mass; forecast thermal cycles; and reliability. With that information, Delphi modified the existing APU to the Gen5 APU configuration (see Figure 1 for the basic outline).

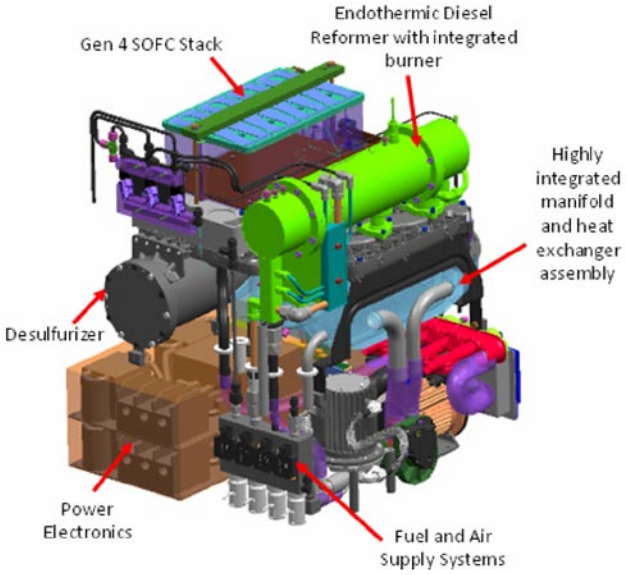

FIGURE 1. DPS3000D Design Level A Layout

Conclusions and Future Directions

The project is on target and will meet the budget and timing requirements. During this next year Delphi will complete the following:

- System/Subsystem Build and Test
- System Integration
- System Characterization
- Demonstration Initiation

FY 2010 Publications/Presentations:

1. June 2010: DOE Hydrogen Program Peer Review; Arlington (Crystal City), VA.; Presentation: "Solid Oxide Fuel Cell Diesel Auxiliary Power Unit Demonstration"; Presented by: Dan Hennessey, Delphi Corporation.