IV.D.1i Ford/BASF Activities in Support of the Hydrogen Storage Engineering Center of Excellence

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BASF, Ludwigshafen, Germany

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Objectives

This project will address three of the key technical obstacles associated with development of a viable hydrogen storage system for automobile applications:

- (Task 1) Creation of accurate system models that account for realistic interactions between the fuel system and the vehicle powerplant.
- (Task 2) Development of robust cost projections for various hydrogen storage system configurations.
- (Task 3) Assessment and optimization of the effective engineering properties of framework-based hydrogen storage media (such as metal organic frameworks [MOFs], covalent organic frameworks, etc.).

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Storage section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) System Weight and Volume
(B) System Cost
(C) Efficiency
(D) Durability/Operability

Technical Targets

This project is conducting vehicle and system level modeling, cost analysis, and materials property assessment/optimization. Insights gained from these studies will be applied towards the engineering of hydrogen storage systems that meet the following DOE 2010 hydrogen storage targets:

- Cost: $4/kWh net
- Specific energy: 1.5 kWh/kg
- Energy density: 0.9 kWh/L

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Approach

As a partner in the Hydrogen Storage Engineering Center of Excellence (HSECoE), Ford will conduct a multi-faceted research project that addresses three of the key engineering challenges associated with the development of materials-based hydrogen storage systems.

First, drawing on our extensive expertise in the engineering of fuel cell (FC) and hydrogen internal combustion engine (H2-ICE) vehicles, we will evaluate and develop system engineering technical elements with a focus on hydrogen storage system operating parameters. This effort will result in a set of dynamic operating parameters and a high-level system model describing the interaction of the fuel storage system with the FC or H2-ICE power plant.

Second, we will leverage the unique capabilities of the "Ford/Massachusetts Institute of Technology cost model" to develop and perform hydrogen storage manufacturing cost analyses for various candidate system configurations and operating strategies. This analysis will facilitate a technology roadmap for potential cost reductions and manufacturing optimization, while providing important feedback to Go/No-Go decisions on prototype design and construction.

Finally, we will evaluate and optimize the "effective engineering properties" of an important class of sorbent materials (MOFs and other framework-like materials) in order to devise improved packing and processing strategies for their use in a systems context. Various mechanical processing routes will be examined (ranging from powders to pelletization to extrusion) in an effort to maximize packing density and heat and mass transfer characteristics.

This work is expected to impact the broader goals for the DOE and FreedomCAR, leading to a significant advance in the engineering of materials-based hydrogen storage systems, refinement in our understanding of the performance targets of hydride materials, and ultimately, the development of commercially-viable hydrogen storage systems.

Accomplishments

The contract for this award was signed on 3/1/2009.

- Participated in the December Center kick-off meeting and the February face-to-face meeting.
- The parameter operating model task (Task 1) was initiated through several teleconference meetings with various project partners. The outcome of the initial modeling discussions was to organize modeling effort into two main technology areas: Performance Analysis and Integrated Power Plant/Storage System Modeling.
- It was determined that the modeling effort by the project partners can best support the HSECoE by providing: (1) confirmation that a virtual H_2 storage system design can operate with a virtual vehicle (i.e. provide hydrogen flow demand within the energy and waste heat budget) and (2) provide H_2 storage system design trade-offs to optimize the performance/targets for a virtual vehicle.
- Reviewed available FC models for waste heat profiles.
- Performed initial comparison analysis of cost estimating approaches and researched the use of a Matlab tool to decompose the H_2 storage system into critical elements for detailed analysis.
- A series of round-robin validation measurements of hydrogen uptake by several candidate framework materials were conducted. These data are summarized in Table 1.

TABLE 1. Round-Robin Validation Measurements of Hydrogen Uptake by Several Candidate Framework Materials

Material	Max. Uptake (wt% H_2)	Pressure @ Max. (bar)	Sample Mass (g)
Basolite Z377 (MOF-177)	6.9-7.3	~50	0.44
Basolite Z100-H (MOF-5)	5.3-5.6	~45	0.30
Basolite Z200 (IRMOF-8)	3.2-3.3	~20	0.86
Basolite Z1200 (ZIF-8)	2.6-2.7	~15	0.50
Basolite M050	~0	-	0.77

Future Directions

- The Framework and Power Plant Modeling plans are to identify the common modeling framework and provide partners with the interaction assumptions. The modeling tasks and efforts between the partners at the early stage of the project are important in order for foundational assumptions to be established. Also, the boundary conditions and modeling structures need to be determined.
- Develop the modeling approach and data sources within the hydrogen storage manufacturing cost analysis Technology Team. Idenitfy the role of previous cost analysis (i.e. TIAX) and the methods for handling of sensitive modeling assumptions from either suppliers or original equipment manufacturers.
- Continued characterization of selected framework materials in powdered form. This will include assessing effective volumetric density as a result of powder compaction.

FY 2009 Publications/Presentations

1. Poster presentation at the 2009 Hydrogen Program Annual Merit Review, D. Siegel and M. Veenstra.