IX.3 Landfill Gas-to-Hydrogen

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Subcontractors:
- Gas Technology Institute (GTI), Des Plains, IL
- Ameresco, Inc., Framingham, MA

Project Start Date: March 1, 2011
Project End Date: December 31, 2013 (no-cost extension from July 31, 2013 to December 31, 2013 is in progress)

Overall Objectives

- Validate that a financially viable business case exists for a full-scale deployment of commercially available equipment capable of converting landfill gas (LFG) to hydrogen under the specific BMW operating environment.
- Validate that commercially available clean-up and reformation equipment can convert BMW's LFG to hydrogen at purity levels consistent with fuel cell industry standards.
- Conduct a side-by-side operational verification of fuel cell material handling equipment (MHE) performance and durability between a test group operating on LFG-supplied hydrogen and a control group operating on delivered hydrogen supplied by an industrial gas provider.

Fiscal Year (FY) 2013 Objectives

- Deliver Mobile Hydrogen Unit and gas clean-up skid to site.
- Complete all necessary electrical and mechanical connections for all equipment.
- Conduct startup activities, commission and shake-down the equipment.
- Produce and validate H2 output meets required specifications.
- Initiate side-by-side trial.

Technical Barriers

This project addresses the following technical barriers from the Market Transformation and Technology Validation sections of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

Market Transformation

(E) A lack of flexible, simple, and proven financing mechanisms
  - Lack of life cycle cost and performance data to demonstrate low investor risks

(I) Lack of cross-cutting information on how to use hydrogen and fuel cell systems in combination with energy efficiency and renewable energy technologies with existing projects

(K) Inadequate installation expertise

Technology Validation

(F) Centralized Hydrogen Production from Fossil Resources

(G) Hydrogen from Renewable Resources

Technical Targets

There are no specific technical targets associated with this particular project. Rather, the landfill gas-to-hydrogen project will focus on validating that integrated systems comprised of commercially available equipment can deliver cost-competitive hydrogen from an initial LFG source under real-world operating conditions.

FY 2013 Accomplishments

- Delivered all project equipment to the host site.
- Completed all necessary electrical and mechanical connections for all equipment.
- Conducted startup activities and initial equipment shakedown.
- Conducted troubleshooting activities to bring product gas constituents into specification.

INTRODUCTION

BMW Manufacturing Company incorporated more than 100 pieces of fuel cell-powered MHE into a new assembly line that become operational 2010. While BMW currently is purchasing hydrogen services from an established industrial gas supplier, they strongly desire a future option where they could produce their own hydrogen, preferably from a renewable source—and ideally as a follow-on effort from their nationally acclaimed 2002 landfill methane project. BMW's original LFG project was implemented in December 2002, and the infrastructure currently allows for collecting and cleaning methane gas from the Palmetto Landfill near Spartanburg, SC, transporting it through a 9.5-mile pipeline to the BMW plant, removing siloxane contaminants on-site, compressing and then using it as fuel for gas turbine electrical generators.

Assessments by BMW of the available quantity of LFG beyond that currently devoted to electrical power generation confirm that, should the LFG-to-hydrogen production initiative prove viable, there would be sufficient LFG available to fuel the entire BMW MHE fleet in both their existing and new facilities. (Note: subsequent management decisions by BMW leadership after commencing this project have raised the on-site fuel cell MHE inventory to 270 units, representing a 100% site-wide conversion from battery power to fuel cell power.)

APPROACH

The over-arching objective of this effort is to validate there is a viable business case for BMW to move forward with a full-scale LFG-to-hydrogen conversion operation should the proposed LFG-to-hydrogen conversion technology prove financially and technically viable. The project would execute in three distinct phases: (1) conduct a feasibility study to examine the potential cost-competitiveness of hydrogen generated from LFG through a capital investment in commercially available equipment compared with hydrogen delivered at current market prices; (2) deploy and test a pilot-scale system (LFG clean-up and hydrogen production) to demonstrate the technical feasibility of converting BMW's unique LFG composition to hydrogen at purity levels consistent with fuel cell industry standards; and (3) provide "real-world" evidence via a "side-by-side" trial that fuel cell-powered MHE performance and durability are consistent between LFG-sourced hydrogen and hydrogen supplied by an industrial gas provider.

Successfully meeting the project objectives will give BWM leadership the confidence to move forward with scale up should they so choose. Additionally, this effort will lay the groundwork for proving the business case for future adopters. As of this writing, two different private sector organizations have approached the project team, expressing interest in potentially adapting the project's results to LFG-to-hydrogen business opportunities in their respective locations.

RESULTS

The project commenced officially on June 17, 2011, with the first phase of an anticipated three phase program of work. This initial phase was an economic feasibility study and business case analysis designed to assess whether a capital equipment investment in on-site LFG clean-up and methane conversion to hydrogen would enable production of hydrogen at or below the cost of having hydrogen delivered to the host site by an industrial gas company. This study completed on October 26, 2011, and was delivered to BMW management. BMW approved the study's conclusions on November 21, 2011, and authorized the project team to proceed to the second phase of the project. A copy of the feasibility study has been provided to DOE.

The "bottom line" conclusion from the feasibility study was that, at BMW's anticipated "full-scale" hydrogen production requirement, the existing LFG supply and front-end gas clean-up equipment at the BMW facility and on-site production of hydrogen using LFG as the hydrocarbon feedstock appears to be cost competitive, if not advantageous, versus hydrogen sourced from vendors, produced offsite and transported to the facility.

Implication for DOE Fuel Cell Technologies Office: Although the analysis presented within the feasibility study is specific to the LFG equipment and constituents at the BMW facility, the basic principles of hydrocarbon feedstock clean-up and reformation to hydrogen should apply to other LFG sources, as well as to agricultural waste streams, wastewater systems, digester gases, and other process off-gases.

(Note: Current incentive policies established by the Environmental Protection Agency regarding "qualified" renewable transportation fuels are under review. Should these reviews extend the existing renewable fuels incentives to hydrogen derived from LFG, the economic advantages that flow from the conclusions drawn above concerning cost competitiveness will become more pronounced at the higher daily production levels, and also might serve to lower the economic competitiveness threshold to smaller daily hydrogen production volumes.)

Throughout the current fiscal year the team has been experiencing difficulty with the performance of the gas clean-up system, initially during post-fabrication testing and currently during post-installation commissioning and acceptance testing. While this technology is well-proven in large-scale applications, the need to scale *down* to pilot size components and systems has proven challenging. Figure 1 depicts the hydrogen generation equipment and LFG clean-up equipment after their arrival at the BMW site.

Hydrogen Generation Equipment
November 12, 2012

Landfill Gas Clean-Up Equipment
November 26, 2012

FIGURE 1. Gas Cleanup Skid And Mobile Hydrogen Unit

Since landing the equipment at the BMW site the team has executed a series of field trials focused on equipment adjustments and adsorbent change-outs in an attempt to achieve the necessary product gas composition. To date, these actions have proven unsuccessful in lowering concentrations of oxygen and nitrogen to acceptable levels. Table 1 summarizes the constituent components of the LFG clean-up system effluent versus the required specifications obtained during troubleshooting trials.

TABLE 1. LFG Clean-Up Skid Product Gas Specifications and Composition

Component	CO_2	CH_4	O_2	N_2
Target Specs	<10%	>90%	<0.2%	<3.5%
Dec 2012	*	*	*	*
Jan 2013	25.0%	63.0%	2.5%	9.5%
Feb 2013	3.6%	77.8%	3.2%	15.4%
Mar 2013	0.7%	68.0%	4.6%	26.7%

In May 2013 the project team initiated a dedicated diagnostic and troubleshooting effort in concert with a third party vendor having specific expertise in removing nitrogen from pipeline methane streams.

CONCLUSIONS AND FUTURE DIRECTIONS

- Complete the troubleshooting protocol currently underway.
- Once the equipment performance meets required specifications, initiate a monitoring period of approximately six to eight weeks to validate the purity of the LFG-sourced hydrogen.
- Secure follow-on funding and execute a “side-by-side” trial comparing the performance of a control group of MHE fuel cells operating on delivered hydrogen with a test group running on LFG-sourced hydrogen.

FY 2013 PUBLICATIONS/PRESENTATIONS

1. DOE Annual Merit Review – 15 May 2013