Transportation Fuel Cell Market Strategies

IEA North American Roadmap Workshop

January 28, 2014

Source: US DOE 1/28/2014
• USG Fuel Cell Transportation Technology Projects

• Renewable Hydrogen Projects

• USG Policies - RFS2/RINs
Deployments help catalyze market penetration and ensure continued technology utilization growth while providing data and lessons learned.

Leveraging DOE Funds:

Government as “catalyst” for market success of emerging technologies.

DOE cost-shared deployments led to >5X additional purchases and orders.

~9,000 ADDITIONAL FUEL CELL LIFT TRUCKS AND BACKUP POWER UNITS PLANNED OR INSTALLED with NO DOE funding

Examples of industry* sectors in DOE ARRA projects

- Telecommunications (e.g. AT&T, PG&E, Sprint, etc.)
- Distribution Centers/Warehouses (e.g. FedEx, Genco, Sysco, Wegmans, Whole Foods, etc.)

*Provided as examples and not intended as endorsement

Source: US DOE 1/28/2014
Fuel cell vehicle fleet deployments will...

**Heavy Duty Vehicles**
- Full-size buses
- Drayage Trucks
- Waste Hauling Trucks

**Medium Duty Vehicles**
- Shuttle buses
- Baggage Tow Tractors
- Delivery Vehicles

... and drive down the cost of H2-fuel and demonstrate techno-economic results

Source: US DOE 1/28/2014
Other fuel cell transportation projects include...

- **Auxiliary Power Units (APUs)**
- **Refrigerated Semi Trucks**
- **Refrigerated Box Trucks**
- **Mobile Specialty Products**
- **Mobile Light Towers**
- **Mobile Generators**

Source: US DOE 1/28/2014
**The Challenge:** Biofuel supplies at levels to comply with the Renewable Fuels Standard (RFS2) – a growing shortfall is projected

**The Opportunity:** Qualify Renewable Hydrogen as a Biofuel

The Renewable Fuel Standard (RFS2) mandates that fuel makers meet a minimum percentage of renewable fuel production.

Renewable fuel credits are called RINs (Renewable Identification Number), and represent 77,000 BTUs of fuel (13 RINs per MMBTU).

RINs are created when an advanced biofuel is sold as a vehicle fuel.

Source: US DOE 1/28/2014
The “New” Business Case: Using biogas to provide both electric power and/or heat and transportation fuel

Source: US DOE 1/28/2014
Wastewater Biogas-to-Hydrogen Project: Orange County SD, California

• Operation on ADG: > 3,900,000 SCF processed & used
• Electricity produced: > 800,000 kWh
• Hydrogen produced: > 7,500 lbs (3,400 kg)

Source: US DOE 1/28/2014
Land Fill Gas to H2 Fuel

Source: US DOE 1/28/2014
Renewable Hydrogen Energy 
Storage

- Operate 65 kg/day PEM electrolyzer under sustained cyclic operation and evaluate frequency variability response
- Produce hydrogen from renewable energy for transportation fuel - one FC shuttle bus for local community bus and two FC buses for Hawaii Volcanoes National Park (HAVO)
- Compare electrolyzer ramp rate capacities to ramp rates required to impact frequency using 1MW Li-titanate battery
- Conduct performance/cost analysis to identify benefits of integrated system including grid services and off-grid revenue streams
- Status: Hydrogen system complete. Initial operation expected Q4 2014

**Partners**

US DOE  
ONR

State of Hawaii  
HNEI

PGV  
MTA

Source: US DOE 1/28/2014
Renewable Electricity-to-H2 Fuel

Hydrogen Delivery Process:

- H2-fueled shuttle buses
- Hydrogen Dispensing under Hawaii Power Park Program
- Geothermal Powered Hydrogen Production
- Hydrogen Dispensing under Grid Management Program

Source: US DOE 1/28/2014
1 Ft. Armstrong
2: Pier 38
3: Airport
4: Scofield Barracks
5: Kaneohe Bay
6: Diamond Head Guard

5-miles radius

Source: US DOE 1/28/2014
## H2 Consumption of Commercial Fuel Cell Technologies

<table>
<thead>
<tr>
<th>Fuel Cell Technology</th>
<th>Estimated Commercial Availability</th>
<th>Estimated Per Unit H2 Consumption (kg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Handling Equipment</td>
<td>Now</td>
<td>1-2</td>
</tr>
<tr>
<td>Bus</td>
<td>Now</td>
<td>20-30</td>
</tr>
<tr>
<td>Heavy Duty Drayage Truck</td>
<td>Now</td>
<td>15-20</td>
</tr>
<tr>
<td>Medium Duty Truck/Bus</td>
<td>2016</td>
<td>5-10</td>
</tr>
<tr>
<td>Tow Tractor</td>
<td>2016</td>
<td>3-4</td>
</tr>
<tr>
<td>Truck Refrigeration APU</td>
<td>2016</td>
<td>5-6</td>
</tr>
<tr>
<td>On-Barge Refrigeration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Young Brothers Demo</td>
<td>Now</td>
<td>100</td>
</tr>
<tr>
<td>* 90 kW On-Barge Container</td>
<td>2016</td>
<td>100-130</td>
</tr>
<tr>
<td>Mobile Generators</td>
<td>2014</td>
<td>1-2</td>
</tr>
<tr>
<td>Mobile Lighting</td>
<td>2014</td>
<td>1-2</td>
</tr>
<tr>
<td>Light-Duty Vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* H2I Demonstration</td>
<td>Now</td>
<td>1</td>
</tr>
<tr>
<td>* Hyundai, Toyota, Honda</td>
<td>2015</td>
<td>1</td>
</tr>
<tr>
<td>* All other auto OEMs</td>
<td>2018</td>
<td>1</td>
</tr>
</tbody>
</table>

- Many commercial fuel cell transportation technologies are available now. These could be “clustered” readily on Oahu and the Big Island, providing the potential for cost effective H2 usage by the customers and also using available H2 fueling infrastructure.
- Most fuel cell technologies would be commercially available by 2016, assuming successful demo project outcomes.
- These fuel cell transportation technologies are the “building blocks” for a successful strategy to transition H2I into a beach head for successful early market launch of a Hydrogen Economy for Hawaii.

Source: US DOE 1/28/2014
Thank You

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For information about the U.S. Department of Energy Fuel Cell Technologies Program:

hydrogenandfuelcells.energy.gov