Hydrogen and fuel cell technical advisory committee meeting

May 9, 2012
Presented by: Prabhu Rao, VP Commercial Operations

Nuvera Fuel Cells
129 Concord Rd. Bldg 1
Billerica, MA 01821
Agenda

- The Journey
  - Lessons Learned

- Current Focus

- Challenges and Opportunities
Company Introduction

- Nuvera Fuel Cells is a global leader in the development and advancement of multi-fuel processing and fuel cell technology

- Operations in US and EU
  - R&D
  - Low Volume Manufacturing
  - Sales & Service

- Total 120,000 sq. ft.

- 132 employees (127 in US)
  - >100 high skilled engineers (88 in US)

- Wholly owned by Hess
US Refueling Opportunity

Hess station network (1400 stations)
>95% Corporate Owned & Operated

Covers #1, 4 & 5 rated sub-regions identified as early FCEV adopters locales (NREL 2006) and >30% U.S. Population
Development cycles of learning

- Technology Development
- Product Development
- Key Suppliers Engagement
- Manufacturing Process Development
- Customer/User Focus
Technological Milestone

Nuvera conducted the world’s first successful demonstration of converting gasoline to electricity with a fuel cell.

1997

**Fuel Source**

- Gasoline
- Ethanol
- Methanol
- Butane
- Natural Gas
- Naphtha
- DME
- Synthetic Fuels
- Etc.

**Nuvera 50 kW<sub>e</sub> Multi-Fuel Processor, LANL 10 kW<sub>e</sub> PROX, Plug Power 500 W<sub>e</sub> PEM Test Setup**

Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified
Fuel Processing Technology
Hydrogen Production Options

Reformer Technologies

Catalytic Reactions

Steam Reforming

Autothermal Reforming

Partial Oxidation

Nuvera Process for Reforming NG, Propane

Vehicular Process for Reforming Methanol

Nuvera Process for Reforming Ethanol, Methane, Gasoline, etc.

These technologies are used in large-scale, dedicated H2/CO facilities, and increasingly in smaller on-site/on-board applications.

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- 300W Propane FCPS
- 30 Nm³/h 99.99% Pure Hydrogen Generator
- 1 kW Propane/NG FCPS
- 1 kW Propane FCPS
- 5 kW Endurance FCPS
- 5 kW NG ATR FP
- 50 kW Gasoline FP
- 10 kW Gasoline FP
- 5 kW NG FCPS
- 2 x 1kW H2 FCPSs

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Lessons learned: Avanti

- Global Partnerships
- Customer Req’ts
- Cyclic SMR’s
- Durable XDS fuel cell
- Champion Efficiency
- Aggressive Cost-outs
- Supervisory Controls
- ECU Development
- Cost of Reliability

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>5</th>
<th>5</th>
<th>Deployments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetAC Eff’y (HHV)</td>
<td>16%</td>
<td>22%</td>
<td>&gt;30%</td>
<td>PowerStream Circa 2001</td>
</tr>
<tr>
<td>Normalized Cost</td>
<td>1.00</td>
<td>0.42</td>
<td>0.16</td>
<td>Avanti GEN1.2 Circa 2003</td>
</tr>
<tr>
<td>Product Offering</td>
<td></td>
<td></td>
<td></td>
<td>Avanti GEN3.0 Circa 2005</td>
</tr>
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</table>
Hydrogen Generation History

On-Board

First Hydrogen Generator
1998

STAR™, gen 1
2000

StartM™, gen 3
2007

PowerStream™, gen 1
2001

Avanti™, gen 4
2006

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CHP

PowerTap™, GEN I
2005

PowerTap™, GEN II
2009 - Present

Hydrogen
The Nuvera Difference – Stack Technology

Our Competitor

Third Party Stack Technology
Limited control over stack design

Graphite Plates
Less durable over lifecycle

Closed Channel-Land Flow Field
Sensitive to temperature extremes

Cooling Cell
Adds complexity to balance-of-plant

Our Stack

Nuvera Stack Technology
Nuvera is in full control of stack design and is focused on continuous improvement

Metallic Bi-Polar Plates
Durable, reliable, and cost-effective

Open Flow Field
Increases the active area of each cell MEA

Cathode Water Injection
Simplified balance-of-plant reduces on-going costs

Conventional Stack

The Nuvera Technology Difference

Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified

Residential MicroPower fuel cell stack example

1993 1995 1997 2000 2001

5 kW 5 kW 10 kW 5 kW 3-30 kW

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Advanced PEMFC Engines

Nuvera has been working with automotive OEMs for over 10 years

- Metallic architecture since 1993
- Patented open flowfield
- 8 MW produced in 7 generations
- High durability and low cost

Fiat Seicento
- Elettra 7kw RE, 2000

Fiat Seicento
- 50kw FCEV, 2003

Fiat Panda
- 80kw FCEV, 2006

Alfa Romeo Mito
- 80kw FCEV, 2010

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PEMFC Stack Design Convergence

**Industrial**
- High durability
- 3 generations of hybrid motive FC systems
- Commercial stage

**Automotive/Aerospace**
- High power density
- 9 car installations
- R & D stage

- XDS-900
- ANDROMEDA
- ORION
- Broad range of industrial vehicle platforms
- Single architecture
- All mobility markets

Range Extender – BEV
Engine – PEMFC EV

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Objective: End up in the shaded region. Enable Cost

Nuvera is uniquely positioned to push the envelope of cost-competitiveness.

Prove Durability

Increase Efficiency

SPIRE

AURORA

Cost Roadmap (2008)
Nuvera - Market applications

- Light Duty EV & Range Extender
- Fuel Cell Forklifts
- Ground Support Equipment
- Truck APU & Reefer
- Industrial Mobility
- Fuel Cell Tractors
- Transportation
- Fuel Cell Bus
- Fuel Cell Vehicle
- Aerospace APU

Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified
Total Power Solution

PowerEdge™
Motive Power Solution

- Direct Replacement of Forklift Lead-Acid Battery

PowerTap™
Hydrogen Supply Chain

- On-Site Hydrogen Generation, Storage, and Compression

An integrated productivity enhancement system for material handling.
Reducing Carbon Footprint

33% less greenhouse gas emissions than battery EVs

34-42% less greenhouse gas emissions than propane, gasoline, or diesel IC trucks

## Nuvera On-Site Experience

*Nuvera's PowerTap is serving customers in multiple markets*

<table>
<thead>
<tr>
<th>Market</th>
<th>Material Handling</th>
<th>Market</th>
<th>Merchant Hydrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer</strong></td>
<td>HEB</td>
<td><strong>Customer</strong></td>
<td>Sacramento, CA</td>
</tr>
<tr>
<td><strong>San Antonio, TX</strong></td>
<td></td>
<td><strong>Statistics</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Statistics</strong></td>
<td>22 months on site</td>
<td><strong>Statistics</strong></td>
<td>7 months on site</td>
</tr>
<tr>
<td></td>
<td>11,500 hours</td>
<td></td>
<td>3,300 hours</td>
</tr>
<tr>
<td></td>
<td>6,000 kg H₂ delivered</td>
<td></td>
<td>5,800 kg H₂ delivered</td>
</tr>
<tr>
<td></td>
<td>99.995% purity</td>
<td></td>
<td>99.9995% (UHP) purity</td>
</tr>
<tr>
<td></td>
<td>&gt; 99.5% availability</td>
<td></td>
<td>Consistent generation of UHP</td>
</tr>
<tr>
<td></td>
<td>of H₂ at pump</td>
<td></td>
<td>Hydrogen at customer site</td>
</tr>
</tbody>
</table>

Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified
### Relative Scaling (Material Handling vs. Automotive)

<table>
<thead>
<tr>
<th>Application</th>
<th>H2 Generator Peak Rating (kgH2/day)</th>
<th>H2 Generator Peak Rating (scfh)</th>
<th>Average H2 Refueling Station Production Capacity(^1,2) (kg/day)</th>
<th>Maximum Vehicle Refuels per Day(^3,4)</th>
<th>Average No. of FCV's Supported(^4)</th>
<th>PTH 1X Storage Bank Scale Factor(^6)</th>
<th>Maximum Class II Forklift Trucks Supported(^2,7,8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Community Station</td>
<td>56</td>
<td>~1000</td>
<td>38</td>
<td>10</td>
<td>92</td>
<td>1</td>
<td>13</td>
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<tr>
<td>Small-Medium Community Station</td>
<td>112</td>
<td>~2000</td>
<td>76</td>
<td>20</td>
<td>184</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Medium-Large Community Station</td>
<td>280</td>
<td>~5000</td>
<td>189</td>
<td>50</td>
<td>461</td>
<td>5</td>
<td>64</td>
</tr>
<tr>
<td>Large Community Station</td>
<td>560</td>
<td>~10,000</td>
<td>379</td>
<td>100</td>
<td>921</td>
<td>9</td>
<td>127</td>
</tr>
<tr>
<td>Small Public Service Station</td>
<td>920</td>
<td>~16,000</td>
<td>622</td>
<td>164</td>
<td>1514</td>
<td>15</td>
<td>209</td>
</tr>
<tr>
<td>DOE Target Public Service Station</td>
<td>1500</td>
<td>~27,000</td>
<td>1014</td>
<td>267</td>
<td>2468</td>
<td>25</td>
<td>341</td>
</tr>
</tbody>
</table>

1. Assumes 69% Capacity Factor to account for seasonal & daily fluctuations in demand
2. Assumes 98% Station Availability (22 days/yr with one 8-hr shift of service)
3. Assumes 80% Fuel Tank Opportunity Refills
4. Assumes 80-miles/gge FCV, 380-mile range & 12000-miles/year
5. Assumes 58% H2 gas utilization factor for cascade storage
6. Assumes 6500psig Cascade Storage, 3 Banks, 27 11-gal ASME cylinders, 20C ambient
7. Assumes 95% Capacity Factor for Material Handling
8. Assumes 1000Ah, 80% Discharge, 3 shift, 6 day/wk, 50 week/yr operation; RP = 52%effy

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PowerTap Single Station Service Capability

<table>
<thead>
<tr>
<th>Case</th>
<th>Reference</th>
<th>Low Demand</th>
<th>High Demand</th>
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</thead>
<tbody>
<tr>
<td>Miles Driven/Year</td>
<td>12000</td>
<td>8000</td>
<td>16000</td>
</tr>
<tr>
<td>Efficiency Ratio (FCV/ICE)</td>
<td>2.0</td>
<td>2.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Miles/gge (FCV)</td>
<td>48</td>
<td>70</td>
<td>29</td>
</tr>
<tr>
<td>Miles/gel. (ICE)</td>
<td>24</td>
<td>32</td>
<td>16</td>
</tr>
</tbody>
</table>

Nuvera Fuel Cells, Billerica, USA is ISO 9001:2008 certified.
PowerTap Product Suite

2010

PTG-50
(12’ L x 4’ W x 9’ H)

2014

PTG-250
(12’ L x 6’ W x 9’ H)

PTG-250 (~80 FCV’s)
PT-250/500
(400/800 FCV’s)

Increased FCV Demand
Refurbished Hardware

Site layout courtesy of Hess Safety Harbor, FL

Nuvera Fuel Cells, Billerica, USA is ISO 9001: 2008 certified
Nuvera PowerTap™ GENIII+ Hydrogen Generator Appliance
125-250kg/day Ultra-High Purity Grade H₂ Capacity, 800-bar Output
Target Footprint Dimensions: 12′Lx6′W
Summary

- Nuvera is focused on creating foundational technologies that can provide product opportunities in many markets
  - Possible due to capabilities of the team, funding source and strategic view

- We will be focused on being a hydrogen provider for low volume applications (50-2500 kg/day)
  - Industrial mobility
  - Transportation
  - Merchant

- Leverage our high power density stack technology to partner with OEM’s or integrators in many markets

- Mainly focused on North American and European Markets in the near term extending to Asia next.