2004 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Review
May 24 - 27, 2004

NextEnergy Microgrid and Hydrogen Fueling Facility

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NextEnergy
Objectives

• To support the DOE “Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project” in the Detroit area

• To collect and analyze data with existing codes and standards and establish a “Best Practices” training and educational program
Objectives - 1

• To integrate, within a core urban environment, critical hydrogen infrastructure components and systems for multi-use operations

• To optimize SYSTEM solutions/integration to advance the hydrogen infrastructure for vehicular and stationary use
Objectives - II

- To provide hydrogen to vehicles at 3,600 psig and 5,000 psig (for demos in the Detroit area)
- To study the system interactions/integration for power generation (~ 1 MW) in a Microgrid with fuel cells, ICE generators, Stirling engines, and solar PV
Blueprint: Plan Layout for Power Generation Systems (Hydrogen and Natural Gas) in the Microgrid

(Note: in the actual poster session, the blueprints will be larger in size)
Blueprint: Vertical View of the Microgrid Power Sources (Hydrogen and Natural Gas)

(Note: in the actual poster session, the blueprints will be larger in size)
# Microgrid Components

<table>
<thead>
<tr>
<th>Component</th>
<th>Power (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Plug Power Fuel Cells (H2)</td>
<td>20</td>
</tr>
<tr>
<td>2-STM Stirling (H2 &amp; NG)</td>
<td>104</td>
</tr>
<tr>
<td>1-Menag EGR IC engine</td>
<td>210</td>
</tr>
<tr>
<td>1-DTE Turbine</td>
<td>355</td>
</tr>
<tr>
<td>2-DTE IC Engine (iPower)</td>
<td>225</td>
</tr>
<tr>
<td>1-Ford/Stuart H2 IC engine</td>
<td>120</td>
</tr>
<tr>
<td>PV Array (Unisolar)</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1064 kW</strong></td>
</tr>
<tr>
<td>Thermal recovery systems (Heating/Chilling)</td>
<td></td>
</tr>
<tr>
<td>Underground electrical</td>
<td></td>
</tr>
<tr>
<td>Underground thermal</td>
<td></td>
</tr>
<tr>
<td>Flex. foundation/interconnects</td>
<td></td>
</tr>
</tbody>
</table>
Budget

- Total NextEnergy Center Project (powered by Hydrogen, Natural Gas, Other Fuels): $22.0 million

THIS PROGRAM ONLY:

- NextEnergy Microgrid and Hydrogen Fueling Facility: $4.54 million
  - NextEnergy share: $2.54 million
  - DOE share: $2.00 million
• Construction Design:
  – Safety: NO above ground hydrogen / gas piping
    (requiring innovative construction of “feed” basement
    -- Class 1, Div 2, Group B classification)
  – Safety: Underground protection for hydrogen
    conduits (Note: NO existing codes for buried
    hydrogen lines!)
  – Modular “plug and play” easy interchange of power
    generators (requiring flexible foundation “feed”
    interconnections from below)
Technical Barriers & Targets - II

• Operations and Control:
  – Study system stability and system economics from diversity of power sources and fuel feeds
  – Provide for automatic and remote shut-offs and shutdowns (pressure sensors and in-duct hydrogen and gas sensors, and flame detectors)

• Power Pavilion:
  – Ensure all power sources are weather-proofed with in-enclosure sensors
Approach:
Leverage the Microgrid Infrastructure to Evaluate System Integration Challenges - I

• Determine the overall economics of hydrogen use for power generation in different power technologies; compare the economics for hydrogen as fuel in vehicular applications
• Compare the hydrogen data with data with other fuel feeds: natural gas, bio-fuels, etc. (within the context of power generation in a microgrid)
Approach:
Leverage the Microgrid Infrastructure to Evaluate System Integration Challenges - II

• Exploit microgrid data to develop high security/reliability power system applications
  – Applications development (e.g. Military, Homeland Sec.)
  – Equipment testing and verification (DG/CHP, ride-through, control/interface gear)
• Utilize hydrogen fueling system for the development of small scale on-site H2 production technologies
• Leverage laboratory to facilitate system integration/packaging
Hydrogen Supply System

Future Work

SMR Based Reformer
5 KG/HR

CPOx Based Reformer
10 KG/HR

To MicroGrid
18 KG/Hr

Vaporizer
20 KG/Hr

Liquid Storage
1,000 KG

High Pressure Compression
50 KG/Day

High Pressure Storage
70 KG

Hydrogen Dispensing
4 Light Duty Vehicles Per Day

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Project Safety - I

• Design & Construction:
  • Innovations in below-ground hydrogen lines (follow natural gas line protocols; develop flexible foundation “feed” interconnects)
  • Classification of “feed” basement as Class 1, Div. 2, Group B (except for non-classified areas for inverters and other electrical switchgear and Class 1, Div. 1 for the sump pump pit)
Project Safety - II

• Operations & Controls:
  • Low pressure sensors for automatic shut-downs and in-duct hydrogen and gas sensors and flame detectors
  • Provision for remote and automatic shut-downs
  • Extensive grounding provisions
• Co-ordination with Praxair and with Michigan Dept. of Environmental Quality for liquid hydrogen storage and refueling
# Project Timeline

<table>
<thead>
<tr>
<th></th>
<th>System Design</th>
<th>Start Final Design</th>
<th>Equipment Ordered</th>
<th>Equipment Delivered</th>
<th>Env Permit Obtained</th>
<th>Begin Construction</th>
<th>System Commissioning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NextEnergy Center</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>05/04</td>
<td>on-going</td>
<td>N/A</td>
<td>04/04</td>
<td>04/05</td>
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<tr>
<td><strong>Microgrid</strong></td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
<td>08/04</td>
<td>02/04</td>
<td>05/04</td>
<td>04/05</td>
</tr>
<tr>
<td><strong>Hydrogen Systems</strong></td>
<td>✔️</td>
<td></td>
<td>05/04</td>
<td>06/04</td>
<td>08/04</td>
<td>04/04</td>
<td>07/04</td>
</tr>
</tbody>
</table>
Technical Progress

• System Designs for NextEnergy Center -- all completed
• Various Power Sources for Microgrid -- specified and ordered
• Final Designs for Center and Microgrid -- accepted (Hydrogen system design to be accepted in May)
• Environmental permits obtained
Interactions & Collaborations

- DTE Technology: Microgrid Design
- Plug Power: 5 kW PEM Fuel Cells (stacks only)
- STM: 55 kW Stirlings (H₂ and natural gas fed)
- iPower: 85 kW units (based on GM engine)
- Stuart Energy: 120 kW Ford H₂ ICE
- Praxair: Liquid Hydrogen and Fueling Station
- Univ of Michigan: Analysis / computations of emissions and efficiencies based on the microgrid components for power generation
Power Generators in the NextEnergy Microgrid

Plug Power 5 kW PEMFC (stack portion only; no reformers; no inverter section) 400 kW Walther Turbine

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Power Generators in the NextEnergy Microgrid

STM Stirlings in outdoor enclosure

85 kW iPWer ICE
Future Work - I

• Develop the Codes and Standards “Best Practices” database and conduct the annual workshop in cooperation with DOE

• Complete and Issue the Teaching Modules and Educational Resources for the “Hydrogen Education Teaching Module”
Future Work - II

• Incorporate reformers into hydrogen supply (steam-methane reforming, CPOx – based reformer):
  • Post-treatment processes for purity requirements
• Explore bio-fuel feeds into Stirling engines (new hot-end designs needed)
• Develop innovations in energy storage, load-management to improve microgrid stability and reliability