"Hydrogen Fuel Cells: Technology and State Policy"

CT Fuel Cell Economic Development Plan

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(CCAT)
Reasons for Market Growth

- World electric consumption is projected to more than double between 2003 and 2030

- Transportation demands for petroleum currently exceed domestic supply. Alternative fuels will be required for energy security

- Increased energy efficiency for transportation and electric generation will be required by all global consumers as traditional fuel prices increase, i.e. oil prices per barrel increases over $100

- Reduced emissions of GHG and primary air pollutant mandates for mobile and stationary applications

- Summer peak electric demand will require new generation resources in addition to conservation measures

- New generation capacity to meet new demand and to replace retiring units
Potential Mature Global Market

- A mature global market could generate between $43 and $139 billion annually.
- If Connecticut captures a significant share of the distributed generation and transportation markets, revenues could be between $14 and $54 billion annually.
- A mature market would require an employment base of tens of thousands.
Market Growth Barriers

• High costs

• Lack of understanding and recognition of fuel cell reliability and durability

• Unappreciated environmental values

• Lack of investment needed to undertake research and development

• Insufficient infrastructure

• Strong competition from rate-base supported conventional grid generation
Employment In 2010

- Approximately 1,300 jobs directly associated with research and development and the manufacture of
- Over 1,600 indirect jobs for a total of over 2,900 jobs statewide
- Total employment of Connecticut’s hydrogen and fuel cell industry, including direct, indirect and induced jobs has grown 28 percent from 2006 to 2010, and is projected to grow by an estimated 12 percent each following year
Economic Value
Fuel Cell Industry Revenue

Source: 2009 Study by Navigant Consulting, Inc.
Economic Multipliers

- For each job the hydrogen and fuel cell industry directly supports, an additional 1.31 jobs are indirectly supported elsewhere in Connecticut.

- For every $1.00 of revenue generated by industry, an additional 84 cents of revenue is received by the state of Connecticut.

- For every $1.00 paid to industry employees, an additional 72 cents is paid by other employers in the supply chain.

<table>
<thead>
<tr>
<th>Economic Multipliers</th>
<th>Employment</th>
<th>Industry Revenues</th>
<th>Employee Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiplier</td>
<td>2.31</td>
<td>1.84</td>
<td>1.72</td>
</tr>
</tbody>
</table>

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State Roadmap Recommendations

- Long-term and predictable tax advantage incentives
- Predictable grant and matching resources for deployment and R&D
- Long-term support for vehicles and H2 refueling
- Increase awareness and knowledge
- Dedicate a percentage of RPS for fuel cell
- State mandates for agency deployment
- Utility Ownership
- Customer choice for state-made technology
Existing State Policy - Renewables

- Fuel cell generation defined as a Class I Renewable Energy
- CHP / heat recovery defined as a Class III Renewable Energy
- Establish Renewable Portfolio Standard (RPS) for Class I and Class III
- RECs awarded for renewable energy projects including fuel cells
Existing State Policy – Regulatory PUC

- Establish a systems benefit charge to fund renewable energy development
- Allow for net metering
- Allow aggregation and net metering of multi-meter buildings
- Establish requirements for renewable energy development
- Waive stand-by rates for fuel cell interconnected buildings
- Waive charges for natural gas delivery
- Low Interest Loans for Customer Side DG
Results - Reducing Unit Costs

With consistent investment to increase fuel cell production, domestic industries will be able to reduce unit costs and potentially capture a larger share of the global market.
Results – Effective Deployment

Targeted deployment of hydrogen and fuel cell technology could effectively meet electric power, thermal and transportation needs, reduce emissions, increase energy efficiency, and reduce costs.

Examples of targets include state public buildings, prisons, universities, hospitals, transit fleets, delivery fleets, major highway fueling stations, etc.
Results - Emissions Reduction and Energy Savings

Fuel cell generation facilities can substantially reduce emissions, greenhouse gases, and energy use

<table>
<thead>
<tr>
<th>Air Emissions</th>
<th>Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{X}</td>
<td>224 tons</td>
</tr>
<tr>
<td>SO\textsubscript{2}</td>
<td>187 tons</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>144,365 tons</td>
</tr>
</tbody>
</table>

Fuel cells would increase transportation efficiency by up to three times

<table>
<thead>
<tr>
<th>Average Expected Energy Use (mpge)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Car</td>
</tr>
<tr>
<td>81.2</td>
</tr>
</tbody>
</table>
Results – RPS Compliance

Projected Capacity from Year to Year Based on the Renewable Portfolio Standards Percent Increase as Mandated by the State of Connecticut from Renewable Energy from Class I

1. Energy Growth Estimates are based on the compound Growth Rate of .98% as provided by The Connecticut Siting Council.
2. Based on 100% load factor
## Results – Cost Effectiveness

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<table>
<thead>
<tr>
<th>Cost of Capital:</th>
<th>Capital Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Debt</strong></td>
<td><strong>Install Cost</strong></td>
</tr>
<tr>
<td>Pre-tax</td>
<td>Total Cost</td>
</tr>
<tr>
<td><strong>Equity</strong></td>
<td><strong>Rate</strong></td>
</tr>
<tr>
<td>Weighted Capital Cost</td>
<td>7.00%</td>
</tr>
</tbody>
</table>

### Finance Term - 12 Years

- **Depreciation** - 5 Years

### Cash Flow Analysis

- **Net Present Value (NPV)**: $534,274
- **Internal Rate of Return (IRR)**: 15%

### Payback

- **4 years**

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<table>
<thead>
<tr>
<th>Technology</th>
<th>UTC FC</th>
<th>Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>KWAC Peak Host Demand Capacity</td>
<td>1,033</td>
<td>75%</td>
</tr>
<tr>
<td>Host approximate Load Factor</td>
<td>5,531,184</td>
<td>95.00%</td>
</tr>
<tr>
<td>KWAC Host Average Energy Demand</td>
<td>2,854,948</td>
<td>95.00%</td>
</tr>
<tr>
<td>Host Expected Return on Equity</td>
<td>.400</td>
<td>95.00%</td>
</tr>
<tr>
<td>KWAC Fuel Cell Installation</td>
<td>31,540</td>
<td>95.00%</td>
</tr>
<tr>
<td>Average Heat Rate</td>
<td>3,328,900</td>
<td>95.00%</td>
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<tr>
<td>mmbtu Heat Input Per Year Required</td>
<td>785,000</td>
<td>95.00%</td>
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<tr>
<td>mmbtu Average generated by UTC FC</td>
<td>16.47</td>
<td>95.00%</td>
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<tr>
<td>Utility Avoided Energy Cost /kWh</td>
<td>3.00</td>
<td>95.00%</td>
</tr>
<tr>
<td>Utility &amp; Nat Gas &amp; LFG Esc. Rate</td>
<td>6.00</td>
<td>95.00%</td>
</tr>
<tr>
<td>O&amp;M Esc. Rate</td>
<td>17.63</td>
<td>95.00%</td>
</tr>
<tr>
<td>CHP Input Fuel $/mmbtu</td>
<td>17.63</td>
<td>95.00%</td>
</tr>
<tr>
<td>Fuel Oil Cost $/mmbtu</td>
<td>50.00</td>
<td>95.00%</td>
</tr>
<tr>
<td>Propane Cost $/mmbtu</td>
<td>50.00</td>
<td>95.00%</td>
</tr>
<tr>
<td>Boiler Natural Gas and Fuel Oil Cost $/mmbtu</td>
<td>30.00</td>
<td>95.00%</td>
</tr>
<tr>
<td>O&amp;M Market Value De-Esc @ 3%</td>
<td>2.00</td>
<td>95.00%</td>
</tr>
<tr>
<td>Natural Gas or Oil Fired Boiler Efficiency</td>
<td>15</td>
<td>95.00%</td>
</tr>
<tr>
<td>- Number of Years in the Analysis</td>
<td>35</td>
<td>95.00%</td>
</tr>
<tr>
<td>Host CL&amp;P Electric Rate</td>
<td>Non Profit</td>
<td>95.00%</td>
</tr>
</tbody>
</table>

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*CL&P* | *UI* | *Non Profit*
Results – Diverse Supply Chain

New England Hydrogen Fuel Cell Supply Chain

- Academia
- Associations
- Component Suppliers
- Fuel & Infrastructure
- Government
- Integrators
- Manufacturers
- Material Suppliers
- Research
- Service Providers
- Support Services
Summary

• There are favorable market conditions for the expansion of the hydrogen and fuel cell industry in the U.S.

• Public investment is appropriate and justified – up to $4 for every $1 of investment

• Investment in hydrogen and fuel cell technology would provide a favorable return

• There are favorable sites for deployment of hydrogen and fuel cell technology to meet the world’s pressing energy needs, improve environmental performance, increase economic development, and create new jobs
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