Ultra Clean 1.1 MW High Efficiency Natural Gas Engine Powered CHP System
Contract: DE-EE0004016
GE Energy, Dresser Inc.
10/2010 – 9/2014

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U.S. DOE Industrial Distributed Energy Portfolio Review Meeting
Washington, D.C.
June 1-2, 2011
Project Overview

Develop and commercialize a 1.1 MW\textsubscript{e} combined heat & power (CHP) package featuring high electrical efficiency and ultra low emissions that meet the California distributed generation rules. This CHP package will dramatically reduce emissions compared to the current electric grid.
Project Objective

2 Develop & commercialize a 1.1 MW_e CHP package

2 Key technical challenge is the emissions requirement

2 Key business challenge is to broadly popularize CHP
Current state-of-the-art

2 >20 MW CHP well accepted in the US
2 1-5 MW scale CHP well accepted in Europe
2 Engine manufacturers supply just engines
2 Developers specify engine, generator and the remaining CHP components
2 Installers build and install the system on a one-off basis
Current state-of-the-art

1. No design feedback to improve reliability, cost and performance
2. Current reciprocating engines not ideal for steam production
3. Current engine NO\textsubscript{x} emissions similar to existing grid
Technical/commercial approach

• New (ARES) combustion concept maintains current lean burn advantages while dramatically lowering emissions

• New combustion concept yields higher exhaust temperature – better for steam

• ARES technology increases electrical efficiency w/o hurting CHP potential

• Most risk retirement accomplished under ARES program

• Package system yields synergies
Technical/commercial approach

2 Waukesha gas engine fleet experience

2 GE leverage
   2 Large supplier to utilities
   2 Full range portfolio
   2 Ability to open markets
Transition and deployment

2 Focus on “top five” states

2 Target industries with coincidence of electrical & heat demand
  – Hospitals, industrial facilities, commercial real estate, green houses
  – 1-6 MW$_e$ demand with a similar heat demand
  – Facilities concerned about energy costs and power security

2 Utilities
  – Demand-side management
  – Grid congestion
Transition and deployment

- Technology deployable across entire product portfolio
  - GE gas engine product portfolio spans 500 – 9,500 kW
- Potential to license IP for < 500 kW sized engines
Measure of success

2 CHP fastest, cheapest way of reducing energy usage and Green House Gases

2 Denmark gets 50% of it’s electricity from CHP, and half of that is from gas engines
Benefits

2. CHP cleaner than existing grid

2. Technical potential of 12.85 GW new CHP identified

2. Assuming 75% utilization would eliminate 78,900 tons NO\textsubscript{x} and 10 million tons CO\textsubscript{2}/year by 2030

<table>
<thead>
<tr>
<th></th>
<th>Grid (lb/MW-hr)</th>
<th>CHP (lb/MW-hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x}</td>
<td>1.94</td>
<td>0.07 w/o heat</td>
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<tr>
<td>CO\textsubscript{2}</td>
<td>1329</td>
<td>1077 w/o heat</td>
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<tr>
<td>SO\textsubscript{2}</td>
<td>5.26</td>
<td>0</td>
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<tr>
<td>Hg</td>
<td>2.7E-5</td>
<td>0</td>
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<tr>
<td>N\textsubscript{2}O</td>
<td>0.026</td>
<td>trace</td>
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</tbody>
</table>
Benefits

1. Additional benefits by avoidance of electric grid losses
2. Low water usage, no combustion residuals
3. Energy security
Commercialization approach

1. Focus on “top five” states first
2. With success, propagate to other states
3. Explore alternative business models
   - Leverage GE Capital
   - Maintenance contracts
   - Bring electric utilities into the tent
Project management & budget

Expected Project Duration: 4 years
Projected DOE Funding: $6,641,565
Total Project Cost: $11,473,068

<table>
<thead>
<tr>
<th>Project Budget</th>
<th>FY11</th>
<th>FY12</th>
<th>FY13</th>
<th>FY14</th>
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<tbody>
<tr>
<td>DOE Investment</td>
<td>$1,462,664</td>
<td>$2,074,500</td>
<td>$1,727,111</td>
<td>$1,377,290</td>
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<td>Cost Share</td>
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<td>$1,176,014</td>
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<td>Project Total</td>
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<td>$2,963,572</td>
<td>$2,903,125</td>
<td>$2,754,315</td>
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## Project management & budget

<table>
<thead>
<tr>
<th>Phase</th>
<th>Milestone</th>
<th>Target Date</th>
<th>Actual Date</th>
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<tbody>
<tr>
<td>1</td>
<td>M/S 1 - Market Opportunity Defined</td>
<td>Feb-2011</td>
<td>Jun-2011</td>
</tr>
<tr>
<td>2</td>
<td>M/S 3 - Design / Dev Concepts Determined</td>
<td>Jul-2011</td>
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<tr>
<td>3</td>
<td>M/S 4 - Technical Solution Ultra-low Emissions Confirmed</td>
<td>Aug-2012</td>
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<tr>
<td>3</td>
<td>M/S 5 - Technical Solution CHP Application Confirmed</td>
<td>Feb-2013</td>
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<tr>
<td>4</td>
<td>M/S 6 - Field Test Location Solidified</td>
<td>May-2013</td>
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<tr>
<td>4</td>
<td>M/S 7 - Release for Pilot Build</td>
<td>Jul-2013</td>
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<tr>
<td>4</td>
<td>M/S 8 - Start Field Site Installation</td>
<td>Feb-2014</td>
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<td>4</td>
<td>M/S 9 - System Performance Requirements Achieved</td>
<td>Jul-2014</td>
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<td>5</td>
<td>M/S 10 - Product &amp; process validation complete</td>
<td>Aug-2014</td>
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<tr>
<td>5</td>
<td>M/S 11 - Project closure</td>
<td>Nov-2014</td>
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Tollgate process utilized with management and DOE approval
Results and accomplishments

1st Phase One Milestone Complete
  2 Preliminary Technical Systems Evaluations

2nd Phase One Milestone ~80% Complete
  2 Market Study / VOC Activities
  2 Market Opportunity Defined

Expecting to exit Phase 1 in June
Path forward

1. Continue following the project plan
2. Early endurance testing to retire the last risks
   2. >2500 hours on engine