GAS TURBINES IN SUPPORT OF GRID MODERNIZATION

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A CULTURE OF CUSTOMER CARE

Solar Turbines
A Caterpillar Company

Caterpillar: Non-Confidential
World’s Largest Manufacturer of Industrial Gas Turbines (1 to 22 MW)

Over 15,000 Gas Turbines Sold

Over 6,000 Gas Compressors Sold

Installations in over 100 Countries

Direct End-to-End Sales & Service

More than 2 Billion Fleet Operating Hours

Global Workforce ~ 8,000 Employees

48 Sales & Service Locations

70% of Products are Exported

Based in San Diego, California, U.S.A.

Subsidiary of Caterpillar Inc. Since 1981
SOLAR GAS TURBINE FAMILIES

Saturn 20
1590 hp/1210 kWE
(Over 5040 Units)

Centaur 40 & 50
4700-6130 hp
3515-4600 kWE
(Over 3660 Units)

Taurus 60
7700 hp/5670 kWe
(Over 1960 Units)

Taurus 70
10,915 hp / 7965 kWe
(Over 800 Units)

Mars 90 & 100
13,220 – 15,900 hp
9450 – 11,350 kWe
(Over 1300 Units)

Titan 130
20,500 hp / 15,000 kWe
(Over 820 Units)

Titan 250
30,000 hp / 21,745 kWe
(Over 40 Units and Growing)

Caterpillar: Non-Confidential
GAS TURBINE FOR CHP APPLICATION

- Gas Turbines are ideal suited for CHP due to:
  - High Mass flow
  - High Exhaust temperature
- Small Footprint
- Low Maintenance
- Low Emissions due to DLE combustion

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CHP IS LOCATED IN EVERY STATE

- **82.7 GW** of installed CHP at over 4,400 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO₂** compared to separate production

Source: CHP Association
CURRENT GENERATION TRENDS

GLOBAL POWER GENERATION CAPACITY ADDITIONS
2010 – 2030 (GW)

- Increase in Renewable Energy – Intermittent power
- Current distribution system operates at capacity limits
- New transmission lines needed - cost intensive and long approval process
- Centralized power generation network is jeopardized by natural disasters e.g. super storm Sandy
How Small Gas Turbines Can Support the Grid:

- Support Grid Stability
- Allows decentralized PG
  - Island Mode / Parallel Operation
  - Increase Reliability
  - Increase Resiliency
- Minimize Investment compared to centralized power generation
- Reduce transmission losses – placed closer to consumer
- Quick start-up
- Flexible load following
- Low Emissions
- High Efficient when CHP is used
UTILITY OWNED CHP

Project: Eight Flags in Florida
Plant size: 22 MW CHP
Usage:
- Power for local utility
- Sell steam to industrial company

Advantages:
- Benefits the Customer with Lower Rates
- Grows Natural Gas Usage
- Reduces Carbon Emissions
- Can Be Used Productively By Electric Utilities
- Provides Returns to Stockholders
TECHNOLOGY IMPROVEMENTS

- Improved Start-up time
- Reduced Emissions
- Higher Efficiency – Simple cycle & CHP
- Increase in power density
- Increase in fuel flexibility on DLE
SUMMARY

✓ Turbines are ideally suited for CHP applications
✓ Turbines below 25 MW are ideally suited for behind the fence power / decentralized power / peaking
✓ Able of operating in parallel to the grid or island mode
✓ Low Emissions
✓ Gas is the cleanest fossil fuel
✓ Gas will have strong availability at relatively low cost for quite some time
## CHP VALUE PROPOSITION

<table>
<thead>
<tr>
<th>Category</th>
<th>10 MW CHP</th>
<th>10 MW PV</th>
<th>10 MW Wind</th>
<th>Combined Cycle (10 MW Portion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Capacity Factor</td>
<td>85%</td>
<td>22%</td>
<td>34%</td>
<td>70%</td>
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<tr>
<td>Annual Electricity</td>
<td>74,446 MWh</td>
<td>19,272 MWh</td>
<td>29,784 MWh</td>
<td>61,320 MWh</td>
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<tr>
<td>Annual Useful Heat</td>
<td>103,417 MWh</td>
<td>None</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Footprint Required</td>
<td>6,000 sq ft</td>
<td>1,740,000 sq ft</td>
<td>76,000 sq ft</td>
<td>N/A</td>
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<tr>
<td>Capital Cost</td>
<td>$20 million</td>
<td>$60.5 million</td>
<td>$24.4 million</td>
<td>$10 million</td>
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<tr>
<td>Annual Energy Savings</td>
<td>308,100 MMBtu</td>
<td>196,462 MMBtu</td>
<td>303,623 MMBtu</td>
<td>154,649 MMBtu</td>
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<tr>
<td>Annual CO₂ Savings</td>
<td>42,751 Tons</td>
<td>17,887 Tons</td>
<td>27,644 Tons</td>
<td>28,172 Tons</td>
</tr>
<tr>
<td>Annual NOx Savings</td>
<td>59.4 Tons</td>
<td>16.2 Tons</td>
<td>24.9 Tons</td>
<td>39.3 Tons</td>
</tr>
</tbody>
</table>

- 10 MW Gas Turbine CHP — 28% electric efficiency, 69% total CHP efficiency, 15 ppm NOx emissions
- Capacity factors and capital costs for PV and Wind based on utility systems in DOE's Advanced Energy Outlook 2011
- Capital cost and efficiency for natural gas combined cycle system based on Advanced Energy Outlook 2011 (540 MW system proportioned to 10 MW of output), NGCC 48% electric efficiency, NOx emissions 6 ppm
- CHP, PV, Wind and NGCC electricity displaces National All Fossil Average Generation resources (eGRID 2012) — 9,572 Btu/kWh, 1,743 lbs CO₂/MWh, 1,5708 lbs NOx/MWh, 6.5% T&D losses; CHP thermal output displaces 80% efficient on-site natural gas boiler with 0.1 lb/MMBtu NOx emissions

Source: DOE/EE-0079 August 2012