Microturbine Based CHP Technology & Applications

April 9, 2015
Houston, Texas

Presented to:
DistribuGen Conference & Trade Show for Cogeneration/CHP 2015

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Agenda

- Technology Overview
- Product Overview
- CHP Configurations
- Case Studies
Technology Overview

Beau Alan Follis
What Is a Capstone Microturbine?

Power generator driven by a small scale gas turbine

- Electrical Efficiency of 26-33%
- In a CHP application achievable system efficiency of 80%+
- Wide range of fuels – 350 Btu to 2500 Btu
  - Up to 7% $\text{H}_2\text{S}$ with C30
- Extremely Low Emissions
  - <9 ppm NOx standard
- Air Bearings
  - No Oils or Lubricants
- Air Cooled
  - No Antifreeze or Coolants
- Variable Speed
  - 45,000 to 96,000 RPM
- Sound Level
  - 65dB at 10 meters
Three Engine Sizes

C30  
C65  
C200
C200 Engine Cutaway
Only One Moving Part

C200 C200 C200 C200 C65 C65 C65 C65 C30 C30 C30 C30

Significantly Reduces Maintenance Requirements

- No Oil or Lubricants
- No Coolants
- No Friction
Capstone Air Bearings

Benefits

- No Oil Consumption or Disposal
- Clean Exhaust Emissions
- Minimal Maintenance
Inverter-Based

- Variable Voltage 400-480 Volts
- Variable Frequency 50-60 Hz
- Superior Transient Handling and Turndown
- UPS Quality Output
- Easy to Parallel ("Multipack")
Solid State Power Electronics

Engine Control Module
- Controls turbine operation
- Sensor less generator control
- Built in dynamic brake

Battery Control Module
- Transient power management
- Bi-directional power control
- Manages battery charge/health

Load Control Module
- Built in protective relays
- Built in synchronization
- Built in paralleling capability
- Grid Connect or Stand Alone
- No transformer required
- IEEE 519 compliant
- UL 1741 certified
Product Overview
Capstone Products

Available For Gas & Liquid Fuels

C30 & C65

C65 ICHP

C200
Packaged Solution

- Operates as a single 600 - 1000 kW Genset
- Three, Four, or Five C200 Units
- Enclosure with ISO Footprint
- Stable combustion from 100% to idle
- Maintenance can be performed on one unit while others continue to operate
- Can be “multipacked” up to 10MW
Certifications

- California CARB 2007 Listed
- UL 2200, the latest generator safety standard
- UL1741, the national grid interconnect standard
- Microturbines were first generators of ANY type state-approved by New York and by California ("Rule 21") for direct-to-grid interconnection
- Also compliant with NFPA, IEEE519, CE, NEC, CSA, ATEX and other internally recognized safety standards.
C1000 ISO Efficiency

Higher Part Load Efficiency
Horizon Power Systems Experience

- > 150 - C30’s
- > 300 - C65’s
- > 200 - C200’s
- 5 Million Combined Running Hours…And Counting
- 550 Years of Combined Operating Run Time

14 Years of Application Experience
Capstone’s Oldest Distributor
Capstone Integrated CHP Packages

C65 ICHP
Integrated Hot Water HX
~380,000 Btu/hr of Hot Water

C200 ICHP
In Development
External Heat Recovery Modules

- Heating
- Cooling
- Dehumidification
- Process
- Direct Exhaust Heat
- 80+% Efficiency

- Hot Water
- Steam
  - Supplemental Firing
  - Two Stage with Hot Water
- Absorption Chiller
  - Exhaust or Hot Water Fired
  - Chilled Water, Hot Water, Simultaneous
  - Supplemental Firing
Case Studies
Masonic Village
Elizabethtown, Pennsylvania

- Continuing-care retirement community and children’s home
- Opened in 1910
- 1,400 acre campus
- Serves 1,700+ residents
Masonic Village 1910

- Originally coal-fired steam turbines produced power for campus
- Burned 5,000 tons of coal/year
- Switched to electric utility power in 1950
- Continued to use coal for steam
- Two 400hp and one 25hp boilers
- Distributed via a 4,800-foot-long underground pipe network
- Required two people to operate 24/7
- Barely 35% efficient
- High emissions
Masonic Village 2002

- Need to reduce carbon footprint and move to next gen technology
- Installed five low emission C60 Capstone Microturbines with 3rd party external heat exchanger
- Provided electricity for power plants operations
- Provided most summer hot water needs and augmented 3-12.6 MMBtu hot water boilers in winter

**Capstone C60 Microturbines**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Units</td>
<td>5</td>
</tr>
<tr>
<td>kW of Electricity Produced</td>
<td>300kW</td>
</tr>
<tr>
<td>BTUs of Waste-Heat Energy</td>
<td>1.5 million</td>
</tr>
<tr>
<td>System efficiency with Capstone</td>
<td>80%+</td>
</tr>
</tbody>
</table>
Masonic Village 2007

- Upgraded units to C65 ICHP, new PLC-based control system, 9 year FPP (24/7 remote monitoring)
- Increased efficiency
- Reduced footprint
- Added 6th C65 ICHP in 2012

<table>
<thead>
<tr>
<th>Capstone C65 Microturbines</th>
<th>2007</th>
<th>2012</th>
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<tbody>
<tr>
<td>Number of Units</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>kW of Electricity Produced</td>
<td>325kW</td>
<td>390kW</td>
</tr>
<tr>
<td>BTUs of Waste-Heat Energy</td>
<td>2.04 MMBtu</td>
<td>2.5 MMBtu</td>
</tr>
<tr>
<td>System efficiency with Capstone</td>
<td>83%</td>
<td>83%</td>
</tr>
</tbody>
</table>
Masonic Village Summary

Capstone CHP Plant Operational
- 13 years

System Run Hours
- 550,000+ hours

Dollars Saved
- $3,262,270

Annual Energy Saved
- 3,178,214 kWh; 19,117 MMBTU hot water

Total Energy Saved
- 34,960,350 kWh; 210,288 MMBTU hot water

Carbon Emissions Reduced
- 45,516 tons
- Equivalent to removing 7,062 cars, planting 11,212 acres of forest
US Government Laboratory Facility
Houston, Texas

- Built in 2008 after Hurricane Katrina destroyed New Orleans site
- SmithGroup Engineering tasked to provide an extremely secure, independent power design that was also energy efficient
- Facility incorporated three independent buses for three different levels of power security:
  - Critical Instrument Loads
  - Essential Loads
  - Non-Essential Loads
- Required an automatic load shed and recovery design
US Government Laboratory Facility

- Capstone power plant incorporates six C65s
- Two independent systems for Critical and Essential Load support
- Four Dual Mode units operate in parallel with the grid for cost savings
  - Three ICHP units generate hot water for laboratory
  - Provides 30% Energy Savings
  - If utility outage, provides 252 kW to Essential Loads
- Two UPS\textit{Source} units operate redundantly independent of grid, to support Critical Instrumentation loads

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<th>Capstone C65 Solution</th>
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<tbody>
<tr>
<td>Number of Units (4 DM, 2 UPS\textit{Source})</td>
</tr>
<tr>
<td>kW of Electricity Provided</td>
</tr>
<tr>
<td>BTUs of Waste-Heat Energy</td>
</tr>
<tr>
<td>System Efficiency with C65 ICHP</td>
</tr>
</tbody>
</table>
US Government Laboratory Facility

Capstone CHP Plant Operational
- 7 years

System Run Hours
- 300,000+ hours

Dollars Saved
- 30% savings over similar facilities (based on Government Audit)

Capstone C65 Solution met all design requirements, both reliably and efficiently
Capstone CHP Value Proposition

- Flexibility in power plant design
- Improved power reliability and energy security
- Reduces carbon footprint and can help achieve sustainability goals
- Extremely low maintenance and factory-backed maintenance plans
- High uptime and proven reliability results in lower cost of ownership
- Custom CHP/CCHP solutions and packaging available
- Provides energy savings with a proven, reliable, clean and green technology
Reliable Power When and Where You Need It
More About Clean and Green CHP

Clean and Green Energy – Innovation with Capstone Microturbines

Capstone Turbine Industrial CCHP Animation

Capstone Turbine Combined Cooling Heat and Power (CHP & CCHP)
https://www.youtube.com/watch?v=eThi1ze1TOI

Microturbine Overview – Capstone Microturbines
https://www.youtube.com/watch?v=_W_ULVQOhkY

www.HorizonPowerSystems.com
About Horizon Power Systems

As Capstone Turbine’s oldest distributor, Horizon Power Systems offers 14 years of expertise selling and servicing Capstone microturbines for the oil and gas and commercial/industrial sectors.

Horizon has installed over 700 clean-green and low-maintenance microturbines for prime and backup power, CHP, and CCHP. For oil and gas, reliable and rugged microturbines operate on pipeline or unprocessed wellhead gas. CHP and CCHP systems can provide commercial/industrial customers onsite power plus heat to create hot and chilled water and steam.

Horizon’s responsive service team uses a fully integrated approach that combines system design, application engineering, fabrication, start up, and lifetime service.

Horizon’s territory – the largest among all distributors – spans Texas, Oklahoma, Arizona, the Rocky Mountain and Gulf Coast States, and Canada’s Western Provinces. Regional offices are in Farmington NM; Denver; Houston; Fort Lauderdale; and Calgary, Alberta, Canada.

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