Microturbine Energy Solutions in the CHP Industry

Presented by

E-Finity Distributed Generation
an authorized Capstone distributor

Power to be Independent
Content

1. CHP: Combined Heat and Power
2. Microturbine Technology
3. Products
4. Packaged Solutions
5. CHP Candidates
CHP

Combined Heat and Power
In 1978, Public Utility Policy Regulatory Policies Act (PURPA) defined cogeneration (CHP) as, “The simultaneous production of electricity or mechanical energy and useful thermal energy”

- “Topping Cycle” – Produces Electrical Energy then recycles exhaust into useful thermal energy
- “Bottoming Cycle” – Produces Thermal Energy first, then recycle waste energy stream into electricity
CHP Advantages

- CHP does two jobs with one “fire” increasing delivered efficiency from grid average of 33% to 80% or higher
  - Electric power and heating produced

- CHP
  - Cuts net fuel per kW-hr in half (vs. electric only)
  - Eliminates transmission losses (vs. grid)
  - Lowers emissions (same emissions for higher energy recovery)
  - Uses 70-80% of fuel’s energy (reduces bills)
Value

Improve project economics

• Get more out of the fuel you are burning
  • Create both electricity and heat for the same energy cost of producing electricity only
• In economic calculations, CHP can be viewed as
  • Lower ‘per kW (electric + thermal)’ fuel cost
  • Higher system efficiency
  • Free heat
• Can create a ‘spark spread’ vs. electric only

Improves economic payback
Utilizing Exhaust Heat

Direct Exhaust

- Exhaust piped directly for use
  - Greenhouse heating
  - Drying processes: furniture, chemicals, agriculture

Indirect

- A heat exchanger transfers exhaust heat to a secondary medium
  - Hot water: building heating, boiler feed, pool heating, digester heating
  - Steam: building heating, industrial processes
  - Absorption cycles (cooling): building or process cooling
Achievable Efficiencies

Steam

Typical overall efficiencies:
- 15psi steam: 65%–67%
- 125psi steam: 55%–57%

Hot Water

Any temp range is possible
Typical overall efficiencies:
- 140°F (typical “domestic hot water”): 80%
- 200°F (manufacturing type temp): 72%

Absorption Chilling (or Adsorption Chilling)

Types:
- Single effect hot water: Efficiencies in the 55%–65% range
- Double effect direct exhaust: Efficiencies up to 70%–85% range

Capstone achieves the highest overall CHP efficiencies
Capstone Microturbine Technology

Reliable power when and where you need it.
Clean and simple.
New Resources & Technology

4 products in one

• Boiler
• Air conditioner
• Electrical generator
• Secure power source
Single Stage Jet Engine

- 1750°F combustion
- Recuperated
- 3 air bearings
- “Electronic” gearbox
- Standalone capability
Patented Air Bearing Turbine

- 1 moving part: turbo generator shaft
- Air bearings
  - No oil or grease
- Air cooled
  - No anti-freeze or liquids
- Variable speed
  45,000 to 96,000 RPM
Vibration Free Combustion

- 1750°F combustion
- Recuperated
- 3 air bearings
Turbine Core
Patented Electronics

- Patented “electronic” gearbox
  - No synchronous generator needed
  - No moving parts!
- Variable voltage 300–500 volts
- Variable frequency 50–60 hz
- Standalone capability
- Built in fault protection
- Fast transfer <7 seconds
  - Clean critical load back up power!!
Inverter Based Electronics

AC to DC Converter

DC to AC Inverter

Battery Controller

Battery

DC Bus

760 VDC

L1

L2

L3

N
Engine Control Module
- All digital DSP control
- Controls turbine operation
- Wide speed control range
- Sensorless generator control
- Small and lightweight
- Built in dynamic brake
- Built in system power supply
- Air cooled

Battery Control Module
- All digital DSP control
- Transient power control
- Bi-directional power control
- Manages battery charge/health
- Air cooled

Load Control Module
- All digital DSP control
- Built in neutral
- Built in protective relays
- Built in synchronization
- Built in paralleling capability
- Grid Connect or Stand Alone
- No transformer required
- 100 kVA rating
- Air cooled
- IEEE 519 compliant
- UL 1741 certified
- NY & CA state certified for direct-to-grid interconnection
Ultra Low Emissions

- Low emission design
- Ultra-low NO\textsubscript{X}
  - Less than 9ppm
  - 14 to .16 g/hb-br
  - Endorsed by the SCAQMD
- No additional catalysis requirement
Interconnection Pre-Approved

- Certified UL 2200 for the latest generator safety standard
- Certified UL 1741 for the national grid interconnect standard
  - No relays or protection needed
- Certified UL 1741_1 Effective 5/07
- Also compliant with NFPA, IEEE519, CE, CSA and other internationally recognized safety standards
Remote System Diagnostics

- **Data logging & storage**
  - Monitors and records key system data 24x7

- **Real-time notification**
  - Alert and local CPST technician notification

- **Balance of plant interactivity**
  - Monitoring of compressors, water flow, and temperatures, etc.
Data Trending
Operation

Lowest Maintenance Available

- Air-cooled
- One moving part
- Air cooled electronics
- No lubricants or antifreeze
- No spark plugs/lifters, etc
- No post-combustion devices or chemicals
- Complete remote monitoring & troubleshooting
Capstone Products
Simple Modular Solutions

Capstone Microturbines

Product Offerings
- Grid connect
- Standalone
- Dual mode
- CHP applications
- Natural Gas
- Propane
- Diesel
- Biogas
- Wellhead Gas
- Digester/Landfill Gas
C30 MicroTurbine

Capstone Microturbines

Product Offerings

- Grid connect
- Standalone
- Dual mode
- CHP applications
- Natural Gas
- Propane
- Diesel
- Biogas
- Wellhead Gas
- Digester/Landfill Gas
## C65 MicroTurbine

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output</strong></td>
<td>65kW Net (+0/- 1)</td>
</tr>
<tr>
<td><strong>Total System Efficiency LHV</strong></td>
<td>82%</td>
</tr>
<tr>
<td><strong>Fuel Flow</strong></td>
<td>842,000 BTU/hr – HHV</td>
</tr>
<tr>
<td><strong>Exhaust Temperature</strong></td>
<td>588°F (305°C)</td>
</tr>
<tr>
<td><strong>Total Exhaust Energy</strong></td>
<td>541,000 BTU/hr</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>NOx (&lt;9 ppm) @ 15% O₂</td>
</tr>
<tr>
<td><strong>Noise Level</strong></td>
<td>65 dBA at 10 meters</td>
</tr>
<tr>
<td><strong>Voltage</strong></td>
<td>400–480 VAC 3 phase, 4-wire wye. 50 or 60 Hz</td>
</tr>
<tr>
<td><strong>SA Voltage</strong></td>
<td>150–480 VAC, 50–60 Hz</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>758 kg (1671 lbs), 2471 lbs for SA</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>83”h x 30”w x 77”d</td>
</tr>
<tr>
<td><strong>Cooling Potential</strong></td>
<td>20 tons</td>
</tr>
<tr>
<td>Characteristic</td>
<td>Performance</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Output</strong></td>
<td>200kW net</td>
</tr>
<tr>
<td><strong>Total System Efficiency LHV</strong></td>
<td>72%</td>
</tr>
<tr>
<td><strong>Fuel Flow</strong></td>
<td>2,280,000 BTU/hr − HHV Steady State</td>
</tr>
<tr>
<td><strong>Exhaust Temperature</strong></td>
<td>535°F (280°C)</td>
</tr>
<tr>
<td><strong>Total Exhaust Energy</strong></td>
<td>1,350,000 BTU/hr</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>NOx (&lt;9 ppm) @ 15% O₂</td>
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<tr>
<td><strong>SA Voltage</strong></td>
<td>150−480 VAC, 50−60 Hz</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>2270kg (5,000 lbs). 7000 lbs for SA</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>98”h x 67”w x 144”d</td>
</tr>
<tr>
<td><strong>Cooling Potential</strong></td>
<td>60 tons</td>
</tr>
</tbody>
</table>
C600 expandable to C800 & C1000

C600 Power Package

C800 Power Package

C1000 Power Package
Packaged Solution

- (3), (4), or (5) C200 Units
- Stackable footprint
- 28’ ISO container design
- Load control from 100% to idle
- Flexible maintenance
- Parts redundancy with C200

<table>
<thead>
<tr>
<th></th>
<th>C600</th>
<th>C800</th>
<th>C1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Power</td>
<td>600kW</td>
<td>800kW</td>
<td>1000kW</td>
</tr>
<tr>
<td>Heat Rate</td>
<td>10,300 Btu/kWh (10,900 kJ)</td>
<td>10,300 Btu/kWh (10,900 kJ)</td>
<td>10,300 Btu/kWh (10,900 kJ)</td>
</tr>
<tr>
<td>Output Current</td>
<td>930 Amps RMS</td>
<td>1240 Amps RMS</td>
<td>1550 Amps RMS</td>
</tr>
<tr>
<td>Nominal Voltage</td>
<td>400 to 480 VAC</td>
<td>400 to 480 VAC</td>
<td>400 to 480 VAC</td>
</tr>
<tr>
<td>Exhaust Gas Temp</td>
<td>535°F (280°C)</td>
<td>535°F (280°C)</td>
<td>535°F (280°C)</td>
</tr>
<tr>
<td>Exhaust Energy</td>
<td>4,050,000 BTU/hr</td>
<td>5,400,000 BTU/hr</td>
<td>6,750,000 BTU/hr</td>
</tr>
<tr>
<td>Sound</td>
<td>65 dBA at 10 meters</td>
<td>65 dBA at 10 meters</td>
<td>65 dBA at 10 meters</td>
</tr>
<tr>
<td>Cooling Potential</td>
<td>180 tons</td>
<td>240 tons</td>
<td>300+ tons</td>
</tr>
</tbody>
</table>
Model C1000
mTIM Logic Controller

- PLC-based master control unit
- Modbus interface to station controls system
- Allows remote monitoring
mTIM Logic Controller

- Monitors building’s load changes
- Automatically shuts down the microturbine
  - highest run hours
  - when not needed (weekends or late evening)
Packaged Solutions
Reliable Onsite Electric

- Peak shaving
- Load following
- Clean reliable back-up power
  - Straight line 60Hz @ 480 Volts
Integrated CHP Module

Model C65 MicroTurbine

Heat Recovery Module

Model C65 MicroTurbine
Integrate with Absorption Chillers

Every C65 MicroTurbine produces 20 tons chilled water

- Can be exhaust-fired or hot water-fired
C200 Turbine
C200 with External HRM
Absorption Chillers

- Yazaki hot water-fired
- 10, 20, 30 & 50 ton units
- Outdoor rated
Absorption Chillers

- Thermax hot water-fired
- Flue gas fired
  - 40–600 Tons
CHP Candidates
Anyone with a consistent use for hot or cold water is a good candidate.

“Typical” candidates are:

- Hotels (24/7 need for hot water and possible cold water for cooling in the summer)
- Hospitals (24/7 need for hot water)
- Manufacturers (24/7 need for cold water)
- Large office spaces (use hot/cold water for heating/cooling)
- Schools/small universities (use hot/cold water for heating/cooling)
- Data Centers (use cold water for cooling)
- Wastewater Treatment Facilities
Hotel

Luxury Hotel on Logan Square

- 365 rooms
- High energy use
- Steam loop customer
Hotel

Combined heat & Power

- 100% hot water
- 30% building electric
- 15% building heat

Emphasis was on:

- Controlling energy costs
- Reduce greenhouse-gas emissions
Hospital Electric & Hot Water

- Commissioned 2002
- 300kW (5) C60 MT’s
- 1,350,000 BTU’s
- 2,500 central loop
Hospital

Electric & Hot Water

- Upgraded 2007
- 325 (5) C65 MT’s
- 2,047,000 BTU’s
- 2012 – 2\textsuperscript{nd} engine core replacement
Business Center

Combined heat & power

- 100% building electricity
- 100% building hydronic heat
- Future 90 tons absorption chilling
- Islanding capable
- Dedicated back up power for exhaust hood containing dangers fumes
Business Headquarters

Electric only

- PPL utility meter set at 5kW
- Electric load Following
- Capstone makes 100% of building electric
University

Red Cross Disaster Relief Facility

Heating, Cooling & Islanding CHP

- 195kW electric load following
- 100% hot water
- 100% chilled water
- Island/Stand alone site
Data Center

Trigeneration – combined cooling, heating & power
- C800 dual mode Capstone Power Package
- Hot water heat exchanger
- 250-ton exhaust fired absorption chiller
- (mTIM) PLC control system

Output
- 800kW electrical output
- 4,250 MBH gross thermal output
- 250 ton chilling output

Standalone clean power for data center UPS
Wastewater Treatment Plant

- CR600 Power Package – Digester Gas
- C1000 Dual Mode Power Package – Natural Gas
- (mTIM) PLC control system

- Digester gas generates 2.5 million kWh of generation annually
- $275,000 savings in annual energy costs
- Recovered heat is used to heat digesters and onsite buildings