



Microturbine Energy Solutions in the CHP Industry

Presented by

E-Finity Distributed Generation
an authorized Capstone distributor

Power to be Independent





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CHP

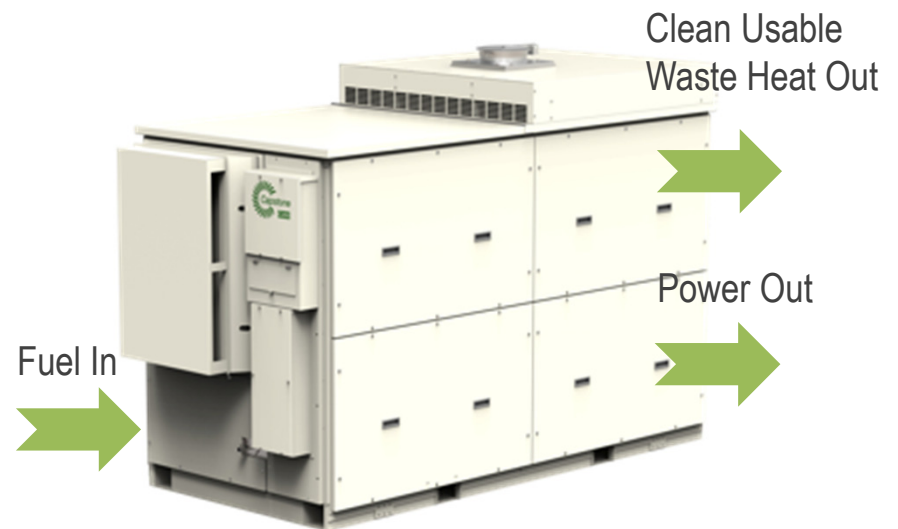
Combined Heat and Power



CHP Defined

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



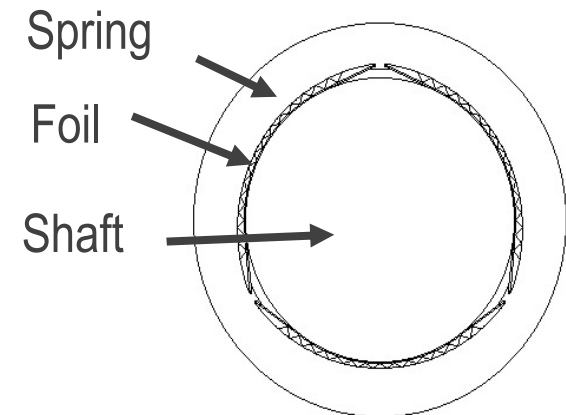
Single Stage Jet Engine

- 1750°F combustion
- Recuperated
- 3 air bearings
- “Electronic” gearbox
- Standalone capability



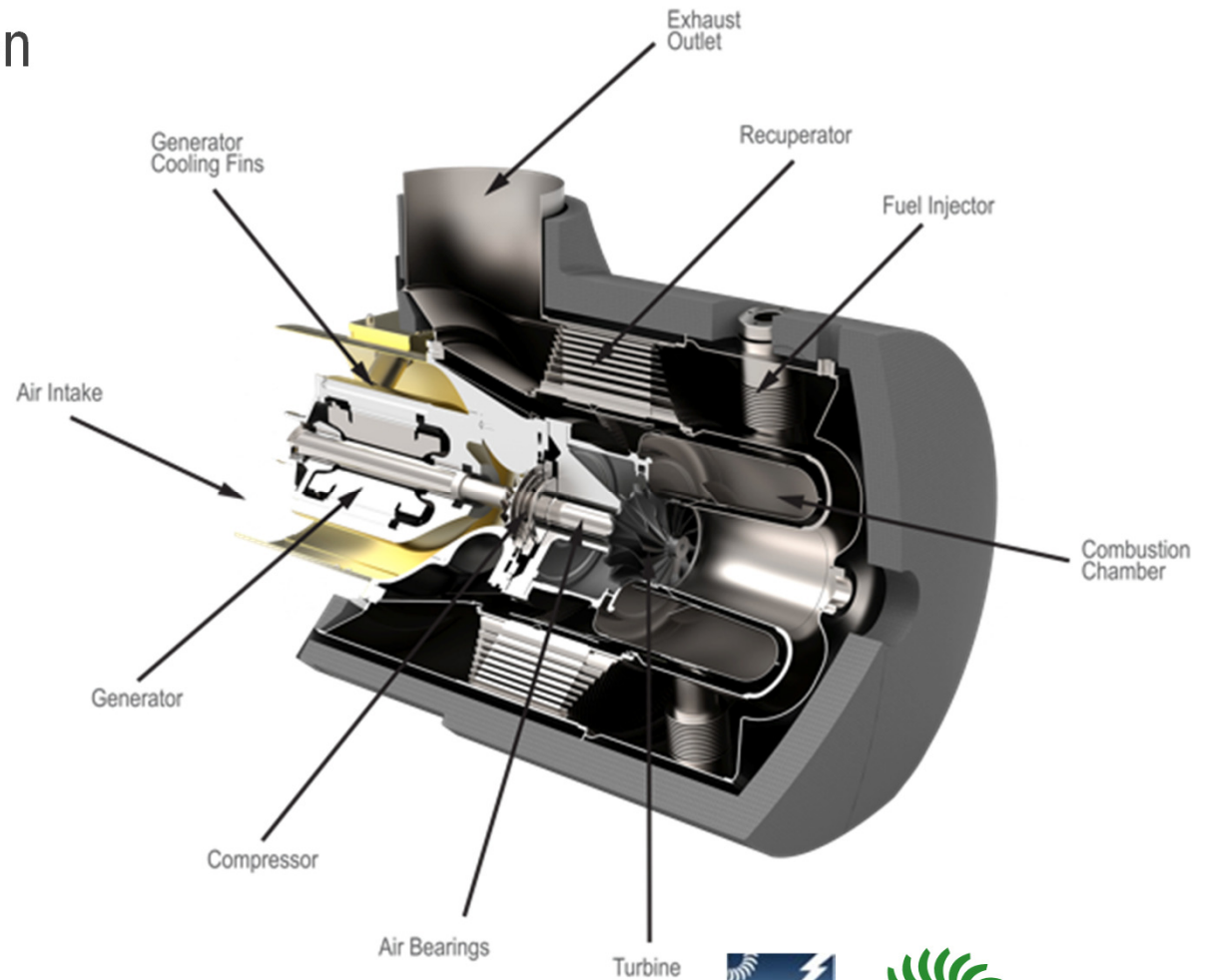
Patented Air Bearing Turbine

- 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

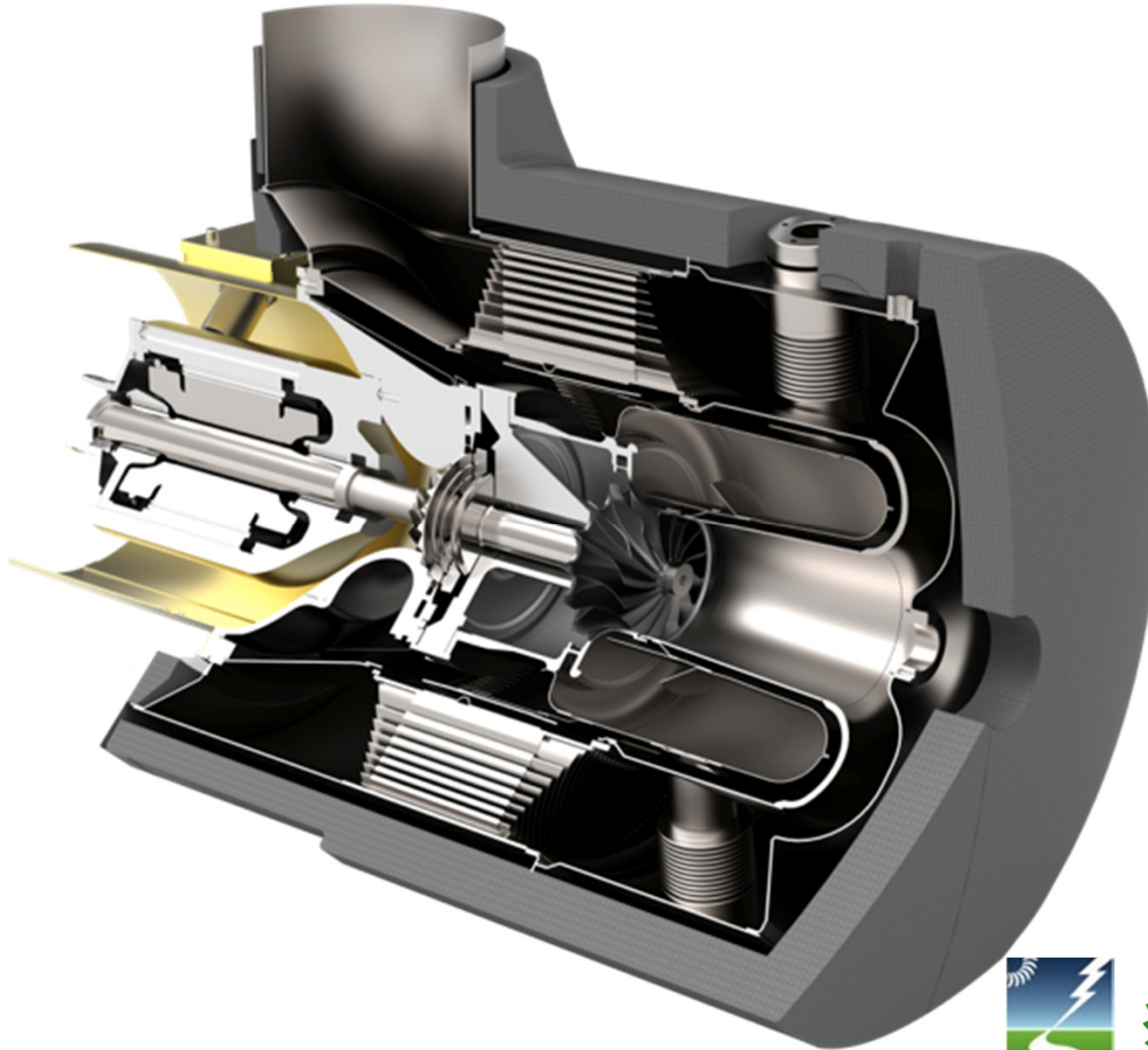


Vibration Free Combustion

- 1750°F combustion
- Recuperated
- 3 air bearings



Turbine Core

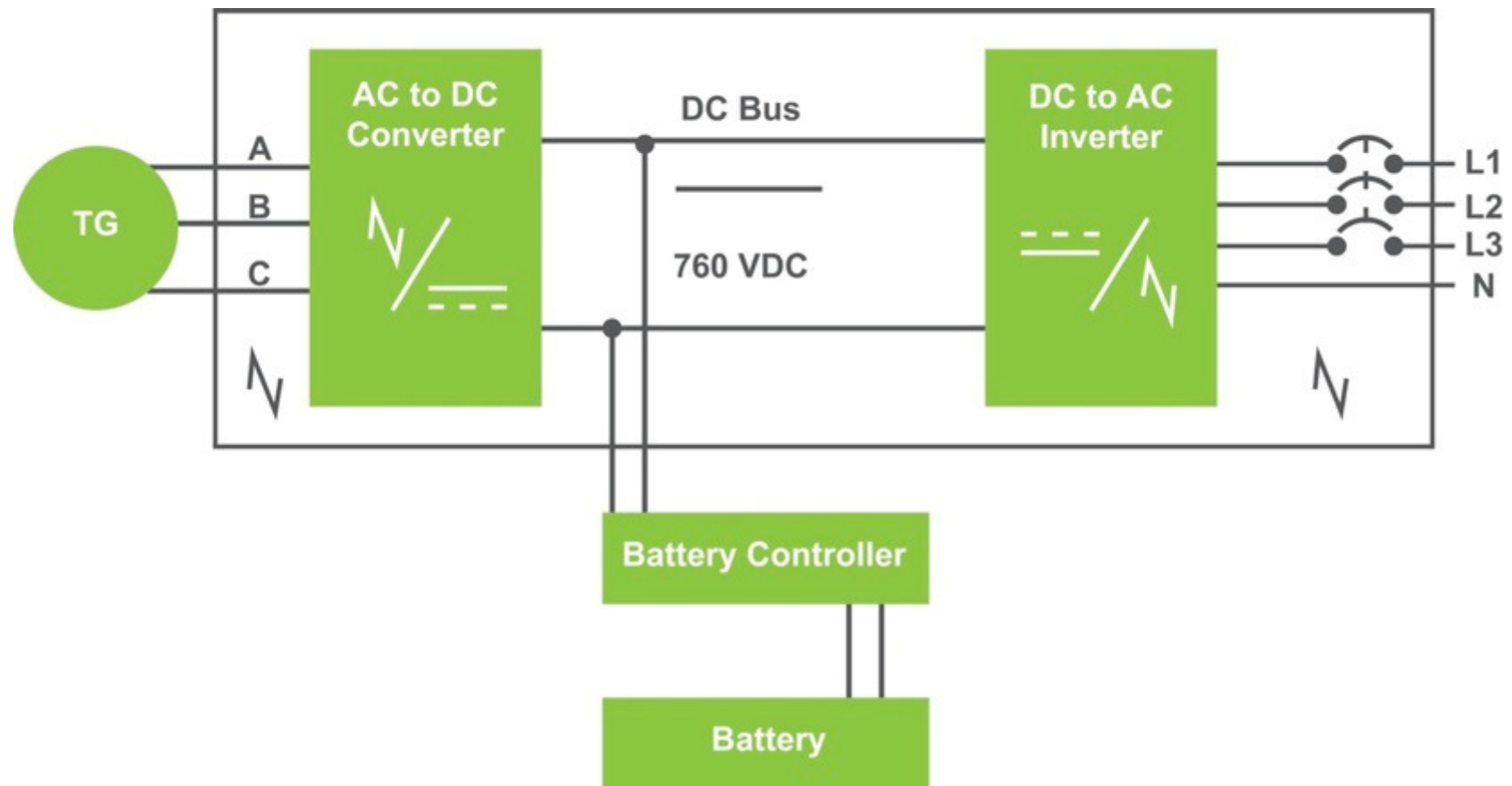


Patented Electronics

- **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



Regulated DC Bus



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_x
 - Less than 9ppm
 - 14 to .16 g/hb-br
 - Endorsed by the SCAQMD
- No additional catalysis requirement



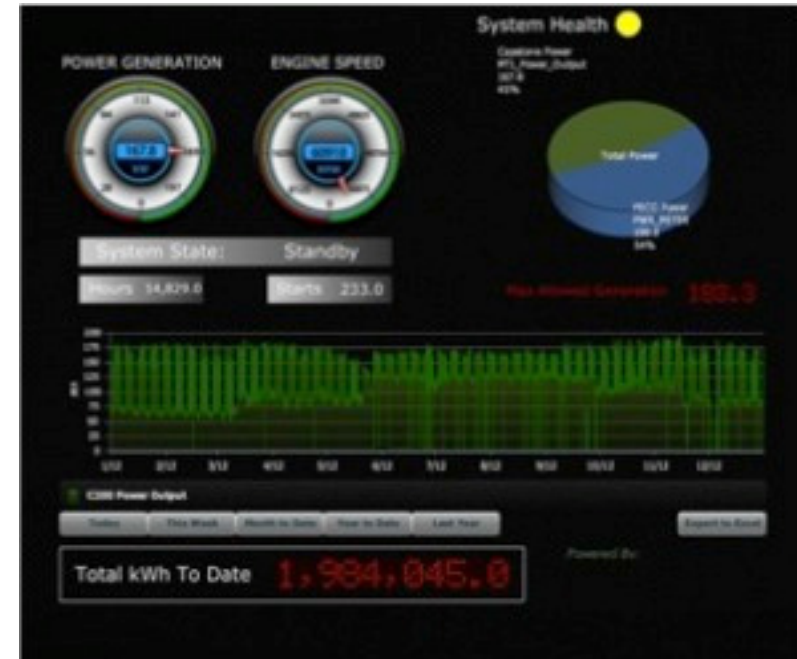
Interconnection Pre-Approved

- 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

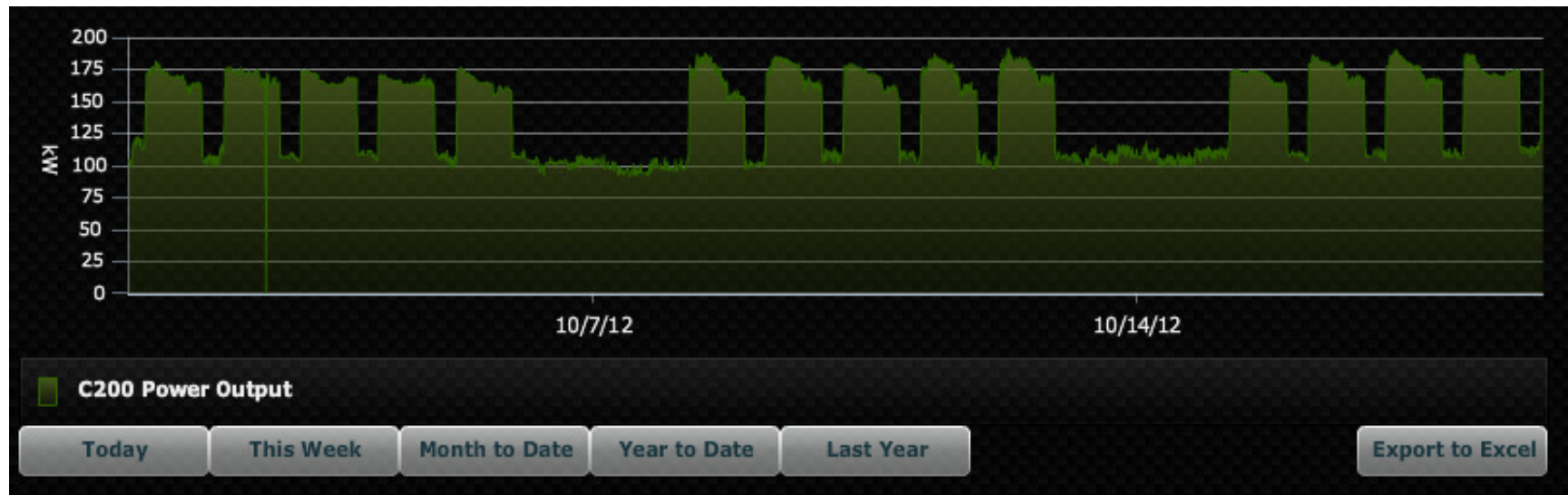


Remote System Diagnostics

- 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

Characteristic	Performance
Output	65kW Net (+0/- 1)
Total System Efficiency LHV	82%
Fuel Flow	842,000 BTU/hr – HHV
Exhaust Temperature	588°F (305°C)
Total Exhaust Energy	541,000 BTU/hr
Emissions	NOx (<9 ppm) @ 15% O ₂
Noise Level	65 dBa at 10 meters
Voltage	400–480 VAC 3 phase, 4-wire wye. 50 or 60 Hz
SA Voltage	150–480 VAC, 50–60 Hz
Weight	758 kg (1671 lbs), 2471 lbs for SA
Size	83”h x 30”w x 77”d
Cooling Potential	20 tons



C200 MicroTurbine

Characteristic	Performance
Output	200kW net
Total System Efficiency LHV	72%
Fuel Flow	2,280,000 BTU/hr – HHV Steady State
Exhaust Temperature	535°F (280°C)
Total Exhaust Energy	1,350,000 BTU/hr
Emissions	NOx (<9 ppm) @ 15% O ₂
Noise Level	65 dBa at 10 meters
Voltage	400–480 VAC 3 phase, 4-wire wye. 50 or 60 Hz
SA Voltage	150–480 VAC, 50–60 Hz
Weight	2270kg (5,000 lbs). 7000 lbs for SA
Size	98”h x 67”w x 144”d
Cooling Potential	60 tons



C600 expandable to C800 & C1000



C600 Power Package



C800 Power Package



C1000 Power Package



Packaged Solution

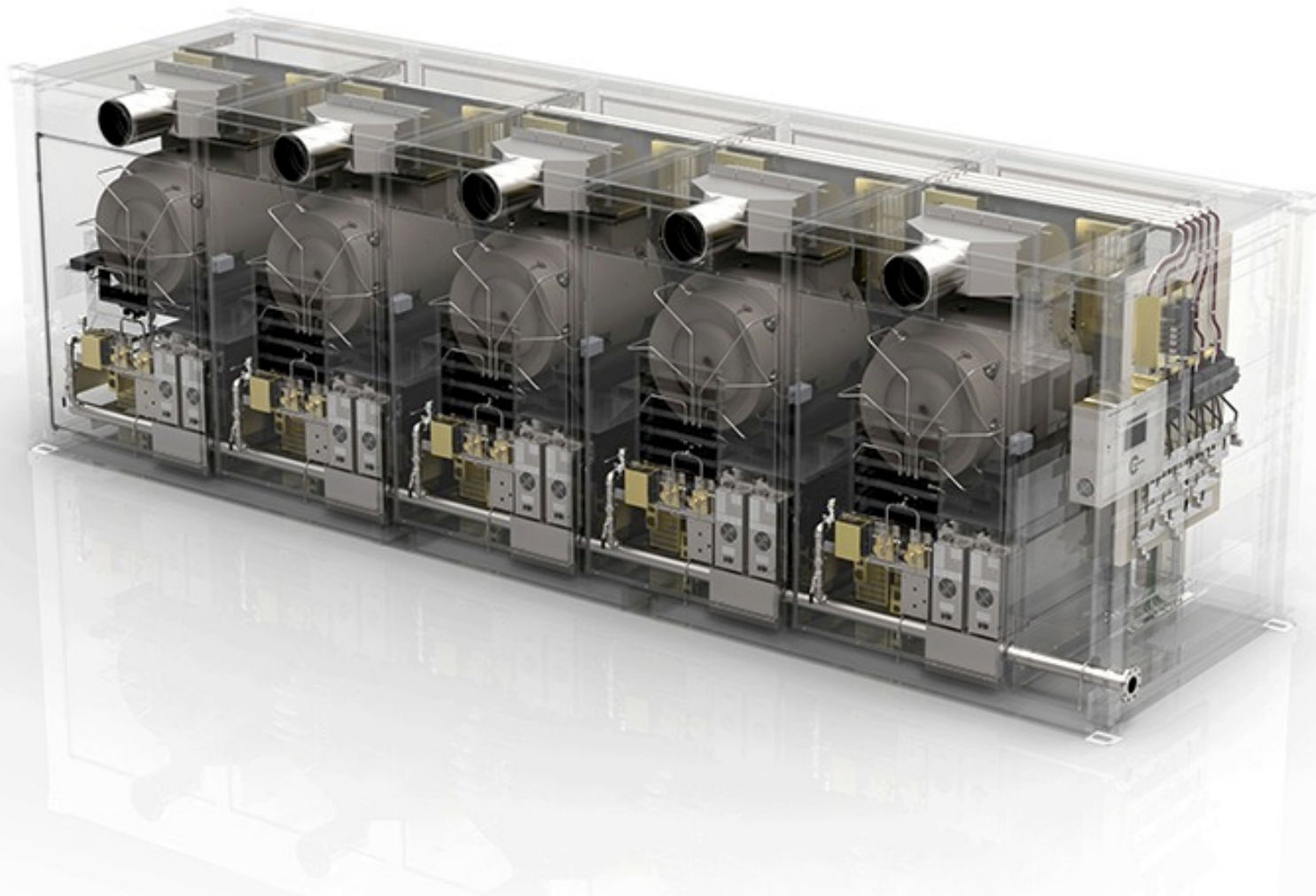
- (3), (4), or (5) C200 Units
- Stackable footprint
- 28' ISO container design
- Load control from 100% to idle
- Flexible maintenance
- Parts redundancy with C200



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



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



Viking Yacht Company,
New Gretna, NJ



Absorption Chillers

- **Thermax hot water-fired**
- **Flue gas fired**
 - 40–600 Tons





CHP Candidates



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 – 2nd 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



Questions & Answers



Gas Gathering & Compression Station, Marshall County, WV
Six Capstone C65 MicroTurbines generate all onsite electrical power



Meter & Relay Site, Proctor, WV
C30 MicroTurbine in a wellhead gas application



Gas Compression Site, WV
Six C65 MicroTurbines provide all onsite electricity & heat for fuel gas conditioning



Water Pumping Facility, Cameron, WV
C800 Power Package providing provides all onsite electricity



Coal Bed Methane Gas Processing Plant, Charleroi, PA
C200 Microturbine in a distributed generation application



Wastewater Treatment Plant, York, PA
Biogas-fueled CR600 in a CHP application & a natural gas-fueled C1000 in a peak shaving dispatch application

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Power to be Independent





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