



# Product Specification

Technical Specifications and Descriptions  
for a Single Capstone<sup>®</sup> MicroTurbine<sup>™</sup> (Enclosed and Recuperated)

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## Summary

This Product Specification describes the Capstone MicroTurbine power generating system (hereafter referred to by Capstone as a MicroTurbine). The MicroTurbine provides on-site electrical power for primary or standby applications, and for peak shaving, base loading, and/or capacity additions. MicroTurbine(s) may generate power in parallel with an electrical utility (Grid Connect mode), or isolated from the utility (Stand Alone mode). The system consists of a turbine engine, solid-state power electronics, a fuel system, and an indoor/outdoor-rated enclosure.

MicroTurbine systems are available in 30, 60, or 65 kW versions, known as C30, C60 or C65 models. The C60 and C65 have an option to include a top-mounted heat exchanger, marketed by Capstone as the Integrated Combined Heat and Power package (ICHP). The ICHP option includes an exhaust heat recovery unit and exhaust diverter to allow full or partial recovery of exhaust energy. This allows the user to realize high total system efficiency with respect to incoming fuel energy, while providing economical operation and operational flexibility.

Major MicroTurbine components include a compressor, a recuperator (exhaust gas heat exchanger), a combustor, a turbine, and a generator. The turbine engine is air-cooled and supported on air-lubricated compliant foil bearings. The compressor impeller, turbine rotor, and generator rotor are mounted on a single shaft, which comprises the only moving part in the engine. Power electronics are solid-state, double conversion type, producing three-phase alternating current output power from the high-frequency alternating current engine output.

## Definitions

- ISO conditions are defined as: 15 °C (59 °F), 60% relative humidity, and sea level pressure of 101.3 kPa (14.696 psia).
- SCFM: Standard Cubic Feet per Minute (standard references ISO temperature and pressure)
- HHV: Higher Heating Value
- LHV: Lower Heating Value
- HPNG: High Pressure Natural Gas
- LPNG: Low Pressure Natural Gas
- kW<sub>th</sub> – Kilowatt (thermal)
- kW<sub>e</sub> – Kilowatt (electric)
- Scf: Standard cubic feet (standard references ISO temperature and pressure)
- SG: Sour Gas
- SLPM: Standard Liters per Minute (standard references ISO temperature and pressure).
- L/DG: Landfill/Digester Gas.

## Performance Ratings at Full Load Power

Table 1 summarizes performance ratings at full load power and ISO conditions.

**Table 1. Performance Ratings**

Product	Net Power Output	Net Efficiency (LHV)	Nominal Net Heat Rate (LHV)	Nominal Generator Heat Rate
<b>Model C30 (HPNG, SG, or L/DG)</b> (without gas compression option)	30 (+0/-1) kW net 3 Phase 400/480 Volts AC 46 A per phase max continuous, 50/60 Hz	26 ( $\pm 2$ )% (Efficiency values might be lower if fuel gas compression is required for L/DG)	13,800 kJ (13,100 Btu /kWh)	12,800 kJ (12,200 Btu/kWh)
<b>Model C30 (LPNG)</b>	28 (+0/-1) kW net 3 Phase 400/480 Volts AC 46 A per phase max continuous, 50/60 Hz	25 ( $\pm 2$ )% (at 5 psig fuel inlet pressure)	14,400 kJ (13,700 Btu /kWh)	12,300 kJ (11,600 Btu/kWh)
<b>Model C30 (Liquid Fuel)</b>	29 (+1/-1) kW net 3 Phase 400/480 Volts AC 46 A per phase max continuous, 50/60 Hz	25 ( $\pm 2$ )%	14,400 kJ (13,700 Btu /kWh)	13,400 kJ (12,700 Btu/kWh)
<b>Model C60 (HPNG)</b> (without gas compression option)	60 (+0/-2) kW net 3 Phase 400/480 Volts AC 100 A per phase max continuous, 50/60 Hz	28 ( $\pm 2$ )%	12,900 kJ (12,200 Btu /kWh)	12,000 kJ (11,400 Btu/kWh)
<b>Model C65 (HPNG)</b> (without gas compression option)	65 (+0/-2) kW net 3 Phase 400/480 Volts AC 100 A per phase max continuous, 50/60 Hz	29 ( $\pm 2$ )%	12,400 kJ (11,800 Btu /kWh)	11,600 kJ (11,000 Btu /kWh)

## Performance Derating

Performance is affected by ambient temperature and elevation. The performance ratings listed are at full load power at ISO conditions. Performance derating occurs at ambient temperatures and elevations above ISO conditions and is also affected by air inlet pressure, back pressure and system parasitic loads (i.e. gas compressor, battery charging).

Typical derating curves for power output and efficiency based on ambient temperature are shown in the curves on the following pages. These curves assume no parasitic losses and zero inlet and exhaust back pressure.

## Electrical Performance Ratings at Full Load Power

Table 2 presents the electrical performance ratings for C30, C60 and C65 MicroTurbines operating in the Grid Connect mode at ISO conditions with zero back pressure.

**Table 2. Electrical Performance Ratings in Grid Connect Mode**

Parameter	Model C30 (HPNG)	Model C60 & ICHP (HPNG)	Model C65 & C65 ICHP (HPNG)
<b>Net Power Output (without gas compression)</b>	30 (+0/-1) kW net 30 kVA max at 480 VAC	60 (+0/-2) kW net 60 kVA max at 480 VAC	65 (+0/-2) kW net 65 kVA max at 480 VAC
<b>Net Electrical Efficiency (LHV)</b>	26 (±2) %	28 (±2) %	29 (±2) %
<b>Nominal Net Heat Rate (LHV)</b>	13,800 kJ (13,100 Btu /kWh)	12,900 kJ (12,200 Btu /kWh)	12,400 kJ (11,800 Btu /kWh)
<b>Nominal Voltage Operating Range</b>	400 to 480 VAC	400 to 480 VAC	400 to 480 VAC
<b>Nominal Frequency Operating Range</b>	50/60 Hz	50/60 Hz	50/60 Hz
<b>Output Voltage Connection</b>	3-phase, 3 or 4 wire wye (The Grid must be neutral grounded)	3-phase, 3 or 4 wire wye (The Grid must be neutral grounded)	3-phase, 3 or 4 wire wye (The Grid must be neutral grounded)
<b>Output Current (maximum)</b>	46 Amps RMS steady state	100 Amps RMS steady state	100 Amps RMS steady state
<b>Current THD</b>	IEEE 519 compliant, 5%	IEEE 519 compliant, 5%	IEEE 519 compliant, 5%

Table 3 presents the electrical performance ratings for a MicroTurbine operating in the Stand Alone mode at ISO conditions.

**Table 3. Electrical Performance Ratings in Stand Alone Mode**

Parameter	Model C30	Model C60	Model C65
<b>Net Power Output</b>	30 (+0/-1) kW net 38.2 kVA max at 480 VAC	60 (+0/-2) kW net 83 kVA max at 480 VAC	65 (+0/-2) kW net 83 kVA max at 480 VAC
<b>Nominal Voltage Operating Range</b>	400 to 480 VAC	400 to 480 VAC	400 to 480 VAC
<b>Frequency Operating Range</b>	10 to 60 Hz	10 to 60 Hz	10 to 60 Hz
<b>Output Voltage Connection</b>	3-phase, 4 wire wye (Neutral must be solidly grounded)	3-phase, 4 wire wye (Neutral must be solidly grounded)	3-phase, 4 wire wye (Neutral must be solidly grounded)
<b>Output Current <sup>(1)</sup></b>	46 Amps RMS maximum steady state	125 Amps RMS maximum steady state	125 Amps RMS maximum steady state
<b>Voltage THD</b>	IEEE 519 Compliant, 5%	IEEE 519 Compliant, 5%	IEEE 519 Compliant, 5%

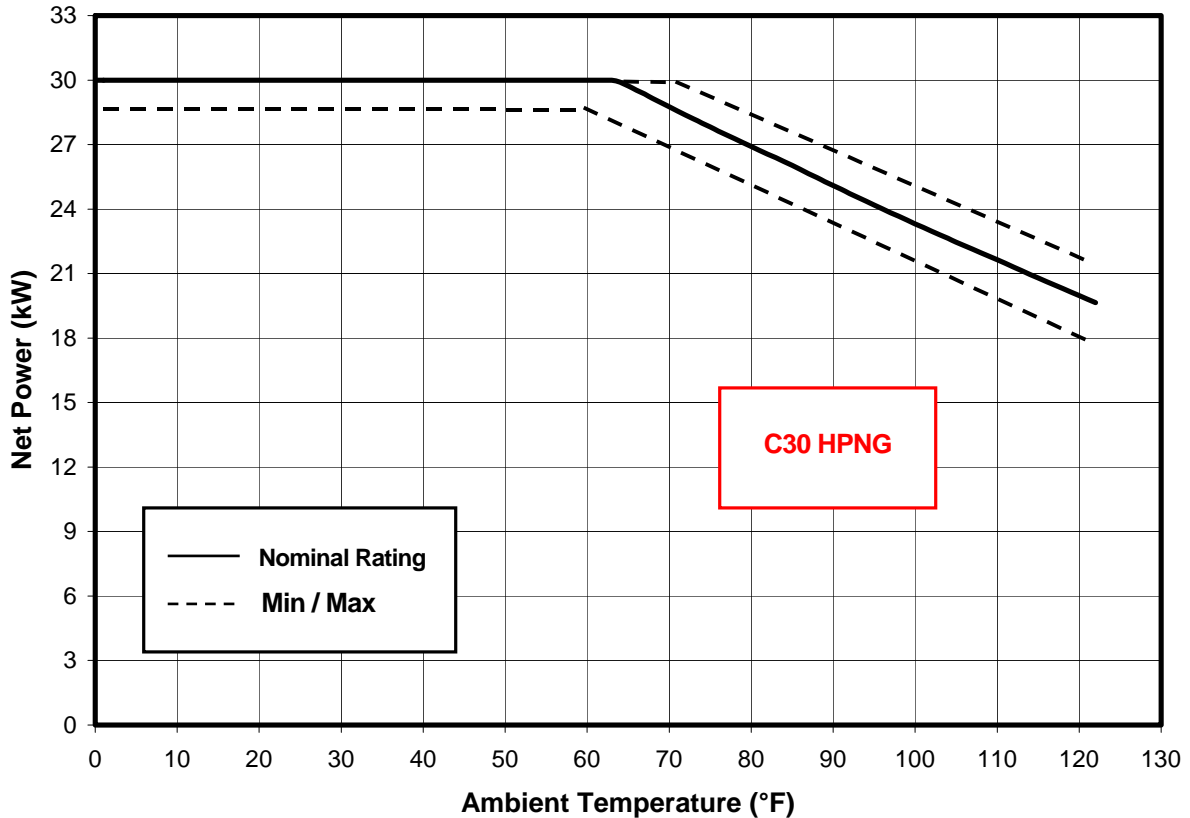
(1) Values assume linear load

## Electrical Performance/Temperature Derating

The electrical performance parameters are listed at full load power and ISO conditions, using natural gas.

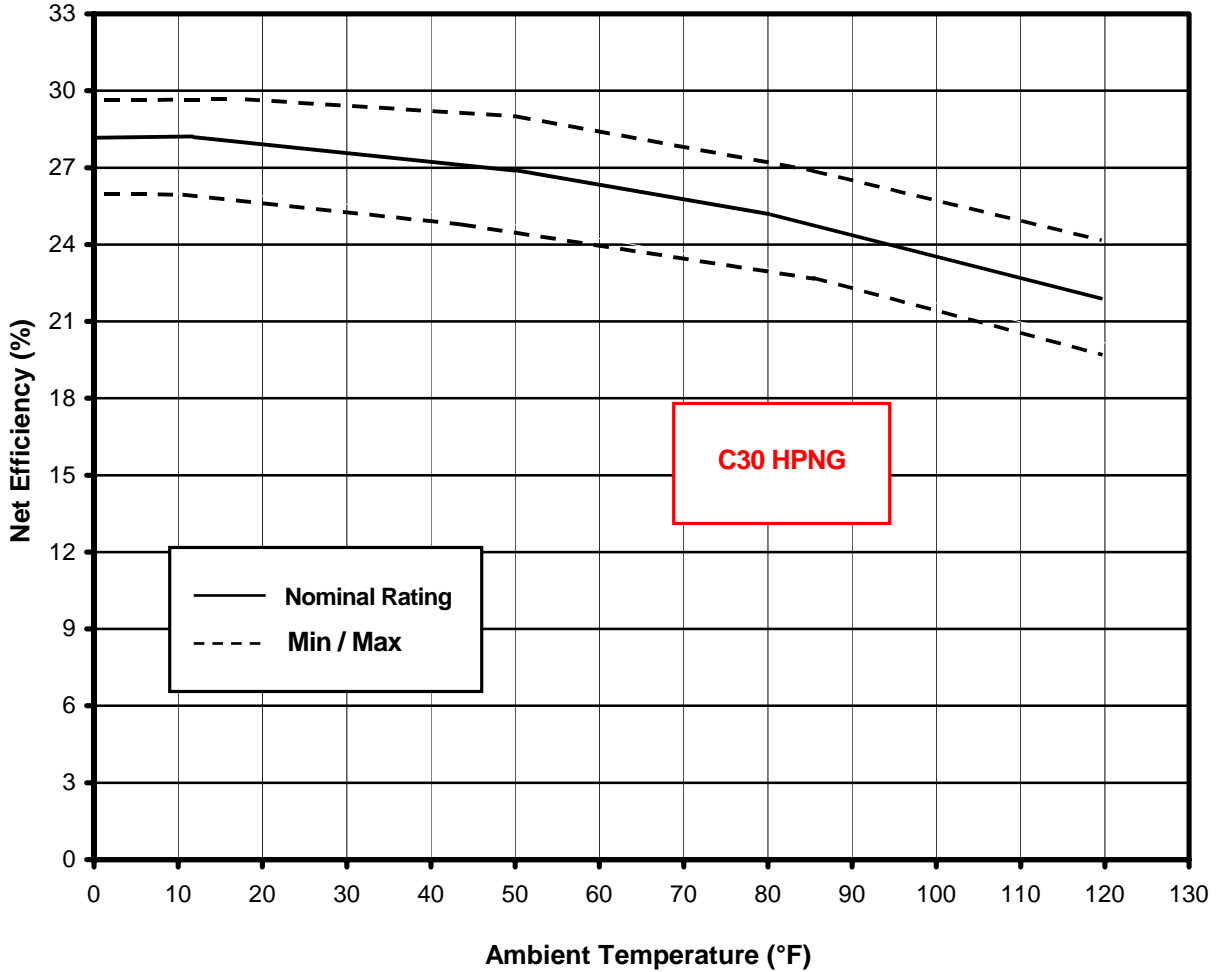
Figure 1 presents the nominal rating and minimum/maximum net power output versus ambient temperature for the Model C30 MicroTurbine (HP Natural Gas, landfill/digester gas, or sour gas only).

Minimum and maximum values refer to factory production test limits.



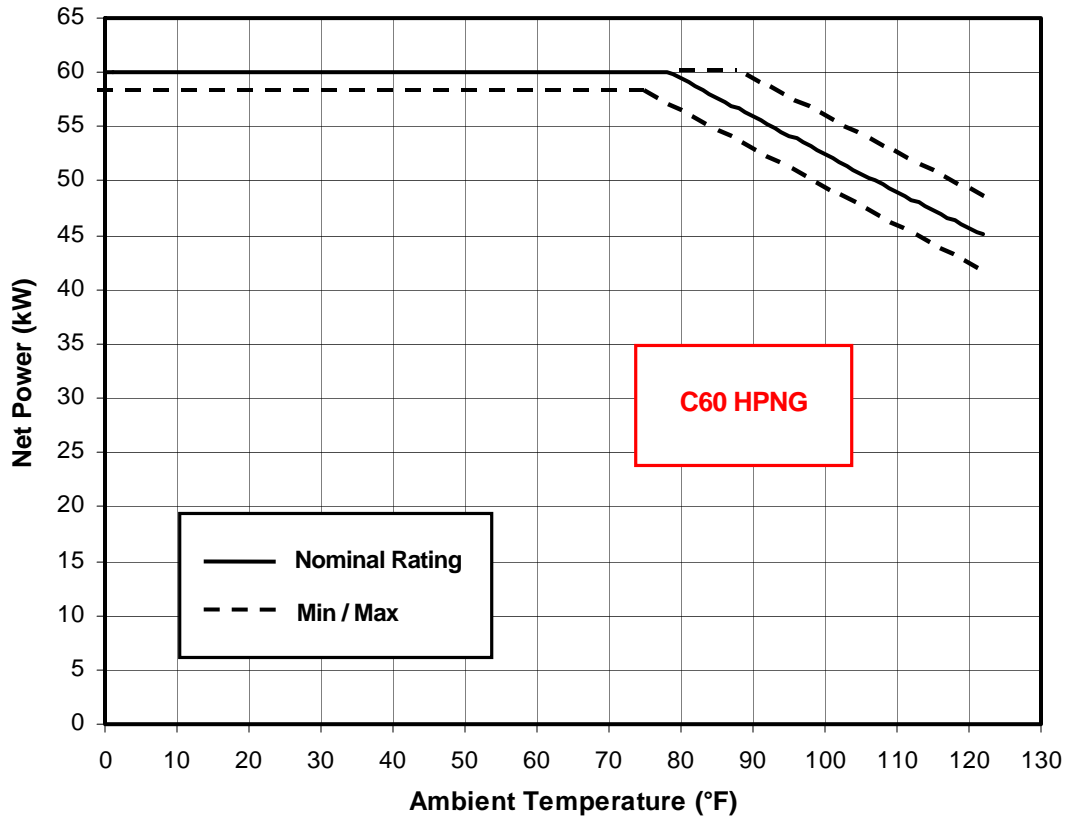
**Figure 1.**  
**Nominal Rating and Min/Max Net Power Output vs. Ambient Temperature at Sea Level with Zero Back Pressure for the Model C30 MicroTurbine, Operating on HPNG, L/DG, or SG Only (without Gas Compression)**

Figure 2 presents the nominal rating and minimum/maximum net efficiency versus ambient temperature for the Model C30 MicroTurbine (HP Natural Gas, landfill/digester gas, or sour gas only).



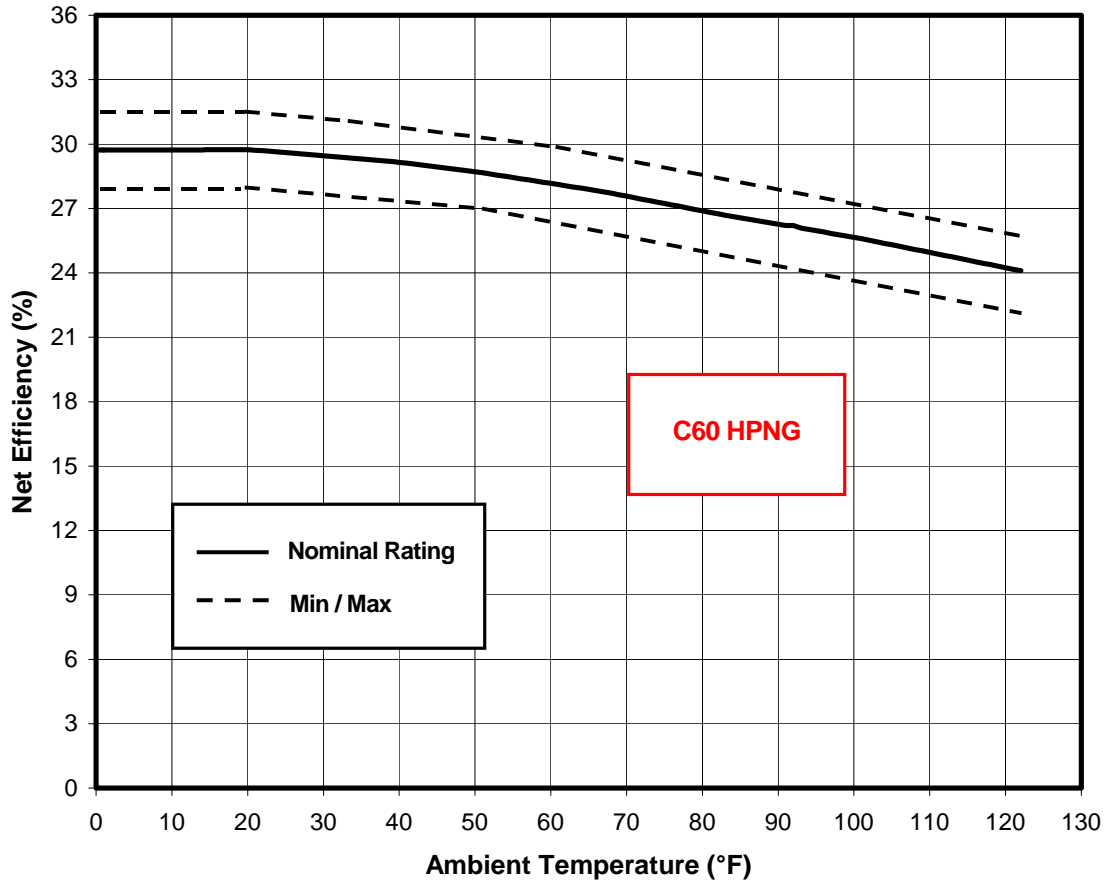
**Figure 2.**  
**Nominal Rating and Min/Max Net Efficiency vs. Ambient Temperature at Sea Level with Zero Back Pressure for the Model C30 MicroTurbine, Operating on HPNG, L/DG, or SG Only (without Gas Compression)**

Figure 3 presents the nominal rating and minimum/maximum net power output versus ambient temperature (at sea level) for the Model C60 MicroTurbine (without gas compression). For the C60 ICHP, this plot assumes heat exchanger is in full bypass mode.



**Figure 3.**  
**Nominal Rating and Min/Max Net Power Output vs. Ambient Temperature at Sea Level with Zero Back Pressure for the Model C60 MicroTurbine (without Gas Compression)**

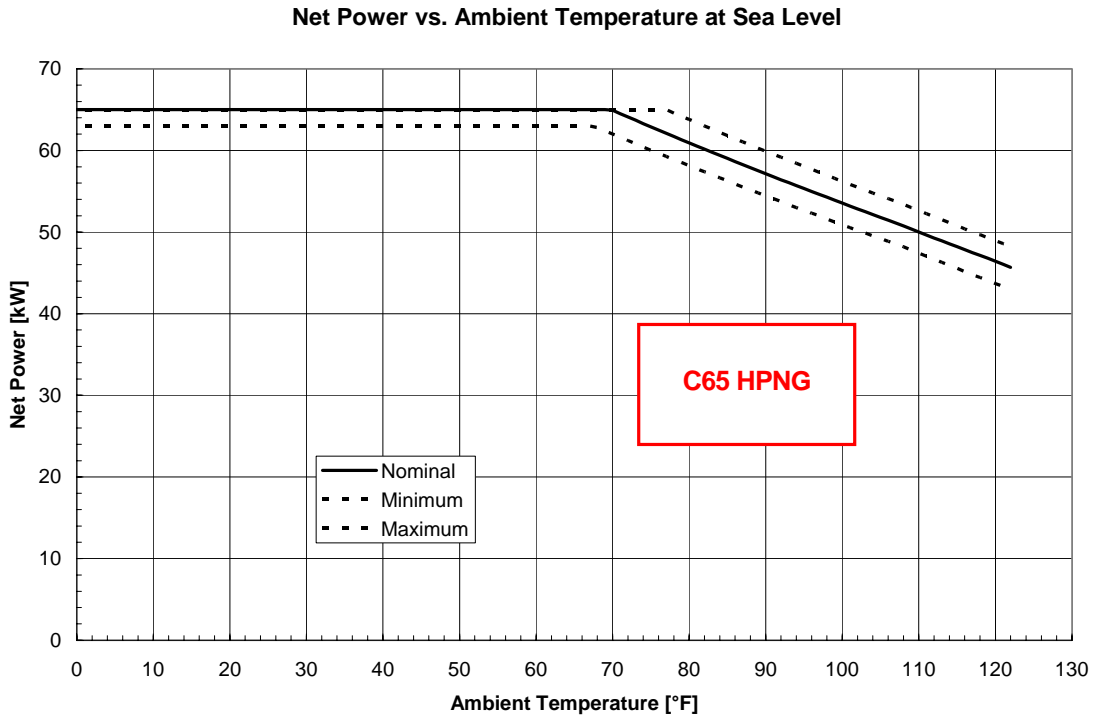
Figure 4 presents the nominal rating and minimum/maximum net efficiency versus ambient temperature (at sea level) for the Model C60 MicroTurbine (without gas compression). For the C60 ICHP, this plot assumes heat exchanger is in full bypass mode.



**Figure 4.**  
**Nominal Rating and Min/Max Net Efficiency vs. Ambient Temperature at Sea Level with Zero Back Pressure for the Model C60 MicroTurbine (without Gas Compression)**

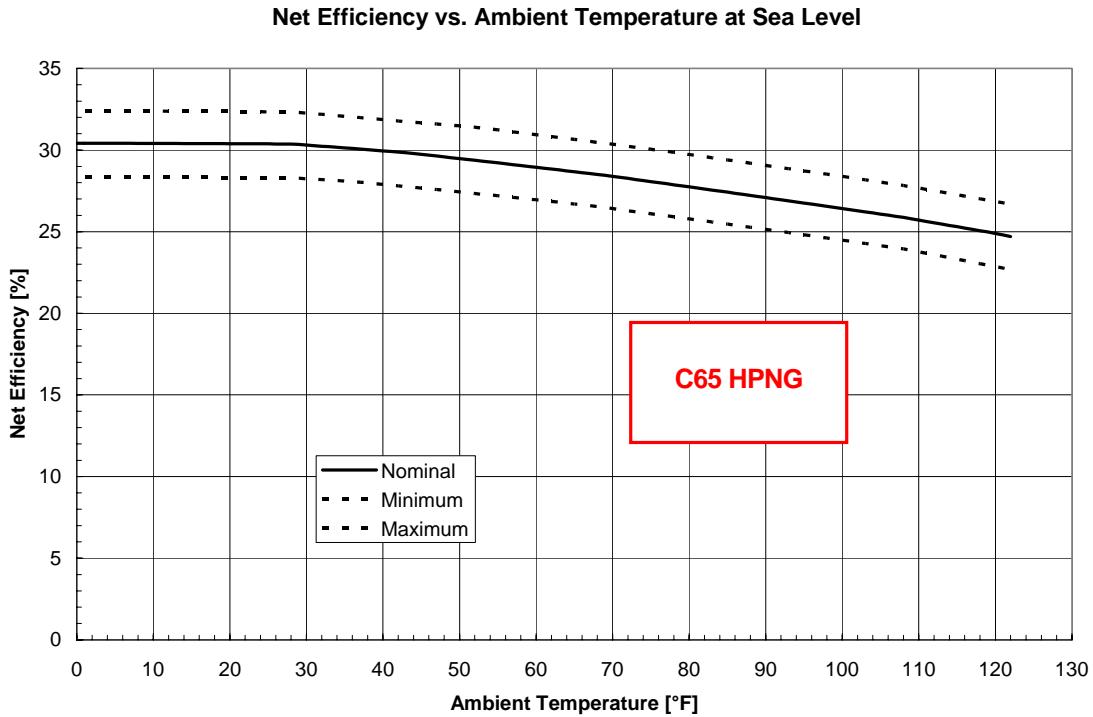


Figure 5 presents the nominal rating and minimum/maximum net power output versus ambient temperature (at sea level) for the Model C65 MicroTurbine (without gas compression). For the C65 ICHP, this plot assumes heat exchanger is in full bypass mode.



**Figure 5.**  
**Nominal Rating and Min/Max Net Power vs. Ambient Temperature at Sea Level with Zero Back Pressure for the Model C65 MicroTurbine (without Gas Compression)**

Figure 6 presents the nominal rating and minimum/maximum net efficiency versus ambient temperature (at sea level) for the Model C65 MicroTurbine (without gas compression). For the C65 ICHP, this plot assumes heat exchanger is in full bypass mode.



**Figure 6.**  
**Nominal Rating and Min/Max Net Efficiency vs. Ambient Temperature at Sea Level with Zero Back Pressure for the Model C65 MicroTurbine (without Gas Compression)**

## Fuel Input Requirements at Full Load Power

Table 4 presents fuel input requirements at full load power and ISO conditions.

**Table 4. Fuel Input Requirements**

Product	Fuel Type	Fuel Heat Content Range (HHV)	Nominal Full Power Steady State Fuel Flow (HHV) (Notes 1 and 2)
Model C30 (HPNG, SG)	NG	30,700 – 47,500 kJ/m <sup>3</sup> (825 to 1275 Btu/scf)	457,000 kJ/hr (433,000 Btu/hr)
	High Btu	46,600 – 79,400 kJ/m <sup>3</sup> (1252 to 2131 Btu/scf)	
Model C30 (LPNG)	NG	30,700 – 47,500 kJ/m <sup>3</sup> (825 to 1275 Btu/scf)	444,000 kJ/hr (420,000 Btu/hr)
Model C30 (L/DG)	Low Btu	12,100 – 32,100 kJ/m <sup>3</sup> (325 to 861 Btu/scf)	457,000 kJ/hr (433,000 Btu/hr)
	Sour Low Btu	12,100 – 32,100 kJ/m <sup>3</sup> (325 to 861 Btu/scf)	
Model C30 (Liquid Fuel)	-	ASTM D975 Diesel Fuel No. 2-D ASTM D3699 Kerosene No. 1-K ASTM D1655 (Jet-A) MIL-DTL-83133E (JP-8) MIL-DTL-5624U (JP-5)	459,000 kJ/hr (435,000 Btu/hr)
Model C60 & C60 ICHP	NG	30,700 – 47,500 kJ/m <sup>3</sup> (825 to 1275 Btu/scf)	849,000 kJ/hr (804,000 Btu/hr)
	LPG	93,700 – 110,000 kJ/m <sup>3</sup> (2516 to 2962 Btu/scf)	
Model C65 & C65 ICHP	NG	30,700 – 47,500 kJ/m <sup>3</sup> (825 to 1275 Btu/scf)	888,000 kJ/hr (842,000 Btu/hr)
	High Btu	46,600 - 67,000 kJ/m <sup>3</sup> (1250 to 1800 Btu/scf)	
	Landfill	12,100 - 22,300 kJ/m <sup>3</sup> (325 to 600 Btu/scf)	
	Digester	20,500 - 32,600 kJ/m <sup>3</sup> (550 to 875 Btu/scf)	
	Propane	91,300 - 95,000 kJ/m <sup>3</sup> (2450 to 2550 Btu/scf)	

Note 1. The ratio of Higher Heating Value (HHV) to Lower Heating Value (LHV) is assumed to be 1.1.

Note 2. Onload fuel flows can be up to two times higher than the steady state values.

## Exhaust Output Ratings at Full Load Power

Table 5 presents exhaust output ratings at full load power and ISO conditions, using natural gas.

**Table 5. Exhaust Output Ratings**

Parameter	Model C30	Model C60	Model C65
<b>Nominal Exhaust Gas Temp</b>	HPNG: 275°C (530°F) Liquid: 275°C (530 °F)	305 °C (580 °F)	309 °C (588 °F)
<b>Nominal Total Exhaust Energy</b>	HPNG: 327,000 kJ/hr (310,000 Btu/hr) Liquid: 327,000 kJ/hr (310,000 Btu/hr)	571,000 kJ/hr (541,000 Btu/hr)	591,000 kJ/hr (561,000 Btu/hr)
<b>NOx Emissions</b>	HPNG: <9 ppm V @ 15% O <sub>2</sub> Liquid: <35 ppm V @ 15% O <sub>2</sub>	<9 ppm V @ 15% O <sub>2</sub>	<9 ppm V @ 15% O <sub>2</sub>
<b>Exhaust Mass Flow</b>	HPNG: 0.31 kg/s (0.69 lbm/s) Liquid: 0.31 kg/s (0.69 lbm/s)	0.48 kg/s (1.06 lbm/s)	0.49 kg/s (1.08 lbm/s)

NOTE: These are the final exhaust temperature and exhaust energy if the heat exchanger is bypassing exhaust heat. Temperature and exhaust energy will be lower while recovering heat.

## Air Flow Requirements at Full Load Power

Table 6 summarizes the nominal air flow requirements of the MicroTurbine systems.

**Table 6. Air Flow Requirements at ISO Conditions with Zero Back Pressure**

Parameter	Model C30 (HPNG)	Model C30 (LPNG)	Model C30 (Liquid Fuel)	Model C60 (HPNG)	Model C65 (HPNG)
<b>Engine Inlet Air Flow</b>	540 scfm (15,291 lpm)	540 scfm (15,291 lpm)	540 scfm (15,291 lpm)	900 scfm (25,500 slpm)	965 scfm (27,300 slpm)
<b>Engine Inlet Air Temp(Note 4)</b>	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)
<b>Electronics Controller Inlet Air Flow</b>	460 scfm (13,025 slpm)	460 scfm (13,025 slpm)	460 scfm (13,025 slpm)	500 scfm (Note 2) (14,500 slpm)	500 scfm (Note 2) (14,500 slpm)
<b>Electronics Controller Inlet Air Temp (Note 1)</b>	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)
<b>Rotary Flow Compressor Inlet Air Flow</b>	Not Applicable	260 scfm (Note 5)	260 scfm (Note 5)	Not Applicable	Not Applicable
<b>Battery and Battery Controller Inlet Air Flow</b>	250 scfm (7,080 slpm)	250 scfm (7,080 slpm)	250 scfm (7,080 slpm)	370 scfm (Note 3) (10,500 slpm)	370 scfm (Note 3) (10,500 slpm)
<b>Battery Inlet Air Temp</b>	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)	-20 to 50 °C (-4 to 122 °F)

Note 1. The Electronics Controller inlet air temperature must be within 2° C (3.6° F) of the Engine inlet air temperature.

Note 2. These values for the Model C60 and C65 Grid Connect version are comprised of 250 scfm for the Load Control Module and 250 scfm for the Engine Control Module.

Note 3. These values for the Model C60 and C65 are comprised of 250 scfm for the Battery Control Module and 120 scfm for the Battery.

Note 4: Minimum operating ambient temperature depends on heat recovery fluid characteristics and the heat recovery system. For water, minimum ambient temperature is 1.7 C (35 °F). The heat recovery system minimum operating ambient temperature is -20 °C (-4 °F).

Note 5. The Rotary Flow Compressor (RFC) cooling air temperature must be within 2° C (3.6° F) of the Engine inlet air temperature, and the RFC Heat Exchanger must be in the air outflow. Additionally, the RFC provides air assist functionality in the Liquid Fuel system only.

## Acoustic Emissions Ratings at Full Load Power

Table 7 presents nominal acoustic emissions ratings, captured at full rated output power at a distance of 10 meters (33 feet).

**Table 7. Acoustic Emissions Ratings**

	<b>Model C60 and C65 (Industrial Package)</b>	<b>Model C30 (Industrial Package)</b>
Acoustic Emissions	70 dBA*	65 dBA

\* Note 65 dBA with inlet silencer option.

## MicroTurbine Dimensions and Weights

Table 8 summarizes dimensions and weights of the MicroTurbine systems.

**Table 8. MicroTurbine Dimensions and Weights**

<b>Parameter</b>	<b>Model C30 (Industrial Package)</b>	<b>Model C60 &amp; C65</b>	<b>Model C60 &amp; C65 ICHP</b>
<b>Height</b>	1943 mm (76.5 inches)	2110 mm (83 inches)	2,390 mm (94 inches)
<b>Width</b>	762 mm (30 inches)	762 mm (30 inches)	762 mm (30 inches)
<b>Depth</b>	1516 mm (59.7 inches)	1956 mm (77 inches)	1956 mm (77 inches)
<b>Weight</b>	405 kg (891lb) (Grid Connect)	758 kg (1671lb) (Grid Connect)	1000 kg (2,200 lb) (Grid Connect)
	578 kg (1271lb) (Dual Mode)	1121 kg (2471 lb) (Dual Mode)	1,364 kg (3,000 lb) (Dual Mode)

## MicroTurbine Temperature Ratings

Table 9 summarizes the temperature ratings of MicroTurbine systems. The C60 and C65, and C60 and C65 ICHP systems maybe stored dry within a temperature range of -40 to 65 °C (-40 to 149 °F). System is not to be stored wet.

**Table 9. MicroTurbine Temperature Ratings**

<b>Parameter</b>	<b>Model C30</b>	<b>Model C60/ C65 (and C60/C65 ICHP)</b>
<b>Operating Temperature</b>	-20 to 50°C (-4 to 122°F)	-20 to 50°C (-4 to 122°F)
<b>Storage Temperature</b>	-40 to 65 °C (-40 to 149 °F)	-40 to 65 °C (-40 to 149 °F)

## Engine Cycling Life

Consult Capstone for specific guidance if application requires more than 10,000 onload operations from idle to full power, or repeated cycling of more than 50% of engine power range within five minute intervals.

## Integral Heat Exchanger

The ICHP heat exchanger, in heat recovery mode, recovers the exhaust energy of the C60 MicroTurbine. Tables 10 thru 12 show the ICHP system heat recovery in full heat recovery mode for water at various inlet water temperatures. The minimum heat recovery is 3 kW<sub>th</sub>(10 MBtu/hr) in full bypass mode.

**Table 10. C60 ICHP with Copper Core Heat Recovery Module**

Water Temperature		Heat Recovery
Inlet	Outlet	
30°C (85°F)	41°C (106°F)	123 kW <sub>th</sub> (420 MBtu/hr)
60°C (140°F)	70°C (159°F)	110 kW <sub>th</sub> (375 MBtu/hr)
85°C (185°F)	94°C (201°F)	98 kW <sub>th</sub> (335 MBtu/hr)

**Table 11. C65 ICHP with Copper Core Heat Recovery Module**

Water Temperature		Heat Recovery
Inlet	Outlet	
30°C (85°F)	41°C (106°F)	126 kW <sub>th</sub> (430 MBtu/hr)
60°C (140°F)	70°C (159°F)	112 kW <sub>th</sub> (380 MBtu/hr)
85°C (185°F)	94°C (202°F)	100 kW <sub>th</sub> (345 MBtu/hr)

**Table 12. C65 ICHP with Stainless Steel Heat Recovery Module**

Water Temperature		Heat Recovery
Inlet	Outlet	
30°C (85°F)	37°C (98°F)	78 kW <sub>th</sub> (265 MBtu/hr)
60°C (140°F)	67°C (152°F)	70 kW <sub>th</sub> (240 MBtu/hr)
85°C (185°F)	91°C (196°F)	63 kW <sub>th</sub> (215 MBtu/hr)

Conditions:

- ±10% performance range
- 2.5 l/s (40 gal/min) water flow
- Full power output @ 60 kW<sub>e</sub> or 65 kW<sub>e</sub>
- ISO Conditions

## Certification Information

Please contact Capstone for the latest certification information.

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