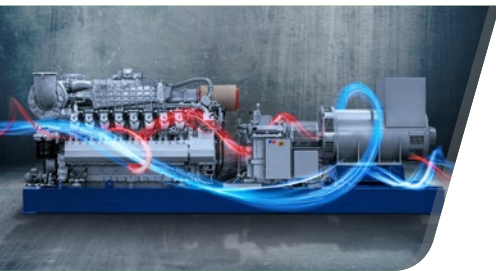


# COGENERATION OPPORTUNITIES AND ON-SITE SPECIFYING FACTORS



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Cogeneration technologies are poised to play an increasingly important role in the energy mix of the future by substantially increasing energy efficiency and independence, while reducing fuel consumption and the emission of greenhouse gasses and other harmful pollutants.

## WHY COGENERATION?

Cogeneration technology, including combined heat and power (CHP) systems and district heating and cooling (DHC) systems, offers many economic and environmental benefits compared to conventional methods of energy production. By simultaneously producing thermal and electric energy from a single fuel source, such as natural gas or biogas, the systems require less total fuel to produce the same amount of energy—and generate enormous cost-savings potential.

Because less total fuel is consumed, greenhouse gas emissions and other harmful air pollutants are also reduced. In fact, CHP technologies are estimated to reduce carbon dioxide (CO<sub>2</sub>) emissions arising from new power generation by more than 10 percent by the year 2030. Cogeneration of energy on-site can also support corporate environmental goals for sustainability and use of renewable resources, while simultaneously reducing the dependence on other regions or countries for imported energy. By increasing energy efficiency and helping to offset costs, cogeneration can give businesses a competitive edge.

## HEAT SOURCES PROVIDE OPPORTUNITIES

Cogeneration systems achieve more than 90 percent energy efficiency by extracting and using thermal energy produced during the generation of electricity—heat that would otherwise be wasted. Systems based on gas-fueled reciprocating engines include several potential heat sources, and the ideal use depends on aligning the heat requirements of the facility with the available heat sources on the system.

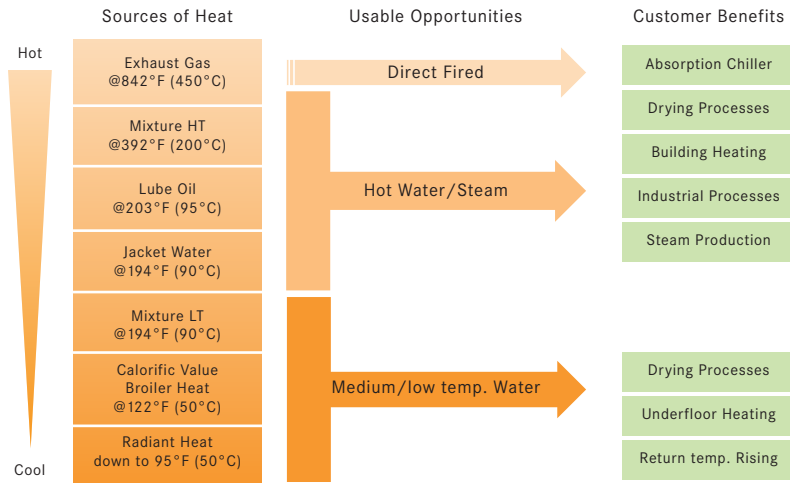
Exhaust gas, for example, reaches temperatures exceeding 450° C—hot enough to support an absorption chiller, which in turn creates cooling energy. Sources such as the lube oil, jacket water or high temperature air/fuel mixture, on the other hand, reach temperatures closer to 90-200° C, which makes them ideal for industrial processes, drying processes, building heat and steam production. Other heat sources below 90° C include the low temperature air/fuel mixture, calorific value boiler and radiator, which are ideal for drying processes, underfloor heating and return temperature heat.

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*To ensure optimal performance and efficiency, a number of factors must be considered when specifying a cogeneration system.*

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## BENEFITS OF COGENERATION



= up to 96% overall Efficiency

When using all the available heat sources, a cogeneration system from MTU Onsite Energy can achieve overall efficiencies of up to 96 percent—a best in class rating and a major improvement compared to conventional methods of energy production.

### SITE-SPECIFIC FACTORS

To ensure optimal performance and efficiency, a number of factors must be considered before installing a cogeneration system.

#### Methane Number

Most gasses are a mix of methane, hydrogen and other gas constituents. The methane number (MN) provides an indication of the gasses tendency to knock—or combust prematurely—which can damage the engine. For example, pure hydrogen would have an MN of 0. A low MN signifies an extremely

explosive gas with the potential to ignite before the spark plug fires, resulting in uncontrolled combustion. Pure methane (CH<sub>4</sub>), on the other hand, would have an MN of 100. Gasses with a high MN are less explosive, and therefore less likely to ignite before the spark plug fires, resulting in a more controlled combustion.

Natural gas has an MN of 80-90, making it ideal for controlled combustion. Gas composites (such as biogas) have an MN between 120-130. Understanding the knock resistance is important when specifying an engine for a gas-powered cogeneration plant.

#### Elevation

Smart marathon runners train for the race conditions they're going to run—especially if higher elevations are involved—otherwise they'll never be able to catch their breath. Similarly, the altitude of an installation site can significantly

## METHANE NUMBERS

Gas	Methane Number
100% CH <sub>4</sub> (Methane)	100
100% H <sub>2</sub> (Hydrogen)	0
90% CH <sub>4</sub> and 10% H <sub>2</sub>	90
Natural gas	80-90
Biogas	120-130

influence the power output of a cogeneration system. As elevation increases, air density decreases, and engines need air to breathe.

When specifying a gas-powered cogeneration system for a high altitude installation, proper preparation and planning are essential to avoid operating below the engine's maximum power rating. For instance, a gas-powered MTU Onsite Energy Series 4000 cogeneration system can operate at full load in altitudes up to 6,700 feet without any derating simply by adjusting its turbocharger nozzle ring, which essentially enables the engine to take deeper breaths.

## ALTITUDE EXHAUST TURBO CHARGER ADJUSTMENT

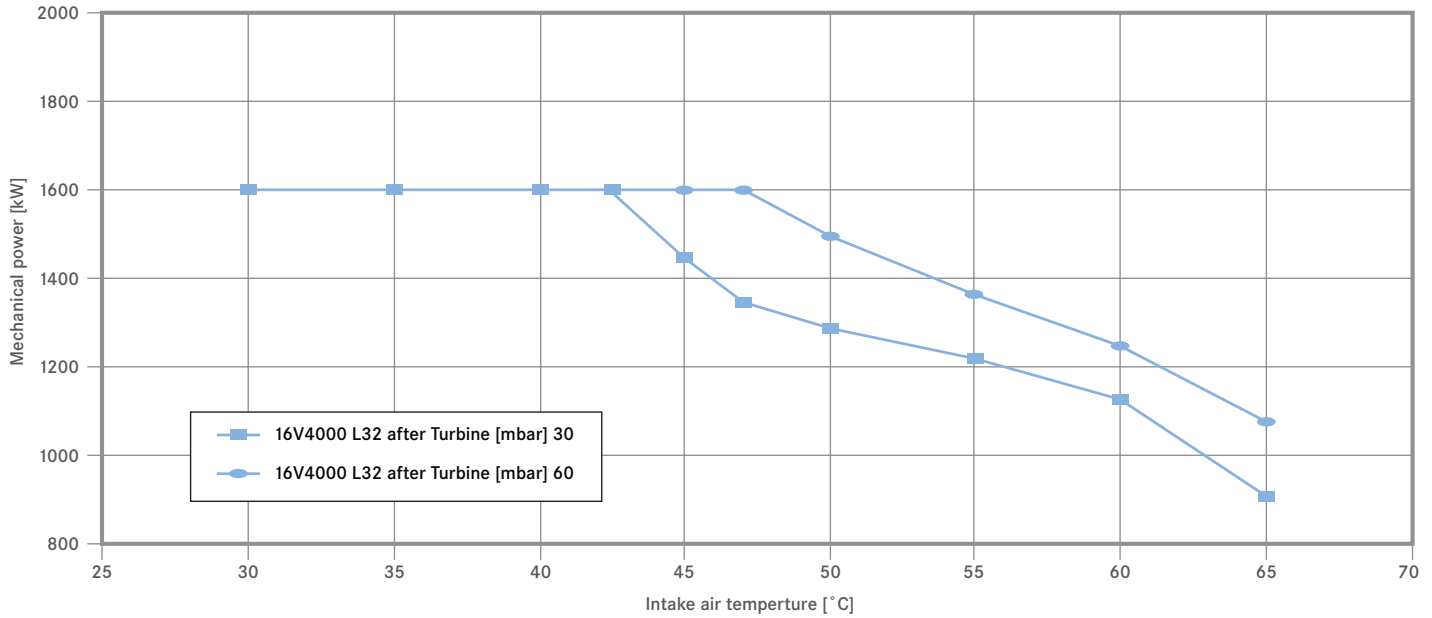
Part Number	TA65	X00065539/X00065540
	TA60	X00065539/X00065540
Limit Value	Intake Air	35°C 45°C
	max. Number of Rotation	850 Hz 827 Hz
Legend	<span style="background-color: #90EE90; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Standard Specification	
	<span style="background-color: #ADD8E6; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Altitude Specification	
	<span style="background-color: #D3D3D3; border: 1px solid black; display: inline-block; width: 15px; height: 10px;"></span> Altitude Specification to reduce the Output	

h <sub>0</sub> [m] p <sub>0</sub> [mbar]	tve [°C] 25	tve [°C] 30	tve [°C] 35	tve [°C] 40	tve [°C] 45	tve [°C] 50
100 1000	2000	TA65	2000	TA65	2000	TA65
300 978	2000	TA65	2000	TA65	2000	TA65
500 956	2000	TA65	2000	TA65	2000	TA65
750 927	2000	TA65	2000	TA65	2000	TA60
1000 899	2000	TA65	2000	TA65	2000	TA60
1250 872	2000	TA65	2000	TA65	2000	TA60+nSensor
1500 846	2000	TA65	2000	TA65	2000	TA60+nSensor
1750 820	2000	TA65	2000	TA60	2000	TA60+nSensor
2000 795	2000	TA65	2000	TA60	2000	TA60+nSensor

## AMBIENT TEMPERATURE POWER DERATING CURVE

### Power Derating Curve for 16V4000L32

Emission Level NOx 500mg/Nm3 @ 5% O2  
 Operation Island mode  
 Note Variation intake air temperature (NT Temp + 53° C)



## EFFECTS OF HUMIDITY AND DEW POINT

	$\epsilon$	$P_{cyl}$	MN	T mix	T intake	Drivers
L33 100kW/zyl	12,8	100 kWm	>70	104	68-86	$\eta_{th}$
L33 110kW/zyl	12,8	110 kWm	>80	104	68-86	$\eta_{ges}$
L32	12,1	100 kWm	>80	127	86-104	Tropic
L32 & red	10,5	max. 100 kWm	<70	127	86-104	Low MN
L32 FB	13,9	100 kWm	>120	104-127	86-104	Biogas

L32 & red.: Special gases with low methane numbers, rough conditions  
 L32: Designed for high ambient temperatures and high humidity  
 L33: High  $\eta_{ges}$ . (kWe+kWth) @ ISO Conditions  
 L32FB: Special version for biogas (sewage gas/landfill gas)

### Temperature

Like elevation, the ambient temperature of an installation site can significantly impact power output. This is because air volume increases as temperature rises. In warmer climates, if the ambient temperatures exceed a certain point, it can become difficult to provide the necessary volume of intake air for the engine to perform optimally, resulting in lower power output. Cogeneration system manufacturers frequently offer different equipment models to account for these variations. And in some cases, the equipment will be installed in a temperature controlled (air conditioned) room to help offset the impact of excessive ambient temperatures.

### Humidity

Air humidity and dew point must also be carefully considered when specifying a cogeneration system. Dew point is the saturation temperature for water and air—the point at which water droplets begin to condense and form. This measure of moisture varies according to atmospheric pressure and humidity. To ensure maximum power output, specifications must include an analysis of humidity and its related dew point temperature based on the climate of the installation site, along with other factors such as methane number and type of gas. Similar to temperature, cogeneration system manufacturers frequently offer different equipment models to account for these variations.

## CONCLUSION

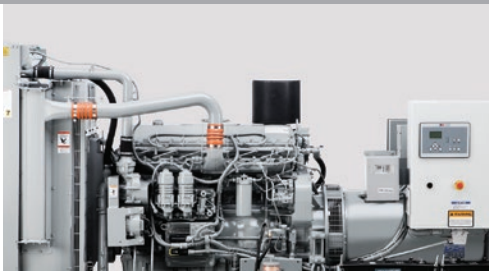
The need for highly efficient electricity, heating and cooling is universal. Cogeneration is a powerful solution that can generate cost savings and environmental benefits just about anywhere in the world. A wide number of applications utilize cogeneration systems, including office buildings, condos, shopping centers, schools, community pools and dairy farms. The key to a successful cogeneration project is proper specification and planning, which should take into account climate- and site-specific factors such as methane number, elevation, temperature and humidity, in addition to thermal and electric requirements. While determining if a facility is an ideal candidate for CHP is an extensive process, exploring the option is a smart move for any facility with simultaneous needs for heat, cooling and electricity. The potential gains of CHP are too great to be ignored.



### MTU Onsite Energy Corporation

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*MTU Onsite Energy is a brand of Rolls-Royce Power Systems. It provides diesel and gas-based power system solutions: from mission-critical to standby power to continuous power, heating and cooling. MTU Onsite Energy power systems are based on diesel engines with up to 3,250 kilowatts (kWe) power output and gas engines up to 2,530 kW.*

