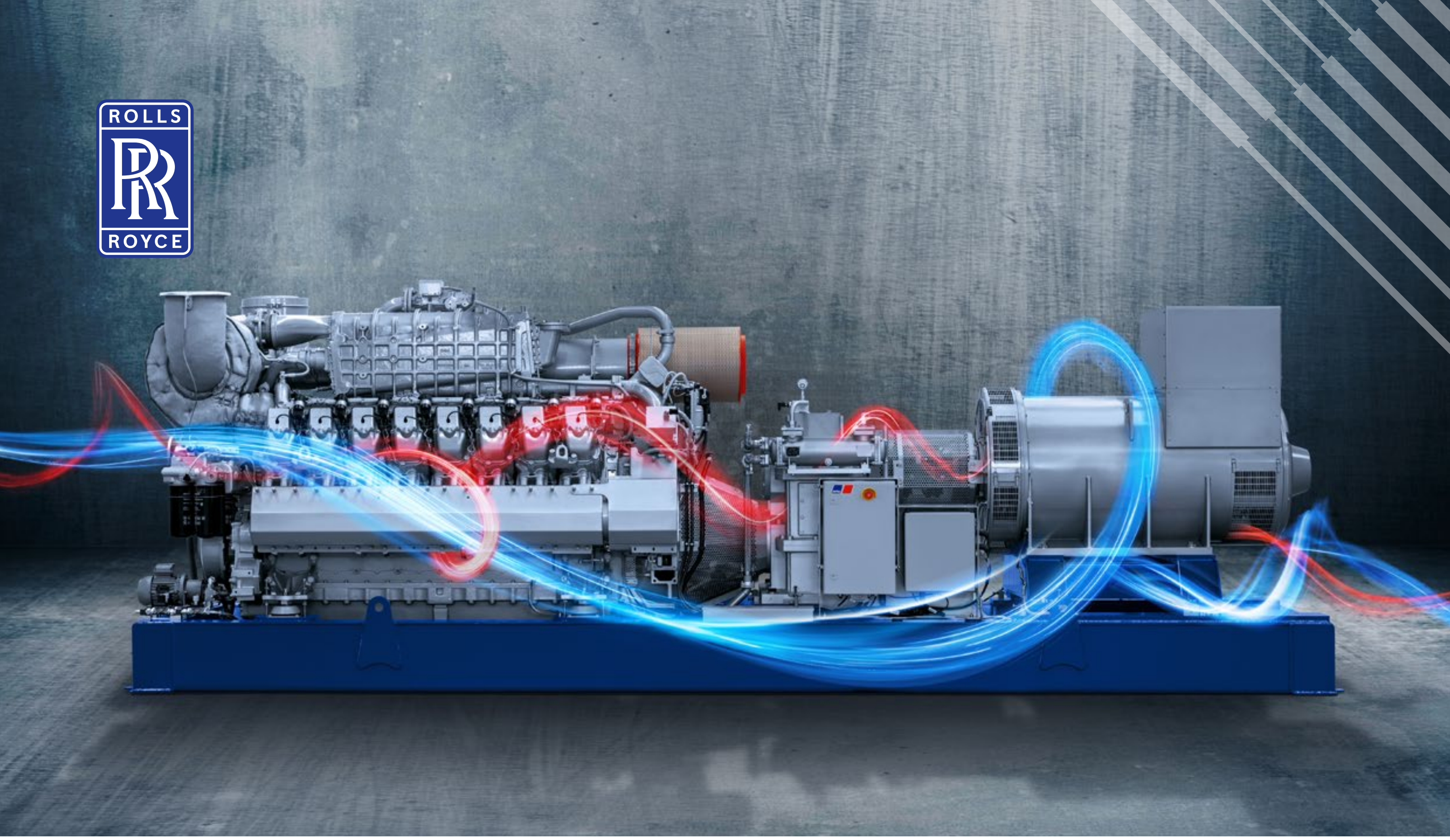

Power Generation

COGENERATION OPPORTUNITIES AND ON-SITE SPECIFYING FACTORS

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.

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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_2) emissions arising from new power generation by more than 10 percent by the year 2030.

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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.

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

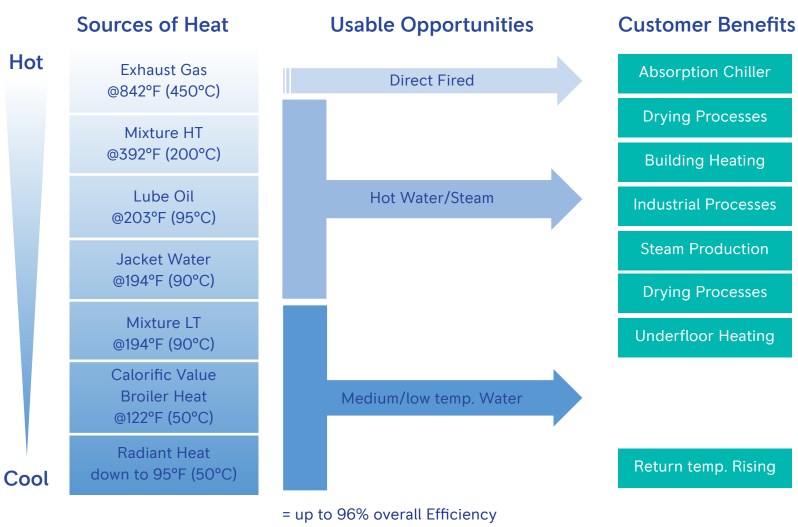
Heat sources provide opportunities

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.

When using all the available heat sources, an MTU cogeneration system 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.

Benefits of cogeneration



Methane numbers

Gas	Methane Number
100% CH4 (Methane)	100
100% H2 (Hydrogen)	0
90% CH4 and 10% H2	90
Natural gas	80–90
Biogas	120–130

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 (CH4), 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.

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	
(turquoise)	Standard Specification
(blue)	Altitude Specification
(purple)	Altitude Specification to reduce the Output

h_0 [m] p_0 [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	2000	TA65	2000	TA60	2000	TA60
300 978	2000	TA65	2000	TA65	2000	TA65	2000	TA65	2000	TA60	2000	TA60
500 956	2000	TA65	2000	TA65	2000	TA65	2000	TA65	2000	TA60	2000	TA60
750 927	2000	TA65	2000	TA65	2000	TA65	2000	TA60	2000	TA60	2000	TA60+ nSensor
1000 899	2000	TA65	2000	TA65	2000	TA65	2000	TA60	2000	TA60+ nSensor	2000	TA60+ nSensor
1250 872	2000	TA65	2000	TA65	2000	TA65	2000	TA60+ nSensor	2000	TA60+ nSensor	2000	TA60+ nSensor
1500 846	2000	TA65	2000	TA65	2000	TA60+ nSensor	2000	TA60+ nSensor	2000	TA60+ nSensor	2000	TA60+ nSensor
1750 820	2000	TA65	2000	TA60	2000	TA60+ nSensor	2000	TA60+ nSensor	1940	TA60+ nSensor		
2000 795	2000	TA65	2000	TA60	2000	TA60+ nSensor	2000	TA60+ nSensor	1880	TA60+ nSensor		

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

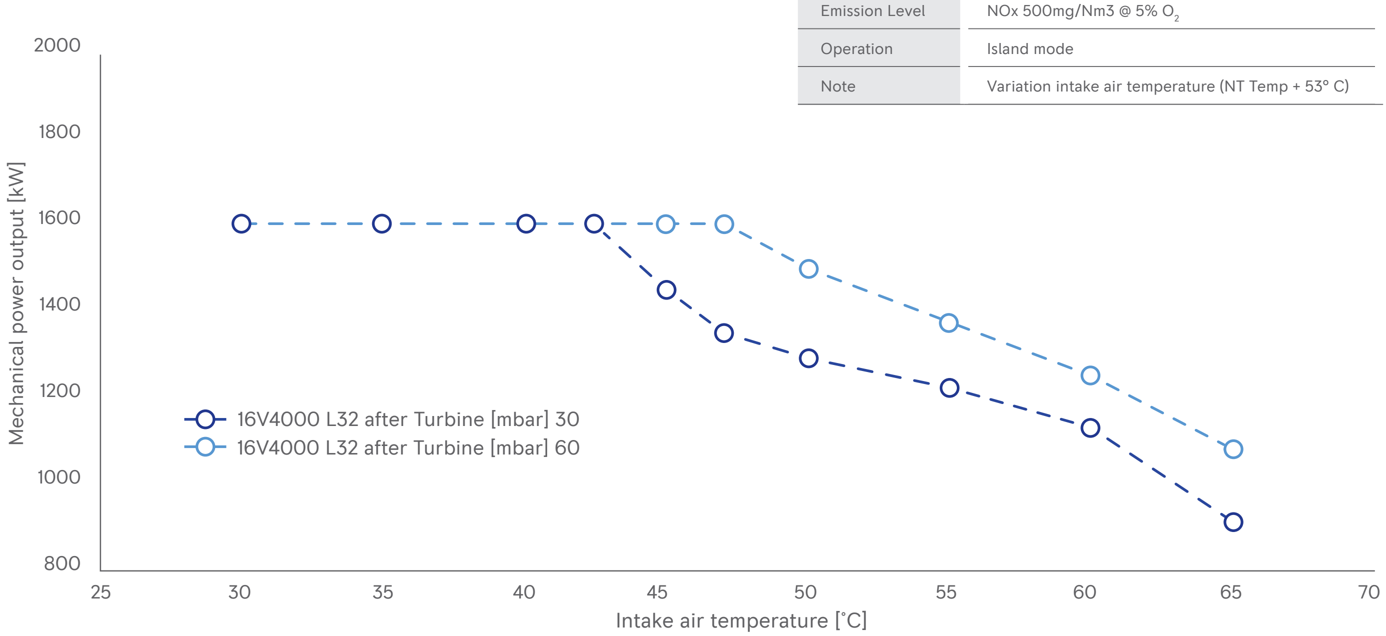
When specifying a gas-powered cogeneration system for a high altitude installation, proper preparation and planning are essential to avoid operating below the engine's maximum power rating. For instance, a gas-powered MTU Series 4000 cogeneration system can operate at full load in altitudes up to 6,700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

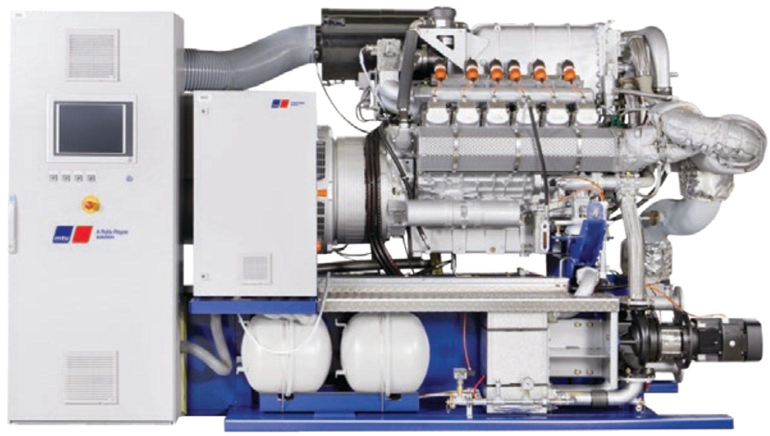
Temperature

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.

Ambient temperature power derating curve

Power Derating Curve for 16V4000L32	
Emission Level	NOx 500mg/Nm3 @ 5% O_2
Operation	Island mode
Note	Variation intake air temperature (NT Temp + 53° C)





Effects of humidity and dew point

Part Number	ε	$P_{cyl.}$	MN	T mix	T intake	Drivers
L33 100kW/zyl	12,8	100 kWm	>70	104	68-86	η th
L33 110kW/zyl	12,8	110 kWm	>80	104	68-86	η 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 ηges. (kWe+kWth) @ ISO Conditions
L32FB: Special version for biogas (sewage gas/landfill gas)

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.

Rolls-Royce provides world-class power solutions and complete lifecycle support under our product and solution brand MTU. Through digitalization and electrification, we strive to develop drive and power generation solutions that are even cleaner and smarter and thus provide answers to the challenges posed by the rapidly growing societal demands for energy and mobility. We deliver and service comprehensive, powerful and reliable systems, based on both gas and diesel engines, as well as electrified hybrid systems. These clean and technologically advanced solutions serve our customers in the marine and infrastructure sectors worldwide.

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