

COMBINED HEAT AND POWER FROM BIOGAS



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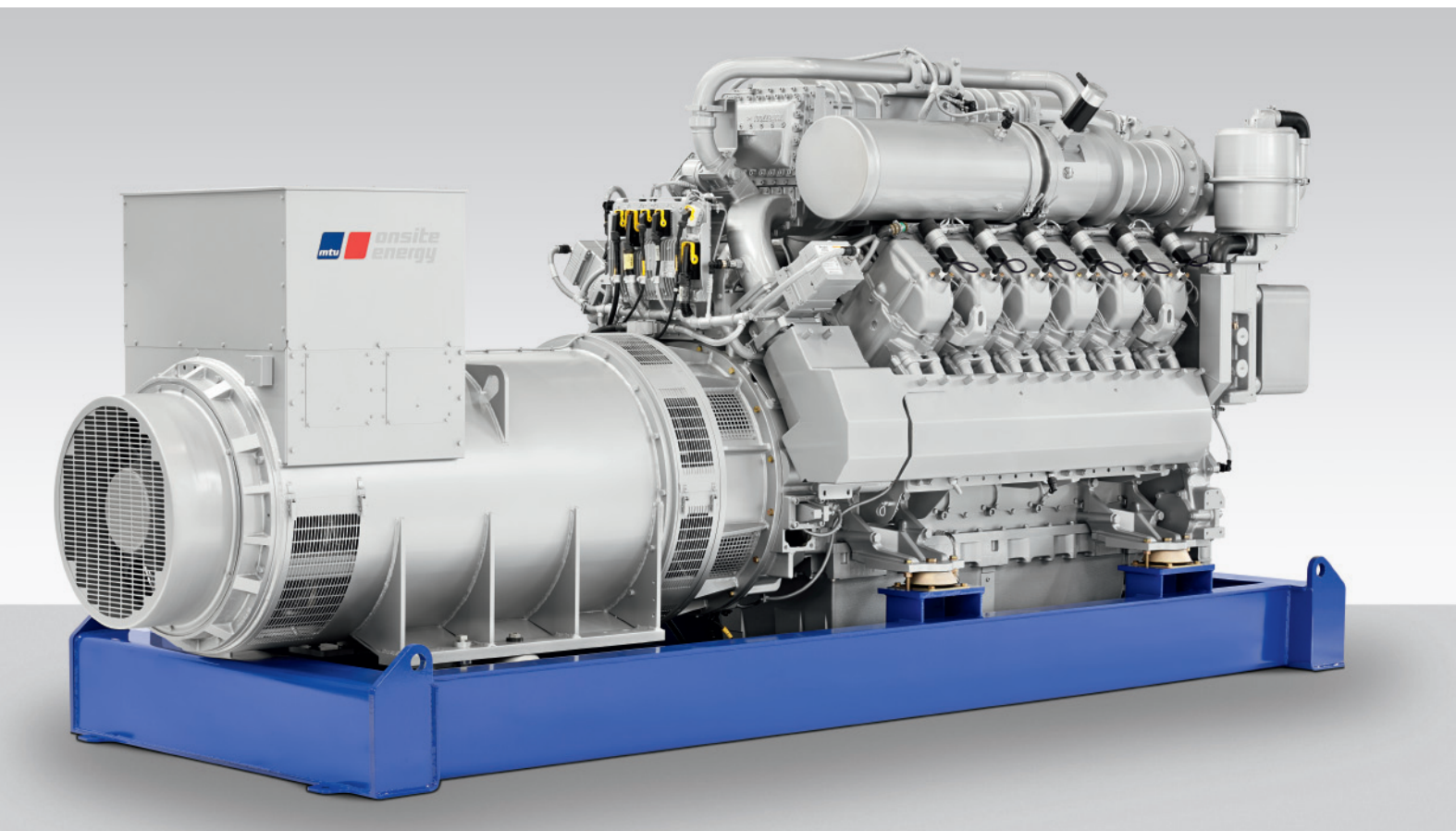
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COMBINING OUR RESOURCES TO SUPPLY YOU WITH DEPENDABLE ENERGY: ANYTIME. ANYWHERE.

MTU Onsite Energy is one of the core brands of Rolls-Royce Power Systems AG, which is a world-leading provider of high- and medium-speed diesel and gas engines, complete drive systems, distributed energy systems and fuel injection systems for the most demanding requirements.

MTU Onsite Energy offers complete power system solutions: from mission critical to standby power to continuous power, heating and cooling. We also provide a full line of service products to help you get the most from your equipment.

Customers around the world trust us to provide reliable power for a wide range of applications, such as healthcare, data centers, airports, farms and independent power stations. Our product portfolio covers diesel generator sets up to 3,250 kW, gas-powered cogeneration systems up to 2,500 kW and gas turbines up to 50,000 kW. This product offering is complemented by medium-speed engines for land-based energy solutions up to 9,300 kW as part of the Rolls-Royce Power Systems AG product portfolio.

More than 60 years of power generation systems expertise and over a century of diesel engine engineering experience have enabled us to provide complete solutions all over the globe. And we continue to develop sustainable alternatives, with systems that produce greener energy from climate-neutral, regenerative fuels, such as combined heat and power (CHP) plants fueled by biogas, landfill gas or sewage gas.

MTU Onsite Energy gas engine systems

We have three types of systems:

- // Gas generator sets: for power generation
- // Combined heat and power modules (CHP), also called block heat and power plants: for the generation of power and heat
- // Combined heat, power and cooling energy modules (CHPC): for the generation of power, heat and cooling energy (in combination with appropriate cooling units)

Since these systems convert the primary energy carrier gas into power, power and energy, or power, heat and cooling energy directly on site, the energy is generated exactly where it is needed – without any transmission losses.

MTU Onsite Energy develops, manufactures and provides gas engine systems for operation with natural gas, biogas and other specialty gases.

Biogas as fuel

In the energy mix of the future, gases from biotic substances will play an important role. These so-called “biogases” include:

- // “Traditional” biogas, emerging during the fermentation of agricultural raw or waste material
- // Sewage gas and sludge gas, generated during wastewater treatment or during sewage sludge digestion
- // Landfill gas, escaping from landfill sites

MTU Onsite Energy gas engine systems utilize the great potential these biogases offer. They generate power, heat and cooling energy from biogas, sewage gas and landfill gas in any combination – ecologically, reliably and highly efficiently. In many locations, government subsidies in a biogas plant even more financially attractive.

With a power range from 190 kW_{el} to 1,950 kW_{el}, our biogas-based systems are applicable for a wide range of uses.



OUR GAS ENGINE SYSTEMS: THREE TYPES. COUNTLESS POSSIBILITIES.

Whatever you require – power only, power and heat or even power, heat and cooling: MTU Onsite Energy systems fulfill your demands.

Power supply

Our gas generator sets can be used to provide power around-the-clock to locations where the power supply is not reliable or even nonexistent. According to the demands, our systems can be deployed for grid-parallel or off-grid operation.

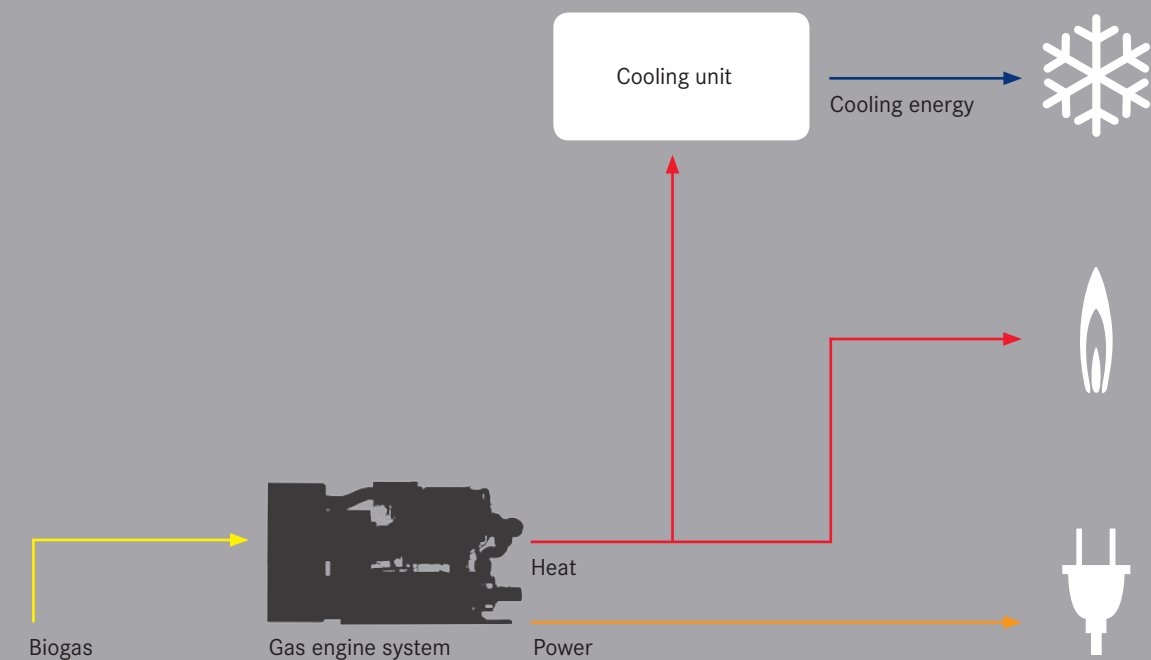
Power and heat supply (CHP)

Many applications require extra heat in addition to power. Hospitals, schools, sports facilities, office and administrative buildings, industrial enterprises with heat-intensive manufacturing methods, department stores and shopping centers often separately generate heat and obtain power from the public grid. CHP plants from MTU Onsite Energy provide a significantly more economical alternative.

Generally, a CHP plant from MTU Onsite Energy consists of a motor-generator unit and heat exchangers for waste heat utilization. The generated power can either be used to cover internal demands or be fed into the public grid. Besides being utilized for heating purposes, the thermal energy can also be deployed as process heat. From engine cooling water to waste gas, the inclusion of various heat sources is individually customized for your unique situation to provide you with the greatest benefit.

Power, heat and cooling supply (CHPC)

Using an absorption or an adsorption chiller, CHP systems can also create cooling energy with their generated heat. This functionality could be used for air conditioning in and office building, for example. The supply of cooling energy plays an important role not only for building climate control – it can be utilized in many different areas, as well as process cooling in manufacturing, for food refrigeration or for ambient cooling in temperature-sensitive areas (e.g. data centers). The generation of cooling energy extends the possibilities of using our CHP systems in a very cost-effective way.



OUR BIOGAS CHP SYSTEMS: SETTING THE STANDARD.

All of the CHP systems we design and implement today are based on the unique, combined know-how of MTU and MTU Onsite Energy with more than 100 years of experience in manufacturing engines and more than 35 years of expertise in the development, design, manufacturing and support of complete systems. As a result, our technology offers convincing advantages.

Efficiency

Our CHP plants offer a promising revenue potential, depending on the surrounding conditions. Size and number of the gensets required are defined by a profitability analysis, which we can carry out in close cooperation with each customer. This analysis demonstrates how much profit a customer can generate by deploying an MTU Onsite Energy CHP system.

Eco-friendliness

The generation of power and heat from regenerative resources is a carbon-neutral way of energy production. For example, our lean-burn engine principle prevents the production of harmful emissions during the combustion process. Emission levels below the limits required by the German “TA Luft“ clean air regulations and similar standards in other countries, can be achieved even without the use of a catalytic converter in many cases.

Sustainability

CHP systems with a combustion engine extract the heat accrued during the combustion process via heat exchangers and provide it to the consumers. The high efficiency of our CHP systems enables up to 40 % reduction in primary energy usage compared to conventional power systems.

Independence

In areas with nonexistent or unreliable public infrastructure, MTU Onsite Energy systems ensure an independent supply of power and heat.

Reliability

Our gas power systems have been proven in many applications and over hundreds of thousands of operating hours. Their high reliability and availability rate are based on a variety of factors that give MTU Onsite Energy the advantage:

- // The MTU Onsite Energy oxygen-content control system guarantees optimum combustion even with variable gas qualities, preventing engine damage.
- // The arrangement of the cooling system enables straightforward integration into existing heating systems.
- // The exhaust heat exchanger is integrated into the engine coolant circulation system, minimizing the risk of heat exchanger damage.
- // The use of largely standardized and carefully selected subassemblies achieves maximum operational safety and reliability.

- // Low fuel and lubricant consumption combined with long component life reduces operating costs.
- // An in-house development department continuously analyzes the data from the field-use of our systems and optimizes the technology on our test benches for a vast assortment of biogas application requirements.
- // Thanks to our extensive service network, you will receive timely support from our experienced service partners – anytime, anywhere. With our MTU **ValueCare** portfolio, we provide comprehensive service solutions which guarantee the efficiency of your system in the long term.



BIOGAS AS FUEL: UTILIZING AGRICULTURAL RAW AND WASTE MATERIAL.

Biogas is created by the digestion or fermentation of organic materials. The basic material is often slurry or solid manure. Regenerative raw materials or waste from the food industry are generally used as co-fermentates. 50 – 70 % of the gas produced this way is composed of the high-quality fuel methane. Carbon dioxide (CO₂), oxygen, nitrogen and trace gases (such as hydrogen sulfide) are its other constituents. A multiplicity of organic materials can be used in a biogas plant. Some systems run entirely on slurry and solid manure, while others exclusively use regenerative raw materials. Frequently, a mixture of materials is used.

An increasing number of commercial operations specialize not only in the recycling of slurry, but also the disposal of organic waste. Examples include food waste from the hotel and catering industries, wholesale markets and market gardens.

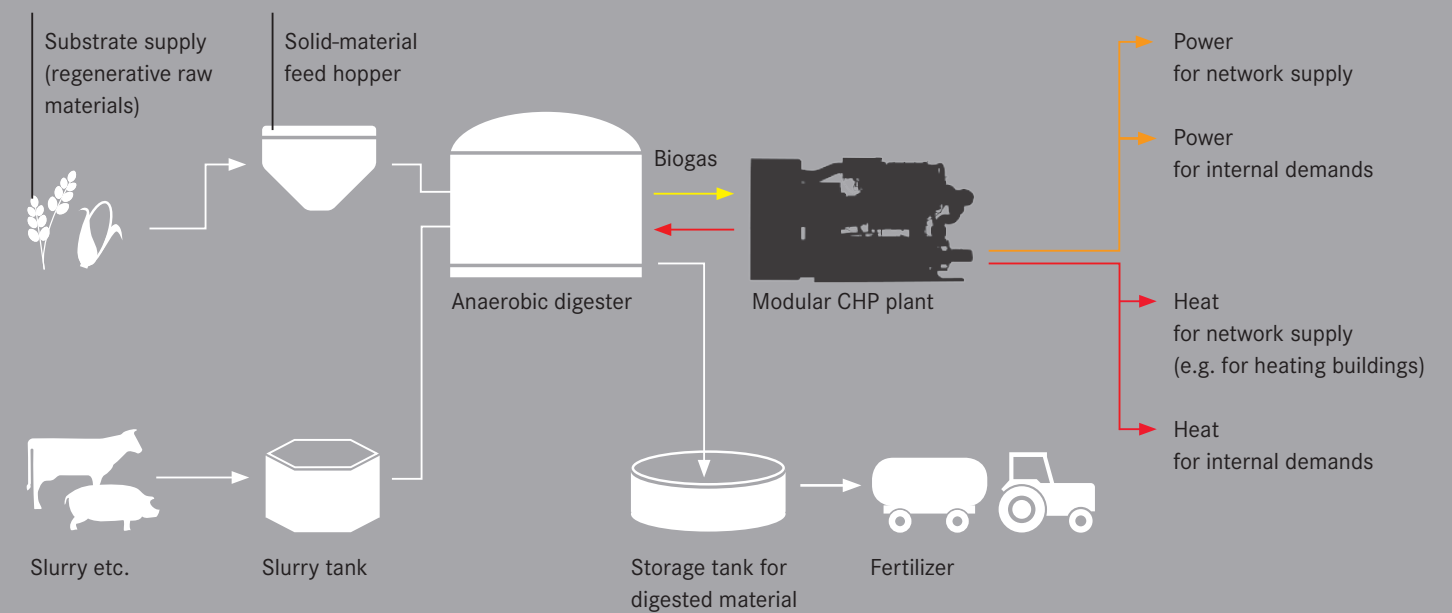
The principle of a CHP system based on biogas is simple and ingenious: The biogas is used to generate power in a manner that is both economical and saves resources. The power produced can either be used to supply the operator's own requirements, or it can be fed into the public power grid (in Germany as provided for by the Renewable Energy Act).

The heat generated by engine operation (as part of waste gas, coolant and oil) is used by heat exchangers to maintain the fermenters' temperature at a constant level, optimal for the fermentation process. Additional heat consumers, such as houses or groups of buildings within the farm or in neighboring residential areas, can also be supplied with heat.

With many years of technological experience and engines that have proven their reliability in the biogas segment, MTU Onsite Energy is able to integrate CHP technology into the overall process and make it profitable.



Biogas plant using regenerative raw materials



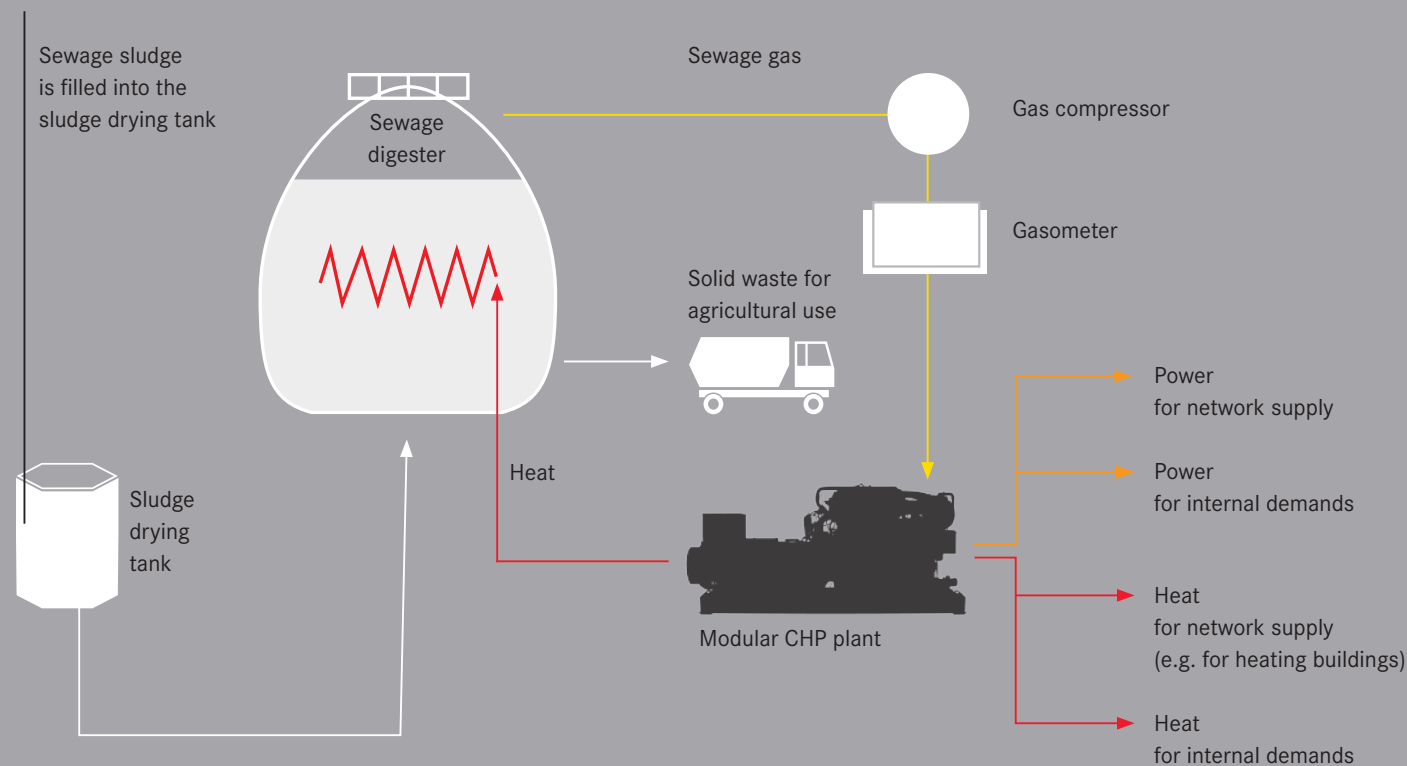
SEWAGE AND SLUDGE GAS AS FUEL: ENERGY FROM EFFLUENT.

Sewage gas emerges during wastewater treatment and sewage sludge digestion – which makes it a fuel available “for free” on site. Therefore, installing CHP modules in sewage plants is one of the most economical ways to utilize waste energy. The numbers speak for themselves: from 6 m³ of sewage, MTU Onsite Energy systems manage to generate on average 1 kWh of electric power and 1.2 kWh of thermal energy.

The efficiently and ecologically generated electric power can either be used to supply the sewage plant itself, or it can be fed into the public power grid for compensation.

During the combustion process, heat is being generated inside the gas engine, which can be utilized for heating up the sewage sludge in the digester or for heating the whole facility. In large-scale plants, excessive high-temperature heat may be available that can be used to pasteurize or dry the sewage sludge.

Plants for producing power from sewage gas, sludge gas and landfill gas attract government subsidies in Germany under the terms of the Renewable Energy Act (EEG): The power generated can be supplied to the public power grid at a fixed compensation rate. There are comparable assistance programmes already in place or in the pipeline in many other countries as well.

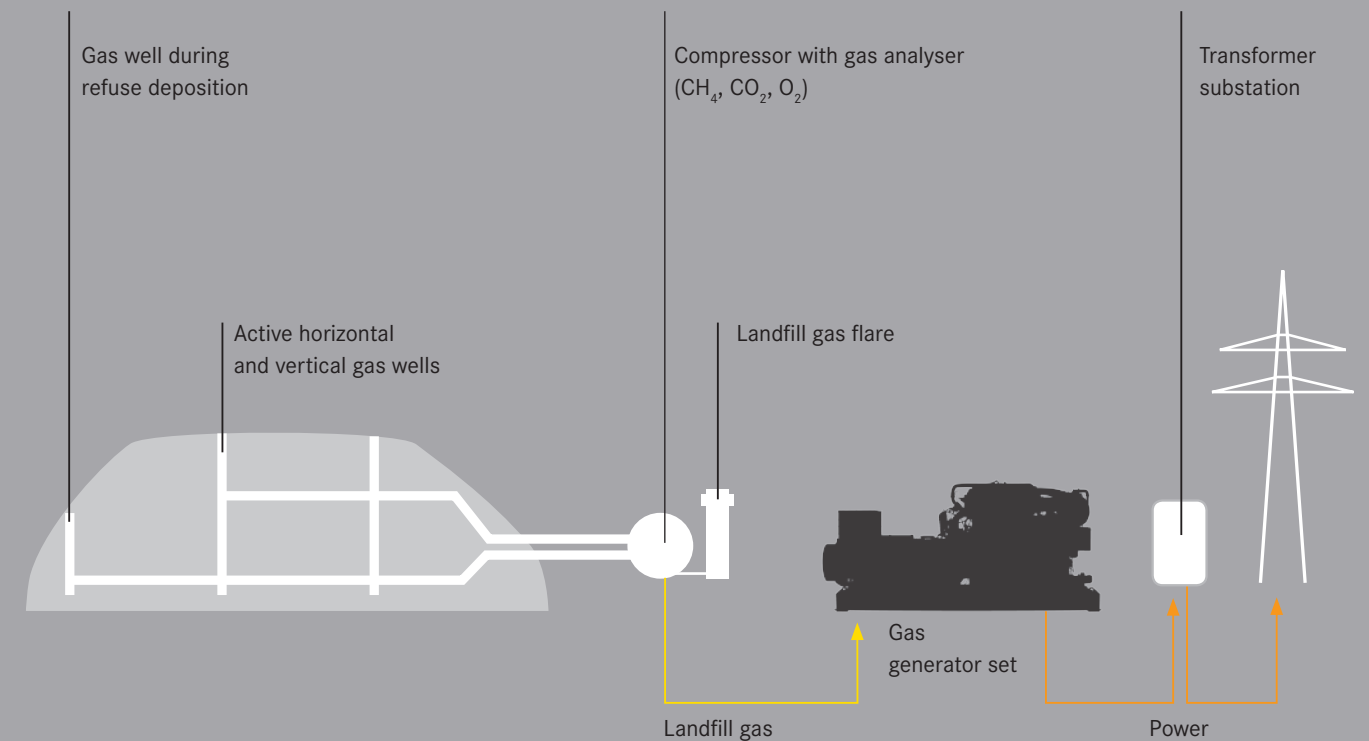


LANDFILL GAS AS FUEL: GAIN FROM GARBAGE.

Properly monitored landfill sites represent economical energy sources. The landfill gas produced by the anaerobic decomposition of organic matter in the deposited refuse has to be captured and removed for environmental reasons. It thus constitutes a virtually free source of energy that can be utilized to generate power using the intelligent gas systems made by MTU Onsite Energy.

Over and above the attractive financial aspects, planned gas recycling also offers a number of other important benefits:

- // Reduction of odor nuisance from landfill sites
- // Prevention of dangerous smoldering fires
- // Avoidance of gas migration
- // Optimization of the landfill site's recultivation process



SERIES 400: COMPACT CHP SYSTEMS.

Output range 190 – 400 kW_{el}

For more than 35 years, we have been delivering compact systems based on the Series 400 gas engines with 6 and 12 cylinders, with an output range from 190 kW_{el} to 400 kW_{el}. Over all those years, our engines have been continuously advanced and optimized. Within their output range, they offer maximum electrical and thermal efficiency and reach an overall efficiency of over 90 %. The Series 400 gas engines are mainly deployed in CHP applications (including thermal use). However, a deployment for just power generation is also possible. The Series 400 gas engines are deployed in CHP systems with heat extraction (from engine cooling water or engine cooling water and waste gas). Optimized components as well as a mature control and monitoring system guarantee the highest reliability. In addition to single module systems, several modules or plants can be combined in a multi-module system. Adjustment to the electrical or thermal load profile is achieved by switching in or shutting down individual modules. Another advantage of multi-module systems is their high level of availability.

Advantages of compact CHP modules

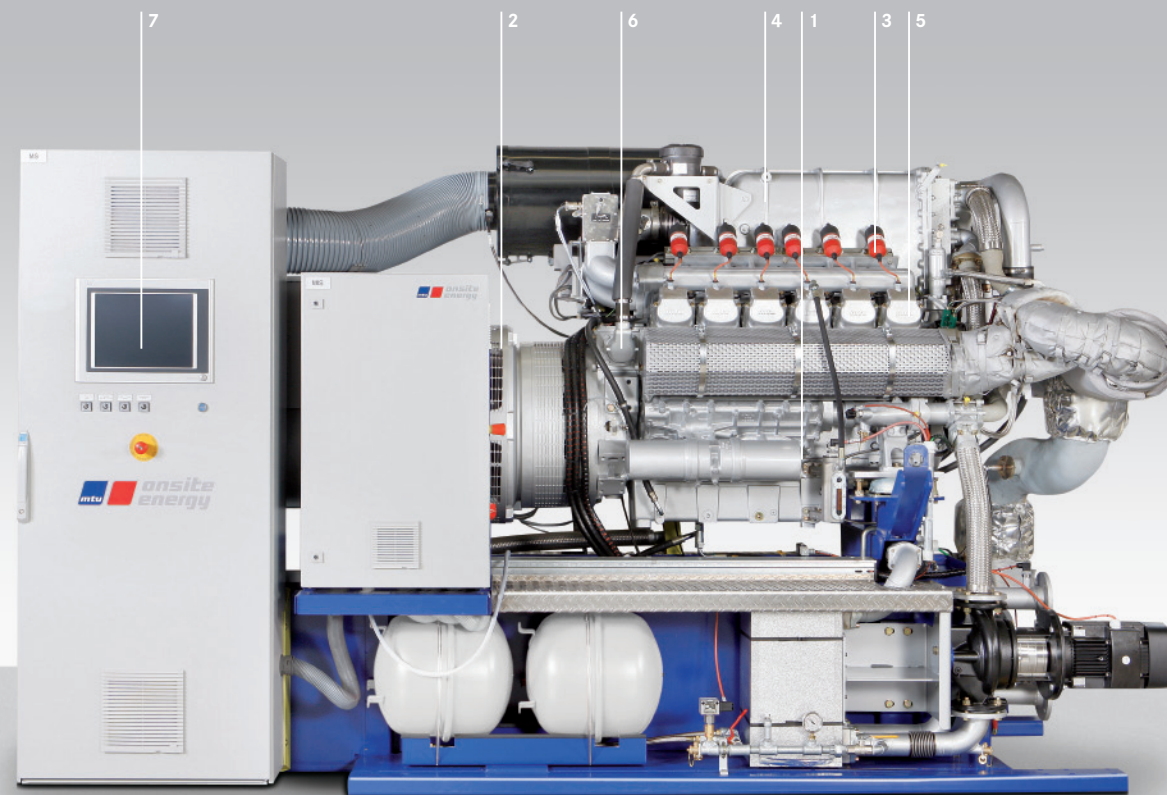
The compact design offers numerous advantages.

MTU Onsite Energy compact modules are:

- // Space-saving
- // Supplied ready to connect
- // Factory tested
- // Available as open or enclosed units
- // Easy to maintain
- // Standardized

Our Series 400 systems can be integrated into existing buildings or be provided as turnkey containerized units.

Many of our systems have already completed well over 100,000 hours of service and still continue to reliably supply power and heat day after day – conclusive proof of the dependability of our engine technology.



Description of individual components

1 Gas engine

// Advanced and proven Series 400 gas engine, optimized for biogas use. Combustion chambers ensure highest efficiency levels in this performance category.

2 Generator

// Optimally tailored to the engine and made by renowned manufacturers, the generator ensures a high level of reliability with the best degree of efficiency.

3 Ignition system

// Ignition systems for individual cylinders allow for the most efficient level of operation for all cylinders, even with variable CH₄ content. The ignition voltage display gives customers information about the state of the spark plugs.

4 Mixture cooler

// The two-stage mixture cooler with large surface area improves engine performance and heat utilization.

5 Knock detection

// Cylinder-specific knock detection and regulation protects the engine from abnormal operating conditions and guarantees safe operation even with biogas containing low levels of methane.

6 Crank-case ventilation

// Improved crank-case ventilation minimizes deposits in intake tract and combustion chamber and guarantees a continuously high level of performance.

7 MTU Module Control (MMC)

// The MTU Module Control (MMC) contains all the important functions necessary for controlling the system. All the auxiliary drives required for the CHP system can be operated from here. The integrated power circuitry minimizes the customer's need for cabling on site.

SERIES 4000: SPLIT-CONFIGURATION CHP SYSTEMS.

Output range 800 – 1,950 kW_{el}

Our split-configuration CHP systems are based on the MTU Series 4000 engines, incorporating MTU's extensive experience of more than 100 years in engine development and manufacturing. With countless hours of operation all around the world, these systems continue to prove themselves around in the most severe conditions all over the world.

For our CHP systems, cylinder versions with 8V, 12V, 16V and 20V are deployed within an output range of 800 kW_{el} to 1,950 kW_{el}.

Within this output range, they offer maximum electrical and thermal efficiency and reach the highest fuel efficiency rates. The Series 4000 gas engines are deployed in both CHP plants without heat extraction or CHP systems with heat extraction (from engine cooling water or engine cooling water and waste gas). Our split-configuration CHP systems can either be integrated into existing buildings or be provided as turnkey containerized units.

Split-configuration indicates that motor/generator and heat module (if applicable) are provided as separate components. Optimized components as well as a mature control and monitoring system guarantee the highest reliability.

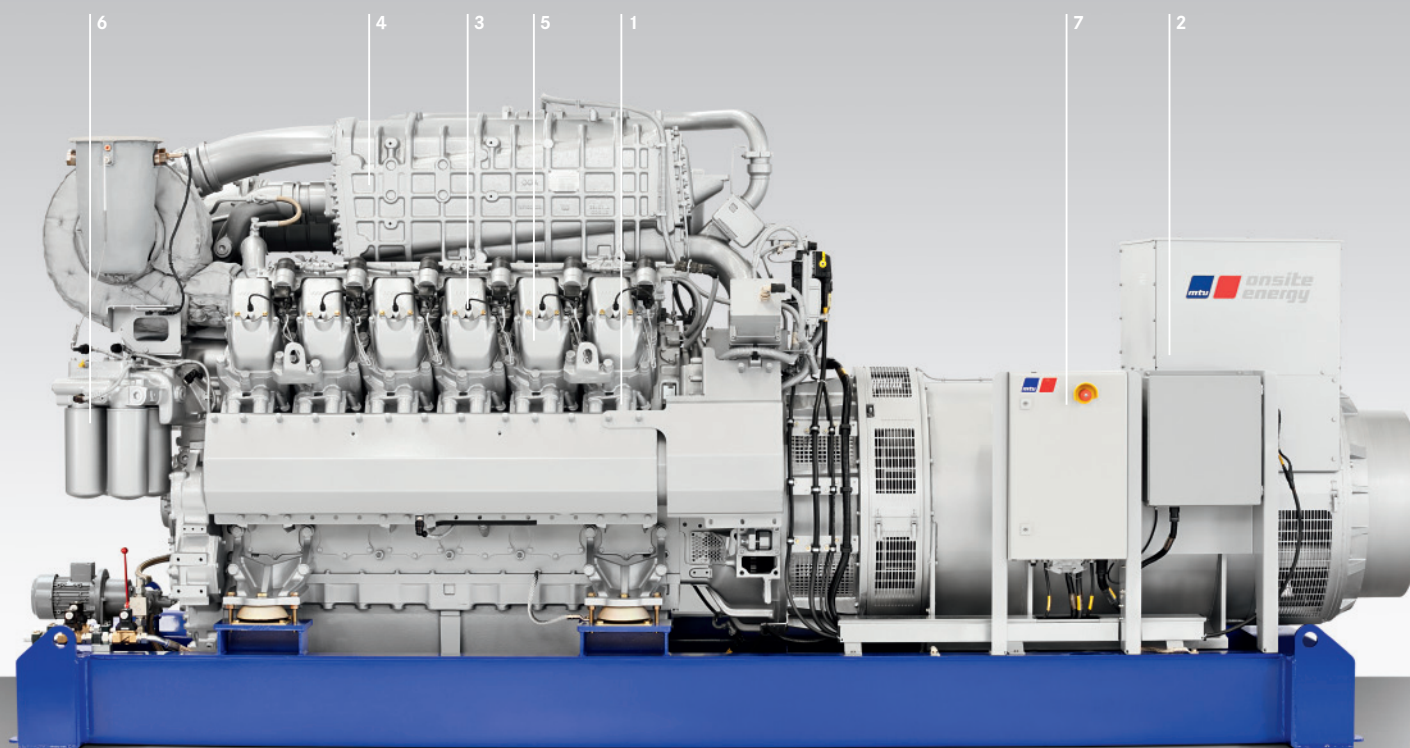
Our CHP systems are often designed as multi-module systems, enabling system performances with optimum efficiency in the upper megawatt range.

Adjustment to the electrical or thermal load profile is achieved by switching in or shutting down individual modules. Another advantage of multi-module systems is their high level of availability.

All our systems are comprehensively factory-tested before being delivered to you.

Advantages of split-configuration CHP systems

- // Separation of the heat generation module
- // Individual modification to customers' requirements
- // Optimal adaptation to the space available at the installation site
- // Warm-water generation with various temperature ranges as well as steam generation with separate waste heat utilization
- // Easier transport
- // Simplified installation



Description of individual components

1 Gas engine

// Advanced and proven Series 4000 gas engine, optimized for biogas use. Combustion chambers ensure the highest level of efficiency in this performance category.

2 Generator

// Optimally tailored to the engine and made by renowned manufacturers, the generator provides a high level of reliability with the best degree of efficiency.

3 Ignition system

// Ignition systems for individual cylinders allow for the most efficient level of operation for all cylinders, even with variable CH₄ content.

4 Mixture cooler

// The two-stage mixture cooler with large surface area improves engine performance and heat utilization.

5 Knock detection

// Cylinder-specific knock detection and regulation protects the engine from abnormal operating conditions and guarantees safe operation even with biogas containing low levels of methane.

6 Crank-case ventilation

// High-quality crank-case ventilation minimizes deposits in intake tract and combustion chamber and guarantees a continuously high level of performance.

7 Motor Interface Panel (MIP)

// Interface with stand-alone Module Control (MTU Module Control MMC)

MTU Module Control (MMC)

// The MTU Module Control (MMC) contains all the important functions necessary for controlling the system. All the auxiliary drives required for the CHP system can be operated from here.

The MMC is housed separately in the control cabinet and is therefore hidden from sight.

MTU MODULE CONTROL: SYSTEM MONITORING – ANYTIME.

MTU Onsite Energy supplies you with the complete system engineering package for your installation. One of the most important aspects is the control system technology. If the generator set is the heart of the system, then the module controller (MMC) is its brain. Our industrial-computer controlled and reliable electronics monitor the engine and the overall system to ensure optimum operation.

The most important features are:

- // Drive and control via PLC (programmable logic controller)
- // Operation and visual display by means of industrial PC and touch-screen panel with color display

- // Visual display of all functional processes and controls
- // Numerous additional controls and functions can be integrated (CH₄, gas tank, heat production mode, heat storage, mains power usage)
- // Networking of multi-module systems via Ethernet
- // Ability to be linked with master control system
- // Wide choice of interface protocols (Ethernet, Profibus DP, Modbus RTU, Modbus TCP/IP, Profinet)
- // Logging of all fault and status messages in a database (up to six months of data can be recorded)
- // Optional remote diagnosis via DSL or ISDN
- // Optional integration of SMS / E-mail client (notification of faults, daily reporting of all meter readings)

ADDITIONAL SYSTEM COMPONENTS: TAILORED TO YOUR NEEDS.

MTU Onsite Energy is your system partner. This means that as well as supplying the actual module or genset, we offer you a whole range of perfectly developed system components.

Gas preparation

Depending on the quality of the biogas, various measures may be required before it can be used. These ensure optimal combustion in the engine and also enable the use of an oxidation catalyst in order to comply with formaldehyde limits (and receive additional incentives). All necessary matching components such as gas cleaning, drying, cooling or reheating systems are available in addition to the gensets or modules.

Oxidation catalyst

Tailored to the respective engine, the catalyst guarantees adherence to specific emissions standards.

Auxiliary drive control and electrical connections

The integrated MMC (MTU Module Control) offers a range of connections and control options, such as hot water pumps, mixed cooling water pumps, extractor fan control, gas warning system, lubricant system, smoke detector and gas compressor.

Gas safety plan

MTU Onsite Energy has developed a comprehensive gas safety plan for entire systems. The plan guarantees protection against internal and external explosions and is TÜV approved. Talk to us – our specialists will be happy to advise you.

Grid Code

In many countries, the technical specifications for feeding power into the public grid are determined in detail. The so-called grid codes define the minimum parameters regarding the dimensioning of the generator as well as the control and safety functions a system has to fulfill in order to guarantee network stability. Our plants fulfill these standards.



CONTAINERIZED SOLUTIONS: COMPACT, FLEXIBLE, AUTONOMOUS.

As a system supplier, we offer a wide variety of solutions. In addition to our gas engine systems for use in buildings, we also provide containerized turnkey units. Compact, complete, flexible and autonomous, they are ideally suitable for mobile power generation or for applications that do not provide enough space for the insertion of a complete gas engine system.

When producing power from biogas, installing the generator set in a container can be a useful alternative to the more common option of permanently installing a static system in a generator room. Our standardized container generator set is designed to meet the requirements of a variety of applications.

The container includes:

- // The generator set
- // The switchgear including control and monitoring system
- // All necessary connection and supply systems (ventilation, lubricant supply, heat recovery, etc.)

Like all MTU Onsite Energy systems, the standard container gensets are capable of fully automatic and continuous operation. The systems start up on their own whenever there is an adequate quantity of gas available, and shut down again automatically when the gas supply is insufficient.

We offer two types of containers:

- // Power Containers generate only electrical energy and are ideal for remote locations or areas with unreliable power supply. They are often deployed in Power Stations.
- // Combined heat and power units (CHP) generate electrical and thermal energy, e.g. for operators whose processes require heat in addition to power.

Advantages of container units:

- // Technically mature, proven and eco-friendly gas engine technology for maximum efficiency and reliability
- // Completely autonomous overall design that does not require an additional building
- // Flexible unit assembly system based on standardized modules and synchronized components
- // Readily available, compact turnkey plug & play solutions
- // Optimal support thanks to a worldwide service network
- // Quality certified under ISO 9001 and DIN EN ISO 14001

CHP PROJECT PLANNING: INDIVIDUAL ADVICE FOR INDIVIDUAL SOLUTIONS.

Our support for your individual CHP system

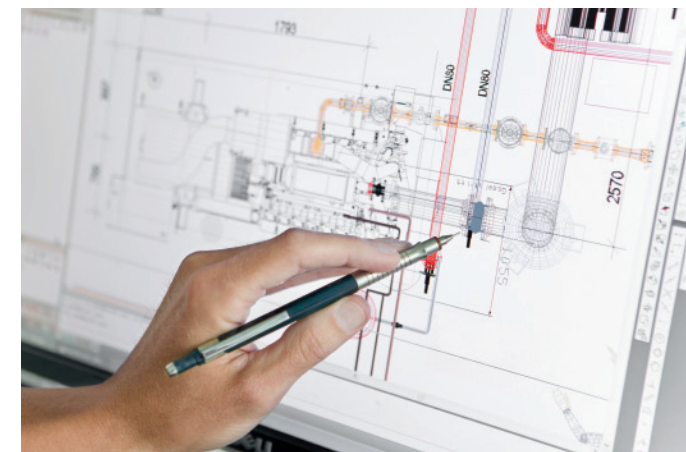
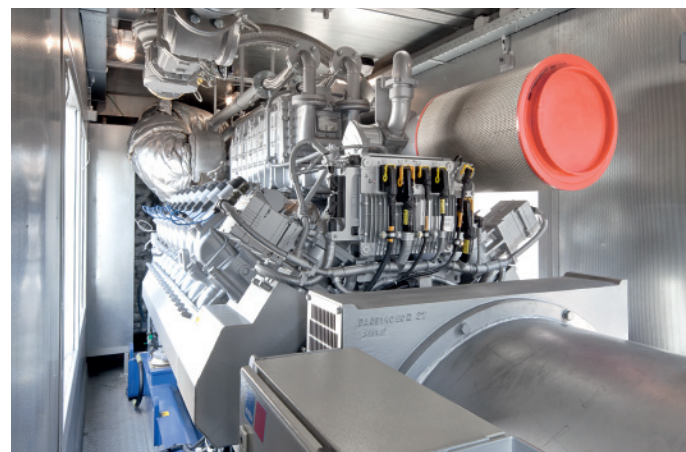
Choosing the appropriate CHP system for your demands depends on various factors. That's why we offer you comprehensive support – all the way from the project conception to its realization.

- // Support in planning your new CHP module
- // Expertise to help you incorporate the CHP module into your application
- // Explanations of the technology behind the engine, system and individual components
- // Proposal creation with budget price for planning phase and fixed price for implementation
- // Design and planning of peripheral systems
- // Advice on service solutions as early as the project phase
- // Help with questions on legal situations (EEG, formaldehyde bonus)

Convincingly economical

Our CHP plants offer a promising revenue potential, depending on the surrounding conditions. We work in close cooperation with you in advance to provide a profitability analysis for your application, defining the size and number of generator sets required. This analysis also shows possible savings within your power supply and how much profit you can generate by deploying an MTU Onsite Energy CHP system.

We will gladly provide you with more information by telephone or visit you for a personal meeting on site.



MTU **VALUECARE:** SUPERIOR SERVICE FOR LONG SYSTEM LIFE AND TOP PERFORMANCE.



Purchasing a MTU Onsite Energy gas power system pays off in many ways. In addition to enhanced performance, efficiency and reliability, we offer a full range of superior service and maintenance support through MTU **ValueCare** – a portfolio of value-enhancing products and services designed for peak performance and maximum uptime. Support is always nearby – anytime and anywhere. For your convenience, MTU **ValueCare** is available worldwide through our MTU Onsite Energy service network.

MTU **ValueCare** includes three product lines:

ValueService

ValueService is a full line of maintenance and repair solutions to help you protect your investment and get the most out of your equipment. From training to Remote Diagnostics, MTU Onsite Energy provides you with all the tools, with support customized to your needs.

// Service Agreements make it easy to plan the cost of maintenance throughout your system's lifecycle. A variety of options are available, including service, repair, maintenance and inspection contracts. The details, terms and periods of each package customized to meet your individual needs, ensuring cost certainty and maximum availability. Professional maintenance is performed by MTU certified technicians, using only genuine MTU new or remanufactured spare parts.

// Comprehensive training is a great way to get maximum efficiency from your equipment. From timely preventive maintenance to minor repairs and simple error corrections, our customized training programs are designed to make your service personnel proficient with MTU Onsite Energy engines and systems – maximizing your return on investment

// “Remote Diagnostics” is a powerful solution that links you directly to a record of your generator set's activity through a secure Internet connection. Through early fault identification, you can act quickly to prevent damage, save on service and repairs, identify spares needed and increase engine efficiency.

ValueSpares

ValueSpares genuine parts and consumables are designed, tested and approved specifically for MTU Onsite Energy systems. Only MTU Onsite Energy can guarantee genuine quality, with **ValueSpares** oils, coolants and filters products that are designed to work seamlessly with your equipment for maximum performance and value.

ValueExchange

ValueExchange provides a full range of genuine remanufactured engine products, engineered to ensure robust, reliable performance. A rigorous reconditioning process ensures the same high standards of performance, service life and quality as new products – including design and model updates. As a result, genuine **ValueExchange** products feature the same technological advancements as new products. When you choose **ValueExchange** products, you get genuine quality, speed and peace of mind while lowering costs.

Local support. Worldwide.

Whenever and wherever you need expert support, MTU Onsite Energy specialists are available through our global service network. This continuous and long-term care ensures high availability, dependability and efficiency throughout the lifecycle of your engines and systems. To find your local MTU Onsite Energy distributor, visit www.mtuonsiteenergy.com.



MTU Onsite Energy
A Rolls-Royce Power Systems Brand

www.mtuonsiteenergy.com