Medium-speed generating sets

POWER PLANT SOLUTIONS
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Rolls-Royce medium-speed generating sets are manufactured by the subsidiary Bergen Engines in Norway.

Through digitalization and electrification, we develop efficient and flexible power generation solutions. We deliver and service powerful and reliable systems, based on both gas and liquid fuel reciprocating engines.

Our fast-starting generating sets are ideal to support intermittent renewable energy sources, ensuring clean and reliable power with maximised efficiency 24/7.

With a variety of installations across the world, we are trusted to deliver complete power solutions to a variety of applications, such as utilities, independent power producers, manufacturing facilities, greenhouses, healthcare, mining sites and nuclear power plants.

The modular design of a power plant based on generating sets, ensures that any future expansions can be done easily, by adding units, and the multi-unit concept also enhances overall plant reliability.

120 MWe Power Plant in Mozambique
The plant is based on 13 B35:40V20 natural gas fired medium-speed generating sets from Bergen Engines and is covered by a 15 year service agreement.
POWER SOLUTIONS FOR A SUSTAINABLE FUTURE

Gas-fired power is likely to play an important role in the energy mix towards 2050, along with increasingly more renewable energy. Additionally, the power industry is moving away from big, often coal-fired, centralized power plants, towards smaller, decentralized microgrids. Along with variable renewables, comes the need for stabilizing power. Medium-speed Bergen engines provide dispatchable, flexible and economic power 24/7.

Low emissions and proven technology
Our latest gas engine series can achieve up to 50% efficiency in open cycle, with emissions kept to a minimum. The engines deliver high efficiency levels at partial loads, and are designed for minimal de-rating at higher altitudes and adverse site conditions. This, together with fast start-up times, transient response, and high availability, makes our gas engines a perfect match for intermittent renewable energy that needs balancing power. Our liquid fuel engines meet the strictest environmental regulations, and are an excellent option when gas is not available. The modularity of our B3X:45 series makes it possible to rebuild the engine to gas operation (or vice versa), if the fuel supply should change, reducing any investment risk.

Grid balancing
With a lot of renewable energy in the electricity networks, frequency and voltage stability can become challenging due to the large and fast variations in power output from renewables. Frequency may also be less stable because the rotating inertia of synchronous systems is reduced. As a consequence, other power sources must be more flexible, have fast starting capabilities, respond to rapid load changes, and be able to start and stop frequently. Our medium-speed generating sets meet these requirements. With multiple units, cascading operation provides the required flexibility, with high efficiency also at part load operation.

To ensure grid stability, grid code certification is becoming a requirement, particularly in countries with a lot of renewable energy. We are investing in a test facility that will make sure we always comply with national grid regulations.

Power-to-X and carbon neutral fuels
With intermittent renewables, power supply will sometimes exceed demand, and this surplus energy can be used to produce synthetic fuels (power-to-x) such as methane gas. The resulting carbon-neutral gas can be used in our gas-powered engines without any need for modifications. Hydrogen, ammonia or liquid methanol are examples of other carbon neutral fuels, if produced with surplus energy from renewables, that may become relevant for power generation. Such carbon neutral fuels can be effective decarbonization agents, using conventional power generation equipment such as reciprocating engines. The modularized design of our engines will make a potential rebuild, so that the engines can be operated on ammonia, hydrogen or other synthetic fuels, possible without extensive modifications.
Hybrid power solutions
Hybrid power solutions such as microgrids are typically power systems that team renewable energy sources with energy storage systems and generating sets, ensuring the that the right amounts of electricity are supplied reliably, efficiently and in an environmentally friendly manner with central control. Changes in both supply and demand require smart asset management to determine what power sources are to be used to supply energy to the end user, and when to feed the storage system.

Power supply to remote locations
Microgrids can supply energy autonomously to remote locations, such as mining operations, rural areas or islands with no access to the public grid. When operated in parallel with existing infrastructure, they can provide an environmentally friendly supply of electric power to industrial companies such as data centres, or local communities while simultaneously providing support for the public grid.

Power system resiliency
Microgrids also make a country’s energy supply more robust and stable, for instance in the case of natural disasters. A microgrid can quickly restore power supply to buildings, and even only to critical services within a facility. Microgrids can provide a reliable and resilient solution in a situation with main-grid instability or outages. That’s why data centres, hospitals and other businesses where energy supply is critical, have relied on microgrids for decades. The combination of rising total electricity generation and the high penetration of renewables will require increased demand for dispatchable back-up power. With medium-speed Rolls-Royce engines, stable power supply 24/7 is guaranteed.

1 CO₂ reduction
Reducing CO₂ is critical to meet target in the Paris Agreement and stay below 2°C global warming.

2 Population end electricity demand growth
World electricity demand is expected to more than double from 2018 to 2050.
Combined heat and power (CHP) and trigeneration

In many cases where power is generated, there is also a need for heat, or the heat can be dispatched where needed in the surrounding community. Waste heat from the engines can be efficiently used to generate steam or hot water for industrial processes, or to drive a combined cycle, with a heat recovery boiler and a steam turbine. The waste heat can also be used to heat water, that is then used for district heating. Tri-generation includes the production of cooling in addition to electricity and heat. By sending the exhaust heat to an absorption chiller, cooled water can be used for air conditioning or refrigeration. Maximised exploitation of the generating sets will make you independent of the national grid, ensuring predictable production costs with the possibility to sell excess energy to other users.

Benefits:
- Energy efficiency beyond 95%
- Low emissions with lean-burn gas engines
- Scalable concept if more power/heat is needed
- Increased profits and independency from the grid
- Superfluous heat and electricity can be sold to other users

Utilization of the CO₂

Carbon dioxide from the engines can be cleaned and reused in greenhouses to boost the growth rate. This way the natural CO₂ levels in the greenhouse atmosphere is enriched to fertilise the growth, by creating the perfect environmental balance. The generated electricity is typically used to power the grow lights, while the exhaust heat is used for heating, and any superfluous electricity or heat can be sold to the grid or to nearby communities. CO₂ can also be used in other industrial processes for the production of carbonated soft drinks.

To cater for the increasing future energy demand, smart energy solutions with maximised efficiency levels will be important to limit emissions. By exploiting the heat emitted from the generating sets, efficiency can reach beyond 95%. This is good for the environment, and an excellent way to reduce operating costs.
Baseload, peaking and grid support

FLEXIBLE OPERATION AND DELIVERY

Rolls-Royce provides reliable, high-performance power solutions for any operational mode. The modular design of a power plant based on generating sets, ensures that any future expansions can be done easily, by adding units. The multi-unit concept also enhances overall plant reliability.

Plant flexibility
A complete power plant based on Rolls-Royce medium-speed generating sets can be built in less than 12 months, also in areas with poor infrastructure. If additional power is required at a later stage, the modular concept makes it easy to extend the power plant, simply by adding more engine modules. Hence, capital investment can be done gradually, as the need for electricity rises. The small footprint makes an engine based power plant ideal both in remote locations to support incomplete grids, as well as in high demand areas such as big cities.

Medium-speed for high reliability and low operating costs
Rolls-Royce medium-speed engines are characterized by high efficiency and operating costs, with optimized part-load capability. With a Long Term Service Agreement (LTSA), our trained service personnel take care of maintenance, ensuring predictable costs and maximum availability. The generating sets will deliver reliable power for more than 25 years of operation.

Our generating sets supply continuous power to the grid with up to 98% availability. Service downtime is easily catered for with an N+1/N+2 configuration. Ensuring 100% power plant output 365 days a year. Typical applications include combined heat and power (industries, greenhouses, public utilities).

Fast power supply to meet periods of heavy demand, often on an infrequent basis, is efficiently met with our fast start mode. Our engines can ramp up to full load in 2 minutes, and the number of starts and stops is unlimited, and does not affect the maintenance program or equipment lifetime. Peaking mode can be exploited to benefit from the spot market tariffs.

To compensate for intermittent renewable generation and other instabilities in a power grid, fast back-up power is key. The fast start and ramp-up capabilities of our flexible generating sets ensure that the grid stability is managed efficiently, both at high and low loads, giving you optimal fuel economy and low emissions.
IN涉及EACH STAGE OF THE PROJECT

Many suppliers talk about flexibility, but at Bergen Engines we really mean it. Each power plant project is different, and each customer has different requirements, so we adapt our approach and scope accordingly. We have all the power generation and power management expertise and will assist you through the entire process, from the planning stage, all the way to a complete power plant.

We often engage with local contractors as they may be best suited for parts of an EPC delivery, and depending on the prevailing situation, the optimal split of tasks can be identified.

Project planning
We can provide expert advice and recommendations, support with feasibility studies, manage communications with local authorities to gain the necessary approvals, take care of grid code compliance, emissions regulations, and other environmental factors related to the power plant footprint. In the concept phase, we adapt the project to ensure all requirements are met, and develop a proposal for a power plant layout and system solution.

Scope flexibility
The illustration on the previous page indicates how we would typically split the delivery scopes into various levels from O1-O4 for a typical standard power plant. But we are flexible, and any components can be removed or added to our scope according to your specific needs or requirements. All equipment and system solutions we supply undergo thorough factory testing, commissioning and verification of performance at site. Each project is assigned a project manager who follows the entire process from contract to project handover.

System integration
Our dedicated engineering team repeatedly delivers reliable solutions for multi generating set power plants as well as for single-unit installations. Our engineering disciplines cover all areas of complete power plants ranging from civil, building structures and services, fire-fighting, foundations, support structures, air intake and ventilation, exhaust, fuel systems, control and electrical systems. Our modularized solutions can easily be integrated to microgrids and/or other hybrid solutions with renewable energy.

Long Term Service Agreements
With our flexible offering of service agreements, you can get a service package that is adapted to your actual situation and needs, all the way from spare parts delivery and technical support on-demand, up to operation and maintenance. Read more on the following pages.

Remote monitoring
All generating sets are delivered with built-in remote monitoring capabilities. Remote monitoring of your power plant will ensure error prevention, unnecessary downtime and reduced operating costs. You can manage your power plant equipment from anywhere in the world, and get first-hand technical support with possibility for remote access when needed. The concept is simple and cost-effective, giving you peace of mind, and assurance that your power plant is performing at its best, always.

1 Typical scope levels
Medium-speed reciprocating engines with up to 98.5% availability

Compact and powerful
The B36.45LB engine delivers 5290 kWe with a very small footprint.

The B3X:45-series
The modular design gives a flexible platform while it carries forward the traditional values of robustness and reliability that have always been at the core of engine designs from Bergen Engines.
High availability and low operating costs

ROLLS-ROYCE MEDIUM-SPEED GENERATING SETS

There’s a proud tradition behind the Rolls-Royce medium-speed generating sets from Bergen Engines. These are robust, reliable and extremely powerful reciprocating engines that meet the strictest environmental requirements.

Lean-burn gas pioneers

Bergen Engines was a pioneer in developing the modern lean-burn gas engine technology, which has been applied to several hundred engines, and which has been developed continuously since the first gas engine was released to the market in 1991. This gas engine is still in operation. We have developed a portfolio of engines that can run on natural gas or biogas - enabling power plant owners to operate with minimum emissions and at class-leading efficiency levels. Designed from scratch to be clean, quick to respond and very fuel efficient, the medium-speed gas engines have proven their reliability over millions of running hours. The highly reliable C-series and the larger B-series represent the latest in lean-burn gas technology, delivering rapid response times and long intervals between overhauls.

Powerful and reliable liquid fuel engines

Liquid fuel engines from Bergen Engines are delivering reliable power worldwide. A combination of high performance, reliability and cost-effective operation ensure powerful customer benefits. Our liquid fuel engines are designed to meet customer needs for power, flexibility and ease of maintenance. All our liquid fuel engines are optimised for operation in combination with an SCR (Selective Catalytic Reduction) system, resulting in considerable reductions of NOx emissions.

Both the gas and liquid fuel variants have been designed from the outset for variable speed and variable load. The engines are serviced on site, delivering reliable power for more than 25 years.

Rolls-Royce medium-speed benefits:

- Excellent fuel economy and low emissions over the full operating range
- Reliable power
- Low lubricating oil consumption (no need to change the oil)
- Proven low life-cycle costs
- Robust, simple and modularised design for easy maintenance
- Equipment health monitoring
- Fast load response
- Low vibration/structural noise
- Compact and modular design with a low weight construction
- Easy installation
- Cylinder pressure monitoring (CPM) for improved load control, and possibility for diagnostics per cylinder (Gas engines)

A complete power range

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<thead>
<tr>
<th>GAS</th>
<th>Power (MW)</th>
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<tbody>
<tr>
<td>C26:33</td>
<td>1,5-2,5</td>
</tr>
<tr>
<td>B35:40</td>
<td>5,6-9,4</td>
</tr>
<tr>
<td>B36:45</td>
<td>3,5-11,8</td>
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<tr>
<th>LIQUID FUEL</th>
<th>Power (MW)</th>
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<tbody>
<tr>
<td>C25:33</td>
<td>1,5-2,3</td>
</tr>
<tr>
<td>B32:40</td>
<td>5,3-7,0</td>
</tr>
<tr>
<td>B33:45</td>
<td>3,2-10,6</td>
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When plant availability and performance are essential, rely on Rolls-Royce service professionals. We believe in standing by our customers throughout the entire service life of their equipment. It’s why more than 80% of our operating plants around the world are covered by Long Term Service Agreements (LTSA), which provide planned and unplanned service support from highly trained and experienced service engineers. In fact, several of these customers have relied on us for more than 20 years - a testament to the effectiveness of the LTSA concept.

Tailored service agreements
Every LTSA is tailored to suit the unique operational needs of the customer, based on an agreed scope of services (including Balance of Plant).

The agreements are individually configured to meet the characteristics of the application they serve, taking into account the available local infrastructure. The LTSA scope is split into four different levels (see overview on next page), ranging from nearly independent customer operation to full operational reliance on Rolls-Royce, with the option to customize service based on the unique needs and requirements of the customer.

The plant owner’s involvement in planned and unplanned maintenance may vary, and often depends on the skills and experience of plant personnel.

Training
Training is a key element of most agreements because it helps operators establish optimal maintenance and monitoring routines. Our training packages impart necessary system understanding and technical skills, reducing the risk of major problems that arise from minor incidents. To ensure plant stability and efficiency, and reduce equipment wear and tear, there’s no substitute for professionally trained operators.

We help you set up your ideal service solution, to accommodate your needs and give you peace of mind.

Increased availability with health management
Preventive maintenance is ensured with remote monitoring and support of your equipment. Many issues can be solved on the fly with real-time data from the plant. Photo credits: Jane Stockdale

Maximised plant availability and reliability
We deliver technical support from highly skilled service engineers. An LTSA ensures predictable maintenance with fixed price per hour rating, and less downtime thanks to contingency stock.
The share of medium-speed customers with an LTSA is more than 80%.

We deliver on-site training of plant operators in daily/weekly/monthly service activities, while scheduled service and equipment tuning is typically performed by Rolls-Royce professionals.
Reference projects

EXPERIENCE ACROSS THE GLOBE

**Baseload - Mozambique**
- **Owner**: Gigawatt Mozambique
- **Place**: Ressano Garcia, Mozambique
- **Genset**: 13 x B35:40V20AG2
- **Total output**: 120 MWe
- **Fuel**: Natural gas

The Ressano Garcia power plant delivers reliable power to the Mozambique national electricity grid. It has the capacity to provide electrical power to 250,000 households.

**CHP - Czech Republic**
- **Owner**: C-Energy
- **Place**: Tabór, Czech Republic
- **Genset**: 4 x B35:40V20 + 2 x B36:45V20
- **Total output**: 37MWe + 23 MWe
- **Fuel**: Natural gas

The success of the first batch of Rolls-Royce engines resulted in the delivery of two of our new B36:45V20 engines, which were delivered in 2019.

**Baseload - Myanmar**
- **Owner**: Zeya & Associates
- **Place**: Yangon, Myanmar
- **Genset**: 3 x B35:40V20AG2
- **Total output**: 28 MWe
- **Fuel**: Natural gas

The prefabricated power plant concept significantly reduced the installation effort at site. The IPP deliver reliable power to the Yangon national grid.

**CHP - Mexico**
- **Owner**: UEN
- **Place**: Agua Prieta, Sonora
- **Genset**: 2 x B35:40V20AG2
- **Total output**: 18 MWe
- **Fuel**: Natural gas

The power plant delivers electricity to companies in the area, and the waste heat is sent to a chilling plant for refrigeration of agricultural warehouses.
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#### Greenhouse - Belgium
- **Owner**: Marc Pittors
- **Place**: Koningshooikt, Belgium
- **Genset**: 2 x B36:45L6AG
- **Total output**: 7 MWe
- **Fuel**: Natural gas

The generated electricity is used to power the greenhouse with artificial lighting, and the waste heat heats up the facility. Cleaned CO₂ is used to boost plant growth.

#### Baseload - Bangladesh
- **Owner**: Energypac
- **Place**: Chittagong, Bangladesh
- **Genset**: 16 x B32:40V16AG
- **Total output**: 112 MWe
- **Fuel**: Liquid fuel

This power plant delivers electricity to Chittagong, the second largest city of Bangladesh. Because of the multi-unit concept, the single units can be run at almost full load at all times, switching off units when demand is low, and maximising efficiency.

#### Industrial CHP - Spain
- **Owner**: Viscofán
- **Place**: Cáseda (Navarra)
- **Genset**: 4 x B35:40V20AG + 1 x B35:40V12AG + 2 x B36:45L6AG + 1 x KVGS18G3
- **Total output**: 50 MWe
- **Fuel**: Natural gas

The 8 engines deliver reliable energy to a meat products wrapping factory, ensuring high availability of the plant at all times.

#### Grid support - USA
- **Owner**: IMG Midstream
- **Place**: Alpaca and Milan, Pennsylvania
- **Genset**: 6 x B35:40V16AG
- **Total output**: 40 MWe
- **Fuel**: Natural gas

The two power plants with three gensets each deliver grid support electricity to the local grid, using locally produced natural gas.