

GE Power

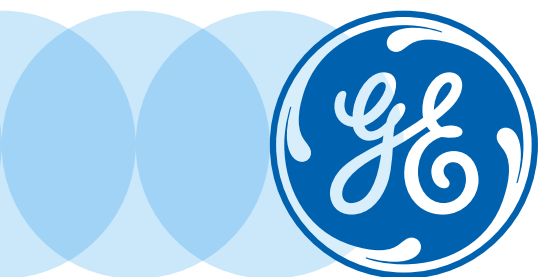
Flexible and efficient Distributed Power

With GE's 10 MW class Jenbacher J920 Flextra gas engine



ecomagination

Flextra

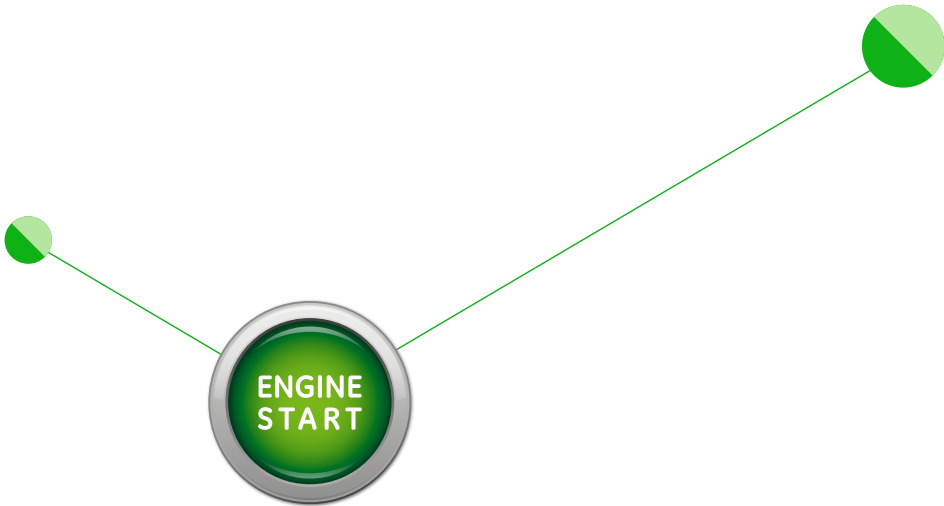


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Attributes of GE's J920 flexible power solutions—by the numbers

| | |
|-----------------------------------|--|
| 398 million | Accumulated operating hours of GE's Jenbacher gas engines |
| 36,000 | Number of GE gas engines operating worldwide |
| 14.7 GW | Amount of available power from the installed Jenbacher gas engines fleet |
| 10.4 MW (50 Hz) - 9.35 MW (60 Hz) | Power output of a single J920 unit |
| 49.9 % | Simple-cycle electrical efficiency (highest in its class) |
| > 90 % | Overall thermal efficiency in cogeneration |
| 80,000 | Operating hours until major overhaul |
| 5 minutes | Time to achieve full power |



Introduction

GE's Distributed Power business is a leading provider of power equipment, engines and services focused on power generation at or near the point of use. Distributed Power's product portfolio includes highly efficient industrial reciprocating engines that generate 200 to 10 MW of power for numerous industries globally. GE's Distributed Power business is headquartered in Jenbach, Austria.

With the new Distributed Power business structure, Jenbacher gas engines become a central part of a unified organization and gain the full benefit of GE's combined commercial and technical strengths. A leader in gas-fired reciprocating engines since their introduction in 1957, GE's technologies generate a quarter of the world's daily electricity—showcasing the role Jenbacher gas engines have played in the evolving global energy industry.

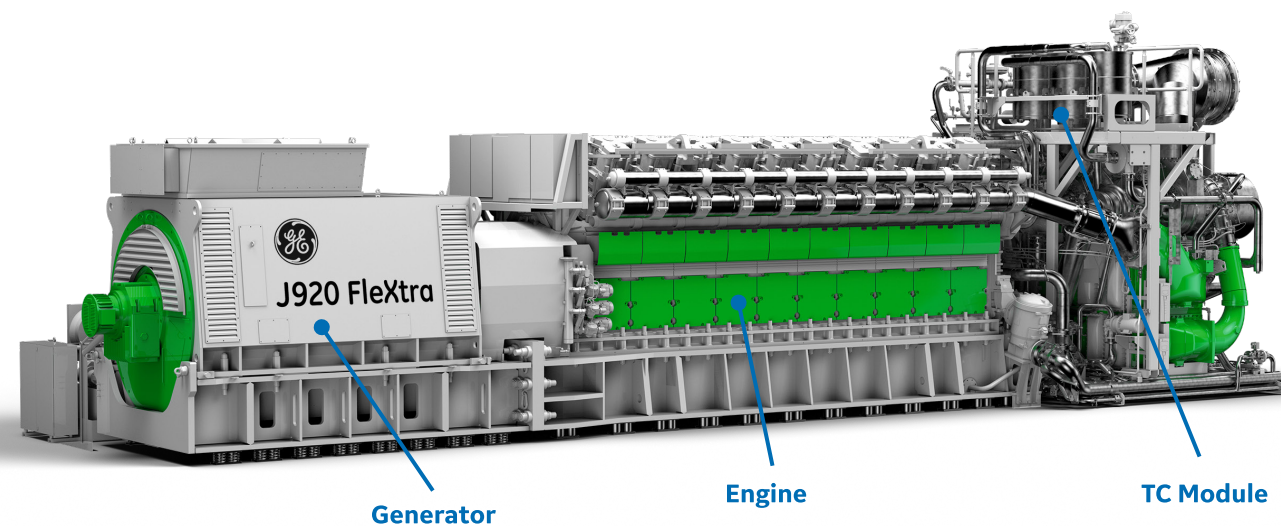


GE's 10 MW class J920 FleXtra engine is part of the Stadtwerke Rosenheim municipal cogeneration plant in Germany

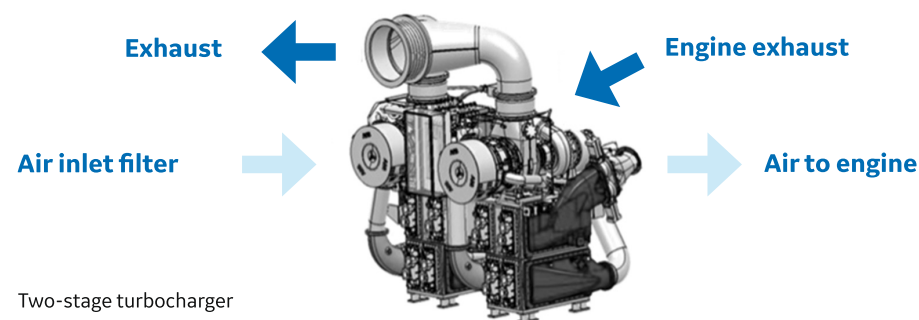
Distributed power generation plays a vital role in providing reliable and long-term power solutions. For instance, developed regions have a growing need for decentralized power to stabilize the grid. As the number of renewable installations continues to rise the need for flexible power generation grows. At the other end of the spectrum, remote communities and facilities can receive distributed power without having to wait for a transmission and distribution network to be established.

The trend toward decentralization and greater energy flexibility has led to a surge in gas engine deployment. Gas engines offer higher simple-cycle efficiency, which translates into lower investment and operating costs. Their short installation time, ability to scale to any plant size and higher efficiency make GE's Jenbacher engines an ideal solution to solve the world's growing need for distributed generation.

“Distributed power generation plays a vital role in providing reliable and long-term power solutions.”



The J920 FleXtra unit consists of three modules: generator, engine and turbocharging (TC) module



GE's J920 FleXtra gas engine: Industry-leading efficiency

GE's flagship of the Jenbacher product line, the J920 FleXtra gas engine, has a capacity of 10.4 MW (50 Hz) or 9.35 MW (60 Hz). The top-of-its-class electrical efficiency of up to 49.9 percent (total efficiency of more than 90 percent for combined heat and power applications) is attained with advanced technologies, such as two-stage turbocharging. Rapid start/stop cycles and the operating flexibility that can be gained by running multiple units, in parallel, make J920 FleXtra gas engines the ideal solution for power generation, district heating, load following and renewable support.

GE's J920 FleXtra engine's two-stage turbocharging enables the achievement of higher electrical efficiency and higher total combined heat and power (CHP) efficiency. The complete J920 engine's turbocharger module consists of four turbochargers, a two-stage turbocharging system, intercoolers, gas train, oil and water heat exchangers, blow-by system, and an electrical cabinet. This enables excellent lean-burn combustion, higher efficiency and lower emissions. Further, J920 FleXtra engine efficiency remains high even in tropical regions and high altitudes.

Key performance data

| Performance Data | J920 FleXtra (50Hz / 1,000 rpm) | J920 FleXtra (60Hz / 900 rpm) |
|-----------------------|------------------------------------|----------------------------------|
| Electrical output | 10,400 kW | 9,350 kW |
| Electrical efficiency | 49.1 % | 49.9 % |
| Heat rate | 7,332 kJ/kWh 6,949 BTU/kWhe | 7,214 kJ/kWhe 6,837 BTU/kWhe |
| Thermal output | 8,600+ kWth | 7,510+ kWth |
| Total efficiency | > 90 % | > 90 % |

Output and efficiency at generator terminals, ISO 3046, Nat. Gas MN >80, Power Factor 1.0, 500 mg/Nm³ (@ 5 % O₂) NO_x, Efficiency at LHV, all direct driven pumps included

Installed dimensions

| Performance Data | Length | Width | Height | Weight |
|------------------|-----------------|-----------------|-----------------|-------------------|
| Engine | 8.4 m / 27.5 ft | 3.2 m / 10.5 ft | 3.4 m / 11.2 ft | 91 t / 201,000 lb |
| Generator | 5.2 m / 17.1 ft | 2.5 m / 8.2 ft | 2.9 m / 9.5 ft | 59 t / 130,000 lb |
| TC Module | 3.2 m / 10.5 ft | 3.9 m / 12.8 ft | 5.1 m / 16.7 ft | 26 t / 57,300 lb |

Power plant solutions

GE's J920 FleXtra gas engine can be deployed in large gas engine power plants, offering a standardized powerhouse plant concept with fast delivery times and lower installation costs. While the size of the facility, actual plant design and layout are site specific, the J920 FleXtra solution has been developed as a modular system with a small footprint. This permits seamless installation for any multiple-engine configuration with flexible size options at top-of-class efficiency levels. When this multiple-engine concept is combined with a five-minute engine startup time, the result is outstanding flexibility for baseload, cyclic and peaking operation.



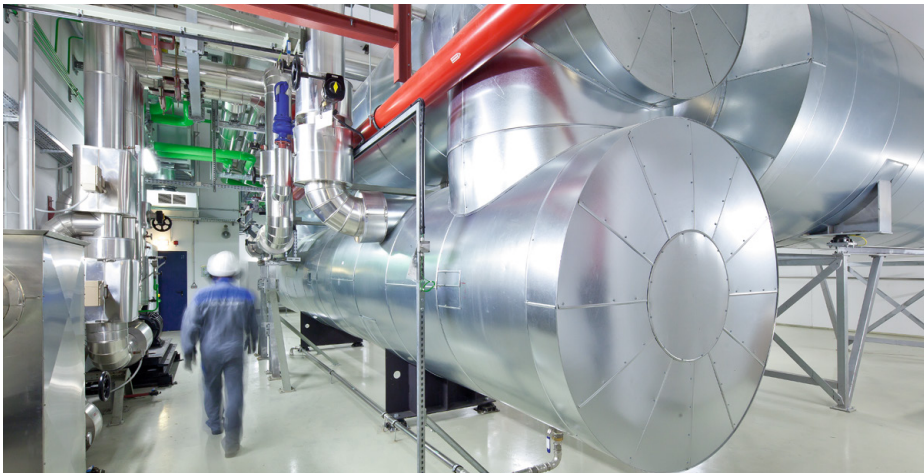
Combined heat and power

CHP concept with two-stage turbocharging

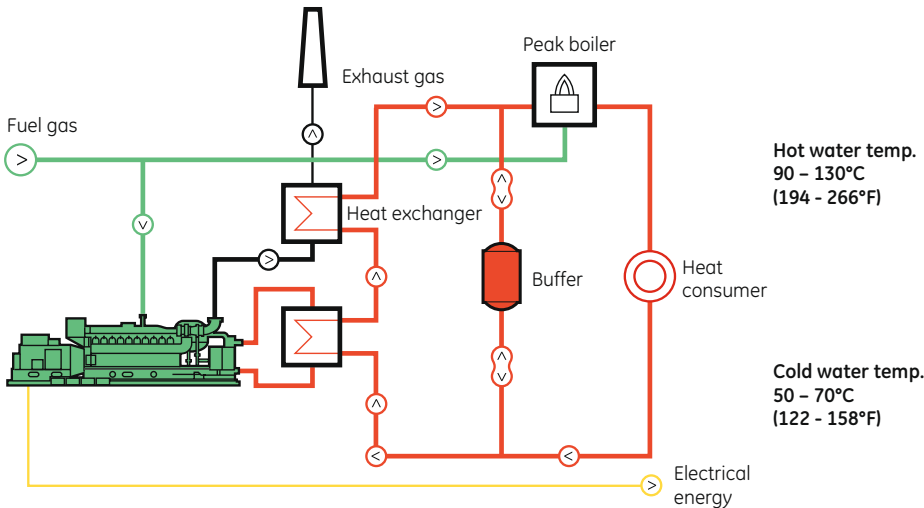
Two-stage turbocharging enables more than 90 percent total efficiency when the J920 Flextra engine is used in a combined heat and power (CHP) plant application that produces hot water. Using the J920 Flextra engine's exhaust heat, a hot water temperature of up to 130°C (266°F) can feed a district heating system and maintain a water return temperature of up to 70°C (158°F).

Note that gas engine power plants for CHP run with constant high electrical efficiency, regardless of whether heat is extracted or not. Installation requires only one additional gas/water heat exchanger (exhaust gas heat exchanger) beyond the generator set.

“Two-stage turbocharging enables more than 90 percent total efficiency.”



Combined heat and power plants are suited to a wide range of applications: as district heating plants or for decentralized supply of power and steam or power and heat



CHP advantage with J920 Flextra

Thanks to 2-stage turbocharging the J920 is a very good solution for combined heat and power applications. It provides about 4 % pts higher total efficiency, because about 800 kW of additional heat can be utilized from the J920 GenSet compared to an equivalent single stage turbocharging engine. Over the course of 15 years, for example, a facility could realize additional revenues from winter heat sales of more than \$ 14 million from a 100 MW CHP power plant.

| | Single stage TC | Two stage TC |
|--------------------------------------|-----------------|--------------|
| Heat output (kWth) | base | + 8,000 |
| Total efficiency (%) | 86 | 90 |
| Additional heat revenues in 15 years | - | \$ 14.4 MM |

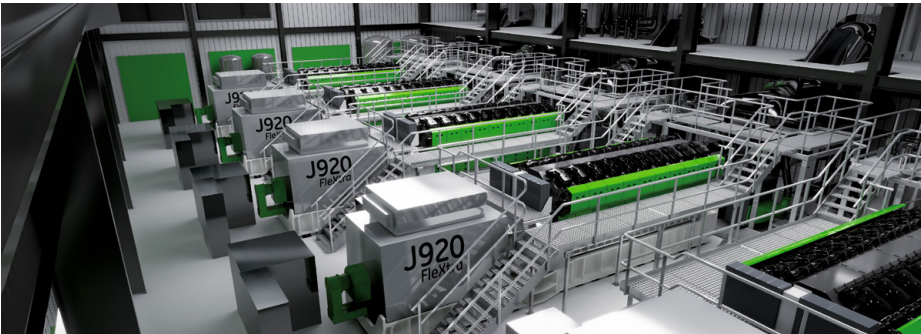
Assumptions: 100 MW, 4,000 oh/yr, 15 years, price for heat 30 \$ / MWh

GE's J920 Flextra engine advantages

J920 Flextra gas engines offer a wide range of benefits

1. Fuel savings

GE's J920 Flextra generator set offers a top-of-its-class electrical efficiency of 49.1 percent for 50 Hz and 49.9 percent for 60 Hz. That adds up to big fuel savings throughout the lifetime of any plant. Over the course of 15 years, for example, an Asian facility could realize fuel savings of as much as \$ 40 million for a 100 MW power plant.



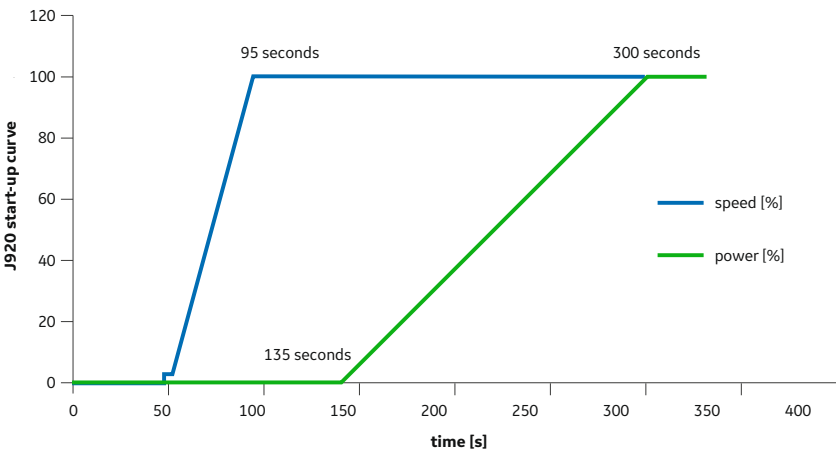
A J920 Flextra-based multiple gas engine power plant

| Fuel savings per region | North America | Latin America/ Africa | Europe | Asia | Assumptions | |
|--|---------------|-----------------------|------------|------------|---------------|----------------------|
| Cost of fuel in \$/MMBTU | \$ 5 | \$ 10 | \$ 12 | \$ 14 | Operation | 6,000 hours per year |
| Savings from J920 unit in 15 years due to efficiency advantage | \$ 14.8 MM | \$ 29.6 MM | \$ 33.6 MM | \$ 39.2 MM | Life of plant | 15 years |
| | | | | | Power output | 100 MW |

Fuel savings per region with 2 % points better efficiency

2. Fast start

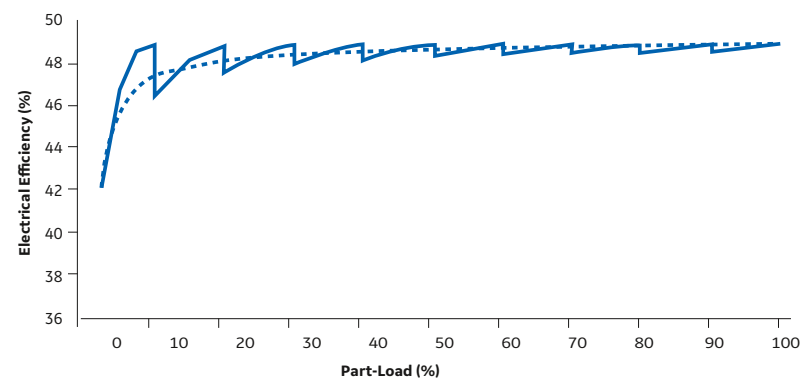
With a pre-heated engine, the J920 Flextra engine offers a five-minute startup from start to full load. Multiple engines can also be started in parallel. This ramp-up capability makes gas engine power plants well-suited to frequent start-stop and load-following operations, without additional maintenance costs.



The J920 Flextra engine has a five-minute startup capability

3. Consistent efficiency

Another big advantage of GE's J920 Flextra gas engine is part-load efficiency in multiple gas engine power plants. Output remains stable in part-load due to the ability to start and stop machines incrementally to meet the targeted output level.



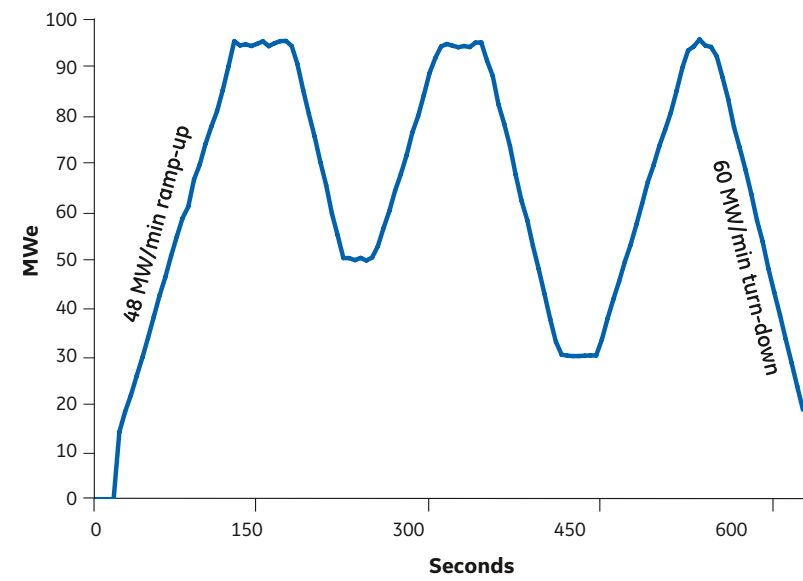
4. Grid firming for renewables

Since the beginning of this century we have seen a massive ramp up of wind and solar installations around the world, and this trend seems to be irreversible. While wind and solar energy have clear environmental benefits, they must be supported by complementary generation to maintain a stable grid. Flexible

resources like the J920 Flextra engine can be activated during periods of low renewable power supply or during tariff spikes. Conversely, the J920 Flextra engine can be quickly curtailed during spells of high feed-in of renewable energy or low energy prices.

5. Load following

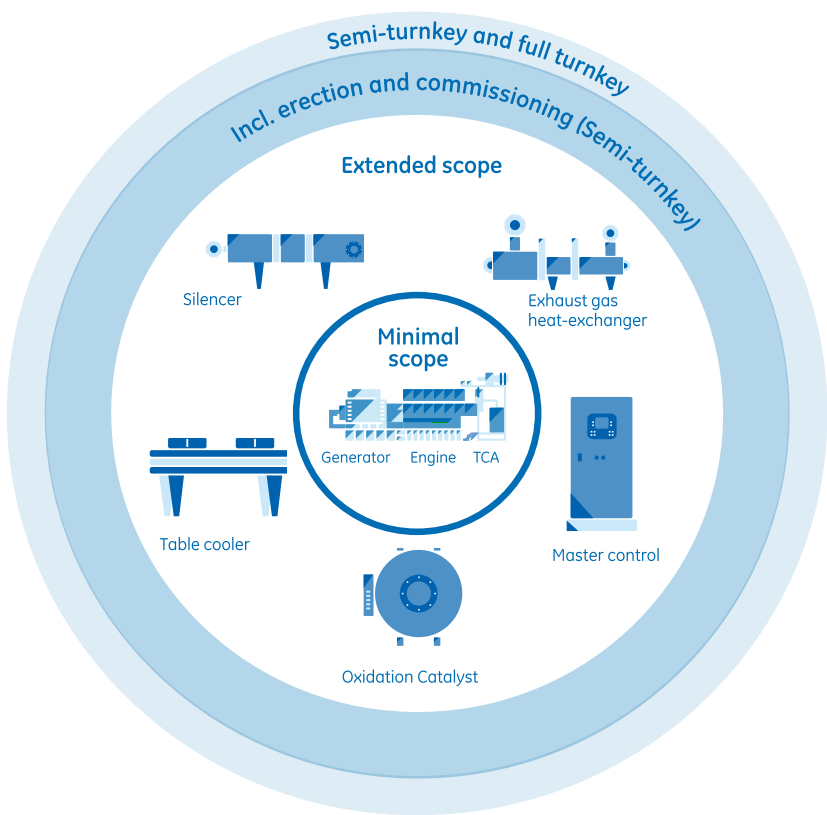
Due to the high levels of volatility in modern dispatch profiles, gas engines need to be able to overcome additional challenges of transient performance and grid code compliance. Peak demand and ancillary services require power plants with fast-load tracking capabilities without any trade-offs in plant efficiency or startup reliability. The J920 Flextra gas engine uses technology specifically designed to fulfill these demanding requirements. This includes a cylinder-individual combustion control system making use of in-cylinder pressure sensing, distributed controllers with embedded software, and individual cylinder gas supply via port injection. As a result, the J920 Flextra engine is able to provide invaluable grid services such as load following, automatic generation control, and supplemental reserve, without impacting maintenance.



A 10-unit J920 Flextra power plant can ramp up and down swiftly in response to changing load requirements

6. Scope of supply options

GE offers customers a range of power plant options. Those requiring the minimum scope option can purchase the J920 Flextra generator set on its own. An extended scope option provides the generator set and auxiliaries, including coolers, selective catalytic reduction (SCR), exhaust stack, etc., all with ensured performance. Installation and commissioning assistance is also available. GE is ready to satisfy any and all procurement requirements.



“The J920 Flextra gas engine uses technology specifically designed to fulfill these demanding requirements.”

7. Uptime

By stacking multiple installed generating units, higher plant availability is maintained whenever one engine is down for scheduled maintenance. Plant output is only slightly reduced, while the other installed engines continue to run. J920 Flextra gas engine flexible solutions for customer needs . GE offers extended scope of the power plant solution and enables developers to bring together commercial turnkey solutions.

8. Emissions reduction

The low-emission technologies present within the J920 Flextra gas engine comply with relevant U.S. Environmental Protection Agency emissions regulations.

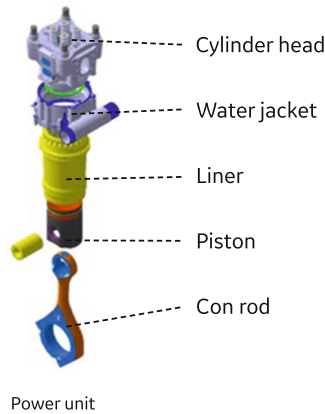
Ease of maintenance

Life cycle management: The right service at the right time—throughout the lifetime of your J920 Flextra engine



The J920 Flextra engine has three major sections: the turbocharger module (TCM), the generator and the engine itself. Once all three devices are mounted, no separation is required during maintenance intervals. All major parts can be serviced from the top without disassembling other components or modules. The main engine one-ton power unit comprises the cylinder head, piston, cylinder liner, conrod and other significant components. Its compact design and individually mountable main assembly

reduces onsite labor time during routine maintenance as the whole unit can be lifted in and out of the crankcase. The J920 Flextra engine, connected to GE's remote monitoring center, ensures that all key engine parameters are actively monitored and can self-adjust for better operating behavior. When support is indicated, experienced service technicians can log in to the motor management system to manage the engine directly and resolve issues. Alternatively, alerts can be sent to plant personnel for local resolution.

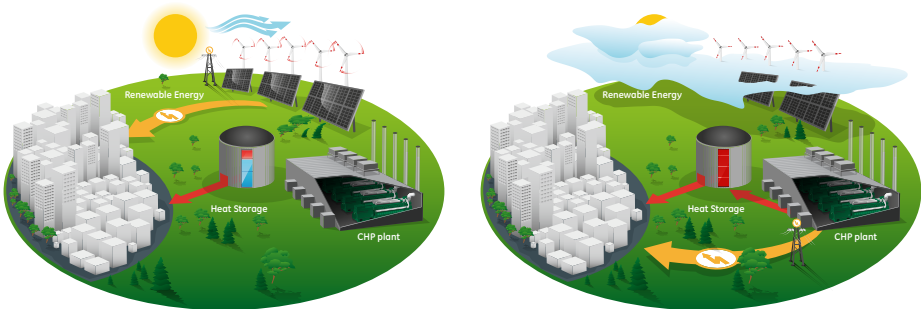


Case study

Rosenheim CHP plant

Stadtwerke Rosenheim is a typical CHP power plant in a German city. It supplies water, electricity, gas, process steam and district heating to residential and industrial customers. With the addition of GE's J920 Flextra gas engine in 2013, this CHP plant generates about 40 percent of the town's electricity and about 20 percent of its heating requirements. Gas engines form a critical piece of the municipality's energy strategy. Given the fast-growing presence of renewable energy sources such as wind and solar power, it became necessary to establish a more flexible energy supply infrastructure.

The Rosenheim CHP plant stores heat in hot water tanks, so the town's gas engines do not need to be constantly operating. As wind and solar energy supplies become available, the facility can switch to these power sources. Heat storage means homes can stay warm without the need to run the reciprocating engines. And, during summertime, when district heating is no longer necessary, the J920 Flextra gas engine supplies peaking and balancing power to the municipality's electricity distribution network.



Over the past decade, many residents of Rosenheim have installed rooftop solar panels, which can add as much as 10 MW to the local grid. But sudden weather changes can cause fast spikes in solar power. The city must compensate for those spikes with its own assets in order to maintain the power balance and stabilize the grid.

Therefore, it is essential to have fast-reacting power generation from gas engines. Because the J920 Flextra gas engine can provide the same flexibility as a smaller gas engine at a much higher electrical efficiency, it is always the first engine to dispatch for peaking power in Rosenheim.



A J920 Flextra large gas engine CHP project with heat storage provides flexible power for the city of Rosenheim. This represents an optimal enhancement for the use of renewable resources, such as wind or solar farms

HanseWerk Natur
CHP plant (Stapelfeld)

HanseWerk Natur's CHP power plant in Stapelfeld is currently North Germany's largest engine cogeneration plant, designed to meet the government's ambitious climate protection targets. GE's high-efficiency 9.5 MW J920 FleXtra gas engine at the heart of the facility works in conjunction with a waste-to-energy plant as well as 19 additional heating plants, combined heat and power systems, and multifunction storage and hybrid plants.

The new facility can supply up to 76 million kWh of electric power annually – enough to power about 21,500 households. In addition, up to 80 million kW of heat can be recovered for more than 6,000 average North German single-family houses. Heat storage units integrated into the plant ensure that the heat supply is maintained at peak load times as well as when the engine is switched off due to high feed-in of renewable energy.

HanseWerk Natur and GE in Jenbach worked together to create a High Efficiency Power Generation (HEPG) model that combines the cogeneration plant with an industrial heat pump, allowing a portion of the J920 FleXtra's waste heat to be optimally used as thermal energy and fed into the heating circuit. In total, the heat pump can increase the annual heat output of the power plant by up to 6.7 million kW.

A prime example of the energy transition under way in Germany, the highly efficient HanseWerk Nature CHP plant provides numerous advantages to operators, customers, and the environment. Simultaneous generation of electric power and heat can conserve up to 35 percent of the primary energy used as well as reduce CO₂ emissions by 60 percent – or more than 11,000 tons per year. The plant's rapid- starting J920 FleXtra gas engine is ideally suited for grid stabilization, a factor growing in importance with increased power generation coming from solar and wind farms in the country.

| | |
|--------------------|-------------|
| Engine performance | 9,513 kW |
| Thermal output | ~ 10,000 kW |
| Total efficiency | > 95 % |



High Efficiency Power Generation (HEPG) circuit combined with an industrial heat pump

Sky Global Power One
power plant

Six of GE's ultra-fast, natural gas-fired Jenbacher J920 FleXtra generator sets are powering the 51 MW Sky Global Power One power plant, which opened in April 2016 in Colorado County, TX, as the largest J920 FleXtra project in North America. The GE units, which also are designed to provide baseload power and combined heat and power (CHP) in industrial settings, deliver high efficiency that reduces fuel consumption and lifetime operational costs.

| | |
|--------------------------------|----------|
| Electrical output (6 units) | 51.42 MW |
|--------------------------------|----------|

The plant implements a long-term partnership between owner-operator Sky Global Partners and the San Bernard Electric Cooperative (SBEC) to provide peaking power to SBEC, which supplies electricity to more than 18,000 members in a seven-county region in south central Texas.

With Texas accounting for one-tenth of total U.S. energy use, and the state's population growing steadily, power supply is having a hard timing keep up with the growing frequency of peak events. Sky Global required a high-performance generating solution that furnished clean, affordable energy, operational flexibility, dependability in emergencies, and capabilities that supported the dynamic ERCOT (Electric Reliability Council of Texas) electricity exchange and its potential to increase revenues.



GE's J920 FleXtra gas engines meet those criteria. Not only do the 8.6 MW units efficiently handle peaking pressures, they can also black start in case of a supply line power interruption and run in island mode to generate power for customers during a grid outage. Another plus is that the plant uses no more water than a single residence.

Ecomagination qualification

As an ecomagination-qualified product, the J920 FleXtra gas engine is the world's most flexible solution for power generation. Ecomagination qualification is GE's commitment to build innovative answers to today's environmental challenges while driving economic growth. The process for ecomagination qualification requires rigorous efforts to drive greater product efficiency and improve environmental performance for the customer, while using fewer resources.

Under the ecomagination criteria, the J920 FleXtra gas engine for combined heat and power has extensive operational and environmental benefits. GE's J920 FleXtra 10.4 MW spark-ignited gas engine for combined heat and power applications is designed to achieve overall efficiency of more than 90 percent, reducing fuel consumption compared to the separate production of heat and electricity. Over the course of a year, a J920 FleXtra engine operating at full load is designed

to require more than 130 million kWh less primary energy input compared to the separate production of heat by a typical natural gas-fired boiler and the delivery of electricity on the EU grid, equivalent to the energy contained in more than 76,000 barrels of oil. As a significant member of the ecomagination portfolio for reciprocating engines, the J920 FleXtra gas engine is designed to increase efficiency while satisfying and exceeding environmental standards.

