GTCC

Gas Turbine Combined Cycle
Power Plants
Power grows when we all work together.

There is a strong demand for energy decarbonization in the world today. One in ten people is forced to live without reliable access to electricity, while global demand for power continues to grow. Mitsubishi Power, Ltd. addresses such needs by providing stable, highly reliable, and clean energy solutions.

Mitsubishi Power, a core subsidiary of Mitsubishi Heavy Industries Group based on a long history of product development and supply for more than a century, has been dedicated to designing, manufacturing, verifying, engineering, installing and providing services for a wide range of proprietary power generation systems.

One of our products is gas turbine combined cycle (GTCC) power plants, which provides incredibly efficient electric power while reducing CO₂ emissions. We also provide next-generation power systems, such as integrated coal gasification combined cycle (IGCC) power plants, steam power plants, geothermal power plants, air quality control systems (AQCS) and digital solutions MHI-TOMONI. Mitsubishi Power is creating a future that works for people and the planet by developing innovative power generation technology and solutions to enable the decarbonization of energy and deliver reliable power everywhere.
What makes GTCC the most suitable choice?

### The key advantages of GTCC thermal power plants

<table>
<thead>
<tr>
<th>High level of thermal efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>In comparison with steam power plants, which offer a thermal efficiency of about 40%, combined cycle power plants deliver a thermal efficiency of about 60% (both figures are based on lower heating values).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Less impact on the natural environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Less carbon dioxide (CO₂)</td>
</tr>
<tr>
<td>- Less nitrogen oxides (NOₓ) and sulfur oxides (SO₂)</td>
</tr>
<tr>
<td>- Less high-temperature wastewater</td>
</tr>
<tr>
<td>- Less water consumption compared to coal generators</td>
</tr>
</tbody>
</table>

**Clean, high-efficiency power**

Gas turbine combined cycle (GTCC) power plants use natural gas to deliver one of the cleanest and most efficient forms of power. Plants employing Mitsubishi Power’s cutting-edge J-series gas turbines are 20% more efficient than conventional coal-fired power plants and have attained the world’s highest level of efficiency of more than 64%.

What’s more, the system’s high efficiency reduces CO₂ emissions by about 50%. Mitsubishi Power installed the first combined cycle power plant for a Japanese power company in 1971. Since then, we have installed numerous units for various customers who depend on Mitsubishi Power not only for the supply and installation of power plants, but also a wide range of ongoing services including inspections, maintenance and MHPS-TOMONiX digital solutions.
How Mitsubishi Power helped deliver low-emission GTCC power to Oklahoma

In 2014, Mitsubishi Power signed a contract to supply a natural gas powered MED1 Gas Turbine, Steam Turbine and associated electric generators to the Grand River Dam Authority (GRDA). The power generation equipment was designed for the GRDA’s new Unit #3 power generation facility in Chouteau, Oklahoma, USA. Also, as part of the project, GRDA signed a 25-year long term service agreement with Mitsubishi Power.

Manufactured at Mitsubishi Power’s main US production facility in Savannah, Georgia, this project was delivered on schedule as the first order for a state-of-the-art 2-stage gas turbine for the US market. Only two days after it achieved successful First Fire on March 14, 2017, it synchronized to the grid to deliver electricity for GRDA.

**First 60 Hz plant to achieve 63% efficiency**

The Oklahoma plant is the first 60 Hz plant in the world to achieve an efficiency of 63%. During the smooth startup process, the MS01J turbine exceeded its performance guarantees and GRDA was selling power to the grid ahead of schedule.

**First Fire was well ahead of schedule**

“It has been my privilege to work with the technology team assembled to create Unit 3 at the Grand River Energy Center,” said Charles J. Barney, Executive Vice President of GRDA.

“These partners all shared our vision to set a new standard for efficiency and reliability. Each partner contributed their best engineers and constructors, and I congratulate them on their exceptional accomplishment. This ultra-efficient electric generator is now integrated with our hydro and wind generation, and will help assure that GRDA customers have low-cost, clean and reliable electricity for many decades,” said Mr. Barney.

Because Mitsubishi Power is focused on GTCC power solutions that reduce environmental burdens, this project is another example of how Mitsubishi Power GTCC technology is playing a key role in preserving the planet by lowering CO2 emissions.
Mitsubishi Power gas turbines made with cutting-edge technology

Small and medium capacity gas turbines (61 MW to 116 MW)
- H-26-series
- H-100-series

Large capacity gas turbines (116 MW to 563 MW)
- M501J-series
- M501G-series
- M501D-series

For 40 Hz
- M501J-series
- M501F-series
- M501D-series

For 50 Hz
- M701J-series
- M701F-series
- M701G-series
- M701D-series

Aero-Derivative Gas Turbines (30 MW to 140 MW)
- FT® MOBILE PAC®
- FT® SWIFT PAC®
- FT®4000D SWIFT PAC®

Powering the world with a full range of gas turbines

To meet the power demands of industries and societies around the world, Mitsubishi Power produces a wide range of gas turbines from the 30 MW to the 563 MW class for power generation and industrial use. These turbines drive the development and supply of highly efficient, clean energy around the world. In fact, Mitsubishi Power has delivered more than 1,500 gas turbines to customers in more than 50 countries worldwide.

Gas Turbine and Combined Cycle Output

Thermal Efficiency of Combined Cycle Systems
Development of the air-cooled JAC-series

The JAC-series gas turbines use air cooling for combustors instead of steam cooling. With performance equivalent to the J-series gas turbines, they produce a high level of reliability including a shorter start-up time.

Advantages of the JAC-series

While the flow path of the compressor and the turbine has the same shape as that of the J-series, the JAC-series has a cooling structure for the blades and vanes of the turbine, which is optimized according to the air-cooled combustor. The combustor uses the air cooling system that has proven its effectiveness and reliability in the GAC-series. JAC-series turbines also feature the low NOx technology used in the J-Series.

The latest models in the J-series and the JAC-series gas turbines. In combined cycle operation, the JAC-series achieves power generation efficiency of more than 44%.

The air cooling system, already verified at Mitsubishi Power’s 1-Point validation facility, has the following features:

- Exhaust heat from the external cooler is recovered in the bottoming cycle in a system that offers excellent efficiency.
- The combustor cooling mechanism is optimized to produce cooling performance equivalent to that of steam cooling.
- This system starts up faster than the steam cooling system.

High-capacity gas turbines for power generation incorporating cutting-edge technologies

J-series gas turbines build on the proven G-series design with advanced technologies developed as part of a Japanese government’s national project to develop a class of gas turbines that have a turbine inlet temperature (TIT) of 1,700°C.

The J-series, with a TIT of 1,600°C is well on its way to meeting the Project’s goal.

Compressor

Advanced 3D design techniques were used to improve the performance and reduce the shockwave loss in the intermediate and final stages. This concept was evaluated using 3D computational fluid dynamics (CFD) software and verified using a full-scale, high-speed research compressor. In addition to variable inlet guide vanes used to modulate air flow, J-series gas turbines are equipped with three variable vanes at the front stages of the compressor. The four stages operate together to modulate the gas turbine air flow, in order to maintain a relatively high exhaust temperature (at load) for improved bottoming cycle efficiency.

Turbine

The blades of turbine rows 1 to 6 are cooled by compressor bleed air, which is cooled by an external air cooler. The vanes of turbine rows 1 to 4 are also air cooled, with row 1 vane cooled by compressor discharge air, and the remaining vane rows are cooled by compressor intermediate stage bleed air respectively. The cooling structure was improved for the G-series turbine, and again for the J-series.

The application of high-performance film cooling, developed as part of the Japanese Government’s National Project, further offsets the temperature increase.

The metal temperature is maintained at the same level as the J-series by utilizing the 1,700°C technology developed in the Japanese National Project. The 100°C (180°F) temperature increase from the G-series to the J-series is offset in part by an advanced thermal barrier coating (TBC).

Compressor

- Turbojet engine
- Advanced thermal barrier coating (TBC)
- Turbojet engine (J-series technology)
- Gas turbine (G-series technology)
- Mitsubishi Gas turbine (MGT) technology
- High-speed cooling technology
- Advanced thermal barrier coating (TBC)
- Turbojet engine technology
- Mitsubishi Gas turbine (MGT) technology
- Material development (metallic single-crystal)
Gas turbines for power generation to accommodate diverse fuels

In 1991, MitsubishiPower developed the M501F-series gas turbines for 60 Hz power generation. The following year, it developed the M701F-series for 50 Hz power generation with similar design features.

Since then, Mitsubishi Power has continued to improve the design of F-series gas turbines. While introducing advanced elemental and material technologies verified by the G-series’ proven track record, the F-series attains continuous performance enhancement.

**Compressor**
Variable inlet guide vanes ensure operational stability at start-up and enhanced performance at partial load in combined cycle operation.

**Combustor**
A premixing low-NOx combustor is composed of a pilot burner surrounded by eight main burners. The combustor has an air bypass mechanism that enables regulation of the fuel-air ratio in the combustion region.

**Turbine**
The rotating blades on the first two stages are free-standing, while the third and fourth stages are integral shroud blades. Stationary vanes are supported by blade rings that are independent at individual stages to prevent turbine casings from being affected by thermal expansion.

High capacity to high output gas turbines for power generation

In February 1997, the first M501G gas turbine with a TIT of 1,300°C entered commercial operation. This series features the use of steam for cooling combustors. The GAC-series, which is the current mainstay model, uses the latest air-cooled combustor technology in place of conventional steam-cooled combustors. Using compressor discharge air for cooling combustors to add operational flexibility by eliminating the need for steam for cooling from the bottoming cycle.

**Compressor**
The GAC uses the existing proven G-series compressor. The advanced axial designs were incorporated to support a large volume, higher efficiency and higher pressure ratio. Variable inlet guide vanes operate to modulate the gas turbine air flow to maintain relatively high exhaust temperatures (at part load) for improved bottoming cycle efficiency.

**Combustor**
The M501GAC has 14 annular combustor cans. The combustor is an ultra-low-NOx design with a single pilot nozzle for diffusion firing surrounded by eight nozzles for premixing firing. Innovations such as an air-cooled, dry-low-NOx combustor and the latest blade technology have been incorporated into the GAC following stringent element and operational model tests.

Similar to the proven steam-cooled G-series, the advanced GAC adds operating flexibility by eliminating steam cooling needs from the bottoming cycle.

**Turbine**
The G-series employs a 3D aerodynamic design in a four-stage axial reaction turbine. Directional solidified (DS) materials with thermal barrier coating (TBC) are applied to the first two stages and the first three stages are air-cooled. The turbine blade rows to 3 are cooled by the compressor bleed air, which is cooled by the external air cooler. The vanes of turbine rows 1 to 3 are also air cooled, with the vanes of row 1 cooled by compressor discharge air. The remaining rows of vanes are cooled by intermediate stage compressor bleed air. Each row of vane segments is supported in a separate blade ring, which is keyed and supported to permit radial and axial thermal response independent of possible external cylinder distortions.
Shared Features of the A-, F- and G-series

Designs backed with 40 years of experience

The A-, F- and G-series incorporate basic design features and concepts developed over 40 years of experience, such as cold-end generator drive, single shaft rotor construction and axial exhaust.

Gas turbines that are easy on the natural environment

- Most efficient use of fossil fuel resources
- Low NOx, CO, UHC and VOC emissions

Overall design

First deployed in the early 1970s, these gas turbines are based on over 40 years of proven experience. The main features are:

- The compressor shaft and drive reduces the effect of thermal expansion on alignment and eliminates the need for a flexible coupling (cold-end generator drive).
- The rotor has a two-bearing structure to support the compressor and turbine ends.
- An axial flow exhaust structure is used to optimize the combined-cycle plant layout.
- Horizontally split casing facilitates field removal of the blades with the rotor in place.

Flexible configurations

Based on our sophisticated combined cycle plant technology and diverse product applications, we not only offer our customers multi-shaft arrangements such as a 2 on 1 configuration, but also a 1 on 1 configuration with the gas turbine, steam turbine and generator connected on the same shaft.

Typical Plant Layout

Simple-shaft 1 on 1 configuration

Aero-Derivative Gas Turbines

Aero-Derivative

- Simple Cycle Efficiency
- More than 41% (ET4000)
- Quick start-up
  - In 5 minutes
- Cooling water not required
- Compact Layout
- Mobile package available for quick delivery

Aero-Derivative Gas Turbine Package

PW power systems (PWPS) supply aero-derivative and industrial gas turbines. PWPS has installed more than 550* industrial gas turbines in over 50 countries worldwide and prides itself on its superior gas turbine repairs and overhauls. The portfolio of PWPS gas turbines offers competitive, efficient and flexible products generating from 30 to 140 MW of power in ET8*, ET4000*.

PWPS gas turbines PWPS gas turbines PWPS gas turbines
**H-25 series**

**Simple Cycle Output**
- 41 MW

**Combined Cycle Output**
- 60-121 MW (1 on 1; 2 on 1)

**Co-generative Efficiency**
- More than 80%

**High Reliability**
- Cumulative total operating time exceeds 6.3 million hours

**Package design advantages**
- Minimizes on-site installation work and time
- Flexible layout
- Short delivery period

**Advantages of the H-25 series**
- Heavy duty structure: A highly reliable design with a focus on ease of maintenance and long continuous operation
- High efficiency: High performance in various power generation cycles (simple, combined and co-generation)
- Fuel flexibility: Natural gas, off gas, syngas, (light oil, kerosene, and bio-ethanol)
- Package: Easy to transport and install

**H-100 series**

**Simple Cycle Output**
- 106-116 MW

**Combined Cycle Output**
- 150-171 MW / 306-364 MW (1 on 1; 2 on 1)

**Stand-alone Gas Turbine**
- Quick start-up in 10 minutes

**Suited to power generation and mechanical drive applications**

**The world’s largest high-efficiency two-shaft gas turbines**

Developed as the world’s largest high-efficiency two-shaft gas turbines, the H-100 series was designed for utility and industrial customers in both 50 Hz and 60 Hz markets. The first unit went into commercial operation in 2010. Mitsubishi Power is always seeking to improve the design of the H-100 series gas turbines by incorporating advanced elemental and material technologies proven by H-25 series’ performance.

**Advantages of the H-100 series**
- Heavy duty design: A heavy and highly reliable structure focused on ease of maintenance and long term continuous operation
- High efficiency: Exceptional performance in various power generation cycles (simple, combined and co-generation)
- Packaging: Easy to transport and install
- The series is applicable not only for power generation but also for mechanical drives.

**For co-generation plants**

A co-generation plant with the H-100 series gas turbine produces the highest steam supply volume in the turbine class and high thermal efficiency. Mitsubishi Power offers system engineering on requests for a combination of electric power and steam.

**System Configuration**

- Fuel
- Air
- Steam
- Generator
- H-25 Gas Turbine
- Water

**Package design advantages**
- Minimizes on-site installation work and time
- Flexible layout
- Short delivery period

**Mechanical drive applications**

H-100 series gas turbines are suitable for mechanical drive applications, especially for driving compressors in LNG plants.

**Features**
- H-100-series models are suitable for 4 to 6 million tons per annum (MTPA) class LNG plants.
- Variable speed operation.
- Start-up with a fully loaded compressor.
- No helper motor or variable frequency driver (VFD) required.
- High nitrogen (N₂) fuel applicability.
- Over 99% reliability.
- Integrated into a gas turbine and compressor package in collaboration with the MH Group's Mitsubishi Heavy Industries Compressor Corporation.
Mitsubishi Power promotes improving power plant availability and the maximization of customers’ asset value by providing long-term service agreements covering all aspects of maintenance for specified periods, reducing the risks associated with plant operation and maintenance and shortening the period of regular inspections and performance upgrades.

Mitsubishi Power provides a one-stop solution for generating equipment and air quality control systems with MiPS®/TOMiN® Digital Solutions.

Solutions to improve thermal efficiency
Our upgrade programs apply advanced technologies used in the latest gas turbines to improve the competitiveness in service plants. The upgrade program for the MT01F-series can achieve a 1.5% improvement in the heat rate by applying the latest F-series gas turbine technologies. In addition, the small/medium-sized M-25F-series gas turbines can be upgraded with the latest turbine parts to achieve a 2% performance improvement in heat rate.

Solutions to improve availability
We offer technical services for improving power plant availability. Those include:
- Shortening the duration of inspection outages through maintenance-friendly product design.
- Providing highly reliable products that use the latest technologies.
- Optimizing maintenance initiatives such as extension of inspection intervals and diagnostic analysis of operating conditions.
- Using remote monitoring services for early prediction or detection to reduce forced outages.

Solutions to improve plant operability
Due to an increase in renewable energy, more flexible operations are required for gas turbine combined cycle power generation. We have developed various programs in response to market needs that reduce gas turbine start-up time, improve load change rate, reduce downtime, optimize restart time and turnaround to enable operation at lower load while improving emissions.

Solutions for power augmentation
We provide solutions that respond to the increase in output of existing GTCC units due to changes in market and economic situations. Among our distinctive technologies, we offer a wide line-up of services including water/steam injection, wet air cooling systems such as fogging systems, evaporative coolers and chillers and an air injection system to increase working air.

Remote monitoring centers
Remote monitoring centers (RMC) have been established in key regions around the world, and our experts in operations and maintenance monitor operating conditions under a 24-hour system. The system provides warnings and detections of anomalies, as well as diagnoses of loss-based performance on operating data that is constantly updated. Customers are provided optimal advice depending on the situation at all times, helping to prevent trouble and maximize each plant’s operations.

Offering long term service agreements (LTSA) for power plants
Mitsubishi Power offers customers-focused solutions which enable operators to achieve top-in-class levels of power plant availability, and in turn help secure the reliability of the overall grid. In designing our LTSA-based solutions, Mitsubishi Power focuses on optimizing plant operations while minimizing maintenance costs, taking responsibility for planning maintenance programs, spare parts supply, dispatch of technical advisors, remote monitoring, and more.

Key support areas of Mitsubishi Power LTSA
- Short and long-term maintenance to minimize plant downtime and optimize operation/maintenance costs.
- Optimization of the LTSA scope and spreading of maintenance costs expenditure over time to minimize customers’ operating costs.
- Supply of quality replacement parts and technical support from highly experienced engineers.
- Utilization of remote monitoring and operating data diagnostic systems to assist with general plant optimization, including fuel change-overs, operating load changes, maintenance interval extensions and more.
- Provision of business risk minimization solutions, such as ways to contend with decreased demand, unexpected plant outages and fluctuations in currency exchange rates.

Operation and maintenance
Mitsubishi Power enables optimal parts replacement timing through constant analysis of remote monitoring data preventing unforeseen outages. In addition to pre-determined offerings, Mitsubishi Power provides a flexible service menu that can be tailored to meet a truly diverse range of customer needs including preventive maintenance based on analysis of big data.

Better operational systems
Based on the operational status of individual plants, Mitsubishi Power offers customized operation plans for each power plant and supports customers in achieving high levels of efficiency and reliability.

Better maintenance plans
Based on a deep understanding of key equipment and operating conditions, Mitsubishi Power determines the optimum inspection interval to help our customers maximize operating efficiencies and equipment life.

Simulator guided operation and maintenance training
Mitsubishi Power provides simulator-based operations and maintenance training programs.
Validation facility

T-point at Mitsubishi Power’s Takasago Works

Purpose
- To validate gas turbine technologies newly applied to achieve higher efficiency, allow operations at elevated temperatures, and reduce NOx.
- To validate the reliability through long-term commercial operations of the highly efficient and environmentally friendly combined cycle power generation.

History
The unit T power plant (T-point) equipped with the M501G-series gas turbine and performance and reliability tests were conducted since 1997, and long-term validation tests had been successfully completed. Then, in February 2011, the gas turbine was replaced with the M701J-series and the commissioning was completed safely in the same year. In 2015, the unit was upgraded to forced air-cooling system. The unit T power plant (T-point) upgraded and replaced T-point started commercial operation in July 2020 with its cutting edge M501JAC-series gas turbine.

Validation of Next Generation Combined Cycle Power Generation

With its combination of gas turbine and steam turbine, T-point 2 is cutting edge combined cycle power plant validation facility. By developing next generation technologies and validating them in T-point 2 OTGC facilities, Mitsubishi Power helps its customers world-wide attain a stable electricity supply.

Long term demonstration of off-site plant control at T-point 2 is conducted from the Mitsubishi Power “Takasago PMC (Remote Monitoring Center). Validation operations are run to increase the reliability of the entire plant including the main equipment such as turbines as well as auxiliary equipment such as pumps and fans. In addition, various applications of MHPS-TOMONI Digital Solution provide new operation parameters of solutions that serve to shorten startup times automatically optimize operation parameters are installed in T-point 2. Mitsubishi Power will also be training its AI applications, allowing T-point 2 to eventually become the world’s first autonomous combined cycle power plant.

Comprehensive capabilities from Development to Manufacturing

Mitsubishi Power is the only company in Japan that handles the entire production process from development, design, manufacturing, construction and commissioning to after sales services for large capacity power plants and their core equipment using its own technologies. For thermal power plants requiring advanced technology and reliability, we capitalize on our comprehensive approach to play a major role.

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**Features of MHPS-TOMONI.**
- MHPS-TOMONI is composed of three solution categories: O&M Optimization, Performance Improvement, and Flexible Operation. The combination of these categories allows us to deliver optimal solutions.
- From utility to industry power plant, MHPS-TOMONI is applicable to a wide variety of power plants.
- MHPS-TOMONI is able to customize for a variety systems such as cloud and edge computing as well as customer’s existing platforms.
- Combining AI and Mitsubishi Power’s knowledge and knowhow, the company has enabled the development of solutions to optimize the operations of the power plant to meet customer’s demands.

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**Roadmap for MHPS-TOMONI.**

- **Autonomous Operation**
  - Optimize operations in response to changes in environment
  - Minimize maintenance costs, improvement reliability

- **Advanced operation and maintenance**
  - Network technologies and OTG technology to social OTM
  - AI directly feeds customer’s experience and process data to enhance performance and efficiency performance through equipment maintenance and timely operations

- **Remote monitoring / assets utilization**
  - Remote monitoring
  - Data analysis
  - Performance degradation
  - Technological development and design based on the world’s leading-edge technologies
  - Development of the latest design and analysis tools
  - New product development
  - Design of independent technologies
  - Manufacturing high-quality products
  - Manufacturing of principal components in Mitsubishi Power facilities
  - Blades and valves of turbines
  - Combustors
  - Turbines
  - Casings and more

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**Table:**

<table>
<thead>
<tr>
<th>Year-Operation Started</th>
<th>1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Type</td>
<td>T-point 1</td>
</tr>
<tr>
<td>Capacity</td>
<td>560/212MW</td>
</tr>
<tr>
<td>Turbine</td>
<td>M501G</td>
</tr>
<tr>
<td>Gas Temperature</td>
<td>1,390°C</td>
</tr>
<tr>
<td>Gas Temperature</td>
<td>1,390°C</td>
</tr>
<tr>
<td>Gas Temperature</td>
<td>1,390°C</td>
</tr>
</tbody>
</table>

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**Figure:**

- T-point at Mitsubishi Power’s Takasago Works
- Validation facility
- Comprehensive capabilities from Development to Manufacturing
- Roadmap for MHPS-TOMONI.

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**Research & Development**

- Design
- Manufacturing

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**Verification in T-point**

- Calibration of power plant
- After sales service of real facilities
- One of the world’s largest on-site testing facilities
- A combined cycle power plant is installed at Mitsubishi Power’s own plant, offering practical operation validation
### Performance

#### Simple Cycle Specs

<table>
<thead>
<tr>
<th>B8a Base Rating (kVA)</th>
<th>PLF Heat Rate (Btu/kWh)</th>
<th>Efficiency (%)</th>
<th>Pressure Ratio</th>
<th>Turbine Speed (rpm)</th>
<th>Exhaust Flow (lbs/hr)</th>
<th>Exhaust Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50kW</td>
<td>116,500</td>
<td>9,620</td>
<td>8,910</td>
<td>39.3</td>
<td>18</td>
<td>3,000</td>
</tr>
<tr>
<td>50kW</td>
<td>195,000</td>
<td>9,750</td>
<td>9,230</td>
<td>37.0</td>
<td>14</td>
<td>3,600</td>
</tr>
<tr>
<td>100kW</td>
<td>852,000</td>
<td>8,352</td>
<td>8,630</td>
<td>44.0</td>
<td>25</td>
<td>3,000</td>
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<tr>
<td>100kW</td>
<td>320,000</td>
<td>8,052</td>
<td>8,150</td>
<td>42.1</td>
<td>23</td>
<td>3,600</td>
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<tr>
<td>100kW</td>
<td>625,000</td>
<td>8,182</td>
<td>7,755</td>
<td>46.0</td>
<td>25</td>
<td>3,600</td>
</tr>
</tbody>
</table>

#### Combined Cycle Specs

| B8a / 66kA | 40,100 | 6,447 | 6,379 | 50.0 | 39,600 | 20,500 | 1:1+25 |
| B8a / 66kA | 121,400 | 6,694 | 6,261 | 50.5 | 77,200 | 62,200 | 2:1+25 |

#### Mechanical Drive Specs

<table>
<thead>
<tr>
<th>B8a Base Rating (kVA)</th>
<th>PLF Heat Rate (Btu/kWh)</th>
<th>Efficiency (%)</th>
<th>Pressure Ratio</th>
<th>Turbine Speed (rpm)</th>
<th>Exhaust Flow (lbs/hr)</th>
<th>Exhaust Temp (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100kW</td>
<td>144,770</td>
<td>9,265</td>
<td>4,652</td>
<td>38.9</td>
<td>18</td>
<td>3,600</td>
</tr>
<tr>
<td>100kW</td>
<td>140,740</td>
<td>9,264</td>
<td>4,614</td>
<td>38.9</td>
<td>20</td>
<td>3,600</td>
</tr>
</tbody>
</table>

#### Aero-Derivative Gas Turbines

| B8a / 66kA | 28,528 | 10,376 | 9,834 | 24.7 | 3,000 | 92     | 496   |
| B8a / 66kA | 70,134 | 8,812 | 8,352 | 40.9 | 3,000 | 182    | 423   |
| B8a / 66kA | 143,376 | 9,808 | 8,348 | 40.9 | 3,000 | 364    | 423   |

| B8a / 66kA | 30,961 | 9,825 | 9,312 | 36.7 | 3,600 | 92     | 491   |
| B8a / 66kA | 70,826 | 8,725 | 8,249 | 41.3 | 3,600 | 182    | 418   |
| B8a / 66kA | 141,567 | 8,702 | 8,248 | 41.4 | 3,600 | 364    | 418   |

### Notes:
1. All ratings are defined at 60% PLF and 10% MCR, 25°C Ambient.
2. The ratings and performance factors are based on the use of flue gas fans.
3. Without flame and exhaust booster.