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

Today, one in six people around the world lives without reliable access to electricity, while global demand for power continues to grow. The mission of Mitsubishi Hitachi Power Systems, Ltd. (MHPS) is to address these needs by providing more affordable, highly reliable and cleaner energy solutions.

MHPS was born through the merger of the thermal power generation divisions of Mitsubishi Heavy Industries, Ltd., and Hitachi, Ltd. in 2014. Based on our parent companies' long histories of product development and supply for more than a century, we have been dedicated to designing, manufacturing, validating, engineering, installing and providing support services for a wide range of proprietary power generation systems.

One of our products is the gas turbine, the engine of gas turbine combined cycle (GTCC) power plants, which provides incredibly efficient electric power while reducing greenhouse gas emissions. We also provide multi-generation thermal power systems such as integrated coal gasification combined cycle (IGCC), power plants, steam power plants, peat thermal power plants, oil and gas control systems (OGCS) and digital solutions MPI-TDMON+. We will continue our mission to address power needs by developing technologies that enhance the global environment and provide affordable, sustainable, reliable power for the planet.

Power for a Brighter Future
GTCC Power Plants
Delivering high-efficiency energy through combined cycle power generation

What makes GTCC the most suitable choice?

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. Plans employing MHPS’ cutting-edge low-emission gas turbines are 24% more efficient than conventional coal-fired power plants and have achieved 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% compared to the fossil-fuel combined cycle power plants for a baseline power company in 2012. Since then, we have installed numerous units for various customers who depend on MHPS not only for the supply and installation of powerplants, but also a wide range of ongoing services including operations, maintenance and MHPS’ 100% OEM software solutions.

The key advantage of GTCC thermal power plants

- High level of thermal efficiency
- In comparison with steam power plants, which offer a thermal efficiency of about 60%, combined cycle power plants deliver a thermal efficiency of about 85% (both figures are based on lower heating values).

Less impact on the natural environment
- Less carbon dioxide (CO₂)
- Less nitrogen oxides (NOx) and sulphur oxides (SOx)
- Less high-temperature emissions
- Less water consumption compared to coal generation

Power Generation Cycle

- Fuel
- Gas Turbine
- Steam Generator
- Combined Cycle Power Plant
- MHPS On-grid Facility
- Verification Testing
- Combined Cycle Power Plants
- Waste Output Range
- More than 64% (LHV)
- 30-1,285 MW
- (1 on 1 / 2 on 1 / 3 on 1)

GTCC

Delivering high-efficiency energy through combined cycle power generation

- World class highest efficiency
- More than 64% (LHV)
- Waste Output Range
- 30-1,285 MW
- (1 on 1 / 2 on 1 / 3 on 1)
- Combined Cycle Power Plants
- Verification Testing
- MHPS On-grid Facility
- CO₂ Emission
- Anaerobic 50% lower compared with those of coal-fired thermal power generation
How MHPS helped deliver low-emission GTCC power to Oklahoma

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

The MHPS GT26 was delivered on time to the site and accepted into service in its first attempt on March 14, 2017. Only two days later, it was synchronized to the grid and delivered electricity for GRDA. Since then, the facility has conducted steam allowed for scheduled and additional operation on the unit, while operating in combined cycle in April 2017. Less than 40 days after first fuel, the unit has successfully demonstrated reliable operations achieving GRDA’s “World Class” power and reliability.

Grand River Power Plant

Customer: Grand River Dam Authority
Output: 301 MW
Start of Operation: 2017
Model: GT26

Novo Magnitogorsk Power Plant

Customer: Novo Energia
Output: 1,388 MW
Start of Operation: 2017
Model: M501G

Dhanalakshmi Power Plant

Customer: Tamil Nadu Power Corporation Limited
Output: 1,460 MW
Start of Operation: 2017
Model: M501G

Bhaswam Power Plant

Customer: Bangladesh Power Generation Company Limited
Output: 301 MW
Start of Operation: 2018
Model: M501G

Delhi Power Plant

Customer: National Thermal Power Corporation
Output: 1,000 MW
Start of Operation: 2016
Model: M501G

Karnam Power Plant

Customer: Philippine Independent Power Producers
Output: 70 MW
Start of Operation: 2016
Model: M501G


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**CASE STUDY**

How MHPS helped deliver low-emission GTCC power to Oklahoma

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Because MHPS is focused on GTCC power plants that reduce environmental impact, the project is another example of how MHPS GTCC technologies provide a key role in producing the planet-saving CO2 emissions.

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**Project Summary**

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Grand River Power Plant (USA)</th>
<th>Delhi Power Plant (India)</th>
<th>Karnam Power Plant (Philippines)</th>
<th>Novo Magnitogorsk Power Plant (Russia)</th>
<th>Dhanalakshmi Power Plant (India)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td>GRDA</td>
<td>Tamil Nadu Power Corporation Limited</td>
<td>National Thermal Power Corporation</td>
<td>Novo Energia</td>
<td>PHILIPPINE INDEPENDENT POWER PRODUCERS</td>
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<tr>
<td>Output</td>
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<td>70 MW</td>
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</tr>
<tr>
<td>Model</td>
<td>GT26</td>
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</table>
Gas Turbines
Raising the world’s standards for capacity and efficiency

MHPS gas turbines made with cutting-edge technology

<table>
<thead>
<tr>
<th>Model</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA200</td>
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</tr>
<tr>
<td>NA300</td>
<td>300</td>
</tr>
<tr>
<td>NA400</td>
<td>400</td>
</tr>
<tr>
<td>NA500</td>
<td>500</td>
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</tbody>
</table>

Large capacity gas turbines (710 MW to 940 MW)

Gas Turbines and Combined Cycle Output

[Chart showing gas turbine output]

Thermal Efficiency of Combined Cycle Systems

[Chart showing efficiency comparison]

To meet the power demands of industries and societies around the world, MHPS produces a wide range of gas turbines from the 60 MW to the 500 MW class for power generation and industrial use. These turbines drive the development and growth of the energy industry.

MHPS has delivered more than 1,500 gas turbines to customers in more than 50 countries around the world.
High-capacity gas turbines for power generation. Incorporating cutting-edge technologies.

Jet-series gas turbines, built on the proven G EMX design with advanced technologies evolved as part of a Japanese government’s strategic project to develop a class of gas turbines that have a rating in the temperature of 1,160°C. This rating, with a 15% T 1 of 1,600°C is the key in moving to meeting the Project’s goal.

The J-series model in the Jet-series and the G EMX gas turbines. In combined cycle operation, the J-series achieves power generation efficiency of more than 64%.

Development of the air-cooled JAC-series

The JAC-series gas turbines are air cooling for combustors instead of steam cooling. With performance equivalent to the G EMX gas turbines, they produce a high level of efficiency including a shorter startup time.

Advantages of the Microturbine

With the base of the component and the turbine, Johnson & Johnson has the same shape as that of the Jet-series. The J-series has a cooling structure for the blade and rotor of the turbine, which is optimized according to the ambient temperature. The combustor uses the aircooling system that has proven its effectiveness and reliability in the JAC-series. In contrast, the JAC-series turbofan also features the beneficial technology used in the G EMX. The J-series is being used in the industrial and power generation market.

Jet-series

Jet-series gas turbines are high efficiency gas turbines. In a combined cycle operation, the J-series achieves power generation efficiency of more than 64%.

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F-series

Gas turbines for power generation to accommodate diverse fuels

In 1995, MHI developed the M701F series gas turbines for 60 Hz power generation. The following year, MHI developed the M701F Series for 50 Hz power generation with similar design features. Since then, MHI has continued to improve the design of these gas turbines. MHI introduces advanced dematerialized and materialized technologies, verified by the Co-axial screw press technology record, to optimize attain commercial performance enhancements.

Compressor

Variable blade guide vanes ensure operability at startup and enhanced performance at parallelized in combined cycle operations.

Combustor

A premixed lean burn combustor is composed of one burner surrounded by eight fuel burners. The compressor has an air bypass mechanism that enables regulation of the fuel rate in the combustion chamber.

Turbine

The existing blading on the F-class Gas Turbines that are fueling, with the third and fourth stages having high-efficiency turbines, are among the lowest pressure loss in the industry. The turbines are equipped with a turbine that is dependent on individual stages to prevent failure caused by being affected by thermal expansion.

High capacity to high output gas turbines for power generation

In February 1997, the M701F gas turbine with a 57 MW, 1,540 kW, 29 MW, and 29 MW turbine was developed, gaining commercial operation. This series features the use of steam for cooling, the steam generator, which is the most efficient method, uses the High-efficiency combustor technology to allow conventional steam-cooled combustor, using compressor discharge air for cooling combustion to add and energized fuel to increase the efficiency of steam for cooling from the bottoming cycle.

Compressor

The G-class uses the existing proven coxied compressor, the advance of blade elements are applied to a first stage and the G-class turbines are steam-cooled. The intake blading is the only steam-cooled component, which is cooled of the steam at rated load. The cavity face of the blades is the last to be cooled, cooled, with the entire of the cooling component discharged at the remaining face area is cooled by conventional steam-cooled compressor (fixed blades). The three and fourth stages on the turbine rotor are steam-cooled. The third and fourth stages are integrated. Each new range is supported in a separate blade ring, which is balanced and supported in normal load and normal operation independent of possible external cylinder vibrations.

Table

<table>
<thead>
<tr>
<th>Turbine</th>
<th>Steam generator</th>
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**Aero-Derivative Gas Turbines**

**Aero-Derivative Gas Turbine Package**

PW power systems (PWPS) supply aeroderivative and industrial gas turbines. PWPS has installed more than 1,250 aeroderivative gas turbines in over 150 countries worldwide and proved itself in its numerous gas turbine repairs and overhaul. The portfolio of PW gas turbines offers competitive, efficient and flexible products ranging from 26 to 146 MW of power, in 17T, 1F, 1F1000.

**Aero-Derivative**
- Simple cycle: 44% efficiency
- More than 41%
- Quick start-up in 5 minutes
- Cooling water not required
- Compact layout
- Mobile package available for quick delivery

**Typical Fleet Layout**

- Single shaft 1 on 1 configuration
- Single shaft 2 in 1 configuration

**Flexible configurations**

PW offers comprehensive gas turbine and engine product solutions, and not only offers customer 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.
Remote monitoring centers

Remote monitoring centers (RMCs) have been established in key regions around the world, and our experts in operations and maintenance monitor operations and maintenance under adverse conditions around the clock. Our system is designed to ensure optimal performance in operating data, as well as the dispatch of human resources, as needed for maintaining performance on operating data that is constantly updated. Customers are provided with optimal service depending on the situation of the contract, relying on remote and on-site maintenance services.

Solutions to improve power plant availability

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- Providing highly skilled products that use the latest technologies
- Optimizing maintenance initiatives such as employing inspection, maintenance, and diagnostic analysis of operation conditions
- Using remote monitoring services for early problems and detection of reduced operational levels

Solutions to improve plant operability

Our solutions to improve plant operability:

- Ensuring continuous energy supply, more flexible operations are required than gas turbine combined cycle power plants. Our solutions to improve power plant availability:
- Providing highly skilled products that use the latest technologies
- Optimizing maintenance initiatives such as employing inspection, maintenance, and diagnostic analysis of operation conditions
- Using remote monitoring services for early problems and detection of reduced operational levels
Verification facility

T-point at MHPS Takasago Works

The purpose of T-point:

T-point provides a working demonstration of new gas turbine

Technology that applies to various applications and

conditions (partially burned cases, high temperature stress,

combined cycle power generation with a higher power

efficiency),

Next-generation combined cycle power generation

MHPS has always focused on research and development for

next-generation highly efficient combined cycle power generation technology.

The T-point facility is the first of its kind in the world.
The T-point facility is scheduled to begin operations in July 2022.

Comprehensive Efforts from Development to Manufacturing

MHPS is one of the leading companies in Japan that handles

the entire production process, from development, design,

manufacturing, construction, and commissioning of advanced

gas turbine power generation equipment. In order to respond

to the high requirements of our customers, we will continue to

establish our comprehensive approach to play an important

role.

Technological Collaboration and Development

Manufacturing technology development

Sustainable environmental impact

R&D Research & Development

Design

Verification & Development

Manufacturing
**Performance**

### Simple Cycle Spec

<table>
<thead>
<tr>
<th>State</th>
<th>Value (kW)</th>
<th>Value (kVA)</th>
<th>Value (%)</th>
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<tbody>
<tr>
<td>State 1</td>
<td>64,100</td>
<td>6,619</td>
<td>57,7</td>
<td>58,9</td>
<td>8,600</td>
<td>8,939</td>
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<tr>
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<td>74,100</td>
<td>7,391</td>
<td>66,7</td>
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### Combined Cycle Spec

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### Mechanical Drive Spec

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### Axial-Flow Gas Turbine

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### Notes
- Data presented are the design conditions. Design conditions: 98% 15% with the exception of State 2 (96% 15%).
- All values are in SI units (kW, kVA, %).
- Performance values are subject to change due to changes in design and operational parameters.
- Figures may not include all operational parameters.

### Diagrams
- Diagrams are not provided.
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