COMBINED CYCLE POWER PLANTS

Delivering flexible, dependable, highly efficient power
Power markets around the world are undergoing a paradigm shift driven by efforts to prevent global warming. These efforts are mainly focused on utilizing renewable energy resources, shutting down coal plants and more recently, expanding energy storage methods. Meanwhile, gas-fired power is emerging rapidly as a cleaner, flexible and highly efficient baseload power source during the transition to a low carbon world that is expected to last decades.

MHPS is working tirelessly to offer the best products towards humanity’s low carbon objective. We design, manufacture, build and commission, combined cycle power plants with all the major components. At the heart of product range sits our gas turbines, developed over several decades and equipped with critical cutting edge technologies to achieve the highest efficiency and reliability in every class.

Our Champion J-series gas turbines have achieved a record breaking 64% efficiency whilst continuing to maintaining the highest reliability on the advanced gas turbines market. This level of efficiency delivers 50% lower CO₂ emissions than a coal plant of the same size.

A GAS TURBINE FOR EVERY DUTY

MHPS gas turbine line-up that ranges from the 28 MW class to the 470 MW has been developed to meet very diverse needs around the world. To date, MHPS has delivered over 800 gas turbines to more than 30 countries to date and contributed to societies and economies worldwide for the better.
J-Series Gas Turbine

Our unremitting efforts in developing the next generation gas turbines has resulted in the M701JAC and M501JAC machines that achieve 1,600°C turbine inlet temperatures, this achievement is due to the advanced cooling techniques and superior materials used in the turbine’s components.

MHPS delivered the first J-series gas turbine in 2011. Since then, 56 units have been ordered (as of October 2018) this has made the J-series “The Champion” in the advanced class gas turbine orders by total capacity.

Besides being the largest gas turbine with record breaking 64% thermal efficiency, J-series has achieved the highest levels of reliability as a result of extensive and long term testing at T-point; our fully operational power plant. T-point has been an immense success in introducing and validating new technologies before stamping our turbines as ‘tested and approved’.

- A compressor shaft end drive reduces the effect of thermal expansion on alignment
- A rotor with simple single-shaft two-bearing support
- A rotor structure with bolt-connected discs that has torque pins in the compressor section and CURVIC couplings in the turbine section to ensure stable torque transmission
- An axial flow exhaust structure advantageous in combined cycle plant layouts
- Horizontally split casings that facilitate field removal of the blades with the rotor in place

T-POINT IN MHPS TAKASAGO, JAPAN
Is the in-house combined cycle power plant for comprehensive verification before field application.

<table>
<thead>
<tr>
<th>PLANT SPECIFICATIONS</th>
<th>M501J</th>
<th>M701J</th>
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<tr>
<td>GT output</td>
<td>330–420 MW</td>
<td>480–560 MW</td>
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<td>CCGT output</td>
<td>480–610 MW</td>
<td>700–820 MW</td>
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<td>Efficiency</td>
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<td>Operational</td>
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GAS TURBINE LINE-UP

- H-25 series
- H-25 series
- H-50 series
- FT4000
- H-100 series
- D series
- F series
- G series
- J series

MW

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<td>J series</td>
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F-Series / H-Series Gas Turbine

The M701F gas turbine was introduced for the 50Hz market in 1992 and designed to cover the power generation needs of utility and industrial sectors. The F series gas turbine has achieved worldwide success and the fleet has accumulated over 10 million operating hours. As of 2018, the fleet leader has surpassed 122,000 actual operating hours.

MHPS has continued to develop the F-series gas turbine to improve overall performance. Each stage of the development has been achieved by introducing improved and validated components and materials from the proven F and G-series gas turbines.

The H-series gas turbines cater for utility and industrial users who require small to medium sized industrial gas turbine based power generation plants. Applications include economical like-for-like replacement of previous generation gas turbines, CHP plants, combined cycle plants and LNG mechanical drive facilities.

**H-50 GAS TURBINE Features**
- Reliable heavy-duty design
- High efficiency
- On-site maintenance
- Suitable system for cogeneration and combined cycle power plant
- Environmentally friendly combustion system and flexible fuel application
- Applicable for Mechanical Drive
- Applicable for Smart-AHAT system

**H-100 GAS TURBINE Features**
- Reliable heavy duty design
- High efficiency
- No-reduction gear
- Replacement of old gas turbine
- On-site maintenance
- Suitable system for cogeneration and combined cycle power plant
- Environmentally friendly combustion system and flexible fuel application

**H-25 GAS TURBINE Features**
- Reliable heavy duty design
- High efficiency replacement of old gas turbine
- On-site maintenance
- Quick delivery
- Suitable system for cogeneration and combined cycle power plant
- Environmentally friendly combustion system and flexible fuel application
MHPS is committed to a low carbon society and we are tirelessly working towards that goal. A huge milestone will be the hydrogen burning gas turbine that we are developing together with our major partners in Europe to convert Magnum Power Plant in Netherlands to a full Hydrogen Gas Turbine by 2023. We have already succeeded in burning a 30% Hydrogen – 70% natural gas fuel mix at a turbine inlet temperature of 1600°C. This resulted in a 10% reduction in CO₂ emissions compared to a full natural gas fired turbine of the same size.

This Carbon-Free Gas Power project aims to produce hydrogen in two ways. The first will be an electrolysis process powered by renewable energy resources during low demand high supply periods and the hydrogen will be transported to Magnum Power Plant to be used similar to a battery during high demand low renewable power supply periods. The second way is by producing hydrogen from natural gas and capturing and storing the emitted carbon dioxide in salt caverns. Either method delivers a process cycle that is fully carbon free. Even though burning hydrogen emits no carbon, nitrogen oxides (NOx) are still emitted. MHPS is further developing the technology to suppress this emission to the level of a gas fired turbine. We have made great strides to achieve this goal in time for 2023.

SOLID OXIDE FUEL CELL-MGT HYBRID SYSTEM
Highly efficient and clean 250 kW-class SOFC-MGT (Micro Gas Turbine) hybrid system:
- High electrical efficiency: SOFC converts fuel to power directly. Additional power generation by MGT utilizing SOFC waste gas.
- Heat recovery: Hot-water or steam is available from MGT exhaust.


Hydrogen Gas Turbine

Digital Solutions

Over the past decade, OEMs like MHPS and power plant operators have increasingly adopted digital and communication technologies to improve plant operation. In early 2017, we unveiled MHPS-TOMONI™, a comprehensive family of digital solutions.

The digital platform harnesses big data, sophisticated analytics and human insights – the combined power of the equipment design and total plant knowledge of MHPS and the owner/operator's engineering, operation and maintenance expertise. A key enabler of the MHPS-TOMONI benefits is remote monitoring and diagnostics technology.

Our AI-based control systems, as a new area of the MHPS-TOMONI, are enhancing performance, efficiency and flexibility for power plants. By analyzing large volumes of complex data acquired during plant operation, these systems use machine learning to provide a wide range of functions such as cost optimization (operating costs, maintenance costs, etc.) and early detection of anomalies.

An early system-level implementation of massive power plant data acquisition and digitalization began in 1997 when MHPS commissioned the “T-Point power plant” at the Takasago Machinery Works in Japan, which is an in-house, fully operational and heavily instrumented Gas Turbine Combined-Cycle power plant. T-Point was followed in 1999 with the full-scale implementation of our first power plant Remote Monitoring Center (RMC) in Japan. This RMC first started monitoring and providing power plants with real-time early warning and fleet benchmarking as well as engineering knowledge to improve reliability, reduce unplanned downtime and implement better outage planning based on predictive analytics. A second RMC was established in 2001, in Orlando, Florida, USA. In 2016, the third RMC was opened in Alabang, Philippines to increase coverage in Southeast Asia and Oceania. Today, these centers monitor and provide support to power plants all over the World.
Turbine and Generator Services

From our strategically located offices, workshops and sister companies, we provide gas turbine, steam turbine and generator services that include field services, component repairs, equipment, original parts, and technical advisors. Our local teams are fully equipped not only for planned outages but also unplanned incidents to provide support at short notice. Our ultimate goal is minimizing down time of power generation assets to maximize financial value for our customers and grids.

Our field service teams work around the clock to provide an all-inclusive service on monitoring, balancing, tuning, commissioning, emergency support, and turnkey outage delivery. We provide component repairs and comprehensive rotor inspections from workshops in Italy, Abu Dhabi, and Saudi Arabia for our European and Middle Eastern customers. Our original spare parts are stored in the UK and delivered to site at very short notice providing peace of mind to our customers. Our robotic inspection capability enables examination of generator interiors without pulling out the rotor, which saves significant time and cost. We offer this service to a wide range of generators that can be conducted during minor and major turbine inspections.

Our Long Term Service Agreement (LTSA) contracts offer a structured approach in order to provide to our customers regarding outage schedules, servicing of their assets from the OEM and control of their budgets. LTSA customers receive upgraded parts to keep their plants competitive in terms of flexibility, lifetime, performance, and quality. The Long Term Parts Management (LTPM) contracts supply parts on a unit basis, which ensures that management cost and negotiation time are minimized while the actual work is being prioritized.
Power for a Brighter Future