Steam 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 (AGCS) and digital solutions

MHPS-TOMONA. 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.
Steam Power Plants

Mitsubishi Power designs and delivers highly efficient and environmentally friendly power generation facilities, including boilers, steam turbines, and generators.

What is a steam power plant?

A steam power plant consists of a boiler, a steam turbine, a generator, and other auxiliaries. The boiler generates steam at high pressure and high temperature. The steam turbine converts the heat energy of steam into mechanical energy. Through proper integration of all equipment, Mitsubishi Power designs and delivers highly efficient and environmentally friendly power plants.

Large Capacity Power Plants

Applying ultra-supercritical pressure technology for highly efficient power generation

Mitsubishi Power has an impressive track record in the field of supercritical and ultra-supercritical pressure coal-fired power plants and has achieved high levels of trust in the market due to the high efficiency and reduced emissions of these plants. Capitalizing on its successful operating experience with this advanced technology, Mitsubishi Power will continue to contribute to the stable and reliable supply of electric power globally, while minimizing the environmental impact.

What is ultra-supercritical pressure?

Under normal atmospheric pressure (0.101 MPa), water boils at 100°C. As the pressure increases, so does the boiling temperature of water. When the pressure is increased to 22.12 MPa, and at a temperature of 374°C, water converts directly from liquid to steam, without the intermediate boiling stage. This is called the critical point, and the pressure above this critical point is called supercritical pressure. Supercritical pressure with a temperature equal to or more than 593°C is called ultra-supercritical pressure.

Integrated Customer Service

Supplying power plants matching customers’ needs

As an EPC contractor, Mitsubishi Power will design, manufacture, deliver, and install entire power plants. From main plant equipment to auxiliary air quality control systems, Mitsubishi Power can integrate the complete plant system to optimize equipment design and efficiency. Main plant equipment, such as boilers, steam turbines, and generators, is custom designed to meet customers’ needs. New units added to an existing power generation station will be seamlessly integrated with existing plant equipment and optimized to meet the specified requirements.

Cogeneration Power Plants

Paving the way for effective use of energy

In some industrial applications, excess energy is produced as part of the normal operating process. In many cases, this energy is wasted. If economically justifiable, another option is to utilize this free source of energy to produce steam and electric power. Utilization of surplus energy as fuel for the production of steam and electrical power is called cogeneration. When optimized and properly integrated with the industrial process, power supply stability improves and impact to the environment is minimized.
Manjung 5 — One of the world’s most advanced power plants

Mitsubishi Power provided ultra-supercritical variable pressure once-through boiler, a steam turbine/generator and flue gas desulfurization (FGD) system, including a seawater FGD for a power plant construction project in Malaysia. A Korean company, Daehin Industrial Co. Ltd. concluded the package contract through a consortium to build an ultra-supercritical coal-fired power plant in 2013. The equipment was delivered to a Malaysian power company, Tenaga National Berhad (TNB) for an ultra-supercritical coal-fired power plant built in Manjung, Perak, located about 300km northwest of Kuala Lumpur, the capital city of Malaysia. This plant is capable of generating 1,300 MW and is the largest of its kind in Malaysia.

Mitsubishi Power signed a supply contract to deliver equipment for this first ultra-supercritical coal-fired power plant in Malaysia and dispatched technical advisors as well as support staff, with many years’ experience working with overseas power plants, for installation and operation. It began commercial operations on September 28, 2017, three days ahead of its target date. On October 16, 2017, Mitsubishi Power received a letter of appreciation from Mr. Young Suk Kang, CEO of Daehin Industrial Co. Ltd. In this letter, he indicated that TNB greatly appreciated the strong technical capabilities of the Mitsubishi Power team throughout the project.

Mitsubishi Power has a proven track record in the field of coal-fired power generation with its high-efficiency system for curbing CO2 emissions. We will continue helping to provide stable power and to reduce environmental impact through our highly-efficient equipment and systems, while effectively responding to various market needs in Malaysia and Southeast Asia and around the world.

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Huidian Zouxian Unit 7 & 8
(China)

Customer
China Huidian Corporation

Output
1,000 MW x 2

Fuel
Coal

Start of operation
2007/2008

Neurath Power Station
(Germany)

Customer
RWE

Output
1,100 MW

Fuel
German lignite coal

Start of operation
2012

Palto Power Plant III
(Indonesia)

Customer
PT Paiton Energy

Output
866 MW

Fuel
Sub-bituminous coal

Start of operation
2012

Hitachi Chikuma Unit 1 & 2
(Japan)

Customer
JERA Co., Inc.

Output
1,000 MW x 2

Fuel
Btuminate coal & sub-bituminous coal

Start of operation
2003/2003

Rajpura Unit 1 & 2
(India)

Customer
L&T

Output
700 MW x 2

Fuel
Indian coal

Start of operation
2014

Kouzinco Unit 111
(Poland)

Customer
ENEA Wytwórczo S.A.

Output
1,075 MW

Fuel
Btuminate coal & sub-bituminous coal

Start of operation
2017
Steam Turbines

Contributes globally to power generation for more than a century with highly efficient and reliable steam turbines that have undergone strict in-house testing.

- **Combined Output:** Over 360,000 MW (2,600 units)
- **Flexible Configurations**
  - Meets Any Requirements
- **Provides Higher Efficiency**
  - High Temperature Steam

Contributing to power generation globally for more than a century, Mitsubishi Power steam turbines are built upon more than a century of R&D and manufacturing experience, and our track record of delivering strictly tested, highly reliable, and efficient steam turbines to customers globally is unmatched.

We offer a comprehensive lineup of steam turbines that include small and mid-sized steam turbines for industrial applications, large steam turbines for thermal power plants, nuclear power plants, and geothermal power plants.

Our highly efficient steam turbine lineup features different applications to meet various operational requirements while contributing to the global CO2 reduction.

**History of Development**

Mitsubishi Power has a century of achievements in the manufacturing of steam turbines. By further developing and upgrading cutting-edge technologies, we design and manufacture highly reliable "Japan Quality" steam turbines that hold up to long-term use and continue to gain the support of customers around the world.

The steam turbine has long been a crucial component of power generation plants and has played a vital role in their operation. Mitsubishi Power has led the world in putting cutting-edge technologies into practical applications, such as the manufacturing of a power generation plant capable of operating at steam temperatures of 400/420°C, thereby fulfilling customer expectations.

Mitsubishi Power will continue its ceaseless technology development and keep offering steam turbines that are environmentally friendly and highly efficient.

**Steam Turbines Product Lineup**

- **Single Casing HP/IP/LP Turbine**
- **Double Casing HP/IP/HP/MP/LP Turbine**
- **MHI Casing IP Turbine**
- **IP Turbine**
- **LP Turbine**

**Specifications**

- **No. of casings**
  - Single casing HP/IP/LP Turbine
  - Double casing HP/IP/HP/MP/LP Turbine
  - MHI Casing IP Turbine
  - IP Turbine
  - LP Turbine

- **Output**
  - Up to 250 MW

- **Main steam**
  - Up to 66.6 MPa / Up to 600°C

- **Reheat steam**
  - Up to 600°C

- **Revolutions per minute**
  - 3000 min⁻¹ (50Hz) / 3600 min⁻¹ (60Hz)

Breakthrough in steam conditions

Mitsubishi Power has steadily contributed to the development of highly efficient steam power plants by raising the operable temperature range of its steam turbines through technology development of turbines. We had already manufactured and delivered many turbines capable of operating at supercritical main steam temperatures of 600°C range, and currently reheat steam temperatures of 420°C is applied to commercial power generation.

On top of this, Mitsubishi Power continues on the next generation technology development with the aim of making turbines capable of operating at ultra-supercritical steam conditions in the 700°C range and 35 MPa for even higher efficiency.

**Up to 1,200 MW**

The length of optimal last stage blade (LSB) and the number of casings are selected based on the steam exhaust conditions. By combining the high pressure (HP) turbine and intermediate pressure (IP) turbine into a single casing, the turbine can be made more compact, thus reducing the number of components and required area for installation. On top of reducing costs related to civil construction and installation works, maintenance is also easier due to both a reduced number of spare parts and required inspection periods. For steam power plants, to increase overall plant efficiency, up to nine extractions for feedwater heating is possible. For the low pressure (LP) turbine, exhaust direction is not limited to downward exhaust, but can also be designed for sideward exhaust.
Boilers

Mitsubishi Power supplies boilers that boast world-leading quality and performance based on stable quality developed over many years and state-of-the-art technologies.

In 1968
Delivered the first Supercritical Pressure Boiler
More than 5,500 units delivered
Proven Track Record
Tower Boiler
Large and High-Efficiency Lignite Combustion
Optimized for Various Types of Coal
From Anthracite to Lignite

Boilers for power generation projects convert the chemical energy contained in fossil fuels such as coal, oil, and gas into heat energy through combustion reactions, and also convert this into high-temperature, high-pressure steam-based heat energy to be supplied to steam turbines used in power generation. This makes a boiler one of the key components of a thermal power plant. Large boilers can reach as many as 80 meters tall, weigh some 10,000 tons and comprise over one million components.

Types of boilers
While various types of boilers are produced depending on the amount, pressure and temperature of the steam they produce and the fuel they use, boilers generally come under one of two categories: drum boilers and once-through boilers.

The furnace that encloses the combustion field is the part of a boiler system exposed to the harshest conditions. Other key components include the superheater, which allows steam to pass through up to the designated temperature, and the economizer, which preheats the water supplied to the boiler.

In a drum boiler, to ensure reliability of the furnace area, a steam drum (an enormous tank) that continually supplies water to the furnace system is set up. On the other hand, a once-through boiler comprises a simpler structure that eliminates this steam drum.

Types of coal
Various types of coal can be used, from anthracite with its high carbon content to bituminous coal, sub-bituminous coal and lignite (brown coal), an even younger coal. Power generating equipment needs to be optimized for these different types of coal. Mitsubishi Power is able to supply the optimum power generating equipment to match any variety of coal, from anthracite to lignite.

Once-through boilers

Overview
Once-through boilers are able to produce steam at higher pressures and temperatures than drum boilers. In steam power plants, raising steam conditions (pressure and temperature) can enable efficiency gains in power generation equipment, allowing an operator to reduce its fuel consumption and CO2 emissions. Mitsubishi Power delivered its first supercritical pressure once-through boiler in 1968, and followed up in 1991 with delivery of the first supercritical variable pressure once-through boiler. In 1993, Mitsubishi Power sought to further improve steam conditions, culminating in the delivery of the first ultra-supercritical variable pressure once-through boiler. Mitsubishi Power boasts an extensive track record of both supercritical and ultra-supercritical variants and conditions to deliver highly reliable boilers.

Technical advantages
- Furnaces
  - Optimized for specific types of fuel – Various burner system layouts for good combustion
  - Burners
  - Low NOX and less unburned carbon – Advance combustion technology
  - Pulverizers
  - Vertical mill for high classification performance at low power consumption – Highly durable and easy to maintain

Specifications

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<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>~1,500 MW</td>
</tr>
<tr>
<td>Main steam flow rate</td>
<td>~2,016 m³/s</td>
</tr>
<tr>
<td>Steam temperature</td>
<td>~400/540°C</td>
</tr>
<tr>
<td>Steam pressure</td>
<td>~157 MPa</td>
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</tbody>
</table>

Tower boilers
Tower boilers are designed to fire various kinds of fuel and are ideal for plants using highly erosive high ash coal.

Performance advantages
- Proven technology and high reliability for combustion with lignite and low-heat-value coal

Fuel sources
- Lignite, sub-bituminous, bituminous, biomass

Technical advantages
- Furnaces
- Optimized to accommodate specific types of fuel
- Small footprint
- Burners
- Low NOx and less unburned carbon – Advanced design based on experience with coal-fired power generation in Europe
- Pulverizers
- Pulverization system for lignite and low-heat-value coal combustion – Vertical mill for high classification performance at low power consumption

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Drum Boilers

In a drum boiler, the circulation of water is produced through the density difference of water in the downcast pipe and the steam-water mixture in the furnace water wall. In low-pressure boilers where this density difference is large, the circulating force is high and a high volume of circulation can be ensured. However, since it becomes difficult to sufficiently maintain circulation volume when the density difference between the two drops due to higher pressure, a pump is installed in the downcast pipe to supplement circulating force. The type that circulates water using only the density difference is known as a natural circulation boiler, while the type that includes an installed pump is known as a forced circulation boiler.

Bubbling Fluidized Bed (BFB) Boilers

A bubbling fluidized bed (BFB) boiler is a boiler that can also handle fuels that are difficult to pulverize or less combustible. The fuel is introduced into a mixture of sand flowing at high temperatures, allowing the fuel to be efficiently combusted. Since Mitsubishi Power delivered its first commercial BFB boiler in 1984, it has established an impressive track record of deliveries. Customers can choose the optimum BFB boiler based on desired power generating output and the characteristics of the biomass to be used. In this way, Mitsubishi Power responds to a diverse range of customer needs.

Supports a wide variety of fuels

In BFB combustion, a material with a large thermal capacity such as sand is used as the flow medium. This allows for the stable combustion of a wide variety of fuels, from moisture-rich fuels to those with low combustibility. In addition to coal, our BFB boilers support a wide array of fuels from wood biomass such as waste wood and construction waste materials to industrial waste such as tires.

Stable emissions of foreign particles

At the bottom of the BFB, the bed drain extraction method is used based on the amount of foreign particles in the fuel. At the same time, the use of an appropriate furnace bottom shape and air nozzle shape ensures that foreign particles carried through the BFB are expelled outside the system in a stable manner, preventing poor flow associated with sedimentation inside the BFB.

Low environmental impact

As BFB combustion allows for sufficient combustion under lower temperatures up to around 900°C, the release of nitrogen oxides (NOx) and other pollutants can be reduced.

Chemical Recovery Boilers

A chemical recovery boiler is a type of biomass boiler that combusts black liquor produced as a by-product in the pulp manufacturing process at paper mills. Black liquor is a fuel derived from wood chips and is regarded as renewable. A chemical recovery boiler not only effectively uses the thermal energy gained by combusting black liquor, but also recovers sodium (carbonate) ingredients that are reused in the pulp manufacturing process, and thus plays an important role in a pulp manufacturing plant. Since it delivered the first such chemical recovery boiler in 1981, Mitsubishi Power has delivered more than a hundred units in over a half century and continues to be one of the leading companies in the field.

High-pressure, high-temperature steam conditions

In 1983, Mitsubishi Power was first in the world to develop and deliver a high-pressure, high-temperature chemical recovery boiler that produced steam at 10 MPa and 500°C. Producing steam at high pressures and temperatures helps to boost generating efficiency in turbine-generating equipment. The highest steam conditions we have delivered to date are a steam pressure of 13.3 MPa and steam temperature of 935°C. Even today, these levels persist as the highest steam conditions for a chemical recovery boiler.

Corrosion protection

With a chemical recovery boiler, the furnace wall pipes and superheater tubes are exposed to a harsher corrosion environment compared with other fossil fuel burning boilers. This harsh corrosion environment is due to the chlorine, potassium, sodium, and sulfur contained in the black liquor used as fuel. Our recovery boilers employ the following anti-corrosion measures to improve the reliability and durability of boiler equipment.

- Furnace wall pipes: Covering with overlaying of 25Cr steel
- Superheater tubes: Use of 25Cr steel tubing

Low NOx combustion

By employing a multi-stage air input method that adds fourth-stage air to the conventional primary, secondary and tertiary air, and eliminating localized regions of excessive air inside the furnace, low NOx combustion can be achieved.

Technical Information

Mitsubishi Power maintains proprietary boiler technologies designed to achieve high reliability and reduce environmental impact.

Low NOx burners

Mitsubishi Power offers low NOx burner technologies for solid, pulverized fuels by combustion method and different firing systems. For coal-fired burners, PM burners are the jet burners which are used for the swirl combustion method in boilers with tangential or air-wall firing systems, while DS* and NR burners are circular swirl burners used for in boilers with the opposite firing method. The basic concepts for improving combustibility, however, are the same for PM, DS* and NR burners. By improving ignizibility in rich fuel flame areas and producing moderate combustion in moderate flame areas, the production formation of NOx emissions is reduced. Combustion air is added to the flame in subsequent stages in order to limit formation to its minimum. At the same time, an excellent burn out ratio is achieved. Mitsubishi Power also offers low NOx burners, both jet and swirl type, for boilers utilizing low rank coal ( lignite ).

Combustion test facility

Mitsubishi Power maintains world-class combustion test facilities utilized to develop even more sophisticated combustion technologies that form the basis of boiler performance including lower nitrogen oxide (NOx) emissions, less unburnt fuel, and a reduced excess air ratio. We are particularly focused on enhancing the following two functions of our combustion test facilities to support cutting-edge technological development.

1. Functions to accurately recreate in-plant combustion phenomena in actual boilers
2. Functions to evaluate flow and combustion at high level of accuracy through precision measurement instrumentation
Air Quality Control Systems (AQCS)

Mitsubishi Power is the world’s only company able to develop its own technology for AQCS including SCR, FGD, and ESP, and is capable of designing the total AQCS area to meet customers’ commercial and environmental needs.

Selective Catalytic Reduction (SCR) System

Mitsubishi Power selective catalytic reduction (SCR) systems remove NOx from flue gas emitted by power plant boilers and other combustion sources to help prevent air pollution at the source. With more than 45 years of operational experience, supplying highly reliable SCR catalysts, Mitsubishi Power’s advanced SCR systems provide efficient, reliable treatment of flue gases.

Special features

Here are some attributes that drive demand for Mitsubishi Power SCR systems:

- High NOx reduction meeting strict emission standards for various fossil fuels at the single-digit level of NOx concentration
- Integrated NOx reduction linked with boilers and HRSGs
- Optimization of catalysts according to the customers’ requirements
- Multiple pollutant control including mercury and low sulfur trioxide
- High reliability
- Longer intervals of catalyst maintenance

Electrostatic Precipitators (ESP)

MitsubishiPower electrostatic precipitators (ESP) collect dust in the flue gas produced by boilers and other combustion sources to meet air pollution control and environmental standards at thermal power plants, steel plants, and various other industrial plants.

Basic principles of ESP

1. A high voltage is applied to the discharge electrode, generating a corona discharge that produces negative ions.
2. The electrically charged dust is accumulated on the collecting electrode by an electrical field.
3. The accumulated dust is removed by rasping hammer (dry ESP), scraping brush (dry ESP), or flushing water (wet ESP).

Flue Gas Desulfurization (FGD) Plant

Mitsubishi Power’s flue gas desulfurization (FGD) plant removes sulfur dioxide (SO2) from flue gas produced by boilers, furnaces, and other combustion sources, contributing to the effective prevention of air pollution. Our Seawater FGD and Wet Lime/Stone-Gypsum FGD systems can both treat a wide range of SO2 concentrations, for greater plant reliability and improved operational economics.

Market leading features

With over 300 FGD plants in operation worldwide, Mitsubishi Power has a leading share of the global market. Here’s why:

- Excellent SO2 removal efficiency meeting stringent emission standards for all kinds of fossil fuels
- Multiple pollutant control with associated environmental control equipment
- High reliability
- Savings on energy and utilities

Statistical collection performance and dust characteristics

Our accumulated know-how in evaluating characteristic assessments on various dust properties and flue gas conditions, together with extensive field experience, is reflected in the ESP design.
Biomass Fuel-fired Boilers
A wide range of biomass mixed co-firing rates can be realized by applying coal/biomass dual system (coal pulverizer/burner) to coal-fired power generation technologies. Biomass co-firing rates can be adjusted without major changes of equipment. In addition, it is possible to have 100% biomass firing in a boiler by adding a small amount of coal ash. Mitsubishi Power has a proven track record in biomass firing modification of 350 MW-class power plant.

Steam Turbines
Steam turbine retrofit through application of latest technology
The occurrence of performance degradation and various other problems related to steam turbines as a result of progressing aged deterioration are caused by creep and fatigue damage over a long period of operation. Mitsubishi Power's proposals for large-scale retrofit projects, such as steam turbine replacement and parts supply, have been adopted and implemented by many customers worldwide.

Shortening of retrofit construction period by application of 3D measurement technology
Mitsubishi Power strives to shorten the construction period for large-scale retrofit projects in order to reduce construction costs and to improve the availability rate of the customers' plant. One example is the shortening of the construction period of a reheat retrofit by using 3D measurement technology. These 3D CAD models are based on precise measurements of existing parts to be re-used, such as the outer casing. Possible interference of small clearances can be detected with the already created 3D models of the inner casings and quick construction work is realized through the execution of necessary fine adjustments in advance.
Remote Monitoring Centers

Remote Monitoring Centers (RMCs) have been established globally and our experts in operations and maintenance monitor operating conditions under a 24-hour system. The system entails warning and detection of anomalies as well as diagnosis of performance loss based on operating data that is constantly updated. Customers are at all times provided optimum advice depending on the situation, which helps prevent trouble and maximizes the plant’s operating rate.

Training Services for Operators

Mitsubishi Power provides high-level training using a simulator to replicate actual plant operation. In addition, lectures calling on Mitsubishi Power technologies and experiences help support the skill development of our clients’ operators and promote stable plant operation.

Long Term Service Agreement for Power Plants

Mitsubishi Power provides customer-focused solutions which enable operators to achieve top-in-class levels of power plant availability and in turn helps secure the reliability of the overall grid. In designing our LTSA-based solutions, we focus on optimizing plant operations while minimizing maintenance costs, taking responsibility for planning maintenance program, spare parts supply, dispatch of technical advisors, remote monitoring, and more.

- Support short and long term maintenance to minimize plant downtime and optimize operation and maintenance costs
- Optimization of the LTSA scope and spreading of maintenance costs over time to minimize customers’ operating costs
- Supply of quality replacement parts and technical support from highly experienced engineers
- Utilization of remote monitoring, operating data diagnostic systems, and more to assist with general plant optimization.

Solutions to Improve Operation Flexibility

Increasing renewable energy use requires more flexible operation for steam power plants. Mitsubishi Power has developed various programs for coal-fired power plants in response to market needs that reduce start-up time, improve load change rate, reduce shut-down time, optimize restart time, and turnaround to enable operation at lower load while improving emission performance.

Comprehensive Maintenance

Mitsubishi Power works to repair the entire plant, whether deteriorated by long-time operation comprehensively and restore output and efficiency. Optionally, we propose lifetime extension of power generation facilities by improving efficiency and environmental performance if needed.

MHPS-TOMONI is Mitsubishi Power’s digital solutions service that optimizes the operation of power plants that play increasingly diverse roles in building a low or decarbonized society.

Tomoni, which means “together with” in Japanese, reflects the importance of collaborating with customers to solve challenges and seize opportunities. Mitsubishi Power’s objective is to harness and leverage big data to provide insights, solve complex problems and maximize overall power plant performance.

Roadmap for MHPS-TOMONI

**Autonomous Operation**
- Optimize operations in response to changes in environment
- Respond to diverse plant operations through simultaneous optimization with advanced technologies using high precision in application Digital Next
- Minimize maintenance costs, improvement reliability

**Advanced operation and maintenance**
- Combine digitalization and O&M technology to superior O&M
- All reduces customers’ maintenance and improving performance and environmental impact management to equipment status and plant operation’s run

**Remote monitoring and diagnosis**
- Leverages IoT for remote monitoring, diagnostic applications
- Remote monitoring
- Detect plant anomalies, offer solutions
- Visualization equipment data, analysis, performance degradation, changes in status

Digital Solutions

MHPS-TOMONI