MITSUBISHI POWER

IGCC

Integrated coal Gasification Combined Cycle Power Plants

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Energy Systems

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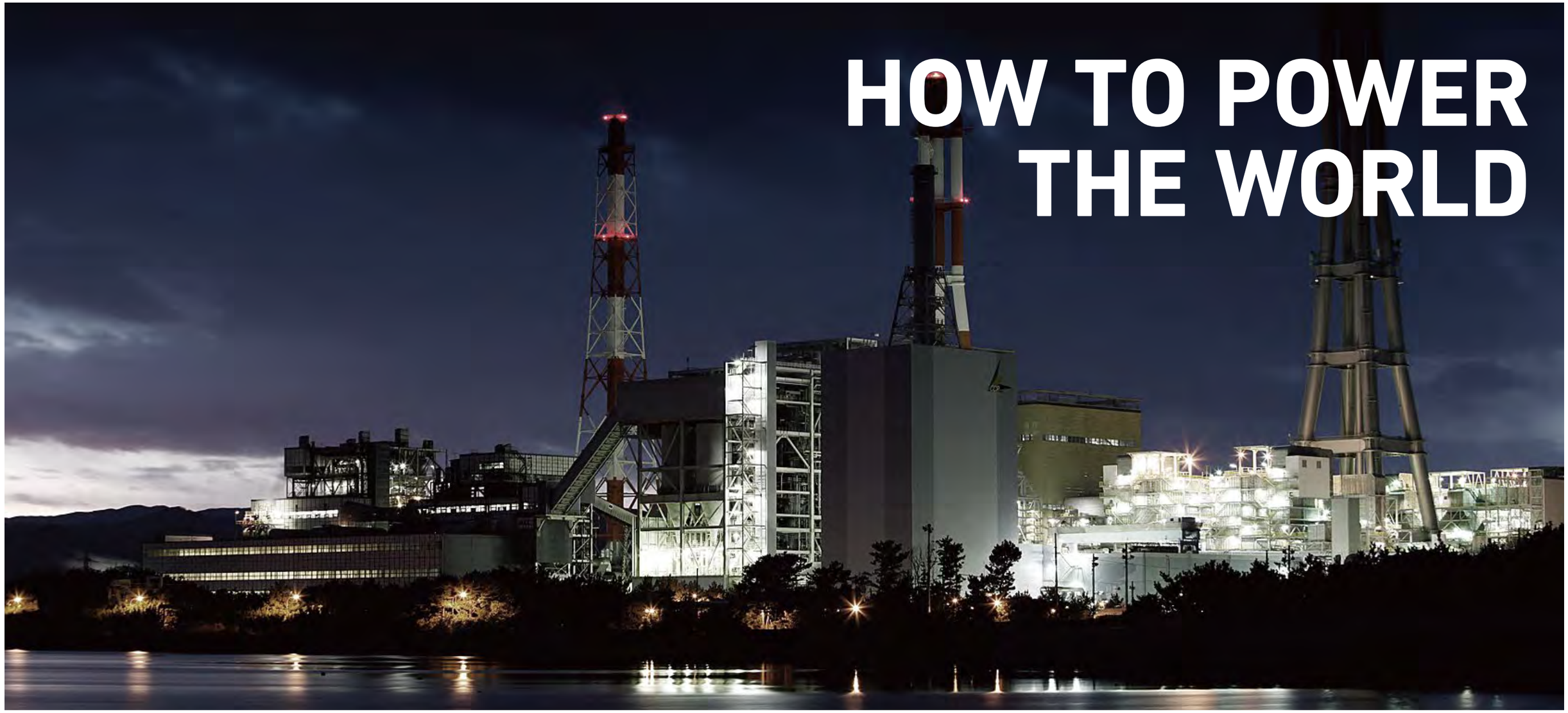
Mitsubishi Power is a power solutions brand
of Mitsubishi Heavy Industries.

MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP



HOW TO POWER THE WORLD

OUR PLANET IS CALLING FOR AFFORDABLE, SUSTAINABLE, HIGHLY RELIABLE AND CLEAN POWER. TOGETHER WE CAN ACHIEVE IT.

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 addresses such needs by providing stable, highly reliable, and clean energy solutions.

Mitsubishi Power, a power solutions brand of Mitsubishi Heavy Industries 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 CO_2 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 intelligent solutions TOMONI™.

Mitsubishi Power combines cutting-edge technology with deep experience to deliver innovative, integrated solutions that help to realize a carbon neutral world, improve the quality of life and ensure a safer world.

IGCC
Power Plants

Mitsubishi Power next-generation IGCC power plants integrate innovative coal gasification technologies and our advanced gas turbines to deliver high efficiency with excellent environmental performance.

World-class Power Generation Efficiency
48% (LHV, net)

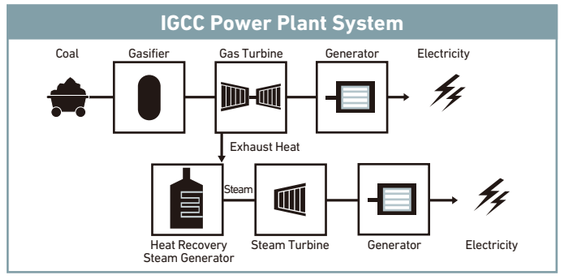
Can Use Low Grade Coal
Coal Flexibility

Low NOx, SOx and Dust Concentrations
Superior Environmental Performance

CO_2 Emissions Compared to Conventional Coal-fired Thermal Power Generation
Up to 15% Lower

A power generation system with high efficiency

IGCC is a next-generation thermal power plant with significantly enhanced power generation efficiency and environmental performance, thanks to a combination of coal gasification and the GTCC plants. Compared with conventional coal-fired thermal power plants. Large IGCC plants can improve power generation efficiency by approximately 15% and significantly reduce emissions.



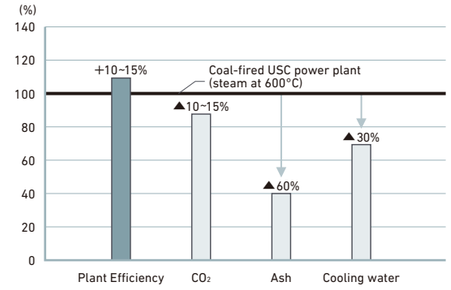
High environment performance

With enhanced system efficiency, IGCC lowers SOx, NOx and dust emissions per gigawatt-hour of electric power generated. It discharges about 30% less cooling water than conventional coal-fired thermal power generation systems.

Less water is required

While the flue gas desulfurization equipment in conventional coal-fired thermal power generation requires a large amount of water for treating flue gas after combustion, IGCC consumes a much smaller amount of water because it treats fuel gas at higher pressure in smaller volumes prior to combustion.

IGCC Power Plant Environmental Performance

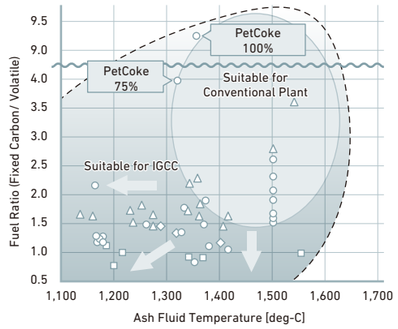


A wide variety of coal types can be used

In conventional coal-fired thermal power generation, it is difficult to use coal with a low ash melting temperature because of slagging and fouling. In IGCC plants the gasifier discharges ash as melting slag, making it suitable for using coal with a low ash melting temperature, opening the way to use types of coal and PetCoke that are not suitable for power generation in conventional coal-fired power stations.

Suitable coal types for IGCC power plants

Symbols show feedstocks, coals and PetCoke that the Gasifier has experience with.



CASE STUDY

Answering the call for lower-emission coal-fired power plants

Specifications for a typical 500 MW class IGCC

	50 Hz	60 Hz
Output	540 MW	460 MW
Net Efficiency	48% LHV	
Fuel	lignite, bituminous, sub-bituminous, etc.	
Gasifier	2-chamber, 2 stage air-blown gasifier	
GT model	M701F	M501GAC

Today, 40% of global electricity depends on coal for fuel, and it will continue to be the primary source of energy in many countries for the foreseeable future. Looking ahead to 2040, in the *World Energy Outlook 2017* the IEA projected about 30% of global electricity will be generated from coal.

However, coal-fired power generation is facing severe challenges. According to the terms for the COP21 Paris Agreement, the rise in global temperatures must be limited to "well below 2°C" compared with pre-industrial levels. To help lower emissions, regulatory agencies worldwide are implementing new environmental safeguards and promoting the replacement of power plants. At the same time, power companies are being compelled to replace older, coal-fired power plants.

In this demanding environment, Mitsubishi Power's next-generation integrated gasification combined cycle (IGCC) power plants offer value-added solutions. IGCC integrates Mitsubishi Power's sophisticated gasification systems with an advanced combined cycle system, significantly boosting the efficiency of coal-fueled power plants while reducing emissions.

Power and efficiency backed by 40 years of development and validation

Satoru Matsuo (pictured), Senior Engineer of the IGCC Process Group explains: "At Mitsubishi Power, we have tested and refined our own and unique gasification technologies in 40 years of operation and validation in pilot gasification plant tests and demonstration runs.

That deep body of knowledge and expertise has enabled us to optimize generation efficiency and ensure stable, reliable operation. For example, in 2013 our Nakoso #10 IGCC plant set a record for 3,917 hours of continuous operation. Yet we are continuing to enhance advanced technologies and optimize IGCC system."

"Compared with a typical 600°C class Ultra Super Critical coal-fired unit, our IGCC system boosts efficiency by 10-15% at transmission end and reduces CO_2 emissions by the same amount. While the global average for CO_2 emissions from coal-fired power plants is 950 g CO_2/kWh at generator terminal, with the IGCC we are targeting emissions of 650g CO_2/kWh at generator terminal.* As an added advantage, gasification enables the use of a wider range of coal, including lignite."

With the power sector responsible for 40% of global CO_2 emissions and coal-fired plants accounting for over 70% of the sector emissions, IGCC has the potential to significantly reduce global CO_2 emissions while producing an affordable and reliable power supply.

Mitsubishi Power's advanced technology is helping to reduce the environmental impact of power generation through IGCC plants, while playing a critical role in lowering global CO_2 emissions.

* Based on IGCC target CO_2 emissions rate (as documented by the Japan Ministry of Economy, Trade and Industry).

Two Types of Coal Gasification Technology

Mitsubishi Power offers two coal gasification technologies: Air-blown and oxygen-blown. Each effectively utilizes coal resources and protects the environment, making IGCC plants more prevalent across the globe.

Air-blown gasifier

The air-blown gasifier causes a reaction between coal and air, as a gasification agent, to generate combustible gas, which is mainly composed of carbon monoxide (CO) and hydrogen (H_2).

This gasifier is based on a two-chamber, two-stage, entrained-bed, which has a combustor (lower chamber) and a reductor (upper chamber). In the combustor, coal and char are burned and high temperature gas is generated. In the reductor, the coal is gasified in the high temperature gas.

Securing the syngas calories necessary for gas turbine combustion, the gasifier melts ash and discharges it smoothly during combustion stage. Therefore, two different roles can be achieved at the same time.

Moreover, by adding oxygen to the gasification air, the calorific value of the syngas is raised, making it suitable for chemical plant applications.

This air-blown technology has changed the general consensus that using air for coal gasification was difficult. It is now a suitable solution for generating power while using less auxiliary power.

Oxygen-blown gasifier

The oxygen-blown gasifier causes a reaction between coal and oxygen, with oxygen as gasification agent, to generate combustible gas mainly composed of carbon monoxide (CO) and hydrogen (H_2).

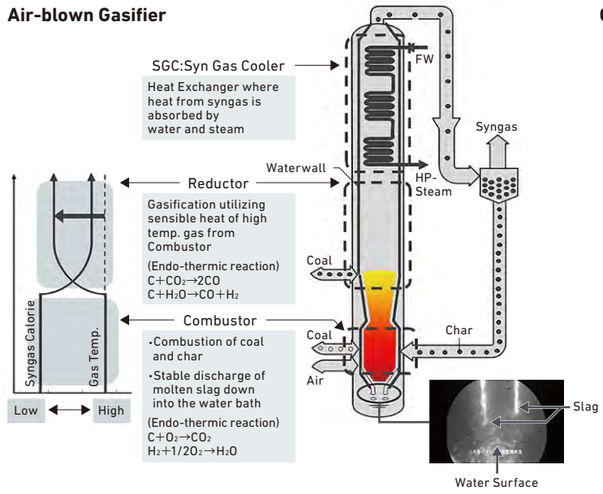
This gasifier is based on a single-chamber, two-stage, swirl-flow entrained-bed equipped with burners in the upper and lower stages of a cylindrical furnace.

Appropriate oxygen-to-coal ratios can be allocated to the upper and lower stages in order to match the lower stage to the temperature required for melting ash and the upper stage to the conditions for an efficient gasification reaction. Moreover, a swirl flow can be generated in the gasifier to allow residence time for coal particles and to suppress the dispersion of char.

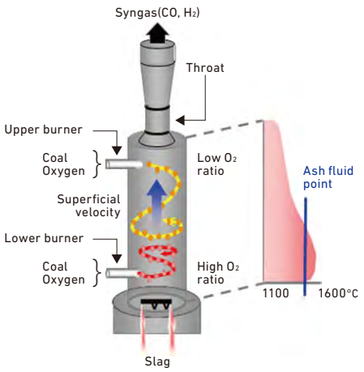
Features

- Higher syngas calorific value than air-blown gasifiers
- Suitable for both power generation and chemical plant application

Air-blown Gasifier



Oxygen-blown Gasifier



Gas Turbines

For more than 40 years, Mitsubishi Power has led the development of gas turbines, integrating the latest advances in aerodynamics, cooling design and material technologies to achieve high efficiency and reliability.

M701F

Evolution of the F-series

The M701F was released in 1992 to serve the 50 Hz market. Over the years, Mitsubishi Power has continued to develop and improve the performance of F-series gas turbines. In each development phase, Mitsubishi Power has introduced improved components and materials from its F- and G-series gas turbine technologies. The F-series gas turbine is a proven reliable design that will satisfy large-scale power generation needs for many years to come.

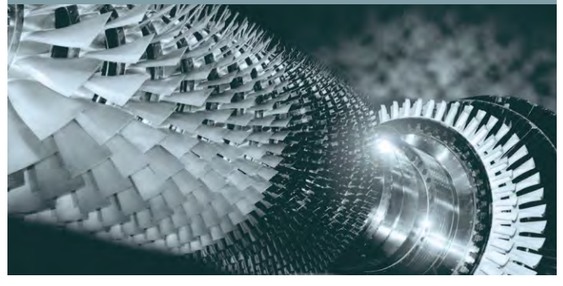
A more efficient compressor
Variable inlet guide vanes operate to modulate the gas turbine air flow in order to maintain relatively high exhaust temperatures (at part load) for improved bottoming cycle efficiency.

Stable combustion with syngas
Syngas is lower in calorific value and combustibility. Therefore, diffusion type combustors, which are different from those used for natural gas power, are employed for IGCC, enabling stable combustion with syngas.

Mitsubishi Power has abundant experience in applications for lower calorific gases, as a by-product of our Ironworks.

A better turbine
The first and second stages on the turbine rotor are free-standing. The third and fourth stages use integral shrouds. 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.

M501GAC



A giant step in gas turbine development

When Mitsubishi Power incorporated its latest air-cooled combustor technology into G-series steam cooled combustors, the advanced GAC was born. It uses compressor discharge air and does not require any external cooling source. The advanced GAC with air cooled combustors improves operational flexibility by eliminating any need for steam cooling from the bottoming cycle.

A higher-pressure ratio compressor
The GAC uses the existing proven G-series compressor. Advanced airfoil designs make for a large volume, high 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.

A four-stage axial-reaction turbine
The G-series employs a 3D aerodynamic design in a four-stage axial-reaction turbine. Directionally solidified (DS) materials with thermal barrier coating (TBC) are applied to the first two stages and the first three stages are air-cooled. The blades for turbine rows 1 to 3 are cooled by compressor bleed air, which is cooled by the external air cooler. The vanes for turbine rows 1 to 3 are cooled in the following manner. Row 1 vanes are cooled by compressor discharge air, while the remaining vane rows are cooled by compressor intermediate stage bleeds.
The first and second stages on the turbine rotor are the free-standing type. The third and fourth stages use integral shrouds. 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.

Bottoming Cycle

Mitsubishi Power steam turbines, boilers and generators deliver advanced combined cycle generating reliability and efficiency.

Steam Turbines

Contributing to global power generation for more than 100 Years
Mitsubishi Power steam turbines are built upon more than a century of R&D and manufacturing experience, and each unit undergoes strict in-house testing. We have a successful track record of delivering highly reliable and efficient steam turbines to customers around the world.

We offer a comprehensive lineup of steam turbines including small and mid-sized turbines for industrial applications, large turbines for thermal power plants, turbines for nuclear power plants and turbines for geothermal power plants. Our line-up serves a range of different applications and operating requirements, and by offering highly efficient turbines that meet the needs of our customers, we are working to reduce CO_2 emissions and preserve the environment.

Heat Recovery Steam Generators

Mitsubishi Power Heat Recovery Steam Generators (HRSG) apply cutting edge technologies to provide world-leading quality, performance and reliability.
An HRSG is a type of heat exchanger that recovers heat from the exhaust gases of a gas turbine to an extreme degree. The heat is replaced with high pressure and high temperature steam, which serves as the power source of a power-generating steam turbine.

Employed with finned heat-transfer tubes, the HSRG features excellent heat-transfer performance. And, a compact design reduces the installation footprint of the equipment.

In addition, Selective Catalyst Reduction (SCR) equipment is installed inside the HRSG, reducing the content of nitrogen oxide in the exhaust gases released into the atmosphere.

Heat recovery steam from gasifier is superheated in HRSG, therefore it also serves as the power source of steam turbine.

Generators

Mitsubishi Power develops a wide range of highly reliable and efficient generators backed by decades of applied experience.

More than 1,000 generators delivered
To date, Mitsubishi Power has delivered more than 1,000 turbine generators around the world. With a strong and long operational track record, Mitsubishi Power has earned an exceptional reputation for product reliability.

Supporting a wide range of power system needs
Mitsubishi Power provides turbine generators that employ a range of cooling systems, including air cooling, hydrogen cooling, and water/hydrogen cooling systems. Mitsubishi Power also offers solutions that span the entire product lifecycle, including service and maintenance.

Control Systems

Today, a wide range of devices and appliances are interconnected, and Mitsubishi Power control systems are processing enormous volumes of data and device information to strike a balance between openness and high security.

Plant Control System

Offering highly reliable control systems

For several decades, Mitsubishi Power has developed and supplied control systems that maintain high reliability and utilization rates while meeting maintenance support and safety requirements throughout the lifespans of machinery and equipment at power plants around the world.

Our proprietary DIASYS Series
Mitsubishi Power's Digital Intelligent Automation System, or DIASYS, maintains high reliability and an impressive utilization rate, while incorporating the extensive expertise and control technologies of a plant manufacturer. DIASYS features a distributed control system (DCS) providing ease of use for all involved, from operators to plant engineers and maintenance personnel.

DIASYS Netmation 4S

Services

Proposing services tailored to meet diverse customer needs

TOMONI HUB in Nagasaki shipyard & Machinery Works

Services & Solutions

Mitsubishi Power provides tailored solutions to meet diverse customer needs, backed with technological expertise gained from extensive experience working with many types of power plants.
Our TOMONI HUBs (Analytics and Performance Center) monitor IGCC plants including gasifiers, 24 hours a day, 365 days a year.
Our operation and maintenance experts provide full support for customer's smooth introduction of this new technology.

Utilizing our cutting-edge digital technology, intelligent solutions TOMONI™, including AI and real-time video monitoring, Mitsubishi Power provides comprehensive solutions to meet customer needs to ensure high availability and efficiency by not only monitoring operational parameters but also diagnosing performance degradation and detecting signs of anomalies.

Mitsubishi Power provides Long-Term Service Agreements (LTSA)*, utilizing remote monitoring data and outage records to assist with general plant optimization such as scheduling planned outages for long-term stable operation.

* Mitsubishi Power can make proposals tailored to customer needs including spare parts supply, turnkey outages, dispatch of technical advisors, and more.