AQCS
Air Quality Control Systems
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 MHPS-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.
AQCS

Mitsubishi Power’s advanced AQCS solutions are built on 100 years of experience to meet the emission standards of the future.

What is AQCS?

Air quality control systems (AQCS) enable power generation and industrial plants to meet the increasingly stringent air quality and emission standards being enforced worldwide, providing environmentally effective and economically efficient solutions that enable even fossil fuel power plants to meet today’s environmental regulations.

Mitsubishi Power advanced technologies help protect the environment.

Mitsubishi Power is a world leader in air quality control systems (AQCS) including selective catalytic reduction (SCR), flue gas desulfurization (FGD), electrostatic precipitator (ESP) and more, offering a range of solutions for reducing emissions.

Mitsubishi Power’s advanced technologies provide vital industries with reliable air quality control, even as we continue to research better ways of meeting our customers’ evolving needs.

AQCS Research & Development

Since the early 1940s, Mitsubishi Power has been engaged in research and development of AQCS, exploring not only NOx, SOx, and particulate control technologies, but also SO2, mercury and other pollutant control technologies for various fuel sources, to meet the stringent emission standards established around the world. We remain committed to R&D endeavors for all our products and technologies and in bringing about continuous improvements for our clients.

Major R&D Advances

- FGD technologies including desulfurization efficiency improvements, fuel diversification, desulfurization agents and reduced auxiliary power and utilities
- SCR and catalyst technologies including NOx removal efficiency improvements, fuel diversification, low SOx/NOx oxidation, mercury oxidation and reduced auxiliary power and utilities
- ESP technologies including dust removal efficiency improvements, fuel diversification, moving electrodes, current control and reduced auxiliary power and utilities
- Multi-pollutant control technologies including mercury and SO2 control

A Brief History of R&D and Commercialization

- SCR
- ESP
- FGD

[Diagram showing timeline and development milestones for SCR, ESP, and FGD technologies, with key dates and milestones highlighted.]
Retrofitting lignite coal-fired power plants to meet stringent air quality standards

**Ugljevik Power Plant**

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Future</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Capacity</td>
<td>200 MW</td>
<td>180 MW</td>
</tr>
<tr>
<td>Fuel</td>
<td>Lignite</td>
<td>Lignite</td>
</tr>
</tbody>
</table>

In Bosnia and Herzegovina, Serbia and Republika Srpska (in the Western Balkans), lignite coal-fired power plants are the primary power sources. However, for many years some power plants in both countries have emitted high levels of SO₂ and dust, impacting the health of local people and adversely impacting the environment. With their application to join the European Union (EU), both countries must focus on lowering emissions in compliance with the EU Industrial Emissions Directive to receive acceptance into the EU. Mitsubishi Power is providing value-added solutions to bring these plants into compliance and extend their lifespan.

In Republika Srpska in Bosnia and Herzegovina, the state-owned power company Elektroprivreda of Republika Srpska (ERS) has operated the lignite-fired Ugljevik thermal power plant since 1985. Providing 8% of generating capacity in Bosnia and Herzegovina and 23% in Serbia, the plant emits nearly 60 times the amount of SO₂ allowed under the Industrial Emission Directive (IED). Faced with closing it if it was unable to achieve compliance, the company created an environmental action plan to construct a flue gas desulfurization (FGD) unit that would reduce SO₂ and dust pollutants by 94%. To meet this stringent air quality target, ERS chose Mitsubishi Power AGCS for its high desulfurization efficiency technologies with the ability to cut up to 99% of SO₂ emissions. Agreement on the project was reached in 2016.

**Advanced Mitsubishi Power AGCS Technologies offer a cleaner air future**

Following on the Ugljevik project, Mitsubishi Power was engaged for a similar project in Serbia, at the Nikola Tesla A Power Plant. The lignite-fired power plant operated by Public Enterprise Electric Power Industry of Serbia, Serbia’s state-run power utility. First commissioned in 1970, the six generation units have a combined capacity of 1,720 MW. The plant generating approximately 25% of Serbia’s electric power makes it a critical source for ensuring a stable power supply in the country. However, the low-grade lignite coal used for fuel has a high sulfur and ash content. Public Enterprise Electric Power Industry of Serbia wanted to take urgent measures to reduce air pollutants including SO₂, NOₓ and dust.

The project, organized by the Japan International Corporation Agency and financed by the Japan Official Development Assistance, calls for the installation of two FGD units, each with a capacity of 650 MW. Mitsubishi Power, supported by its European subsidiary based in Dusseldorf, Germany, is responsible for project management, design, supplying the main systems and dispatching technical advisors for installation. With these units, which are among the largest in the world, the project aims to slash SO₂ emissions to less than 200 mg/Nm³ to be in compliance with the IED when completed in 2021.

Key factors for the selection of Mitsubishi Power for this critical AGCS project include its value-added solutions to align with the customer’s strategy. Advanced FGD technologies for lignite-fired boilers and a successful track record of supplying more than 300 units worldwide.

**Hiroo Unit 5 & 6 (Japan)**

- **Client**: TEPCO Fuel & Power Inc.
- **Fuel**: Coal
- **Generating Power**: 800 MW
- **Start up**: June 2004, December 2013
- **Product**: AGCS Total Solution

**Kostolcno PS Unit 6 thru 8 (Poland)**

- **Client**: Energa Polska Sp. z o.o.
- **Fuel**: Coal
- **Generating Power**: 340 MW
- **Start up**: July 2017
- **Product**: SCR

**Fast Track 3A (Manjung #5) (Malaysia)**

- **Client**: TNB Western Energy Berhad
- **Fuel**: Coal
- **Generating Power**: 1,000 MW
- **Start up**: September 2017
- **Product**: Gasifier FGD

**Izdemir (Turkey)**

- **Client**: Izdemir Enerji Elektrik Uretim A.S.
- **Fuel**: Coal
- **Generating Power**: 350 MW
- **Start up**: December 2014
- **Product**: Moving Electrode Type Dry ESP

Through projects like this, Mitsubishi Power AGCS solutions contribute to sustainable development providing access to affordable power, improving the quality of life and supporting economic growth in various countries. Mitsubishi Power continues to work to reduce the environmental impact of power and industrial plants in Europe and around the world by offering high performance, high-efficiency air quality control systems that enable customers to meet the world’s most stringent emissions regulations.
Total AQCS Solutions
Mitsubishi Power's comprehensive AQCS solutions enable power plants to meet stringent environmental standards.

Mitsubishi Power is the only company successfully developing its own technologies for the total AQCS area. In addition, Mitsubishi Power can help make power plants become environmentally compliant to meet future strict regulations.

High efficiency AQCS
We have developed a new flue gas treatment system consisting of an ESP, FGD and non-leakage gas-gas heater (GGH) which achieves effective treatment of flue gas so that the system can control dust emissions to be well within stringent regulations.

Furthermore, in urban areas where even more stringent limits are required, wet ESP can be installed downstream of the FGD. With a GGH installed upstream of the ESP, the dust removal efficiency of ESP can be improved markedly.

Mechanisms for high efficiency AQCS
High efficiency AQCS has the following additional features:

1. Improved ESP Performance and Lower Dust Emissions
   Decreases ESP Inlet Gas Temp.
   Decreases Electrical Resistance of Dust
   Improves ESP Performance

2. Higher SO₂ Removal Performance
   Effective removal of SO₂ contributes to additional enhancements including protecting equipment from corrosion and preventing blue plumes.

Addressing the global demand for mercury control solutions
In addition to our NOₓ, SO₂, SO₃, and particulate control technologies, Mitsubishi Power has developed mercury (Hg) control technologies that satisfy the global demand for managing multiple pollutants.

Mercury control mechanisms
Step 1: Oxidation of gaseous mercury using SCR catalyst
Step 2: Absorption and neutralization of mercury on ash particles, captured by ESP or BF
Step 3: Control and absorption of mercury (HgCl₂) at wet FGD

Major mercury control methods and technologies
- Mercury Oxidation Catalyst: Triple Action Catalyst (TRAC™)
  Mitsubishi Power’s proprietary TRAC™ optimizes the oxidation of mercury and reduction of N₂O, and achieves similar levels of SO₂ to SO₃ oxidation.
- Halogen Injection
  Our halogen injection technology enhances mercury oxidation in the SO₂. Mercury chloride is removed by the wet scrubbers.
- Technology to prevent re-emission of mercury in wet FGD
  Our Oxidation-Reduction Potential Control prevents the re-emission of mercury chloride in limestone-gypsum slurry in wet scrubbers.
SCR
The Mitsubishi Power range of advanced SCR systems offer highly-efficient solutions for cleaning flue gases.

<table>
<thead>
<tr>
<th>Maximum Capacity</th>
<th>Max. NOx Removal Efficiency</th>
<th>Low Environmental Impact</th>
<th>SCR Catalyst</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,075+ MW</td>
<td>95%+</td>
<td>Slip NH₃ &lt; 2ppm</td>
<td>High Reliability High Durability</td>
</tr>
</tbody>
</table>

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 40 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 meets 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 to the customers’ requirements
- Multiple pollutant control including mercury and low sulfur oxide
- High reliability
- Longer intervals of catalyst maintenance

SCR for Thermal Power Plants
Application Range
NOx Removal Efficiency: Max. 95%
Treated Gas Flow Rate: 3,140,000 Nm³/h, wet Fuel: Coal, Oil, Gas, Residual Oil, etc.

Gas Turbine Simple Cycle (GTSC)
Application Range
NOx Removal Efficiency: Max. 95%
Treated Gas Flow Rate: 1,540,000 Nm³/h, wet Fuel: Gas, Oil

Gas Turbine Combined Cycle (GTCC)
Application Range
NOx Removal Efficiency: Max. 95%
Treated Gas Flow Rate: 2,820,000 Nm³/h, wet Fuel: Gas, Oil

FGD
Mitsubishi Power’s advanced FGD Systems enable power plants to meet today’s toughest environmental regulations.

<table>
<thead>
<tr>
<th>Maximum Capacity</th>
<th>Max. SO₂ Concentration of Inlet</th>
<th>Max. SO₂ Removal Efficiency</th>
<th>Proprietary Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,100+ MW</td>
<td>80,000+ mg/Nm³ (Coal fired)</td>
<td>99.9%+</td>
<td></td>
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</tbody>
</table>

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 Limestone-Gypsum FGD systems can both treat a large range of SO₂ concentrations, for greater plant reliability and improved operational economics.

Market leading features
With over 360 FGD plants in operation worldwide, Mitsubishi Power has a leading share of the global market. Here’s why:
- Excellent SO₂ removal efficiency that meets stringent emission standards for all kinds of fossil fuels
- Multiple pollutant control with associated environmental control equipment
- High reliability
- Savings on energy and utilities

Wet limestone-gypsum FGD system
Suitable for large-scale flue gas treatment, this system uses limestone as a low-cost absorbent and produces gypsum powder as a stable and valuable by-product.

Seawater FGD system
This system is a good choice in regions with softer regulations on SO₂ emissions. The simple equipment configuration contributes to a lower initial cost compared to a wet limestone-gypsum FGD system.

Major components of seawater FGD
The seawater FGD system consists of two major components: a grid tower scrubber, or a double contact flow scrubber (DCFS), and an aeration basin. In the DCFS, seawater absorbs SO₂ from the flue gas, it is then pumped to the aeration basin, where the SO₂-rich seawater is treated to make it suitable for discharge back into the sea.
ESP
Advanced ESP technologies for collecting flue dust realize cost-efficient air pollution control.

Mitsubishi Power electrostatic precipitators (ESP) collect dust in the flue gas produced by boilers and other combustion sources to meet air pollution control and meet 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).

Dry ESP
Mechanisms for removing dust from the collecting electrode
Fixed and moving-type electrodes have different mechanisms for removing accumulated dust from the collecting electrode.

Fixed electrode type
A rasping device removes the dust accumulated on the collecting electrode.

Moving electrode type
In a moving electrode system, the collecting electrodes consist of short strip elements joined by chains, which slowly move in the flue gas.

The dust that accumulates on the strip elements is scraped off by brushes integrated into the dust collection hoppers.

Wet ESP
Advantages of the Wet Electrostatic Precipitator
- Wet ESP suits applications requiring a higher degree of gas purity at the flue outlet than can be achieved by dry ESP.
- By using water to remove the collected dust, a wet ESP achieves high dust removal efficiency (down to 1 mg/m³) without being adversely affected by the high or low electrical resistivity of dust.

Services
Mitsubishi Power’s comprehensive range of AQCS services economically and efficiently optimize Mitsubishi Power and third party AQCS system performance over their life cycles.

MHPS-TOMONI+ optimizes AQCS operations
MHPS-TOMONI+ supports not only boilers and steam turbines but also contributes to the efficient and economic operation of AQCS. The entire plant and each piece of its equipment are remotely monitored with Mitsubishi Power simulators continually analyzing and evaluating operational data. Potential problems can be detected early and rapidly addressed to ensure normalization of the plant performance, avoiding unplanned downtime.

Optimizing SCR operation, maintenance and catalyst replacement
As an SCR system supplier, Mitsubishi Power offers an extensive range of customer-focused after-sales services including operation and maintenance efficiency plans and optimizing on-going SCR performance by evaluating catalyst samples against actual plant operating conditions and diversified flue gases.

The key to maintaining SCR system performance over time is the SCR catalyst, which requires maintenance and replacement as its active elements gradually deteriorate from flue gas composition over years of operation.

Mitsubishi Power offers a wide range of catalysts with high reliability that contribute to increased NOx removal efficiency with a low SO1 to SO2 conversion ratio, low pressure loss, mercury oxidation and denox removal.

Example of removed SO2 amount vs limestone consumption.

Structures with our comprehensive integrated AQCS services
Our comprehensive integrated AQCS plant services enable our customers’ plants to meet current and future regulations for NOx, SOx, dust and wastewater quality. Our services include upgrading existing AQCS, to meet new standards or manage deterioration of aging plants. We have breadth experience with not only our supplied plants but also with third party supplied technologies as well.

Our service teams have wide-ranging experience not only with Mitsubishi Power AQCS technologies and equipment, but also with other non-GEM equipment and plants.
MHPS-TOMONI, 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 of Power Plants.**

- **Autonomous Operation**
  - Optimize operations in response to changes in environment

- **Advanced operation and maintenance**
  - Minimize maintenance costs, improve equipment reliability

- **Remote monitoring / Smart visualization**
  - Leverage IoT for remote monitoring, diagnostic applications

**Features of MHPS-TOMONI.**

- MHPS-TOMONI is comprised 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 technology and Mitsubishi Power’s knowledges is second to none. The long history has enabled to develop solutions to optimize the operation of the power plant to meet customer’s demands.

**Experience around the world**

Since the early 1960s, Mitsubishi Power has delivered a wide range of environmental conservation systems, integrated flue gas treatment systems and gas-gas heat exchangers to industrial and power customers around the world, installing more than 1,400 SCR’s, 400 FGDs including marine Exhaust gas Cleaning System, and more than 3,300 ESP’s.

Data as of June 2020