Decarbonizing existing infrastructure as a decisive step in the Energy Transition

The MHI Group Technological Capabilities Backed by a Long History and Extensive Achievements

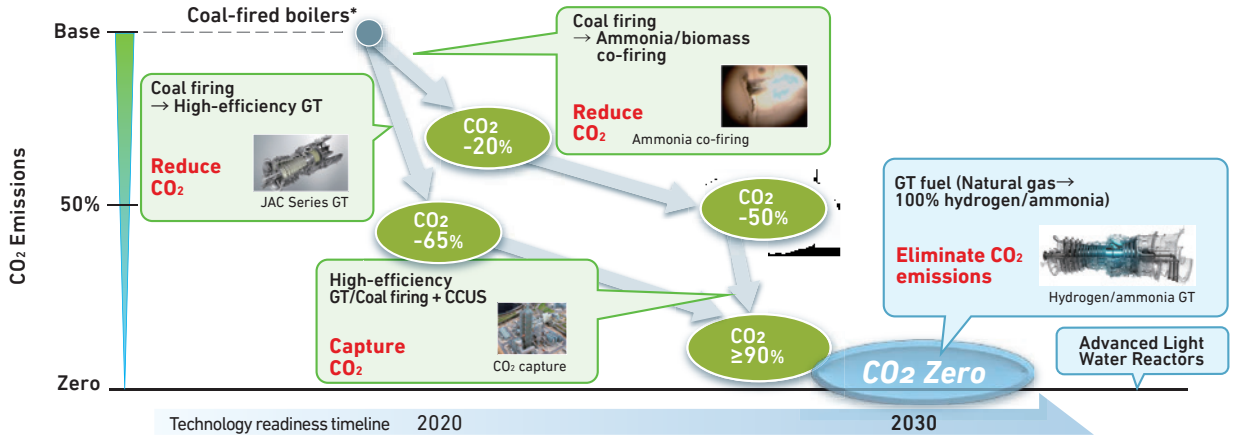
Going all the way back to Japan's first domestically produced steam turbine in 1908, MHI Group's Gas & Steam Power Systems businesses have developed in step with the world's growing demand for electricity. Through our history of development and production spanning more than a century, MHI has grown into one of the world's top-class manufacturers of gas turbines used for power generation. The ability to fire fuel at high temperatures is essential to achieving high efficiency in a gas turbine, which is currently one of our mainstay products. Thanks to cutting-edge technology development efforts in such areas as aerodynamics, cooling, and materials science, MHI brought the world's first 1,600°C J Series gas turbine to market in 2011. MHI Group gas turbines are in operation around the globe, with accumulated orders of over 1,600 units worldwide.

During the Energy Transition, in order to achieve the widespread implementation of solutions including decarbonization through efficiency improvements in existing infrastructure together with conversions from fossil to clean fuels, as well as CO_2 capture, existing infrastructure will need to be replaced in a phased manner over a long period of time. Moreover, technology development will require sustained effort over a long timeframe. Here, MHI's strengths will be on full display: analysis of operations data gathered during often decades of after-sales servicing of our products, continuously developing technology and human resource bases, and a stable financial foundation to support these important resources.

Roadmap to Decarbonizing Existing Infrastructure

The Energy Transition faces different circumstances and issues in each country and region. The demand is high for sound economics in combination with positive environmental impact, making it important to keep costs within a range that society as a whole can bear. At MHI Group, in order to achieve a sustainable Energy Transition while maintaining people's current standard of living, we believe that the phased decarbonization of power generation systems is necessary. To that end, we are proposing solutions that help to reduce CO_2 emissions.

Reducing, capturing, and eliminating CO_2 is one path to decarbonizing thermal power.
Another path is to reduce CO_2 emissions through maximum utilization of nuclear power, a carbon-free energy source.



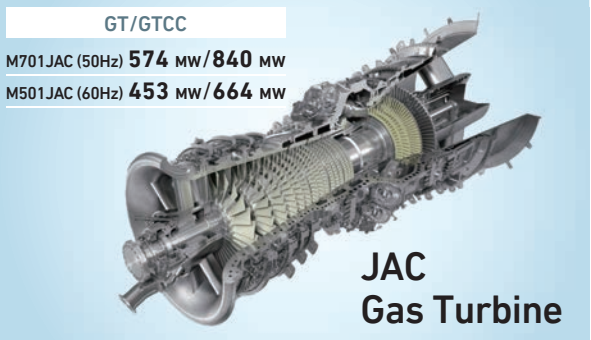
*Based on CO_2 emissions from subcritical pressure coal-fired boilers

Replacement with GTCC

Existing coal-fired thermal power generation systems can reduce CO_2 through the co-firing of low- or carbon-free fuels. CO_2 can also be reduced by replacing coal-fired systems with high-efficiency gas turbines. GTCC power generation systems using cutting-edge JAC Series gas turbines have achieved a power generation efficiency of 64%, the highest level in the world. The result is an up to 65% reduction in CO_2 emissions compared to conventional coal-fired thermal power generation systems. MHI's high-efficiency, highly reliable JAC Series gas turbines also satisfy customer needs as a lower-carbon alternative to coal-fired thermal power as a baseload power source.

In every stage of the process, from gas turbine R&D, design, validation, manufacture, installation, and trial operation to after-sales services, MHI Group provides quality that customers trust.

The Cutting-Edge JAC Series Gas Turbine
Replacing coal-fired thermal power with gas-fired GTCC alone can cut CO_2 emissions by up to 65%.

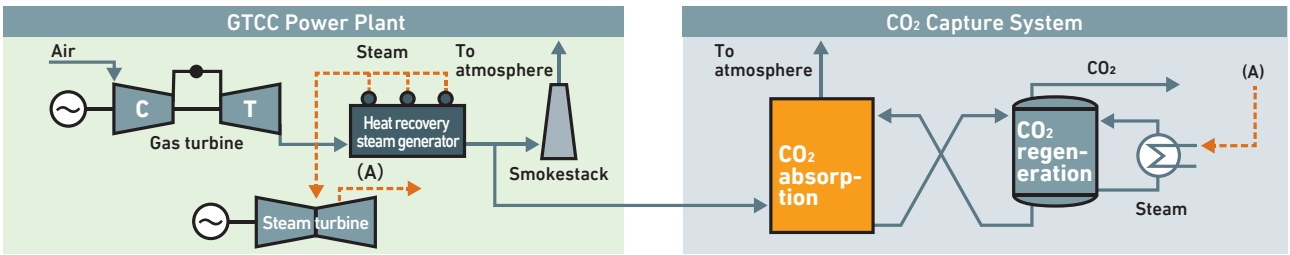


High efficiency: 64% CC efficiency	■ High pressure ratio compressor (25:1) ■ Enhanced air-cooled combustors ■ Advanced thermal barrier coating (TBC)
Reliability: 99.5% reliability	■ Cumulative operation hours: > 2 million hours ■ Booked units: 113 units (J Series as of July 31, 2023)
Fuel flexibility: Compatible with a variety of fuels	■ Fossil fuels (natural gas, oil) ■ Clean fuels (hydrogen)

High-Efficiency GTCC + CO_2 Capture System

MHI Group has developed the KM CDR Process™ and Advanced KM CDR Process™ in collaboration with Kansai Electric Power Co., Inc. since 1990. Both of these technologies employ a chemical absorption method using a proprietary amine absorbent. We have delivered CO_2 capture systems for use in chemical plants and power generation facilities worldwide. As of September 2023, we are the global leader in market share for commercial flue gas CO_2 capture plants on a capacity basis. The demand for combinations of high-efficiency GTCC power systems with CO_2 capture systems is increasing worldwide, driven by the establishment of legal frameworks supporting decarbonization, such as the Inflation Reduction Act (IRA) in the U.S. In 2022, we were awarded front-end engineering design (FEED) contracts for CO_2 capture systems to be applied to GTCC power plants in Alberta, Canada and Aberdeenshire, Scotland. These are just two examples of how we are responding to our customers' decarbonization needs.

By applying a CO_2 capture system to a high-efficiency GTCC power system, it is possible to capture over 90% of the CO_2 emitted.



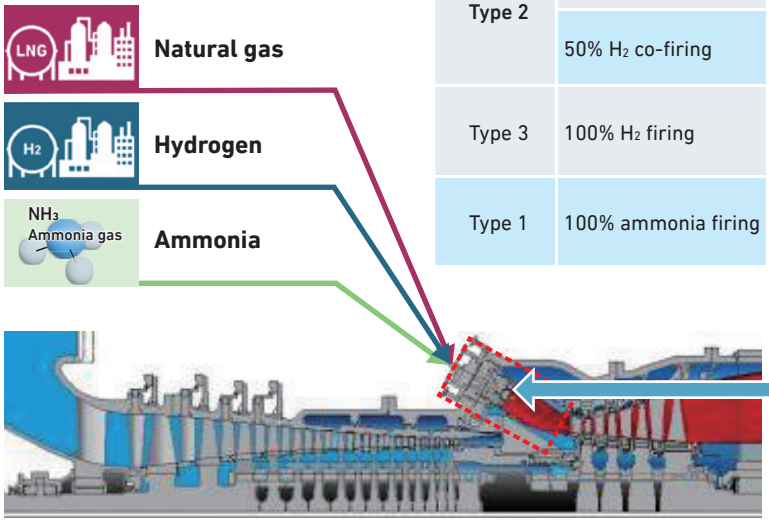
Hydrogen- and Ammonia-Fired Gas Turbine Development

In response to customer requests for a method to effectively utilize refinery and steel plant off-gas, since the 1970s, MHI has manufactured gas turbines which fire off-gas containing hydrogen. Since the 1980s, MHI has developed technology to fire hydrogen in 15 MW-class gas turbines. Leveraging our experience developing and operating combustors for these industrial applications, MHI is working hard to develop next-generation combustion techniques which will make 100% hydrogen firing possible by resolving technical issues, such as hydrogen's especially high combustion rate.

MHI has completed development of a large frame gas turbine combustor enabling 30% hydrogen co-firing. We also successfully conducted a combustion test with a 50% hydrogen mix in 2022. At this milestone, we effectively cleared the EU taxonomy's 270 g/kWh CO_2 emission standard. Going forward, we will develop new types of combustors aiming to launch 100% hydrogen firing for small- to mid-size gas turbines in 2025, and for large frame gas turbines in 2030 or thereafter. Phased validation of these combustion technologies is set to begin in FY2023.

Another valid approach to decarbonization is utilizing ammonia, which acts as a hydrogen carrier and is easier to handle than hydrogen on its own. MHI has also begun work on the development of a 40 MW-class gas turbine that directly uses 100% ammonia fuel. We are pursuing combustor development in the lead up to commercial unit operation and market launch in FY2025 or thereafter.

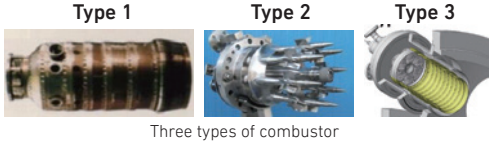
Able to convert a natural gas-fired gas turbine to hydrogen or ammonia firing – and thereby achieve decarbonization – simply by replacing the combustors and adding a fuel supply system



Type 1	100% H_2 firing	Development complete for small- to mid-size GTs
Type 2	30% H_2 co-firing	Development complete for large frame GTs
	50% H_2 co-firing	2022: Successful combustion tests for large frame GTs
Type 3	100% H_2 firing	2024: Combustion tests planned for small- to mid-size GTs Starting 2025: Combustion tests planned for large frame GTs
Type 1	100% ammonia firing	2024: Combustion tests planned for small- to mid-size GTs Validating in lead up to commercial unit operation and market launch in 2025 or thereafter

Combustor replacement

Convert to H_2/ammonia firing by replacing combustors and adding fuel system



Three types of combustor

Decarbonization Technology Development Bases

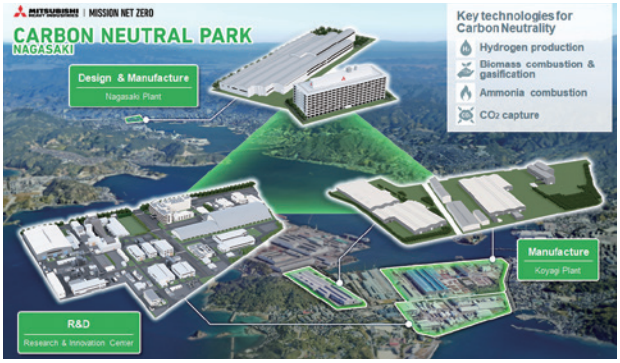
MHI is currently pursuing the development of thermal power decarbonization technologies primarily in the cities of Takasago (Hyogo Prefecture) and Nagasaki (Nagasaki Prefecture), both of which are home to MHI manufacturing facilities and Research & Innovation Centers. At Takasago Hydrogen Park, we are building a facility to perform long-term validation of the latest elemental technologies under actual operating conditions using a commercial-scale GTCC system. We are also building Nagasaki Carbon Neutral Park as the base for the development of these elemental technologies. The process of bringing to market products that have undergone a series of elemental technology development cycles as well as commercial operation-level validation testing raises the reliability of the products developed.

Takasago Hydrogen Park

Takasago Machinery Works – the base for development, design, manufacture, and validation of MHI's gas turbine products – is home to Takasago Hydrogen Park, which will be the world's first integrated validation facility for hydrogen technologies covering all of the steps from hydrogen production to power generation. At the Park, in addition to alkaline water electrolysis, we plan to perform phased testing and validation of a variety of hydrogen production technologies including MHI proprietary solid oxide electrolyzer cell (SOEC), next-generation anion exchange membrane electrolysis (AEM), and next-generation turquoise hydrogen production technology, which will produce CO_2-free hydrogen through the pyrolysis of methane into hydrogen and solid carbon. With this validation facility, we believe MHI will be able to contribute greatly to the wide-scale application of hydrogen and the practical implementation of hydrogen power generation.

Nagasaki Carbon Neutral Park

Established in the city of Nagasaki, Nagasaki Carbon Neutral Park began operation as MHI Group's main site for developing energy decarbonization technologies. At the Research & Innovation Center in Nagasaki, in addition to the hydrogen production technologies being validated at Takasago Hydrogen Park, we are developing elemental technologies for ammonia firing, CO_2 capture, and the synthesis of fuels from biomass which are suitable for use as sustainable aviation fuel (SAF). In parallel, we are accelerating product development and commercialization by applying the thermal energy systems design and manufacturing capabilities developed at Nagasaki Shipyard & Machinery Works' Nagasaki and Koyagi Plants.



MHI Group Vision

While meeting the immediate energy demands of the day, we aim to achieve a Carbon Neutral world by combining cutting-edge power generation technologies and optimized energy solutions. This is MHI Group's vision for the Energy Transition. We view efforts to decarbonize existing power-generation systems as a significant opportunity for MHI Group which also allows us to fulfill our responsibility as a world-class manufacturer in this industry.

Through the development and practical implementation of hydrogen- and ammonia-fired gas turbines – which can contribute to decarbonization – together with CCUS systems and other decarbonization solutions, MHI Group is collaborating with partners worldwide in order to achieve global Carbon Neutrality.