Helping Fight Climate Change by Accelerating Decarbonization

Balancing Economic Development and Reducing Environmental Impact of Economic Activity as We Shift to a Decarbonized World

Fulfilling Our Role as a Company Supporting Fundamental Infrastructure and Aiming for Sustained Growth

MHI Group has contributed to the development of our world by supplying the machinery systems that build fundamental infrastructure. However, as exemplified by SDGs, the issues the world faces in recent years have grown more complex, people's values have become more diversified, and technological innovation has accelerated. Against this backdrop, for MHI Group to continue to answer the needs of all our stakeholders, we will need to go deep into these issues, explore changes in values and technologies, and respond flexibly as a corporation.

To ensure MHI Group remains relevant in the future amid these drastic and uncertain changes, in 2018 we launched MHI FUTURE STREAM (MFS) as an initiative to drive ongoing innovation. As a result of trend analysis in society, economy, and technology, we determined that one area our Group should focus on is to meet the needs of a decarbonized society as a means of solving the challenge of assuring both economic development and reducing our environmental impact. Electricity and other power sources are indispensable for the development of human livelihoods and industries, and as developing countries continue to raise their living standards, global demand will continue to increase. At the same time, when it comes to the problem of climate change, it is important to provide a stable and economically viable electricity supply, while also lessening environmental impact of economic activity. MHI Group has made both economic development and reduction of environmental impact the core of its business strategy, and we will work to develop our business so as to progress toward the achievement of a carbon-free society.

Leveraging Combined Group Strength to Meet the Needs of the Energy Transition Age

Amid growing awareness of climate change issues and the increasing urgency of reducing CO_2 emissions, MHI Group aims to provide a variety of products and solutions that contribute to decarbonization in power generation and other fields.

For example, our existing products and solutions include nuclear power systems that emit no CO_2 and provide large-scale stable power sources, CO_2 capture and utilization technologies (CCS*1 and CCUS*2), and renewable energies such as offshore wind power and hydrogen mixed combustion turbines.

In the field of nuclear power, we will continue to support the safer restarting of existing nuclear power plants (light-water reactors) and help develop the nuclear fuel cycle. We are also developing a next-generation light-water reactor that achieves the world's highest levels in both safety and economics. Looking further into the future, we will also work to develop power reactors for small-scale grids and on-board reactors for marine vessels.

We are also developing solutions in anticipation of a coming proliferation of hydrogen usage. Our solutions include 100% hydrogen combustion turbines using hydrogen derived from renewable energy, and hydrogen production using high-temperature gas-cooled reactors (HTGRs).

MHI Group will leverage our combined abilities to provide solutions for the energy transition through product and technology integration, and contribute to solutions to climate change and other issues facing our world.

*1 CCS: Carbon Capture and Storage
*2 CCUS: Carbon Capture Utilization and Storage

MHI Products and Solutions to Accelerate Decarbonization

Renewable Energy

MHI offers a variety of solutions to meet the ever-increasing demand for renewable energy.

In offshore wind power generation, we are rolling out business through MHI VESTAS OFFSHORE WIND A/S, a joint venture with Vestas of Denmark specializing in offshore wind power generation equipment, meeting growing demand for offshore wind in Europe, the United States and Asia Pacific. In addition to the supply of offshore wind power systems, in July 2020 we signed a collaboration agreement with Denmark's Copenhagen Infrastructure Partners P/S (CIP) for the development of an offshore wind power project in Hokkaido. Acting on the opportunity presented by this collaboration with CIP, we will expand into the offshore wind power generation business.

Furthermore, to better regulate fluctuating power generation, a characteristic of renewable energy, and to maintain a balance between supply and demand, we have commenced initiatives to provide power generation systems that combine storage batteries and Power to Fuel*3.

In addition, MHI Group provides Organic Rankine Cycle (ORC) generation systems, which use geothermal heat, waste heat recovery, biomass, and solar heat to efficiently generate zero carbon electricity from medium- and low-temperature heat sources. ORC systems use medium- to high-temperature heat-transfer oil to heat and evaporate an organic working medium in an evaporation unit. The steam produced then rotates the turbine to achieve clean and stable power generation.

*3 Power to Fuel refers to technologies that use the electric power generated from renewable energy to produce hydrogen and other alternative fuels.

Special Feature: Helping Fight Climate Change by Accelerating Decarbonization

Next-Generation Light Water Reactors and Small-Modular Light Water Reactors

Nuclear power is a carbon-free energy capable of stable, large-scale supply with zero CO_2 emitted during operation. As such, it holds promising prospects for ongoing use as a crucial baseload power source. In order to help deliver decarbonization with nuclear technology, MHI Group is working to develop next-generation light water reactors with the world's highest levels of both safety and economics. In terms of safety, in the interest of further enhancing compliance with Japan's new domestic regulatory standards established after the lessons learned from the Fukushima Daiichi Nuclear Power Station accident, we will aim for the world's highest level of safety by incorporating the following measures all the way from the design stage:

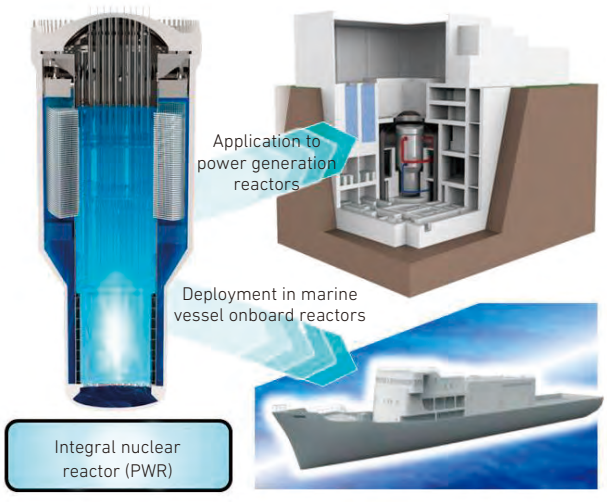
(1) Strengthening of safety functions (multiplicity and diversity) based on the principle of "stop, cool, and confine" without fail in the event of an accident
(2) Strengthening measures against natural disasters (external hazards) such as earthquakes, tsunamis, fires, and tornadoes
(3) Strengthened security against terrorism/cyber terrorism and intentional aircraft collisions

In terms of economic efficiency and operability, we aim to create plants capable of providing society with stable and affordable power supply into the future by improving operability and maintainability, raising efficiency, as well as reducing running and construction costs.

In addition, especially in terms of social acceptability, through discussions with experts and electric power companies at academic societies and other venues, we are working to specify the requirements for next-generation light water reactors, and we have commenced conceptual design and technological development.

Furthermore, in order to meet the diverse needs of power sources in the future, we are also developing a small integrated nuclear reactor (small light water reactor) as we look to expand into power reactors for small grids and marine vessel onboard reactors compatible with mobile usage. Based on well proven pressurized water reactor (PWR) technology, we use a unique integrated reactor design with the vital machinery built into the reactor vessel, and attain high safety levels by, in principle, eliminating the occurrence of accidents due to loss of reactor coolant.

Next-generation light water reactor



Small-modular light water reactors
(power generation reactors, marine vessel onboard reactors)

CO_2 Capture, Utilization and Storage

With the growing concern around the world for global warming, attention is being directed towards CO_2 Capture, Utilization and Storage (CCUS), which captures the CO_2 emitted from the burning of hydrocarbons so that it can be put to effective use or permanently stored underground.

MHI Group started developing technology for CO_2 capture from combustion flue gas in 1990, and the first commercial plant was delivered in 1999 for a Malaysian fertilizer company. Globally, MHI holds a large market share in the field of CO_2 capture. MHI developed the KM CDR Process® *4 with The Kansai Electric Power Co., Inc. The KM CDR Process® captures more than 90% of CO_2 in the gas it treats with a product purity of 99.9 vol%. MHI's technology delivers superb energy-savings and high reliability. MHI has studied and optimized the CO_2 capture plants so that it can be used on a wide range of combustion gases from fuels such as heavy oil, coal, natural gas, and biomass.

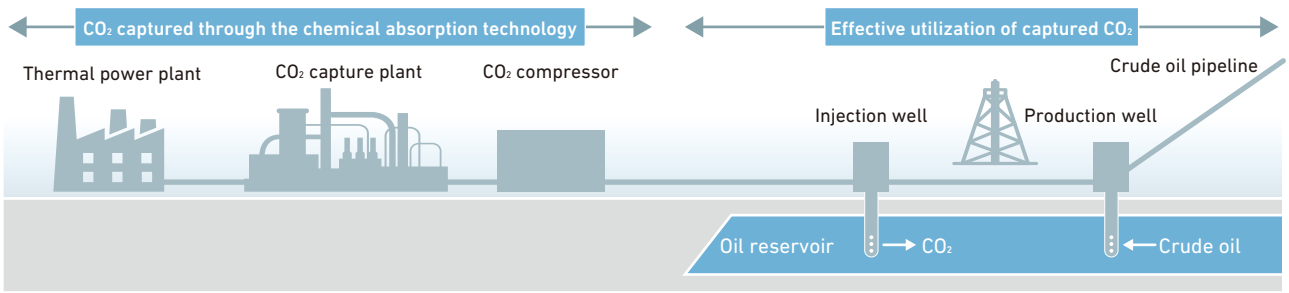
We recently announced participation in a new bio-energy with carbon capture and storage (BECCS) pilot project in the UK. BECCS has the potential to reduce CO_2 emissions in the atmosphere (net negative CO_2 emission) by combining biomass power generation, which on its own is considered carbon neutral, and CO_2 capture technology which can capture 90% of CO_2 emissions from the power plant.

Underground CO_2 storage has also gained attention as a way to prevent CO_2 emissions to the atmosphere. Permanent storage in various geologies is possible, and governments have been incentivizing this option. Additionally, Enhanced Oil Recovery (EOR) can utilize captured CO_2 by injecting it into an oil field to recover crude oil left underground (only 20% to 30% of which can be recovered conventionally), giving CO_2 a commercial value while storing it permanently underground.

*4 KM CDR Process® is a registered trademark of Mitsubishi Heavy Industries Engineering, Ltd. in Japan, the United States of America, the European Union (EUTM), Norway, Australia, and China

Mobile CO_2 capture unit to be deployed for the BECCS pilot project in the UK

CO_2 capture plant (world's largest CO_2 capture volume of 4,776 tons / day for a power plant application)



Special Feature: Helping Fight Climate Change by Accelerating Decarbonization

Developing Solutions for the Coming Age of Hydrogen

Hydrogen energy is a storable energy that emits no CO_2 when burnt, and has good prospects for use in a wide range of fields such as power generation, industry, and transportation. If we can store hydrogen of the type that emits no CO_2 at the manufacturing stage, and make stable use of it when required, we will make great strides toward the transition to a decarbonized world.

In addition to participating in projects to convert natural gas-fired power plants to hydrogen fuel, MHI Group is working to develop hydrogen manufacturing technologies using renewable energy or high-temperature gas-cooled reactors (HTGR), and is also engaged in measures for the effective usage of CO_2 using hydrogen.

Magnum Power Plant Project in the Netherlands
(one of the world's largest 100% hydrogen fired power projects).

Projects to Convert Natural Gas Fired Power Plants to Hydrogen Fuel

MHI Group has a track record going back to 1970 of supplying gas turbines to power plants using hydrogen mixed fuel, with aggregate running time now exceeding 3.5 million hours. When it comes to large gas turbines as well, in 2018, we achieved 30% hydrogen mixture combustion technology with our own in-house developed combustion unit technology, and we are now engaged in a variety of projects around the world.

In the Netherlands, MHI Group is part of a project to convert primarily natural gas fired gas turbine combined cycle (GTCC) plants that we have delivered to that country to hydrogen fired. The project aims to convert 440 MW of those facilities to 100% hydrogen fired by 2025. This is expected to reduce the amount of CO_2 currently emitted annually by those facilities by approximately 1.3 million tons.

In addition, in Utah, USA, we plan to deliver GTCC power generation equipment using hydrogen-fired large-scale gas turbine technology commercialized by MHI Group. We will commence operations with a hydrogen co-firing rate (mixture ratio by volume) of 30% in 2025, and aim to reach 100% hydrogen operation by 2045. Converting Utah over to 30% hydrogen co-firing will contribute to annual CO_2 emissions reductions of up to approximately 4.6 million tons (equivalent to absorption by forests roughly 2.4 times the surface area of Tokyo). Furthermore, the

Broad operational track record
Over 3 million hours

Rich track record of hydrogen co-firing, in over 30 gas turbines since 1970

Technology validation of latest advanced class gas turbines
30% H_2 co-firing

STEP 1 (completed)

Hydrogen co-firing
30vol% H_2
Pre-mixed combustor
(NEDO sponsored program)

World's largest hydrogen power generation
100% H_2 firing

STEP 2 (by 2025)

Hydrogen firing
100vol% H_2
Diffusion combustor
(Magnum Project in the Netherlands)

Further advancement in technology
High Efficiency

STEP 3 (by 2030)

Hydrogen fired
100vol% H_2
Multi-cluster combustor
(NEDO sponsored program)

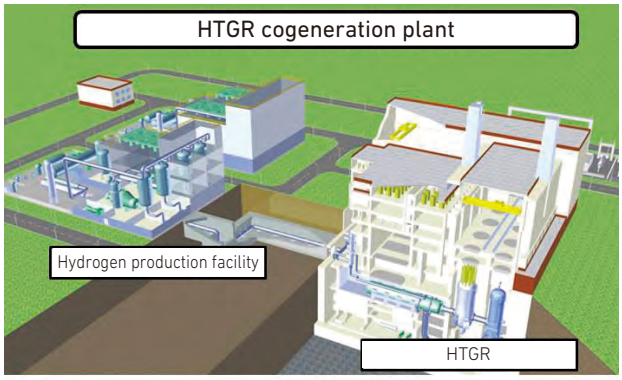
hydrogen used by GTCC power generation facilities is expected to make use of the energy storage project using renewable energy-derived electricity in Utah, in which MHI Group is a participant. The project takes hydrogen and other substances extracted by hydro-electrolysis using renewable energy and stores them in a salt mine in Utah. It aims to develop 1000 MW energy storage facilities, which would be one of the world's largest for 100% renewable energy-derived hydrogen.

HTGR-based Hydrogen Production and Electric Power Cogeneration

Up until now, the majority of nuclear energy has been used for power generation, with only narrowly limited use outside the field of electric power. However, as we work toward achieving decarbonization, there are mounting expectations for innovation in multipurpose usage of nuclear energy since it emits no CO_2 during operation.

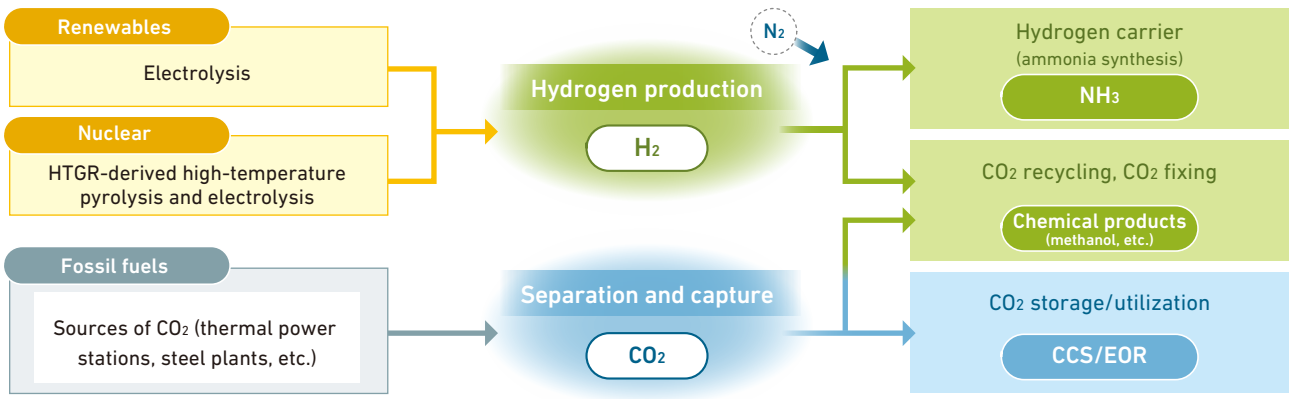
High-temperature gas-cooled reactors (HTGRs) are capable of extracting ultra-high temperature heat of over 900°C, which is much higher than conventional light water reactors, and they are being considered for use in various industrial processes such as hydrogen production.

With an eye on increasing demand for hydrogen in the future, MHI Group is working to develop HTGR cogeneration plants that achieve both high-temperature heat utilization and power generation, providing stable, affordable, mass-quantity hydrogen production. We will contribute to achieving a decarbonized hydrogen-based economy in various industrial fields, including the steel industry, which is working toward the use of hydrogen-based reduction technologies.



Effective Utilization of CO_2 Using Hydrogen

We are working on effective usages for CO_2 as well, such as the refining of methanol and other chemicals using hydrogen generated by hydro-electrolysis and pyrolysis using renewable energy and nuclear energy, and CO_2 separated and captured by CO_2 capture units from fossil fuels used at thermal power plants and steel mills.



CCS: Carbon dioxide Capture and Storage
EOR: Enhanced Oil Recovery