

MHI Group's Carbon Neutrality Initiatives

To enhance corporate value and achieve growth in the medium to long term by resolving some of society's most pressing issues, MHI Group identified what we call Materiality to address in 2020. One of these issues was to provide energy solutions to enable a carbon neutral world.

Then, in October 2021, as a company-wide goal that put this Materiality into concrete terms, we announced MISSION NET ZERO, our commitment to achieve Carbon Neutrality by 2040. Here, we introduce our general approach to realizing Carbon Neutrality along with details on specific initiatives.

2040 Carbon Neutrality Declaration

MHI has defined two growth areas to focus on in its 2021 Medium-Term Business Plan (MTBP), announced in 2020: "Energy Transition," which aims to decarbonize the energy supply side, and "Smart Infrastructure", which aims to realize the decarbonization, and promote the energy efficiency, and manpower saving in the energy demand side. MHI Group is committed to promoting the business strategies of these two areas, and to advancing the decarbonization of the existing businesses, electrification, and intelligence, in order to achieve Net Zero by 2040, and to help create a carbon neutral society.

Realizing a carbon neutral society is a global issue and we believe that as a technology leader, with a proven track record in the field of decarbonization, it is MHI's responsibility to help lead the fight against climate change. To this end, each and every one of us will act to implement a Net Zero future, working closely with all of our stakeholders, including clients, partners, academia and local and national governments.

► For more details about our 2040 Carbon Neutrality Declaration, please visit our website at:
<https://www.mhi.com/expertise/carbon-neutral>

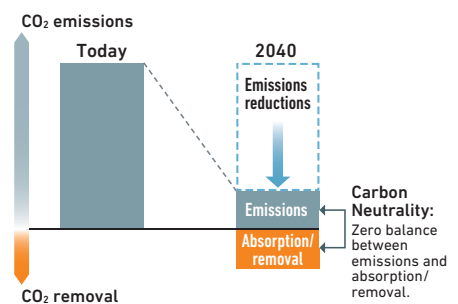
MISSION NET ZERO



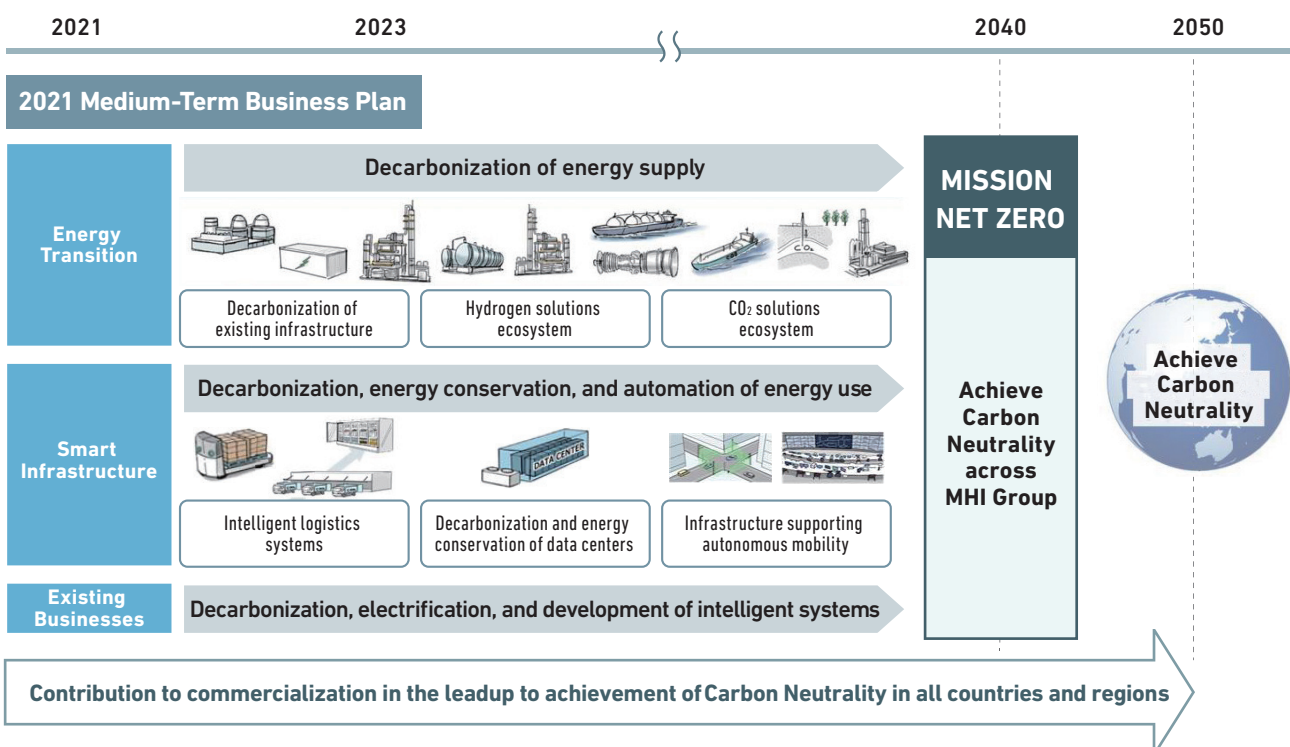
What Is Carbon Neutrality/Net Zero?

Carbon Neutrality refers to the state where net CO₂ emissions – after subtracting CO₂ absorption and removal – become zero. In other words, after reducing CO₂ emissions as far as possible, we will offset the remaining emissions that cannot be eliminated either by absorption with afforestation or reuse, or removal through methods such as underground sequestration to achieve a balance of zero, or Net Zero.

The diagram on the right explains the concept of Carbon Neutrality.



▶ Roadmap to MISSION NET ZERO



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CO₂ Emissions Reduction Targets

Under MISSION NET ZERO, our 2040 Carbon Neutrality Declaration, MHI Group's first goal is to reduce our CO₂ emissions (Scopes 1 and 2) to 50% of 2014 levels by 2030 and reach Net Zero emissions by 2040.

Our second goal focuses on Scope 3 emissions, the majority of which arise from customers' use of our prod-

ucts. We aim to reduce CO₂ emissions throughout our entire value chain to 50% of 2019 levels by 2030 after deducting reductions from CCUS* and to reduce them to Net Zero by 2040.

*CO₂ Capture, Utilization, and Storage

Target year	Reduce CO ₂ emissions across MHI Group Scopes 1 and 2	Reduce CO ₂ emissions across MHI's value chain Scope 3 + CCUS reductions
2030	-50% (Compared to 2014)	-50% (Compared to 2019)
2040	Net Zero	Net Zero

* Scopes 1 and 2: Calculation based on GHG Protocol

Scope 3: Calculation based on GHG Protocol. However, we also account for reductions achieved by CCUS as an MHI original index.

What Are Scopes 1, 2, and 3?

The definitions of Scopes 1, 2, and 3 CO₂ emissions provided by the GHG Protocol* are presented in the figure to the lower right. Scope 1 is MHI Group's direct CO₂ emissions, which are generated mainly from the combustion of fuels. For example, if the heat needed for production equipment in a production facility is generated by a boiler installed on-site, the CO₂ emitted as exhaust gas from that boiler falls under Scope 1.

Scope 2 is indirect emissions associated with the use of electricity, heat, and steam provided by other companies. The main component of this is electricity use. For example, when using electricity purchased from a power utility in buildings and production facilities, the CO₂ emitted during the generation of that electricity falls under Scope 2.

Scope 3 is emissions from other

companies up- and downstream from our Group in the value chain. Upstream, CO₂ emitted during the production and transportation of raw materials, for example, falls under Scope 3. Downstream, CO₂ emitted from the operation and disposal of our Group's products, such as electric generation equipment, falls under Scope 3.

GHG Greenhouse Gas

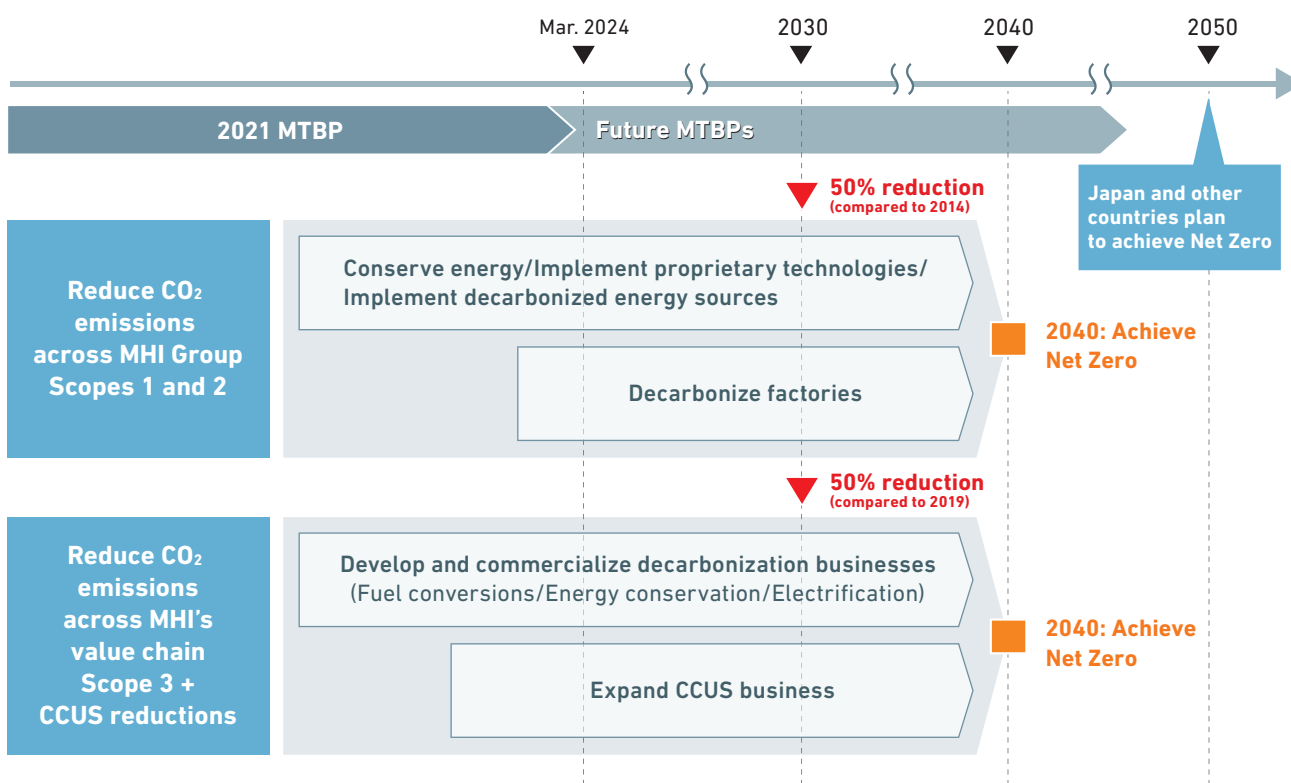
***GHG Protocol**
A globally recognized standard for calculating and reporting greenhouse gas (GHG) emissions. This standard was developed with the involvement of government agencies around the world under the leadership of the World Resources Institute (WRI), a U.S.-based environmental think tank, and the World Business Council for Sustainable Development (WBCSD).

Roadmap and Initiatives for Realizing Carbon Neutrality

Under MISSION NET ZERO, our 2040 Carbon Neutrality Declaration, MHI Group aims to achieve net zero CO₂ emissions by 2040, ten years earlier than the 2050 goal announced by many countries including Japan. We chose this timing by taking into account the lead time for our Group's products and technologies to enter service.

This goal is an expression of our determination to set an example by realizing Carbon Neutrality before the rest of the world does.

▶ Roadmap and Initiatives for Realizing Carbon Neutrality



MHI Group's Carbon Neutrality Initiatives

Scopes 1 and 2

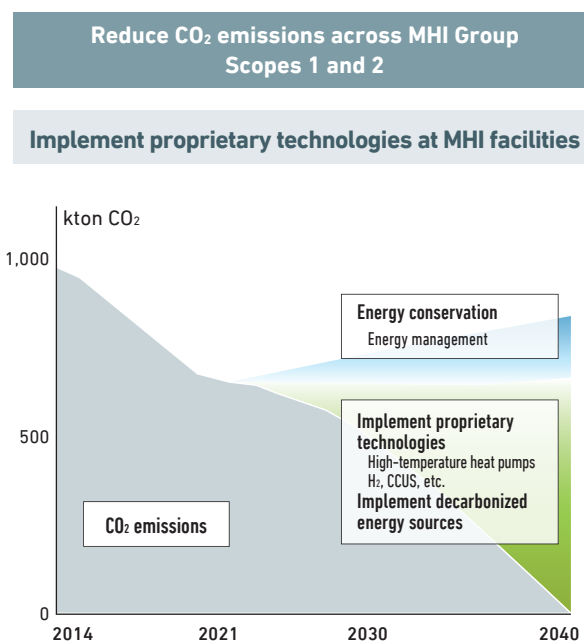
MHI Group's Scopes 1 and 2 emissions were approximately 940,000 metric tons in 2014. In 2021, these emissions were already reduced by over 40% to approximately 550,000 metric tons. To accelerate these efforts even further, we will implement decarbonization solutions at our own production facilities first. Then, we will realize Net Zero Scopes 1 and 2 emissions by 2040 utilizing clean energy.

Specifically, we have started considering implementation of decarbonization products and solutions, such as streamlined energy use in production processes, electrification of heat sources with heat pumps, CCUS, and efficient use of non-fossil fuels with AI-enabled energy management systems.

In June 2022, MHI concluded a basic agreement with The Chugoku Electric Power Co., Inc., under which Chugoku Electric will supply MHI with green power generated by solar panels installed at MHI's Mihara Machinery Works under a combination of on-site and off-site power purchase agreements (PPAs). In this way, we plan to decarbonize all electricity consumed at the facility by the end of 2023. As a result, annual CO₂ emissions from Mihara Machinery Works will be reduced by approximately 10,000 metric tons.

Scopes 1 and 2 emissions present a challenge for the decarbonization of not only MHI's but also other companies' facilities. By using our own facilities as test beds

for decarbonization solutions and applying the results of these efforts to our customers' plants, we can unlock some of MHI Group's businesses' latent potential and become a major driving force toward achieving Carbon Neutrality in industry overall.



Scope 3 + CCUS Reductions

Reducing Scope 3 Emissions

MHI Group's Scope 3 emissions in 2019 were calculated at approximately 1.5 billion metric tons. The scale of these emissions has a significantly higher impact on the world compared with that of Scopes 1 and 2.

With regard to these Scope 3 emissions, we are developing core products and technologies to decarbonize both

energy supply and use. We are working to achieve rapid commercialization in order to reduce emissions.

MHI Group's Energy Transition initiatives are aimed at the decarbonization of the energy supply. As a first step, we are increasing efficiency by replacing existing thermal power plants. MHI's JAC-Series large-frame gas turbines offer the world's highest level of efficiency, and MHI is steadily accumulating experience winning orders,

delivering, and operating this product all over the world. By replacing standard thermal power plants with these highly efficient gas turbines, which emit less CO₂, we can make progress in reducing our Scope 3 emissions.

Utilization of Hydrogen and Ammonia

Using hydrogen and ammonia is expected to achieve dramatic reductions in CO₂ emissions. Hydrogen is a clean energy source that does not emit CO₂ during combustion. Furthermore, earth has abundant supplies of hydrogen in the form of water. Ammonia is also drawing attention as a carbon-free fuel. Like hydrogen, it emits no CO₂ during combustion and offers the additional benefit of being easier to transport and store than hydrogen. There is also much infrastructure already in place around the world to manufacture ammonia.

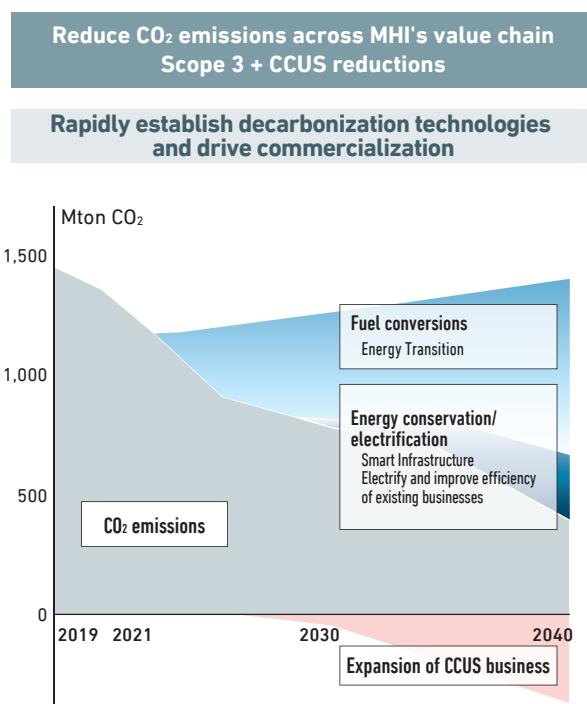
MHI Group will promote the decarbonization of existing thermal power plants through fuel conversions to hydrogen and ammonia, thereby decarbonizing existing infrastructure. For example, during hydrogen combustion tests, we have completed development of up to 30% mixed hydrogen firing in large-frame gas turbines, and we have overcome technical challenges to attain stable combustion of a 50% hydrogen mix. We are conducting validation testing of 100% hydrogen firing with the aim of commercializing for small and mid-sized gas turbines in 2025 and large-frame gas turbines in 2030. Furthermore, we are jointly developing a combustor that can handle both mixed and 100% ammonia firing for use in existing coal-fired boilers, with validation planned to start by 2028. Since single-fuel and mixed hydrogen and ammonia firing can be achieved in existing power plants after a certain amount of modification, this existing power generation infrastructure can continue to be utilized, thereby allowing us to realize decarbonization while reducing the cost to the wider community.

Furthermore, in the area of energy use, we are developing breakthrough hydrogen technologies to decarbonize the steel industry, which accounts for 7 to 10% of global GHG emissions. Currently, coal is used in the iron ore reduction process (the process of removing oxygen from iron oxide, the primary component of iron

ore), which generates large quantities of GHG. Since April 2021, MHI has operated a pilot plant with the world's first hydrogen-based fine ore reduction (HYFOR) process aiming to convert the industry to a decarbonized process using hydrogen. We are conducting validation tests in the leadup to commercialization of this technology.

Furthermore, as a part of our efforts to establish a value chain encompassing all processes from hydrogen production to use, MHI is currently building Takasago Hydrogen Park, an integrated testing facility for hydrogen production, storage, and electricity generation, which is slated to begin operations in 2023. Takasago Hydrogen Park will be located adjacent to Takasago Machinery Works' combined cycle demonstration power plant. Its hydrogen production facility will use a water electrolysis system and will also conduct sequential testing and validation of next-generation hydrogen production technologies such as methane pyrolysis, which produces turquoise hydrogen by splitting methane into hydrogen and solid carbon.

► Please see "A Conversation with the CTO: MHI Group is making important contributions toward realizing Carbon Neutrality" on page 24 for details.



MHI Group's Carbon Neutrality Initiatives

CCUS' Contributions to Net Zero

We have introduced our multifaceted approach to reducing Scopes 1, 2, and 3 emissions. However, what makes MHI's 2040 Carbon Neutrality Declaration unique is its deduction of emissions reductions achieved through CCUS from Scope 3 emissions.

While it is possible to reduce CO₂ emissions by decarbonizing existing infrastructure and the other methods already mentioned, it is not possible to eliminate emissions completely. According to our current estimates, even in 2050, approximately 4 to 13 billion metric tons of annual CO₂ emissions are expected to remain. This is due to the existence of industries where CO₂ emissions are hard to abate, such as steel and cement manufacturing. To realize Carbon Neutrality, it will be necessary to capture the CO₂ coming from these industries.

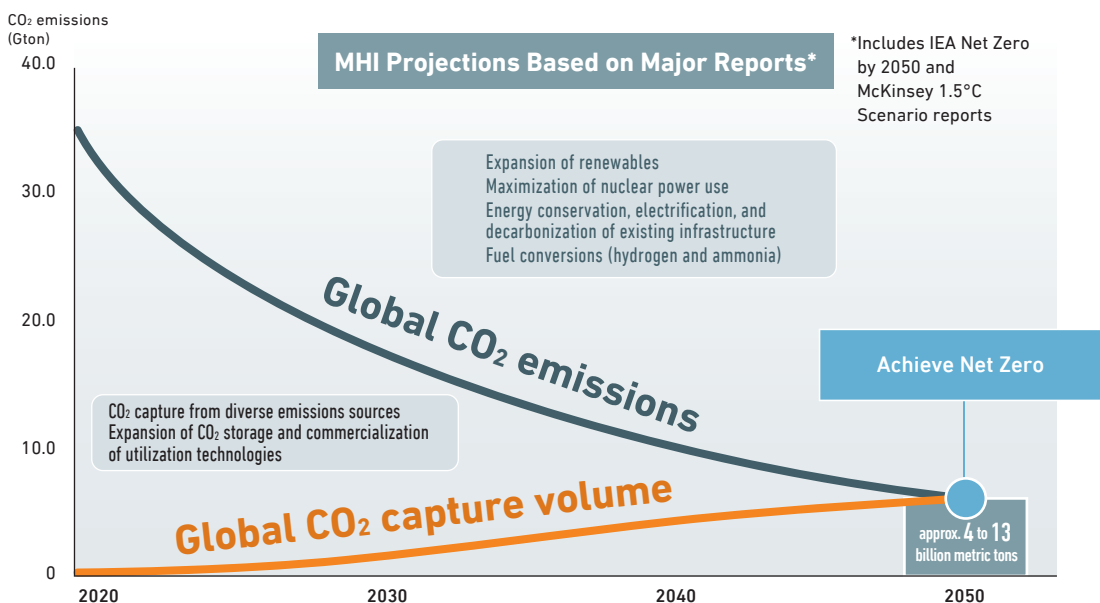
MHI Group has worked with Kansai Electric Power Co., Inc. since 1990 to develop a chemical-based CO₂ capture process using an amine absorbent. Today, MHI Group has a strong track record in delivering commercial CO₂ capture plants to projects in countries around the world, and we are the global market share leader in CO₂ capture from exhaust gas on a capacity basis.

For example, MHI delivered a plant with a capacity to capture 4,776 metric tons* of CO₂ per day to the Petra Nova Carbon Capture Project in the U.S., the world's largest CO₂ capture plant. MHI's CO₂ capture technology was also selected for use in a project to capture CO₂ emissions from a biomass power plant belonging to Drax Group, a major U.K. power utility. If this project is realized, it will reduce CO₂ emissions by over 8 million metric tons per year.

*Capacity as of the publishing of this report.

We are also promoting various initiatives in response to diverse needs associated with building a CO₂ solutions ecosystem, creating businesses that will not only capture CO₂ but will also encompass all aspects of CCUS, including transportation, storage, and utilization.

We defined our CO₂ reductions target as Scope 3 + CCUS reductions not only because MHI Group is the established global leader in CO₂ capture technology and delivered capacity, but also to show our contributions to achieving Carbon Neutrality through the commercialization of CCUS and the establishment of a CO₂ solutions ecosystem.



A Digital Platform Connecting the CCUS Value Chain

Practical application of CCUS (CO₂ Capture, Utilization, and Storage) will be essential for achieving Carbon Neutrality. Below, we introduce CO₂NNEX, a digital CCUS platform that MHI is developing together with IBM Japan, Ltd. to accelerate its implementation.

Current Status of CCUS and Challenges to Be Addressed

CCUS involves the capture of CO₂, its storage underground, and its recycle as, for example, a raw material in chemical products.

Today, global CO₂ emissions are around 40 billion metric tons per year. Many countries are taking steps to reduce this volume by shifting away from fossil fuels to renewable energy, among other measures. However, even with these efforts, annual emissions of around 4 to 13 billion metric tons are projected to remain in 2050. To achieve Carbon Neutrality, it will be necessary to capture this CO₂.

However, CO₂ capture is struggling to grow, as the applications and storage capacities for captured CO₂ are currently limited, and the high costs associated with CCUS make it uneconomical. For this reason, of the approximately 40 billion metric tons of CO₂ emitted in 2022, the amount captured remained at less than 0.1 billion metric tons.

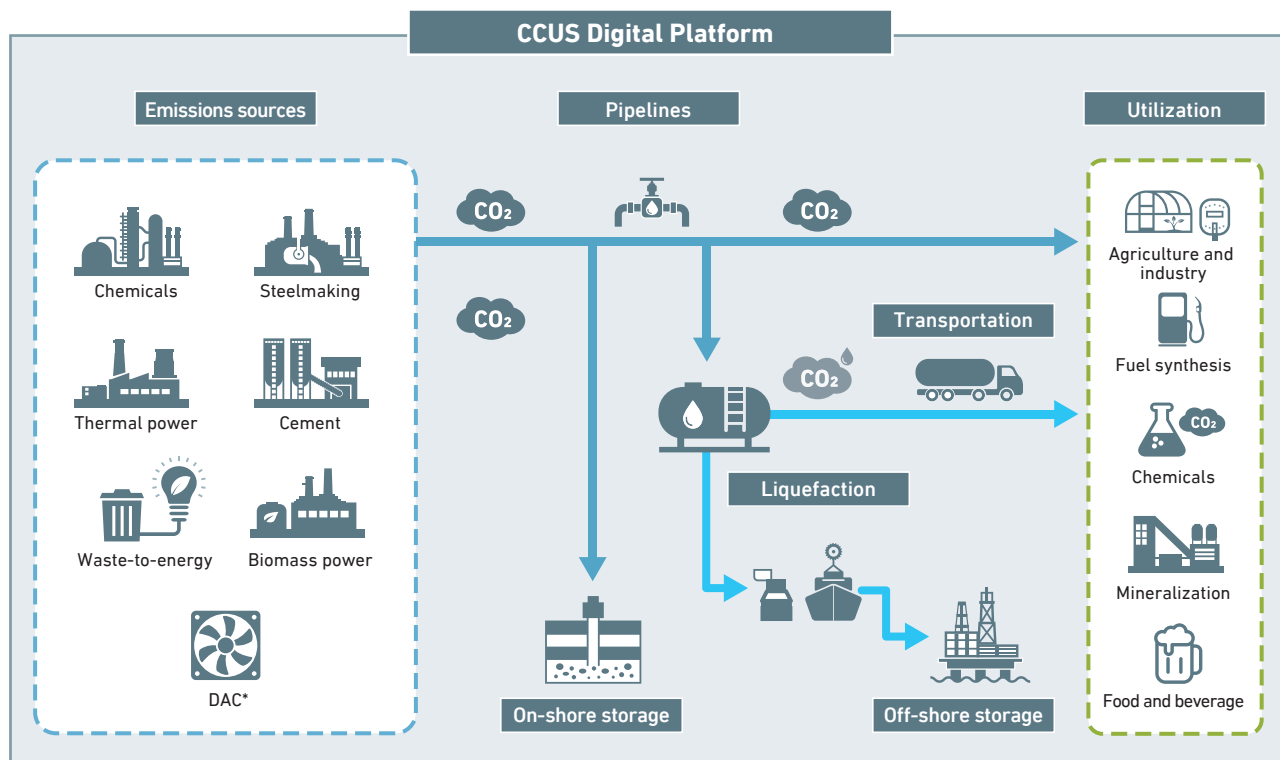
Connecting the CCUS Value Chain

All captured CO₂ needs to be transported downstream in the CCUS value chain for reuse or storage. Furthermore, businesses utilizing CO₂ as a raw material cannot operate with confidence without a stable and economical supply of CO₂. Moreover, it is not possible to actively increase the amount of CO₂ capture without assurance that all remaining unused CO₂ will be safely sequestered underground.

Conversely, if we can effectively build a CCUS value chain connecting all of the parties active in CO₂ capture, transportation, utilization, and storage, then both utilization and capture volumes can be expected to grow dramatically. In addition, if carbon pricing schemes—details to come later in this article—can give CO₂ economic value, then many parties will participate in economic transactions in the CCUS value chain, thus giving rise to a CO₂ solutions ecosystem from which completely new business models can emerge.

MHI Group's Carbon Neutrality Initiatives

► Realizing a CO₂ Solutions Ecosystem



*Direct Air Capture

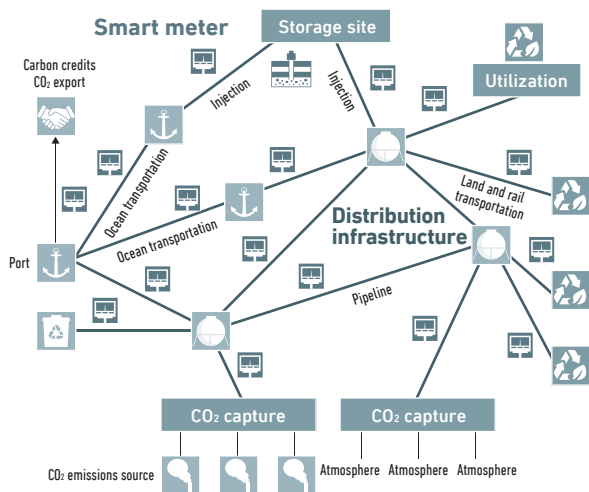
Connecting the Real and Virtual Worlds of CCUS

CO₂NNEX is a digital platform designed to maximize the environmental value of CO₂ reductions. When CO₂ is circulated among the users connected by the platform, CO₂ transaction-related information will be converted into data, visualized, and tracked. Those records will be certified and provided by a secure, tamper-proof method.

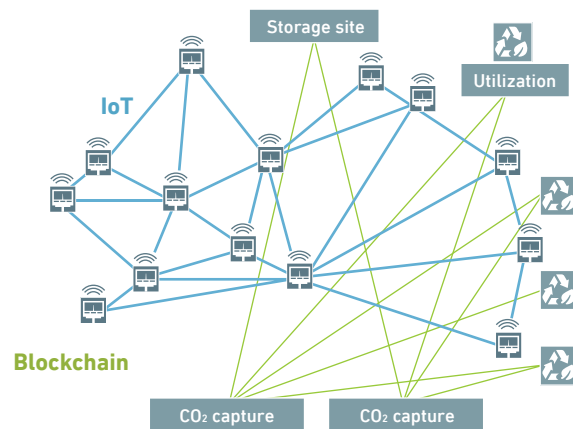
Users in the CCUS value chain include businesses involved in the capture, utilization, storage, and transportation of CO₂ as well as the carbon trading. These various businesses will be connected through infrastructure in the form of pipelines, shipping lines, railways, and trucking lines, forming distribution channels.

One important aspect of this project is the digitalization of distribution. CO₂NNEX will use smart meters with a common interface at key points in distribution channels to enable users to see at a glance the volume, origin, and destination of CO₂. This will enable CO₂ reductions to be tracked with hard data. The system will be a digital twin, a mirror image of the real world in virtual space.

► The CO₂NNEX Concept



Real world (Distribution infrastructure)



Virtual space (Digital platform)

Accurate Visualization of CO₂ Distribution

Currently, the CCS and CCU value chains are mainly formed based on agreements between individual parties including emitters and transportation, utilization, and storage providers. CO₂NNEX will connect these individual value chains to create a network of CCUS value chains which has an even broader user base. The realization of this kind of CCUS value chain is expected to enable freer and more flexible transactions of environmental value derived from CO₂ reductions. As a result, the volume of CO₂ capture and distribution is expected to grow exponentially.

Along with tracking the distribution of CO₂, CO₂NNEX will also use blockchain technology to ensure a high level of security, enabling safe and fair CO₂ transactions and ensuring that distribution information is recorded in a tamper-proof format.

The introduction of carbon pricing schemes* around the world in the near future will enable environmental value trading in monetary form by emitters, with certifying organizations verifying companies' CO₂ reductions in the form of credits. In addition, these credits will likely be able to be traded like financial instruments in a credit market

by various parties, including individual investors. Accurate record-keeping and tracking by CO₂NNEX will provide evidence of environmental value, which will be essential for many parts of the carbon economy, such as the assessment of subsidies and the monetary value of credits.

*Carbon pricing curbs greenhouse gas emissions by placing a fee on emitting and/or offering an incentive for emitting less. The price signal created shifts consumption and investment patterns, making economic development compatible with climate protection.

(Source) The United Nations Framework Convention on Climate Change. "About Carbon Pricing." Accessed November 2, 2022.

<https://unfccc.int/about-us/regional-collaboration-centres/the-ciaca/about-carbon-pricing#What-is-Carbon-Pricing?>

CO₂NNEX will also enable the supply of highly reliable data to various service providers. This will attract diverse business operators to monetize this new environmental value within CO₂NNEX, forming a completely new business ecosystem related to CCUS. For example, in addition to funding providers – such as governments and financial institutions – individual investors as well as businesses and consumers within virtual spaces – such as the metaverse and Web 3.0 – are expected to play a part in the new CO₂ solutions ecosystem.

MHI Group's Carbon Neutrality Initiatives

Future Outlook

On the topic of CCUS, in addition to projects already operational in North America including Enhanced Oil Recovery (EOR), CO₂ commercial storage operations are expected to reach full scale in North America and Europe around 2025. Large-scale CO₂ storage projects are being announced one after another, mainly in Europe, the U.S., and Canada, where various systems have been put in place, such as tax incentives, subsidies, and carbon pricing, which are expected to promote investment.

Meanwhile, in Japan, serious discussions are taking place regarding the design of systems for the storage and use of CO₂. For example, the CCS Long-Term Roadmap Study Group of the Ministry of Economy, Trade and Industry released its interim summary in May 2022. In this document, the government committed to establishing a business environment to enable the start of commercial CO₂ storage in Japan or overseas by 2030. In the area of CO₂ utilization, progress is being made on the development of CO₂ absorbing concrete and implementation of CO₂ as a raw material for chemical products.

MHI Group intends to seize the business opportunities created by the rapid expansion of the CCUS market, which is expected to start in the mid-2020s. We aim to become a key player by 2030 or thereafter, when the CCUS market is expected to be in full-scale operation. We are planning for the CO₂NNEX digital platform to be fully implemented by around 2025.

That said, the CO₂NNEX concept cannot be realized by MHI alone. MHI Group and IBM Japan, as the coordinators of this open platform, will create new solutions within CO₂NNEX while collaborating with CCUS service providers in both the real and virtual worlds.

In this way, MHI Group is moving beyond our conventional manufacturing businesses and our role as a follower to encompass new sales channels related to CO₂ – including the possibility of expansion into B2C. As a CCUS platform developer, we will contribute to the realization of a CO₂ solutions ecosystem and the achievement of Carbon Neutrality.

