

Innovation Management

Technology & Intelligence Integration

Approach/Policies

The IHI Group aims to create a world where nature and technology work in unity, and has undertaken the challenge of developing technology that continuously provides new value by envisioning a variation of future possible solutions for complex social issues and cultivating technology in cooperation with various partners. In proceeding with technology development, introducing model-based development has enabled us to formulate optimal development plans by identifying developmental bottlenecks and theoretical limits through a variety of simulations at an earlier stage. In addition, we conduct simulations instead of demonstration tests for scaling up development with the aim of shortening development periods and putting developed technology into practical use as soon as possible.

Priorities in Technology Development

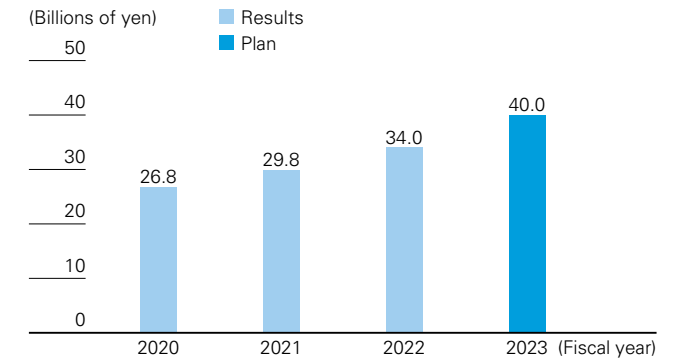
In order to achieve its vision for the growth, development-focus, and core businesses in the Group Management Policies 2023, the IHI Group concentrates research funds and human resources on the fields of these businesses to conduct technology development.

In the fields of aero engines and space, which are both our growth businesses, we are in the midst of developing technology related to the weight reduction and electrification of aircrafts and equipment as well as sustainable aviation fuel (SAF) to make aircraft eco-friendly.

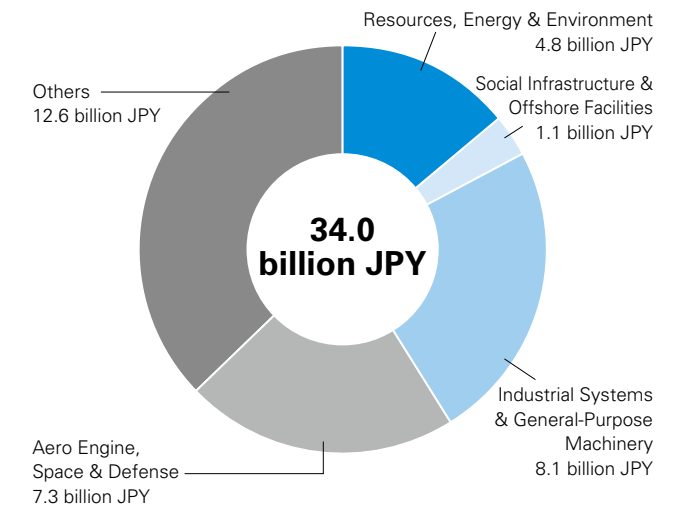
In the clean energy field, which is our development-focus business, ammonia is positioned to be a sustainable fuel that does not emit CO₂ when combusted. In order to stimulate its demand and build a value chain for it, we are proceeding with the development of a highly efficient ammonia-fired gas turbine. In 2022, we successfully demonstrated the world's first CO₂-free power generation (2MW class) using only liquid ammonia as fuel, thereby reducing greenhouse gases generated during combustion by 99%.

Within fields concerning resources, energy & environment, social infrastructure, and industrial systems & general-purpose machinery, which are our core businesses, we work on reducing CO₂ emissions and labor as well as automation on the basis of life-cycle businesses.

Changes Regarding Research and Development Expenses



Research and Development Expenses (FY2022, Breakdown by Business Areas)



Innovation Management

Achieving a Carbon-neutral World

Combined application of technologies is essential for the IHI Group to contribute to achieving carbon neutrality by 2050. Consequently, we are simultaneously developing a variety of technologies, including alternative fuels with no CO₂ emissions, carbon recycling, and energy management systems.

During the transition period toward carbon neutrality, it is also necessary to research and develop technologies for enhancing the efficiency of existing power generation plants and for reducing CO₂ emissions.

In addition, the IHI Group works to efficiently gather carbon data and convert it into an environmental value.

Ammonia as Carbon-neutral Fuel

The IHI Group has been developing technology for using ammonia not only as an inexpensive, safe hydrogen carrier but also as a carbon-neutral fuel with no CO₂ emissions during combustion. We plan to demonstrate ammonia firing at a commercial level for the first time in the world, and are steadily preparing toward this large-volume firing of fuel ammonia (20% of heating value). With our overseas partners, we are considering production of green ammonia derived from renewable energy.

The IHI Group's biomass power generation business has received contracts to refurbish many thermal power plants into plants for single-fuel firing of biomass power generation*¹. We are involved in every aspect of the biomass power generation from construction to operation and maintenance and support operations optimal for providing carbon-neutral power.

*¹ Single-fuel firing of biomass power generation refers to the use of only biomass fuel in thermal power generation plants. Unlike co-firing that uses biomass fuel partially with the main fossil fuel, single-fuel firing of biomass fuel is considered to have net-zero CO₂ emissions.

Carbon Recycling

The IHI Group is also promoting the development of carbon capture and utilization (CCU) technologies, which include the capture of CO₂ from exhaust gas of power plants or factories with the chemical absorption technique, the direct capture of CO₂ from air with the direct air capture (DAC) technology and the conversion of captured CO₂ into valuable products, such as methane used as fuel, lower olefin used as a raw chemical material, and SAF. We have commercialized methanation equipment, which produces combustible e-methane (synthetic methane) fuel through catalytic reaction between CO₂ emitted from plants and other facilities and hydrogen. It uses an originally developed catalyst that boasts one of the longest service life spans in the world. Methanation is a key technology for carbon neutrality because it enables the utilization of existing city gas infrastructures.

The IHI Group continues to investigate and develop SAF, which will help reduce CO₂ emissions from aero engines. Regarding the development of SAF synthesis technology, we are conducting joint research with the Institute of

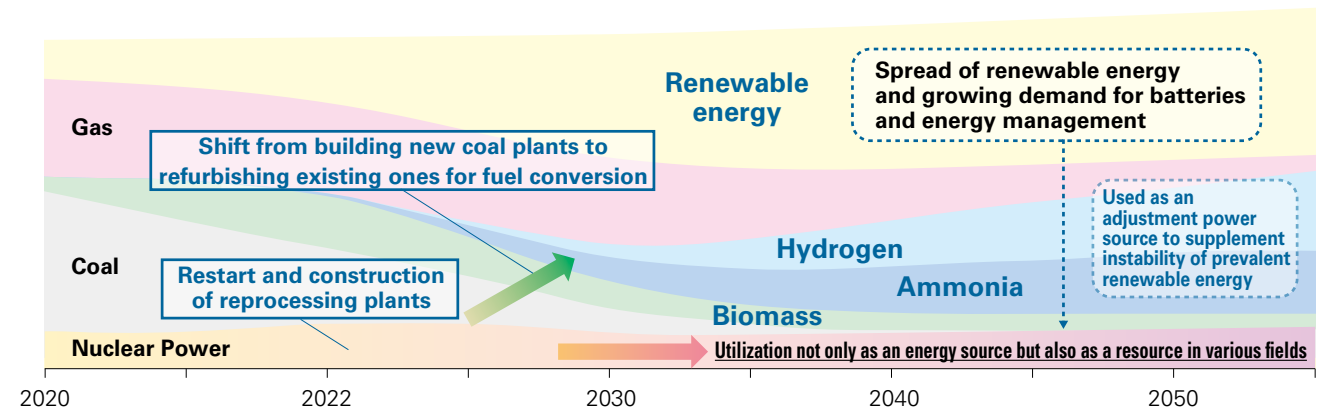
Sustainability for Chemicals, Energy and Environment (ISCE²)*². Based on the knowledge gathered during another ongoing joint development of lower olefin synthesis using CO₂ as a raw material, we have developed a catalyst with high performance in SAF synthesis by efficiently exploring and adjusting test conditions such as catalyst composition and reaction conditions using machine learning, which is a type of AI. This catalyst has achieved the world's top-level performance as an SAF synthesis catalyst that directly causes H₂ and CO₂ to react, recording a 26% yield of liquid hydrocarbons with five or more carbon atoms (C₅₊ yield), which are a raw material for SAF.

*² ISCE²: An affiliated research institute of the Agency for Science, Technology and Research (A*STAR) in Singapore

Energy Management Systems

The IHI Group is advancing the development of numerical models and algorithms by utilizing AI technologies to optimize the configuration and operation of energy systems.

Estimated Change in Proportion of Primary Energy Resources by 2050



Innovation Management

Structure

The IHI Group encourages rapid innovation through extensive collaboration with universities, research institutes, and customers.

As represented by the establishment of the IHI-ISCE² Sustainable Innovation Centre and IHI x Tohoku University Co-creation Research Center of Ammonia Value Chain for Carbon Neutrality, the IHI Group is collaborating with various partners to take advantage of each other's respective strengths and working to develop pioneering technologies.

In addition, we are seeking new technologies, joint research themes, and partners within Japan and overseas (North America, Europe, and Asia). For this purpose, we utilize the IHI Tsunagu Lab and the i-Base (Ignition Base) as hubs for open innovation where we put design thinking into practice toward rapid commercialization to cultivate new business opportunities for the IHI Group.

Education/Awareness Building

i-Base Initiatives

The IHI Group is working on a variety of projects at its innovation hub i-Base with the aim to achieve early commercialization of new ideas.

We focus on rapidly validating the concept of new ideas through short-term Proof of Concept (PoC), where we create a scenario for commercialization and analyze its value hypothesis. Based on the results, we concentrate resources on ideas with a high potential of success and advances research and development toward early commercialization.

We established a structure to promote the speedy creation of new businesses by incorporating design thinking, which helps understand problems from the user's perspective and create innovation, into business development and by modifying design thinking to be our new style of development suitable to our business model.

We provide training programs on design thinking throughout the IHI Group.

Developing human resources through the programs will help us create new value to meet the needs of our customers and society. This is how we advance the establishment of a system allowing us to continually create innovative ideas.

Initiatives

Main Public-Private Sector Initiatives

Direct Synthesis of CO₂-free Ammonia

The IHI Group participated in the New Energy and Industrial Technology Development Organization Feasibility Study Program on Energy and New Environmental Technology. Through this program, we aim to achieve technology that can directly synthesize CO₂-free ammonia from water and nitrogen. We are striving to build a carbon-free value chain by actively promoting the development of hydrogen and ammonia production and application technologies.

Utilization of Hydrogen

The IHI Group began supplying e-methane to vehicles for the first time in Japan, specifically to the Odekake Minibus, a community bus for senior citizens operated by Soma City in Fukushima. It is part of a smart community project conducted under the cooperation of Soma City with the goal of contributing to local production and consumption of photovoltaic power as well as regional promotion and development.

The e-methane that began being supplied to the bus is manufactured at the Soma IHI Green Energy Center using green hydrogen produced with electricity generated by a solar power generation facility. By supplying it to one of the Odekake Minibuses, from e-methane production to its use as vehicle fuel, we are conducting a series of demonstrations regarding this process.

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Industry–University Initiatives

Japan

The IHI Group established a joint research program with Yokohama National University at the Research Center for Artificial Intelligence in an effort to expand applications for AI technologies in various IHI products and services as well as on manufacturing sites. To promote ever-evolving development, we are also expanding the collaboration to foster specialists in AI technologies throughout the IHI Group.

In September 2022, we established IHI Corporation x Tohoku University Co-creation Research Center of Ammonia Value Chain for Carbon Neutrality in the Material Solutions Center at the Tohoku University. The center researches issues in creating an ammonia value chain from production, transport, and storage to consumption and their solutions to achieve a carbon-neutral society through the use of ammonia, which is a clean energy source that does not emit CO₂ during combustion.

North America

In North America, the IHI Group quickly gathers diverse information on new technologies and joint research subjects for carbon solutions, and on energy and environmental policy trends in North America by capitalizing on its relationships with the MIT Energy Initiative and MIT CEEPR as well as its network of venture capitalists and startup companies.

Asia

In Singapore, we conduct joint development with A*STAR across a wide range of fields, including our unique catalyst technology, to produce valuable products such as methane gas, lower olefin, and SAF from CO₂, next-generation transportation, and advanced manufacturing technologies.

Europe

In Europe, the IHI Group established the IHI Additive Manufacturing Lab in the United Kingdom as a site to advance the development of additive manufacturing technology. In addition, to promote the use of road mapping to design technology and business strategies, we belong to IfM Engage's Strategic Technology and Innovation Management Consortium.

Innovation Management

Intellectual Property

Approach/Policies

The IHI Group promotes intellectual property activities in an integrated manner with both its management policy-based business and technological strategies. The business environment surrounding us differs from division to division and from company to company. Consequently, there are individual needs for intellectual property activities. The Intellectual Property Department of IHI Corporation drafts a Basic Policy on IHI Group Intellectual Property every year. Individual divisions and affiliated companies refer to this policy to establish their own intellectual property policies tailored to their unique business, technology, and development environment.

The Basic Policy on IHI Group Intellectual Property in fiscal 2023 is currently focusing efforts on these three priority measures:

- (1) Intellectual property activities that contribute to growth and development-focus business expansion as well as furthering and advancing life-cycle businesses
- (2) Early detection and defense against intellectual property risks
- (3) Strengthening the intellectual property management system supporting business and improving intellectual property literacy

Intellectual Property Strategy

By utilizing intellectual property in our business activities to help solve social issues and increase customer value, we are working to achieve sustainable growth for the entire IHI Group. Regarding the Clean Energy Field listed as our development-focus businesses in the Group Management Policies 2023, the IHI Group is among the world's top companies in terms of the number of patent applications filed for ammonia combustion technology. As we continue filing

first-rate patents, we will continue intellectual property activities to also ensure superiority in fields other than combustion technology. In our growth business and core businesses as well, we use intellectual property information to formulate strategies to solve social issues.

Education/Awareness Building

Intellectual Property Education

Besides basic training programs regarding intellectual properties, the IHI Group provides education, according to purpose, covering how to read patent publications, patent search, copyright, trademarks, etc. From fiscal 2021, some mandatory courses have become optional so that only those who need those courses can take them. This change in system, despite the decrease in enrollment, has allowed learners to select courses according to their own needs and learn at their own pace. We will monitor the number of learners with this system and enhance human resources at an early stage. Furthermore, we disseminate information about intellectual property within the IHI Group to improve intellectual property understanding and awareness. We also invite various lecturers for special courses related to further developing the skills of those who play a key role in our intellectual property strategies.

Intellectual Property e-Learning Participants

(Unit: People, Scope: IHI)

Item	FY2019	FY2020	FY2021	FY2022
Step 1 (First-year employees)	167	187	94	45
Step 2 (Second-year employees)	154	166	77	34
Step 3 (Third-year employees)	246	154	62	28
Step 4 (Fourth-year employees)	281	235	65	26
Step 5 (Fifth-year employees)	249	271	66	23

Results

Number of Patent Acquisitions (Unit: Reports, Owner: IHI)

Item	FY2019	FY2020	FY2021	FY2022
Number of patent acquisitions	1,094	819	711	608

Regional Comparison in Number of Patents

(Unit: Reports, Owner: IHI)

Item	FY2019	FY2020	FY2021	FY2022
National patents	4,150	3,867	3,866	3,989
Foreign patents	3,502	3,808	3,936	3,818
United States	724	747	817	856
Europe (excluding Turkey)	1,240	1,750	1,774	1,697
China	561	582	605	593
Korea	199	120	125	134
BRICs (excluding China)	142	125	120	69
Other	636	484	495	469

Initiatives

Protecting Intellectual Property

To protect intellectual property, the IHI Group decides whether to acquire rights through patent filings or to conceal this knowledge. We file necessary patent applications worldwide based on global business expansion. We carefully select countries to file patent applications through the forecasts in business and technology development.

We respect third-party intellectual property rights. We search activities of patent filings and patent acquisition of other companies to reduce business risks.