

Innovation Management

Technology Development

Approach

As stated as part of the IHI Group's management philosophy "Contribute to the development of society through technology," the IHI Group believes it is the Group's responsibility to keep providing solutions that help solve social issues through its engineering capabilities centering on "Monozukuri" technology. "Monozukuri" technology means the technology used to improve the competitiveness of products and services offered, by strengthening the capabilities required in development, design, supply, manufacture and construction.

The 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.

Governance

The IHI Group has set up a Research and Development Council to adequately manage and operate its overall R&D activities and maximize the effectiveness of its research and development efforts. The Council is chaired by the Executive Officer in charge of Group Engineering, managed by the Corporate Research and Development Division. The Research and Development Council deliberates over the direction, progress or appropriate budget allocation of research and development (including specific research projects, equipment investment, and investment and financing) for the entire Group. It is the chairperson's role to provide deliberation results and clarification to the Management Committee or the Board of Directors.

In fiscal 2023, the Group held a total of three councils to discuss the progress and appropriate budget allocation of important research and development regarding growth businesses, development-focus businesses, and core business. In fiscal 2024 also, the Council is held in the same structure and manner as previously.

● Research and Development Structure



● Research and Development Council

Chairperson	Executive Officer in charge of Group Engineering
Council members	CEO, Senior Executive Officer, Executive Officers (In charge of Group Engineering, In charge of Group Sales, In charge of Business Relating to Corporate Planning Division, In charge of Group Finance & Accounting), Presidents of Business Areas, General Manager of Strategic Technologies Division, General Manager of Corporate Research & Development Division, General Manager of Business Development Division, General Manager of Intelligent Information Management Division, General Manager of Corporate Marketing & Sales Division, General Manager of Corporate Planning Division, and General Manager of Finance & Accounting Division
Secretariat	Corporate Research and Development Division
Number of meetings convened in FY2023	3

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Strategy

Priorities in Technology Development

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

In fiscal 2024, the Group strengthened the structure of the Corporate Research & Development Division in order to accelerate the transition process from technology development into commercialization. Up until recently, technology development to explore new technological and business areas had been collectively carried out by the Technology Platform Center, but the development functions toward new product launches were extracted and transferred to a newly-established Integrated Development Center. This organizational division will further promote fundamental technology development and provision of higher added value to products and services in collaboration with business divisions and affiliated companies, allowing technology development to move into commercialization quickly.

Growth Businesses

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

Development-focus Businesses

In the field of clean energy, which is the 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, the Group is proceeding with the development of a 100% ammonia combustion gas turbine along with ammonia

combustion technology for large-scale thermal power generation boilers.

Conventional Businesses

Within fields concerning resources, energy & environment, social infrastructure, and industrial systems & general-purpose machinery, which include the Group's conventional businesses, it promotes CO₂ emissions reduction and labor-saving technology as well as automation on the basis of lifecycle business.

Risks

Currently, international conditions and market environment are changing with astonishing speed, and existing businesses and technologies are likely to become obsolete within a short period of time. Under these circumstances, if the Group is unable to quickly provide services and products that solve social issues, there is potential risk of losing its competitiveness. This could have a significant effect on corporate value and financial condition. Moreover, if future predictions turn out to be incorrect, new ideas and developed technologies may not function as predicted in the market or cause unexpected issues.

Opportunities

The IHI Group possesses fundamental technologies including rotating machinery, combustion, and welding, developed over many years as a specialist in both industrial and social infrastructure. In addition, through the development of new technology, products, services, and business models in response to market changes, it is possible for the Group to maintain providing new value. Furthermore, the introduction of development methods that utilize simulation technology (for example, model based development) can shorten development time and enable developed technologies to be put to practical use

sooner, thereby leading to the creation of business opportunities. This gives the IHI Group a major opportunity to strengthen its competitiveness and ensure business sustainability, directly contributing to an increase in corporate value.

P.4 Medium-term Management Plan

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Initiatives

Achieving a Carbon-neutral World

Combined application of multiple technologies is essential for the IHI Group to contribute to achieving carbon neutrality by 2050. Consequently, the Group is simultaneously developing a variety of technologies, including replacement into CO₂-free fuels, 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 from them.

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

Utilization of Carbon-neutral Fuels

Efforts toward Making Use of Ammonia 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. With this in mind, the Group aims to develop a 100% ammonia combustion gas turbine system by 2030.

In 2023, IHI signed a joint development agreement (JDA) with GE Vernova's Gas Power Business. Going forward, combustion technology concepts will be evaluated for their ability to meet key operational requirements and the impact on the entire power plant.

In addition, the Group is proceeding with the world's first demonstration of ammonia firing at a commercial level, and is steadily preparing for this large-volume firing of fuel ammonia (thermal capacity ratio: 20%). With its overseas partners, the Group is considering production of green ammonia derived from renewable energy.

In order to promote the use of ammonia as fuel, the Group believes it necessary to build a value chain from production, transportation and storage to utilization, and for this purpose, established the IHI Corporation x Tohoku University Co-creation Research Center of Ammonia Value Chain for Carbon Neutrality together with Tohoku University. The Center is in the process of exploring issues and finding technological solutions for building this value chain.

Biomass Power Generation

The IHI Group has received contracts to refurbish many existing thermal power plants into plants for single-fuel firing of biomass power generation*¹. The Group is involved in every aspect of the biomass power generation from construction to operation and maintenance and supports 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. Single-fuel firing of biomass fuel is considered to have net-zero CO₂ emissions.

Carbon Recycling

Capturing CO₂ and Converting It into Valuable Products

The IHI Group is also promoting the development of CCU*² 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.

Methanation 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.

*² Carbon dioxide capture, utilization

Sustainable Aviation Fuel (SAF)

The IHI Group continues to investigate and develop practical applications for SAF, which will help reduce CO₂ emissions from aero engines.

Regarding the development of SAF synthesis technology, the Group is conducting joint research with the Institute of Sustainability for Chemicals, Energy and Environment (ISCE²)*³. Based on the firsthand knowledge gathered during another ongoing joint development of lower olefin synthesis using CO₂ as a raw material, the research was conducted by efficiently exploring and adjusting test conditions such as catalyst composition and reaction conditions using machine learning, which is a type of AI. As a result, a catalyst with high performance in SAF synthesis was developed. This catalyst has achieved the world's top-level performance as an SAF synthesis catalyst that causes H₂ and CO₂ to react directly, recording a 26% yield of liquid hydrocarbons with five or more carbon atoms (C₅₊ yield), which are a raw material for SAF.

In fiscal 2023, the joint research began identifying issues during the scale-up process and giving consideration to the system flow design toward the goal of determining the specifications of a bench scale machine.

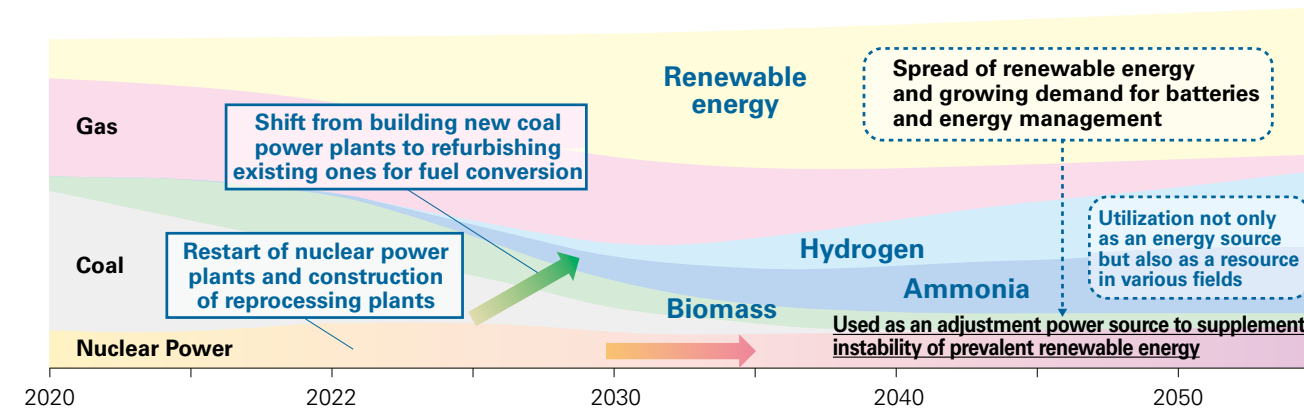
*³ ISCE²: An affiliated research institute of the Agency for Science, Technology and Research (A*STAR) in Singapore

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Energy Management Systems

The IHI Group believes energy management will become increasingly important based on predictions concerning the proportion of energy resources in the future. For this purpose, the Group is proceeding with the development of numerical models and algorithms by utilizing AI technologies to optimize the configuration and operation of energy management systems.

● Estimated Changes in Energy Resource Proportions by 2050



Open Innovation

The IHI Group believes collaboration with external partners is important. Taking part in the global ecosystem communities, it encourages rapid and high-quality innovation through extensive collaboration with universities, research institutes, and customers.

In addition to the above-mentioned collaborations with Tohoku University and the ISCE², the Group began a new joint research with Stanford University SUNCAT in fiscal 2023. Under these collaborations, the development of pioneering technologies is ongoing by taking advantage of the respective strengths.

In 2019, the Group established the Ignition Base (commonly known as i-Base) as a base for open innovation.

With the goal of achieving early commercialization through collaboration with external parties, i-Base provides the Group with opportunities for deep discussions with its customers and helps it create new businesses. In addition, the Group is seeking new technologies, joint research themes, and partners in Japan and overseas (in North America, Europe, and Asia).

Interfirm Collaboration in the Industrial Robotics Field

In order to accelerate the development of technology related to robot operating system (ROS), the IHI Group has been a participant in the ROS-Industrial Consortium since 2023. The Consortium is an open-source project bringing the advanced capabilities of ROS software to industrial-related hardware and application. The Group and the ROS-Industrial Consortium are in joint development of a group control system (maintaining a high level of efficiency in operation and control of multiple robots). The Group is making contributions toward accelerating the social implementation of robots by providing demonstration fields to the Consortium while acquiring knowledge about ROS industrial applications and system development.

Creating New Value through Innovative Thinking and Ideas via External Collaboration

The IHI Group is conducting research and development on technology for reusing CFRP (Carbon Fiber Reinforced Plastic) found in aircraft parts. As part of this process, through discussions with companies in different industries, the Group is exploring applications and products other than aircraft use to find new value. Moreover, in cooperation with Tohoku University of Art & Design, the Group is in the midst of conducting research focused on finding value beyond its lightweight and super strength properties.

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Product Innovation

The World's Largest Methanation Equipment

The IHI Group is developing methanation equipment, which is one of CCU equipment to manufacture fuel of e-methane (synthetic methane) through catalytic reaction between CO₂ emitted from plants and other facilities and hydrogen. Consideration is being given toward scaling up the conventional standard model (with a methane production of 12.5 Nm³/h) to a medium-sized model (500 Nm³/h) and even greater models. Taking a look at an example, the Group received a contract in 2022 that it would deliver a methanation unit for a carbon-recycling blast furnace*⁴ in the East Japan Works Chiba District of JFE Steel Corporation in 2025. The unit is supposed to recycle 24 metric tons of CO₂ per day from exhaust gas and produce 500 Nm³ of methane per hour.

IHI's methanation equipment currently holds one of the largest manufacturing capabilities in the world. The Group regards this contract as a good opportunity to work on materializing even greater equipment.

*⁴ This carbon-recycling blast furnace is under construction in the course of developing low-carbon technologies using external hydrogen and CO₂ contained in blast furnace exhaust gas, based on the "Hydrogen Utilization in Iron and Steelmaking Processes Project, Japan's Green Innovation Fund," the New Energy and Industrial Technology Development Organization (NEDO)'s commissioned and subsidized research and development project JPNP21019.

100% Ammonia Gas Turbine Combustion System

In 2022, IHI successfully demonstrated the world's first CO₂-free power generation using a 2 MW-class gas turbine fueled only by liquid ammonia*⁵. In 2023 the Company signed a joint development agreement (JDA) with GE Vernova for a new combustor that uses fuel ammonia for GE Vernova's gas turbines. Combustion testing is being conducted at IHI's facilities in Japan with the aim of practical application by 2030.

*⁵ The New Energy and Industrial Technology Development Organization (NEDO)'s commissioned research and development project JPNP21020

Ammonia Combustion Equipment

Since 2024, IHI has conducted the world's first large-scale demonstration tests (thermal capacity ratio: 20%) of ammonia fuel conversion for the large-scale commercial coal-fired power generator at the JERA Hekinan Thermal Power Plant (Hekinan City, Aichi Prefecture)*⁶. In addition to steadily conducting these tests, the Company is also working to establish high-ratio combustion technologies fueled 50% or more by ammonia in thermal power plants and toward developing a 100% ammonia-fueled combustion burner.

*⁶ Development of Technologies for Carbon Recycling and Next-Generation Thermal Power Generation / Research, Development, and Demonstration of Technologies for Ammonia Co-Firing Thermal Power Generation, subsidized by the New Energy and Industrial Technology Development Organization (NEDO)

Process Innovation

Business Platform to Link Data throughout Compressor Life Cycle

Using modular designing for its compressor designs, the IHI Group began operating a business platform in 2022 enabling customer information and product data to be linked from sales to after-sales service. This platform enables the Group to quickly prepare the estimates and design drawings just by inputting customer requests and to shorten procurement to production lead times by 30% in modular designed units. Additionally, by linking data to after-sales service, the Group is able to streamline its preparation of its services by 30% and deliver timely proposals to customers based on information obtained on-site, which has contributed to a reduction in customer downtime.

Smart Factory for Vehicle Turbocharger Parts

At its overseas turbocharger parts factories, the IHI Group conducts improvement activity from every aspect, including production planning, logistics, process changes, quality control, productivity, and production cost management, promoting DX in each area.

Through the centralization and visualization of factory data, the Group has improved overall equipment effectiveness (OEE).

This makes it possible for the Group to reduce the days for inventory turnover*⁷ required by approximately 40%, which in turn reduces production cost.

*⁷ Days for inventory turnover: the ratio of inventory to daily sales

Changes Regarding Research and Development Expenses

(Unit: Billions of yen, Targets: IHI Group)

Item	FY2020	FY2021	FY2022	FY2023
Research and Development Expenses	26.8	29.8	34.0	39.3

* The total value for each item is rounded off and may not match the figures in the breakdown.

Research and Development Expenses (Breakdown by Business Area)

(Unit: Billions of yen, Targets: IHI Group)

Item	FY2020	FY2021	FY2022	FY2023
Resources, Energy & Environment	3.7	3.2	4.8	6.0
Social Infrastructure	0.7	0.9	1.1	1.1
Industrial Systems & General-Purpose Machinery	7.4	6.9	8.1	9.5
Aero Engine, Space & Defense	7.1	7.1	7.3	8.8
Others	7.7	11.5	12.6	14.0

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Intellectual Property

Approach

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 the Group 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 2024 is currently focusing efforts on these three priority measures:

- (1) Intellectual property activities for promoting business portfolio reformation
- (2) Addressing risks hindering business scenario execution
- (3) Strengthening the intellectual property management system supporting business and improving intellectual property literacy

By utilizing intellectual property in its business activities to help solve social issues and increase customer value, the IHI Group is working to achieve sustainable growth for the entire Group.

Governance

The IHI Group has appointed a manager of intellectual property at each of its divisions and affiliated companies to formulate intellectual property policy and encourage business and technology strategies for making use of intellectual property.

Strategy

In the clean energy field, the IHI Group is working to build an ammonia value chain as well as develop and promote businesses based on ammonia fuel technology, a Development-focused Business listed in its Group Management Policies 2023. In order to gain an objective understanding of individual business environments and its own strengths, the Group builds patent portfolios and formulates strategies that utilize the IP landscape*. In its growth businesses and conventional businesses as well, the Group uses intellectual property information to formulate strategies to solve social issues.

* IP landscape: A portmanteau combining intellectual property (IP) and landscape (scenery, environment, outlook) used to refer to utilizing the results of analyzing intellectual property information to formulate corporate management strategies and inform company management decisions as well as to refer to corporate management conducted with a focus on intellectual property.

Risks

The IHI Group monitors and looks into patent applications and patents by other parties during its technology development and business activities, in order to reduce and avoid the risk of becoming technologically disadvantaged or being involved in patent disputes with other companies. Furthermore, to prevent risk of damage to the IHI Group's reputation from imitations of its products and services, the Group is working to protect its trademarks and take countermeasures against counterfeit products.

Opportunities

The IHI Group, expanding its business globally, takes appropriate steps in the protection, management, and utilization of its intellectual property, which are essential for sustainable Group growth and for providing and improving corporate value. Along with protection of intellectual property, the Group regards partnerships with other

companies as important for contribution to global technological development. As the Group strives to utilize intellectual property in relation to core technologies, it is also working on standardization to promote market development and quick delivery of technology. Regarding ammonia fuel, the Group is in active cooperation with related organizations and companies engaged in activity toward achieving international standardization.

Initiatives

Education/Awareness Building

Intellectual Property Education

Besides basic training programs regarding intellectual properties, the IHI Group provides education covering submitting invention, patent search, copyright, trademarks, etc. Most of this training is conducted online through e-learning, making attendance more convenient and encouraging independent learning. The Group is working toward improving intellectual property understanding and awareness through a variety of methods that include specific division or rank training, lectures on industrial property, training to develop future human resources skilled to carry out an integrated strategy involving intellectual property, business and technology, and through regular information updates from the Intellectual Property Department.

● Intellectual Property Course Participants (Total)

(Unit: People, Scope: IHI and affiliated companies in Japan)

Item	FY2021	FY2022	FY2023
Intellectual property (overview and basics)	364	156	407
Engineering and manufacturing company basics (intellectual property part)	145	450	260
Patent search (basic)	6	7	36
Submitting invention, reading patent publications	31	18	67
Copyright	185	10	141

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Intellectual Property Protection

The IHI Group protects the inventions it develops by acquiring rights through patent applications and keeping know-how confidential. The Group carefully selects countries to file patent applications through the forecasts in global business and technology developments.

The decision to keep or abandon acquired rights is made with consideration toward the future competitive environment and cost-effectiveness. Any know-how is strictly kept confidential based on internal regulations and contracts.

Number of Patent Acquisitions

(Unit: Reports, Owner: IHI and affiliated companies in Japan)

Item	FY2020	FY2021	FY2022	FY2023
Number of patent acquisitions	819	711	608	564

Regional Comparison in Number of Patents

(Unit: Reports, Owner: IHI)

Item	FY2020	FY2021	FY2022	FY2023
Domestic patents	4,104	4,167	4,119	4,094
Foreign patents	3,972	4,244	4,245	4,078
United States	777	843	879	906
Europe (excluding Turkey)	1,780	1,888	1,894	1,852
China	603	667	661	608
Korea	135	134	139	137
BRICs (excluding China)	140	144	124	72
Others	537	568	548	503

*Figures for domestic and foreign patents between FY2020–2022 have been revised.