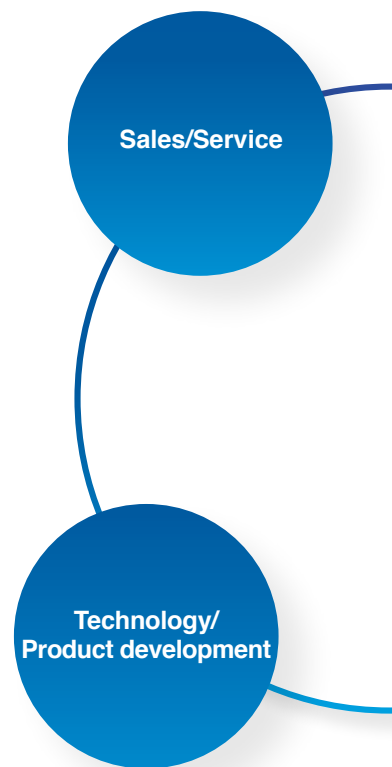


Implementing the Solution Concept “i³-Mechatronics”

The Yaskawa Group is promoting company-wide reforms centered on the implementation of “i³-Mechatronics” to address customers’ challenges and provide optimal solutions in the areas of “sales and service,” “technology and product development,” and “production.” We aim to create sustainable value through product development and manufacturing innovation from a global perspective and enhancing proposal capabilities based on data.

► Strengthening the strategic approach to the customers’ supply chain

By reorganizing our sales structure from product-specific to region-specific and product-mix, we are able to offer proposals that best address customer issues and strengthen our relationships with customers. The Quality and Service Division manages the usage and operating status of shipped products in a database and proactively proposes timely updates and maintenance to customers, leading to effective service activities.



Customer Story

Automating the raw material handling process at Suntory Osaka Plant

At Suntory Osaka Plant, Yaskawa's robots use AI to automate the raw material handling process by accommodating a wide variety of raw material packaging formats.

Suntory is constantly working on labor-saving initiatives in order to increase productivity and employee satisfaction, and has expertise in automating the process of the development of ingredient and flavor, filling, and packaging. However, there was no precedent for automating the process of handling unstable materials. In this project, Yaskawa's proposals, technology, and flexible coordination capabilities based on its experience in the food and beverage industry were very reliable. Also, what the “i³-Mechatronics” concept calls for, such as improving quality through the use of data and ensuring versatility so that a single robot can handle a variety of tasks, have a lot in common with Suntory's philosophy of automation. Despite trial and error in the early stages of development, we were able to work together based on mutual trust. Going forward, we aim to utilize the data obtained through automation and expand it to existing plants. We expect Yaskawa to propose more flexible and multifunctional automation utilizing MOTOMAN NEXT and other technologies.

Junichi Sawazaki

Technical Strategy Planning and Development Department
Senior General Manager
Suntory Holdings Limited



Raw material feeding by robot

In this project, we conducted thoughtful discussions, including our management, to gain trust so that Suntory's long-term vision and issues are shared with us. Yaskawa's management is enthusiastic about promoting “i³-Mechatronics,” which makes it possible to respond flexibly to customers. In addition, since “i³-Mechatronics” was born, I feel that we have been able to have discussion with customers that relate to the strategy of the entire plant and company. In this project, we did not only respond to immediate requests, but also tried to design long-term scenarios centered on “i³-Mechatronics.”

Building trust is essential for solution-based sales. Although trust cannot be established overnight, in our more than 100 years of history, Yaskawa has earned the trust of many customers, who have chosen us as their partners in solving problems. I believe that our track record and technological capabilities will be our strength in spreading and implementing “i³-Mechatronics” in the future.

Shanji Xu

Assistant Manager
Eastern Japan Sales Dept.



Mr. Sawazaki of Suntory (left), Xu of Sales Division (right)

► Strengthening technology development capabilities to create value for customers

Development systems and corporate technology division have been consolidated at Yaskawa Technology Center (YTC), creating an environment in which we can work consistently through planning, development, production, and quality control. In addition, by integrating development processes, we realize global cross-business development. As quality information and customer requests and issues are now shared globally, we are able to work together in product development and quality control that accurately reflect them.

► Advancement of own manufacturing through “i³-Mechatronics”

We are consolidating production equipment development work that was previously distributed among plants, improving the skills of engineers and speeding up equipment construction. We are expanding manufacturing based on “i³-Mechatronics” concept practiced at our mother plants in Japan and highly productive equipment globally, reducing man-hours and standardizing equipment. In addition, indirect operations such as procurement and production planning are integrated into a common system, and production information is visualized in real time, achieving efficient operation and reducing indirect man-hours.

Production

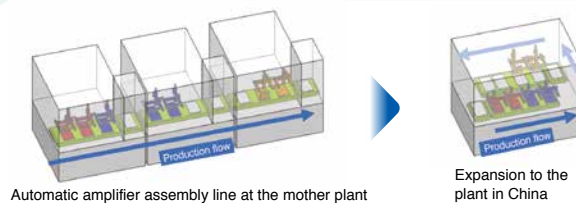
Improving production equipment development at YTC

YTC has strengthened collaboration between production technology and product development, shortening the production preparation period and improving the level of completion. In the past, jigs and tools and equipment were examined based on 2D drawings created at the end of product development. Now, by using 3D design data from the early stages of development, process design, equipment planning, and production simulation can be visualized, improving the efficiency of examination. This process has enabled timely feedback to the design department, stimulating discussion among departments, and greatly improving the quality of cooperation. Furthermore, by strengthening collaboration through data, production preparation man-hours have been reduced by approximately 25%. In addition, we are working to build an overall optimal

production system that can flexibly respond to customer needs by conducting simulations assuming various conditions, such as fluctuations in production volume and production at plants in Japan and overseas. In fact, in the production of servo amplifiers, we established an automated production line that is unitized for each element at the mother plant. Then, when we expanded the production line to the plant in China, we customized the product composition and plant layout in accordance with local conditions. By doing so, we were able to start up production facilities that meet local needs in a short period of time and with high reliability.

Kanta Yamaguchi

Section Manager
Production Technology
Promotion Section



Global technology collaboration in iC9200 development

iC9200 was launched in September 2024 as a controller that can control multiple devices such as servos and robots in a single unit. Functions to promote “i³-Mechatronics” globally are added to it, such as support for communication networks widely used in Europe and the United States and ensuring safety. Due to the characteristics of the product, development of iC9200 was conducted jointly in Japan, the United States and Europe. To enable rapid development on a 24-hour basis, we adopted a cloud-based development environment that centralized source code, tasks, and development processes in one location. By assigning roles across regions to take advantage of the strengths of each location and streamlining the development process, the product development period was significantly reduced to 4 years*, and products with high compatibility and security were born in a short period of time.

*Previously, about 10 years



iC9200

The development of the iC9200 is a testament to the teamwork and innovation of the Yaskawa Group. We look forward to new updates and feature expansions that will further enhance the product. I am excited to see how customers will leverage the flexibility and functionality of the iC9200 to drive innovation in their industries.

Edward Nicolson

Ph. D., Senior Director, Development
YASKAWA America, Inc.



Through joint development within the Yaskawa Group, the iC9200 has incorporated regional functionalities and standards, making it a product well suited for global markets and able to meet the specific needs and preferences of individual regions. Since launch, customer feedback has been positive, with several projects currently underway.

John Glorieus

Strategic Portfolio Manager iCube
Control, Value Stream Motion
YASKAWA Europe GmbH



Environmental management

To accelerate our global environmental efforts, including those of our overseas affiliates, we established a Group Environmental Policy in fiscal 2015.

Yaskawa group environmental policies

Environmental Philosophy

Based on the Management Principles of the Yaskawa Group, we recognize that the conservation of the global environment is one of the most important issues for all humankind. In every stage of our business operation, we contribute to the realization of a sustainable society through our proactive environmentally conscious actions.

Environmental action guidelines

1. Participation by everyone

We strongly believe that we all should participate and take responsibility in order to achieve realization of biodiversity conservation, and a low-carbon and recycle-based society.

2. Environmental contribution by innovative technologies

For the future prosperity of society, we will contribute to the improvement of the global environment through our products and services developed by technological innovation that will be useful in a wide range of applications in communities worldwide.

3. Environmental consideration of products and services

We strive to reduce the environmental impacts of our products and services, for their entire life-cycle, from research and development, product design, procurement, manufacturing, distribution and usage through to end-of-life handling.

4. Aiming for future-oriented goals and objectives

We aim to heighten social and environmental excellence not only by complying with applicable environmental laws and regulations but also by establishing our own future oriented goals and objectives. We will continue to improve our environmental management and to endeavor to minimize environmental risks.

5. Improvement of environmental awareness

We strive to improve environmental awareness among all of us by education and enlightenment about our relationship with the environment from a broad perspective so that each of us can independently implement the environmental activities.

6. Information disclosure and communication

We are committed to disclosing information about our environmental activities and communicate proactively and openly with stakeholders for deep mutual understanding.

ISO 14001 certification status

We began acquiring ISO 14001 (Environmental Management System) certification for our production sites in 1998, and in 2014, we obtained integrated certification for our domestic production sites.*

We are also expanding certification to production sites of group companies, including those overseas, and will continue to promote environmental management globally based on ISO14001.

* Scope of ISO14001: All stages of production activities, products, and services at Iruma Plant, Yahatanishi Plant, Nakama Plant, Yukuhashi Plant, and Yahatahigashi Plant, as well as at affiliated companies on their premises.

Goals and progress of the mid-term environmental plan

	Mid-term plan targets for FY2025		Progress in FY2024	Self-evaluation
Green processes	The Group's CO ₂ emission reduction rate	30% (Compared to FY2018)	23.4%	○
	CO ₂ -free electric power rate	75% (Yaskawa Electric)	62.7%	○
	Reduce volume of waste discharged by the Group	FY2018 results (3,986 tons) or less	2,536 tons	○
	Proper water management	Reduce volume of water consumed by Yaskawa Electric Reduce by 1% compared to FY2022 results (169 thousand m ³)	169 thousand m ³	△
Green products	Contribution to reducing CO ₂ emissions through products	120.00 million tons (Cumulative since FY2016)	133.80 million tons	○
	Compliance with the RoHS Directive	100%	Nonconformity occurred in one model	×
Management	Increase in the number of companies covered under EMS in the Yaskawa Group	Environmental impact load ratio: 99% or greater	99%	○

Self-evaluated achievement ratios to targets: ● 130% or more, ○ 100% or more, △ 50% or more, × under 50%

Contributing to a decarbonized society through products

It is said that about half of the world's electricity consumption comes from motor drives. We will contribute to the carbon neutrality of the world by improving the energy-saving performance of motors and their control devices.

Calculation Logic of Reduction Contribution by Products

Examples of applicable products	Overview of calculation logic
AC drive equipment 	Reducing CO ₂ by saving energy when an induction motor is driven by an AC drive Ex.) Energy saving rate at the time of AC drive operation for fan/pump is used.
PM motor 	Reducing CO ₂ by energy saving by switching an induction motor to a PM motor Ex.) Energy saving rate by switching to PM motor is used.
PV inverter 	Reducing CO ₂ by creating energy when general electricity is switched to CO ₂ zero renewable energy generation Ex.) Utilization rate of typical solar power generation equipment is used.
Robot 	Reducing CO ₂ by saving energy by switching to the latest model of robots Ex.) Energy saving rate by switching to slim and light weight robots and regenerative power collection function is used.

“CCE100” a unique environmental indicator

We have set the target “CCE100” to make the CO₂ reduction contribution by our products 100 times greater than the CO₂ emissions from our business activities by 2025.

CO₂ reduced through products

CO₂ emitted by the Group

≥ 100

(Contributions of more than 100 times in 2025)

The aim of this indicator is to promote both “internal CO₂ emission reduction” and “development and market launch of highly energy-efficient products. This indicator enables us to realize decarbonization activities with the participation of all employees, including those in development, design, and sales.

Efforts to reduce CO₂ emissions

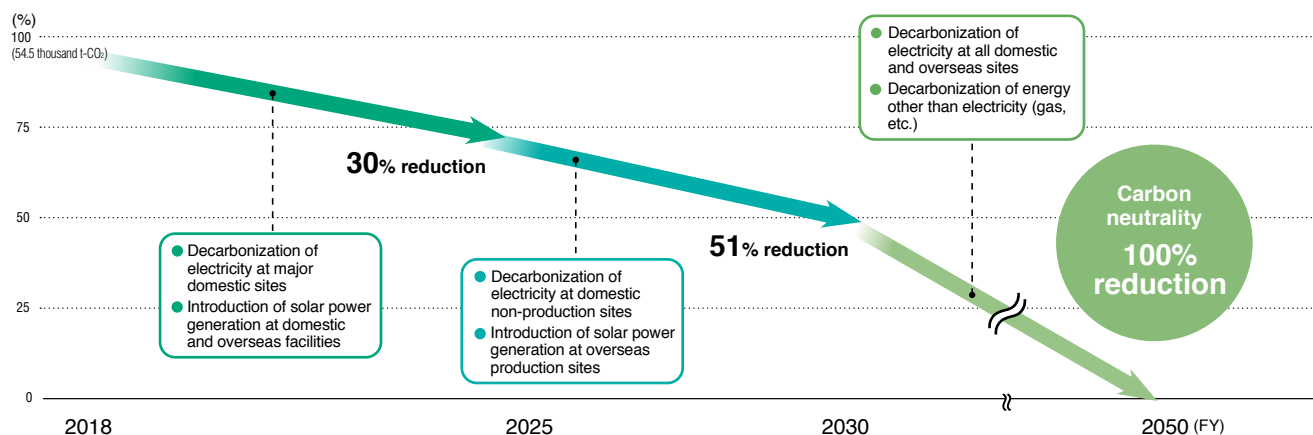
In fiscal 2024, we introduced 220 kW of solar power generation equipment at our U.K. plant and 4,150 kW at our Changzhou plant in China, bringing the total amount of solar power generation introduced to 13 MW for the entire Group. Regarding electricity purchased from power companies, the Chubu Robotics Center switched to CO₂-free electricity in May 2024, and the Yukuhashi Plant switched to CO₂-free electricity in February 2025. As a result, the CO₂-free power ratio for the entire Yaskawa Group in FY2024 was 40.1%, and 62.7% for Yaskawa Electric Corporation on a non-consolidated basis. Meanwhile, we worked to reduce energy consumption through stable operation of solar power generation facilities, investment in energy-saving equipment, and energy-saving activities.

We are also implementing initiatives to reduce CO₂ emissions in the supply chain through decarbonization support such as factory energy efficiency audits for suppliers and customers.



Energy efficiency audit

Milestones for achieving carbon neutrality by FY2050



Management of water use

We monitor water usage monthly to detect leaks and other problems as early as possible. When new buildings are constructed, we promote the installation of real-time remote monitoring equipment. In addition, our head office building uses rainwater, which covers approximately 97% of our water consumption. In FY2024, we had no violations or penalties against laws or regulations related to water use.

Initiatives to reduce water withdrawal

Our production processes do not rely heavily on water, and most of our water withdrawal is for human consumption and sanitary purposes. We are working to reduce water withdrawal by taking measures against water leakage and switching to water-saving equipment. In particular, we are actively promoting the use of water-saving toilets and other measures to reduce water consumption when constructing new buildings.

Evaluation of water risks

We evaluate water risks at the Yaskawa Group's production plants in Japan and overseas using "Aqueduct"

Evaluations indicated that six plants in China and one plant in India are located in high water stress areas. In fiscal 2024, 27.1 thousand m³ of water was withdrawn at sites located in high water stress areas, accounting for 10% of the entire Yaskawa Group. Water storage tanks are installed at sites with risk of drought, and sandbags are placed at sites with risk of flooding.

* Water risk assessment tool published by the World Resources Institute (WRI)

Resource recycling and resource conservation

Our 2025 target in our mid-term environmental plan is to reduce waste emissions to less than the fiscal 2018 result (3,986 tons).

In order to reduce wood waste, which is the largest part of our waste emissions, we have changed to a returnable box system in which wooden boxes for transporting purchased parts at the Yahatanishi Plant are not disposed of but returned to delivery companies. In addition, the Yukuhashi Plant converted wooden pallets into valuable resources.

These efforts resulted in 2,536 tons of waste emissions in fiscal 2024, which is less than the fiscal 2018 result.

As future initiatives, we will work to reduce the amount of plastic used and convert waste plastic into valuable resources in order to promote the reduction of waste plastic, which is the second largest source of waste after wood waste.

Proper management of chemical substances

We utilize chemSHERPA, a scheme for communicating information on chemical substances compliant with the international electrical standard IEC62474, for the management of chemical substances contained in products to comply with regulations such as the RoHS Directive and REACH Regulation.

Approaches for biodiversity and TNFD response

The Yaskawa Group recognizes that our business activities are based on various services provided by biodiversity in order to realize a sustainable society, and we will promote biodiversity conservation through our business and social contribution activities. In the future, we will analyze risks and opportunities using methods consistent with the TNFD recommendations to clarify the impact of risks and opportunities on our own business activities and on natural capital and biodiversity.

Endorsement of TCFD recommendations and initiatives

Yaskawa group expressed its support for the TCFD Recommendations in September 2019, and in September 2020, we participated in the Ministry of the Environment Support Project for Scenario Analysis of Climate Risks and Opportunities in line with the TCFD Recommendations. Through these and other activities, we disclosed information related to climate change based on the TCFD recommendations in May 2021. Going forward, we will continue to enhance information disclosure related to climate change and continue to conduct business activities that are even more environmentally friendly, in order to contribute to the realization of a sustainable society and further enhance our corporate value.



Information Disclosures Based on TCFD

<https://www.yaskawa-global.com/company/csr/env/tcfid>

Governance

Based on the Sustainability Policy, the Board of Directors and the Management Committee identify sustainability issues and targets (materiality) as important issues for sustainable growth and determine measures to resolve them. The Sustainability Committee, chaired by the President, is attended by the heads of relevant divisions and outside directors as advisors to monitor and accelerate the implementation of sustainability measures for the entire Group.

In addition, the Sustainability Committee monitors important issues related to climate change, and the PDCA cycle for overall implementation, including other measures, is managed by the environmental promotion system operated by the environmental promotion supervisor appointed by the president. In addition, the compensation of directors (excluding outside directors and directors who are members of the Audit and Supervisory Committee) incorporates the degree of achievement of CO₂ emission reduction targets through our products in their evaluation, with the aim of realizing sustainable corporate activities and responding to social issues.

Strategy

We examined the risks and opportunities posed by climate change in our main businesses of motion control, robotics, and systems engineering.

Risks and opportunities include “transition” risks and opportunities arising from changes in climate change countermeasures and social demands, such as policies and regulations, as well as “physical” risks arising from natural disasters and rising temperatures. These risks and opportunities can be extracted and used for business operations. These risks and opportunities are extracted and their impacts on business activities are evaluated on a four-point scale of “extremely serious,” “serious,” “moderate,” and “minor. For the identified risks and opportunities with “extremely serious,” “serious,” or “moderate” impact, we conducted a scenario analysis of 2°C and 4°C, assuming a society in 2030. We found that the impact of these analyses on our financial plan is more likely to be an increase in sales due to opportunities than a decrease in sales for our group due to risks.

As a response to the opportunities, the Yaskawa Group will promote development in its efforts to automate/optimize factories based on “i³-Mechatronics,” which is the goal of the long-term management plan “Vision 2025,” and in the challenge to new mechatronics application areas for the sustainable development of society.

2°C scenario

A certain response is required to the intensification of unusual weather, but the response to the rising cost of materials and resources is more important.

On the other hand, there are opportunities created by moving forward with reductions in carbon, such as expanding demands for factory automation devices, industrial AC drives, and renewable power generation equipment, as well as a solutions business that increases productivity and energy saving performance in the factories and equipment of companies by using these devices.



Extreme weather



Rising prices of materials and resources



Equipment for renewable power generation

4°C scenario

Carbon reduction is not promoted and unusual weather intensifies, so the response to physical risks caused by this are considered the most important challenges.



Extreme weather



Endorsement of TCFD recommendations and initiatives

Business impacts related to risk and opportunity factors

Risk/ Opportunity	Transition/ Physical	Factor	Time axis ^{*7}	Impact
Risk	Transition	Carbon price	Short to long term	Increased fuel and material procurement costs due to the introduction of carbon taxes by national governments.
		Government policies on carbon emissions	Short to long term	Increased costs (e.g., purchasing clean energy) that accompany the introduction of emissions trading and the strengthening of emissions regulations.
		Transformation to energy savings and carbon reductions	Mid to long term	Production impacts due to price increases and procurement difficulties for reasons such as insufficient related materials from electrification and the transition to electric vehicles.
		Recycling regulations	Short to long term	Increased costs from using substitute materials, etc., due to regulations such as those on plastics.
		Growth of low-carbon technologies	Mid to long term	Increased investment costs, such as R&D costs, due to increased competition in the energy saving performance of products against a background of increasing demands for energy savings.
		Changing behavior of investors and customers	Mid to long term	- Increased support costs due to investors and customers preferring companies that are more environmentally responsive. - Decreased company valuation and loss of business opportunities due to delayed responsiveness to environmental responsibility related to information disclosure and procurement.
	Physical	Increasing average temperatures	Mid to long term	- Increased energy costs due to increased air conditioning energy in our factories. - Need to move production sites where the risk of flooding exceeds tolerances due to sea rise.
		Intensification of unusual weather	Mid to long term	Operation stoppages, reductions in production, and additional investment to restore equipment from typhoons, tornadoes, and flooding.
Opportunity	Transition	Transformation to energy savings and carbon reductions	Mid to long term	- Increased demands for factory automation devices and industrial AC drives due to increased energy saving needs. - Expanded business opportunities for solutions that increase the productivity and energy saving performance of factories and equipment. - Expanded demand for solar power generators and wind power/geothermal power/biomass power generation equipment due to feed-in tariff incentives and so on.
		Changing behavior of investors and customers	Mid to long term	Increased investor valuation, increased ESG investment, and increased corporate value due to expansion of businesses that contribute to the environment.

Risk management

The Yaskawa Group has established the Risk Management Committee with a committee head appointed by the president to swiftly and accurately handle risks that may pose a problem either directly or indirectly to the management and business operations of the Group. The Risk Management Committee evaluates, manages, plans measures, and implements those measures for companywide risks.

This committee also evaluates and manages risks related to climate change. When a crisis occurs, this

committee establishes a crisis response headquarters according to the level of the crisis and implements a suitable response.

The Risk Management Committee shares information with the Board of Directors, Management Committee, and Sustainability Committee, and it supervises and monitors risk management for the entire company while also attempting to enhance risk management companywide by ensuring consistency in risk assessments and materiality analysis.

Metrics and targets

In order to manage the risks and opportunities associated with climate change and to address the issue of climate change, which is a challenge that must be addressed on a global scale, the Group has set the goal of achieving virtually zero (carbon neutral) CO₂ emissions (Scope 1 + Scope 2) from its global business activities by 2050, and

as a milestone to achieve this goal, the Group has set the “2050 CARBON NEUTRAL CHALLENGE” to reduce its CO₂ emissions by 51% by 2030 compared to 2018. As a milestone, we have set the target to reduce CO₂ emissions in 2030 by 51% from the 2018 level.

We have also set a target of reducing CO₂ emissions

Main scenarios used in the scenario analysis

- Used mainly to analyze transition risks: IEA^{*1}, SDS^{*2}, STEPS^{*3}
- Used mainly to analyze physical risks: IPCC^{*4}, RCP2.6^{*5}, RCP8.5^{*6}

*1 International Energy Agency

*2 Sustainable development scenario

*3 Stated policies scenario

*4 Intergovernmental panel on climate change

*5 Scenario in which the average temperature of the world rises about 2°C over the average temperature before the industrial revolution

*6 Scenario in which the average temperature of the world rises about 4°C over the average temperature before the industrial revolution

*7 Definitions of "short term," "medium term," and "long term" in time frame
Short term: 1 year, medium term: 2-3 years, long term: 10 years

*8 Definitions of "minor," "moderate," "serious," and "extremely serious" in valuation

Minor: less than ¥100 million; moderate: ¥100 million to ¥1 billion; serious: over ¥1 billion to ¥10 billion; extremely serious: over ¥10 billion

	Measures	Evaluation ^{*8}
	- Reduce energy consumption by installing energy-saving equipment and optimizing operations through energy management systems - Install solar power generation equipment - Strengthen cooperation with suppliers and select materials and fuels with less environmental impact - Promote replacement with high-efficiency equipment through the Internal Carbon Pricing System	Serious
	Install solar power generation equipment	Moderate
	- Sign long-term contracts with suppliers that can provide a stable supply - Reduce the use of materials by downsizing products	Serious
	Reduce the amount of materials used by downsizing products	Minor
	Develop high-efficiency, energy-efficient products that differentiate us from our competitors	Moderate
	Strengthen the provision of information to stakeholders through annual reports and integrated reports	Minor
	- Reduce energy consumption through an energy management system that monitors and manages energy use in real time - Enhance disaster preparedness at current production sites and improve flood and storm surge preparedness - Increase risk preparedness by installing disaster prevention equipment and providing disaster training for employees	Moderate
	- Develop a business continuity plan (BCP) and clarify procedures for responding to natural disasters - Install disaster prevention equipment and conduct disaster prevention training for employees to increase their ability to respond to risks - Install watertight boards and sandbags and place critical equipment at high locations to prevent flooding	Serious
	- Reduce energy consumption by developing highly efficient FA equipment and industrial inverters - Provide solutions for customers' smart factories by promoting "i³-Mechatronics" - Strengthen competitiveness by developing power conditioners - Reduce energy consumption per unit of production by improving energy efficiency of robots, shortening production lead time by utilizing robots, and improving straight line ratio (reducing defects). - Reduce energy consumption by eliminating lighting, air conditioning, etc. that take human comfort into consideration with the introduction of robots	Extremely serious
	- Strengthen the provision of information to stakeholders through annual reports and integrated reports - Promote initiatives to improve ESG assessments	Minor

upstream and downstream of the supply chain (Scope 3) by 15% in 2030 compared to 2020, which we aim to achieve by supporting our suppliers' decarbonization efforts and by making motor drives smaller and more efficient.

In addition, in order to contribute to the reduction of CO₂ emissions through the supply of products such as inverters that boast the world's highest performance using our core power conversion technology, we have set a

Future initiatives

With the dissolution of TCFD in October 2023, the publication of IFRS S2^{*9}, and the EU's efforts to address CSRD^{*10}, new disclosure standards are beginning to be implemented, and it is becoming necessary to respond to

target of "CCE100 We are working on our business activities under the goal of "CCE100," which aims to make our products contribute to CO₂ emission reductions at least 100 times greater than the CO₂ emissions of the Group by 2025.

To achieve these goals, we have introduced an internal carbon pricing system (internal carbon price: 5,000 yen/t-CO₂) and are actively promoting environmental investment.

them. We will prepare for disclosure in line with trends in disclosure standards.

^{*9} Disclosure standards for "climate-related disclosures" published by the IFRS Foundation

^{*10} Corporate Sustainability Reporting Directive: The European Commission's Corporate Sustainability Reporting Directive



Please refer to the following URL for Yaskawa's Scope 1, Scope 2 and Scope 3 emissions.
<https://www.yaskawa-global.com/company/csr/group/esg-data>



Customer Story

Bringing Craftsmanship to Robots

Toyota and Yaskawa's Bold Challenge: The Story Behind SFA Method*¹ Development

GAZOO Racing Company of Toyota Motor Corporation, which is responsible for motorsports activities and sports car development, continues to take on the challenge of global motorsports with the belief of "Roads Build People, and People Build Cars." In 2024, Yaskawa collaborated with Toyota to develop SFA method used for roll cage*² welding. This enabled us to significantly shorten the manufacturing time of rally and race cars and improve welding quality, thereby contributing to Toyota's goal of "making better cars."

We spoke with Mr. Kawakita of GAZOO Racing Company, Toyota Motor Corporation about the joint development of SFA method with Yaskawa.

Q. What triggered the development of SFA method?

In August 2023, Chairman Akio Toyoda, also known as Morizo, visited a production site in Finland, where Toyota's rally car manufacturing base is located, and pointed out that the long production lead time was an important issue. In fact, it takes at least 1 month to produce a rally car, making it difficult to quickly respond to orders received and causing customers to wait for a long time. Therefore, we received a direct request from the Chairman to improve production efficiency by utilizing Toyota Production System (TPS*³), and this was the impetus for the new project. In the rally car manufacturing process, even the skilled welders take 2 to 3 weeks per vehicle to manually weld roll cages, which takes a particularly long time. Therefore, we prioritized automation of this process and developed SFA method.

Q. Why did you choose Yaskawa Group as a partner?

While evaluating different equipment to solve the problem, we felt that Yaskawa's welding power source had the greatest technological potential. After reviewing the samples that Yaskawa produced, we felt that it could achieve quality comparable to that of experienced welders, so we chose Yaskawa as a partner. Just as people say "When it comes to arc welding, Yaskawa is the best," the vast experience and knowledge that Yaskawa has accumulated within the company was impressive. We were very grateful that we were able to advance development while learning this know-how through Mr. Shibata, the engineer from Yaskawa in charge of this project, and we feel that Yaskawa has taken the lead in this development.

Q. What were the difficulties in the development process?

The first challenge was how to make use of the welding power source, which we felt had potential, in order to achieve welding strength that would not deform under a load of approximately 10 tons, as required by the FIA*⁴ safety standards. Together with Mr. Shibata, we verified how to use the welding power source from scratch and made adjustments to parameters like current, voltage, and the order of welding to ensure the required quality. However, it took even longer to address the distortion caused by welding heat. Correcting the distortion required delicate adjustments of the welding speed and the way in which heat was applied. Even after 3 months of trial and error, we were unable to find a definitive solution. As this was an unprecedented challenge, we did not hesitate to exchange opinions with each other and explored all possibilities. As a result, we came up with a method to weld slowly to avoid distortion rather than to correct. Mr. Shibata turned this idea into reality as the movement of a robot and SFA method, which is to repeatedly melt and solidify in fine cycles, instead of welding metal all at once, was born. We feel that the key to our success was that we were able to move away from the premise of "repeating as quickly as possible" in the production of commercial vehicles and came up with the concept of "welding slowly and carefully."

Roll cage welding



Manual work



Work with robots (SFA method)



Q. What are the results of this collaboration?

The automation of the roll cage manufacturing process with welding robots has reduced the process from 2 to 3 weeks to three days, which is a significant achievement. In addition, SFA method uses robots to achieve high-quality welding that is difficult to achieve manually, such as reducing the weight of the bead^{*5} and improving welding strength and appearance. The welding achieved by SFA method is expected to contribute to improving vehicle handling by increasing body rigidity. The initial goal was to shorten lead times, but as a result, we were able to realize technological innovations that will enhance the competitiveness of not only rally cars but also race cars and commercial vehicles, and we see great potential for future development.

Q. What are your plans for future collaboration with Yaskawa?

I have the impression that Yaskawa is steadily advancing its own technological strategy by calmly assessing technological trends, selecting key elements, and focusing resources on them, rather than simply following current technological trends. If the direction of manufacturing we aim for matches Yaskawa's technological focus, there is a strong possibility that we engage in joint development with Yaskawa again.

^{*1} Abbreviation for Sequence Freezing Arc-welding. A method of welding slowly and carefully by repeatedly melting and solidifying.

^{*2} Metal pipe frames installed inside vehicles to protect occupants.

^{*3} Toyota's original production method, which aims to "eliminate waste thoroughly and shorten lead times in order to deliver cars ordered by customers in good quality at low prices and in a timely manner" with the premise of making workers more comfortable.

^{*4} An abbreviation for Federation Internationale de l'Automobile

^{*5} Joints where molten metal fuses with the base material during welding and then cools and hardens.



Atsushi (kye) Kawakita

Project General Manager
Production Planning and
Engineering Development
GR Management Div.
GAZOO Racing Company
TOYOTA MOTOR CORPORATION

Column



Shota Shibata

Welding & Jointing Technology
Development Sect.
Manipulator & Application
Technology Dept.
Robot Technology Dept.
Robotics Div.

SFA method was developed with Mr. Kawakita over a year of 2024. When I was offered the opportunity to jointly develop the technology, I remember that I felt more excitement than anxiety about being involved in the development of a world-first technology. I was also able to work enthusiastically on the development because it was a technical field in which I was strong. After a lot of trial and error, we changed our mindset to move the robot slowly and carefully. As a result, we were able to achieve multiple results, such as reducing lead time and improving welding quality. I am very pleased that Toyota has praised us for this.

In this technology development, we collected a variety of information, conducted experiments, and verified the robot movement in order to reproduce the manual process and craftsman's intuition, and succeeded in reproducing the craftsmanship in the robot. I feel that the knowledge learned from this project will be very important not only for the automotive industry but also for the further spread of welding robots in the world. The next step for Yaskawa Group is to apply this know-how to the autonomous robot "MOTOMAN NEXT." Through this development, I learned a lot about the movements of expert welders who respond flexibly to events that occur during welding. If we can pre-program them into MOTOMAN NEXT to respond to basic welding and develop the function where customers can individually choose detailed settings, such as specific types of sound and ranges for slowing down, after the robot is introduced, we will be able to further expand the market by providing them as a package.

Basic concept

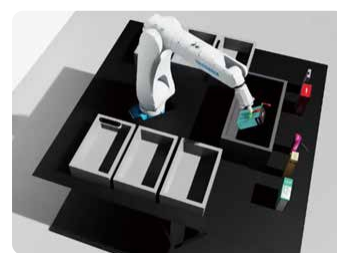
The Yaskawa Group will continue its efforts to develop products and technologies that are the world's first and best in the world. Through a wide range of initiatives, such as combining these products and technologies, strengthening support for digital data solutions, and expanding collaborations with universities and other companies, the Yaskawa Group will create solutions that solve management issues for customers and contribute to the realization of a sustainable society.

Yaskawa Technology Center (YTC), our technology development base, has created a system that consolidate dispersed development functions and can handle everything from technology and product development to mass production prototype. In addition, by strengthening cooperation between business divisions and corporate technology division, we can quickly respond to market needs and improve development efficiency and quality by sharing information through YASKAWA Digital Transformation (YDX). Based on a technology roadmap that anticipates future market changes, YTC functions as a core base for creating new value.

With regard to intellectual property, the Yaskawa Group will promote its intellectual property strategy in conjunction with its business plan and technology strategy, and support business development by preventing intellectual property disputes, accurately protecting its own technologies, and responding promptly to technology agreements that match business characteristics.

Developing new technologies and business domains through open innovation

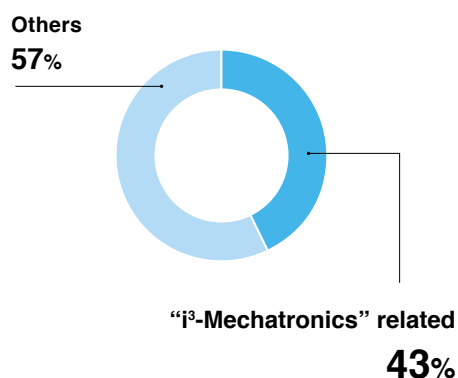
We are promoting industry-academia-government collaboration with companies and schools with seed technologies in order to strengthen technology development that captures market changes and embodies customers' future needs. While advancing AI robotics, we launched "MOTOMAN NEXT," an autonomous robot with AI equipped with NVIDIA's GPU as standard. "MOTOMAN NEXT" uses NVIDIA's high-performance GPU and software that can accurately simulate robot movements. By building the entire environment in which robots work into a simulation, "MOTOMAN NEXT" can efficiently complete everything from AI learning using a large number of workpieces to motion verification. We decided to collaborate with NVIDIA because of the ability to seamlessly deploy applications implemented in a simulation to real machine environments (Sim2Real). We are currently advancing demonstration activities for social implementation of Sim2Real.



Robot work environment in a simulation

Measures for intellectual property

Patent application rate in FY2024



In the areas of "factory automation and optimization" and "mechatronics application fields," which are set forth in "Vision 2025" long-term business plan, we are pursuing strategic patent applications with the aim of building a patent network that contributes to our business. In particular, in the field of "factory automation and optimization," with "i3-Mechatronics" as its main focus, we are focusing on obtaining patent rights for application technologies that utilize AI and IoT, in addition to our core products such as Σ-X, iCube Control, and MOTOMAN NEXT. We are also actively pursuing patent rights in mechatronics application fields, such as PV inverter for solar power generation for self-consumption and automation technologies in the medical and agricultural fields, to support business growth.

We are strategically applying for these patents based on our technology roadmap, and we are building an intellectual property portfolio based on a thorough evaluation of the contribution of those patents to our business.

We are also developing a global intellectual property protection system in cooperation with the overseas bases of the Yaskawa Group.

We are also focusing on internal education. We are working to further strengthen our intellectual property activities by instilling the importance of intellectual property throughout the company by conducting intellectual property education for each level and technical field.

Differentiating factor of core technologies

Three core technologies that form the technology development in the Yaskawa Group's business domain of "motors and their applications" are "motion control", "robotics" and "power conversion". These are the core competencies of the Group.

Motion control technology includes motor technology, control technology, encoder technology, and communication technology. Robotics technology consists of robotic arm technology and robot control technology. Power conversion technology includes conversion technology, and technology for miniaturization and higher efficiency.

They are widely applied to our products and are the foundation for our strength.

Motion control

	Explanation	Differentiating factor
Motor technology	Technology to achieve miniaturization, high torque and efficiency of the motor and smooth rotation and quiet driving	We have pioneered the development of split core technology and applied a high-density winding technology called concentrated winding to our products. In order to further increase the winding density, we are working on the development of higher performance winding technologies, such as pressure-formed coil technology, which is able to increase the space utilization ratio by press forming after winding coils larger than the space available.
Control technology	Technology that enables precise control of three elements of an object – position, speed, and torque – in response to commands received from the controller.	We have pioneered the application of adjustment-less control to reduce variations in device characteristics. This technology enables devices with different moments of inertia and friction to achieve the same position response. In our new products, Σ -X, the inertia variation range has been expanded from 30 times to 100 times, and we are working to further improve performance.
Encoder technology	Technology to accurately control the rotating position of the motor by detecting the rotation angle of the motor.	We are developing encoders with the industry's highest level of accuracy and functionality. In Σ -X series, we are working to develop new value-added technologies along with higher accuracy. For example, the encoder is equipped with a sensing function to collect data, and we are adopting a compact battery-less encoder that achieves overall length reduction by replacing self-generating components with solid-state batteries.
Communication technology	Technology required for FA (factory automation) equipment to communicate at regular intervals without delay	We have developed MECHATROLINK, an open communication standard, to realize high-speed, highly synchronous and reliable communications between multiple devices. In addition, by a semiconductor chip (ASIC) that implements our proprietary control technology, we provide excellent real-time motion control and supports the high competitiveness of our products.

Robotics

	Explanation	Differentiating factor
Robotic arm technology	A group of technologies that integrates the design and manufacturing of mechanisms, such as arm structures, actuators (motor and reducer modules), power transmission mechanisms, and link shapes.	Aiming to expand into unautomated areas, we have launched MOTOMAN NEXT, an autonomous robot for digital twins, for the first time in the industrial robot industry. In addition, to improve the performance of robots, we are studying new materials to reduce the weight of the arm, developing an optimal motor for high precision and high response of the drive unit, and developing technology to reduce noise.
Robot control technology	Technology to enable the arms of industrial robots to perform specific actions	Technology development for high speed and high precision is also applied to MOTOMAN NEXT. Among them, the functions required for recognition and judgment are equipped as standard. Judgment is realized by an autonomous control unit equipped with a GPU, and task is realized by a robot control unit. In addition, we are working on autonomous distributed manufacturing using planning technology to automatically calculate optimal routes and task procedure and recognition and judgment technology using AI.

Power conversion

	Explanation	Differentiating factor
Conversion technology	Technology to control the voltage, current, and frequency of the input power supply to convert it to the intended output	We are applying a new material, SiC (Silicon Carbide)/GaN (Gallium Nitride) power semiconductor, to power conversion equipment, and are working on miniaturization, high efficiency, and high-frequency output of equipment by utilizing circuit including parasitic components, and simulation technology for heat and stress. In addition, the switching operation of SiC/GaN power semiconductors is much faster than that of conventional Si (silicon), which increases electromagnetic noise emitted from equipment. To reduce noise, from the perspective of generation, emission, and the mechanisms of propagation of electromagnetic noise, we are also working to clarify them, and to establish methods for estimating noise levels.
Technology for miniaturization and higher efficiency	Switching control technology and new device application technology to reduce the loss that occurs during reverse conversion* of voltage	

* Reverse conversion: Converting an AC voltage to a DC voltage, and then converting the DC voltage to a desired AC voltage and frequency