R&D STRATEGY

Mitsubishi Electric R&D Strategy

Mitsubishi Electric Corporation

January 15, 2025

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Contents

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Key points

1. **Promote research and development that drives sustainable business growth through our strong components and digital technologies**

2. **Developing Foresight Technology[*1] that fundamentally solves social issues**

*1 Foresight technology: Technologies developed with foresight, aiming to make a significant impact on society and business.

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1 Overview of R&D Strategy

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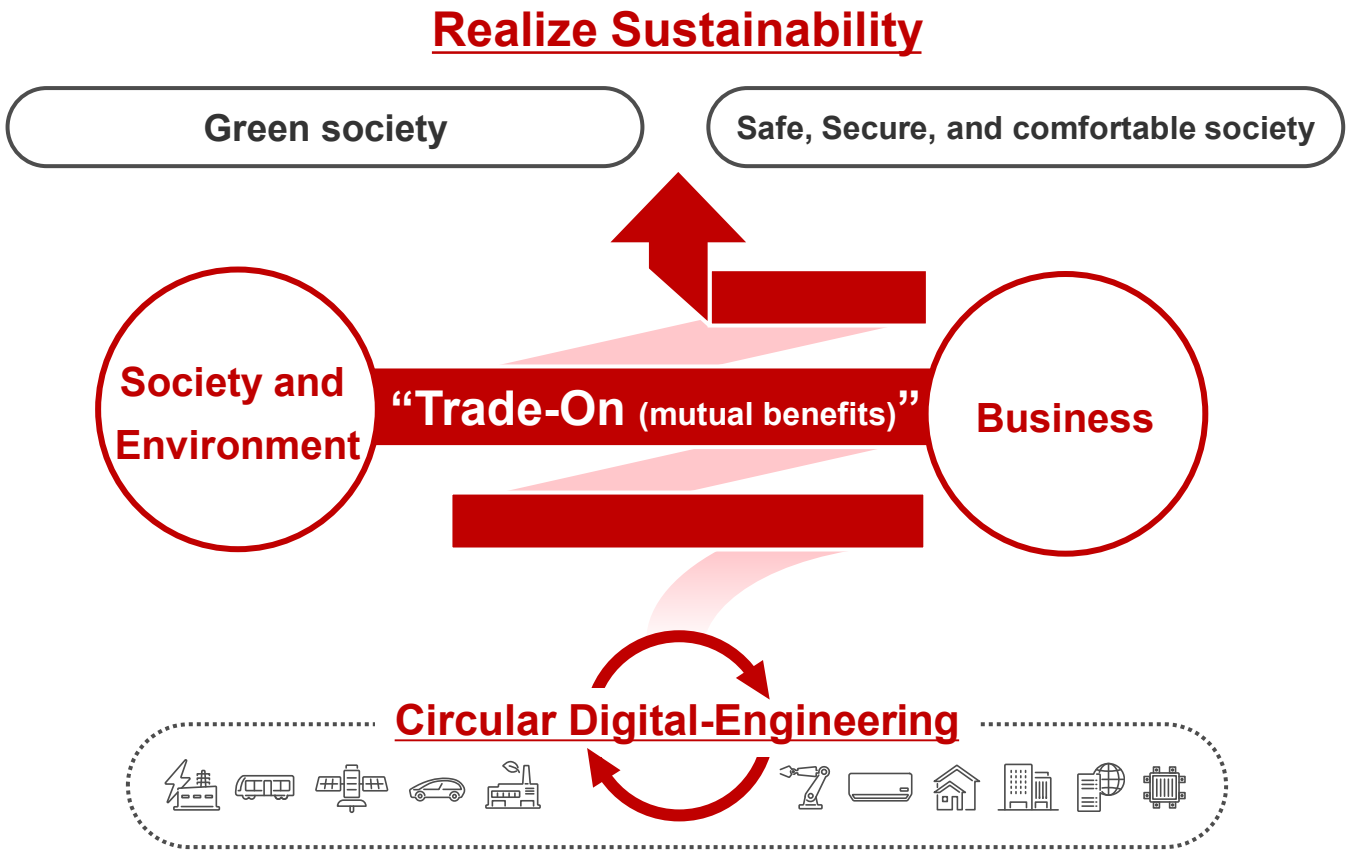
Basic Policy for Realizing Sustainability

By positioning the realization of sustainability as the cornerstone of our management, we will accelerate our Trade-On initiatives, which involve developing our business while enriching society and the environment through innovation based on Circular Digital-Engineering and realize sustainability.



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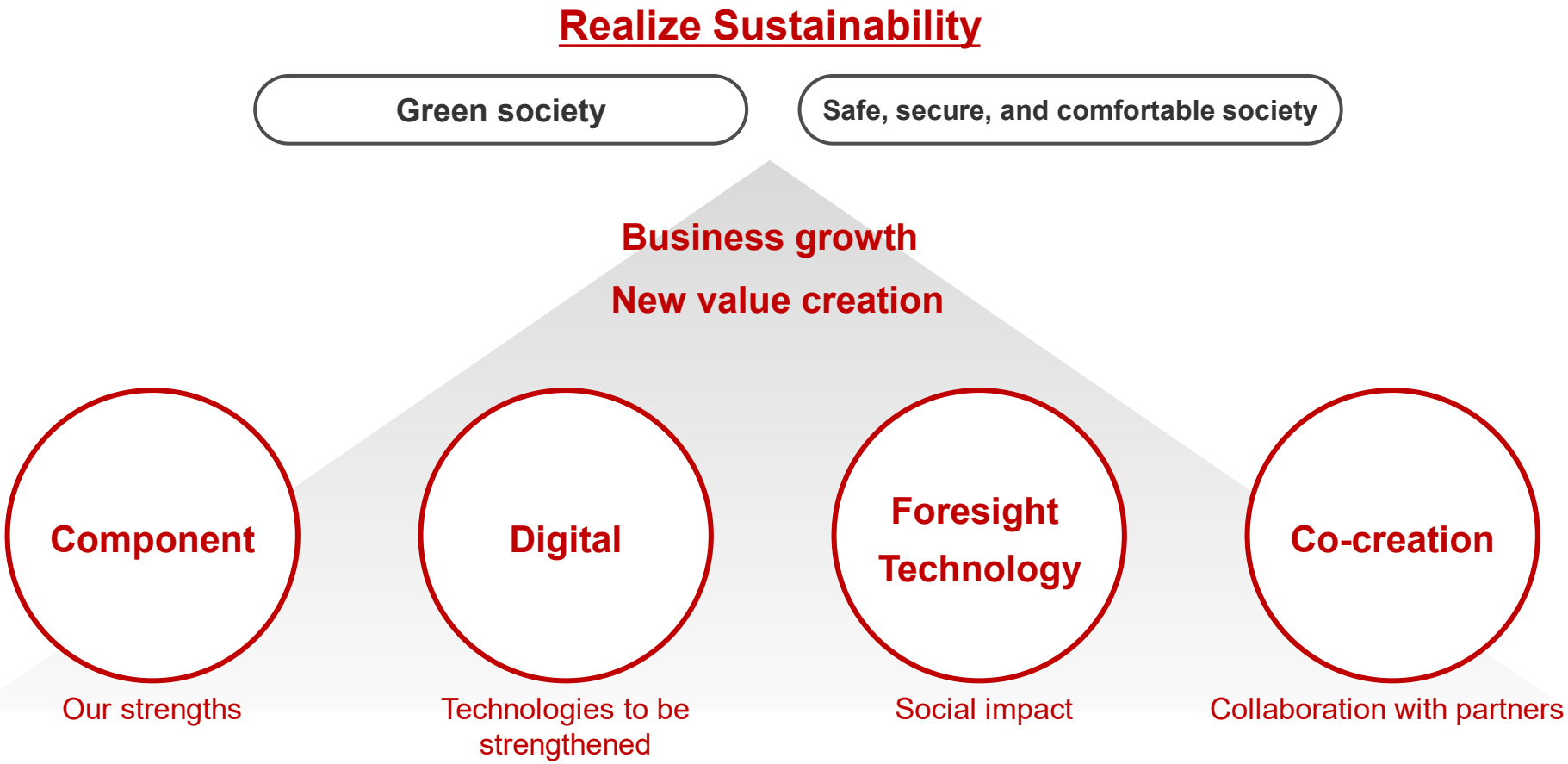
R&D Strategy

Creating new value through our strong components and digital technologies to drive sustainable business growth.

Developing and co-creating Foresight Technologies[*1] that impact society and business, to create new value that fundamentally solves societal challenges..



*1 Foresight technology: Technologies developed with foresight, aiming to make a significant impact on society and business.

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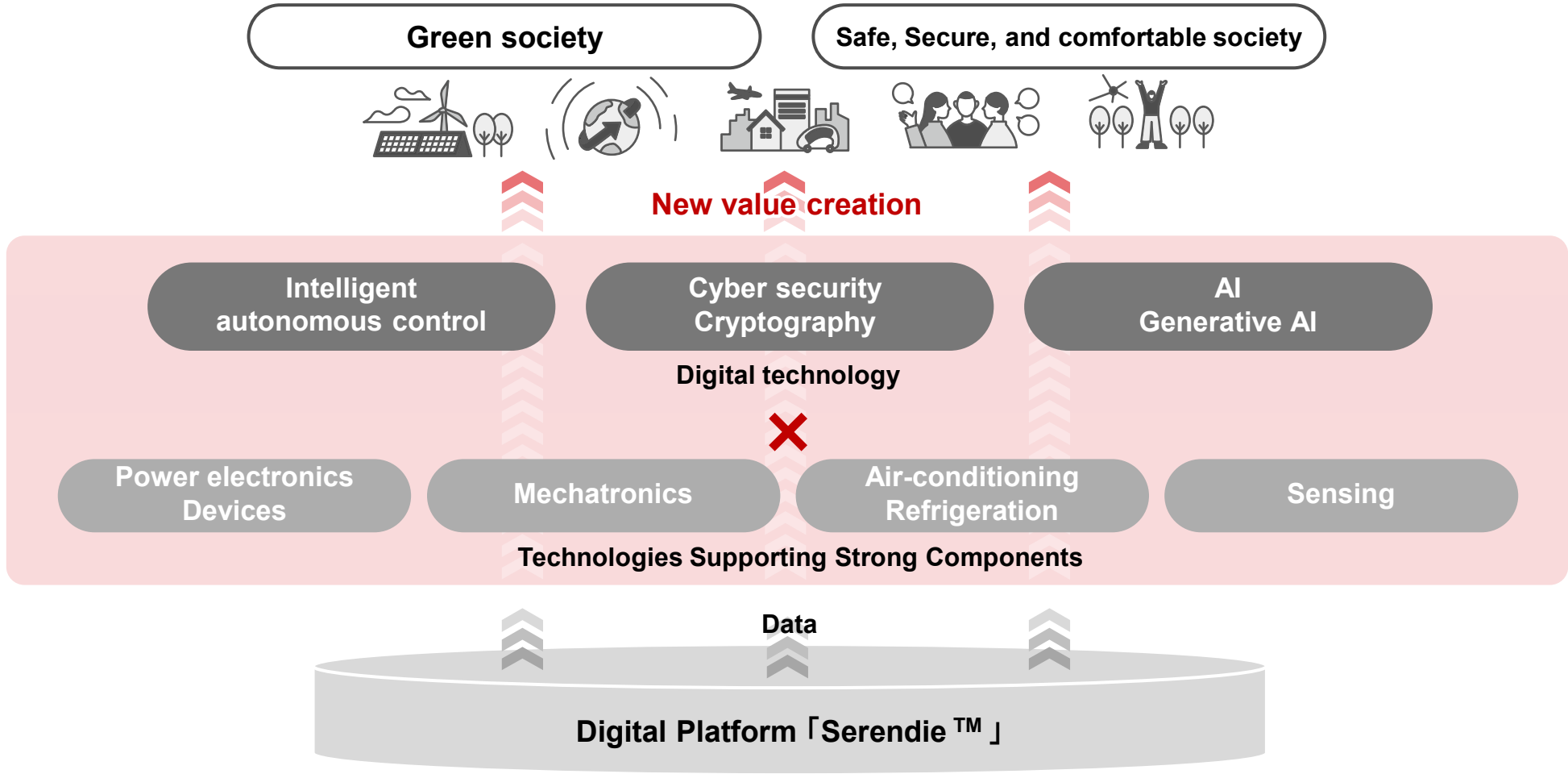
Technology Domains to be Strengthened

To create new value using the data obtained from Serendie™, we will strengthen the technologies supporting strong components and advanced digital technologies, aiming to realize a green society and a safe, secure, and comfortable society.



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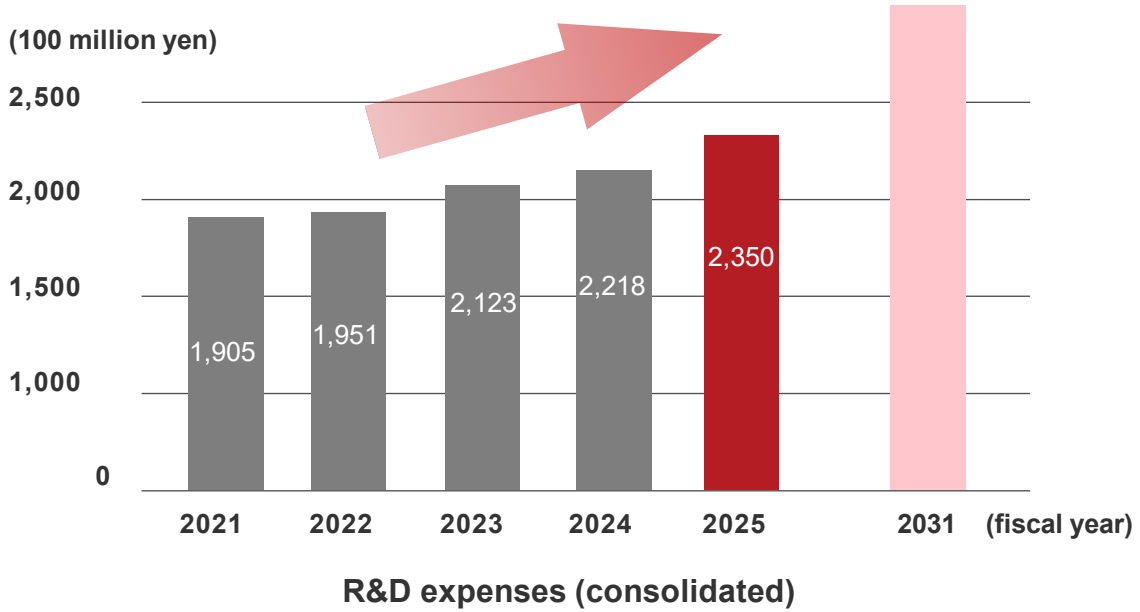
R&D Investment

We continue to invest in R&D and initiatives for creating new value that will strengthen our market competitiveness and support sustainable growth.

R&D investment



R&D expenses (consolidated)

Open innovation

Invest 100 billion yen in industry-academia-government collaboration-related R&D (FY2025 to FY2031)

Strengthen comprehensive organizational collaboration and promote R&D in a timely manner.

- Exploration and R&D of Themes for Realizing a Sustainable Society
- Development Aiming to Model the Entire Circular Ecosystem and Achieve Economic Rationality
- R&D and Demonstration Experiments Related to Green Energy

The University of Tokyo | Institute of Science Tokyo | Kyoto University | Waseda University | NEDO*1 | NICT*2 | National Institute of Advanced Industrial Science and Technology | ITRI*3

Collaboration with startups

Accelerate initiatives in innovation domains to solve social issues.

- Cartken (Robot delivery service, USA)
- QunaSys (Algorithms for quantum computers, Japan)
- Scibreak (Direct current circuit breaker, Sweden)
- Cognitive Research Labs, Inc. (Decision-making support system in the cognitive domain, Japan)
- Novel Crystal Technology, Inc. (Gallium oxide power semiconductor, Japan)

*1 NEDO: New Energy and Industrial Technology Development Organization *2 NICT: National Institute of Information and Communications Technology *3 ITRI: Industrial Technology Research Institute (Taiwan)

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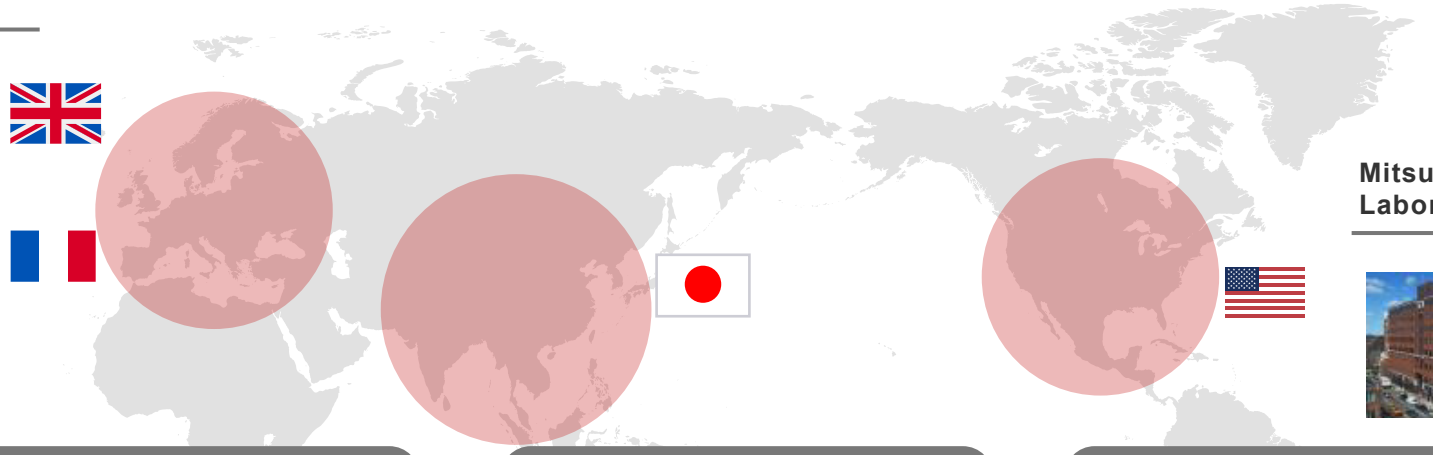
Global R&D

In addition to fundamental research through networks with overseas research bases and universities, we promote co-creation mainly in North America, Europe and Asia.

Mitsubishi Electric R&D Centre Europe (MERCE)

Mitsubishi Electric Research Laboratories (MERL)

Europe

Co-creation in leading region for environmental policy

- **Participation in the REACT*1 project**
  Optimization of energy demand
- **Participation in the Berlin TXL*2 project**
  Energy efficiency and comfort of buildings

Asia

Co-creation in growing markets

- **Comprehensive joint research with ITRI*1**
  Recycling-oriented economy, development of environmental technology and acceleration of PoC

North America

Acquiring innovative technology and co-creation

- **Taking on the challenge of new domains**
  Logistics and flight management using drones
- **Collaboration with Top Conferences**
  Hosting Co-creation Related to AI and Image Processing

Strengthen co-creation centered on research, manufacturing, and sales bases

*1 REACT: A European demonstration project on energy self-sufficiency for remote islands *2 TXL: A smart city developed and managed by Tegel Projekt GmbH *3 ITRI: Industrial Technology Research Institute (Taiwan)

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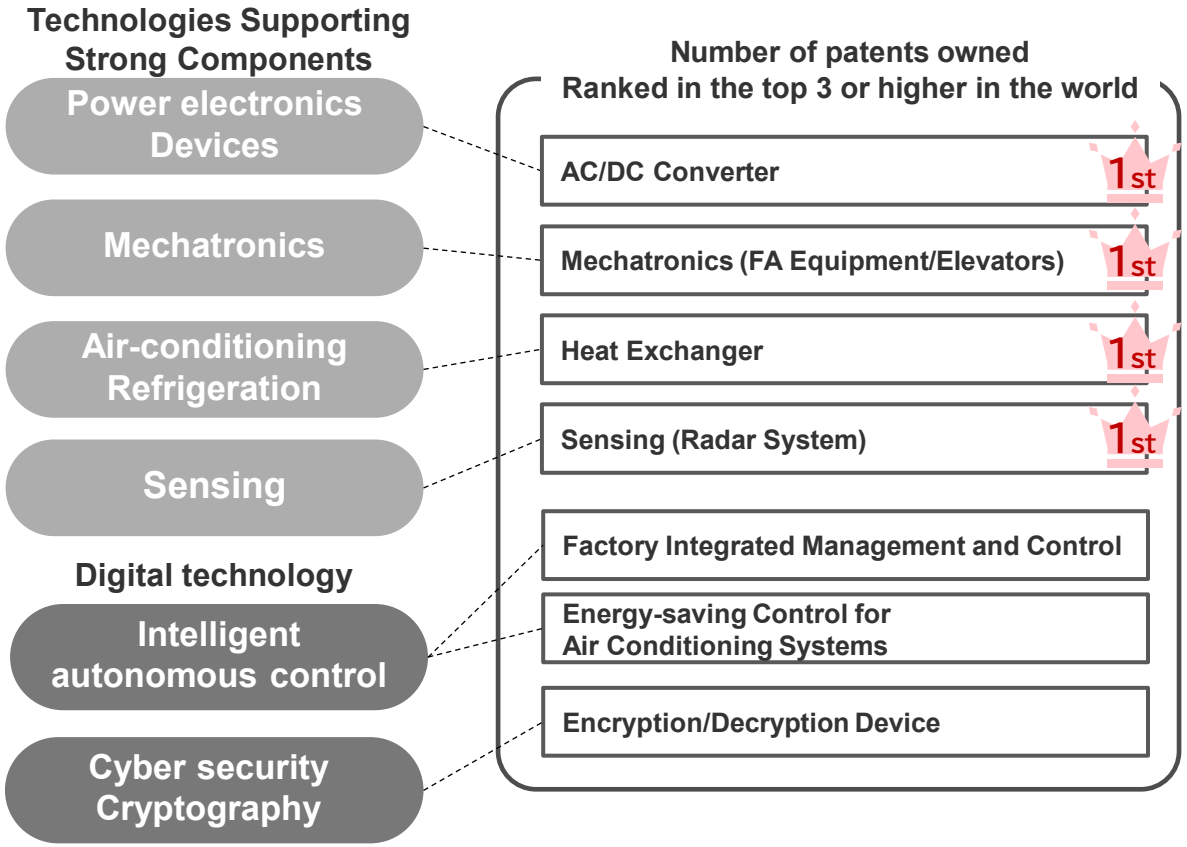
Intellectual Property

Stock (Number of patents owned)

Component-related patents, which account for more than 50% of the approximately 70,000 globally owned patents, continue to support our business.



Flow (Number of applications)

Enhance applications related to AI, generative AI, and solutions as digital technology that increases the value of components.

Ratio of AI and generative AI

Before setting KPI (FY2021)	Current (FY2024)	Target (FY2026)
3%	14%	15%

Ratio of solutions

Before setting KPI (FY2021)	Current (FY2024)	Target (FY2026)
10%	22%	30%

The above two ratios were indicated using KPIs in FY2021.
The target values were set as a ratio to the total number of patent applications we filed.

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Standardization Activities and Dissemination of Research Results

Strengthen global standardization activities and technology presence in alignment with business and R&D strategies.

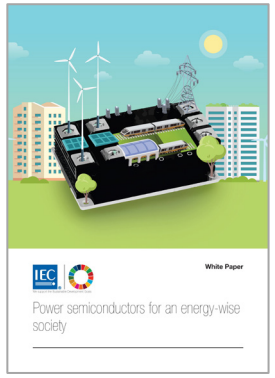
Strengthen international standardization activities

As part of our business strategy, we will enhance activities to secure market superiority through rule-making. Over 600 members, including key roles in international standardization organizations like the IEC Vice President, will present the direction of technological development globally.

- Power semiconductors

  To improve quality and convenience, we proposed the need for the development and expansion of international standards and certification systems.

  IEC White Paper "Power Semiconductors for an Energy-Wise Society"



- CC-Link IE TSN *1 *2

  We integrated TSN technology, standardized by IEEE*3, into the industrial network field and obtain international standards early. Using CC-Link IE TSN will enhance the convenience and performance of FA equipment, contributing to market expansion.

CC-Link IE TSN

Papers accepted at top international conferences

Actively present research findings at world-class international conferences

- NeurIPS2024 (AI and machine learning)

  Physical detection, accelerating learning of models, Large-scale vision-language models, enhancing language models, etc.

- IROS2024 (Robotics and AI)

  Cooperation between humans and robots, robot learning architecture, learning-free, optimization through enhanced learning, modeling of acoustic characteristics, etc.

- CANS2024 (Cryptography and network security)

  Verification of characteristic probability for collision attacks, etc.

- ISC2024 (Information security)

  Quantum key recovery attacks, quantum version of the multi-bridge attack, etc.

- Advanced Quantum Technologies 2024 (Quantum)

  Quantum optics, etc.

*1 TSN: Time-Sensitive Networking *2 CC-Link IE TSN: Control & Communication Link Industrial Ethernet TSN *3 IEEE: Institute of Electrical and Electronics Engineers

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2 Development Strategy for the Technology Domains to be Strengthened

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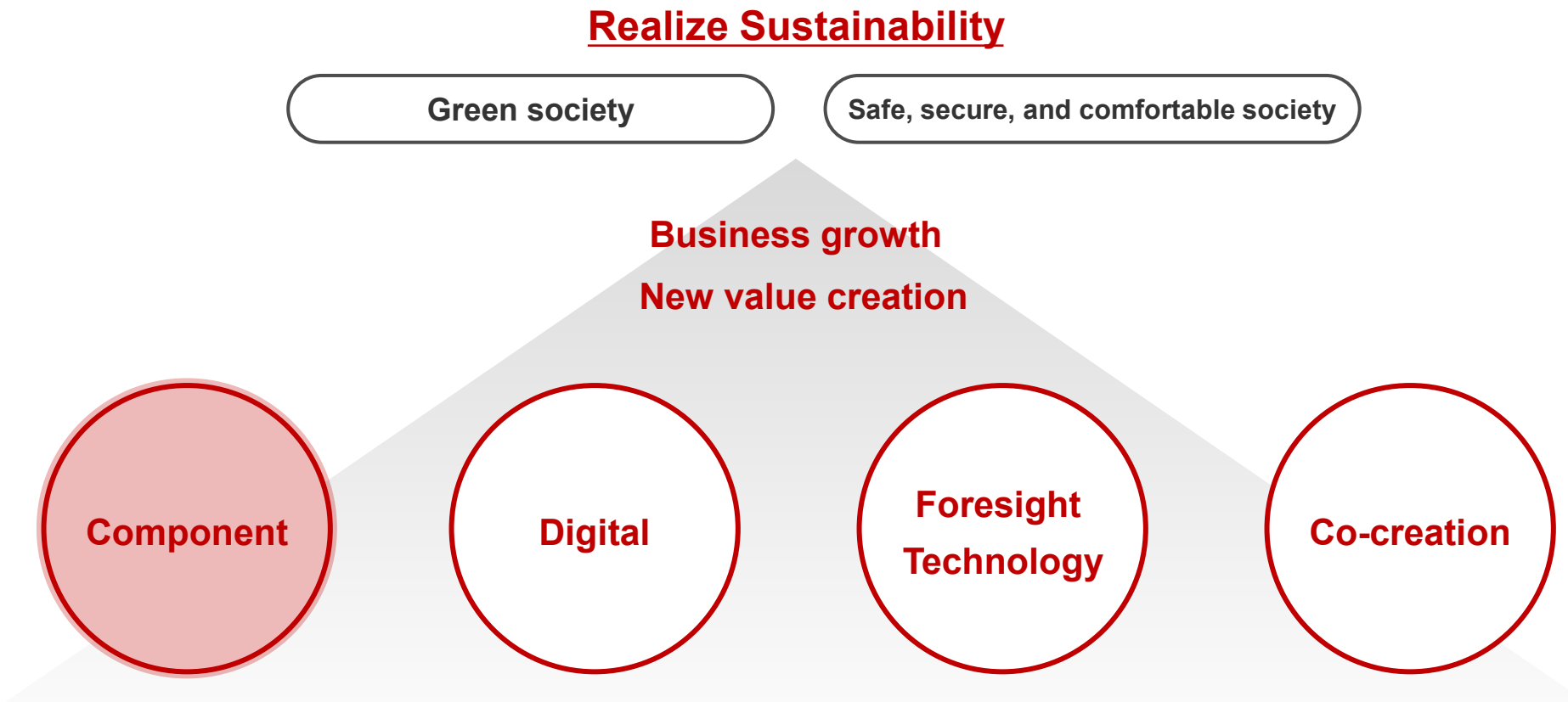
Explanation Covered by Chapter 2, Section 1



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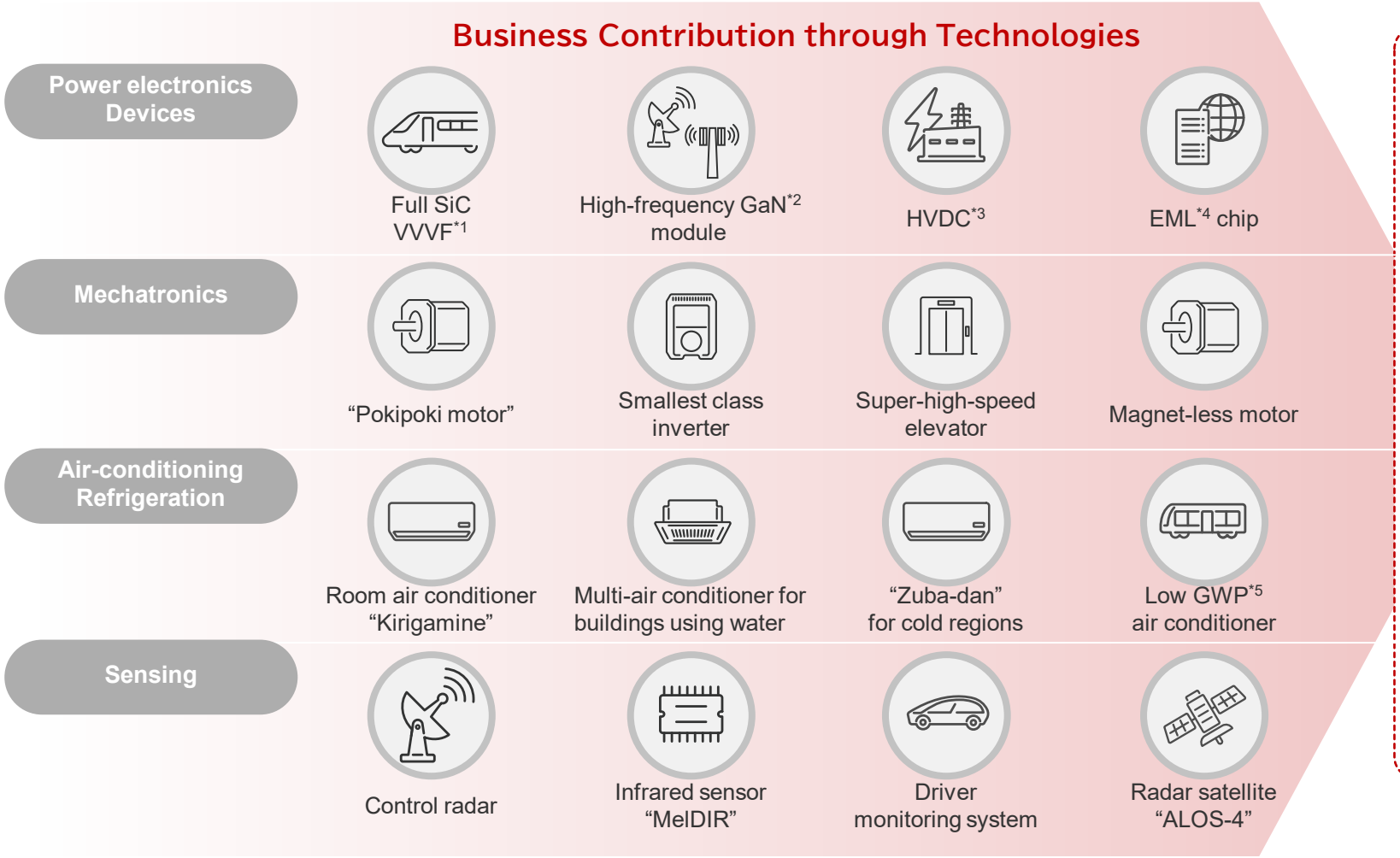
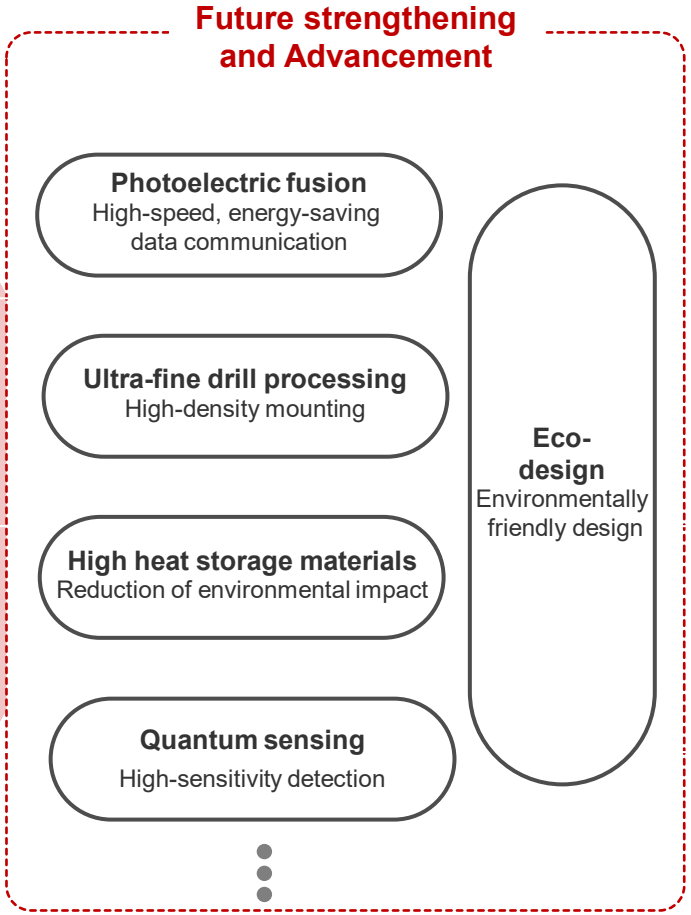
Technologies that Support Strong Businesses

We aim to strengthen and advance technologies that have supported our core components, leveraging our strengths to achieve further business growth.





*1 VVVF: Variable Voltage Variable Frequency *2 GaN: Gallium Nitride *3 HVDC: High Voltage Direct Current *4 EML: Electro-absorption Modulator Laser *5 GWP: Global Warming Potential

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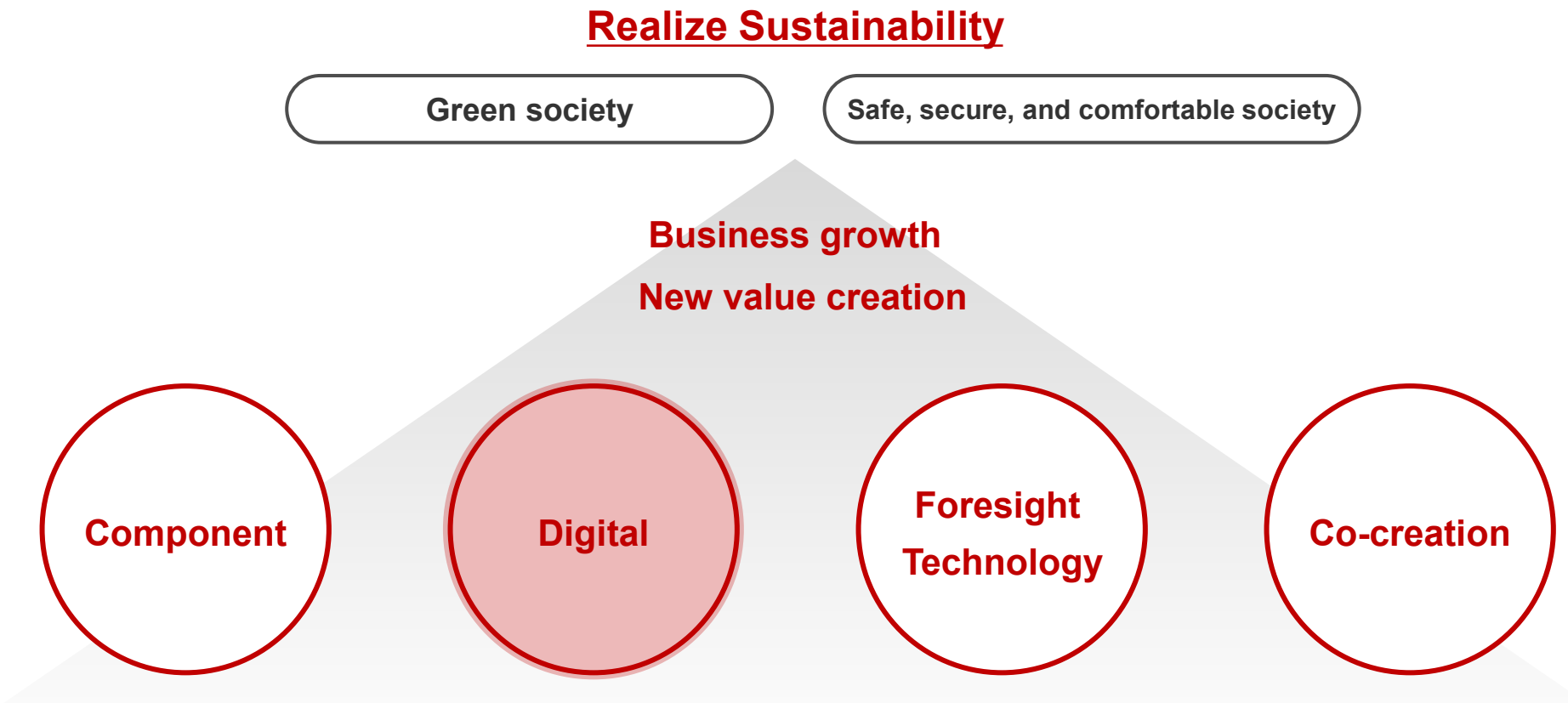
Explanation Covered by Chapter 2, Section 2



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Intelligent Autonomous Control

Leveraging our expertise in control technologies from fields like FA, building systems, air conditioning and refrigeration, and space, we enable integrated and autonomous operation of large-scale systems with complex interactions.

Complex systems optimal control technology

Optimization of complex operational planning involving multiple systems and predictive control (Winner of IEEE Best Paper Award)

Building heat modeling and control technology

Achieve optimal predictive control of air conditioning equipment without the need for precise setting of model parameters (Related patent*2, ranked No. 1)

Lightweight block chain technology

Realize peer-to-peer transactions with small computers through a distributed algorithm that derives the optimal solution with few calculations

Total Management

Autonomous

Robot autonomous control LLM*3

Multiple LLM*3 systems communicate with each other to derive the optimal solution, **reducing errors in** robot **motion by half** (Winner of NeurIPS Best Paper Award)

High-precision positioning technology

Achieve **2.5 times** greater accuracy in positioning moving objects with AI that infers Wi-Fi signal environment (Winner of the IEEE Best Paper Award)

Audio separation and recognition technology

Achieve stress-free voice interaction between devices and robots even in noisy environments (Winner of the Best Paper Award from IEEE and others)

*1 QoW: Quality of Work *2 Related patents: Number of applications and number of quotations (based on our survey) *3 LLM: Large Language Models

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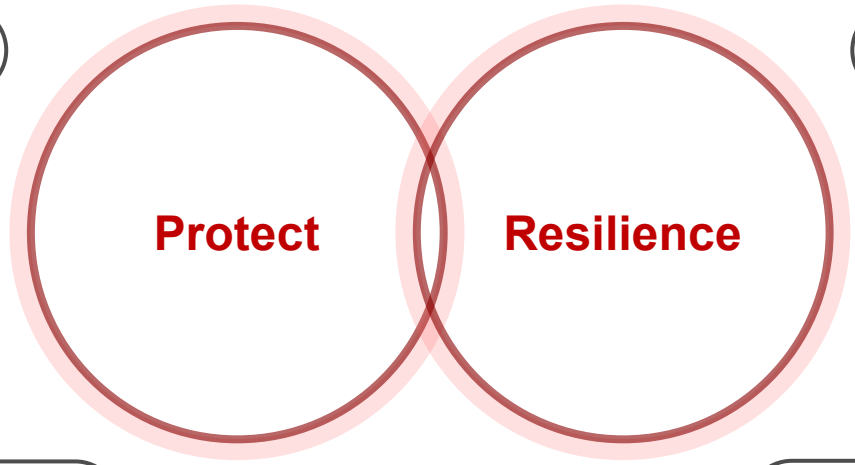
Cyber Security and Cryptography

Leveraging our strengths in cybersecurity and encryption technologies developed in critical infrastructures such as energy and facilities, we provide robust defense against various attacks and minimize the impact in the event of an attack.

Assure safety in the event of a contingency for critical infrastructure

Have a wealth of knowledge regarding advanced cyber attacks and provide effective protection

Identify the scope affected by incidents and ensure continued operation and early recovery



Attack Detection Technology

By training with AI-generated simulated attack logs, we can detect sophisticated cyber attacks.

Concealed search technology

A unique method that allows searches to be performed while remaining encrypted, maintaining concealment

Post-quantum cryptography (PQC) technology

Realize of encrypting system that can maintain security even when using a quantum computer (Related patent *1, ranked 3rd)

Privacy protection technology

Technology for the safe and secure utilization of sensitive information
(Winner of awards in both the offense and defense categories at the NeurIPS competition)

Attack simulation technology

Evaluate the impact on systems when they are attacked and build effective countermeasures (Related patent, ranked 2nd)

Dynamic micro-segmentation

Dynamically manage areas covered by the network and restrict available areas in real time

*1 Related patents: Number of applications and number of quotations (based on our survey)

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AI and Generative AI

Maisart

Leveraging our strengths in physical modeling, simulation technology, and compact AI developed through our robust components, we deliver highly adaptable and reliable technologies that cater to diverse environments in various fields such as maintenance and manufacturing.

Neuro-Physical AI technology

Utilize physical modeling and simulation technologies
High-precision control with **1/10** the learning data compare to the conventional systems

Compact and real-time technology

Lightweight and high-performance AI that can be installed in edge devices
Learning speed for abnormal detection using images is **40 times** faster compared to that required by conventional systems.

Environmental adaptation technology

Use AI to infer the cause of the discrepancy with the simulator, allowing adjustment to environmental and condition changes in maintenance sites, etc.

Adaptation

Reliability

AI Technology for Human Collaboration

Through dialogue between designers and AI, AI proposes designs that meet requirements, **reducing the design time of novice designers by 85%.**

Distributed Cooperative AI Agents

AI Agents Collaborate to Optimize Complex and Diverse Tasks, such as Variable Production

Performance assurance technology

AI autonomously learns stable control, identifies constraint conditions, and maintains control and performance within those conditions.

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3 Initiatives for Further Growth in the Future

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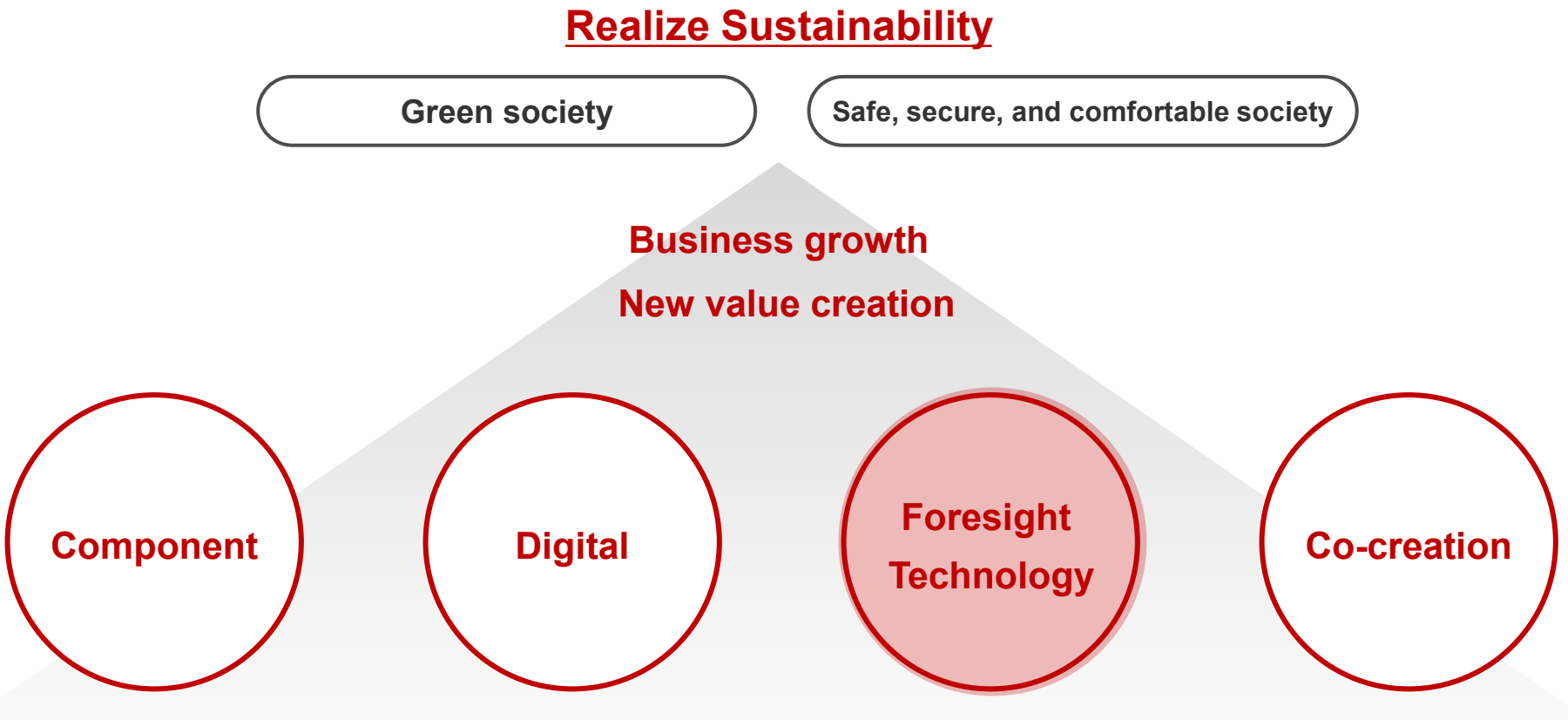
Foresight Technology

Aiming to make a significant impact on society and business, we develop with foresight based on insights into technological potential and changes in the social environment. And challenge ourselves to create new value by combining new and existing technologies.



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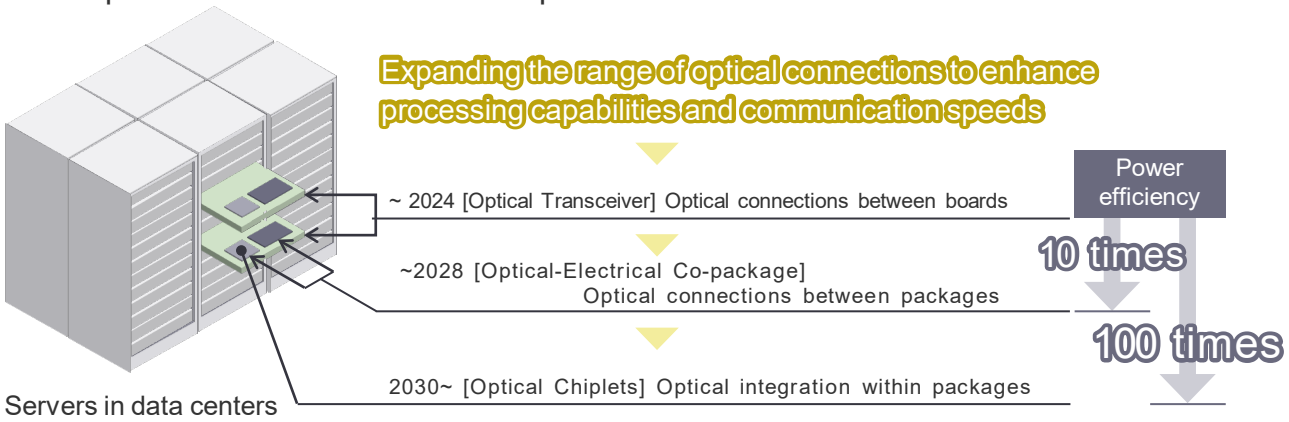
Case 1: Photonics-Electronics Convergence Technology

With the rapid development of generative AI services, reducing the power consumption at data centers, which are expected to account for 15% of the world's total power consumption in 2050, is an issue of great importance. We contribute to the development of AI technology and energy conservation through photoelectric fusion technology, which enhances computing performance and significantly reduces power consumption.

Social value

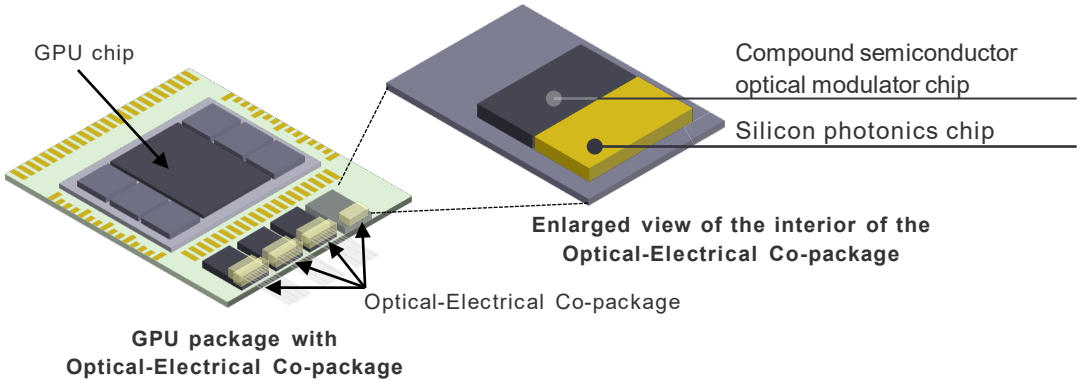
- By replacing electrical connections with optical connections within devices through photoelectric fusion technology, we achieve high-speed circuits and reduced power consumption, addressing the power consumption issues of data centers.
- The realization of optical co-packages and optical chiplets expand the range of optical connections, significantly enhancing the data processing capabilities and communication speeds of data centers.



Introduction process of optical-electrical fusion technology

Advantage of our technology

- Our company possesses high-density integration technology for both compound semiconductors and silicon photonics. We focus on devices that combine the high-efficiency emission and high-speed modulation of compound semiconductors with the low-cost, high-density integration of silicon photonics.
- In the field of compound semiconductors, we leverage the high-speed, high-capacity technology developed through the development of EML*1 chips.



Example of a compound semiconductor and silicon photonics fusion device: Optical-Electrical Co-package

*1 EML: Electro-absorption Modulator integrated Laser diode

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Case 2: Carbon Recycling Technology

Achieving carbon neutrality requires reducing dependence on fossil fuels. By developing carbon recycling technology with our partners, our company contributes to the establishment of an integrated EMS[*1] to reduce the manufacturing costs of liquid synthetic fuels made from CO_2.

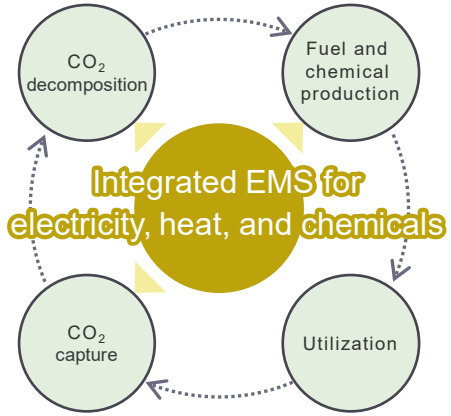
Social value

- By utilizing CO_2 as a resource and recycling it into liquid synthetic fuels, we can reduce CO_2 emissions into the atmosphere. These fuels also have the advantage of high energy density, similar to fossil-derived gasoline.
- An integrated EMS that manages and optimizes electricity, heat, and chemicals helps reduce the manufacturing costs of liquid synthetic fuels, addressing a key challenge and promoting their adoption in society.

	Energy density per volume	Energy density per weight
Liquid fuel (fossil-based)	High	High
Liquid synthetic fuel	**High**	**High**
Gaseous fuel (such as H)	Medium	High
Battery	Low	Low

Source: Agency for Natural Resources and Energy

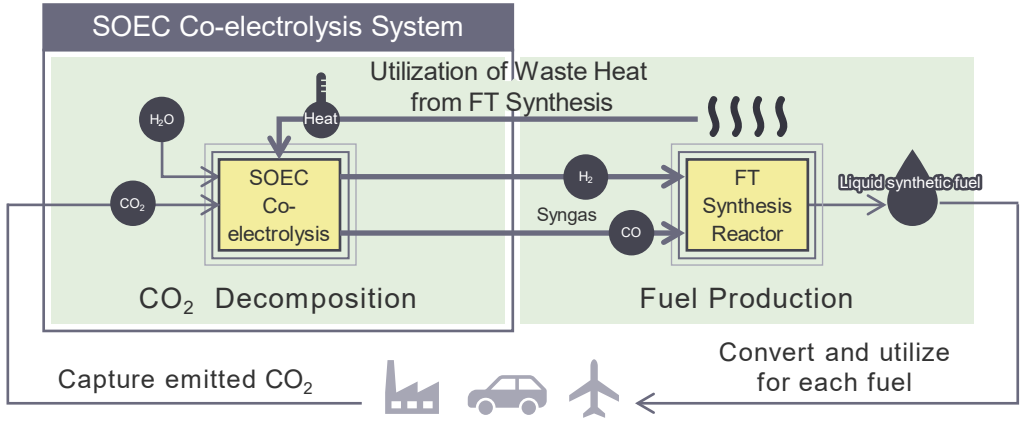
Comparison of energy density



Utilization for fuels and chemicals through carbon recycling

Advantage of our technology

- Our company has expertise in EMS that integrates components and systems for power control, building air conditioning, and plant monitoring.
- We are advancing SOEC[*2] co-electrolysis for efficient liquid synthetic fuel production by optimizing system configurations and operating conditions to improve efficiency and reduce costs[*4] .



Overview of the SOEC co-electrolysis system using waste heat from FT synthesis[*3]

*1 EMS : Energy Management System
*2 SOEC: Solid Oxide Electrolysis Cell
*3 FT synthesis: Technology for the synthesis of hydrocarbons from carbon monoxide and hydrogen using the Fischer-Tropsch reaction

*4 This research and development was selected for the "Research and Development for Practical Application of SOEC Co-electrolysis," an additional public offering in the "Carbon Recycling and Next-Generation Thermal Power Generation Technology Development (JPNP16002) / CO_2 Emission Reduction and Effective Utilization and Practical Application Technology Development / CO_2 Utilization Technology Development for Liquid Fuels / Research and Development on Next-Generation FT Reaction and Integrated Liquid Synthetic Fuel Production Process" of the New Energy and Industrial Technology Development Organization (NEDO).

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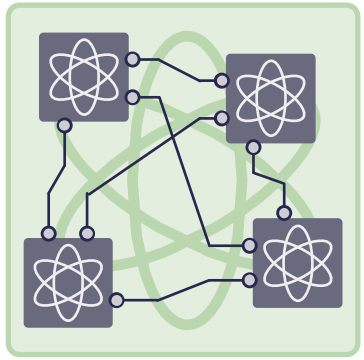
Case 3: Quantum Technology

To realize a quantum future society, we are promoting the development of quantum control system technology that enables scalable quantum information processing, including virtual large-scale quantum computing, and the research and development of quantum-resistant cryptography to protect existing infrastructure.

Social value

- By sharing entangled states among multiple quantum computers via a network, we contribute to the enhancement of computational and measurement performance and stable operation.
- To prepare for the threat of cryptographic decryption by quantum computers, we are replacing cryptographic technologies with quantum-resistant cryptography to improve the security and robustness of existing infrastructure.



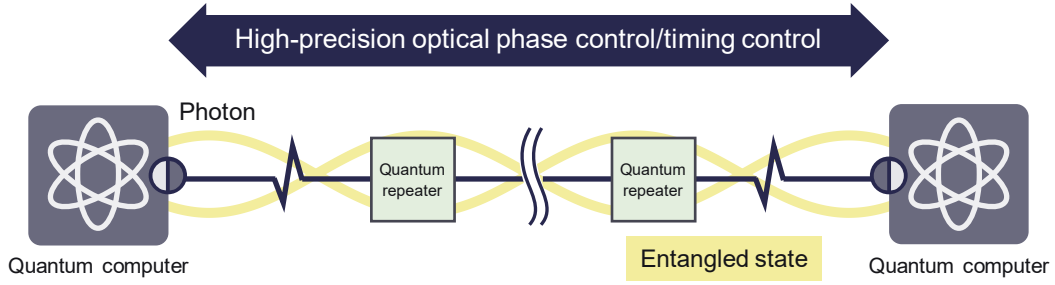
Practical application of a virtual large-scale quantum computer

Deployment of post-quantum cryptography

*1 FTTH: Fiber To The Home

Advantage of our technology

- We possess technologies necessary for the high-precision synchronization of photons required for sharing entangled states, such as high-power lasers and optical phase and timing control technologies proven in FTTH*1.
- Our cryptographic technologies have been implemented in various business fields, and we are continuously conducting research on quantum-resistant cryptography through participation in national projects.



Sharing and Synchronizing Entangled States via a Network among Quantum Computers

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Conclusions

1. Promote research and development that drives sustainable business growth through our strong components and digital technologies

2. Developing Foresight Technology that fundamentally solves social issues

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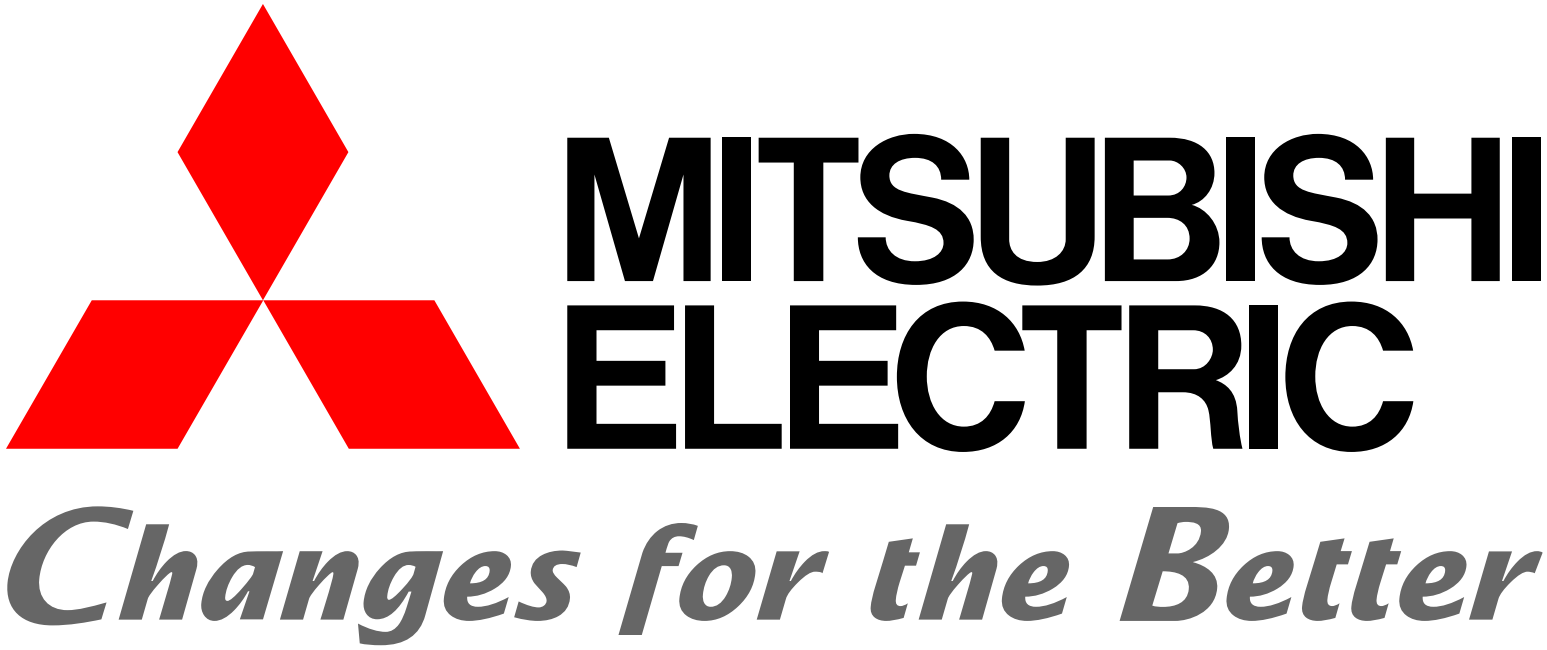
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