

# Research and Development

## Message from the Head of the R&D Center

GS Yuasa released its R&D roadmap through 2050 in Vision 2035.

The R&D Center, which is primarily responsible for the development of next-generation batteries, pursues development from the most long-term perspective among the research and development divisions of GS Yuasa and promotes research and development with a policy of pursuing research and development with top priority given to delivering truly valuable products and services to customers. Currently, the center proceeds with research and development, focusing on (1) permeation of corporate philosophy, (2) establishment of competitive advantage through differentiation, and (3) realization of high added value strategy, and produces results steadily in the development of next-generation batteries.

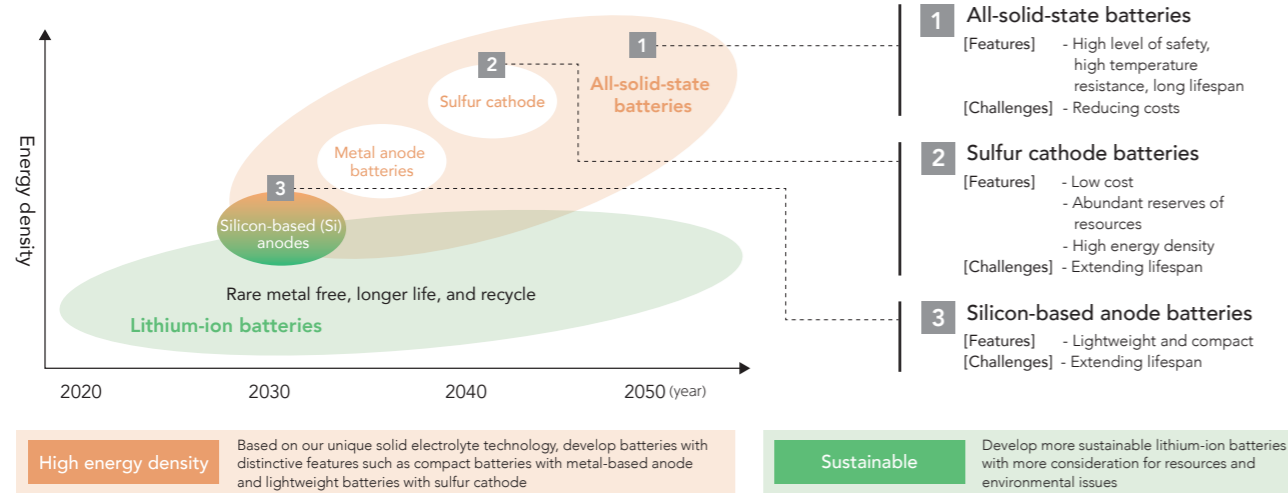
In research and development of all-solid-state batteries, the center pursues technology development to differentiate ourselves from other companies in terms of both battery performance and manufacturing costs, and the current success is GS Yuasa's proprietary high-performance solid electrolyte with high ionic conductivity with superior water resistance. For silicon anode batteries, the center is trying to achieve a balance between mass energy density, cycle performance, and life performance in order to develop truly valuable batteries. For sulfur cathode batteries, the center succeeded in demonstration of a mass energy density of 500 Wh/kg (more than twice that of the current lithium-ion batteries) and is currently working on further performance improvement to achieve differentiation with battery performance (lightness, life, reliability).

The R&D Center will continue to tackle the challenge of technological innovation for early commercialization of next-generation batteries by taking advantage of the R&D Center's strength: cooperation with experts who are well versed in battery technology and analysis technology.



**Hiroaki Yoshida**  
Officer, Head of the R&D Center,  
GS Yuasa International Ltd.

## Roadmap for research and development



## Research and development system



## TOPICS Research and development of next-generation batteries

### All-solid-state batteries

In 2021, we succeeded in developing a nitrogen-containing sulfide solid electrolyte with high ionic conductivity of a sulfide solid electrolyte, a key material for commercialization of all-solid-state batteries, and boosted water resistance, and are currently working on improving it. GS Yuasa is conducting joint research with Osaka Metropolitan University on development of next-generation storage batteries and next-generation motors, a technology proposal selected in April 2022 for the NEDO Green Innovation Fund (the selected research topic is "Next-Generation Storage Battery and Motor Development").

### Silicon-based anode batteries

By developing technologies that achieve both high energy density and long service life in silicon-based anode batteries, which face many practical challenges, we demonstrated in 2023 high energy density of 400 Wh/kg, which exceeds that of conventional lithium-ion batteries. The silicon-based anode is a technology is also applicable to all-solid-state batteries, and this represents substantial progress in terms of the practical application of next-generation lithium-ion batteries.

### Sulfur cathode batteries

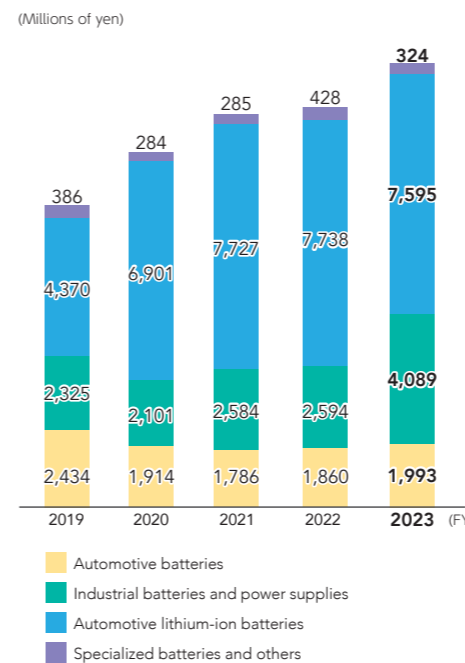
For the five-year period from FY2019 to FY2023, we engaged in research and development of lithium-sulfur batteries in the NEDO project for practical application of advanced propulsion systems for aircraft, aiming to mature the technology to a level where it can be proposed for next-generation aircraft. Even after project completion, we continue challenging the early commercialization of next-generation batteries.



## Research and development in segments

In each segment, the Group conducts active research and development activities from fundamental technologies to product and manufacturing technologies.

### Changes in R&D expenses by segment



### FY2023 R&D topics

- Automotive batteries (Japan)**
    - Promote the development of auxiliary batteries for HEVs and BEVs
    - Release batteries with reduced burden of refill maintenance and improved durability, both of which are achieved through technology development with EN batteries for replacement
  - Automotive batteries (Overseas)**
    - Start the development of VRLA (AGM)\* batteries with the Turkish site
    - Expand the variety of auxiliary batteries for automobiles (for use with a 12V power supply) in the European market, and promote market introduction
  - Industrial batteries and power supplies**
    - Promote the development of products that allow for saving air-conditioning power of a storage battery facility through improved high thermal resistance, for example, batteries for use in a data center
    - Promote the development of products suitable for market needs of products for forklifts at the site in Thailand
    - Start the development of a large-capacity PCS for use with a storage battery system, and plan to release two models within FY2024
    - Develop an outdoor power storage board for a storage battery system, and plan to release it within FY2024
  - Automotive lithium-ion batteries**
    - Promote the development of the next model of a cell/module to be delivered to new car manufacturers as a battery for HEVs
    - Proceed with the development of new batteries for PHEVs with an energy density higher than that of conventional batteries by 40% or more and with high output and long life, and start mass production in FY2024
    - Regarding 12V lithium-ion batteries, promote the development of next-generation auxiliary batteries for BEVs
    - Promote the development of batteries using high-capacity silicon anodes as post-lithium batteries
  - Specialized batteries and others**
    - Succeeded in developing a cell with a mass energy density of 500 Wh/kg in the research and development of lightweight lithium-sulfur batteries in the advanced aircraft system commercialization project
    - Promote the development of new membrane products in the membrane area
- \* Valve-regulated lead-acid batteries.

# Intellectual Property

## Message from the Director in Charge of Intellectual Property

To realize our long-term vision "Vision 2035," it is necessary to improve corporate value by strengthening intellectual capital. To strengthen intellectual capital, I think we need to secure key patents for stable business growth and secure patents considering the feasibility of other companies. Such patents that will serve as a core of the future business are called "essential patents" in the company. We make adjustments for key technology with responsible persons in the research and development division, conduct detailed patent analysis on the technology, and file a patent application with special care. We will continue to ensure that our efforts lead to results in cooperation with business and development divisions and patent offices.



**Ryoichi Okuyama**  
Managing Director, In charge of intellectual property and the lithium-ion battery business, GS Yuasa International Ltd.

Currently, the intellectual property division supports about 300 national patent applications a year, overseas patent applications, patent search, a clearance activity, patent alliance with other companies, and patent litigation. Recently, the division also conducts comparison with competitors by IP landscape and intellectual property evaluation in the event of business absorption or business tie-up and is indispensable for GS Yuasa to formulate its management strategy.

It takes a long time for intellectual property activities to produce results and so the time when current activities bear fruit may be after 2035; however, with the confidence that a business backed by intellectual property rights is a truly strong business, we will continue to support our corporate philosophy of "Innovation and Growth" through intellectual property activities.

## Intellectual property strategy

**FY2024 policy** Further promote the reform of the process of obtaining an intellectual property right, and increase (essential) intellectual properties that are truly necessary to improve business value, creating steps for utilization.

### <Main initiatives>

#### 1 Calculation of patent scores and patent inventory

We made use of a patent analysis tool to analyze our own patents and those of other companies, calculated patent scores to measure the degree of contribution of intellectual property activities to medium- to long-term growth and expansion of profits, visualized the position of the Group's intellectual property rights, and shared the results with management, the business units, and the development divisions. We will use patent score information to make an inventory of patents possessed, consider priority areas, and leverage promising patents.

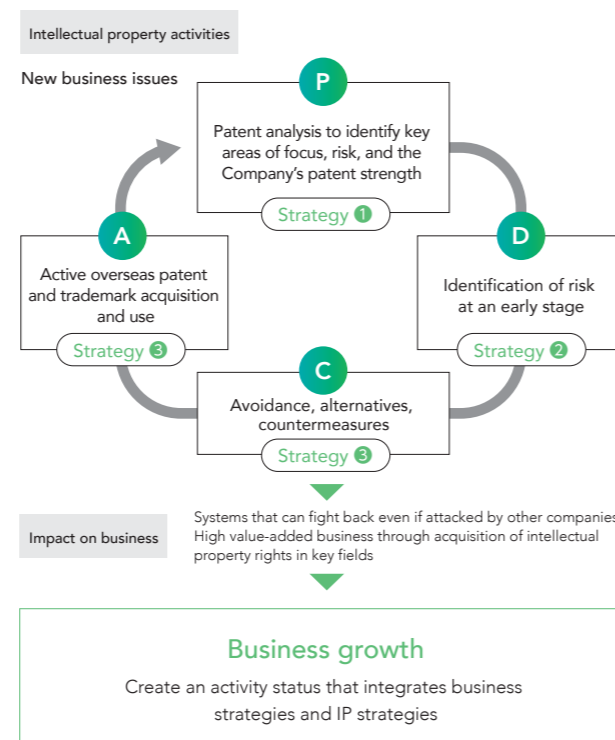
#### 2 Reforming the rights acquisition process by using specialized and intellectual property information

We scrutinized the technologies that the development divisions focus on and regarded technologies that can significantly influence future business as key technologies. Not like activities for normal patent applications, we will not only consider filing a defensive application of the company's own technology but also consider the feasibility of other companies and avoidance technologies with in-house specialists in order to build a strong patent network.

#### 3 Acquisition of patent rights in new business fields

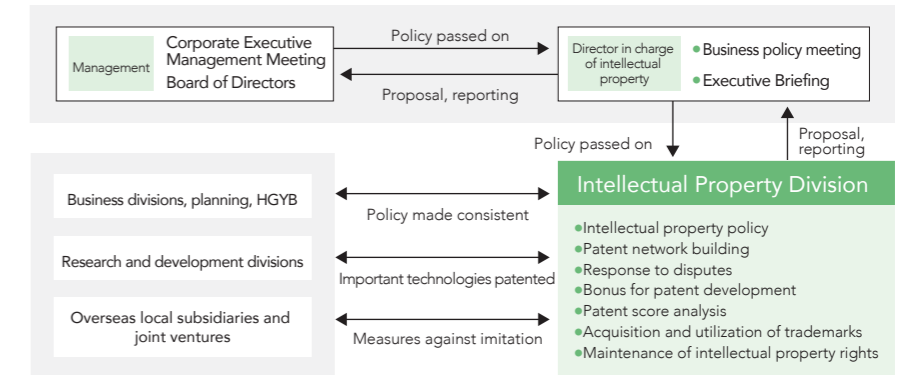
We have started measures to identify patents related to the provision of "Koto" at an early stage before providing solutions and services toward achieving Vision 2035. This means creating patent assets that will be necessary for collaborating with other companies in the future. In FY2023, 12% of the patent applications filed by GS Yuasa were related to "Koto-zukuri" (service creation) and is expected to increase to 16% in FY2024.

### Image of the Group's intellectual property activities



## Intellectual property systems

The intellectual property division is positioned as an administrative department at headquarters. The department is responsible for application and management of patents and trademarks of the entire GS Yuasa Group, plans various measures related to intellectual properties to increase added value of business, and is pushing hard to realize them in cooperation with relevant divisions.

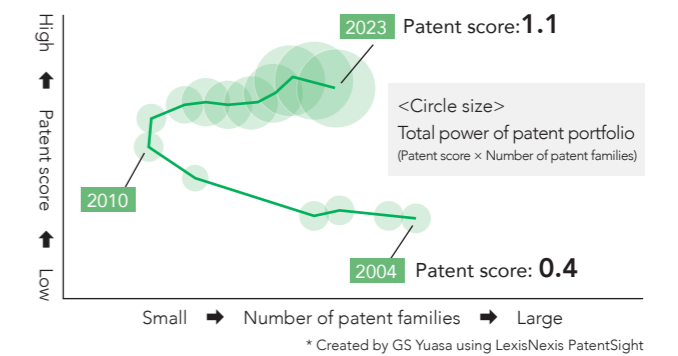


## Intellectual property creation activities

The Group increases truly necessary patents for improving business value and promotes turning technologies into entitlements in overseas countries with a large market size through cooperation between the intellectual property division and the business and development departments.

Regarding the patent score, which represents measured quality per patent possessed on the basis of the number of citations by other companies, located on the longitudinal axis and the number of patent families, which is obtained by organizing and counting similar patents, on the horizontal axis, changes in the results of intellectual property creation activities so far are shown. The patent score has grown significantly compared to that at the time of the corporate merger in 2004.

### Changes in the Group's patent score (2004 to 2023)



## Communication with management

At the beginning of each fiscal year, we hold a business policy meeting to discuss activity policies with management as well as Executive Briefings twice a year to report on these policies, new issues, and the status of disputes. In addition, we participate in Corporate Executive Management Meetings, etc. as necessary.

### Themes at an Executive Briefing (partial list)

- Situation of patent infringement lawsuits from competitors in Japan
- Patent score calculation
- Building a network of important patents

## TOPICS Initiatives to prevent imitation products

We filed a lawsuit against a copycat firm for trademark infringement to stop the manufacturing and sales of imitation products in China. At the High People's Court of Jiangsu Province, our claim was accepted effective March 28, 2024, and a judgment became final. The amount of compensation for damages was 2 million yuan (approx. 40 million yen).

A dispute over patent infringement is also underway, and we conduct an activity to eliminate obstacles by any third party through intellectual property rights in order to help business growth.

