

Actively Investing in New Technology and New Product Development

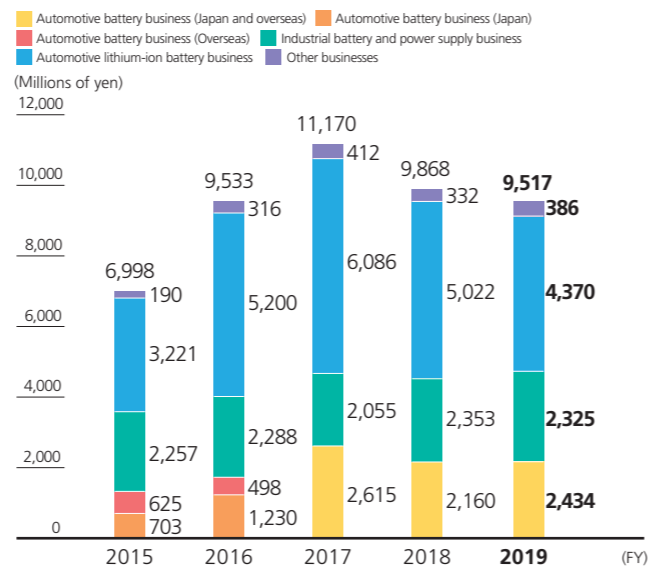
Corporate structure

The GS Yuasa Group carried out proactive research and development covering basic research through to the development of products and manufacturing technologies for every business segment: Automotive Batteries, Industrial Batteries and Power Supplies, Automotive Lithium-ion Batteries and other businesses.

In Japan, research and development of automotive batteries is conducted mainly by the GS Yuasa's Technology Development Department, Automotive Battery Technology Department, and GS Yuasa Energy's Technology Development Department. Overseas, the main actors are the technology development departments of overseas production bases, GS Yuasa's Technology Development Department, Automotive Battery Technology Department, and GS Yuasa Asia Technical Center Ltd. Research and development of industrial batteries and power supplies is carried out by GS Yuasa's Technology Development Department, the Engineering Department of the Industrial Battery Production Division, the Development Department of the Power Supply Systems Production Division, the Production Department of the Lighting Division, and the Technical Production Department of Yuasa Membrane Systems. Research and development of automotive lithium-ion batteries is being conducted by GS Yuasa's Research and Technology Development Department, Lithium Energy Japan's Technology Department, and Blue Energy's Technology Development Department. Research and

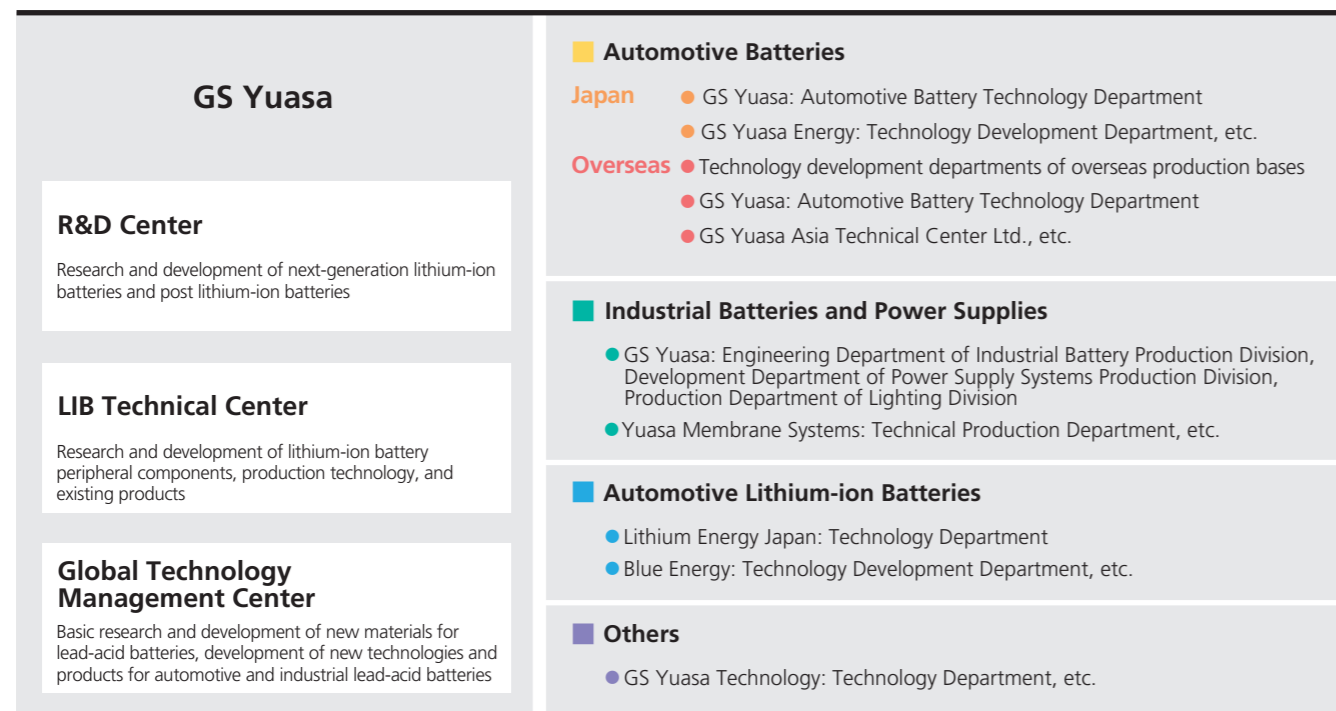
development in other sectors is carried out by GS Yuasa's Research and Technology Development Department and the GS Yuasa Technology's Technology Department, respectively.

Research and development costs



Note: The costs in the automotive battery business for Japan and overseas have been totaled since fiscal 2017.

Outline of R&D framework



R&D conditions by business sector

Automotive battery business (Japan)

In the automotive lead-acid battery field in Japan, adoption of our EN (European Norm) batteries for European vehicles manufactured by Japanese manufacturers is increasing, and so far, we have successfully expanded to a wide-ranging lineup of the ECO.R ENJ series compliant with those standards including six varieties for general use (LN0-LN5), and three varieties for ISS vehicles (LN2-IS, LN3-IS, and LN5-IS). In addition, in response to an increase in demand for replacement of EN batteries for vehicles made by Japanese manufacturers overseas, in fiscal 2019, we expanded the same variety overseas. Further, we have updated the environmentally-friendly ECO.R by actively using recycled materials. We have enhanced durability against deterioration from low-level electrical discharge, which is increasing as a result of changes in riding formats such as vehicles used primarily for short trips, as well as changes in vehicle control. We also improved durability against high temperatures in engine compartments, which is of concern as a result of increased temperatures due to climate change and higher-power engines.

In the area of lead-acid batteries for Japanese-market motorcycles, we are engaged in developing new technologies for leisure bikes, general commuter bikes, and others. In the motorbike sector also, interest in eco-friendly vehicles, such as ISS vehicles and HEVs, is rising. The high durability and excellent charge acceptance performance of our batteries make them preferred choices for such applications as well. Additionally, we are developing lead-acid batteries exclusively for motorcycles that are the eco-friendly vehicles.

Automotive battery business (Overseas)

In the field of automotive lead-acid batteries for overseas markets, we are developing products and manufacturing technologies for charge control vehicles and ISS vehicles produced and used overseas. At Turkey's Inci GS Yuasa Aku Sanayi ve Ticaret Annimim Sirketi which was incorporated in 2015, we developed the LN2, LN3, and LN5 of the "YBX5000" series of lead-acid batteries for high performance start-up and are also developing lead-acid batteries for ISS vehicles in the European market. We are also developing auxiliary batteries for HEVs and EVs produced and used overseas and will roll them out

to markets in stages.

For the overseas motorcycle market, we developed medium-capacity class valve-regulated lead-acid batteries for medium-sized motorcycles, responding to the expanding production of such motorcycles for export in Southeast Asia, and are conducting phased market deployment. We also developed valve-regulated lead-acid batteries for commuter motorcycles and ISS motorcycles in the Indian market, which is expected to grow substantially. This has boosted our product lineup and has resulted in orders for use in new bikes.

Additionally, we have developed valve-regulated lead-acid batteries with special exhaust structures, while utilizing motorcycle battery technologies for use in European luxury car system startup and as backup batteries. We have introduced them to the European repair market and are working on expanding the types of batteries for such purposes.

Industrial battery and power supply business

In the industrial lead-acid battery field, we are developing valve-regulated lead-acid batteries with greatly improved high-rate / short-time backup performance for use in data centers and 5G base stations, for which demand is expected to grow in North America and other overseas markets. Currently, we are steadily proceeding with advanced trial production on a mass production line, and plan to expand the product lineup in the future. Earlier, we developed an industrial lead-acid battery at our Vietnam plant and started production in fiscal 2017. In order to meet the strong demand of the communication market in Southeast Asia and further expanding the lineup, we launched mass production of four 2V type products and a new 12V front terminal type product in fiscal 2019. In Japan, the SNS-TN series, which combines Japan's highest level of discharge durability with long life in standby use, was launched in fiscal 2019 for applications with relatively frequent discharges, such as in railway ground equipment.

In response to expanding overseas demand for lead-acid batteries to be used in battery-powered forklifts, we launched new products in China (5 DIN type products), Thailand (2 DIN type products), and Pakistan (3 EB battery type products).

In the power supply market sector, we developed

the general-purpose UPS "Acrostar THA2-1000" (1 kVA) with a constant inverter power supply system. Power consumption has been reduced by 20% compared to the previous model, a significant reduction further enhanced by the adoption of the Smart Eco Mode system. Thanks to an extension of the standard design life of the UPS itself to eight years, running costs can also be reduced. In addition, we have developed the V2X bidirectional charger "VOXSTAR" that enables charging / discharging of EVs and PHEVs.

Most V2H equipment is designed for home use, and single-phase equipment with a maximum power consumption of 6 kW is the norm, but for public use, we have successfully realized the industry's first V2H-certified equipment with a 3-phase design and a capacity of 10 kW. Configuring a V2X system in combination with a stationary storage battery type PCS makes it possible to actively use vehicle storage batteries in a system that not only is suitable for business continuity planning (BCP) applications but also offers energy management system (EMS) compliant regulating force.

In the field of industrial lithium-ion batteries, we launched the "LIM50EL series" of lithium-ion battery modules. While being compatible with the conventional "LIM50EN series," we have succeeded in reducing the capacity degradation during cyclic operation to about 50% and the capacity degradation during float operation for backup applications to less than 50%. As a result, the new products can support extended use with frequent charge / discharge cycles which makes them suitable not only for disaster mitigation infrastructure facilities but also for playing an active role in the power demand adjustment market. We also developed the large-scale battery storage system module "LEPS-1-16." By adopting a newly developed cell with improved energy capacity and increasing the number of cells mounted per module from 12 to 16, we were able to increase volumetric energy density by a factor of 1.73 as compared to the earlier "LIM50EN-12." The modules will be installed in the world's largest storage battery system with an output of 240 MW and a capacity of 720 MWh, to be built in the town of Toyotomi, Hokkaido, to mitigate fluctuations in wind power output.

In the lighting sector, we worked on expanding our palette of HID replacement LED lamps and other lineups, and our LEGA

Lamp R was honored with the 2019 Energy Conservation Grand Prize.

In the field of environment-related equipment, we harnessed the graft polymerization technology applied to battery separators to embark on developing electrolytic diaphragms for hypochlorous acid generators. We are also developing membranes with less clogging for membrane bioreactors (MBR) and are working on expanding sales to large customers.

■ Automotive lithium-ion battery business

The basic research on lithium-ion batteries included studies aimed at increasing the reliability, safety, and energy density of medium and large-sized batteries. To improve the performance of lithium-ion batteries, we explored materials for next-generation positive and negative electrodes and improved their capabilities. We also conducted research on post lithium-ion batteries.

With regard to automotive lithium-ion batteries, we are engaged in enhancing mass production capabilities of products for EVs, PHEVs, and HEVs. We are widening our product palette with a focus on even better reliability and higher safety. We are also developing automotive 12V lithium-ion batteries.

■ Other businesses

Our other business activities include research and development of lithium-ion batteries for aircraft and spacecraft applications and research on post lithium-ion batteries.

In the aviation sector, we have supplied lithium-ion batteries used in the Boeing 787 aircraft. In the space exploration sector, our lithium-ion batteries for rocket applications have been adopted for the liquid fuel rockets H-II A, H-II B, and Epsilon.

In December 2016, the H-II Transfer Vehicle Kounotori 6 began transportation of lithium-ion batteries to be used for supplying power to the International Space Station, and transportation of all batteries was completed by the H-II Transfer Vehicle Kounotori 9 launched on May 21, 2020.