Product competitiveness

Medium-term goals

Create strong next generation products

As the transition to a data society accelerates due to the spread of IoT, AI, and the 5G, demand for semiconductors and flat panel displays is increasing, as is the requirement for their diversification and high performance. Tokyo Electron promotes leading-edge research and development to meet the fast-changing demands for technological innovation through product marketing, and provides equipment and services to meet various applications. We also continuously strive to reduce the environmental impact of our products, factories, and offices. By providing technology that contributes to the development of devices with even lower power consumption, we endeavor to preserve the global environment. We will contribute to the further development of industry and society through the timely creation of the best, high-value-added products with cutting-edge technology, and continuing to provide the best service supporting those products.

Main activities

Research and development

Tackling technological innovation

Environmental contribution of products

Research and development
Research and development for the future, Development system, Shift Left, Product marketing, Intellectual property management, Collaborating with consortiums

Tackling technological innovation
Research and development for next generation computing, Promoting digital transformation (DX), Addressing advancements in display

Environmental contribution of products
Medium- and long-term environmental goals, Products that contribute to a sustainable society, Initiatives for product environmental laws and regulations

SDGs initiatives

- Create innovative technologies by promoting innovation, to help build a sustainable society
- Contribute to the reduction of environmental impact on a global level by providing products and services that are conscious of the environment

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE — Industry, innovation and infrastructure

13 CLIMATE ACTION — Climate action

17 PARTNERSHIPS FOR THE GOALS — Partnerships for the goals

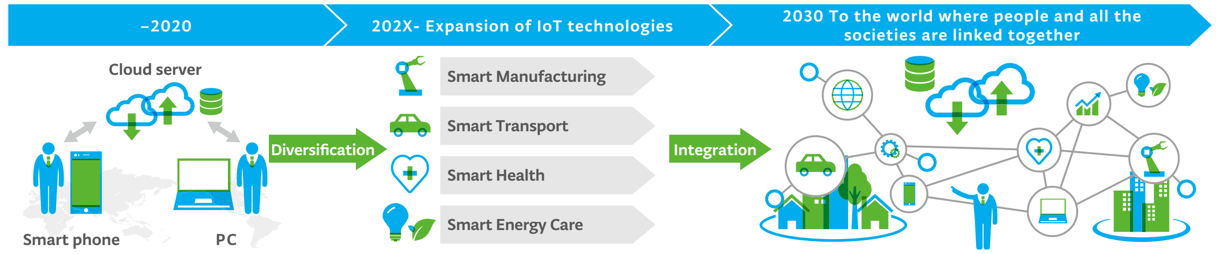
SUSTAINABLE DEVELOPMENT GOALS

Research and development

Research and development for the future

As lifestyles and business models undergo dramatic changes in the era of IoT, it is anticipated that the use of semiconductors will expand in all industries, and there will be demands for even more advanced technologies. In an age where electronics are a more familiar part of people's lives, and there is an ever-growing need for semiconductors, Tokyo Electron (TEL) is continuously engaged in rigorous discussion regarding new, necessary technologies and TEL's contribution. TEL Technology Vision 2030 summarizes these discussions, and is distributed within our company in order to provide information and seek feedback. In addition, our entire company is committed to research and development in the future.

Increase and growth of semiconductor applications



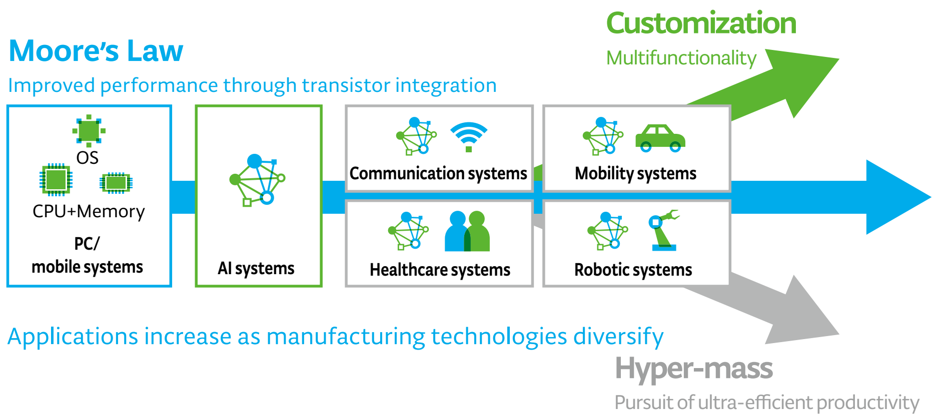
Development system

With advances in the performance of semiconductors resulting from miniaturization technology, the emergence of new devices due to manufacturing technologies capable of accommodating more flexible designs, and the growth of a market requiring large volumes of devices in step with the development of IoT, the semiconductor market is becoming increasingly diversified. Consequently, amid the need for diversification in manufacturing technologies, TEL promotes technology development and technology innovation for the next generations, and has built a system in which its Development & Production Divisions collaborate with Business Divisions to bring high-value-added products into the market in a timely fashion.

Led by our Corporate Innovation Division, which was established in 2018, we have also been implementing further enhancements to our process integration capabilities, such as deposition and etching technologies, based on our wide lineup of semiconductor production equipment. In January 2020, we established TEL Manufacturing and Engineering of America to optimize manufacturing functions in the U.S. region and improve operational efficiency.

We are currently working on utilizing AI to strengthen the development of control software further, and in the testing phase of the manufacturing process, we have succeeded in reducing the number of wafers used from the usual five lots to just one lot. AI technologies have also made it possible for us to cut liquid chemical use by about 20%, helping us to use resources more efficiently.

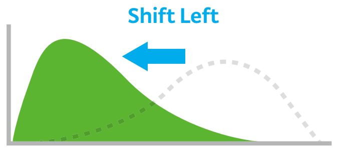
Market heading toward diversification



Shift Left

TEL is focused on advancing the "Shift Left" approach, investing resources (including technology, personnel, and money) into the early processes of product development. Together with customers who conduct research with a vision beyond even the next generation and who aim to accelerate the speed of development further, we have created a technology road map, and are engaged in developing the various technologies required for its realization.

In fiscal year 2020, responding to the growing customer need for production equipment to take up less space, we succeeded in improving equipment efficiency per unit area by maximizing the use of clean rooms and providing more productive equipment. Through proposals of unique technologies, we promote on-site collaboration for early delivery of evaluation units at customers' plants and research and development laboratories, shortening the period between technology development and the conversion to mass production equipment and maximizing efficiency.

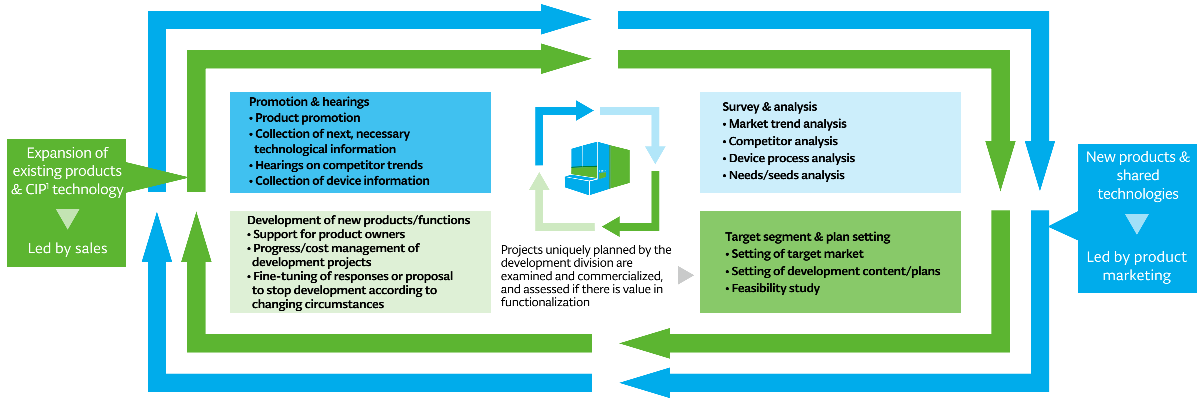


- Joint development of multi-generation technology road map with customers
- Promotion of early engagement
- Maximization of yield for customer devices and equipment operating rate from early stages of mass production, and also reduction of environmental impact
- Promotion of improvement in work efficiency and per person productivity, and further increase in investments into human resources and development
- Increase in equipment efficiency per unit area, by achieving higher productivity and using less space

Product marketing

TEL is promoting effective product development by having its sales departments and product marketing departments appropriately play their respective roles. Our sales departments take the lead in making improvements and adding functions to existing products that have already been delivered, and provide customer feedback to our development divisions. Our product marketing departments, meanwhile, take the lead in the development of new products, and share guidelines based on market trends and competitor analysis with the development divisions resulting in product development that contributes to value creation for customers. They also consider the commercialization of plans and the addition of functions proposed by our development divisions, and formulate strategies for collaborating with partner companies and consortiums. Through their activities, our product marketing departments are helping to effectively promote our important "Shift Left" approach.

Involvement in product development by sales departments and product marketing departments



1 CIP: Continuous improvement program

Intellectual property management

In its intellectual property-related activities, TEL's basic policy is to contribute to increased corporate revenues by supporting business activities through appropriate protection of intellectual property (IP). IP personnel assigned at R&D/manufacturing sites and headquarters assess each project from various angles, including R&D and marketing perspectives, building IP portfolios aligned with technology, and product strategies in an effort to boost competitiveness. In 2018, in order to uphold our worldwide advantage in the IP field, we maintained a global patent application rate[2] of approximately 70% for the ninth consecutive year, and achieved high patent approval rates (83% in Japan and 86% in the United States). Furthermore, as we globally expand research and development and industry-academia collaborative initiatives related to our business, the number of joint patent applications in collaboration with partner companies, universities, and other research institutes around the world has reached 51 applications with 20 companies and 10 organizations in the last two years.

Cumulative number of technology inventors

4,300

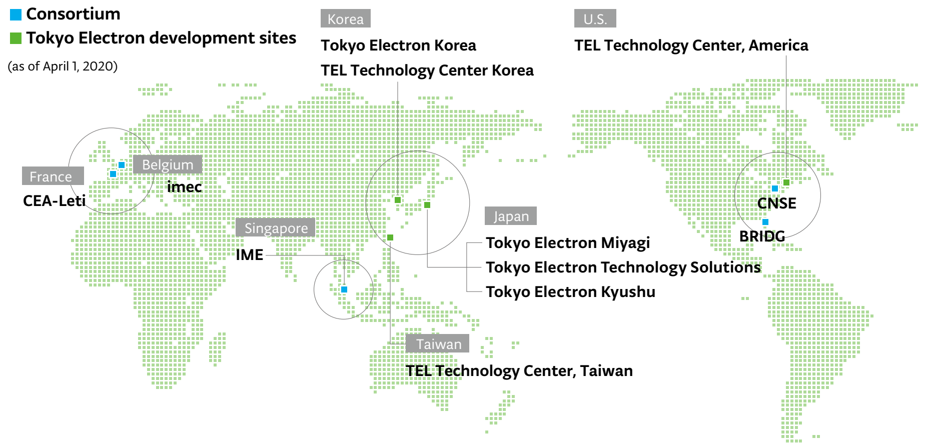
2 Global patent application rate: Percentage of invention applications filed in multiple countries

To increase IP awareness, we continuously educate our engineers, who are the foundation of our R&D strategy, and in total, around 4,300 engineers have become inventors. Additionally, because we often handle highly confidential information, including technological information of our customers and collaborative partners, we also focus on confidential information management education.

Collaborating with consortiums

By collaborating with international and domestic consortiums, TEL is enhancing its own research and development capabilities, and is working to further develop cutting-edge technologies. With three bases in Japan and additional bases in the United States, Belgium, and Singapore, we collaborate with device manufacturers in Japan and abroad and with global research institutes to promote research into next generation semiconductor production technology. In fiscal year 2019, we began participating in a global research hub developing next generation AI hardware, and in fiscal year 2020, we have been promoting collaboration in technologies and applications that speed up evolution, from development to market launch. One example has been our cooperation with BRIDG[1], a not-for-profit, public-private partnership located in the U.S. state of Florida.

Our engagement in these consortiums includes the development of cutting-edge processes for existing devices and the development of manufacturing technology for chips designed for AI computing.



1 BRIDG: BRIDG is a not-for-profit, public-private partnership specializing in advanced system integration, microelectronics fabrication, III-V materials deposition for sensors, optoelectronics, and high-speed transistors. BRIDG offers production process technologies, research and development capabilities, and 200 mm microelectronics fabrication geared toward system miniaturization, device integration, hardware security, and product development key to aerospace/defense and the IoT/AI revolution. Supported by Osceola County, University of Central Florida, Florida High Tech Corridor Council, and others, BRIDG provides the physical foundry infrastructure and collaborative process to connect challenges and opportunities with solutions; "Bridging the Innovation Development Gap" making commercialization possible.

■AI chip development

In cooperation with partner companies in the United States, TEL is participating in the development of AI chips. The development system we have built is completely integrated, from the architecture stage examining semiconductor design for AI systems through to incorporation into circuits and physical design, and from manufacturing through to research on the materials development level. Besides developing software necessary for AI to work, we are engaged in the development of materials, processes, and equipment geared for manufacturing, leveraging our partner companies' knowledge of design and architecture.

■Initiatives in Japan

Responding to societal demands regarding energy and labor, TEL is participating in a project that brings together a group of advanced companies with the science, engineering, humanities, and social sciences departments of Tohoku University, Kyoto University, and Yamagata University.

The project defines three specific non-competitive areas, namely: (1) edge computing devices for IoT with extremely low power consumption, (2) hybrid integrated power devices for high-efficiency energy conversion, and (3) intelligent electronics systems for highly efficient labor-intensive transportation systems, and carries out research activities designed to create innovative technologies and build a joint industry-academia platform for the development of human resources. Tohoku University, the lead organization in these research activities and projects, hopes to contribute to creating new, world-leading industries by achieving synergies with its competitive project for a center for industry-academia collaboration.

As for project outcomes, as a consequence of developing new processes and process integration technologies in the manufacture of spin-transfer torque-magnetoresistive random access memory (STT-MRAM[2]), in a world first, we succeeded in achieving both high performance and high rewrite tolerance[3] in STT-MRAM, thereby contributing to the practical implementation of STT-MRAM and helping to expand its areas of application.

2 Spin-transfer torque-magnetoresistive random access memory (STT-MRAM): A nonvolatile memory based on the operating principle of the tunnel magnetoresistance (TMR) effect (the phenomenon in which electrical resistance changes depending on the direction of magnetization of two ferromagnets separated by a thin insulator in a magnetic tunnel junction (MTJ) element) using spintronics (the engineering use and application of both the charge and spin of electrons in a solid)

3 High rewrite tolerance: Tolerance for an unlimited number of data rewrites

Tackling technological innovation

Research and development for next generation computing

As use of the IoT, linking a multitude of devices to the Internet, expands rapidly in society, demand for semiconductors processing massive amounts of information quickly and efficiently, such as in data collection and management, analysis, and visualization, is continuing to grow. At the same time, progress is taking place in the development of neuromorphic devices, inspired by human neural circuits. When processing information on computers that use conventional architecture, there are considerable losses in energy consumption. Such computers used in data centers consume tens of kilowatts of power, whereas the human brain uses only about 20 W. Similarly, while the operating frequency[1] of today's semiconductor devices is 5 GHz, the human brain is believed to run at just several tens of hertz. Progress is being made in research and development on neuromorphic devices modeled on these human brain movements. They utilize synaptic connections[2] based on analog devices to replace the processing and memory functions, which had previously been only divided between the digital logic and memory of a conventional microprocessor. The aim is to achieve a higher degree of information processing with low power consumption. These neuromorphic devices require an approach of integrating analog to digital. In addition to conventional pursuit of circuit miniaturization, development is underway for functions that mimic human neural circuits, including resistive analog neuro device[3], and nonvolatile resistive random access memory[4]. Furthermore, with a focus on the energy consumed calling memory from arithmetic circuits, much is being done for faster and more energy-efficient processing capacity by devising a better arrangement of arithmetic circuits and memory.

Leveraging its strengths in deposition and patterning technologies, Tokyo Electron (TEL) has initiated research efforts into new materials needed for semiconductors that will be the core of next generation computing, such as neuromorphic devices, quantum computers, logic-memory integration mixing memory with logic (compute-in-memory, memory-driven computing), as well as innovative manufacturing processes for utilizing these materials.

1 Operating frequency (or clock speed): The number of signals per second to adjust the pace of processing of multiple electronic circuits

2 Synaptic connections: A junction formed between neurons (cells making up the nervous system of an animal) regarded as having an important role in learning and memory

3 Resistive analog neuro device: Electronic devices capable of continuously changing resistance

4 Nonvolatile resistive random access memory: Random access memory that uses nonvolatile resistance transformers

Promoting digital transformation (DX[5])

As the environment for utilizing AI has developed and AI has become a more familiar part of people's lives, TEL is expanding the opportunities for AI application, and is continually striving to achieve highly stable equipment operation and greater efficiency in development activities. By monitoring the operating status of semiconductor production equipment in real-time, and using AI to analyze that data, we aim to improve equipment operation efficiency and to use resources more efficiently, such as maintenance of equipment performance, achieving wafer process uniformity, cutting down on test wafers, and avoiding unexpected downtime. TEL's specialized AI department, launched in 2017, plays a key role in the development of algorithms and other projects to use AI to analyze the vast volumes of data output from equipment. Since 2018, we have also been promoting DX across our entire company, not just in development activities but also in the education of personnel who can utilize digital technology. AI workshops, for instance, have been held to share the latest technology trends and to boost internal collaboration.

5 Digital transformation: Digital transformation (DX) refers to the act of utilizing digital technology to transform a product or entire company while responding to changes in society

Addressing advancements in display

As communication devices become more sophisticated and diverse in the age of IoT and 5G, higher performance is required for displays built into those devices. Displays are continuously evolving, in terms of higher image quality, built-in sensors, flexibility of design, and lower power consumption.

In particular, Organic Light Emitting Diode (OLED) displays, which are used widely in smartphones and televisions, are expected to expand to various applications including IT and automotive, because of their high image quality and outstanding design flexibility.

TEL has released Elius™ inkjet printing equipment designed for forming the emitting layer on OLED displays. Elius can significantly reduce the consumption of materials in the manufacturing process compared with the conventional evaporation process. It contributes greatly to cut manufacturing costs for medium and large OLED displays. In order to make the displays compatible with the diverse organic OEL materials that determine their characteristics, TEL is advancing development that allows swift deployment of cutting-edge knowledge into our device technology.

For the manufacturing process of the thin film transistor (TFT) array, which drives liquid crystal displays (LCD) and OLED displays, we also developed Impressio™ and Betelex™ plasma etch systems, as well as the Exceliner™ coater/developer. Impressio and Betelex use PICP™ [6], a plasma reactor with higher energy efficiency, reduces power consumption by up to 20%, and achieving precise processing and stability in mass production. Exceliner, equipped with our original Air Floating Coater, permits higher throughput while maintaining excellent film uniformity and saving chemical costs.

TEL continues to reduce environmental impact by improving productivity and yield.

6 PICP™: Original plasma reactor developed by TEL which produces extremely uniform high-density plasma on panel substrates

Environmental contribution of products

Medium- and long-term environmental goals

Tokyo Electron (TEL) is working toward the conservation of the global environment by upholding the environment related medium- to long-term goals detailed the below.

Medium-term goals (2030)

Products: 30% ↓ Reduce per-wafer CO_2 emission (as compared with 2013)

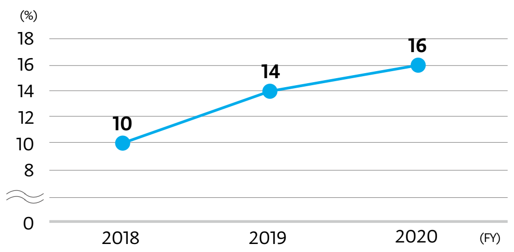
Facilities: 20% ↓ Total CO_2 emissions (as compared with 2018) | 1% ↓ Reduce year-over-year energy consumption at each factory and office (per-unit basis, annual goal)

Long-term goal (2050)

As a leading corporation in environmental management, Tokyo Electron works actively to conserve the global environment. We strive to contribute to the development of a dream-inspiring society by proactively promoting the reduction of environmental burden of both our products and facilities, and at the same time, providing evolutionary manufacturing technologies that effectively reduce the power consumption of electronic products.

Products that contribute to a sustainable society

Reduction in CO_2 emissions for products



Of the total CO_2 emissions from TEL's value chain, emissions during product use account for 90%. For this reason, TEL has made it a key corporate objective to promote environmentally friendly product design, and lower the energy consumption of its products. In fiscal year 2020, we set a medium-term environmental goal for the key models of each business unit (BU), namely, to reduce per-wafer CO_2 emissions by 30% by fiscal year 2031 (compared with fiscal year 2014). Furthermore, in order to achieve this medium-term goal, we set an interim goal of reducing per-wafer CO_2 emissions for the key models of each BU by 20% by fiscal year 2025 (compared with fiscal year 2014), and we have been promoting specific activities. In fiscal year 2020, we formulated a roadmap for achieving this goal for our key models, and we established guidelines for calculating CO_2 emissions, incorporating the usual energy and water usage, as well as process gas and chemical substance usage, product footprint, volume, and weight, reduced frequency of parts maintenance and increased lifespan, and shorter time to equipment launch. Based on these guidelines, the reduction in CO_2 emissions for equipment shipped in fiscal year 2020 in comparison to baseline equipment was calculated as 16%. We also began examining environmental technology strategies for achieving our medium- and long-term environmental goals. As we work to further raise environmental awareness, we will continue to incorporate environmental technologies as an important added value in our technological strategies. We will continue to promote further activities for achieving our medium- and long-term environmental goals.

Initiatives for product environmental laws and regulations

In order to comply with each country's environmental laws and regulations pertaining to products, TEL proactively collects information and takes appropriate action as required. An example of our efforts for EU REACH[1] is that we properly investigate and disclose information on the presence of any chemical substances in articles. In terms of the format used for our investigations, we previously used the Article Information Sheet (AIS) format promoted by the Joint Article Management Promotion-consortium (JAMP[2]), but since fiscal year 2021, in order to address chemical substance regulations for concentrations in the parts per billion (ppb[3]), we have adopted the chemSHERPA[4] format, which will become widespread as the industry/international standard. As for efforts for GHS[5] requirements, we provide safety data sheets (SDS[6]) when selling chemical products, and we promote the local procurement of chemical products. In explaining and addressing the frequently revised environmental laws and regulations, we continue to offer "web-based training for Product Environment Compliance" to all employees, and we provide suppliers with information on the relevant environmental laws and regulations. TEL will continue to rapidly monitor each country's environmental laws and regulations and strive to take appropriate action.

1 EU REACH: An EU regulation pertaining to the Registration, Evaluation, Authorization, and restriction of CHemicals

2 JAMP: Joint Article Management Promotion-consortium

3 ppb: One part per billion (1×10^{-9})

4 chemSHERPA: A data entry support tool for appropriately managing information on chemical substances in products across an entire supply chain

5 GHS: Globally Harmonized System of classification and Labelling of Chemicals

6 SDS: Safety Data Sheet (Safety Data Sheet refers to the document containing hazard information about chemical substances that is issued when a company transfers or provides chemical substances, products containing chemical substances, to another company.)