

Investor's Guide Business Part

Notes:

- This material is composed mainly of basic contents to promote understanding of Yaskawa for analysts and investors.
- Figures in this document are rounded off and may differ from those in other documents such as financial results.
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YASKAWA ELECTRIC CORPORATION
(TSE6506)

1. Motion Control

1-1. AC servo & controller

1-2. Drives

2. Robotics









3. System Engineering

1. Motion Control

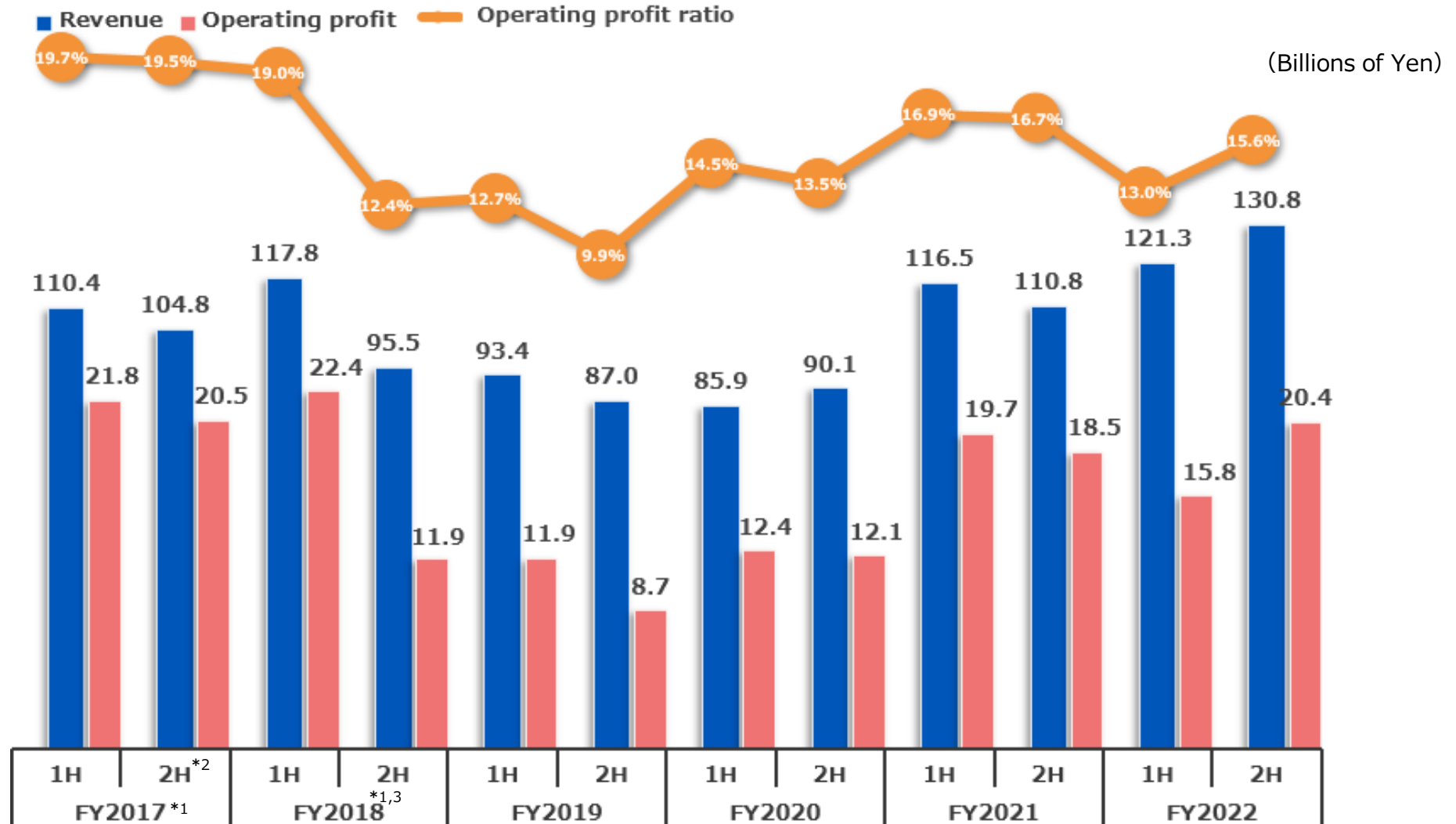


Product Basics

- Motion control product includes “AC servo & controller” and “AC drive”.
- Main difference is subjects and types of control.

	AC servo & controller	AC drive
Subject of control	Position and speed of motor-driven machines 	Rotational speed of motors 
Features	<ul style="list-style-type: none"> • Move exactly and steadily to the commanded position and speed 	<ul style="list-style-type: none"> • Provide smooth and stable movement by freely changing the speed of rotation • Contribute to energy saving by adjusting the speed of rotation and reducing wasted power consumption
Range of use	Narrow : Field where high speed and precision are required	Wide : Life related, industrial equipment, etc.
Application	   <div> Machine tool Semiconductor production equipment Industrial robots </div>	   <div> Elevator Air conditioning fan Conveyor </div>

Revenue / Operating Profit (Motion Control)



*1 Data up to FY2018 are based on Japanese GAAP (After FY2019, IFRS was applied) *2 The data for FY2017 are made on a reference basis. (September 21, 2017 – March 20, 2018)

*3 Reflects the impact of the reclassification of segments in FY 2019

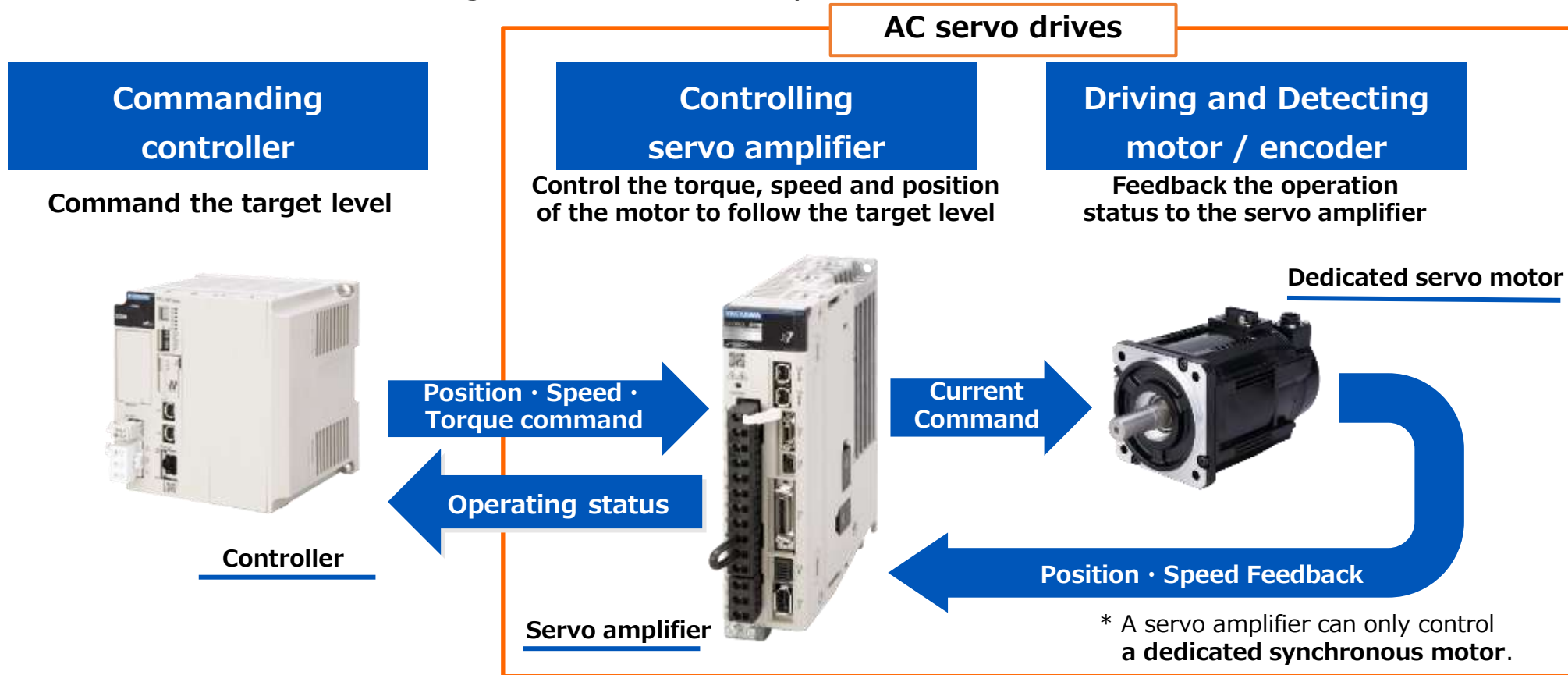
1-1. AC servo & controller



Product Basics (1/3)

What is an AC servo drive ?

An automatic controller consisting of a servo amplifier and a servo motor that follows the target level indicated by the controller



The purpose is to improve equipment performance and stabilize quality through highly accurate position, speed and torque control.

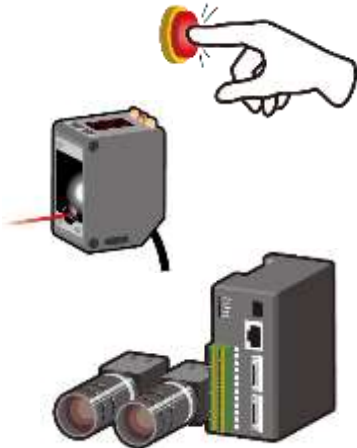
Product Basics (2/3)

What is a controller?

A control equipment that controls AC servo drives, AC drives, and robots, etc.

Input

Push buttons, sensors, cameras, etc.



Processing program

Input information and control output



Controller (MP Series)

Output

AC servo drives, AC drives, robots etc.

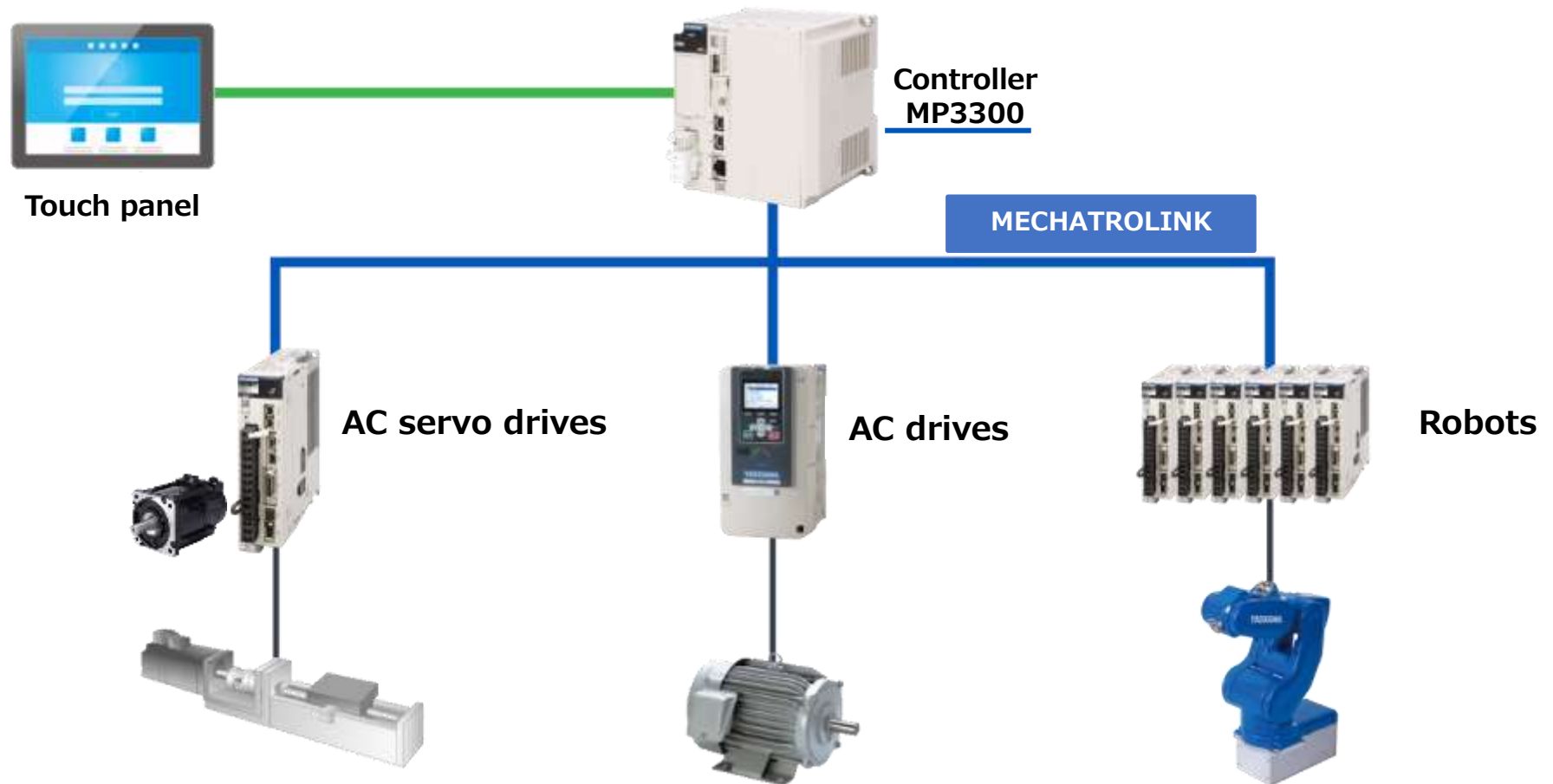


The purpose is to improve productivity through highly accurate control

Product Basics (3/3)

Flowchart of controller (MP Series)

Receive signals from touch panels to control AC servo drives, AC drives, and robots, etc.



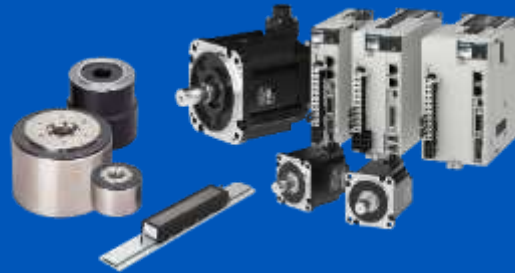
Applications and Market

Machines for semiconductor, LCD & electronic component

- Semiconductor manufacturing Equipment
- LCD manufacturing equipment
- Electronic component processing and assembly equipment



AC servo motor



Supports motion control for various applications

General industrial machines

- Metal processing machine
- Wood processing machine
- Resin molding machine
- Food processing machine
- Packaging and filling machine
- Logistics and transportation equipment
- Printing machine
- Textile machine
- Papermaking



Machine tools

- NC lathe
- Machining center
- Milling machine
- Grinder



Robots

- Industrial robot
- Clean transfer robot
- Vacuum transfer robot



Product Lineup

Wide lineup to accommodate to various applications

Controller



YRM-X
YRM controller



MP3200
Integrated machine
controller top model



MP3300
Modular machine controller



MP3100
Board type



MP2000
Board type / Modular type
All-in-one type

Network



MECHATROLINK (MECHATROLINK-II, MECHATROLINK-III, MECHATROLINK-4) ,
other Field Network

MIRAMOTION



Galvano controller



2D



3D

Galvano scanner

AC Servo Drives

Σ -X Series



SERVOPACKs

Σ -XS model
Single-axis
AC200V
50W to 15kW

Σ -XW model
Two-axis
AC200V
200W to 1.0kW

Σ -XT model
Three-axis
AC200V
200W to 400W



Rotary Servomotors

SGMXA model
Low inertia,
high-speed
50W to 7.0kW

SGMXJ model
Medium inertia,
high-speed
50W to 750W

SGMXG model
Medium inertia,
high torque
300W to 15kW

SGMXP model
Medium inertia,
flat type
100W to 1.5kW

Σ -7 Series



SERVOPACKs

Σ -7S model
Single-axis
AC100V/200V
11W to 15kW

Σ -7W model
Two-axis
AC200V
200W to 1.0kW



Rotary Servomotors

SGM7M model
Low inertia,
ultra-small capacity
3.3W to 33W

SGM7J model
Medium inertia,
high-speed
50W to 750W

SGM7A model
Low inertia, high-speed
50 to 7.0kW

SGM7P model
Medium inertia, flat type
100W to 1.5kW

SGM7G model
Medium inertia, large torque
300W to 15kW



Direct Drive Servomotors

SGM7E model
Coreless,
Inner Rotor
2N·m to 35N·m

SGM7F model
With Core,
Inner Rotor
Small capacity
2N·m to 35N·m
Medium capacity
45N·m to 200N·m

SGM7D model
With Core,
Outer Rotor
1.3N·m to 240N·m

Large-capacity Σ -V Series

Linear Servomotors

SGLG model
Coreless
12.5N to 750N

SGLFW2 model
With core F
45N to 2520N

SGLTW model
With core T
130N to 2000N



SERVOPACKs

SGDV model
22kW to 55kW

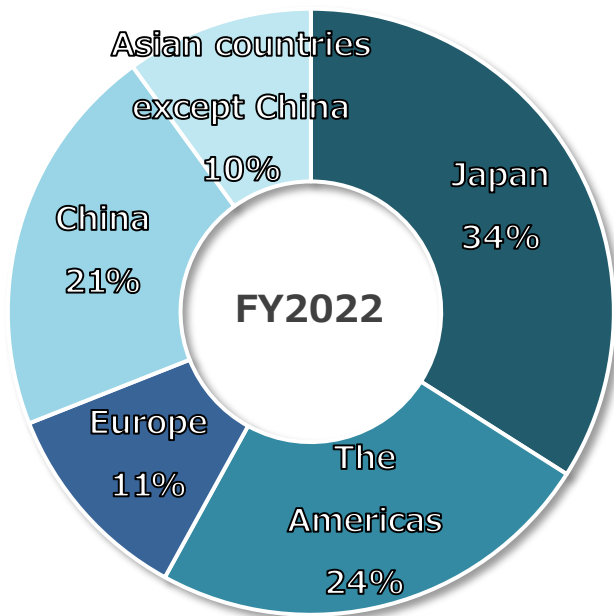
Rotary Servomotors

SGMVV model
Large capacity,
Low inertia
22kW to 55kW

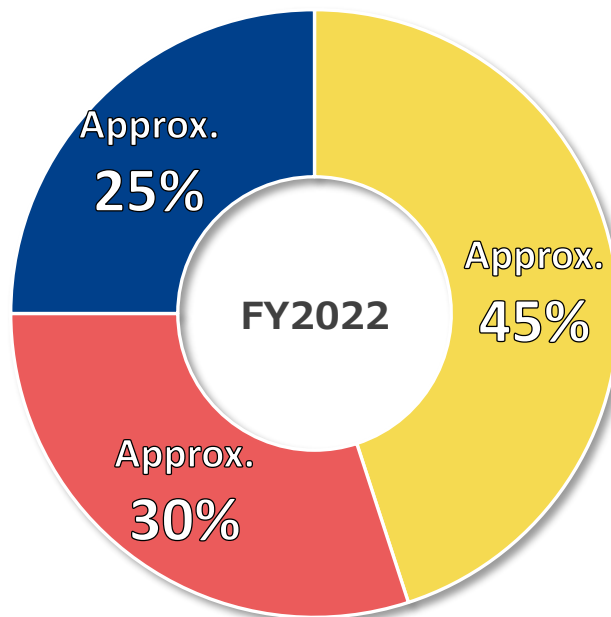


Revenue Breakdown by Region and Application, Market Share

Breakdown of revenue by region

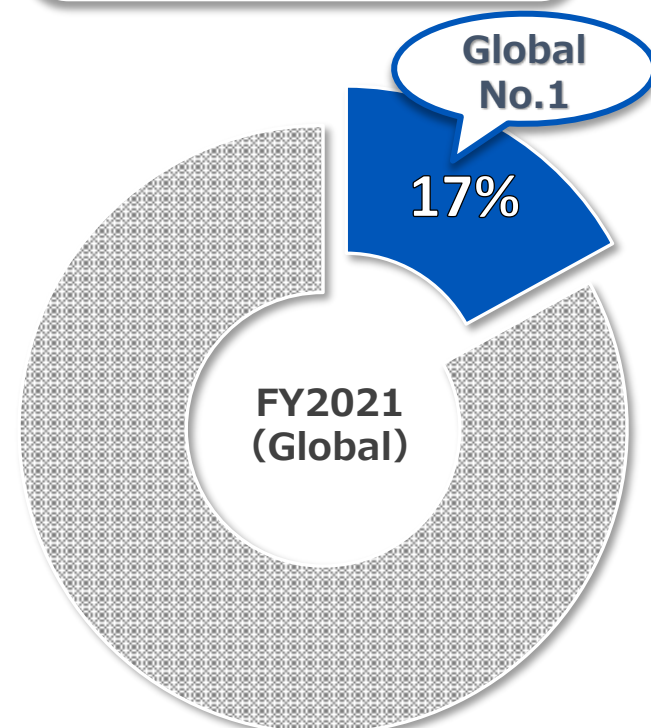


Revenue breakdown by application



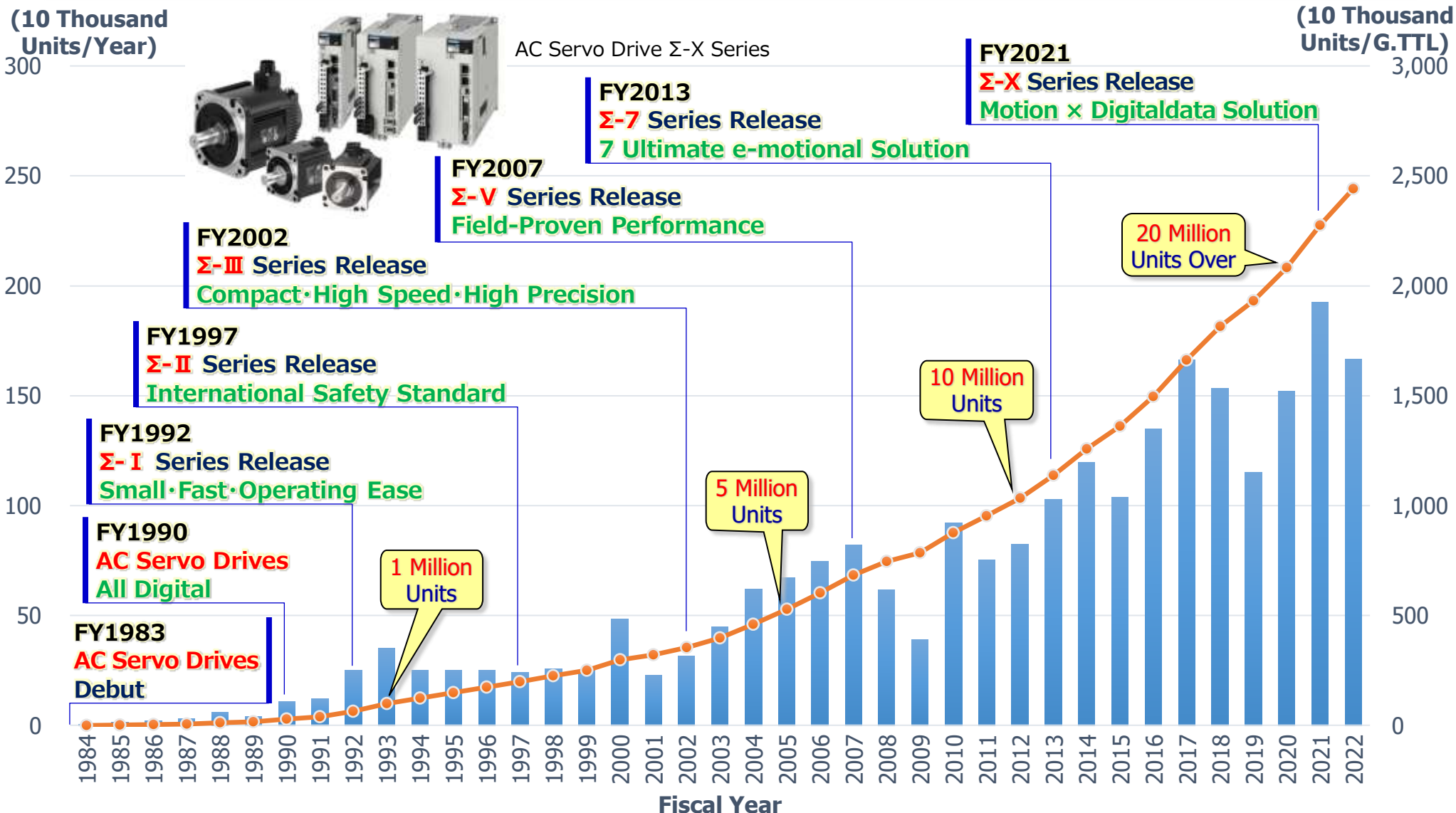
- Electronics-related industries including semiconductor, FPD and electronic components
- Machinery-related industries including machine tool, metal processing, press machine and robots
- Other (Packaging, textile, injection molding, etc.)

Market share



[Note] Company estimate

Total Shipment



New Product Features (1/3)

Features of Σ -X Series – Improvement of motion performance

Maximum motor rotation speed

The maximum rotation speed of the motor has increased from the earlier value of $6,000 \text{ min}^{-1}$ to $7,000 \text{ min}^{-1}$.



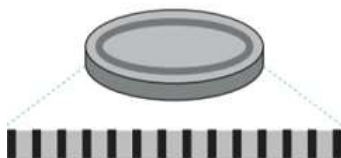
Applicable models:
All SGMXJ and SGMXA models

Equipped with a high-resolution 26-bit encoder

The resolution* of the encoder has been increased to 26 bits, four times that of the earlier model. 24 bits of encoder resolution is position precision resolving 1 revolution of a motor to 67 million pulses

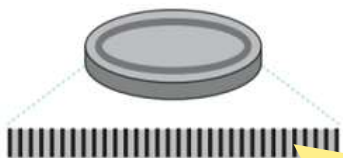
Earlier model

Encoder resolution 24 bits
≈ 16 million pulses/rev



Σ -X

Encoder resolution 26 bits
≈ 67 million pulses/rev



Four times
that of
the earlier
model

Increased position resolution/stop precision
→ Precise stops

*Ability to measure how finely a motor rotation can be split

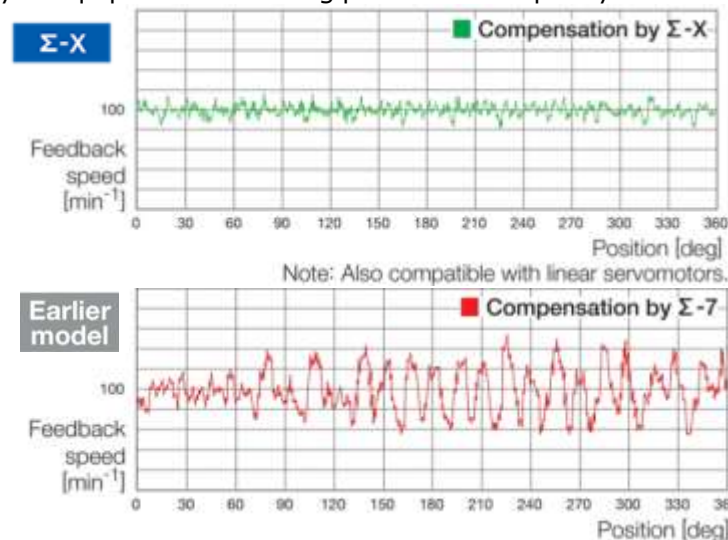
Speed frequency response

Speed frequency response has changed from 3.1 kHz for the earlier model to 3.5 kHz. Maximizing the following performance for the speed reference improves equipment productivity.



Improved control precision and smoothness

Smoother drive is possible from a more effective speed ripple compensation algorithm for cogging compensation. This helps reduce inconsistency in equipment machining precision and quality.



New Product Features (2/3)

Features of Σ -X Series –Sensing and use of data

**The servomotor acts as a sensor and collects various data.
It can be used for preventive maintenance of equipment.**

Σ -X uses the servomotor as a sensor to sense and monitor the parts used by the servo and the servo's installation environment. This can be useful for accurately determining maintenance periods and for preventing sudden failures.

■ Sensing Items

Encoder Power-on Time
Encoder Supply Voltage
Encoder Battery Voltage
Motor Rotation Count
Maintenance Prediction Monitor: Bearing
Maintenance Prediction Monitor: Oil Seal
Acceleration Sensor Monitor

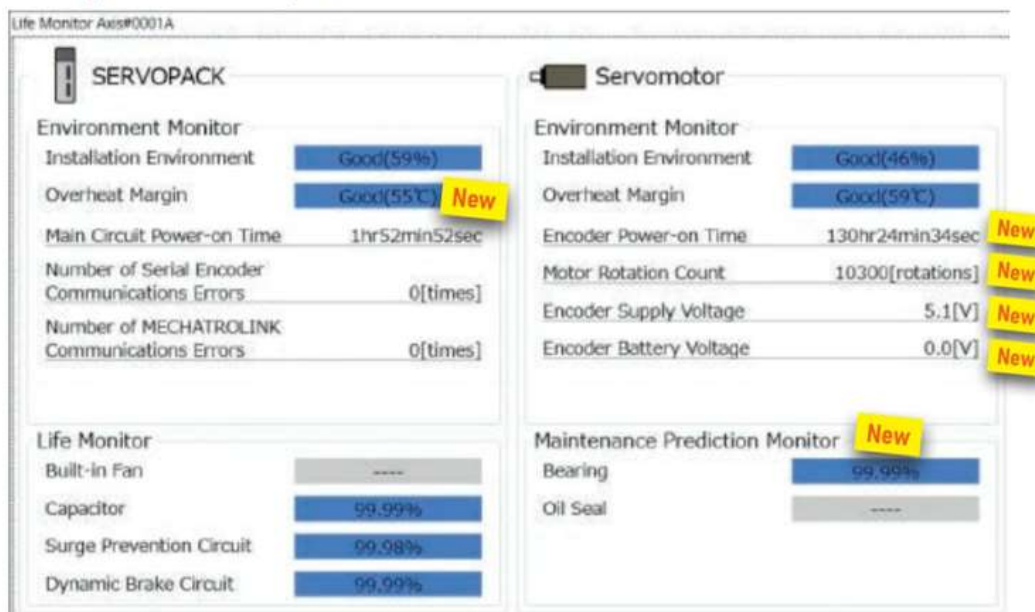
New



Estimated External Disturbance Torque
Number of Serial Encoder Communications Errors
Settling Time
Amount of Overshoot
Residual Vibration Frequency
Estimated Vibration
Maximum Value of Accumulated Load Ratio
Number of MECHATROLINK Communications Errors
Margin until Overload
Temperature Margin until Servomotor Overheats



- Both installation environment information and the service life of parts used by the servo can be monitored.



New Product Features (3/3)

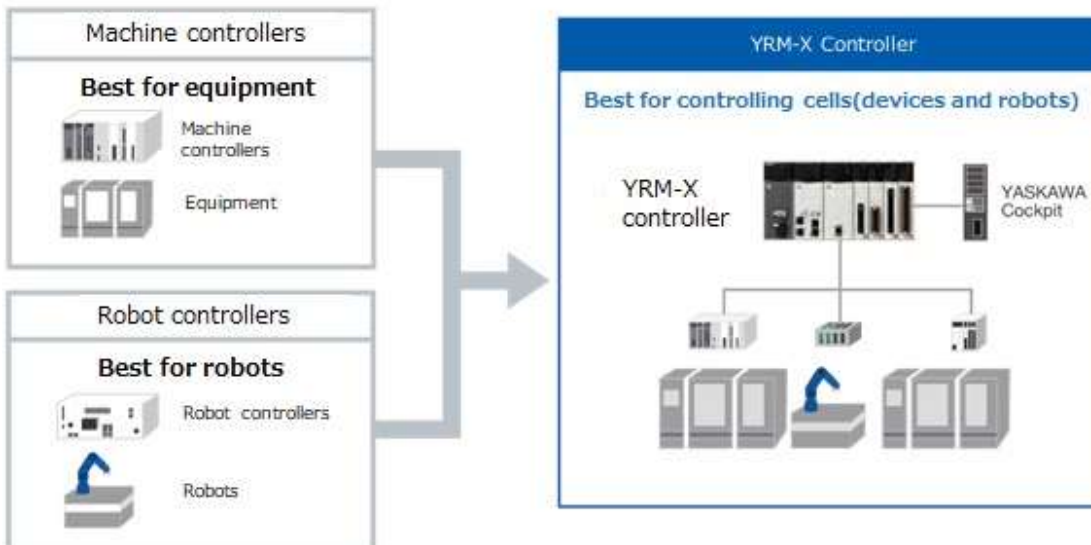
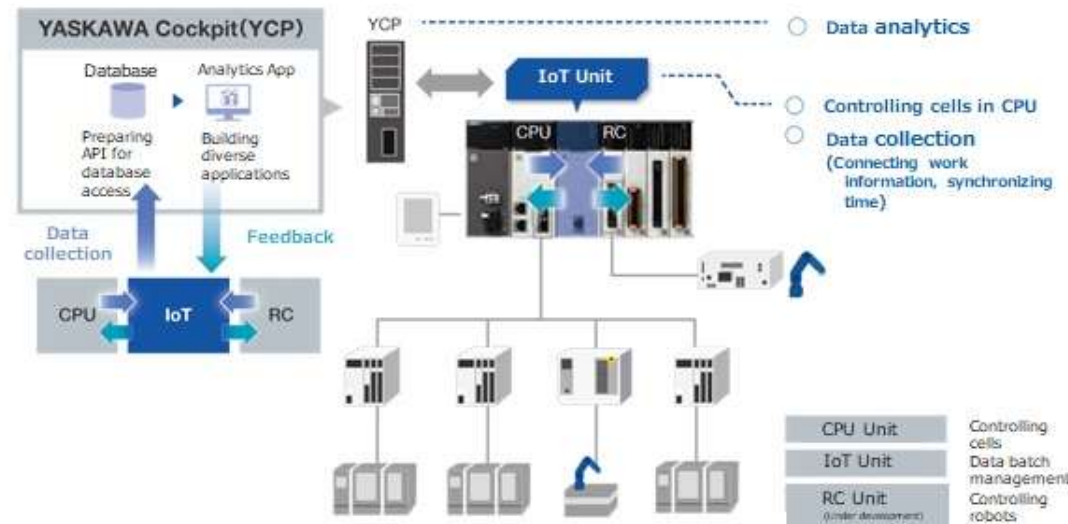
Features of YRM-X controller



YRM-X controller

① Controller controlling cells

Cells : A connected equipment where data relatedness exists
e.g.) Facilities composing devices or/and industrial robots etc. and working on common tasks



② A controller that enables to integrate equipment, robots, and data and turn data into movement

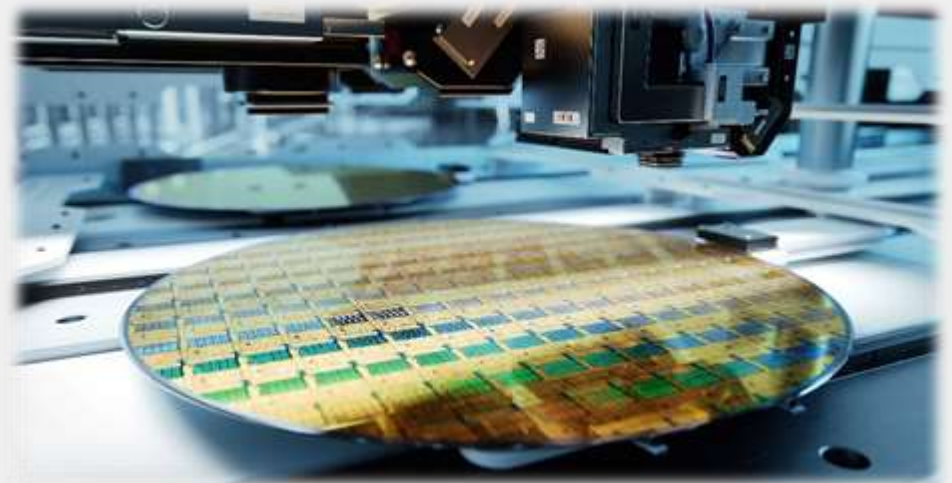
- Real-time understanding of the status of an entire cell by acquiring synchronized data of equipment and robots is possible. The results of analysis of the acquired data are fed back to the entire cell as "data" and "motion" to realize automation of manufacturing (stable operation, stable quality, and process improvement).

(Reference)

Application of AC servo & controller

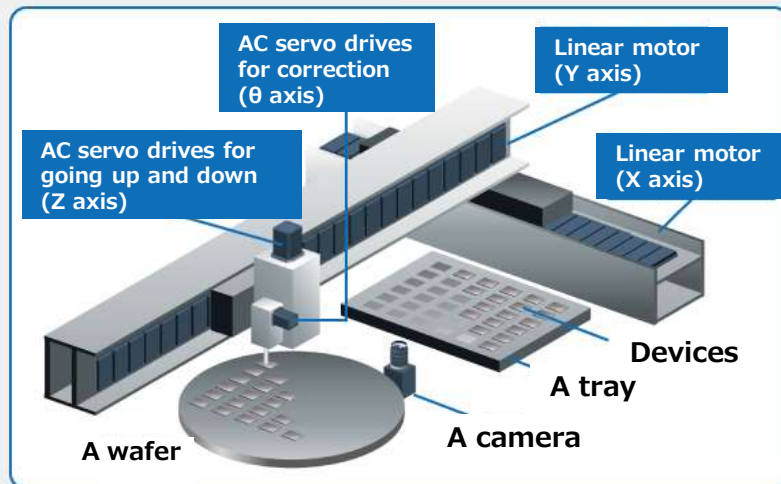


Electronic component



Semiconductor production equipment

Structure of die bonder



Metal processing machine



Injection molding machine

1-2. Drives



Product Basics (1/3)

What is an AC drive?

Device for controlling rotation speed by changing voltage and frequency supplied to motor

Commanding controller

Direct operation command or operation command via controller



Controller

Controlling AC drive

Convert voltage and frequency set internally and externally and output to the motor



AC drive

Driving and Detecting motor / encoder



General induction motor
Synchronous motor

Forward/Reverse

Operation command

Power signal

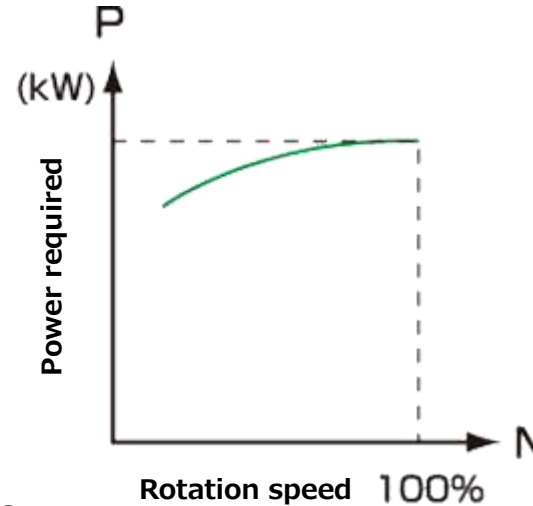
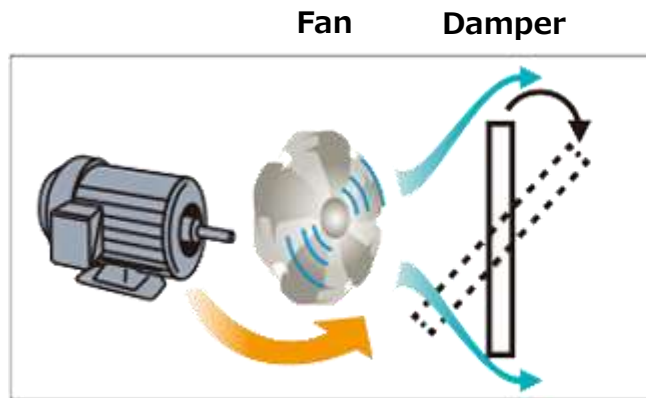
Encoder feedback

※AC drives can control motors from **other companies**

Product Basics (2/3)

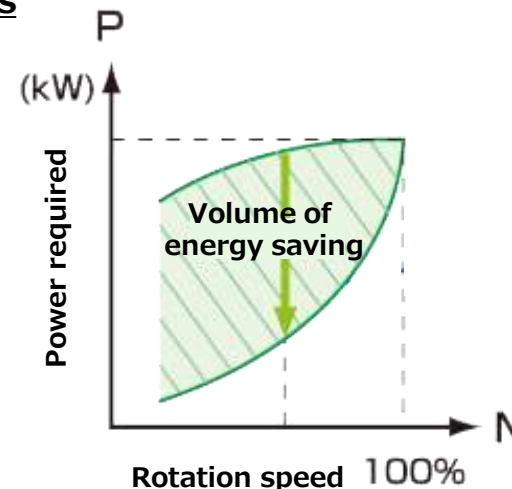
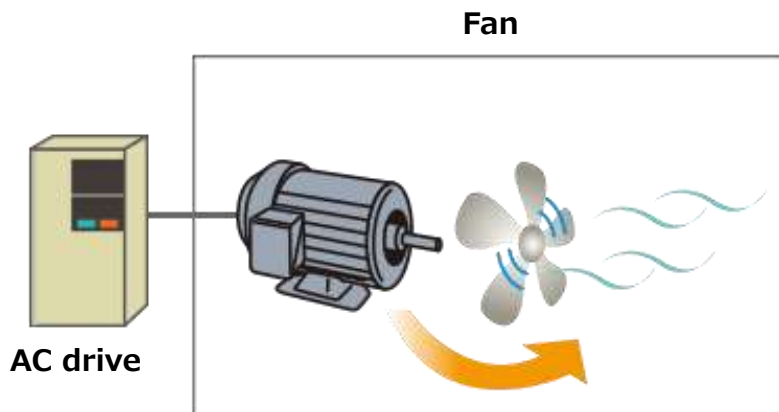
What are energy conservation benefits of AC drives?

◆ Conventionally, motors had constant speed + damper



Without AC drives, the rotational speed of the motor cannot be changed, so the air volume is adjusted with a damper (on-off valve).

◆ Variable speed motor control by AC drives

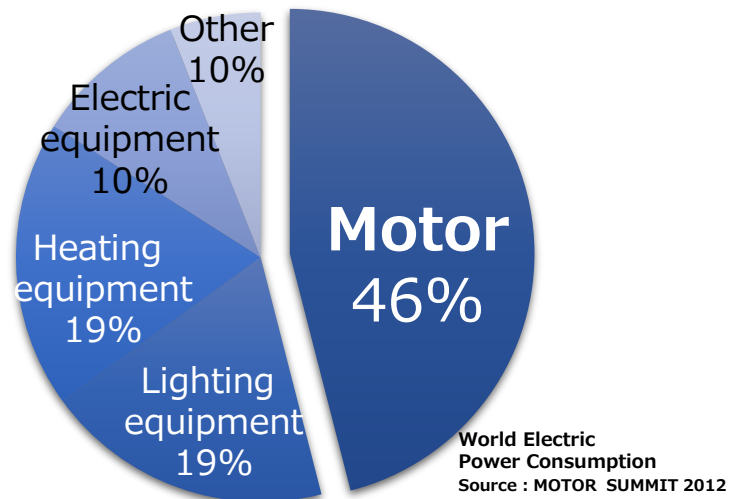


AC drives can adjust the motor speed according to the required air quantity, resulting in saving a lot of energy.

Product Basics (3/3)

The reason AC drives are needed

- ◆ Motor takes about half of the world's electric power consumption



- ◆ Global regulations have accelerated the high efficiency-oriented needs towards motors

Country (Region)	High efficiency laws and regulations enforcement schedule									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
JPN	IE1					Top Runner Regulation IE3				
USA	IE3 (such as the leg mounting, conventional IE2 regulated goods)					IE3				
	IE2 (such as flange type)									
CHN	IE2					IE3				
EU	IE2					IE3 or IE2+AC Drive				
KOR	IE2					IE3				

Bibliography : JEMA(July,2018)

- ◆ High efficiency motors require AC drives

Efficiency Classified

High
↑
Efficiency
↓
Low

IE5 Ultra Premium High Efficiency Motor
IE4 Super Premium High Efficiency Motor
IE3 Premium High Efficiency Motor
IE2 High Efficiency Motor
IE1 Standard Motor

Motor Type

Permanent magnet motors, Magnet-assisted Synchronous reluctance motors	}	AC drives required
Permanent magnet motors, Magnet-assisted Synchronous reluctance motors		
Permanent magnet motors, Synchronous reluctance motors		
Induction motors	←	AC drives required in EU
Induction motors		

Applications and Market

Fluid machinery

- Air conditioning system
- Fan/pump
- Compressor
- Vacuum pump



AC drive/PM motor



**Supports motion control
for broad applications**

General industrial machine

- Metal processing machine
- Food machine
- Wood processing machine
- Textile machine
- Resin molding machine
- Chemical machine
- Papermaking and printing machines
- Packaging and filling machines
- Environment-related machine
- Life-related machine



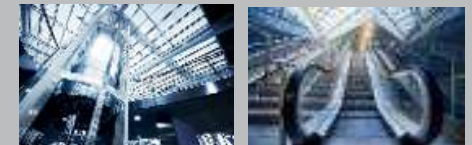
Conveyance machine

- Conveyor
- Crane
- Hoisting machine
- Multistory parking garage



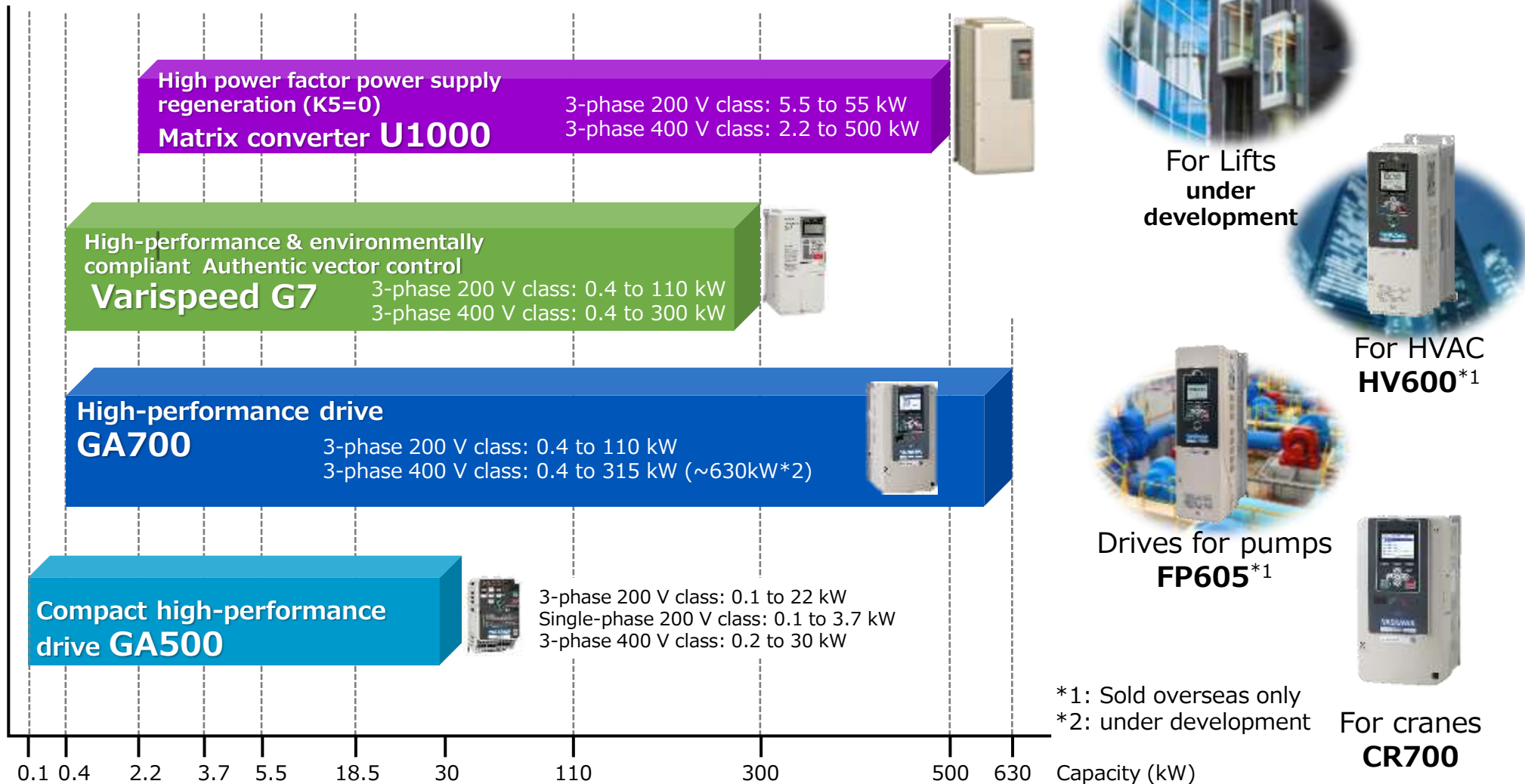
Lift

- Elevator
- Escalator
- Light lift
- Automated warehouse



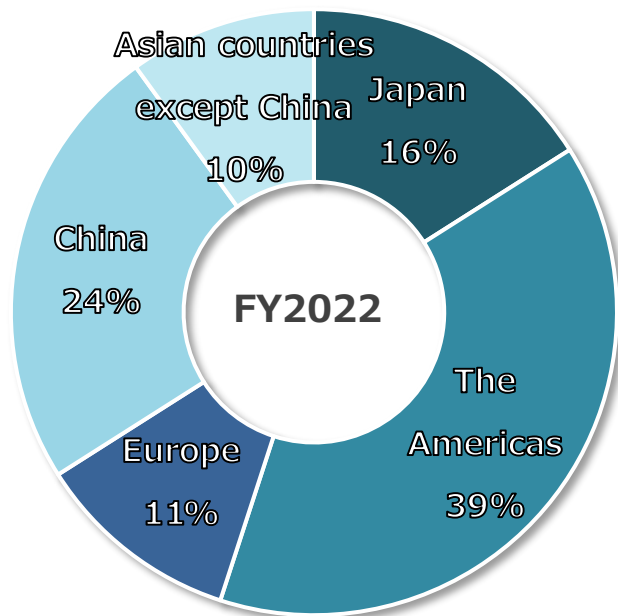
Product Lineup

Develop lineup for application-specific products, including power supply regeneration and vibration suppression functions

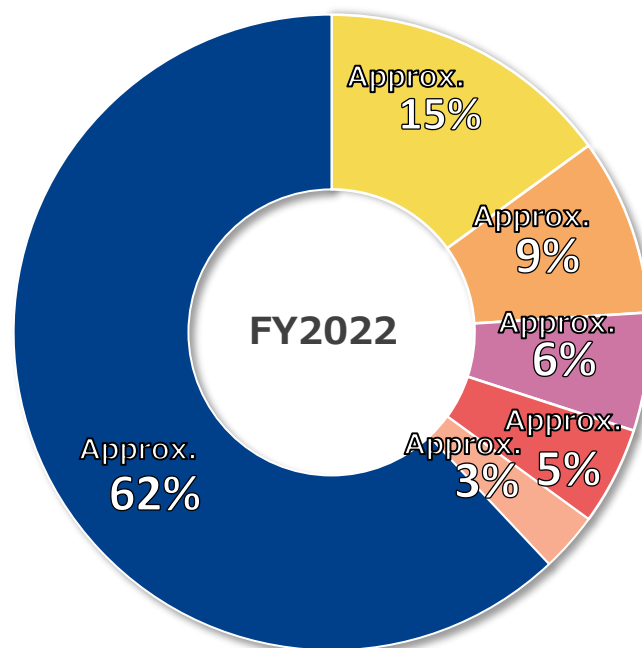


Revenue Breakdown by Region and Application, Market Share

Breakdown of revenue by region

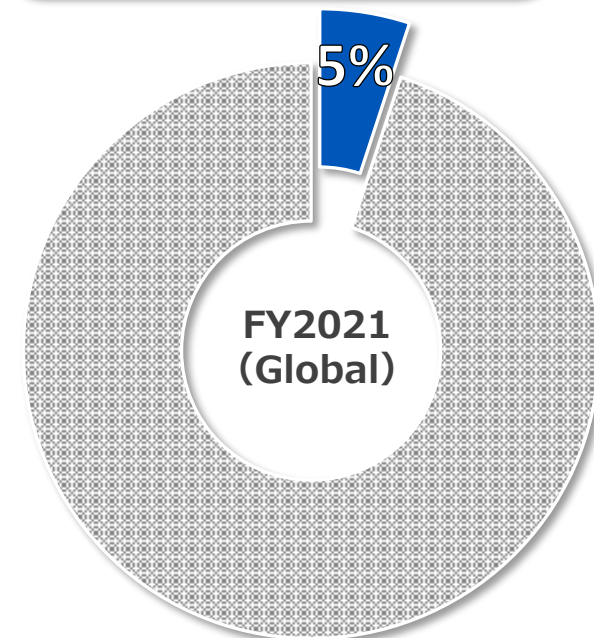


Revenue breakdown by application



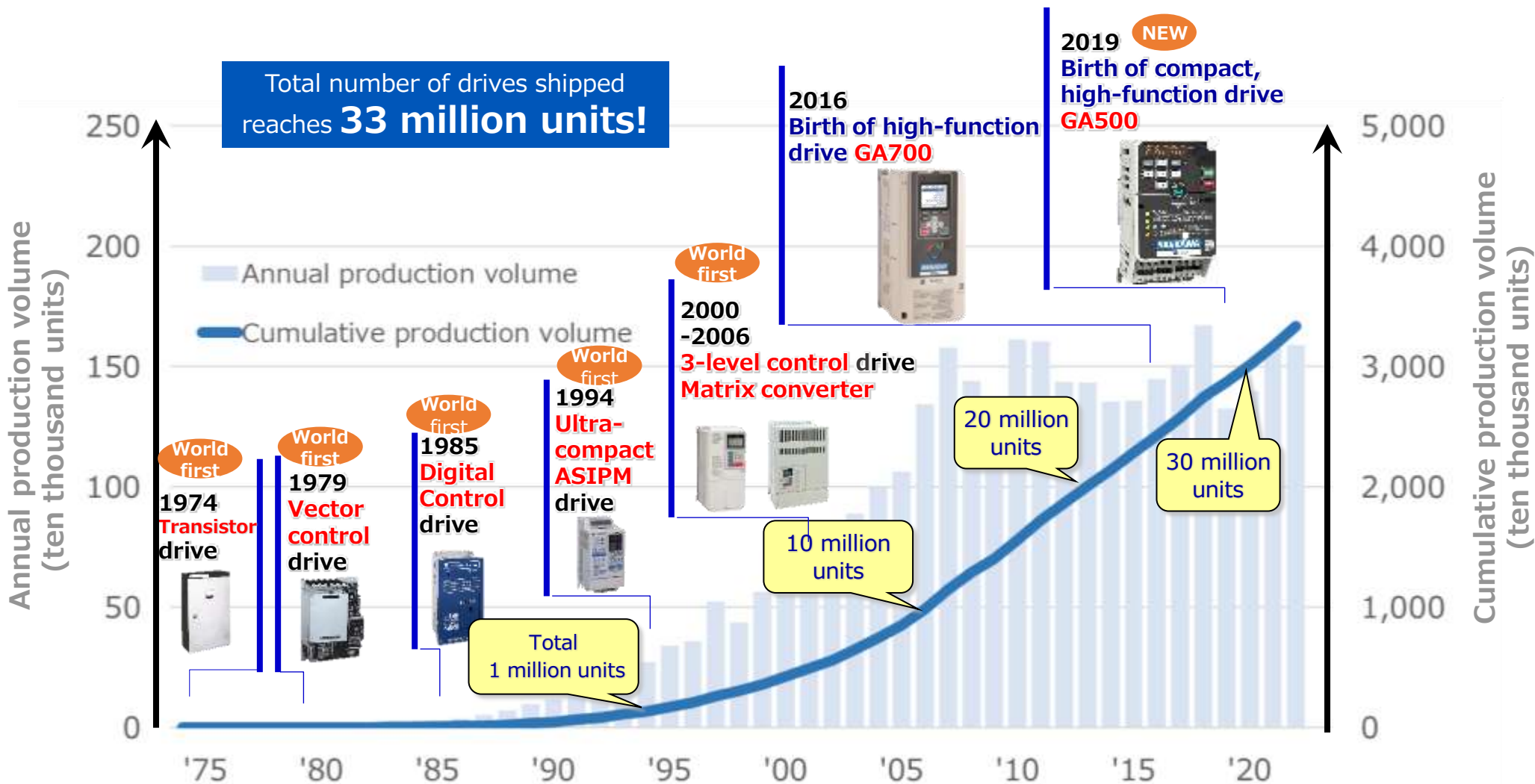
- Air-conditioning systems for buildings (HVAC and compressors)
- Cranes and hoists
- Oil & gas
- General-purpose machinery / Other (Textile machinery, metal processing machinery, packaging machinery, conveyors, etc.)
- Pumps and fans
- Elevators

Market share



[Note] Company estimate

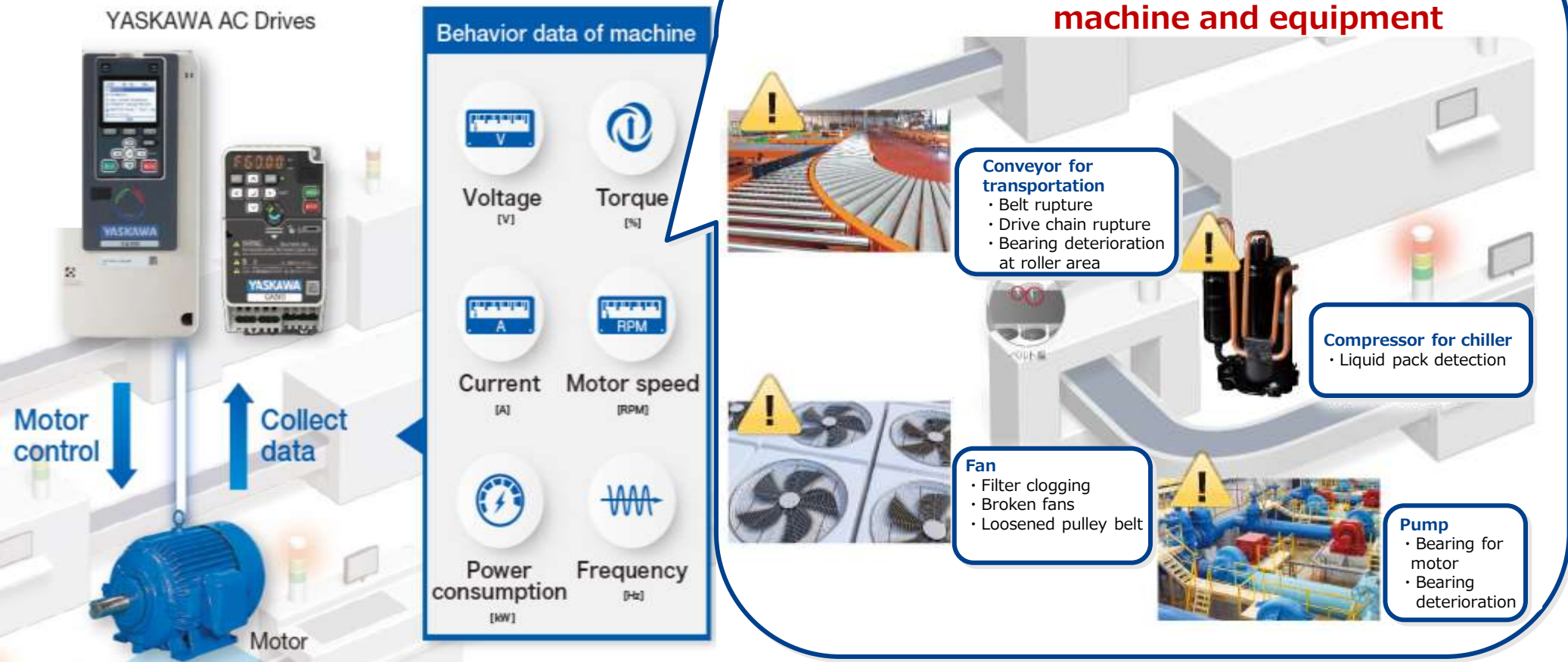
Total Shipment



Features of Yaskawa's products (1/2)

Unique detecting function

Monitoring machine behavior data through AC drives and preventing serious troubles by detecting machine changes in detail



Features of Yaskawa's products (2/2)

Energy-saving initiatives

Selling **PM motor** achieving high-efficiency, energy-saving operation when used in combination with AC drives

Lineup



Eco PM motor flat type

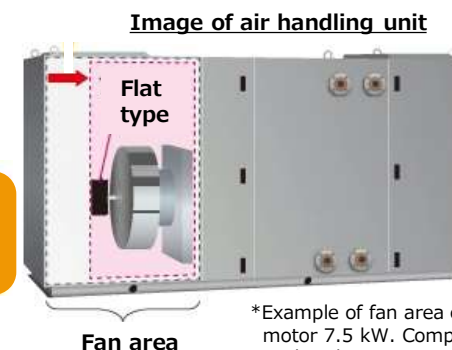
- Achieving the highest (IE5) efficiency of the five efficiency classes
- Contributing to space-saving, resource-saving, and energy-saving by significant reduction of motor length
- Decreasing noise level by reduction of fans



IPM motor SS7

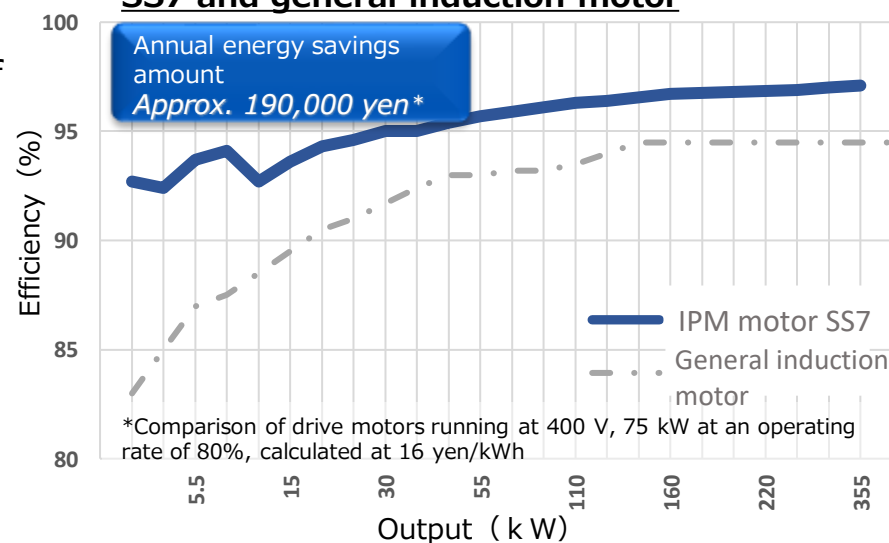
- Realizing the high efficiency which is nearly the second highest (IE4) of the five efficiency classes
- Compact and lightweight, contributing to resource conservation

Installation area
25%* reduction



*Example of fan area of motor 7.5 kW. Comparison with induction motor.

Comparison of efficiency between IPM motor SS7 and general induction motor



(Reference)

Application of AC drives



Cranes



Fans



Pumps



Conveyors



Automated
warehouse

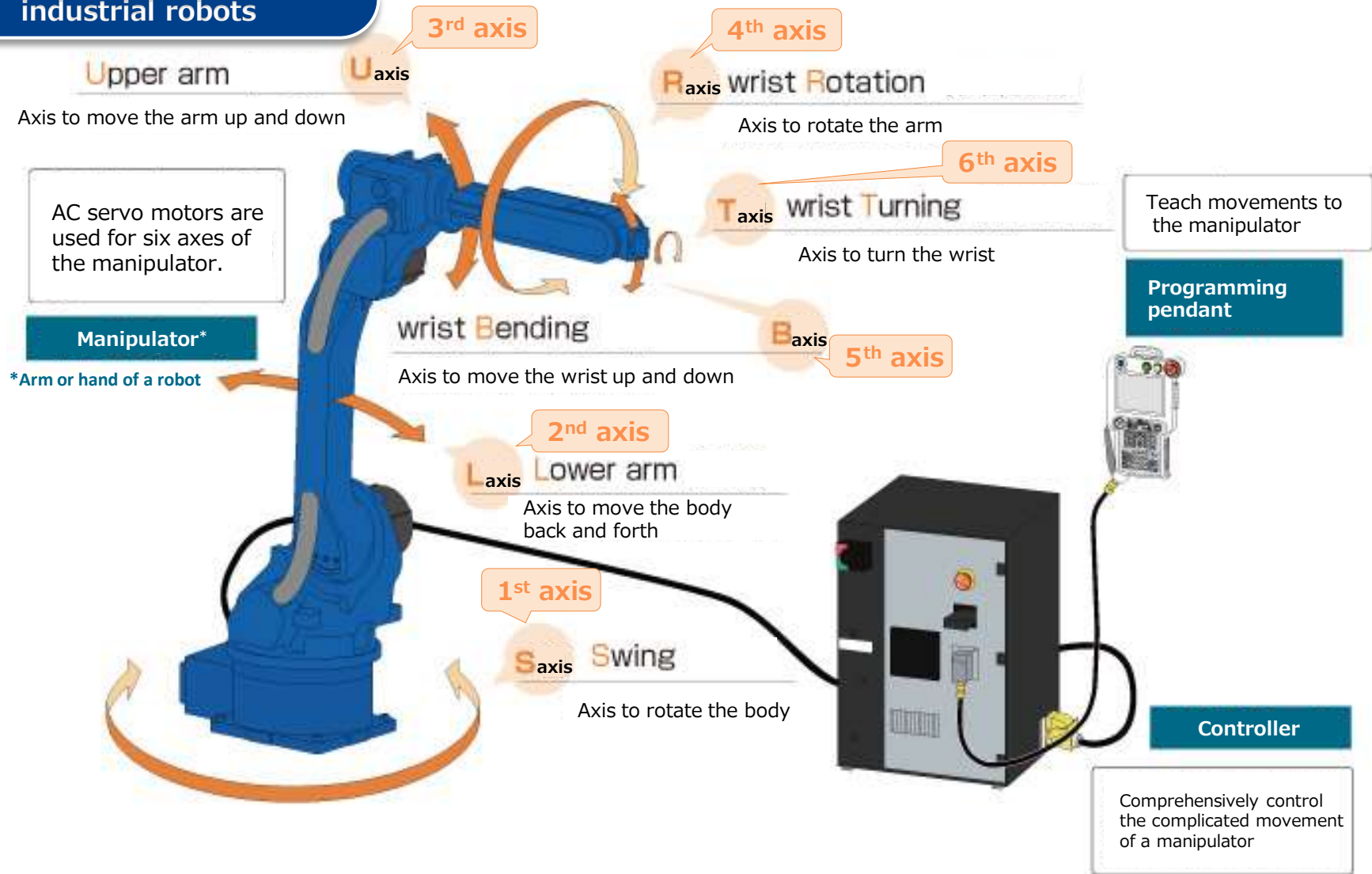
YASKAWA

2. Robotics



Product Basics (1/2)

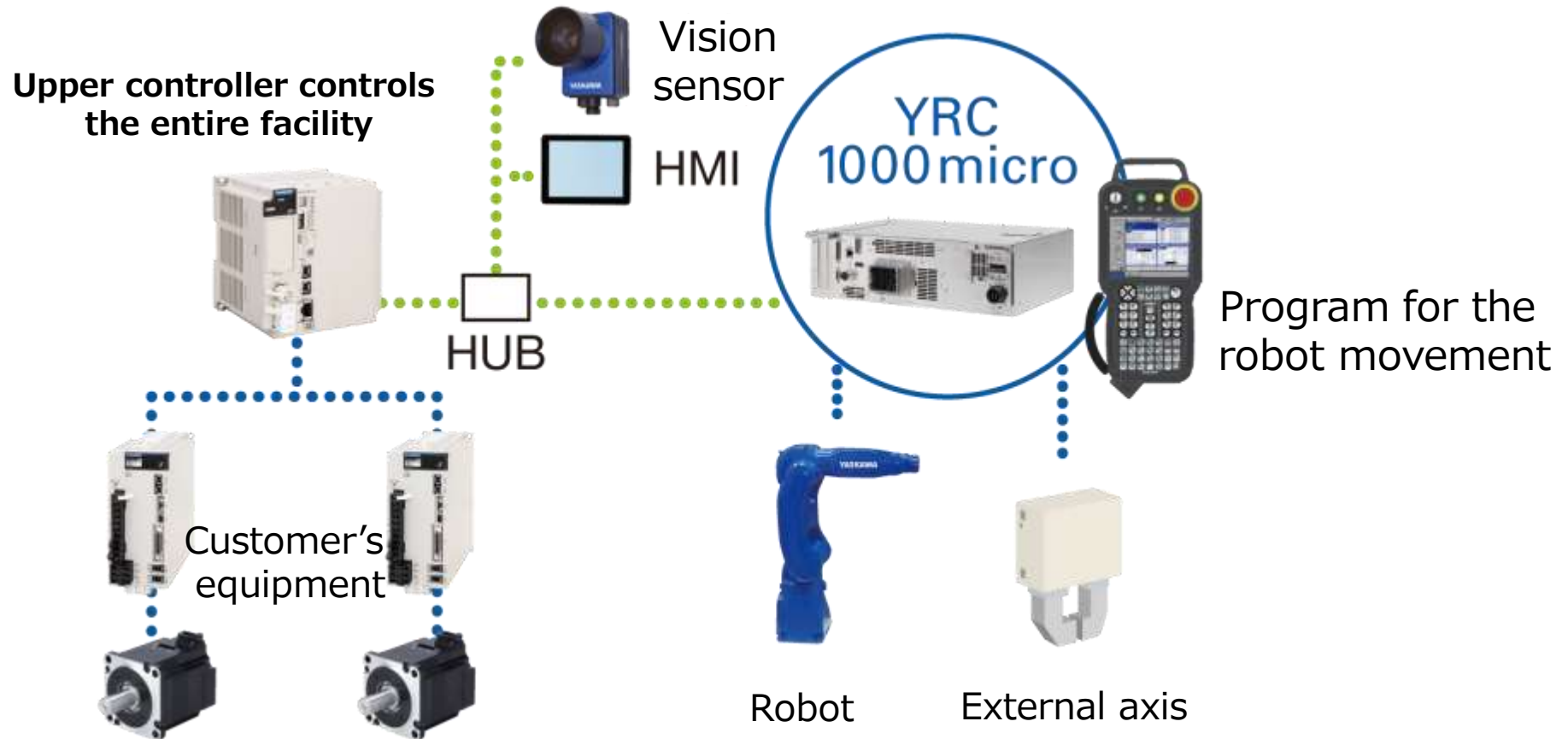
Basic configuration of industrial robots



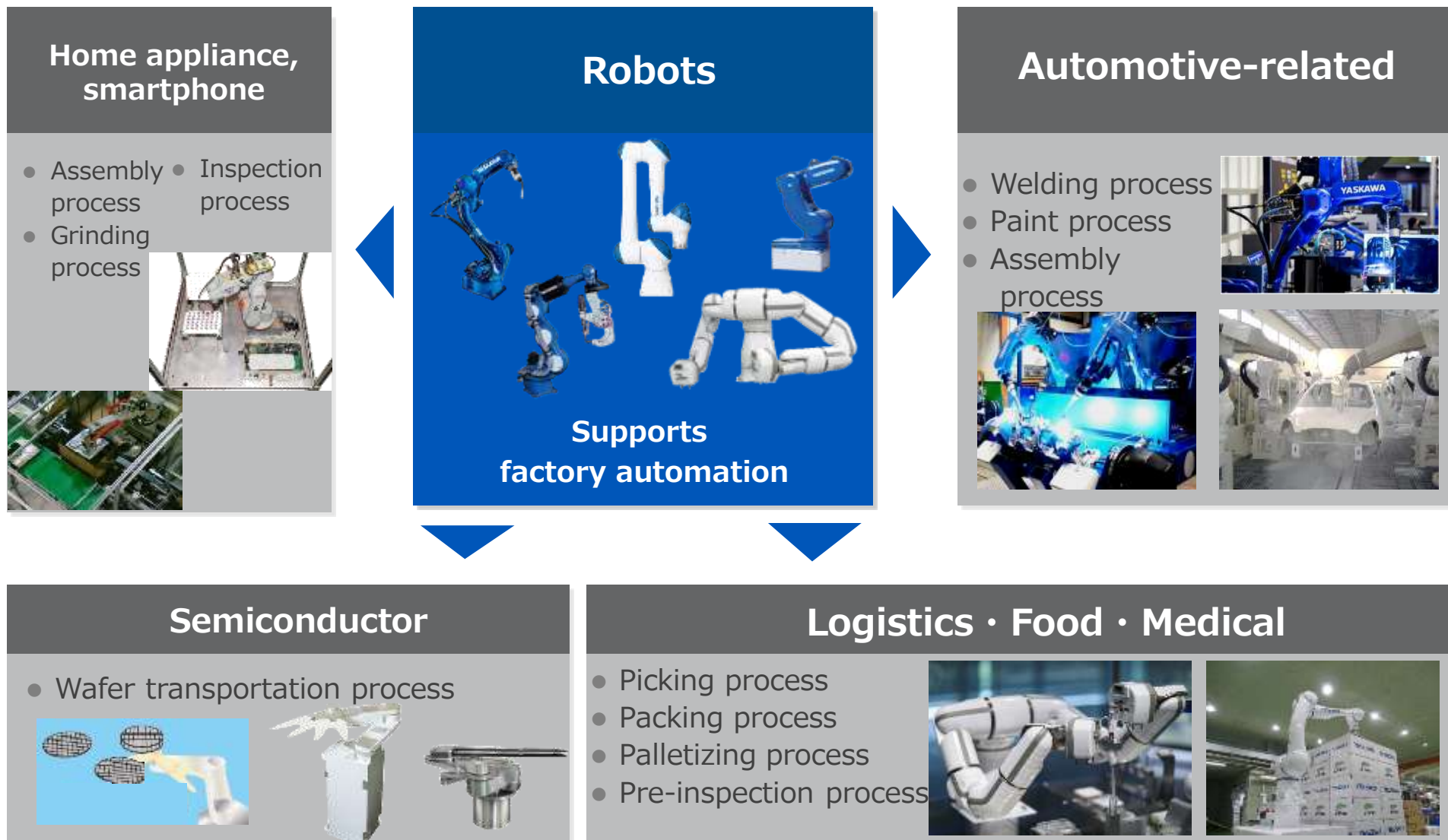
Product Basics (2/2)

Image of robot control

- A robot motion program is created in the dedicated robot controller (e.g.: YRC 1000 micro) with a teach pendant.
- The upper controller such as MP controller controls the entire facility including starting the operation program and collecting operation status data.



Applications



Product Lineup

Industrial robots for automotive and other markets

Arc Welding



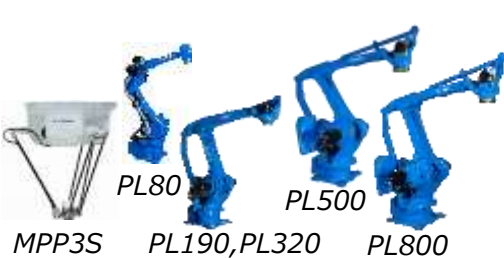
Spot Welding



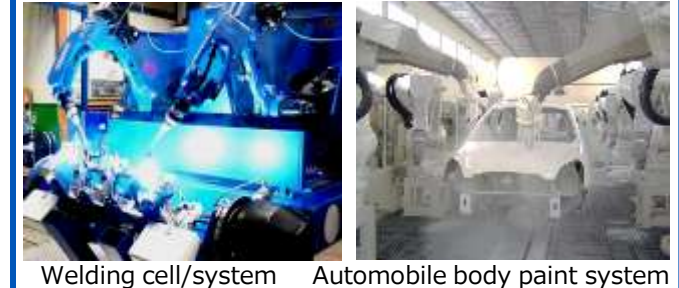
Paint



Picking, Packing, Palletizing



Handling



Clean room robots (Semiconductor)

Collaborative

Dual Arm

Semicon.

Wafer Transfer

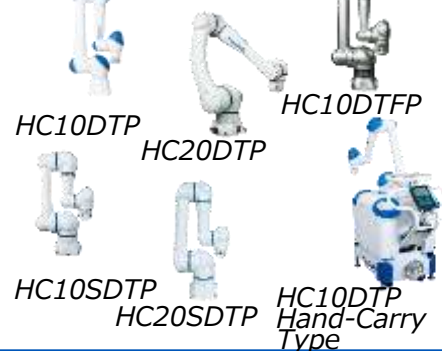
SEMISTAR-M,V series

Clean Robot

Vacuum Robot

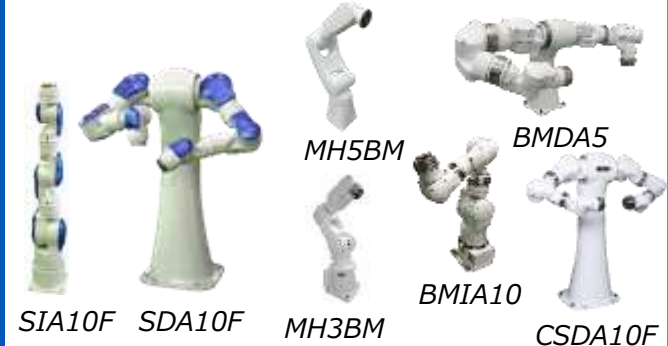


Collaborative

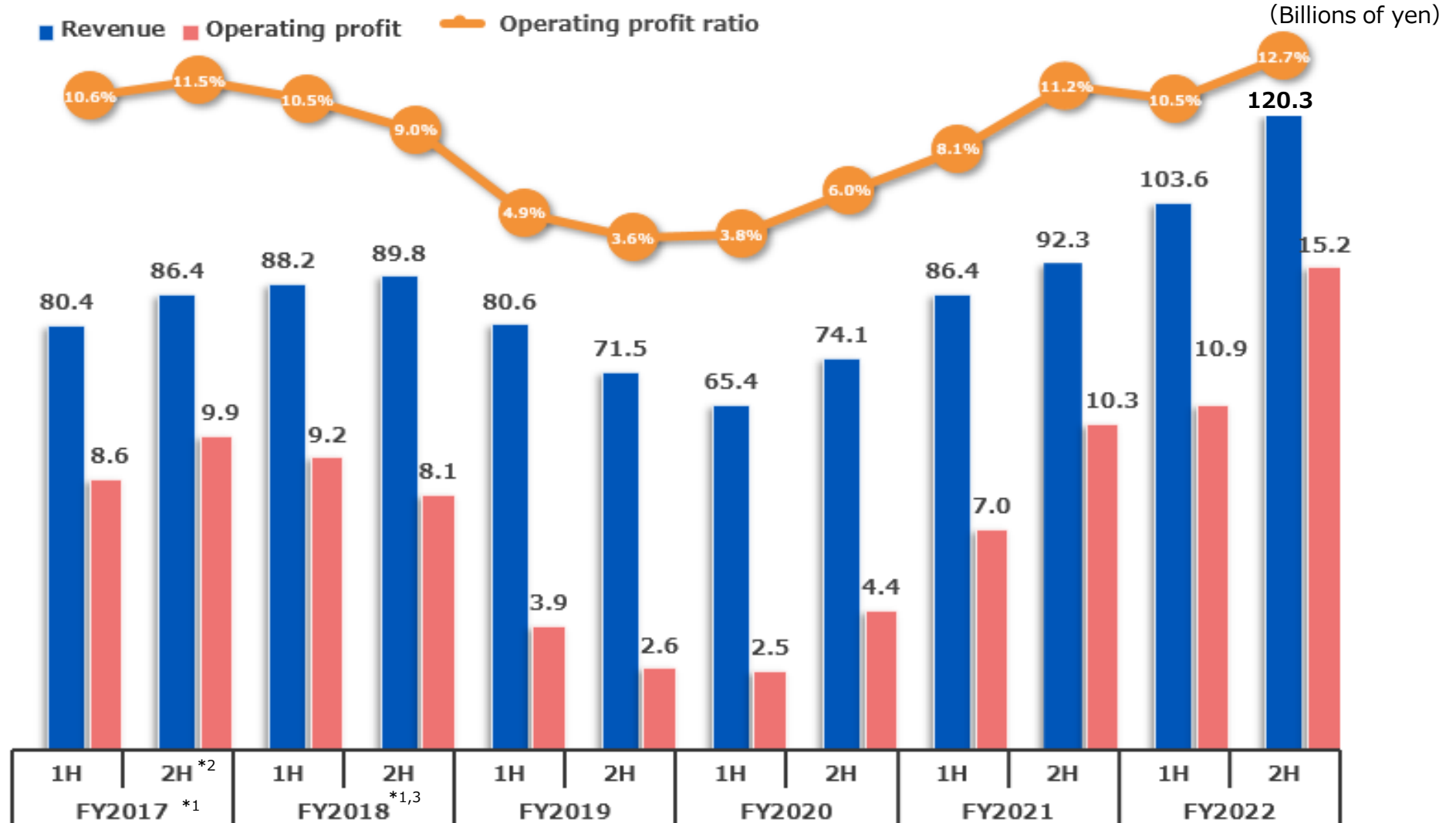


Transfer, assembly

Biomedical



Revenue / Operating Profit (Robotics)

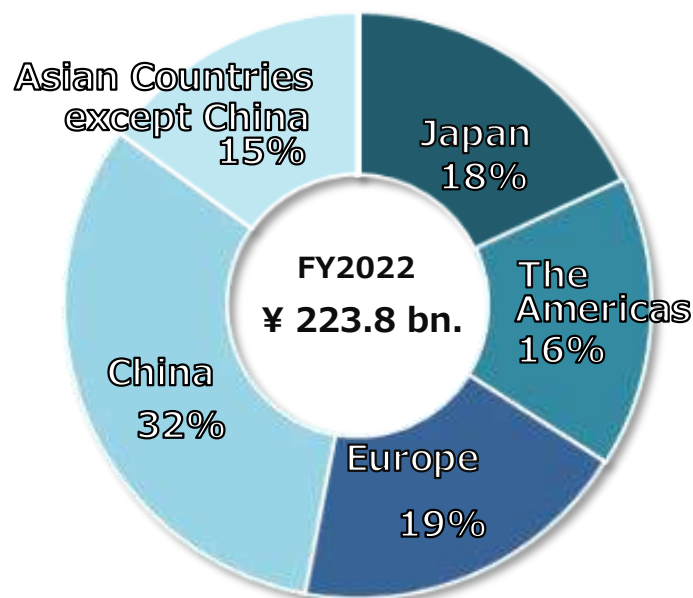


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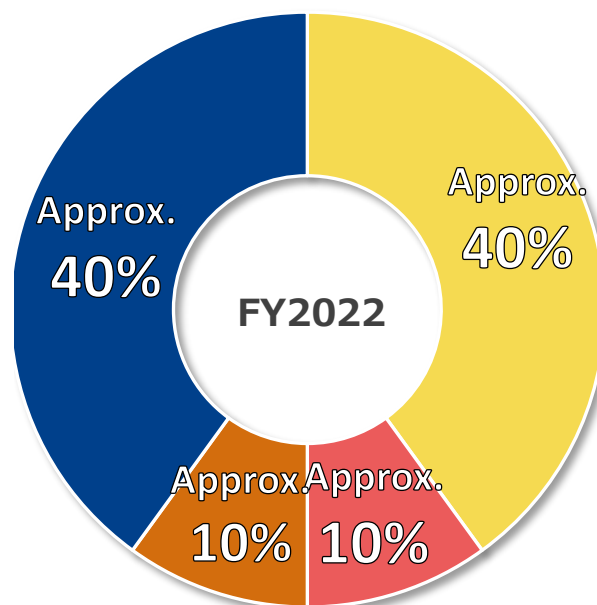
*3 Reflects the impact of the reclassification of segments in FY 2019

Revenue Breakdown by Region and Application, Market Share

Breakdown of revenue by region

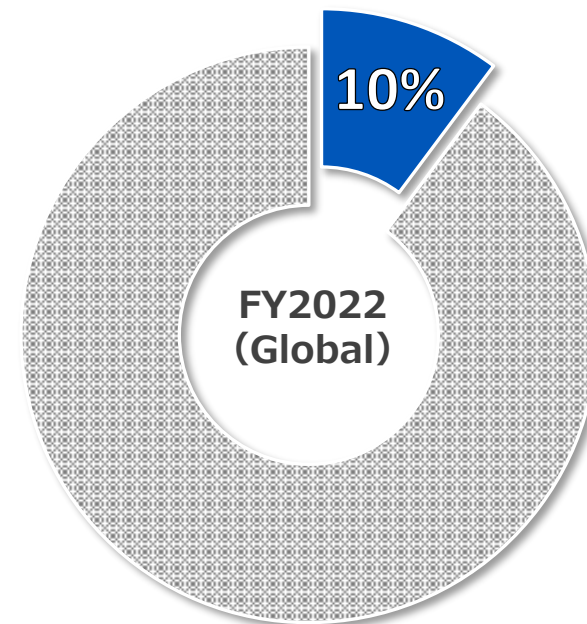


Revenue breakdown by application



- Automotive-related applications (Arc welding, spot welding, painting, etc.)
- Semiconductor and LCD related applications
- 3C (Home appliance, smartphone, etc.)
- General / Other (Handling, etc.)

Market share



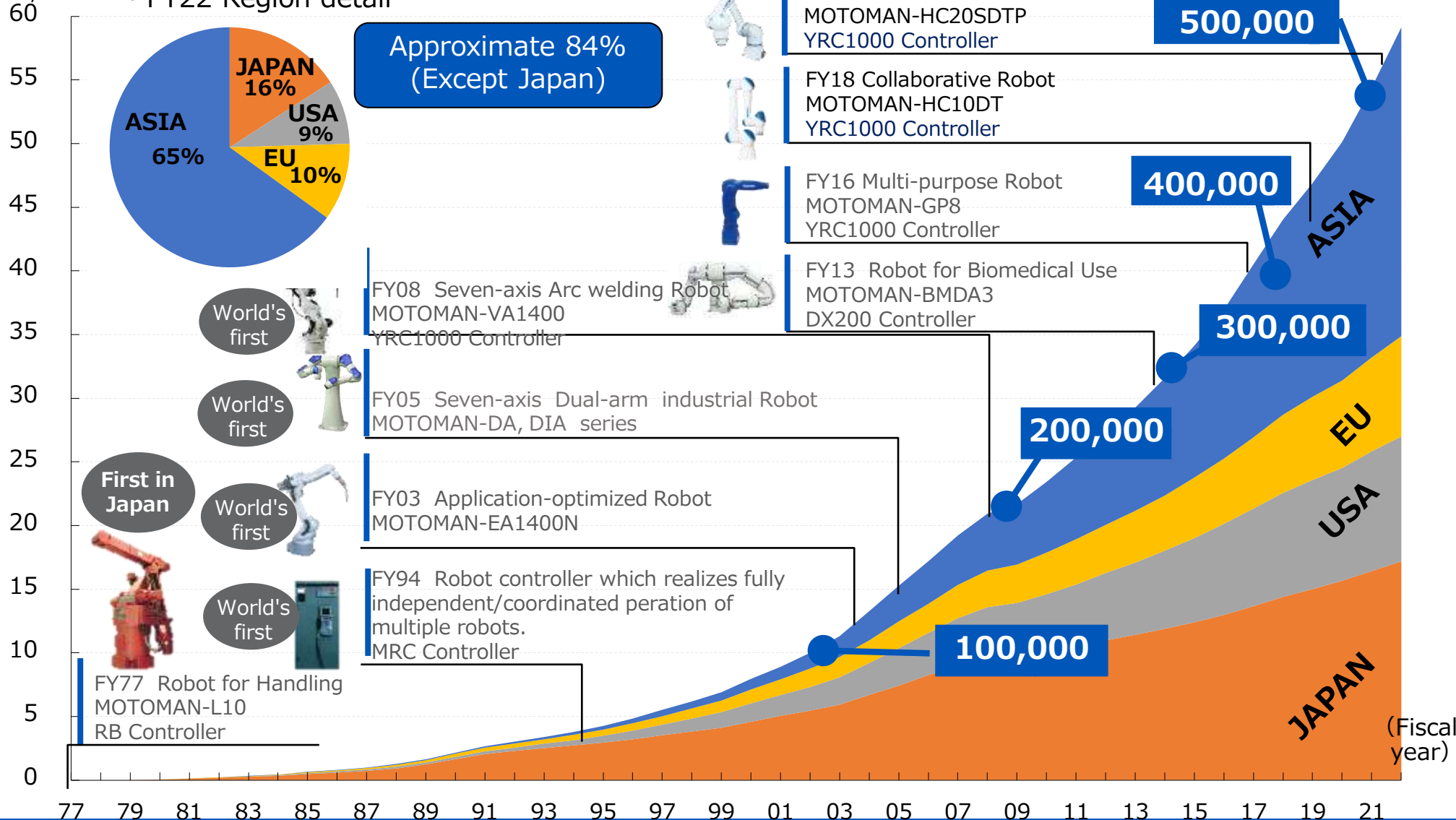
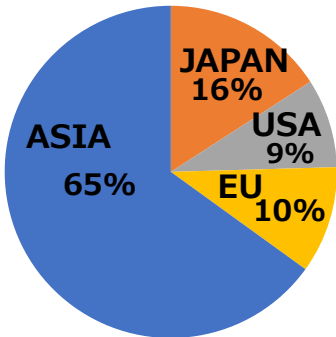
[Note] Company estimate

Total Shipment

Over
590,000 Units

(× 10,000Units) FY22 Region detail

Approximate 84%
(Except Japan)



Arc Welding

Contributed to the automation of parts processing in various industries, including the automotive industry requiring high welding quality and productivity.

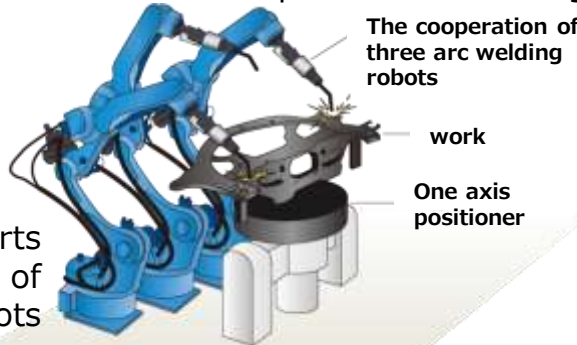


AR1440

Arc welding of auto parts with the cooperation of three robots



The work point of arc welding



Spot Welding

A welding method in which two steel plates are crimped together, a large electric current is passed through them, and make them high temperature. It is used in automobile body joining



SP225H

Hollow arm is designed for spot rigging.

Car production line
Spot welding system



SP100B

7-axis structure enables to install in high density



Handling

Provide wide variation of robots (payload: 0.5 - 600kg) to contribute automation of customers' production line



MotoMINI
(Payload 0.5kg)

GP4
(Payload 4kg)

GP8
(Food specification)

GP12
(Payload 12kg)

**NIKKEI 2017
Best Product/
Service award**



Handling of tomatoes with small robots MotoMINI

Collaborative

MOTOMAN-HC series is designed to collaborate with human

Realize the cost reduction

- 1) Elimination of the safety fences by the safe structure and function.
- 2) Saving spaces because of elimination of safety fences.

Smart functionality

- 1) Robot teaching can be simplified by the direct teaching function and Smart Pendant.

Expansion of the applicable area by extensive product lineup

- 1) Dust & Drip-Proof Specifications
- 2) Food Specifications
- 3) High payload type
- 4) Hand-carry type



HC10SDTP
(Dust & Drip-Proof Specifications)



HC20DTP
(Dust & Drip-Proof Specifications)



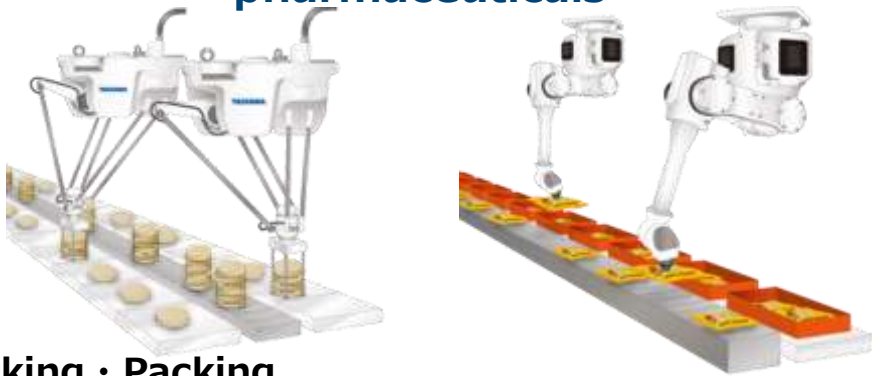
HC10DTP
(Food Specifications)



HC10DTP
(Hand-carry type)

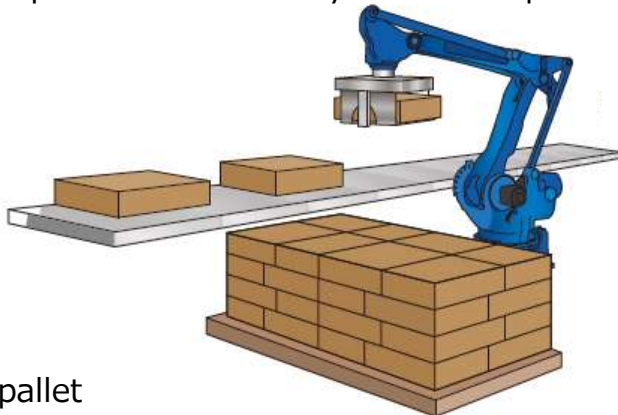
Picking • Packing • Palletizing

Contributing to automated conveyor system for food, cosmetics and pharmaceuticals



Picking • Packing

Grabbing and lining up items on a conveyor belt and packing them in boxes



Palletizing

Placing boxes on a pallet

Painting

- Installing a paint gun and painting cars and small parts
- Explosion-proof for work in an environment with flammable gases



Automobile Industry
(Painting Car Body)
MPX2600



General Industry
(For medium-size work piece)
MPX1950

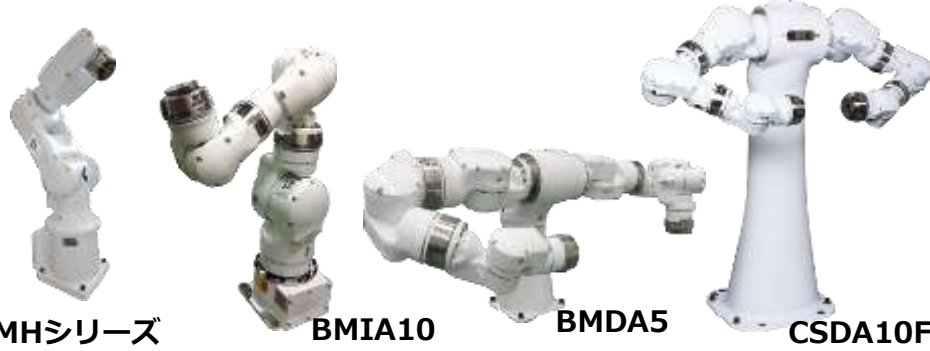
Car painting by painting robot and door opener robot



Bio Medical

Best for automation in Bio-Medical field which requires hygiene control

- Resolve challenges such as manual variations and errors, risk of exposure to powerful drugs, and long routine work
- Use of analytical equipment and containers used by humans



Application Examples

- Bio analysis
- Drug development
- Preparation of anticancer

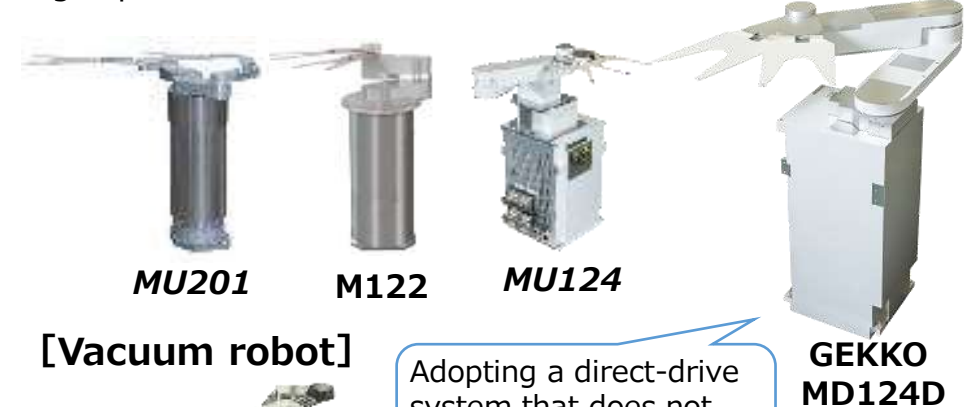


Clean Robot

A wide range of products to meet diverse needs

[Clean robot]

High speed and reliable clean robot for wafer transfer



[Vacuum robot]

Adopting a direct-drive system that does not require a speed reducer



Surrounding equipment designed for wafer transfer

Traverse axis Pre-aligner

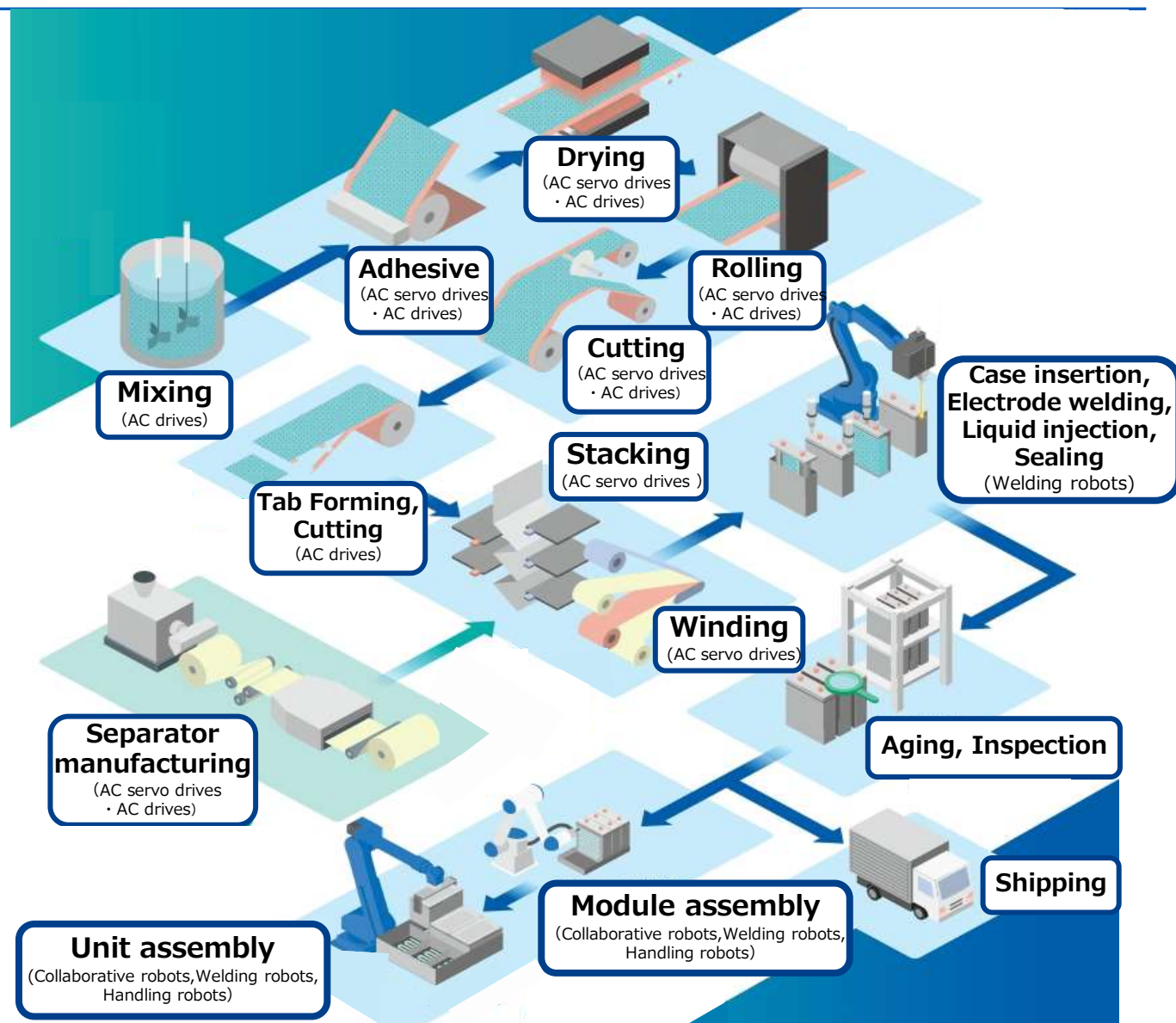


(Reference)

Use of Yaskawa products in the manufacturing process of lithium-ion batteries

The lithium-ion battery market is expected to grow about **1,000 times** * (compared to 2021) in 2040 as the adoption of EVs accelerates.

Yaskawa products are used in many of the manufacturing processes, contributing to higher efficiency and performance.



*Nov. 2022, Fuji Keizai Co., Ltd.

3. System Engineering



System Engineering Business



The diagram illustrates the 'System Engineering Business' as a holistic approach centered on 'To People, Communities, and the Future'. It features two main pillars: 'Environmental energy business' (green) and 'Social system business' (blue). The background is a stylized landscape with a river, city, and nature. Various icons and labels represent different business areas: photovoltaic power generation, wind power generation, drinking water treatment facility, steel plant, and sewage treatment plant. The central text 'To People, Communities, and the Future' is surrounded by 'Various solutions supporting society and industry'.

Environmental energy business

Social system business

Photovoltaic power generation



Wind power generation



Drinking water treatment facility



Steel Plant



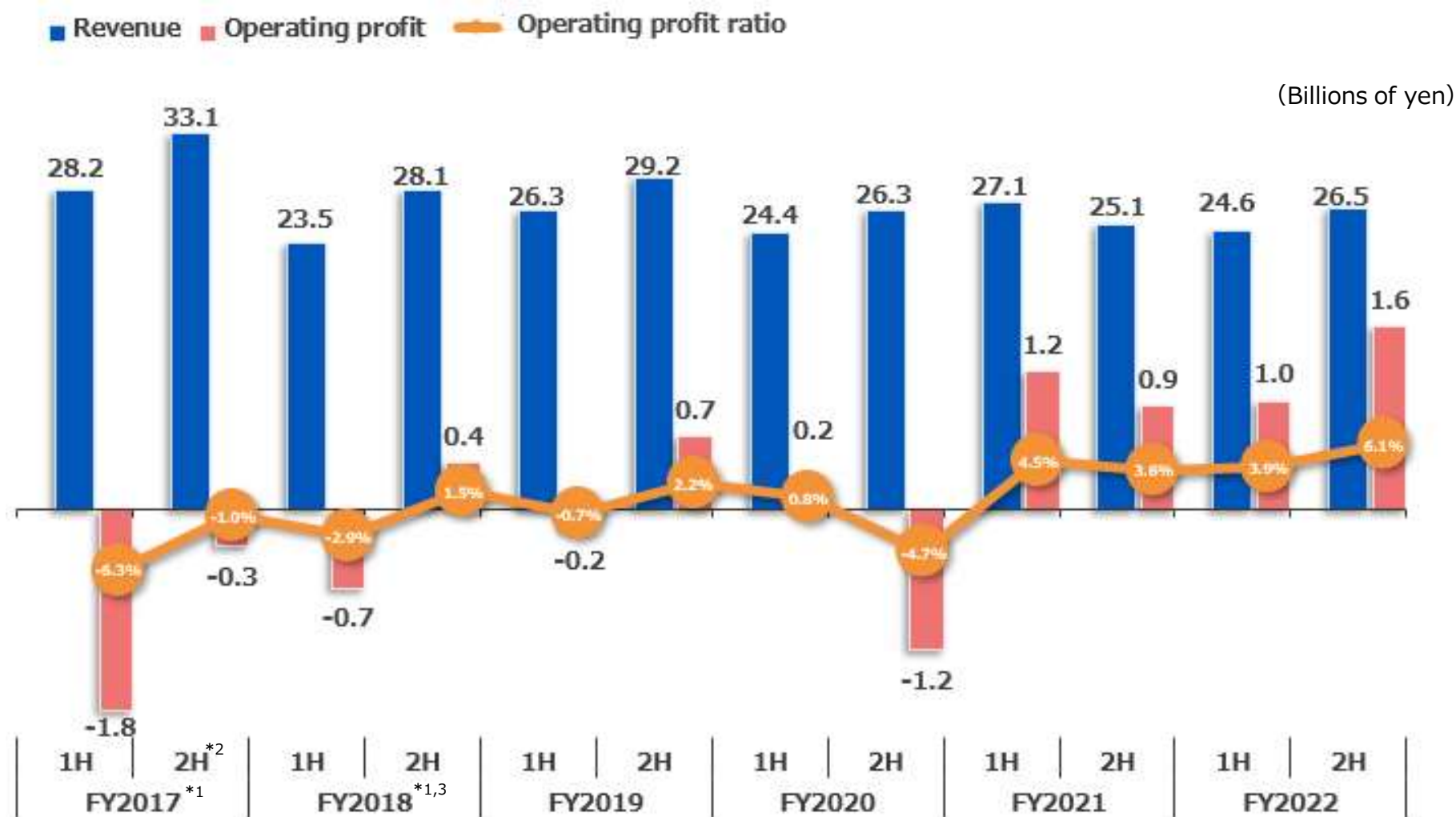
Sewage treatment plant



**To People,
Communities, and
the Future**

Various solutions supporting
society and industry

Revenue / Operating Profit (System Engineering)

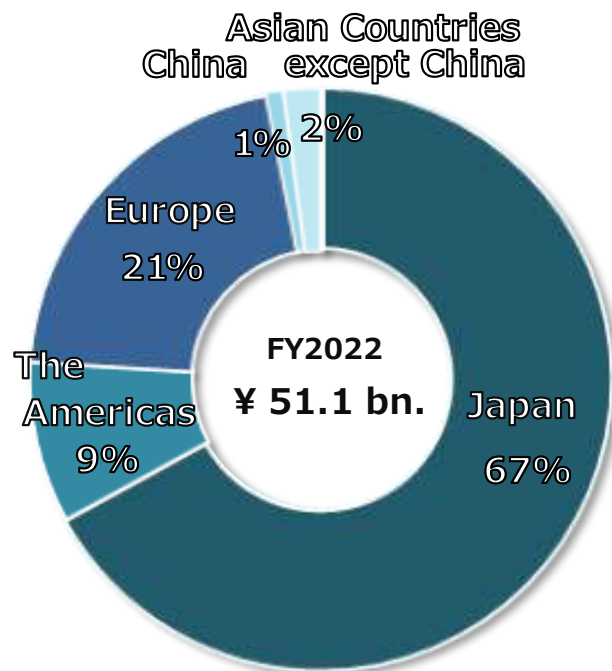


^{*1} Data up to FY2018 are based on Japanese GAAP (After FY2019, IFRS was applied) ^{*2} The data for FY2017 are made on a reference basis. (September 21, 2017 – March 20, 2018)

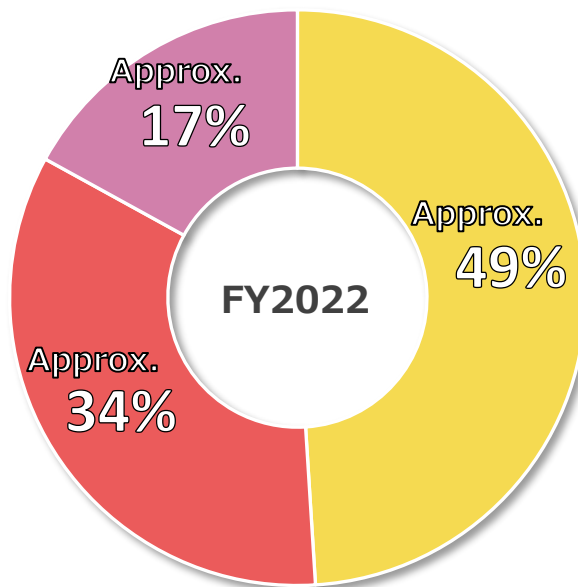
^{*3} Reflects the impact of the reclassification of segments in FY 2019

Revenue Breakdown by Region and Application, Market Share

Breakdown of revenue by region



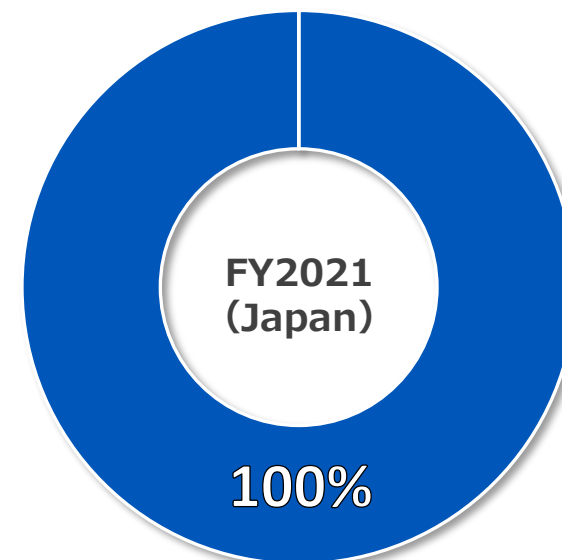
Revenue breakdown by application



- Industrial automation drive (Steel, industrial electric, crane)
- Environmental energy
- Social system

Market share

Steel plant systems (Blast furnace)



[Note] Company estimate

Product Lineup (Environmental Energy Business_ Large-Scale Wind Turbine)

With the proven power conversion technology, realize the maximum electricity output from wind power

Convert energy from wind turbines to **high-efficiency and high-quality power** with our PMGs* and full-power converters.

*Permanent magnet synchronous generator



Stored in nacelle

Stored in bottom of tower

Product Lineup

Permanent magnet synchronous generator



Low-speed type



Medium- speed type



High-speed type

• Output

1.1~9.5MW

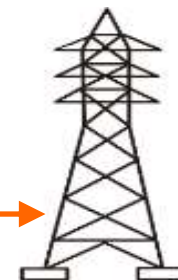
- High efficiency and high reliability are achieved by signature shape and magnet position

Full-power converter



Power conversion efficiency 97%

Switchgear



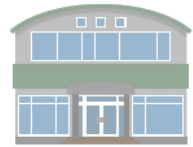
Power grid

Product Lineup (Environmental Energy Business_Solar Power Generation)

We sell PV inverter for solar power generation

Supporting a wide range systems, from self-use and low-voltage grid connection less than 50kW to mega solar.

For industrial, low voltage (10~50kW)



Public facilities/
Self consumption/PPA



Ground mounted small scale solar(FIT/FIP)

9.9kW 200V class 3-phase built-in transformer

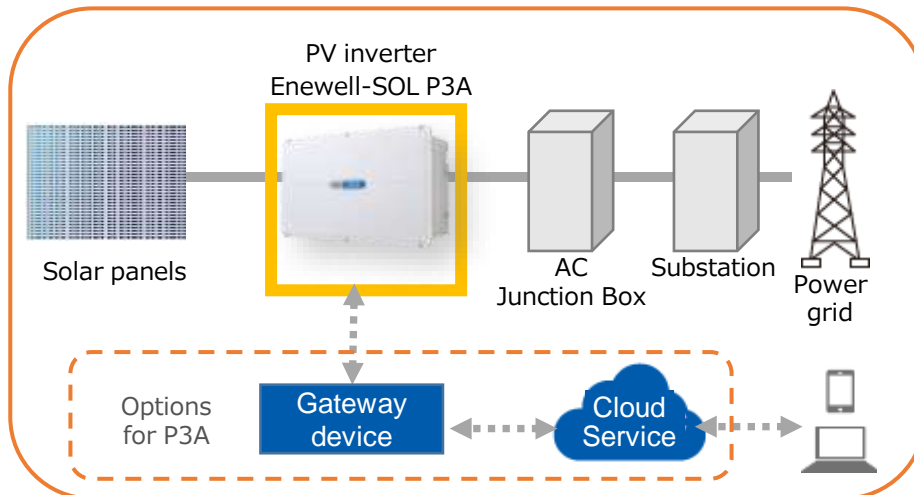
Enewell-SOL P2H

Insulation transformer integrated.

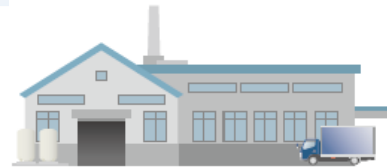
Good for
self-consumption



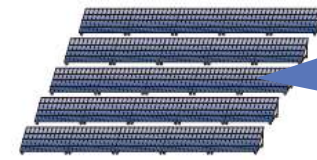
System configuration



For Medium and High voltage systems



Plant · Factory /
Self consumption/PPA



Mega solar (FIT/FIP)

The large system
scale reduce the
cost by increasing
the voltage.

25kW 200V class 3-phase

Enewell-SOL P3A

Optimized for self-consumption systems.
Helps slim down system footprint

Optimized for
self-consumption



10/9.9kW 200V class 3-phase

Enewell-SOL P2A

large-capacity system possible by
the distributed installation

Good for
self-consumption



65kW 400V class 3-phase

XGI1000

Contributes to total cost reduction



150kW 500V class 3-phase

XGI1500

Specialized to utility scale by largest output in class



Product Lineup (Social System Business_Water Treatment Plant)

Yaskawa supports the advanced operating management and maintenance management of social infrastructure including water treatment plant.

Main target facilities

Waterworks Facility



Sewerage Facility



Centralized Monitoring & Control Facility



Centralized Monitoring & Control Facility



Electric products for water supply and sewerage

Monitoring control



Human Machine Interface
CP-540

Power receiving and distribution
electricity self-generation



Medium-voltage
Enclosed
Switchboard

System Controller
CP-3550



Product Lineup (Social System Business _ Steel Plant)

Contributing to stable continuous operation with high reliability by providing dedicated control systems and electrical equipment that meet the needs of various facilities in steel plants

Key process

Features of the equipment

Application features/Yaskawa strengths

Blast furnace



Blast furnace



Control room

- The process of making hot metal from iron ore
- Stable operation and long-term continuous operation under adverse environment are required.

- ① **100% share of raw material charging control in Japan**
- ② **Stable production** of consistent quality pig iron in response to changes in the operating environment
- ③ High-reliability products and system redundancy enable **long-term continuous operation**

Continuous casting



Continuous casting equipment

- Step of solidifying molten iron from a blast furnace
- Stable operation is essential because equipment shutdowns have a major impact on operations.

- ① **Domestic market share: 50% or more**
- ② System redundancy and reliability design for **stable operation**
- ③ Implement **backup control** to prevent internal coagulation in case of trouble.

Process / cold rolling



Process line equipment



Cold rolling mill

- Final process of steel manufacturing process
- Continuously process connected steel plates (Surface processing, heat treatment processing, etc.)

- ① **High-precision and high-function line control** that makes the most of years of accumulated control technology
- ② High-precision control of steel plate speed, tension, slack, etc. by drive system
- ③ Large number of products delivered in Japan and overseas

YASKAWA