

Power Systems Business Plan

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President and CEO of Power Systems

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Mitsubishi Heavy Industries, Ltd.

- 1. Business Overview**
 - 1-1. Sales Overview**
 - 1-2. Management Structure**
 - 1-3. FY2018 Major Topics**
- 2. 2018 Medium-Term Business Plan Progress Status**
 - 2-1. Outlook**
 - 2-2. Review of FY2018**
 - 2-3. 2018 Medium-Term Business Plan Strategies and Measures**
 - 2-4. Individual Business Strategies**
 - 1. Clean Gas Power**
 - 2. Steam Power**
 - 3. Nuclear Power**
 - 4. Compressors**
 - 5. Aero Engines**
 - 6. Marine Machinery**
 - 7. Offshore Wind Turbines**
- 3. Looking to The Future beyond 2020 - What is our sustainable business ?**
 - 3-1. Global Power Market Trends**
 - 3-2. Long-Term Business Strategies**
- 4. Summary**

1. Business Overview

1-1. Sales Overview

1-2. Management Structure

1-3. FY2018 Major Topics

2. 2018 Medium-Term Business Plan Progress Status

2-1. Outlook

2-2. Review of FY2018

2-3. 2018 Medium-Term Business Plan Strategies and Measures

2-4. Individual Business Strategies

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2. Steam Power

3. Nuclear Power

4. Compressors

5. Aero Engines

6. Marine Machinery

7. Offshore Wind Turbines

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3-2. Long-Term Business Strategies

4. Summary

1-1. Sales Overview

Renewable Energy

- Offshore wind turbines*



MHI VESTAS OFFSHORE WIND

- Power plant generation pumps
- Chemical plant pumps
- Water jet propulsion systems



Nuclear Power

- Pressurized water reactors (PWR)
- Nuclear fuel cycle facilities



Pressurized water reactor

Rokkasho Reprocessing Plant

Marine Machinery

- MET Turbochargers
- Marine boilers & Steam turbines



MET Turbocharger

Clean Gas / Steam Power

- Gas turbine combined cycle (GTCC) systems
- Clean coal and integrated coal gasification combined cycle (IGCC) systems
- Aero-derivative gas turbines



Gas turbine



IGCC plant

- Geothermal power plants
- Environmental plants
- Organic Rankine Cycle (ORC) systems

Compressors

- For chemical plants
- For power plants
- For oil & gas applications

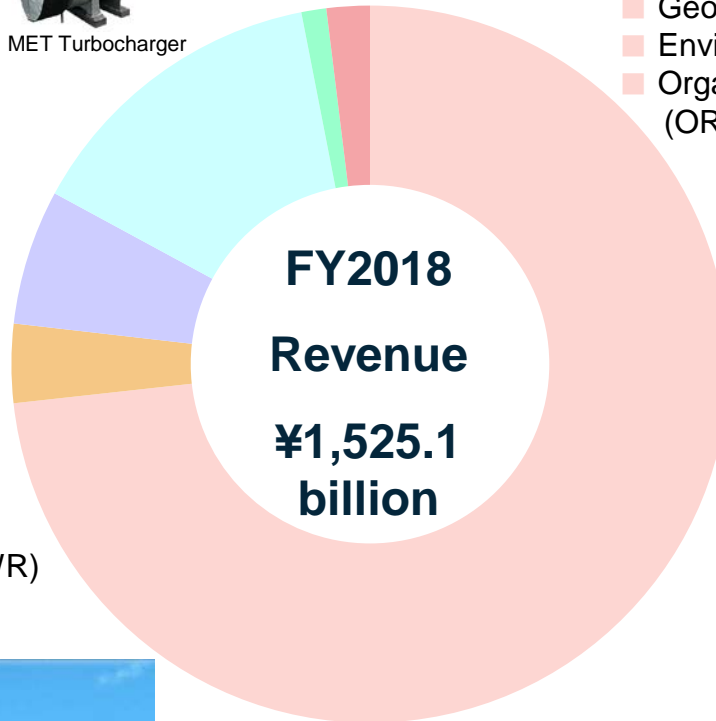


Aero Engines



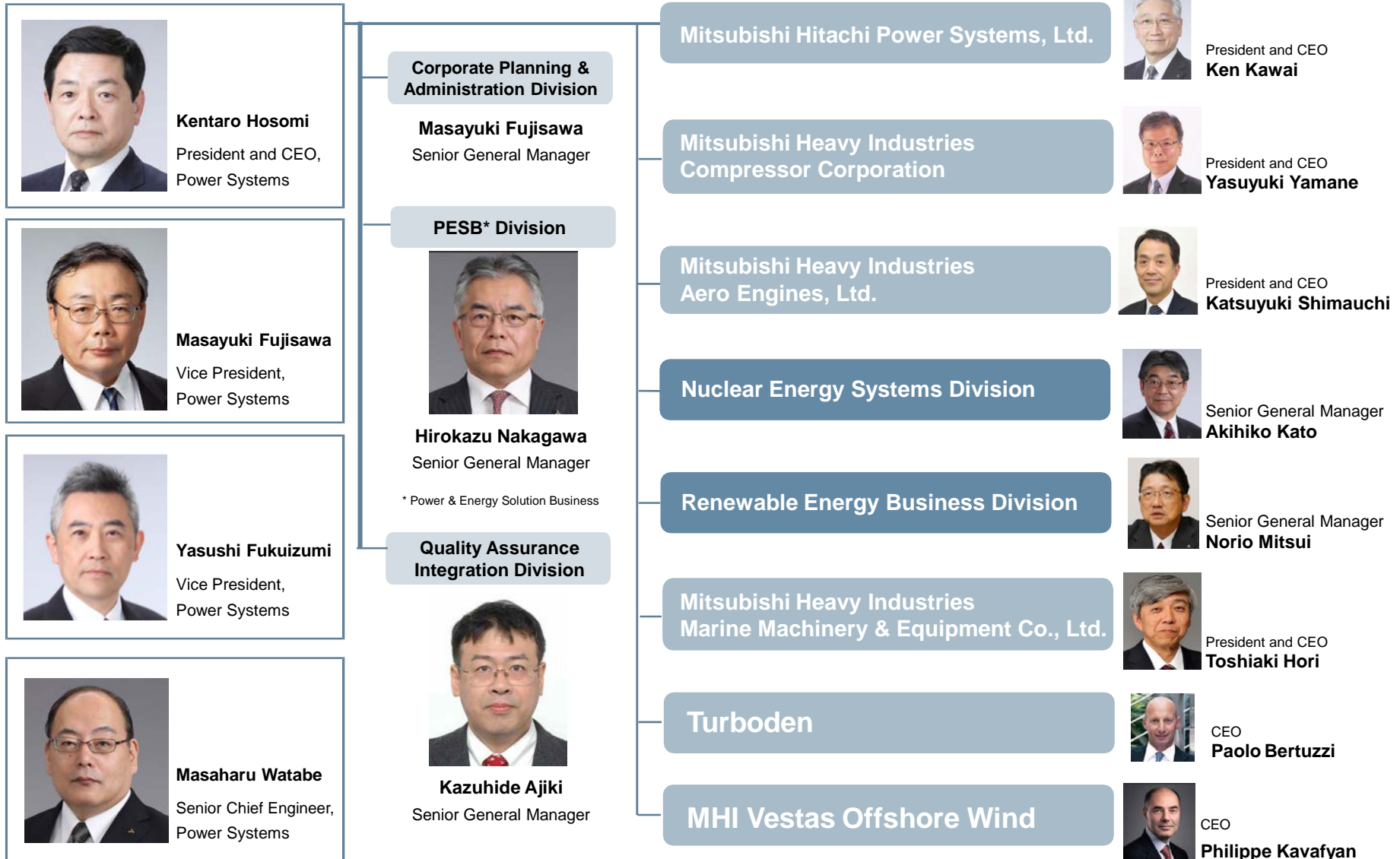
V2500

(photo courtesy of Japan Aero Engines Corporation)



* MHI Vestas Offshore Wind (MVOW), which handles operations in offshore wind power generation facilities, is not factored into the sales figure because it is an equity-method affiliate.

1-2. Management Structure



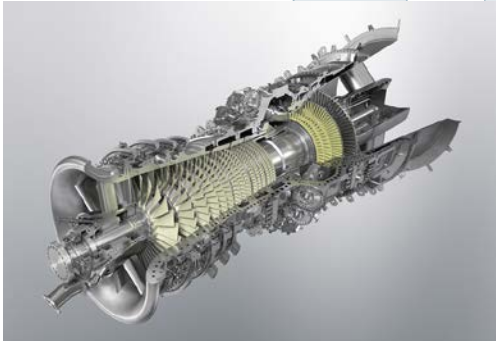
1-3. FY2018 Major Topics

JAC-Series Gas Turbines

Orders received: Thailand: 8 units US: 2 units

Heavy-Duty Gas Turbines

No.1 global market share (41%) in 100 MW and above class*



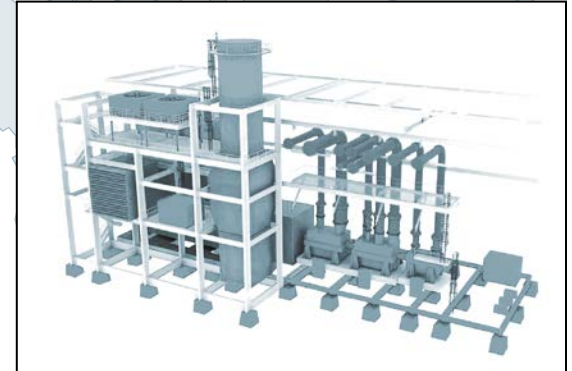
Offshore Wind Turbines

Order received for 100 units of V164-9.5 MW from Moray East, UK



H-100 Gas Turbine and Compressor Modular Package

Received technical qualification by oil majors



Flue Gas Desulfurization (FGD) Systems

No.1 global market share (61%)*



MET Turbochargers for Diesel Engines

Introduced small, lightweight, high-efficiency models into market



Aero Engines

Completed assembly of first domestically produced unit of new PW1200G for MRJ/SpaceJet



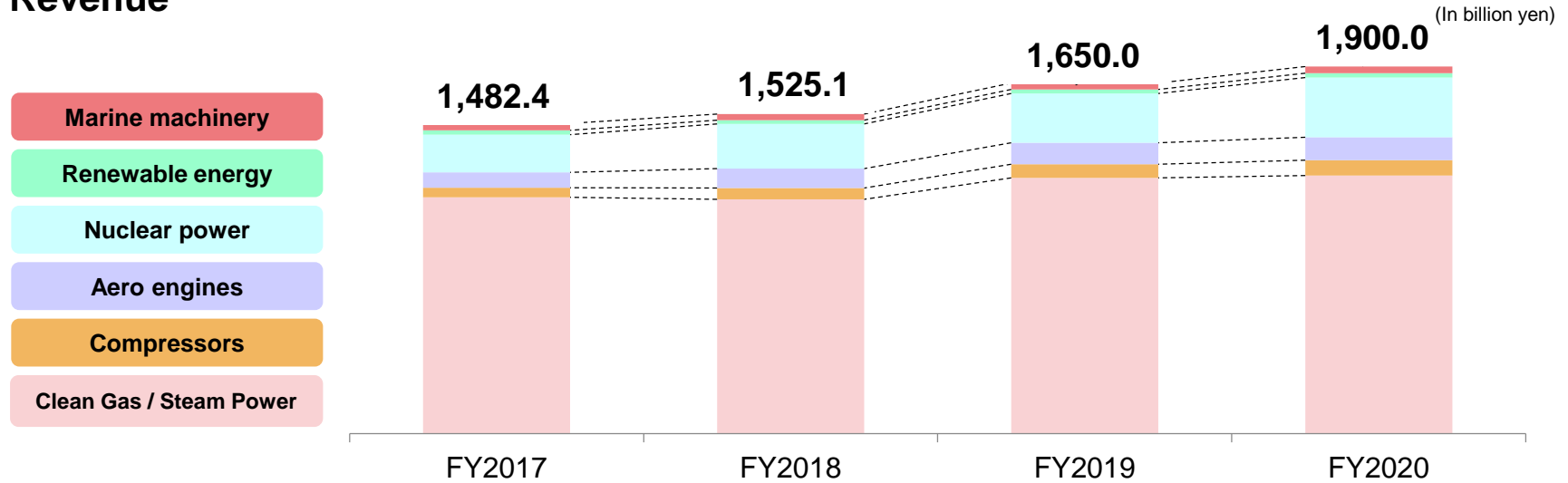
* According to data compiled by McCoy Power Reports

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 - 2-2. Review of FY2018
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 - 3-1. Global Power Market Trends
 - 3-2. Long-Term Business Strategies
4. Summary

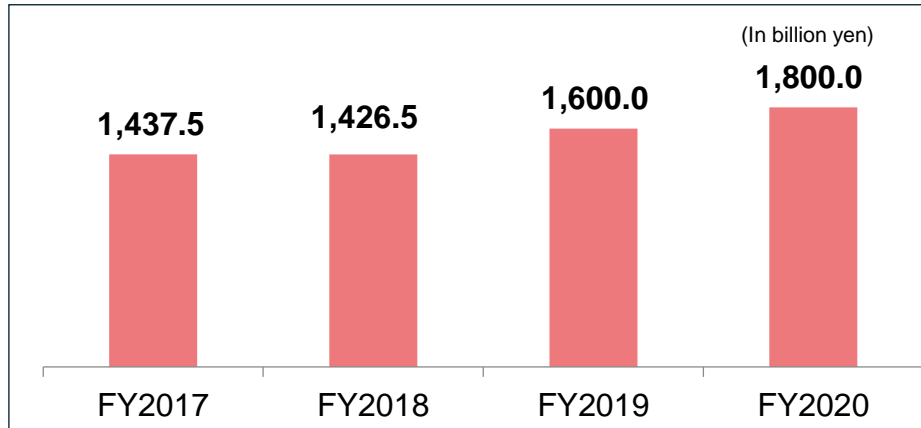
2-1. Outlook

■ Achieve 10% profit margin in FY2020 by fulfilling backlogged orders and optimizing resources, including reducing fixed costs and total assets

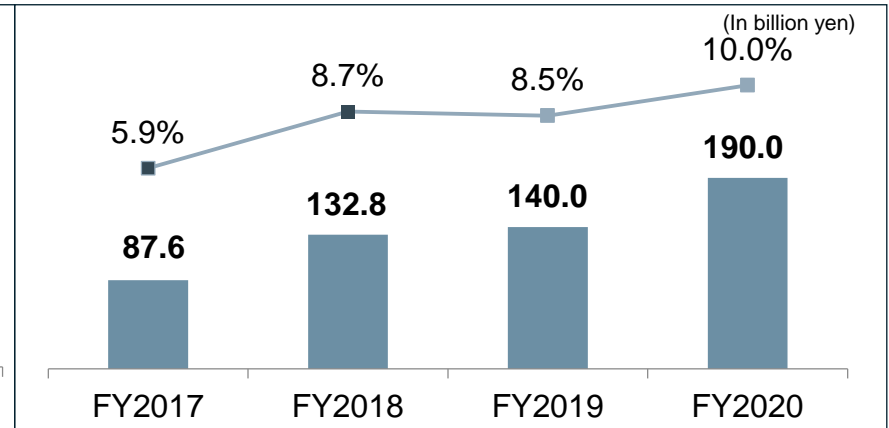
Revenue



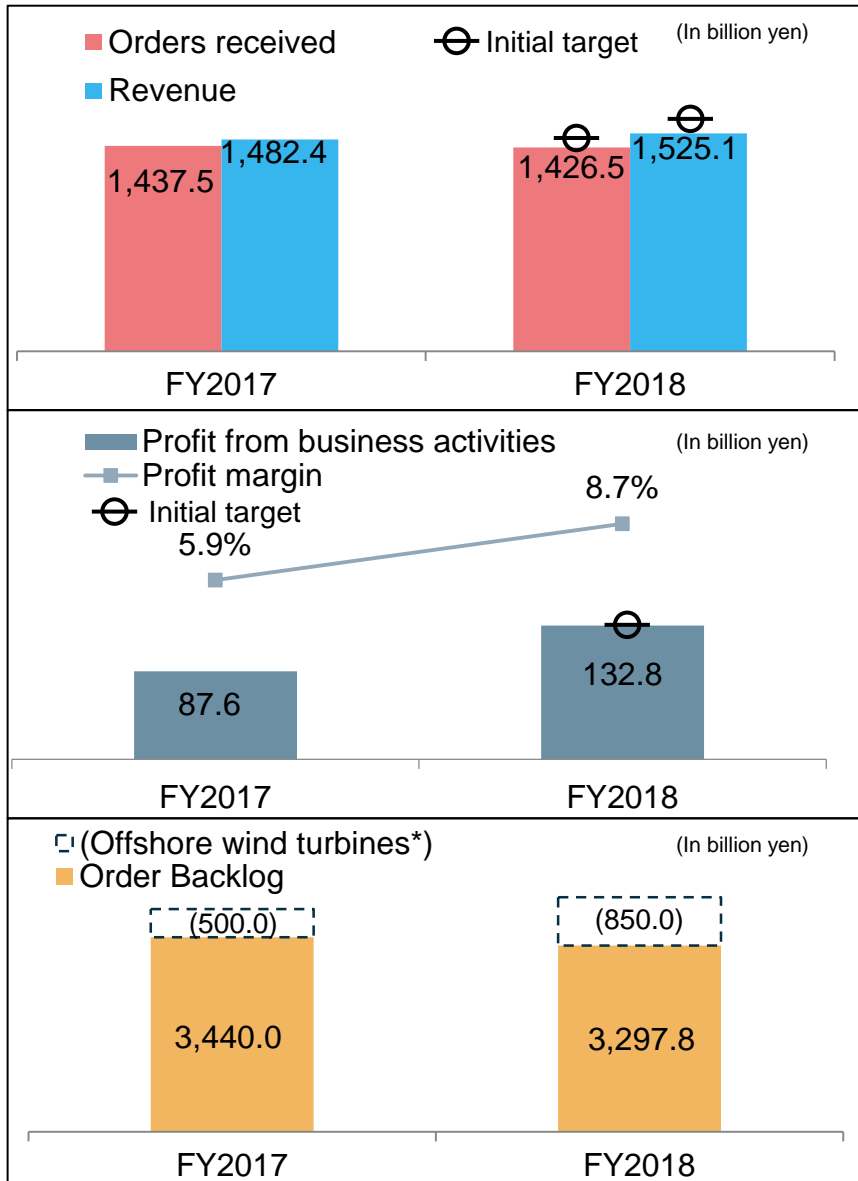
Orders Received



Profit from business activities



2-2. Review of FY2018



FY2018 Results

- **Maintained business plan (Order, Sales, profit) by recovering from the cancellation of a coal-fired project in Japan**
 - Increases in service business, compressors, etc.
 - Profit margin improved on squeezing and efficient management of assets
- **Secured No.1 market share in medium/heavy-duty gas turbines in a competitive market**
- **MVOW's market share expanded in growing offshore wind turbine market**
- **Order backlog reduced with good progress in constructing new plants**
 - Strategies to improve profitability:
 - Further expansion of service business
 - Increase share in growing products
 - Launch new businesses and solutions business
 - Accelerate structure conversion of steam power business (factory reorganization and resources shift)

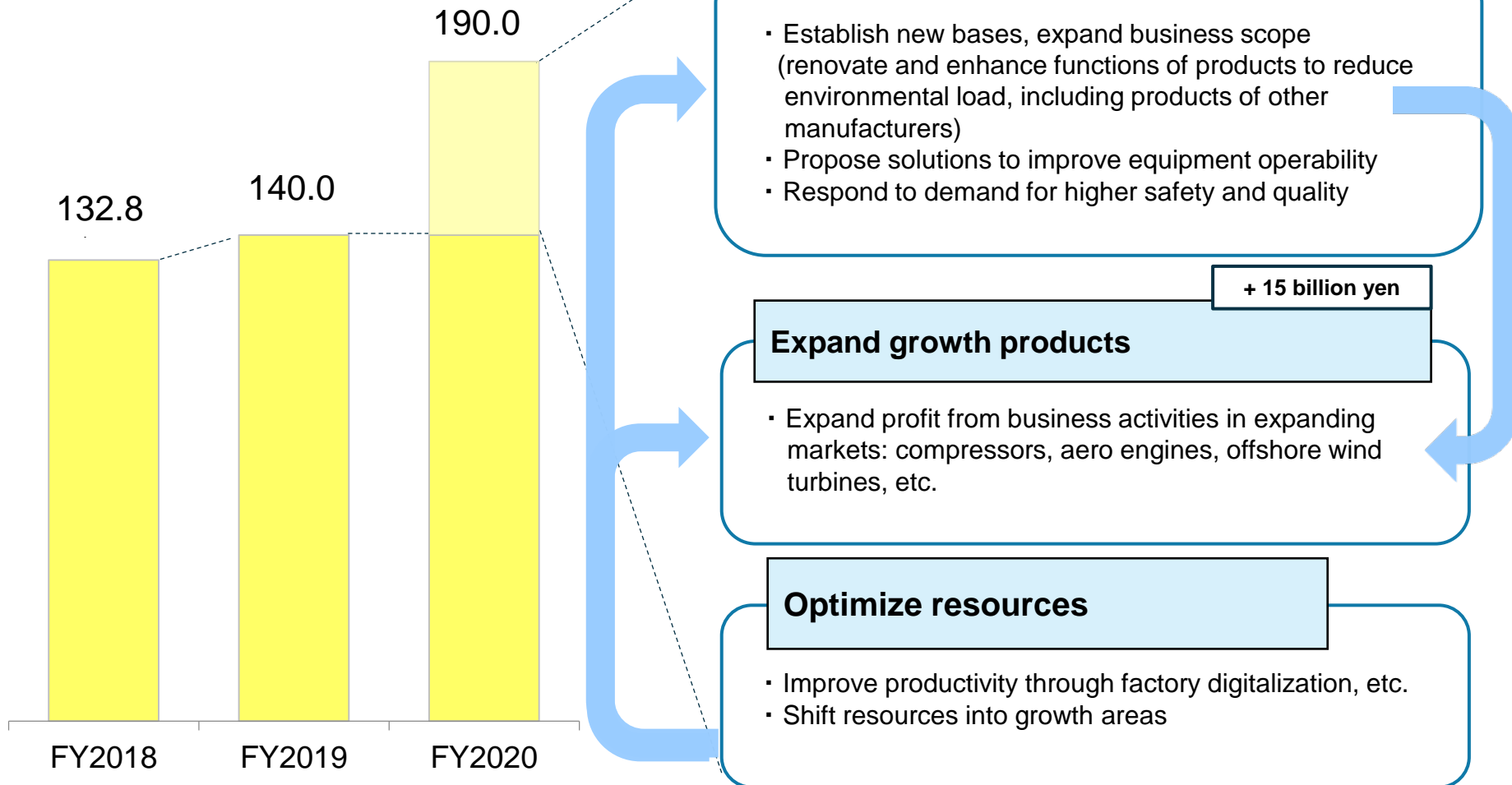
* Figures for offshore wind turbines are shown for reference purposes only. These operations are handled by MHI Vestas Offshore Wind (MVOW), an equity-method affiliate.

2-3. 2018 Medium-Term Business Plan Strategies and Measures (1/2)

- Measures for achieving 10% profit margin: expand service business, scale up growth products, optimize resources

Business profit

(In billion yen)



■ Strengthen the business foundation by expanding the service business and increasing share in growth products

Service business expansion

Solutions business



Environmental solutions

Gas / Steam Power

Heavy-duty, high-efficiency gas turbines (JAC Series), Low-emission solutions
Additional installations of environmental systems

Nuclear power

Comprehensive support for restarting of domestic plants
Installing severe accident management facilities

Marine machinery

Provide solutions for tightening SOx regulations

Market expansion

Aero engines

Expansion of MRO* business



Compressors

Improvement and expansion of service network

* MRO: Maintenance Repair and Overhaul

Expand service business through business growth

Business expansion of growth products

Reinvesting into growth products generated from service business

Clean Gas / Steam Power

Expand business in small/medium gas turbines (for driving compressors for LNG main engines, rapid start-up models)
Establish mass production ability of SOFC

Compressors

Expand sales to US gas processing compressors (strengthen MCO-I)

Aero engines

Expand and improve ability to manufacture parts for A320neo (PW1100G-JM)

Marine machinery

Expand market share in turbochargers for four-stroke marine engines

Offshore wind turbines

Strengthen mass production ability; enter US, Taiwan and Japan markets



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2-4-1. Clean Gas Power

Business Environment

- Solid market expected over medium to long term with expansion of the LNG market
- Realizing a low carbon society together with renewable energies
- Eventual shift to a carbon-free society

Results and Strategies

Expand market share in Heavy duty gas turbines

■ Heavy-duty gas turbines

Results: Orders increased: 6 units in FY2017 → 13 units in FY2018

- JAC series achieved 64% efficiency (70% CO₂ reduction), 27 orders / LOI received

Strategy: Technology development to further reduce environmental load

- Efficiency improvement, higher temperatures technology application
- Product development responding to low-carbon society (hydrogen-powered gas turbine, etc.)

■ Small/medium scale gas turbines

Results : Orders increased : 2 units in FY2017 → 18 units in FY2018

- Distributed generation systems, cogeneration (H Series)
- Mobile trailer system: (aero-derivative MOBILE PAC®, Easy installation and startups.)

Strategy: Sales expansion with multiple applications

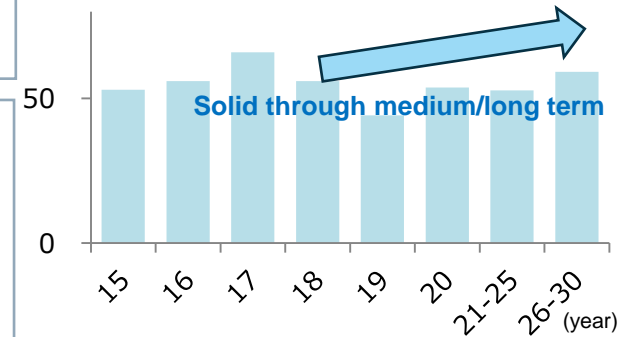
- Renewable adjusted flexible operation, distributed generation, compressor driven, floating power generation facilities

■ Solutions services

Results: Taiwan PJ Renovation of existing plant (Low NOx, efficiency and output improvement, plant optimization with MHPS-TOMONI)

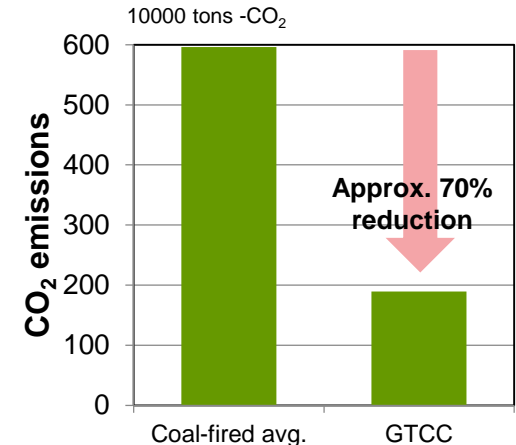
Egypt PJ: Renovation of existing plant (Efficiency and output improvement, reliability enhancement for long term operations.)

Scale of Market for New Gas-fired Power Plants (GW/year)



Source: 2015-18 results : McCoy Power Reports 2018
From 2019 (adjusted to order placement basis)

CO₂ Reduction (1,000MW class)



In 1,000 MW class (Approx. 1.7 million households), reduces CO₂ equivalent to 3 million vehicles

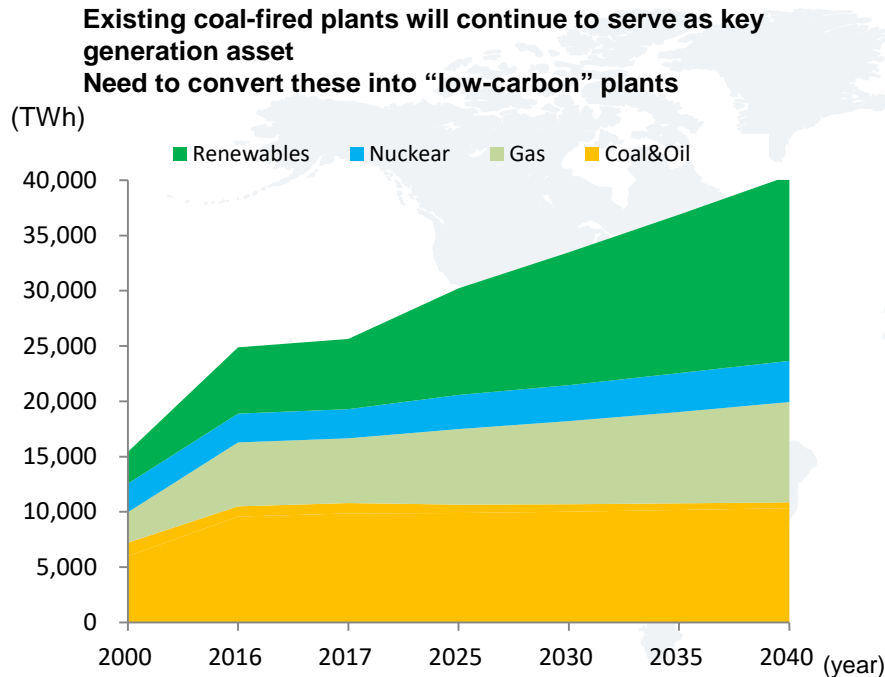
Source: World Energy Outlook 2018, and MHPS data

2-4-2. Steam Power (1/2)

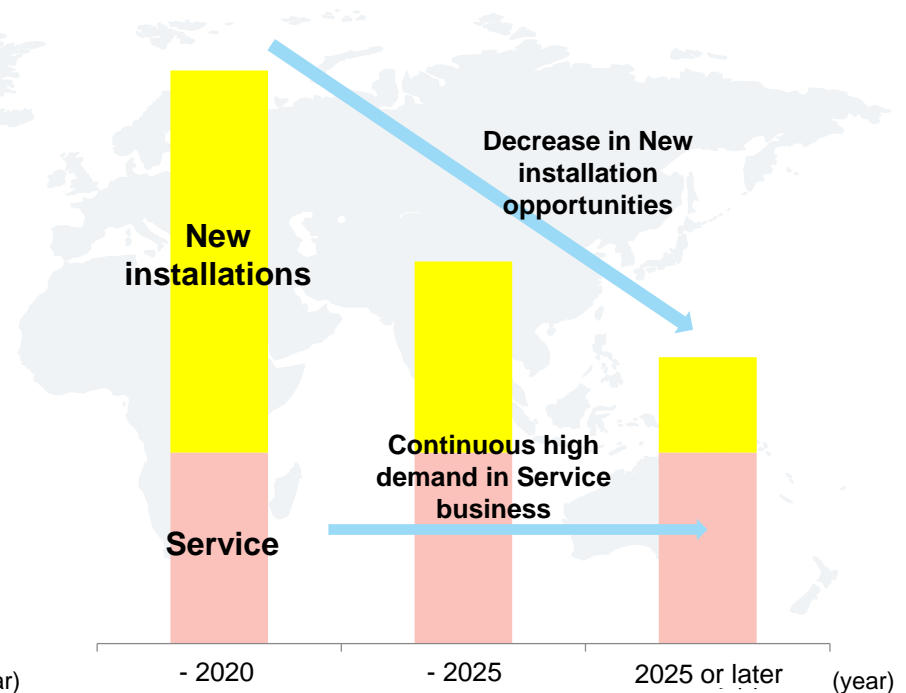
Business Environment

- New build market for coal plants is shrinking. Global trend toward low-carbon and carbon-free societies.
- Demand still remains for emerging countries with energy security needs.
- Strong demand for modernizing existing plants reducing CO2 and other environmental emissions.
- Increased interest in Biomass and Geothermal as renewable energies.

Breakdown of global power generation (TWh)



Steam Power business outlook (Revenue)



2-4-2. Steam Power (2/2)

- Adjusting to market trend (fixed cost reduction / reorganization shifting to services)
- Solution based business responding to low-carbon society

■ Optimize resources for post 2021

[PMI progress at MHPS]

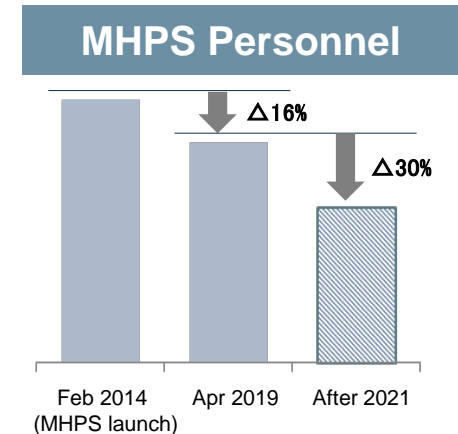
- Domestic: Steam turbines → consolidation to Hitachi Works
Boilers → Nagasaki and Kure Works unified operation
- Overseas: Reorganization adjusting to business scale
(Downsize in China, Europe, Australia, etc.)

[Shifting resources]

- Shifting to services.
- Reallocating to other MHI Group businesses
- Optimizing manpower through shift to digital factories

■ Provide solutions for low-carbon market

- Expand AQCS business (2018 No.1 global market share in FGD)
- Cutting-edge technologies (IGCC, high-efficiency USC, CCS/CCUS)
and environmental solutions (AQCS, FGD)
(Boiler rehabilitation life extension, steam turbine efficiency improvement, environmental systems additions, etc.)
- AI / IoT solutions (MHPS-TOMONI)
(O&M cost reduction and fuel cost reduction through operation optimization,
longer inspection intervals, reduction in manpower through remote monitoring services,
supporting optimized O&M resources.)



2-4-3. Nuclear Power

Business Environment

- Nuclear power is evaluated globally as an important base load power source as it can contribute to reduce CO2 emissions.
- In order to assure the long-term and continuous operation of nuclear power plants, establishing the nuclear fuel cycle is strongly desired.

Results and Strategies

As a leading company in the nuclear power industry in Japan, MHI is helping solve energy issues by maintaining and developing outstanding technologies of our own that will respond to long-term needs.

1) Light water reactor O&M Service

- Steady implementation to comply with new regulations
- Supporting the early completion of severe accident management facilities
- Expanding maintenance work to enable safe and stable operation for 60 years

2) Nuclear fuel cycle

- Supporting on schedule completion of reprocessing facilities and MOX fuel plants
- Proposing maintenance work to enable safe operation after completion (collaboration with Orano)

3) New-build and future reactors

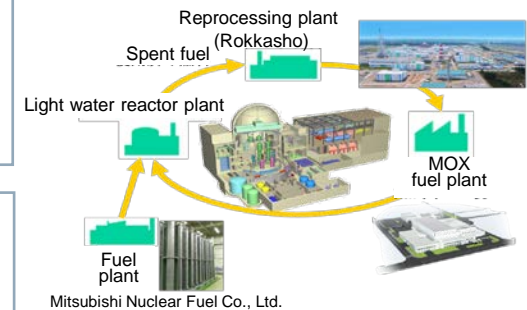
- Developing new reactors with enhanced safety for upcoming new-build projects
- Developing future reactors such as fast reactor, small-modular reactor, high temperature gas cooled reactor

4) Decommissioning initiatives

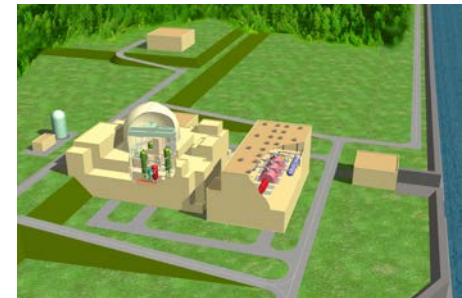
- Supporting the decommissioning of light water reactors using technologies as a plant supplier
- Focusing on technology development for core debris removal from Fukushima Daiichi plant to enable stabilization

MOX: Mixed OXide fuel

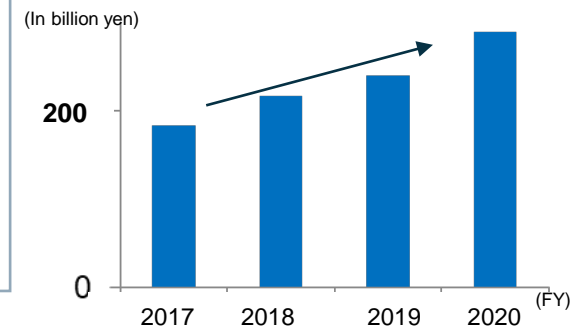
Cover All Processes of Nuclear Power Industry



Conceptualization of Safe Reactor (future plant)



Business Scale (Revenue)



Business Environment

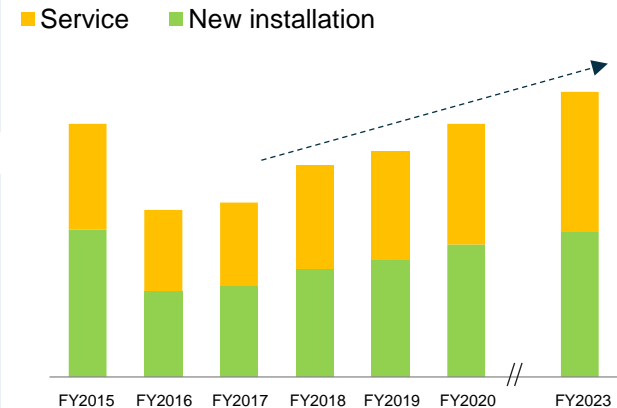
- Market scale will sustain expansion through the long term. In FY2018, investments were brisk especially in the field of ethylene
- Maintaining the top market share in petrochemicals

Results and Strategies

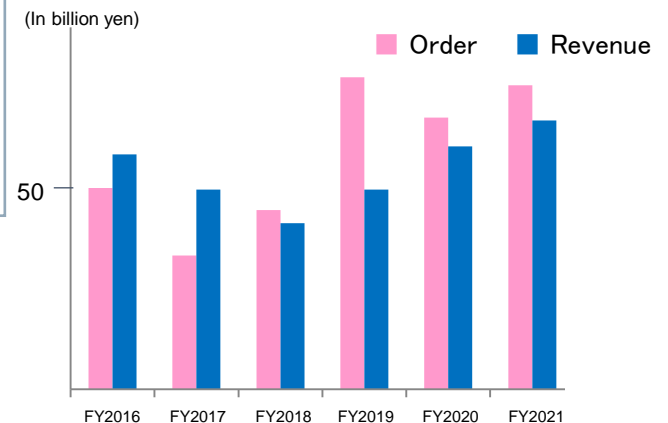
- In the promising oil & gas market, expand compressor train sales by collaborating with MHPS gas turbines
- To respond quickly to US demand for gas processing plants, currently investigating introducing test stand into our US shop and building a fully integrated local production system
- Expand service business
 - Expand and improve service bases (Americas, Middle East, Asia)
 - Strengthen solutions business response (remote monitoring)



Market Scale of Compressor Business



Business Scale (Order / Revenue)



2-4-5. Aero Engines

Business Environment

- Growth market sustained by robust aircraft demand. Over next 20 years, demand for approx. 83,000 engines (¥130 trillion)
- Broad participation in new fuel-efficient, low-noise engine business (PW1100G, Trent, etc.), contributing to reducing environmental load
- MRO business to become ever more brisk, driving market expansion

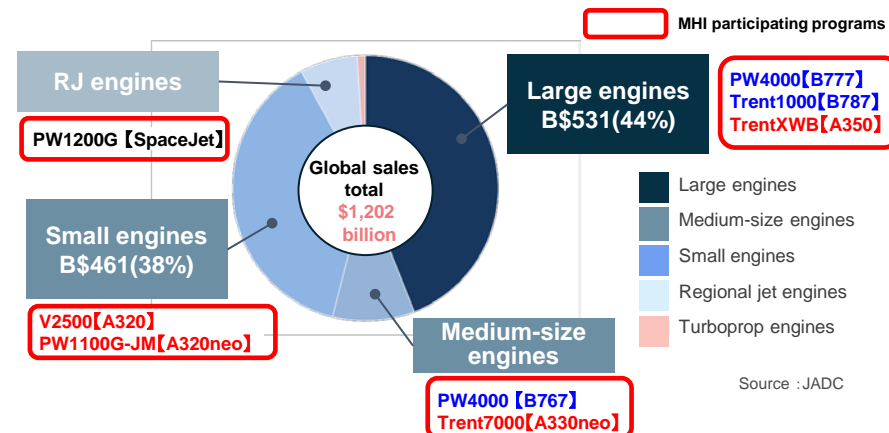
Results and Strategies

- Strengthen facilities and personnel in response to business expansion
 - ⇒ Mobilizing Groupwide resources,
 - Increase production of parts
 - Launch MRO business for PW1100G-JM installed in A320neo
- Expand business areas utilizing technological synergies within MHI group
 - ⇒ - Expand participation in development through deeper collaboration with OEMs (P&W, RR)
 - Expand business areas further by establishing and commercializing parts repair technologies

MRO: Maintenance Repair & Overhaul QCD: Quality, Cost, Delivery
 OEM: Original Equipment Manufacturer P&W: Pratt & Whitney
 RR: Rolls-Royce

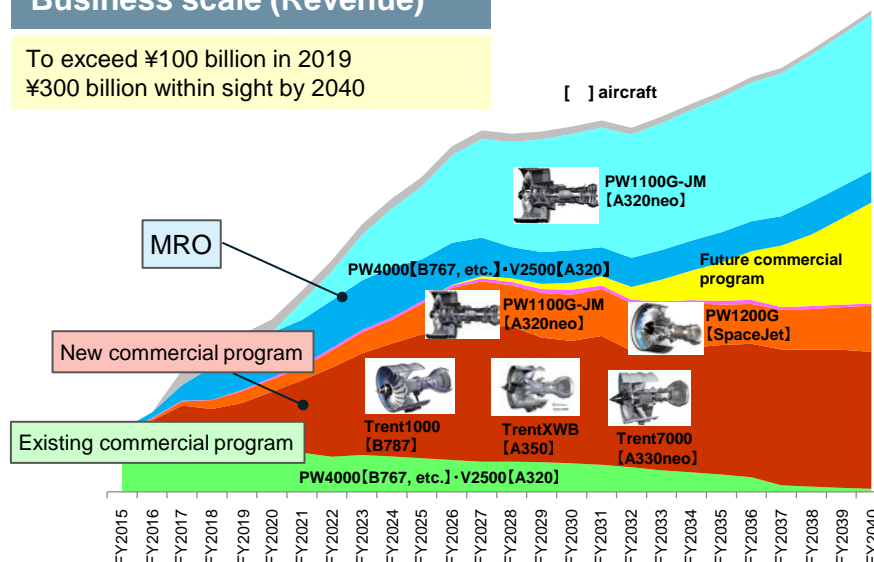
Market Scale and Growth Potential

Over next 20 years, demand for approx. 83,000 engines totaling ¥130 trillion



Business scale (Revenue)

To exceed ¥100 billion in 2019
 ¥300 billion within sight by 2040



2-4-6. Marine Machinery

Business Environment

- New shipbuilding market recovering since bottoming out in 2016
- Maritime environmental regulations (SOx, CO2) tightening
- Engine market for turbochargers growing steadily

Results and Strategies

- Develop new types of turbochargers* to expand business. Capture new customers in Europe and China.
- In service business, orders are robust for boiler fuel conversion work responding to tightened SOx emissions regulations.
- Together with customers, currently using digital technologies to develop new technologies for substantially reducing CO₂ emissions. Focus on applying other area products and technologies to marine machinery, with sales support. (SOx scrubbers, gas fuel supply systems, deck machinery, water jets, etc.)

* Features of new turbochargers:

- 1) **MET-MB II** (axial-flow turbocharger for 2-stroke engines)
Turbocharger downsized by increasing air flow volume (+16%)
- 2) **MET-ER** (radial turbocharger for 4-stroke engines)
Compact size and fewer parts (-30%)
High pressure ratio response and high response

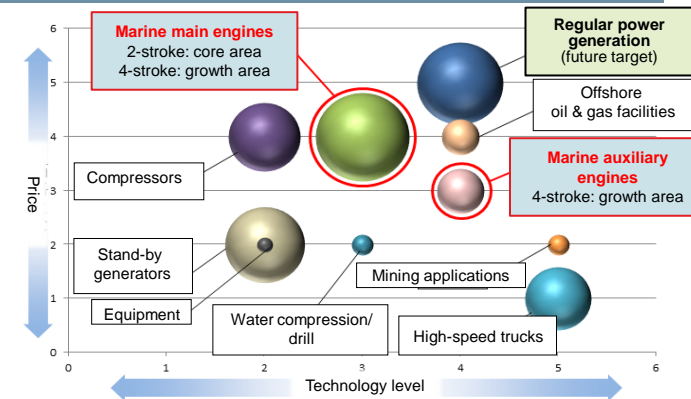
MET-MB II



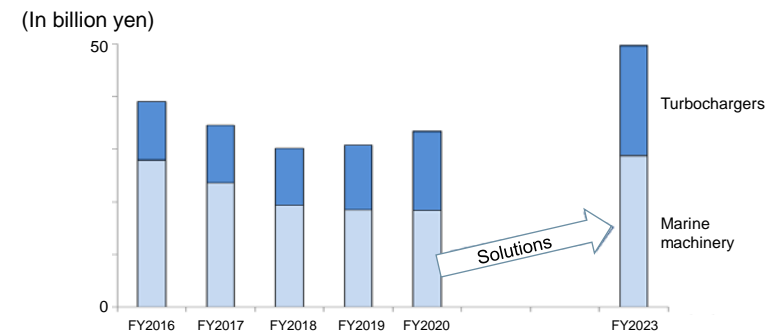
MET-ER



Turbocharger Market Structure and Targets



Business scale (Revenue)



2-4-7. Offshore Wind Turbines

Business Environment

- Offshore wind turbine market growing faster than anticipated
- Market expected to expand from current focus on Europe first to North America, then Asia (Taiwan, Japan, India, Vietnam, etc.) and other regions (approx. 4-6GW/year)
- Entered offshore wind market in April 2014 upon establishing MVOW with Vestas
- Market share increasing steadily; order backlog and preferred supplier as of FY2018-end totaled 8.7GW

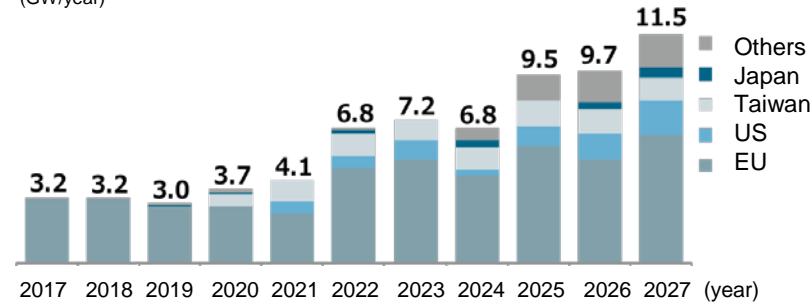
Results and Strategies

- Respond to market expansion by strengthening mass-production systems
 - Launch world's largest turbine: V174-9.5MW
 - Establishing bases and developing markets in Japan, Taiwan, US
 - Strengthen support from MHI
 - 1) Engineering support (production, control, development, etc.)
 - 2) Support development in US, Asia



Offshore Wind Turbine Market (excluding China)*

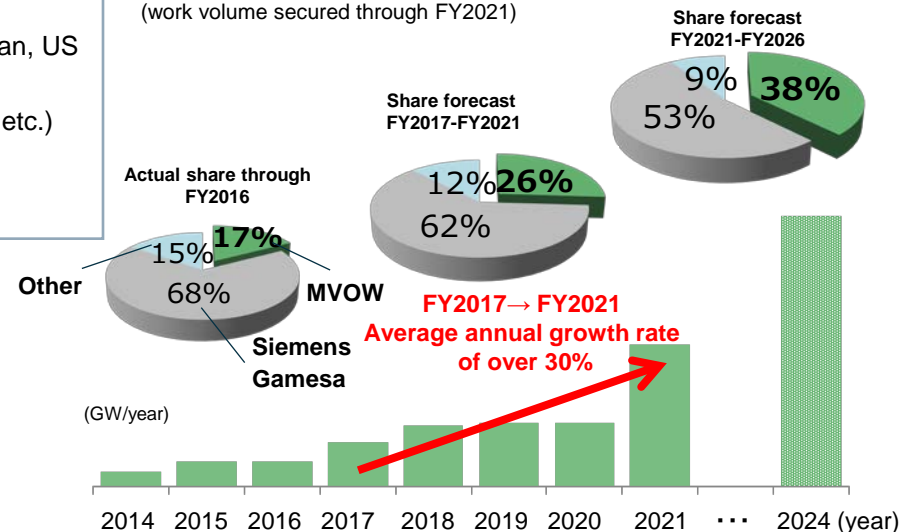
(GW/year)



Revenue and Market Share

Business scale projected to expand significantly

(work volume secured through FY2021)

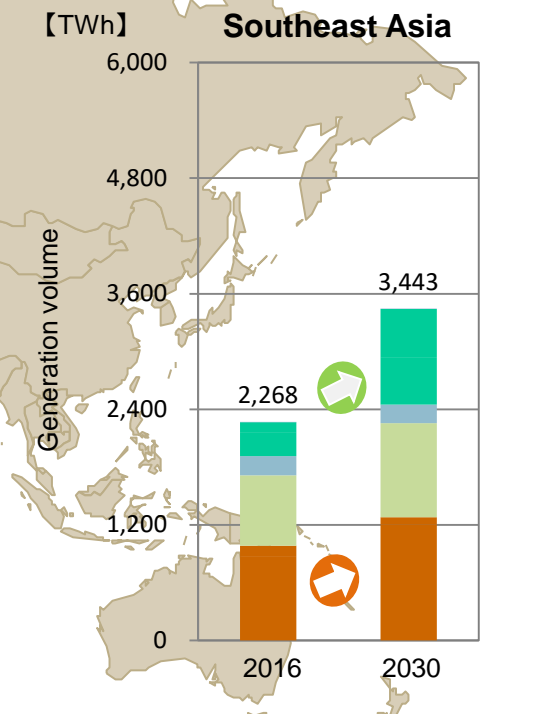
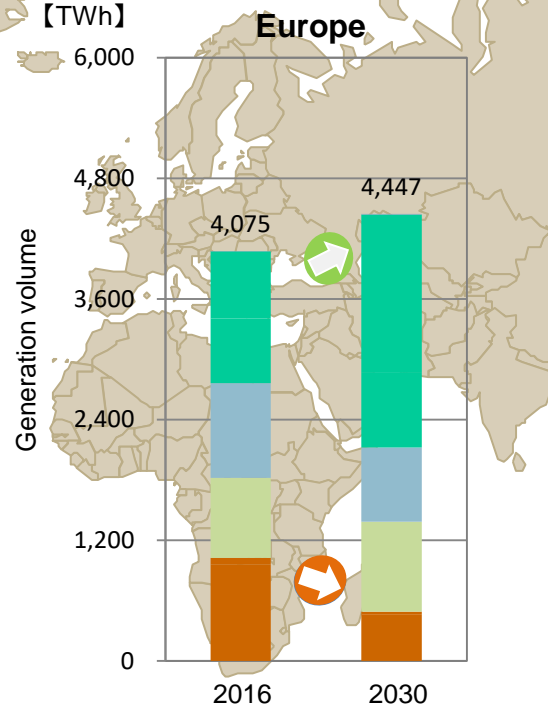
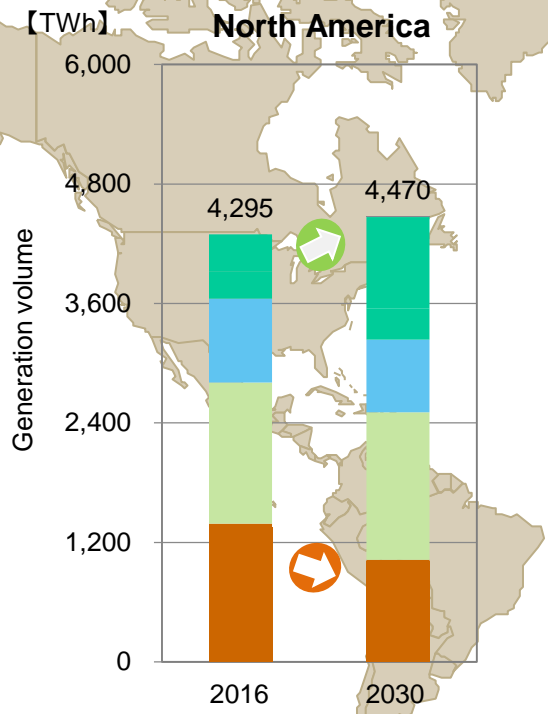


Source : Wood Mackenzie (installation basis/year)

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 - 2-4. Individual Business Strategies
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 2. Steam Power
 3. Nuclear Power
 4. Compressors
 5. Aero Engines
 6. Marine Machinery
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4. Summary

3-1. Global Power Market Trends (1/2)

■ Power demand will continue to grow worldwide. (2016: 24,919TWh → 2030: 33,510TWh)
 [US/Europe] Carbon-free → Electrification [Southeast Asia] Power demand increase driven by economic growth
■ Generation method Share of renewable energy will increase worldwide, gas and nuclear remain solid
 [US/Europe] Coal retiring [Southeast Asia] Coal remaining one of major power sources



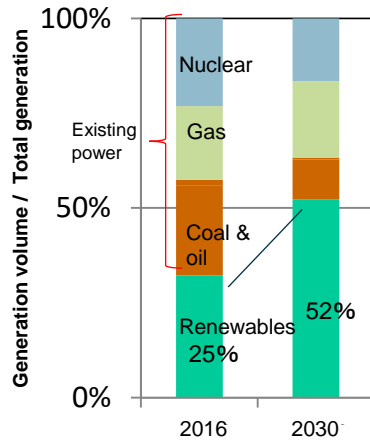
■ Renewables (including hydro)
 ■ Coal & oil
 ■ Gas
 ■ Nuclear

Source : World Energy Outlook 2018

3-1. Global Power Market Trends (2/2)

- Although power demand will grow worldwide and renewables will increase, there is a limit to responding to today's demand with renewables alone
- Gas will play a key role as a backup power source complementing renewables, and nuclear as a baseload source

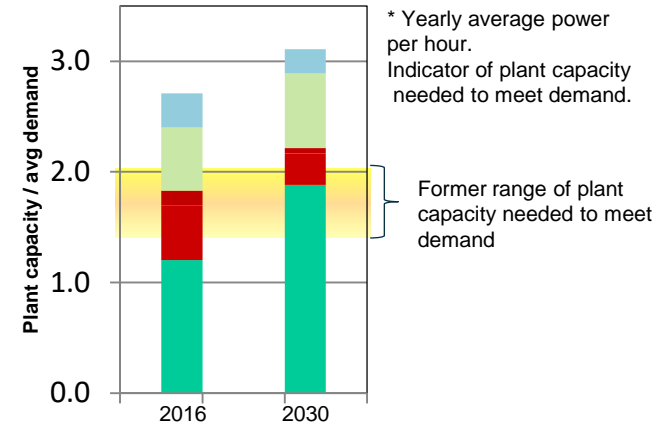
Power breakdown (%)



Generation volume, Average capacity factor

	Generation volume	2016	2030
Solar	↗	12%	13%
Wind	↗	23%	30%
Coal	↘	48%	37%
Gas	↗	34%	30%
Nuclear	↘	74%	76%

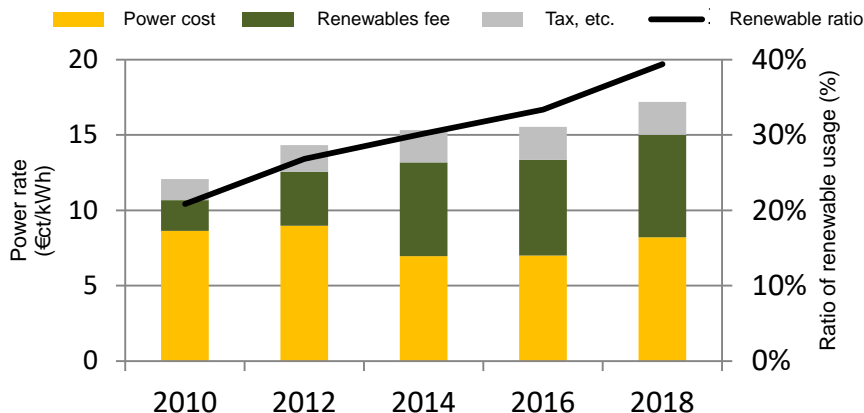
Plant capacity / avg annual power*



Source: From WEO2018

Europe

Increase in power rate (industrial) in Germany with introduction of renewables



As ratio of renewable energy usage, which has a low capacity factor, increases, facilities to meet power needs (kW) become excessively necessary. (Challenges: rising power rates, power excess, etc.)

Expanding demand for technologies to sustain renewable power generation: load adjustment, baseload power supply, etc.

Realize sustainable society by providing balanced energy infrastructure

Supply side solutions



Key Index Approach

Demand side solutions

Stable supply of affordable and less CO2 emissions power source

Increase efficiency and improve operability as baseload power supply



High-efficiency GTCC X



IGCC X



Nuclear



Hydrogen gas turbine

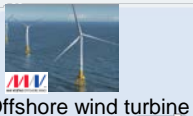


CCS/CCUS

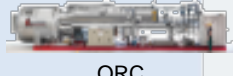


Future reactors (high-speed, compact, high-temperature gas)

Combination with renewable energy, support technologies



Offshore wind turbine



ORC



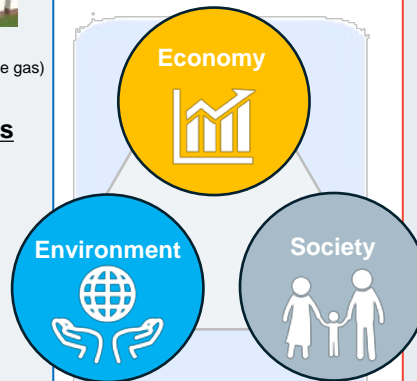
Rapid start-up gas turbine



ESS/Energy Storage



Providing well-balanced, high-quality energy infrastructure



Improve productivity and lower energy consumption and costs

Improve factory productivity



Achieve visibility and energy saving



Sign detection



Demand forecasting

Demand side management



DR/VPP



Utility packages



EMS

Reduce environmental load and utility costs



O&M, asset management



Overall optimization



Infrastructure adoption



Technology strength

X

AI IoT

X

Workplace strength



ESS: Energy Storage System DR: Demand Response VPP: Virtual Power Plant EMS: Energy Management System

Propose “high-quality energy infrastructure” which realizes sustainable urban development from the planning stage, using the Key Index Approach (QoEn)

Society

- Employment per GDP
- Health, Education
- Public sector efficiency ratio
- Electricity usage
- Etc.

Economy

- Power rates, Demand
- Network stability
- Digitalization
- R&D investment
- Etc.

Environment

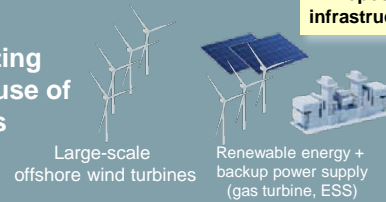
- CO₂ emissions
- Energy consumption
- Renewable energy ratio
- Recycling ratio
- Etc.

Indication of direction of high-quality energy infrastructure “Quality of Energy”



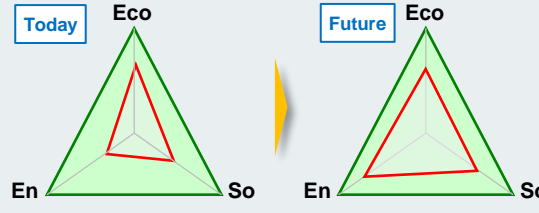
Case 1

Area targeting expanded use of renewables



Proposed infrastructure

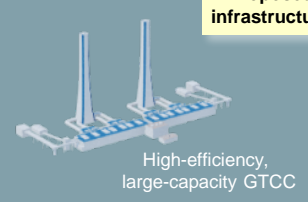
Using backup power supply, realize renewable usage and lower power rates



Eco: Economic indicator En: Environmental indicator So: Social indicator

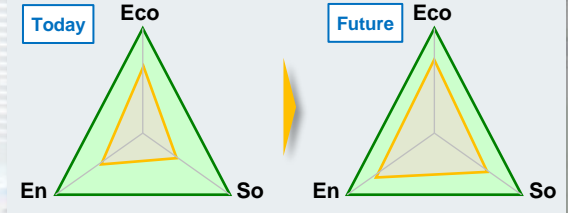
Case 2

Area targeting effective use of resources



Proposed infrastructure

Using a high-efficiency power supply, realize stable supplies and reduced environmental burden



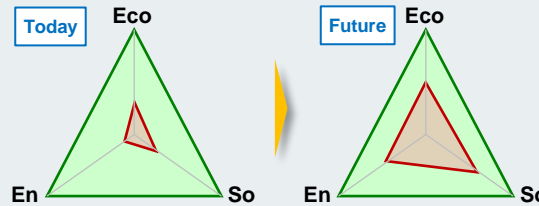
Case 3

Area targeting simultaneous economic growth and clean environment



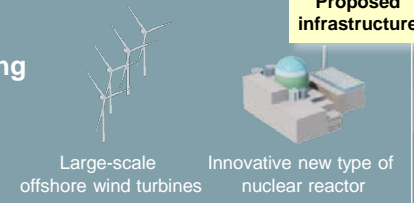
Proposed infrastructure

Using a high-efficiency power supply, realize stable supplies and reduced environmental burden



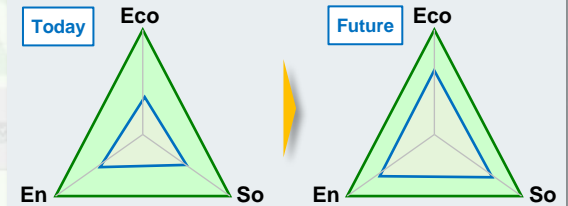
Case 4

Area lacking resources



Proposed infrastructure

Using CO₂-free power supply, contribute to higher energy self-sufficiency



QoEn and related logos are filed for trademark registration.

- 1. Business Overview**
 - 1-1. Sales Overview
 - 1-2. Management Structure
 - 1-3. FY2018 Major Topics
- 2. 2018 Medium-Term Business Plan Progress Status**
 - 2-1. Outlook
 - 2-2. Review of FY2018
 - 2-3. 2018 Medium-Term Business Plan Strategies and Measures
 - 2-4. Individual Business Strategies
 1. Clean Gas Power
 2. Steam Power
 3. Nuclear Power
 4. Compressors
 5. Aero Engines
 6. Marine Machinery
 7. Offshore Wind Turbines
- 3. Looking to The Future beyond 2020 - What is our sustainable business ?**
 - 3-1. Global Power Market Trends
 - 3-2. Long-Range Business Strategies
- 4. Summary**

4. Summary



MOVE THE WORLD FORWARD

**MITSUBISHI
HEAVY
INDUSTRIES
GROUP**

Reference Materials

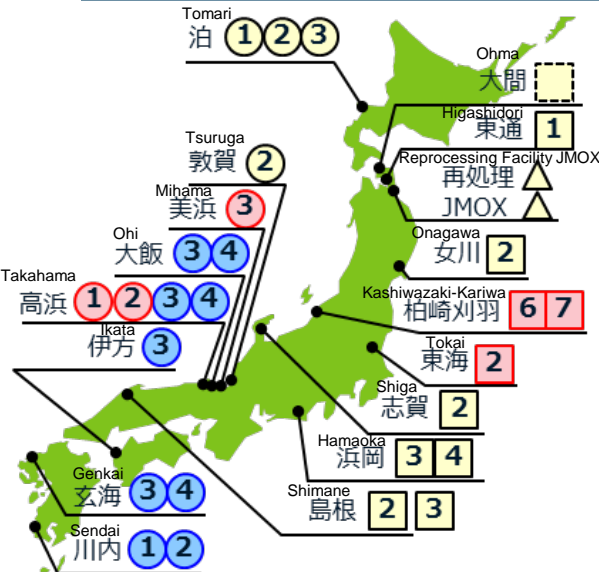
Nuclear Power Business

- 1) Light Water Reactor O&M Service Initiatives
- 2) Initiatives for Nuclear Fuel Cycle Activities
- 3) Initiatives for New-built and Future Reactors
- 4) Decommissioning Initiatives

1) Light Water Reactor O&M Service Initiatives

- Compliance with new regulatory standards for PWR plants is proceeding smoothly, with 9 units already restarted
- Installing severe accident management facilities for restarted plants and maintenance work to enable 60 years of operation are moving steadily forward
 - ⇒ In the case of severe accident management facilities, MHI supports power companies, considering/promoting process shortening
- To achieve stable energy supply in Japan, BWR plant restarts are also recognized necessary
 - ⇒ In response to the requests from BWR utilities, MHI is providing supports in available area based on the experience in PWR plants
- Also respond to component export projects, to maintain our technological capabilities

Reactor restarts



BWR: In operation Installation authorized
 PWR: In operation Installation authorized
 Reprocessing-related: Under deliberation Under deliberation

PWR: Pressurized Water Reactor BWR: Boiling Water Reactor

Maintenance Work Examples



Steam generator replacement



Core structure replacement

2) Initiatives for Nuclear Fuel Cycle Activities

- To reduce excess plutonium and maintain the nuclear fuel cycle, on time completion of Rokkasho Reprocessing Plant (RRP) and MOX Fuel Fabrication Plant (J-MOX) are necessary
- As a core company of both projects, taking the lead in supporting Japan Nuclear Fuel Ltd. (JNFL)
- Applying knowledge of Orano (France), into which MHI has invested, proposing extended maintenance programs that will contribute to stable operation after completion

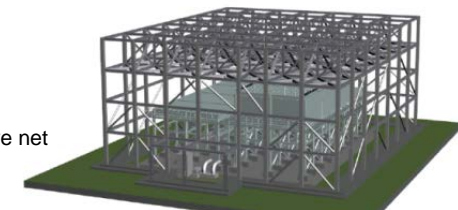
[Examples of requirements of new regulations]

	2018	2019	2020	2021	2022	2023	2024~
RRP	Work for compliance with new regulations				▼ Completion (1st half of FY2021)		
	(seismic strengthening, emergency response headquarters, etc.)					Inspection / Repair / Operation support	
J-MOX	Work for compliance with new regulations				▼ Completion (1st half of FY2022)		
						Inspection / Repair / Operation support	

1) New emergency response headquarters (conceptual rendering)



2) Cooling tower tornado-resistant measure (protective net)

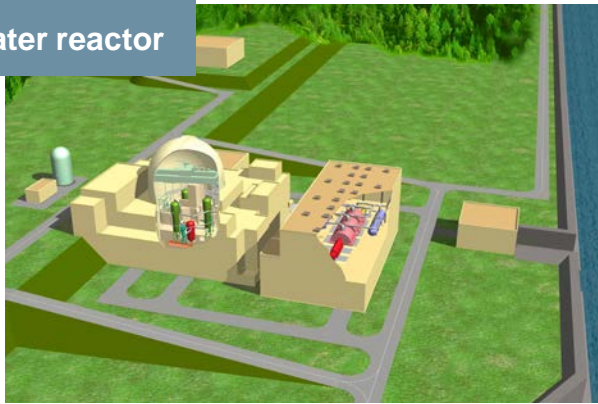


Framework for protective net

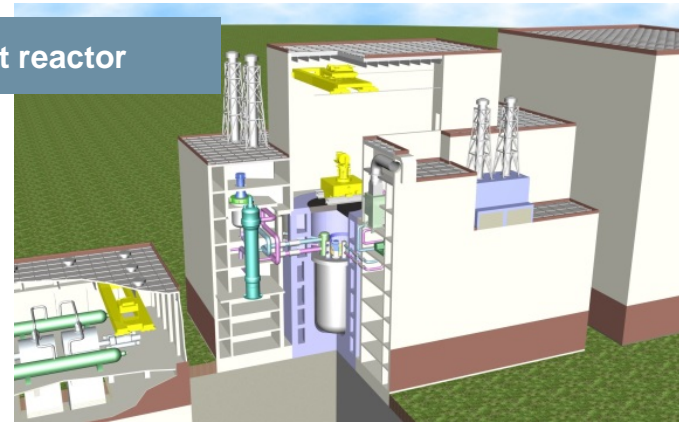
3) Initiatives for New-build and Future Reactors

- Started developing a new concept in order to realize enhanced safety for new-build light water reactors
- Accelerate to develop the design of innovative future reactors* such as fast reactor, small-modular reactor and high-temperature gas-cooled reactor
- For overseas markets, collaborate with EDF of France in consideration of its economical feasibility

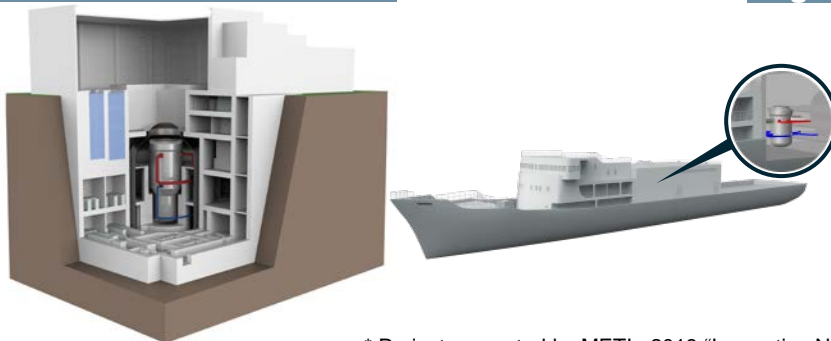
Light water reactor



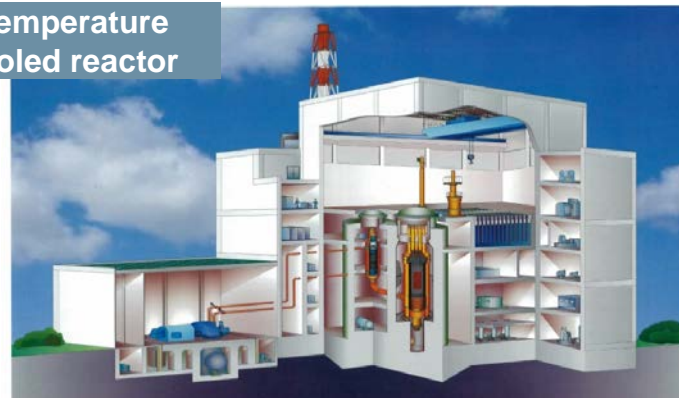
Fast reactor



Small-modular reactor



High-temperature gas-cooled reactor



* Project supported by METI. 2019 “Innovative Nuclear Technology Development Support Projects Responding to Social Needs”
EDF: Électricité de France (French power company)

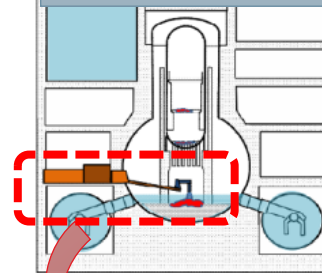
4) Decommissioning Initiatives

- For the decommissioning of light water reactors, supporting the utilities in the areas where MHI has advantages as a plant supplier
 - MHI is already undertaking first phase of work for the decommissioning PWR plants
 - Providing proactive support for stabilization of Fukushima Daiichi, even though they differ from PWR plant facilities
- (To remove debris—a critical challenge—plans call for phased implementation on small scale using a method conceived by MHI)

Light water reactor decommissioning
Sampling inside reactor vessel



Fukushima Daiichi decommissioning
Debris removal method and equipment



Horizontal access method

Enables access to debris from shortest distance



Debris removal robot arm tester

As a member of IRID, under development as a project financed by METI for decommissioning and handling contaminated water. One proposal (prototype) for equipment to be used after removal scale has expanded.