Power Systems Business Plan

Kenji ANDO

Senior Executive Vice President, President and CEO of Power Systems, and President of Mitsubishi Hitachi Power Systems, Ltd.

June 5, 2018

Mitsubishi Heavy Industries, LTD



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"POWER & ENERGY SOLUTION PROVIDER"

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1-1. FY 2017 Sales Overview



Renewable Energy

Offshore Wind Turbines*



- **Power Generation Pumps**
- **Chemical Plant Pumps**
- Water Jet Pumps





Nuclear Power

- Pressurized Water Reactors (PWR)
- Nuclear Fuel Cycle



Pressurized Water Reactors

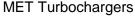


Rokkasho Reprocessing Facility

Marine Machinery

- ■MET Turbochargers
- Marine Boiler & Turbine







Gas / Coal / Geothermal

- Gas Turbine Combined Cycle(GTCC)
- Clean coal, IGCC
- Aero-derivative Gas Turbines
 - Geothermal Power Generation
 - **Environmental Plants**
 - Organic Rankine Cycle Systems



Gas Turbines (GT)



Integrated coal Gasification Combined Cycle (IGCC)

Compressors

- For Chemical Plants
- For Power Plants
- For Oil & Gas **Applications**



Aero Engines



V2500

Photo courtesy of Japanese Aero Engines Corporation

1-2. FY2017 Major Projects



Highly Efficient Gas Turbines

Thailand

Received order of Advanced GTCC



Poland Received order of Advanced GTCC



Environmentally Friendly Technologies

Serbia

Received order of world's largest flue gas desulfurization (FGD) system



Fuel-Efficient Aircraft Engines

Next-generation aircraft engine for MRJ

Mitsubishi Heavy Industries Aero Engines assembles first unit



Zero Emission Power

Japan

Received first order of a SOFC-MGT hybrid system for industrial-use distributed power



Germany

Received order for 31 units of V164-8.0MW offshore wind turbines (Order received by MVOW)



GTCC: Gas Turbine Combine Cycle

SOFC: Solid-Oxide Fuel Cell

MGT: Micro Gas Turbine

1. Business Overview

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2-1. Review of 2015 Medium-Term Business Plan



Challenges in FY2015 Medium-Term Business Plan

- Orders received & Net sales: Rapid market change in power business
- Operating income: Imbalance between business scale and fixed costs

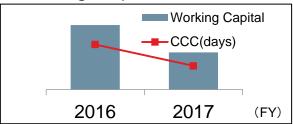
Achievements of 2015 Medium-Term Business Plan

- Launch of power & energy solution business
- Creating synergies among turbo machinery businesses
- Improved financial foundation (reduced working capital, shortened CCC)

Opportunities

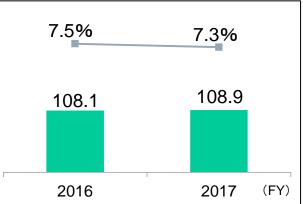
- New business development by power & energy solutions coexisting with growing renewable energy
- Efforts of synergies among turbo machinery businesses
- Continue to pursue PMI activities while steadily executing the many projects on hand.

Working Capital & CCC



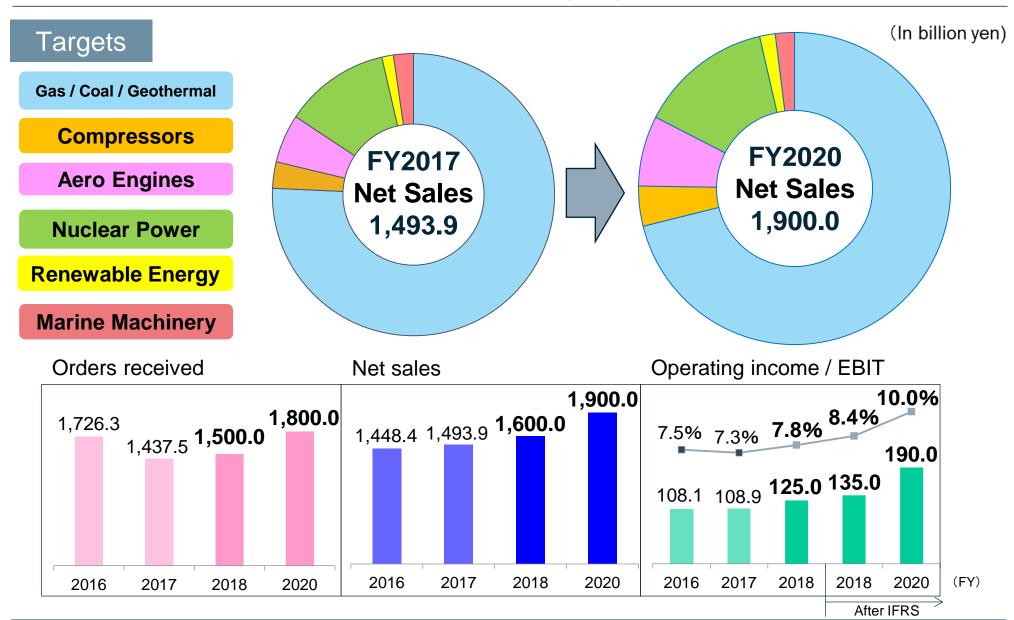


1,726.3 1,437.5 1,448.4 2016 2017 2016 2017 Operating income (In billion yen)



2-2. 2018 Medium-Term Business Plan (1/2)

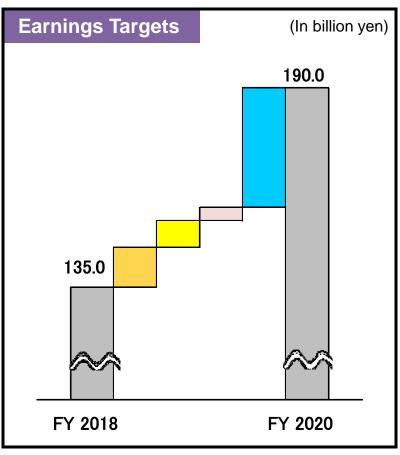




2-2. 2018 Medium-Term Business Plan (2/2)



Initiatives for Achieving Earnings Targets		
Gas/Coal/ Geothermal Power	 Efficient execution and profit improvement for order backlog Expand services business Improvement work for existing facilities (e.g. reduce carbon emissions, higher efficiency) Digitalization, -Optimize O&M, etc. Reorganization of domestic & overseas bases through PMI 	
Nuclear Power	 Promote and ensure safety of construction and compliance with new domestic regulatory requirements. Carry out various maintenance works after restart Support completion of nuclear fuel cycle process facilities Support stabilization of Fukushima Nuclear Power Plant Strengthen risk management for overseas projects 	
Aero Engines	 Expand business volume in response to robust commercial aircraft demand Promote the engine overhaul and repair business 	
Renewable Energy (MVOW, Pumps, etc.)	•Strengthen competitiveness in response to the expansion of the offshore wind turbine market	
Others (Compressors, Turbomachinery Synergies, Power & Energy Solution Business, etc.)	 Increase orders for new compressors and services in preparation of an upturn in the oil & gas market Promote synergies within a broad range of MHI group turbo machinery technologies Develop unique businesses within the Power & Energy Solution Business function 	



Note: Impact of IFRS conversion is negligible.

2-3. Turbomachinery Synergies



Expanding natural gas production and applications for a low-carbon society

Mitsubishi Heavy Industries Compressor Corporation

X

MHPS

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LNG production solutions

H-100 GT-driven LNG compressor train



MHPS: Mitsubishi Hitachi Power Systems, Ltd.

Oil & gas related products business

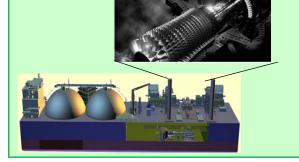
X

MHPS

Ш

LNG to Power

Powership equipped with H-25 GTs



Uptake of renewable energies

MHPS

×

Mitsubishi Heavy Industries Aero Engines, Ltd.

Ш

Flexible power generation to support renewable energies

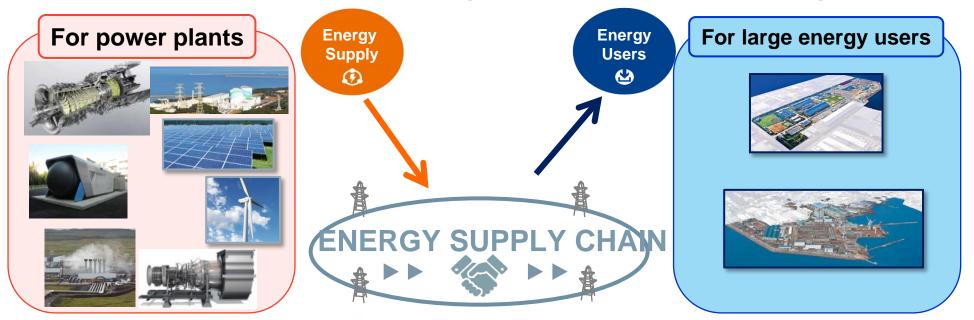
Aero-derivative GTs



2-4. Power & Energy Solution Business



Comprehensive Management System Utilizing Al/IoT



Mitsubishi Hitachi Power Systems MHPS-TOMONI^{TM *1}

- Flexible operation
- **Performance improvement**
- **O&M** optimization



Mitsubishi Heavy Industries

ENERGY CLOUD®

- **Administration support**
- **O&M** support
- EMS, optimal utilization system
- Failure detection, Improved reliability

EMS: Energy Management System

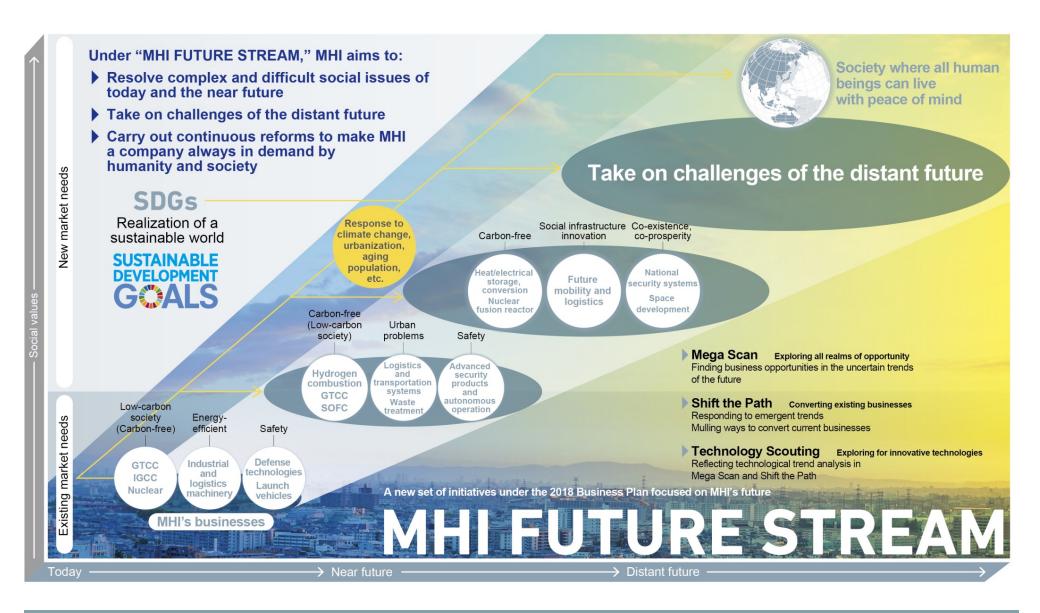
^{*1} MHPS-TOMONI TM is a trademark of Mitsubishi Hitachi Power Systems Ltd.

^{*2} ENERGY CLOUD® and related logomarks are registered trademarks of Mitsubishi Heavy Industries, Ltd. In Japan.

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 - 3-2. Power Systems Mission Statement
 - 3-3. Challenges of Expanding Renewable Energy Use
 - 3-4. Power Systems Strategies Toward a Carbon-Free Society
 - 3-5. Future Energy Infrastructure
 - 3-6. Solutions for Achieving "+2°C Scenario" for Climate Change
- 4. Individual Business Strategies
- 5. Power Systems Mission Statement: "POWER & ENERGY SOLUTION PROVIDER"

3-1. MHI FUTURE STREAM





3-2. Power Systems – Mission Statement



Why?

Provide stable clean energy solutions for a sustainable society

What?

Provide decarbonizing solutions (low carbon / zero emissions)

How?

Focus strategy around 3E+S in the future (2030s, 2040s, and 2050s)

Who?

MHI Power Systems can provide advanced technologies & integrate multiple solutions



MHI as a "POWER & ENERGY SOLUTIONS PROVIDER" of the future

3-3. Challenges of Expanding Renewable Energy Use (1/2)



While wider use of renewable energy is essential, <u>a stable backup power supply is also indispensible</u>

Australia: Wide-reaching power outage results in suspension of major resource operations and disruptions to public transportation.

In September 2016, a severe storm hit the state of South Australia and <u>a large power outage occurred</u> (wind power-generated electric power, which accounts for about half of the state's electricity supply, was cut off and lines from neighboring states were also interrupted).

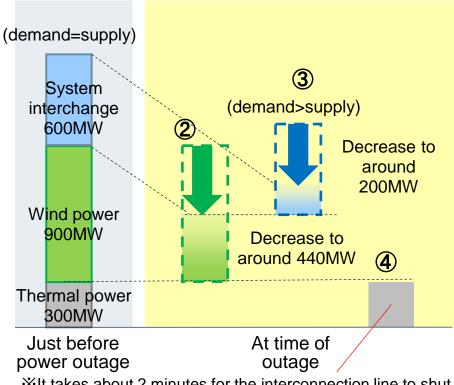
1. A storm damages power transmission lines

- Unable to flexibly adjust power output due to minimum utility frequency requirements.
 Wind-generated power equivalent to 460MW is automatically cut off from the grid.
- 3. Attempts are made to offset the decrease in wind power generation with system interchanges, but the degree of power loss is too great and results in an automatic shutoff of lines to neighboring states (to ensure operation of those grids).
- 4. Attempts to use gas-fired thermal power to make up for the loss of electricity from wind power generation and from the grid could not be carried out in time.



Wind power generation accounts for about 50% of electricity supply; stable backup power supply is insufficient.

→→Balance between renewable energy and backup power supply is crucial.



※It takes about 2 minutes for the interconnection line to shut off after the loss of wind power supply.

3-3. Challenges of Expanding Renewable Energy Use (2/2) — time constraints, uneven regional distribution

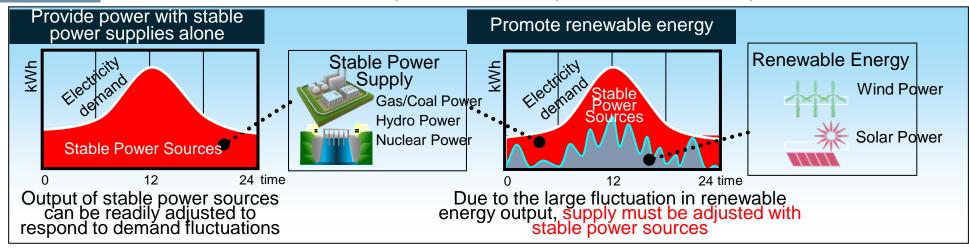


Time Constraints

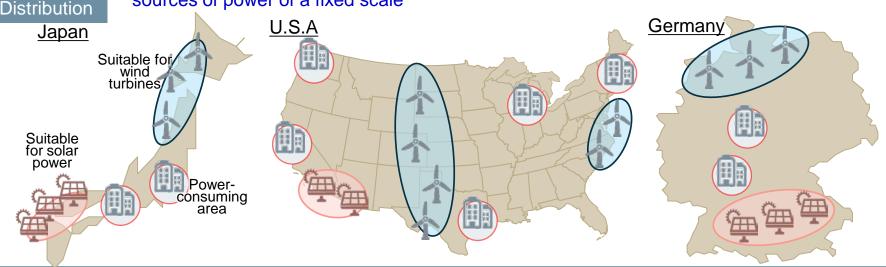
Uneven

Regional

Compensate for imbalance between renewable energy output fluctuations and power demand with more enhanced and flexible operation of thermal power and other stable power sources



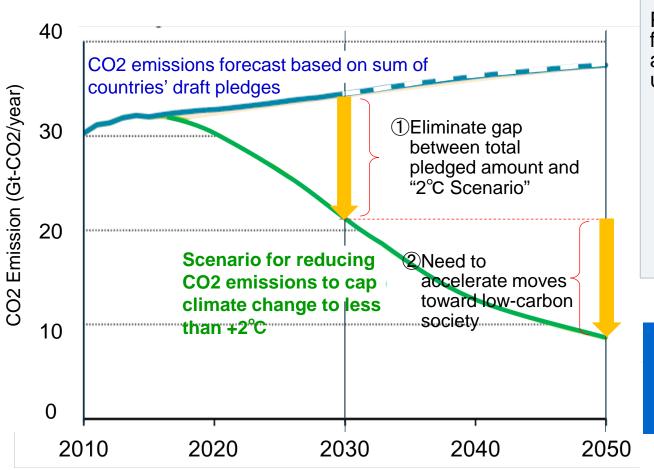
High volume power-consuming areas that are distant from renewable energy fields require stable sources of power of a fixed scale



3-4. Power Systems Strategies Toward a Carbon-Free Society (1/2)



Challenges of Paris Agreement, Capping Climate Change at less than +2°C



To achieve the goals of the Paris Agreement, the following are needed in addition to more widespread use of renewable energy:

- Promotion of highly energy-efficient equipment and systems
- CCS and CCUS plants for recycling CO2 produced as emissions
- Fuel conversion toward using lower-carbon fuels

Need for integration of sophisticated power generation equipment and systems with a wide range of technologies

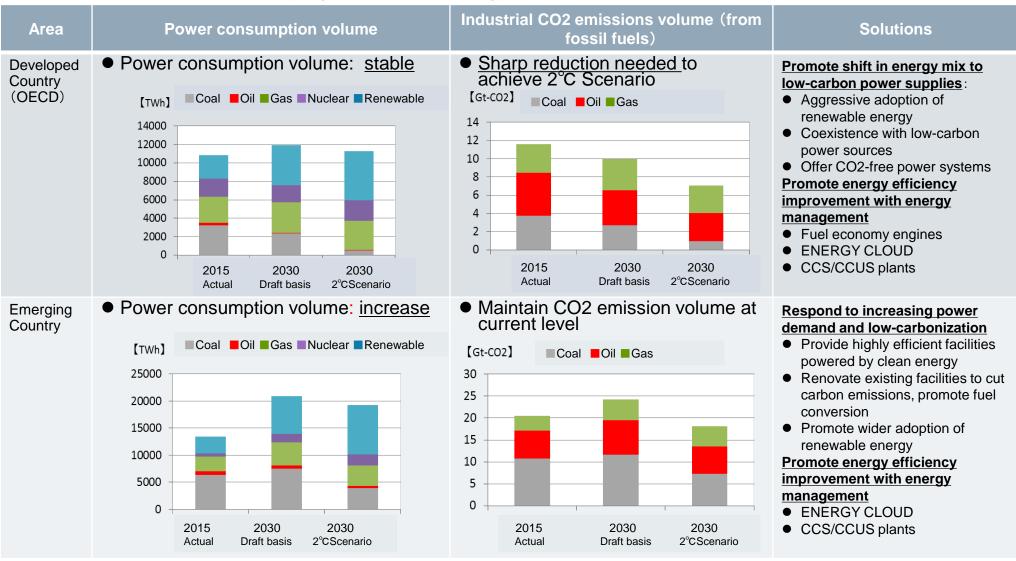
CCS: Carbon dioxide Capture Storage

CCUS: Carbon dioxide Capture, Utilization and Storage

3-4. Power Systems Strategies Toward a Carbon-Free Society (2/2)

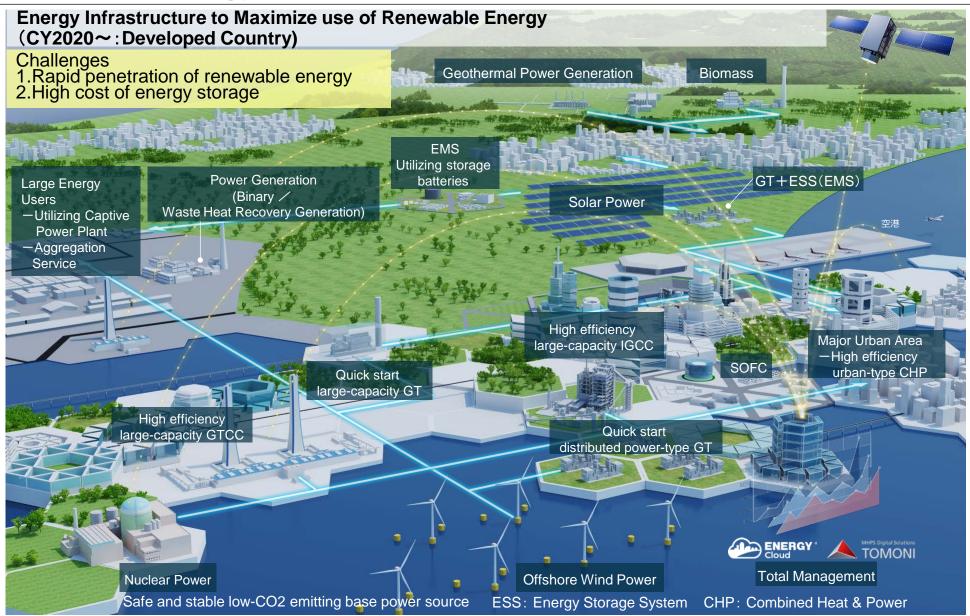


Regional initiatives to Achieve Paris Agreement \rightarrow Combination of Renewable Energy and Low-Carbon Power Supply (gas/nuclear energy)



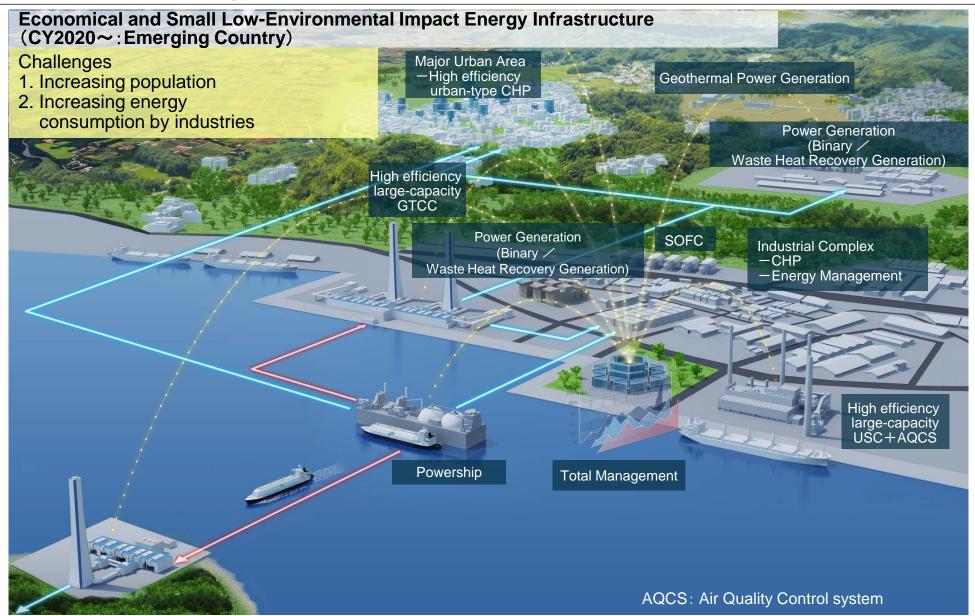
3-5. Future Energy Infrastructure (1/3)





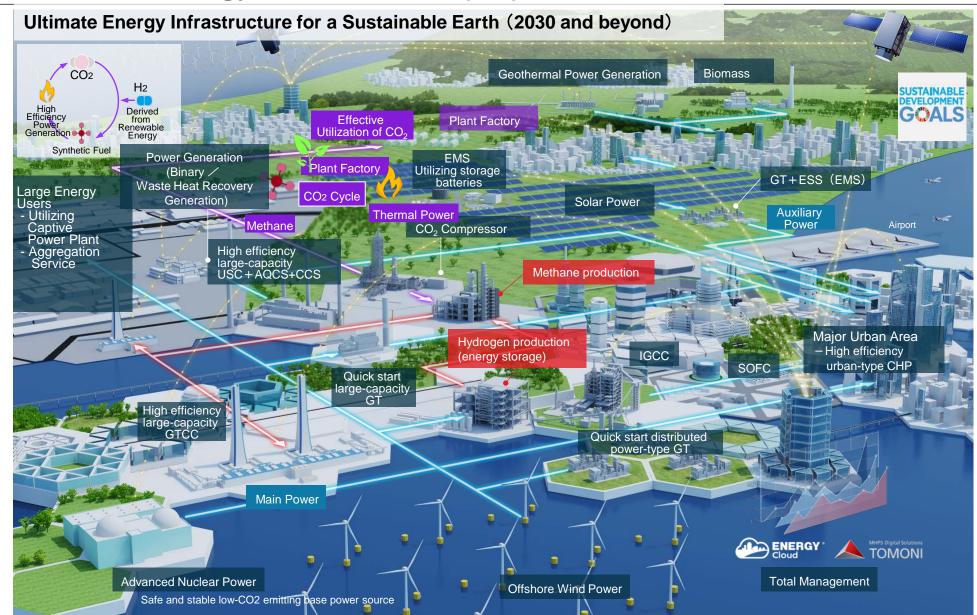
3-5. Future Energy Infrastructure (2/3)





3-5. Future Energy Infrastructure (3/3)





3-6. Solutions for Achieving "+2°C Scenario" for Climate Change (1/3)



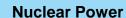
Sharply lower carbon



GT fueled by Hydrogen/Ammonia/ Methane



SOFC



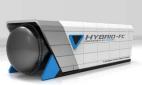






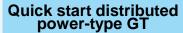








Utilize and complement renewable energy





Offshore Wind Turbine



Distributed Geothermal Power Plant/Biomass

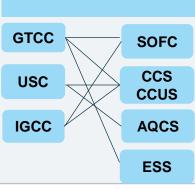


CCS & CCUS



System Hybridization

Integration



GTCC+SOFC (Triple Combined Cycle)



Power & Energy Solution Business (Utilizing Al/IoT)





- Draft business investment plan together with customer.
- Participate in asset management, including financing.

3-6. Solutions for Achieving "+2°C Scenario" for Climate Change (2/3)



CO

2018-2020

2020-2030

After 2030

(CY)

Quick start distributed power-type GT



■ Reaches full load in 5 minutes

■ Reduces NOx emissions



■ Quick start of large-capacity machinery



High efficiency large-capacity GTCC



■ 1,650°C-class GT

■ CC Efficiency 64%+





■ Next-Generation GT

■ CC Efficiency 67%+

■ Efficiency reaches 70% + when combined with SOFC

GT fueled by Hydrogen/Ammonia/ Methane





Mixed-fuel combustion power plantsDevelopment & testing



■ Mono-fuel combustion plants

Development & testing

Commercialization



CO₂

CO₂ Zero

3-6. Solutions for Achieving "+2°C Scenario" for Climate Change (3/3)



CO

High Efficiency Large-Capacity USC+AQCS



High Efficiency Large-Capacity IGCC



Nuclear Power



2018-2020

Promote AQCS



2020-2030

Combine CCS & CCUS plants



After 2030

(CY)

xed-

Ammonia mixedfuel plant



- Commercialization
- More economical



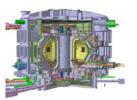
Triple Combined Cycle Integrated with SOFC



 Restart operation of light water reactor (in compliance with new regulations)



■ Fusion Reactor



Credit © ITER Organization, http://www.iter.org/

CO₂

CO₂ Zero

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 - 4-5. Mitsubishi Heavy Industries Marine Machinery & Equipment (MET Turbochargers)
 - 4-6. Mitsubishi Vestas Offshore Wind (Offshore Wind Turbine)
- 5. Power Systems Mission Statement: "POWER & ENERGY SOLUTION PROVIDER"



Circumstances

- Market for new coal-fired power plants is shrinking due to sharp increase in environmental awareness and growing use of renewable energy
- Firm need for low environmental impact gas-fired power as a stable source of power supply

Challenges

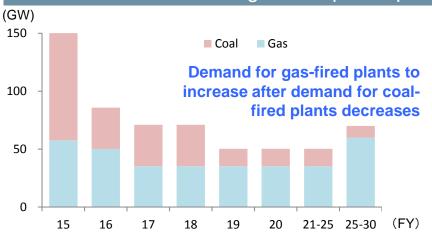
 Adapt business structure to respond to changes in the circumstances (products, services, management systems and resources)



Solutions

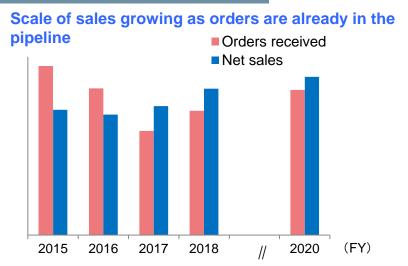
- Promote and enhance functionality of clean energy products toward realizing a low-carbon/carbon-free society
- Provide solution services by utilizing the newest digital/software technologies
- Expand business sphere with effective utilization of technologies and resources
- Optimize management systems and resource allocation in line with expansion of business sphere and transition to new structure

Scale of market for new gas/coal power plants



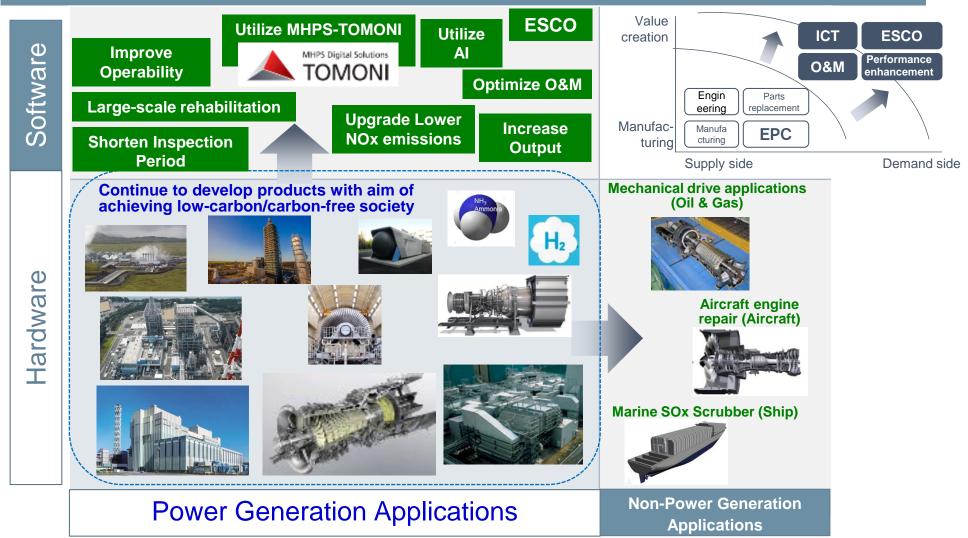
Source: FY2015-2017(actual) Mc Coy Power Report; figures after 2018 are our forecasts.

Orders & Net Sales





Respond to changes in the circumstances by expanding the business sphere and by adapting the new business structure



ESCO: Energy Service Company

4-1. Mitsubishi Hitachi Power Systems Digital Solution



Aim to Achieve Optimal Operations by 2030s

Time Axis

2030s



Optimize Operations

Management based on

Supply/Demand Estimates

Automated autonomous operation



Advanced O&M

O&M support



O&M monitoring

Optimization of overall efficiency (group management level)

Remote operation (labor saving, more reliable)

Longer intervals between inspections

- Early detection, automated warnings for malfunctions/anomalies and recovery measures
- Operating life extension measures, placing orders for spare parts

Performance improvement and optimization (equipment and plant levels)

Shorter schedule for regular inspections

Higher operating ratios and productivity improvement

Preventive maintenance, Short-term peak operation, Eco operation, Recommend replacement parts during regular maintenance, Lower minimum load, Increase rate of load change

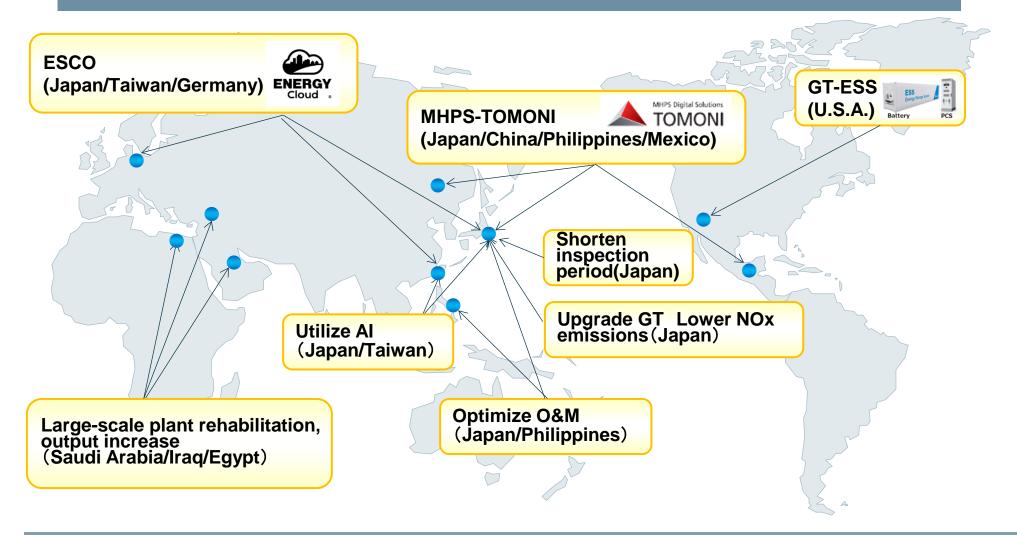
Data gathering & evaluation (digitalization)

Current

4-1. Mitsubishi Hitachi Power Systems Expansion of Solution Service



Transition from Product Manufacturing to Value Creation Work Together with our Customers to Provide Solutions with Value for our Customers



Nuclear Turbine, Generator, Reactor Pressure Vessel (1/2)



Major Product Technologies

PWR

Steam Turbine, **Heat Exchanger**

BWR

Plant Engineering

Generator

RPV

World's leading RPV Manufacturing Capacity

Turbine Plant

Technologies

Various

Leading-edge technology

74 inch blade

Performance results of leading systems

Performance and reliability verification technologies







World's largest High Speed Balance (HSB)

Japanese market

(Strengthen expansion of after-sales services 1

- Support plant restarts
- Increase reliability (extend lifespan, improve performance) (20~22% power supply configuration by 2030)

Overseas market

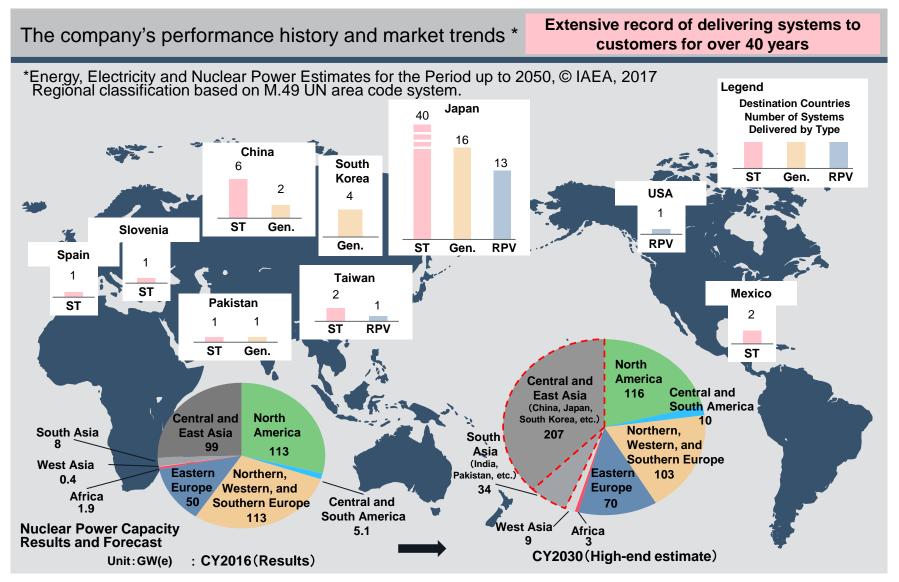
Approach regions seeing expansion in demand]

- Supply turbines to countries where demand is growing
 - (China, India, etc.)
- Respond to rebuilding demand in developed countries

PWR: Pressurized Water Reactors BWR: Boiling Water Reactors RPV: Reactor Pressure Vessel ST: Steam Turbine Gen.: Generator





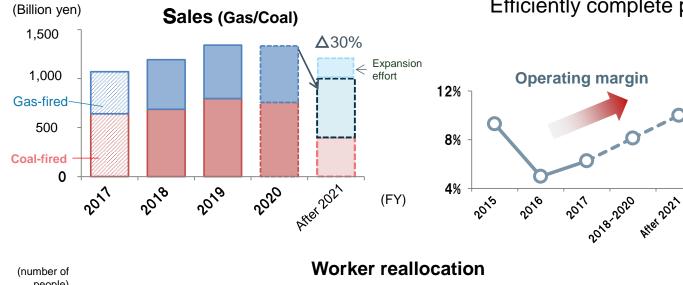


RPV: Reactor Pressure Vessel ST: Steam Turbine Gen.: Generator





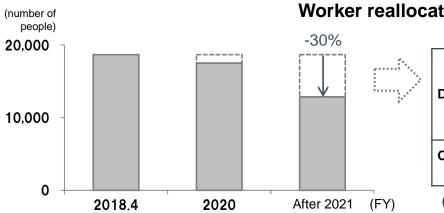
Promote structural shift to increase added value and to be ready for scale-down of coal-fired power systems business from 2021 Study the 2018 Medium-Term Business Plan to implement necessary initiatives



Efficiently complete projects / improve earnings

(FY)

- Reduce fixed costs
 - Improve business management efficiency
- **Utilize digital technologies** Plant automation Utilize AI to pass on technical skills Digital marketing



Damadia	Natural attrition + hiring restraint	-5%
Domestic	Reallocation, job changes	-15%
Overseas	Company / works reorganization*	-10%
(* Mainly Boiler / Steam Turbine)		

- Reallocation resources to growth businesses
- Focus on gas-fired power, renewable energy, digital/solutions businesses

4-2. Nuclear Energy Systems (1/2)



Circumstances

- Domestic: Positioned as key base load power supply
- Overseas: Nuclear power generation needs increasing, especially in emerging countries

Challenges

- Seek for world's highest level of safety
- Strengthen product competitiveness (cooperation with French companies, etc.)
- Make steady progress of maintaining and enhancing skilled nuclear technology



-

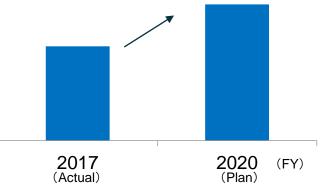
Promote initiatives for conforming to new domestic regulation

- Support preparation on waiting nuclear power plants restarting and large-scale renewal projects
- Support successful completion of construction of nuclear fuel cycle facilities

Solutions

- Support stabilization of Fukushima Daiichi Nuclear Plants (development of remote-controlled robots, etc.)
- Strengthen risk management for overseas projects (Sinop project in Turkey)
- Strengthen alliances with Orano and Framatome by investment

Responding to all processes in nuclear energy cycle Reprocessing plant (Rokkasho) Spent fuel Light water reactor plant MOX fuel plant Fuel (MOX : Mixed Oxide) Mitsubishi Nuclear Fuel Co., Ltd. (MNF) **Net Sales**



4-2. Nuclear Energy Systems (2/2)



2018 Medium-Term Business Plan (FY2018-FY2020)

Make steady progress of maintaining and enhancing skilled nuclear technology in preparation for coming carbon –free society

- Promote initiatives for conforming to new regulations (severe accident management facilities, etc.)
- Develop large-scale renewal projects
- Support successful completion of construction of nuclear fuel cycle facilities





Medium to Long Term Business Outlook (CY2021-2030s)

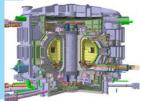
Pursuing new business sphere

- Make efforts for new plants, including Sinop project in Turkey
- Prepare for removal of fuel debris from Fukushima Daiichi Nuclear Plant
- Contribute to intermediate storage facilities for spent fuel
- Commitment to decommissioning projects into full scale activities
- Promote R&D for fast reactor and fusion technology
- Promote strategic maintenance planning for 60 years operation (continual attention to safety, improve reliability)
- Deepen collaboration between Japan and France









Credit © ITER Organization, http://www.iter.org/

4-3. Mitsubishi Heavy Industries Compressor (Compressor)



Circumstances

- Moderate recovery in plant construction demand since late 2017 as oil price stabilized
- Intensified Competition among players in oligopolistic market

Challenges

- Strengthen the business base to survive global competition
- Strengthen service business offerings



Solutions

- Tie-up offering with MHPS gas turbine to expand sales of compressor trains in Oil & Gas market
- Strengthen cost competitiveness and shorten delivery times to maintain top share in petrochemical market

 - Optimize procurement process
 Improve manufacturing process (casing: cast steel → šteel plate)
- Expand service business
 - Strengthen service bases (US, Saudi Arabia, South Korea, Russia)
 - Strengthen IT, online services
 - (remote monitoring)

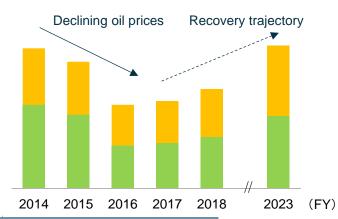


Service



Market scale of compressor business

New Units



Orders & Net sales



4-4. Mitsubishi Heavy Industries Aero Engines (Aero Engines)



Circumstances

- Growing market sustained by robust aircraft demand
- Further growth of engine MRO market

Challenges

- Response to continuous production increase
- Expand business scope



Solutions

- Mobilize resources available in the business domain
- Al/IoT initiatives for smart factories and Advancing in SCM
- Expands capability/resources for MRO and part repairs (GTF engine MRO, repair technology development)
- Enhance contribution in development programs thru cooperation to customer value (P&W, RR)

MRO: Maintenance, Repair & Overhaul SCM: Supply Chain Management

P&W: Pratt & Whitney RR: Rolls-Royce GTF: Geared Turbo Fan

Business scope (Net sales) 200 billion yen of sales in sight Grow the business to 100 billion yen in sales Defense aero engine **Commercial MRO**

2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

Smiling Curve of Aero Engines business

New Commercial Program

Program

OEM

Material

Tier1

Existing Commercial

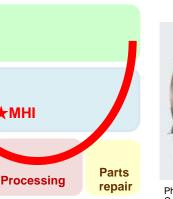




Photo courtesy of Japanese Aero Engines Corporation

[development [Production] [Aftermarket] & design]

★MHI

(FY)

4-5. Mitsubishi Heavy Industries Marine Machinery & Equipment (MET Turbochargers)



Circumstances

- New shipbuilding market recovering since bottoming in 2016
- Stable market growth continuing for stationary engine segment



Marine Turbocharger

Turbochargers for power generation and mechanical drive engines (MET-SRC)



Challenges

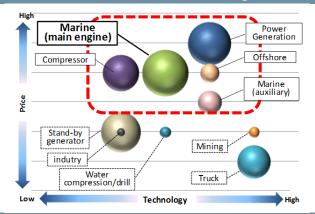
- Maintaining market share of products for marine engines
- Step up pace for making inroads to new areas (turbochargers for power generation and mechanical drive engine applications)



Solutions

- To maintain market share while new shipbuilding market recovers, introduce a successor model of the large air flow-type turbocharger for low-speed marine engines
- Develop and release new models for power generation and mechanical drive engine applications (low cost, high compression ratio)
- Optimizing turbocharger design with the aim of having customers adopt them as their standard specifications (area indicated by red dashed line in exhibit to the right)

Market structure & Target



MET Turbocharger (Net sales)



MET: Mitsubishi Exhaust gas Turbocharger

4-6. MHI Vestas Offshore Wind (Offshore Wind Turbine)



Circumstances

- Growing renewable energy becomes a prominent resource of electricity
- European market continuing to grow, and US, Taiwan, and Japan markets are expected to be emerging (around 4~6GW/year)
- The second largest share of offshore wind turbine market (cumulative market share)

Challenges

- Respond to market growth and strengthen competitiveness
- Further improve economic performance
- Adjust for the variable renewable energy



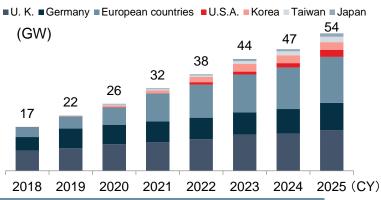
Solutions

- Respond to market growth by strengthening mass-production systems
- Introduce the world's largest turbine, output 9.5MW, to the market (install in 2019)
- Add on higher value by combining with flexible power sources (e.g. small GT)



Offshore Wind Turbine Market

(Survey by research institutes)





- 1. Business Overview
- 2. 2018 Medium-Term Business Plan
- 3. Vision of Power Systems in the Future
- 4. Individual Business Strategies
- 5. Power Systems Mission Statement: "POWER & ENERGY SOLUTION PROVIDER"





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