

Power Systems Business Plan

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President and CEO of Power Systems

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Mitsubishi Heavy Industries, Ltd.

Hello, my name is Kentaro Hosomi and I am the President & CEO of our Power Systems Domain. Today, I would like to explain our current business strategy.

1. Business Overview

1-1. Sales Overview

1-2. Management Structure

1-3. FY2018 Major Topics

2. 2018 Medium-Term Business Plan Progress Status

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

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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

This is the agenda of our presentation. So we will start with the results from last year as well as where we stand now. We will also talk about our outlook for the 2018 Medium-Term Business Plan, and objectives beyond that time-frame.

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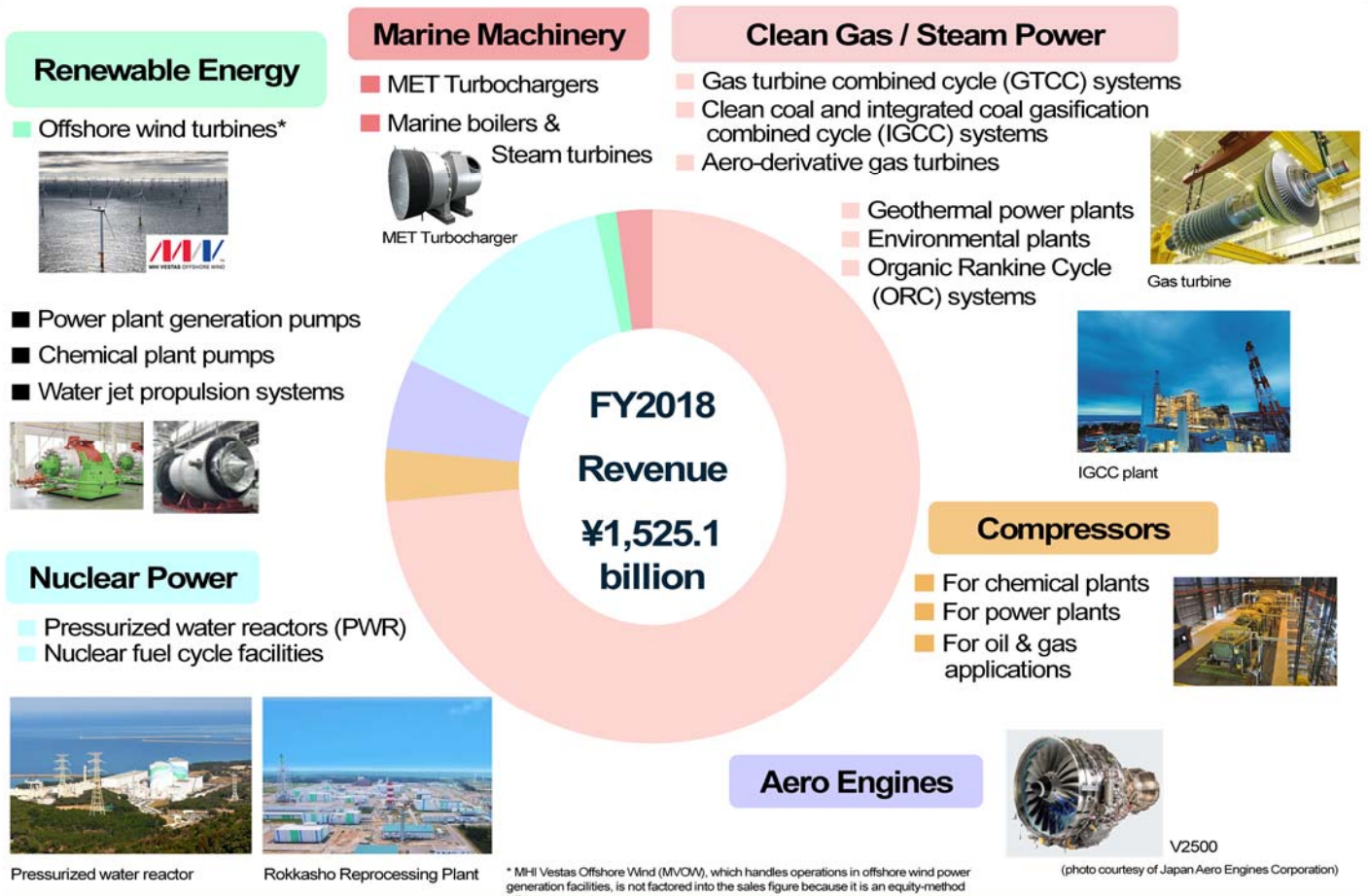
3-1. Global Power Market Trends

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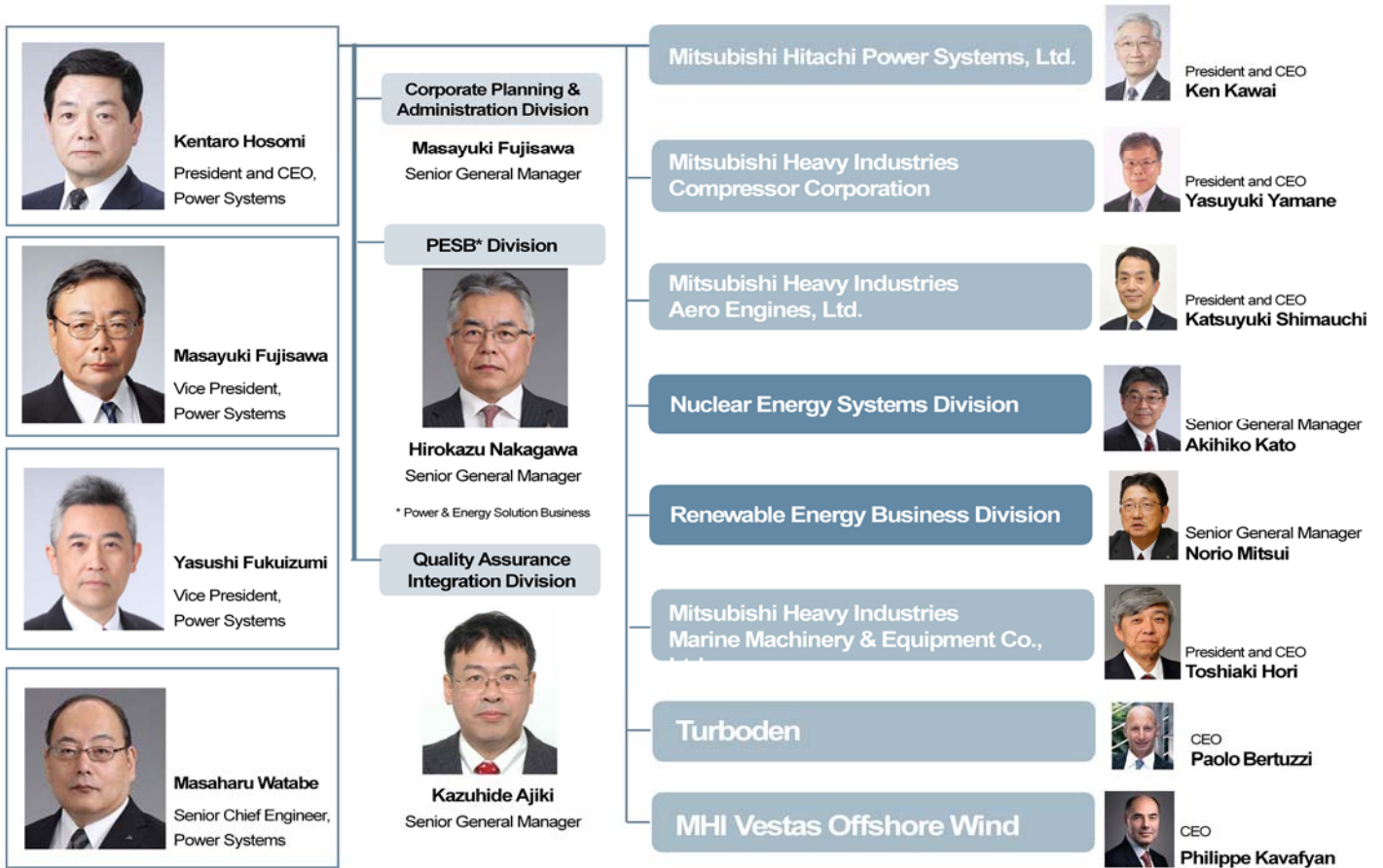
I am aware that many of you understand our businesses already, but would like to briefly explain the products and businesses of our domain.

1-1. Sales Overview



This page will give you an idea of the content and size of our major businesses. FY2018 revenue for the entire domain was 1.5 trillion yen. Revenues from our offshore wind turbine business is not included here, since MHI Vestas Offshore Wind is an equity method affiliate.

1-2. Management Structure



Here you can see our domain management structure.

Today here we have Mr. Yasushi Fukuizumi, Vice President and Senior Executive Fellow, Mr. Ken Kawai, President CEO of Mitsubishi Hitachi Power System and Mr. Akihiko Kato from the Nuclear Energy System Division

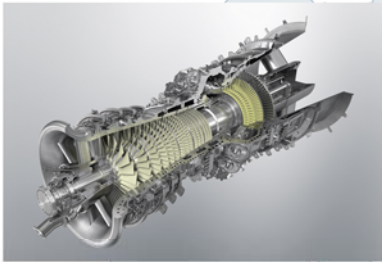
1-3. FY2018 Major Topics

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*



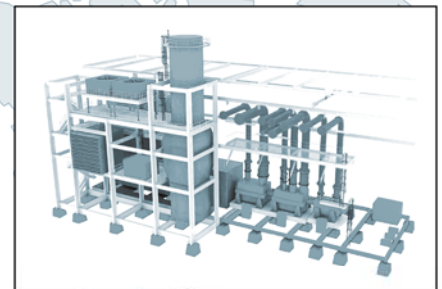
Offshore Wind Turbines

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

Here are some major developments or outcomes from FY2018. It is important to note that we have achieved the No.1 global market share in, both 100 MW and above class heavy-duty gas turbines, as well as flue gas desulfurization equipment (FGD).

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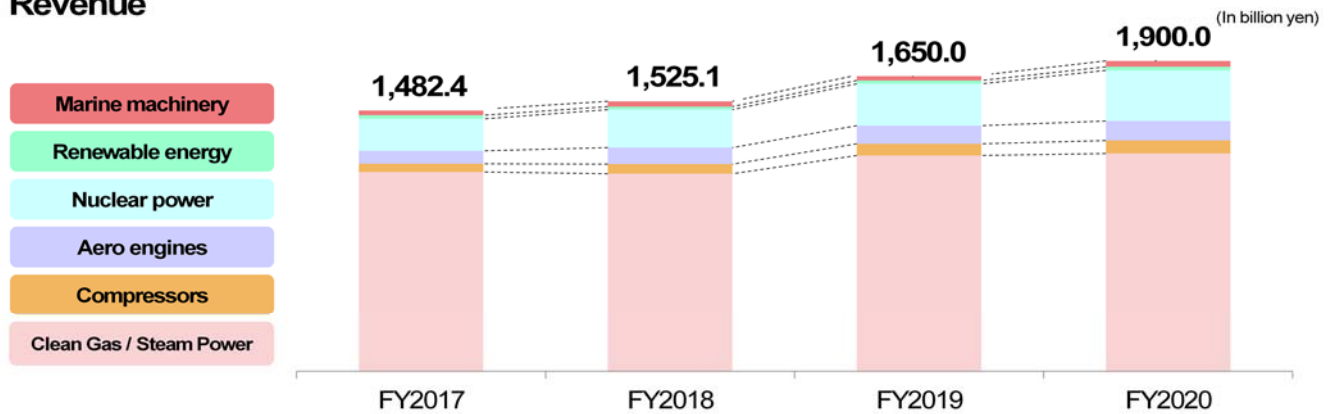
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Now I would like to explain the first year results and outlook for the 2018 Medium-Term Business Plan.

2-1. Outlook

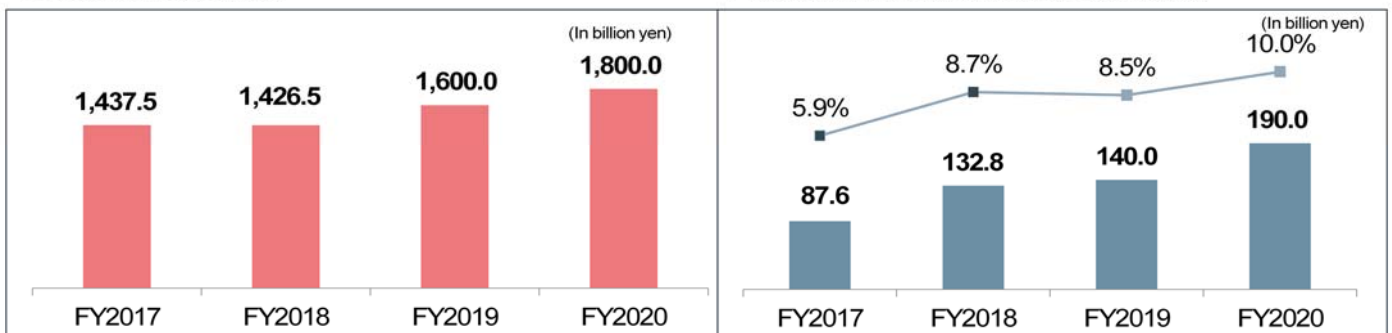
■ Achieve 10% profit margin in FY2020 by fulfilling backlogged orders and optimizing resources, including reduced fixed costs and total assets

Revenue



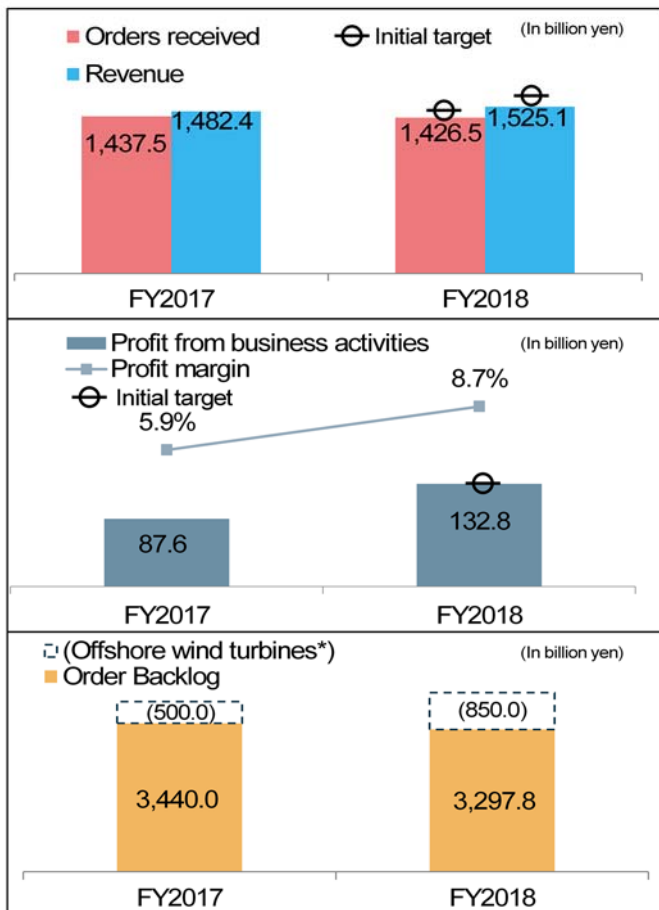
Orders Received

Profit from Business Activities



As mentioned last fiscal year, under the 2018 Medium-Term Business Plan, we target 1.9 trillion-yen in revenues and a 10% profit margin in FY2020. There is no change in this outlook.

2-2. Review of FY2018



* 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.

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FY2018 Results

- **Maintained business plan trajectory (Order, Sales, Profit) by recovering from the cancellation of a coal-fired project in Japan**
 - Increases in service business, compressors, etc.
 - Profit margin improvement by squeezing and efficient management of assets
- **Secured No.1 market share of medium/heavy-duty gas turbines in a competitive market**
- **MVOW's market share expanded in a 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)

As for orders received in FY2018, it should be noted that there was a cancellation of a steam power project and some delays for other projects. However, we were able to offset these subsequent decreases with increases in our service and compressor businesses. As a result, we were able to reach our initial targets made at the beginning of the year. As for gas turbines, the tough market environment continued from FY2017 into FY2018. But despite this, heavy-duty turbine orders doubled in comparison to FY2017 and we secured the No.1 global market share.

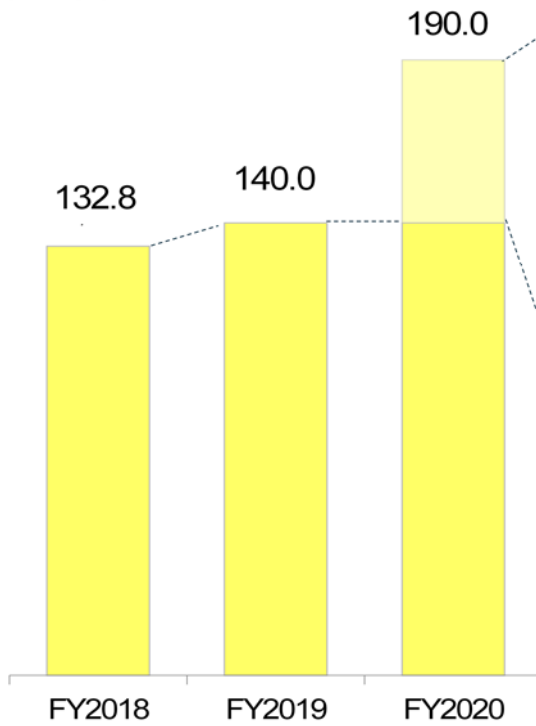
In addition, thanks to measures improving return on assets and the growth in the offshore wind turbine market, Mitsubishi Vestas Offshore Wind (MVOW) performance was enhanced and profit margin improved by 2.8 percentage points.

In terms of order backlogs, the so-called book-to-bill ratio fell below 1 for 2 consecutive years. So backlogs in FY2018 slightly dropped. But with the steady progress and work in process, profitability will be maintained and measures are underway to further improve the profit margin. Details are provided in the next page.

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

Business profit

(In billion yen)



Expand service business

+ 35 billion yen

- Establish new bases, expand business scope (renovate and enhance functions of products to reduce environmental load, including products of other manufacturers)
- Propose solutions to improve equipment operability
- Respond to demand for higher safety and quality

Expand growth products

+ 15 billion yen

- Expand profit from business activities in expanding markets: compressors, aero engines, offshore wind turbines, etc.

Optimize resources

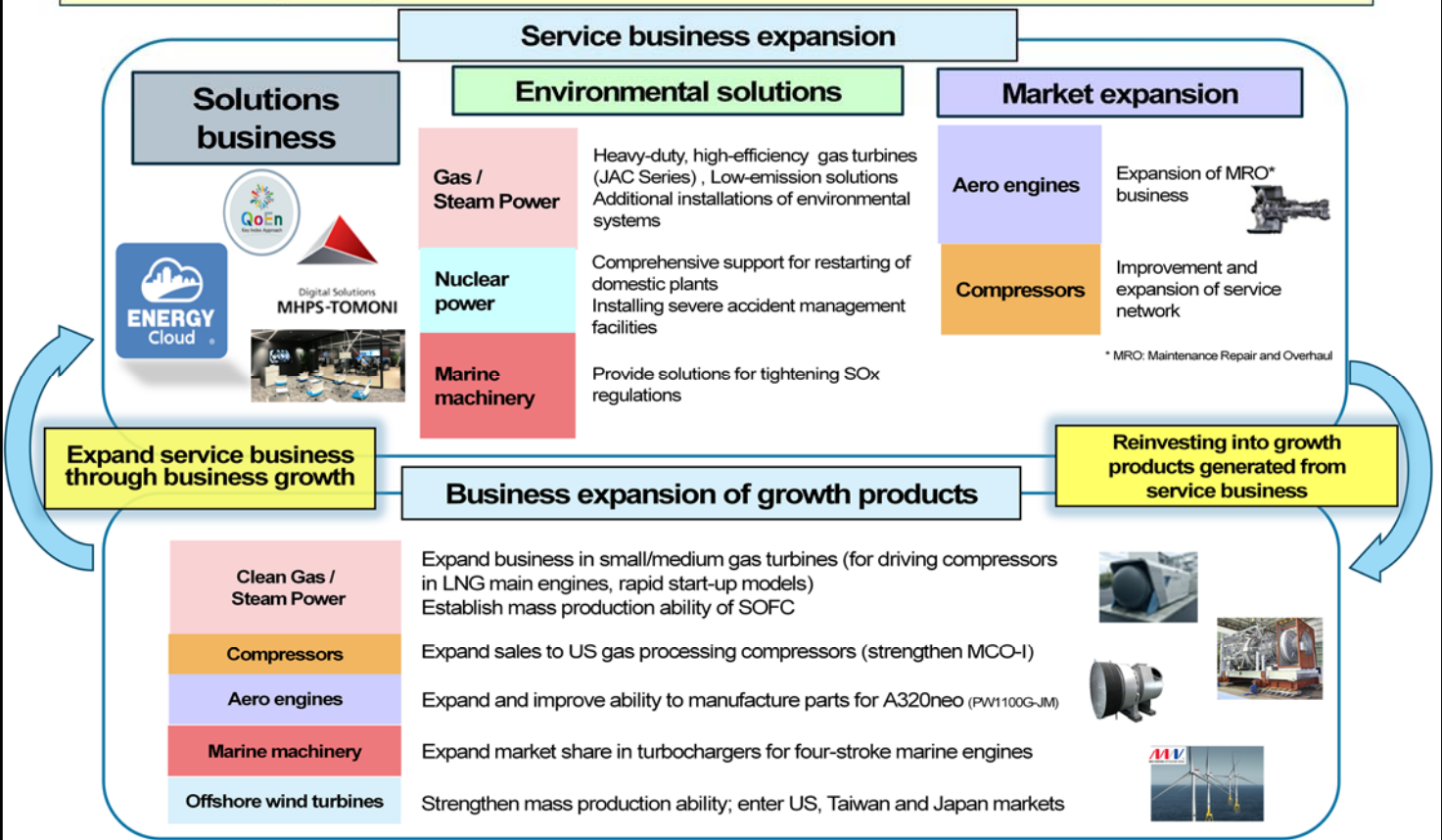
- Improve productivity through factory digitalization, etc.
- Shift resources into growth areas

First is the expansion of our service business. As for the existing plants under operation, the need for environment friendly technology and enhancement of operability is strong. Therefore, we have established new overseas bases to respond to these requirements promptly.

As for the nuclear power business, we will continue to enhance safety and quality of existing plants through works such as severe accident management facilities, and addressing the needs of the customers

The market for compressors, aero engines, and offshore wind turbines are expanding, and through investment in these growing products, we will increase business size and profit. As for steam power, we will be executing high load backlog orders efficiently at our digitalized and automated facilities. The resources for steam power projects will be allocated to service business and growth areas for resource optimization. Through these activities we plan to achieve a 10% profit margin in FY2020, and enhance our business base to maintain this profit level.

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



In our core businesses, such as gas, steam and nuclear power, we cannot expect growth with new installations as we have seen in the past. However, in order to support the renewable energy market, current fossil power plants are also necessary to stabilize the grid.

We are thinking environmental friendly service menus such as high efficient and low emissions will satisfy these needs. They would serve as a driver for our services business expansion.

Here is an example. In November 2018, we obtained an order from a Taiwan Power Company for the improvement of efficiency and services by optimizing operations with MHPS-TOMONI for their 7 gas turbines that had been in operation since 2003. As you know in Taiwan, the introduction of offshore wind turbines has been under discussion these days. This example shows fossil power will serve as an important role even though renewable energy penetrates.

Also, we foresee the aero engine market will continue to expand. We are hence enhancing our maintenance repair overhaul (MRO) business under this market situation.

Likewise, the compressor market is expanding, and we are building our service network in the Americas, Middle East and Asia. The revenue generated by our services business will be invested into growth products, therefore we will be able to expand our business size and expect further growth of our services business. We will be establishing this virtuous cycle and keeping it on track.

Solid Oxide Fuel Cell (SOFC) solutions are expected to be utilized in distributed power, and as we announced last week, we have established a joint venture for mass production of cylindrical cell stacks with NGK Spark Plug Co., Ltd. .

In addition, the followings are the areas we see business opportunities in ;

LNG utilization expansion

Flexible power sources assisting the introduction of renewable energy.

Aeroengine and marine machinery market expansion as transportation increases for passengers and goods.

Deployment of the offshore wind turbine business outside of Europe

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Now I would like to give you more details on our segmented business strategies.

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 temperature technology applications
- Product development geared towards realizing a 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 startup)

Strategy: Sales expansion with multiple applications

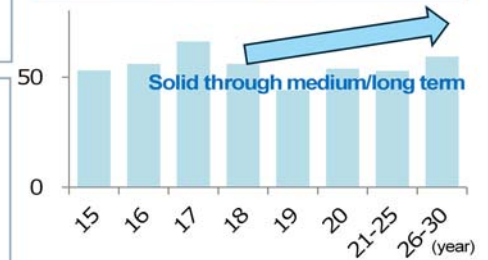
- Renewable adjusted flexible operation, distributed generation, compressor driven, floating power generation facilities

■ Solutions services

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

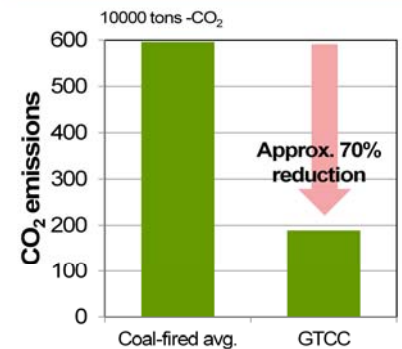
Egypt PJ: Renovation of existing plant (Efficiency and output improvement, reliability enhancement for long term operations.)

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

As for clean gas power, a stable market is expected globally due to the start of the full-fledge export of North American shale gas as LNG. Because of CO₂ reduction as shown in the graph of this page, and of flexible base load operation, firm demand is expected over medium to long term.

As for heavy-duty gas turbines, we achieved the No.1 global market share in 2018.

We have launched the JAC (J-series Air-Cooled) gas turbine (the inlet temperature at 1,650 °C) and just recently have received an order from J-Power in the US Jackson Project. In order to meet the demand for a low carbon society, we are engaged in development of higher efficiency gas turbines and also hydrogen-fired gas turbines with zero CO₂ emissions.

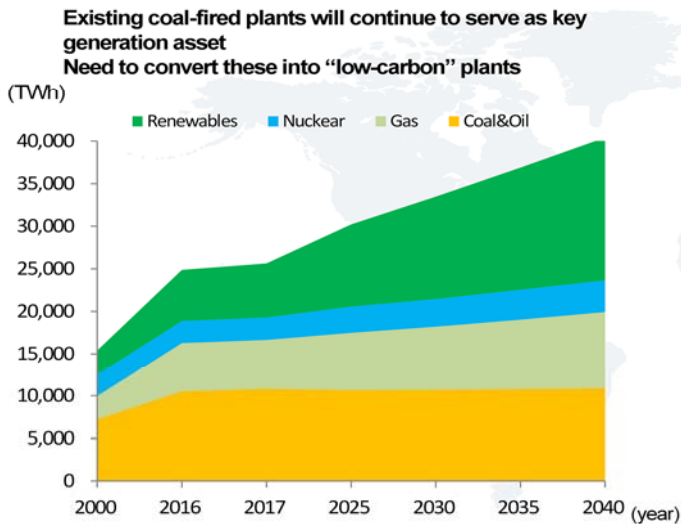
As for the small/medium scale gas turbines, we have line-ups including aero-derivative gas turbines by PWPS and our H series. In FY2018, we had a significant increase in the orders. We will continue to promote these small/medium-scale gas turbines by providing models with multiple applications such as flexible operation, distributed generation, industrial co-generation, and compressor drivers.

For the energy supply side, we will be providing solutions and services to customers with MHPS-TOMONI adopting AI/IoT, which realizes advanced operability and easy maintenance.

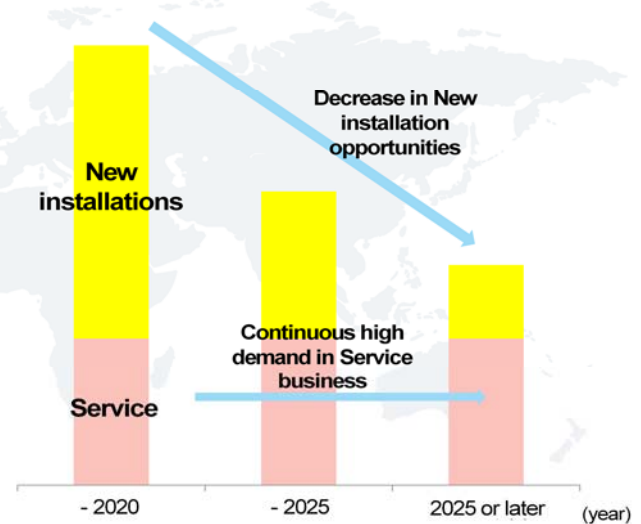
Business Environment

- **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)



This slide shows the steam power business environment. We foresee the new build market for steam power plants is shrinking due to the global trend towards low carbon and carbon-free societies. However, we are thinking that demand for steam power still remains for emerging countries, especially in Asia for energy security needs

As environmental awareness increases, the need for environmental-friendly coal-fired plants in these emerging countries is still strong. So we will meet such requirements by providing products with lifecycle cost inclusive of environmental measures, high performance reliability and suitable life cycle costs, including after-sales-services as well as environmental protection technologies.

Although the new build market will decline as shown in this graph, existing steam power plants will continue to serve as key generation assets.

We will maintain our services business scale for this area, for example, by taking in competitors' plants such as those from China. We are going to secure technologies and resources to cope with customer's requirements.

However, the revenue is projected to fall to 2/3 compared to the peak period. And based on this forecast, various measures are already being taken.

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

Results and Strategies

■ Optimize resources for post 2021

[PMI progress at MHPS]

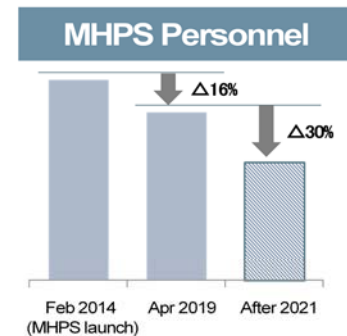
- Domestic: Steam turbines → consolidation to Hitachi Works
Boilers → Nagasaki and Kure Works unified operation
- Overseas: Reorganization adjusting to business scale
(Downsize in China, Europe, Australia, etc.)

[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.)



MHPS: Mitsubishi Hitachi Power Systems, Ltd AQCS: Air Quality Control System FGD: Flue Gas Desulfurization Equipment USC: Ultra Super Critical power plant
CCS: Carbon dioxide Capture Storage CCUS: Carbon dioxide Capture, Utilization and Storage O&M: Operation & Maintenance

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The first measure is the optimizing of resources.

After the establishment of MHPS, post-merger integration (PMI) has been working out as scheduled and will be completed. We have been reorganizing our factories in Japan and overseas. Furthermore, we will proceed to shift resources to our services business and other MHI group businesses, adjusting to future business volume. Moreover, management efficiency will be enhanced by optimizing manpower through the shift to digitalized factories.

We will maintain our services business volume. We believe it is important to meet customer's needs with the right balance of environmental, economic performance and efficiency to achieve this.

We will realize the following solutions in utilizing our overseas networks;

- Enhancement of economics by improving the efficiency of our plants and also of competitor's existing plants
- Additional environmental protection system installation such as FGD (Flue Gas Desulfurization System)
- Maintenance efficiency enhancement and manpower reduction solutions by MHPS-TOMONI.

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

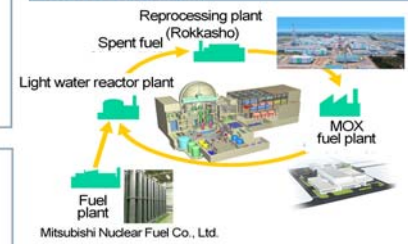
- Developing new reactors with enhanced safety for upcoming new-build projects
- Developing future reactors such as fast reactor, small-modular reactor, high temperature gas cooled reactor

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

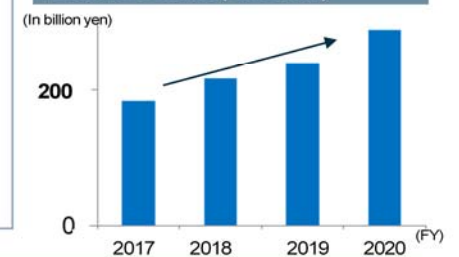
Cover All Processes of Nuclear Power Industry



Conceptualization of Safe Reactor (future plant)



Business Scale (Revenue)



As for nuclear power, its positioning as an important base load power will remain for a stable supply of energy and CO2 reduction. In Japan, the early establishment of nuclear fuel cycles is essential for the reduction of excess plutonium.

As a leading company in the nuclear power industry in Japan, we will continue to work towards nuclear power safety enhancement, securement and advancement of its design, production and construction technologies.

Currently, efforts are underway in collaboration with various utility companies to implement compliance to new regulations and to complete severe accident management facilities at the earliest phase possible. Moreover, maintenance work is expanded to enable safe and stable operation for 60 years, as approved by Nuclear Regulation Authority.

As for nuclear fuel cycles, we are assisting Japan Nuclear Fuel Limited for the early completion of reprocessing facilities in MOX fuel fabrication facilities. Also, we are proposing maintenance work to realize safe operation after their completion in collaboration with the French company Orano, with which MHI has an equity relationship.

As for the long-term, in anticipation of future new installment plans, we have started to explore the development of new reactors with enhanced safety that can address the safety and economic needs of society. We will continue to develop future reactors such as fast reactors, small modular reactors and high temperature gas cooled reactors in accordance with the government's strategic road map.

The stabilization of the Fukushima Daiichi Plant is a crucial issue for the nuclear industry. Therefore, we will assess the decommissioning effort through the use of core debris removal robots regardless of the difference in the reactor models. Recently we have revealed robotics tools for the removal of core debris. We will continue to assess in this decommissioning effort.

2-4-4. Compressors

Business Environment

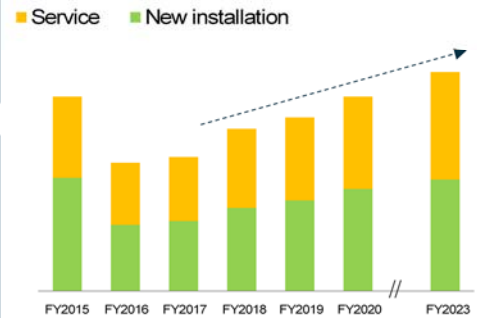
- Market scale will sustain expansion through the long term. In FY2018, investments were brisk especially in the field of ethylene
- Maintaining the top market share in petrochemicals

Results and Strategies

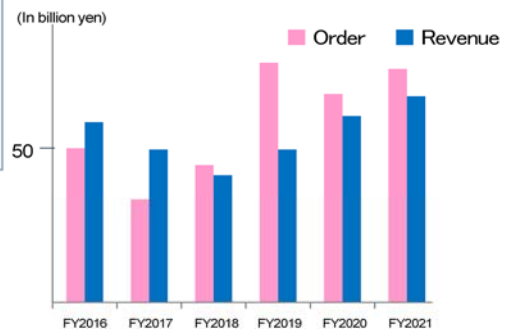
- In the promising oil & gas market, expand compressor train sales by collaborating with MHPS gas turbines
- To respond quickly to US demand for gas processing plants, currently investigating introduction of a test stand into our US shop and building a fully integrated local production system
- Expand 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)

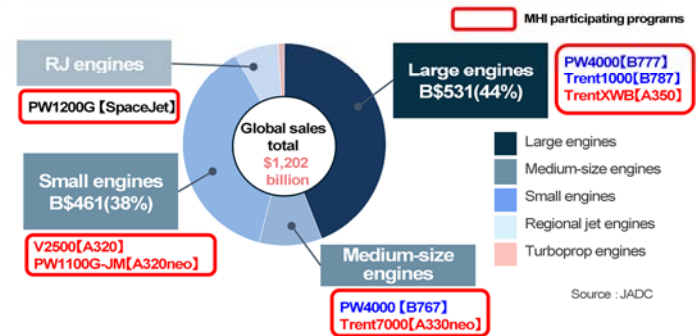


We believe that the compressor market is expanding after a temporary downturn. In FY2018, investments were brisk especially in the field of ethylene, and we maintained the top share in the petrochemical field. We have been trying to enter the oil and gas field including LNG. Our compressor train in combination with MHPS GT was adopted for the first time for the Mozambique project in which Exxon participates. We will work to expand the business in this field in the future. In the United States, the shale gas market continues to be active and inquiries for gas processing plants are strong. So we will strengthen our factory in the US to enable us to respond quickly.

2-4-5. Aero Engines

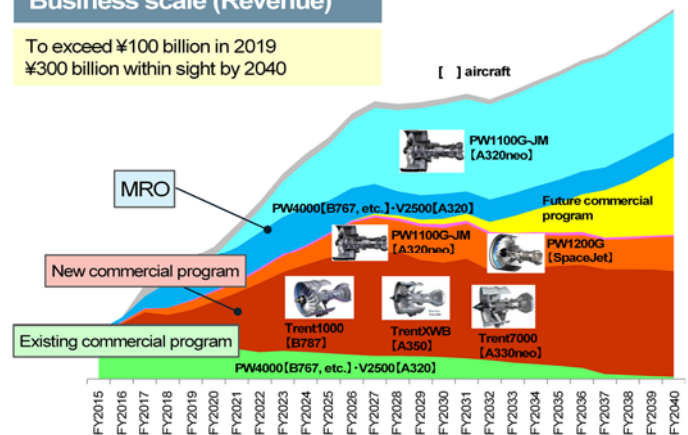
Market Scale and Growth Potential

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



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 the 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

The aero engines market is growing, supported by strong and steady aircraft demand. We are participating in the PW 100G program and Trent, which are cutting-edge engines that are in high demand. We are foreseeing the production growth surpassing revenues of 100 billion yen in FY2019.

In addition, we will strengthen our Maintenance Repair & Overhaul (MRO) business.

For this, we think it is important to further reinforce our efforts for technology advancement. So in this area, we have synergies with technologies cultivated within MHI group companies such as gas turbines for power generation.

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

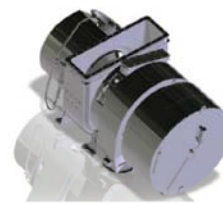
Results and Strategies

- 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

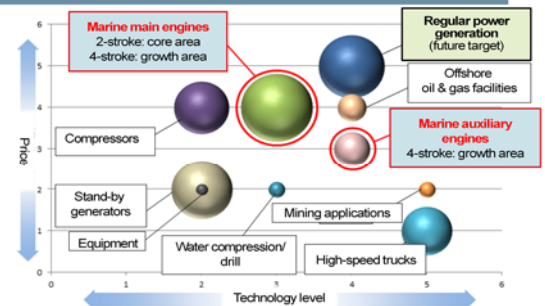
MET-MB II



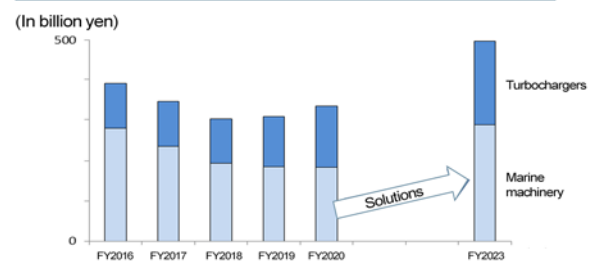
MET-ER



Turbocharger Market Structure and Targets



Business scale (Revenue)



Next is our marine machinery business.

Currently, our main marine machinery products are marine turbochargers, particularly for 2-stroke and 4-stroke auxiliary engines. The engine market for these turbochargers is expected to grow steadily for the time being backed by the new shipbuilding market that bottomed out in 2016.

We already have a considerable market share for 2-stroke engines. We plan to further expand sales with a new turbocharger for 4-stroke engines, so we are expanding sales channels for our customers in Europe and China.

In addition, orders for boiler fuel converter work are increasing in response to the tightened SOx emission regulations that will come into effect next year.

Mitsubishi Heavy Industries Marine Machinery and Equipment Company (MME) is doing this business and this company is enjoying high praise from customers such as ship owners and shipyards globally. MME is also supporting sales activities with MHI group companies since MME has excellent relationships with its customers.

2-4-7. Offshore Wind Turbines

Business
Environment

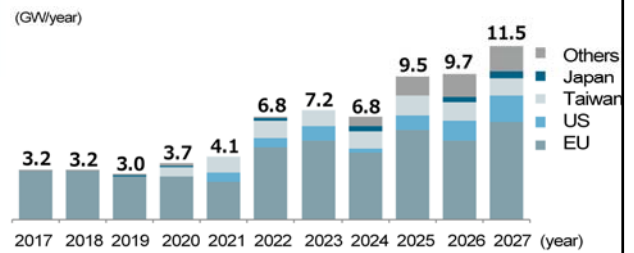
- Offshore wind turbine market growing faster than anticipated
- Market expected to expand from current focus on Europe to North America, then Asia (Taiwan, Japan, India, Vietnam, etc.) and other regions (approx. 4-6GW/year)
- Entered offshore wind market in April 2014 upon establishing MVOW with Vestas
- 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

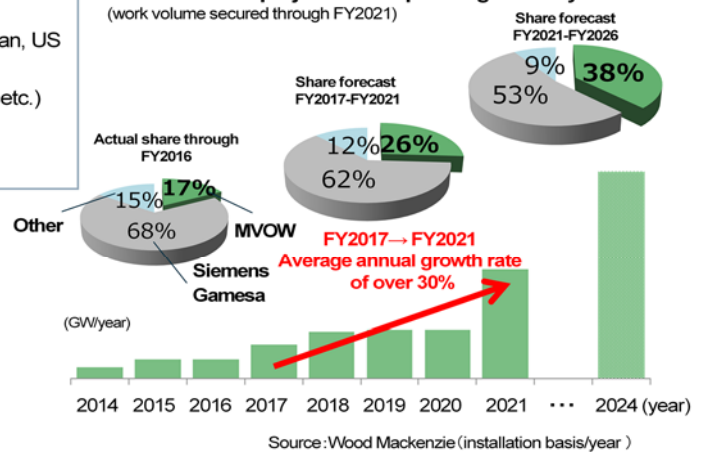


Offshore Wind Turbine Market (excluding China)*



Revenue and Market Share

Business scale projected to expand significantly
(work volume secured through FY2021)



Next is the offshore wind turbine business.

In the last few years, the offshore wind turbine market has been expanding faster than expected, especially in Europe. In the future, the location of the wind turbines is expected to expand from Europe to North America, and then followed by Asia, including Taiwan, Japan, India and Vietnam. The average annual growth of the business from FY2017 to 2021 is expected to be over 30%. MHI Vestas Offshore Wind (MVOW) which was jointly established 50-50 with Vestas, the world's leading offshore wind turbine supplier has been increasing its share year by year. Its backlog at the end of FY2018 is 8.7 gigawatts. We will strengthen mass production capability at MVOW for these orders. We believe MHI can contribute with our power of work and know-how to this expansion.

In addition to this, we are supporting MVOW for its start-up of V174, which has the world's largest output of 9.5 megawatts and its penetration into new markets such as Japan, Taiwan and the United States. Now MVOW is aiming for the top share in the entire global market.

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

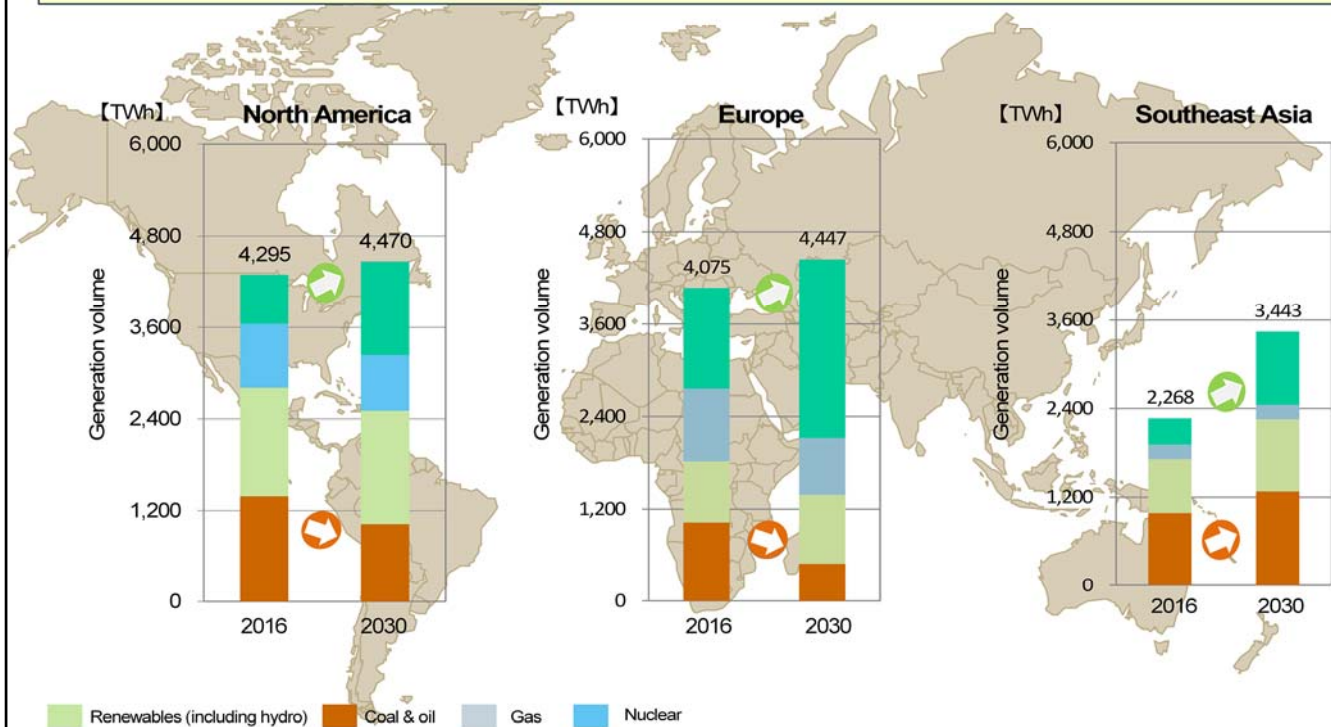
As mentioned, we believe we can achieve these targets by steadily executing the 2018 Medium-Term Business Plan.

We are also developing services, solutions, and growth products based on the needs expected after the 2018 Medium-Term Business Plan period.

Here I would like to talk about the SDGs that we consider from a longer term perspective. That is our vision of a sustainable society and our contribution to society.

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



Source : World Energy Outlook 2018

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Here, I would like to talk about what measures will be taken according to trends in the global power market towards 2030.

Global power consumption is expected to grow by more than 30% in 15 years from 2016 to 2030. The progress in electrification in Europe and the US, and the increase in power demand due to the economic growth in Southeast Asia are the main reasons behind this.

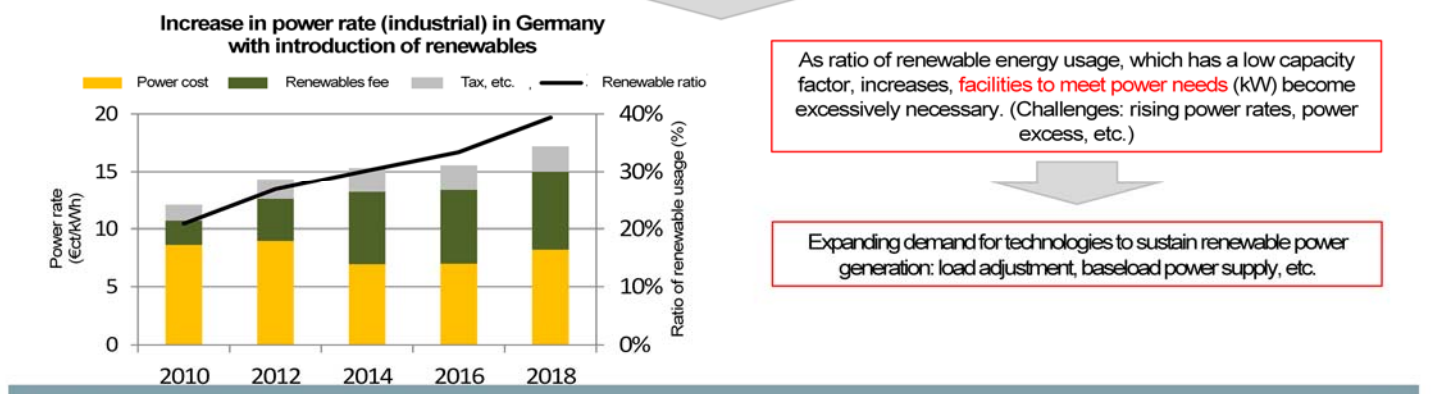
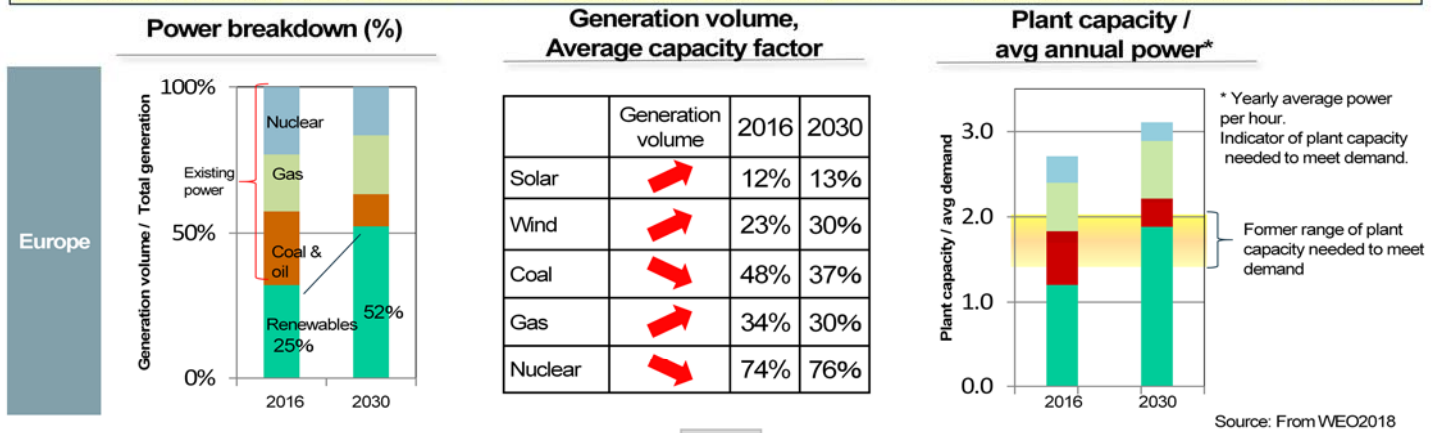
To cover this growth, it is clear that the introduction of renewable energy is likely to grow substantially worldwide.

Steam power will decline in Europe and the United States, but gas-fired power and nuclear power generation are expected to remain stable in these areas. A steady increase in steam and gas power is expected in Southeast Asia.

De-carbonization and a low carbon society are being called for globally. The introduction of renewable energies will continue to increase. But it is also fair to say that thermal power will also continue to play a role as an important power source.

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



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In Europe, the introduction of renewable energy has progressed dramatically since the beginning of the 21st century. This trend continues in the future with the percentage of renewable energy generation to total electricity generation amounting to 52% by 2030 in Europe.

On the other hand, the amount of electricity generated by renewable energy is influenced by natural conditions and even if technological advances are made, the plant capacity will be less than 15% for solar power and 30% for wind power, combining onshore and offshore. As a result, the total installed capacity will increase to just over three times the annual average power.

Installed capacity of the power generation facilities is determined by annual average power, taking peak power plus reserve capacity into consideration. There are differences among countries but they have been approximately 1.5 to 2 times the annual average power.

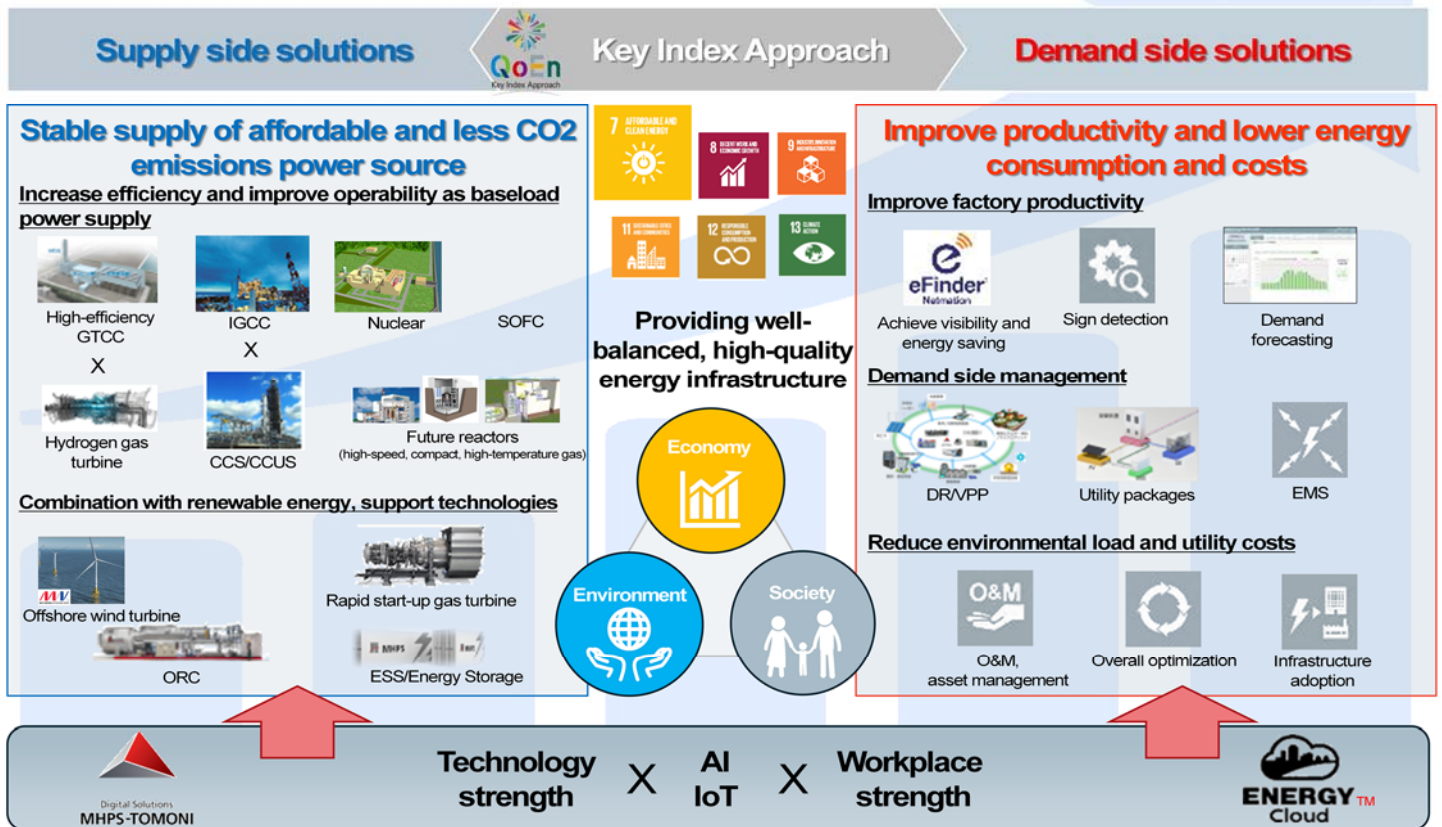
Consumers will have to bear the cost of excess capacity and the fluctuations in renewable energy through power rates.

Germany is an example of this. In Germany, power rates have risen sharply with the penetration of renewable energy. Can we say that this situation is sustainable? That's our question.

In order to take the benefits of renewable energy, it becomes more important to balance thermal and nuclear power by adjusting the load fluctuations and reducing the burden on the grid.

While responding to these needs, we are also promoting the development of technologies such as hydrogen power GT, which can achieve both low carbon and stable supplies. We will contribute to the realization of a sustainable low carbon society by collaborating with our partners.

Realize sustainable society by providing balanced energy infrastructure



SOFC: Solid-Oxide Fuel Cell ESS: Energy Storage System DR: Demand Response VPP: Virtual Power Plant EMS: Energy Management System

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There are several elements in sustainable development goals. To aim for a low carbon society, we will provide a balanced energy infrastructure so that it is truly sustainable and will contribute to society.

On the supply side, we will achieve economic, environmentally stable supplies and safety (3E + S), by supplying systems that combine our products with renewable energy which bring low carbon emission and better operation efficiency.

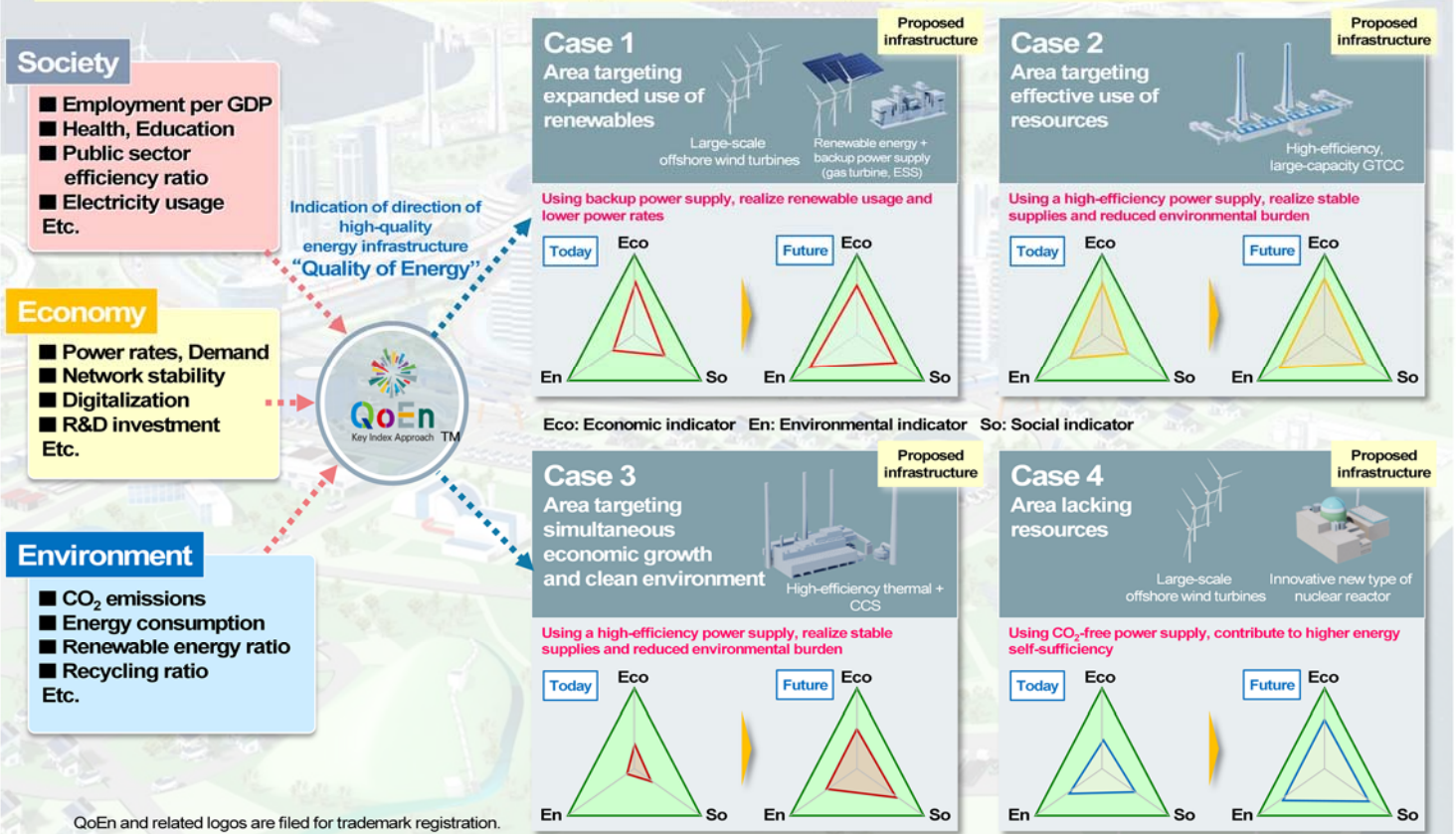
On the other hand, in addition to development and provision of our own products, we will supply a total solution utilizing AI/IoT technologies to meet the needs of not only the supply side, but also the demand side as well.

On the supply side, we can achieve more improved performance and operability for existing plants.

On the demand side, we will be proposing energy saving solutions and AI tools such as ENERGY CLOUD™ which provides factory operation know-how and covers facility planning, operation, and maintenance.

We have taken one step further and have started to identify and support the needs for introducing energy infrastructure from the initial planning stage of area development.

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



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The key index approach we propose here is “high quality energy infrastructure”. This is called “QoEN” and we are deploying this concept with the logo. The purpose of this is to support necessary energy supplies and sustainable growth of the target area.

In order to realize a sustainable society, it is essential to grow while balancing society, economy, and environment. In “QoEN”, first, these three indices of the target area are quantified and shown and expressed in the form of triangles so that comparison with other areas can be made possible and the balance is understood easily.

In this way we are able to understand what kind of energy infrastructure is needed. We can exercise PDCA (plan, do check & action) after the introduction of such an infrastructure.

In many parts of the world, there are different situations and goals. The index “QoEN” can be used from the very early stages of area development, and is aimed at visualizing the ideal state of high quality energy infrastructure .We believe that we can offer the optimal proposal for each area.

We are currently working on a development plan for the New West Sydney Airport area utilizing “QoEN” in collaboration with an Australian university.

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There is no doubt we are in a global shift towards a low carbon and decarbonized society over the long-term. However, there is no single way to get there. The key that guides the path and reflects the social and economic needs of the people living in the area is “sustainability”.

In order for our business to be sustainable, it is necessary for that business to support a sustainable society.

I would like to share with you our vision of a sustainable society, created by our power division as a summary of my presentation.



We believe we have to aim for a sustainable society with well-balanced energy sources. The world's power supply is shifting from steam power generation to renewable energies, such as wind power. While renewable energy is clean, it is unstable. For example, on sunny days and windy days, generating more power than demand leads to reverse power flow. MHI is committed to supporting a society driven by renewable energy through clean products such as nuclear power generation, hydrogen GT, IGCC, CCUS and various service solutions such as the ENERGY CLOUD and MHPS- TOMONI.

Additionally, by utilizing our key index approach “QoEN”, we will be able to propose customized planning and improvements to optimize total energy solutions in any given area.

Thank you very much for your attention.

MOVE THE WORLD FORWARD

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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: PWR: Reprocessing-related:
 In operation: Installation authorized: 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 the Rokkasho Reprocessing Plant (RRP) and the 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

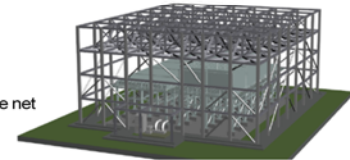
[Examples of requirements of new regulations]

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

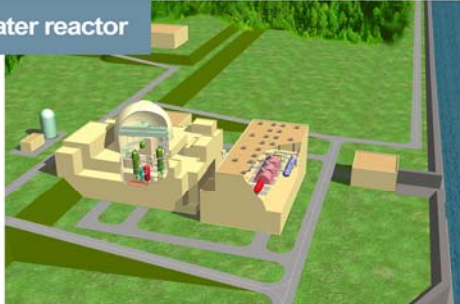


Framework for protective net

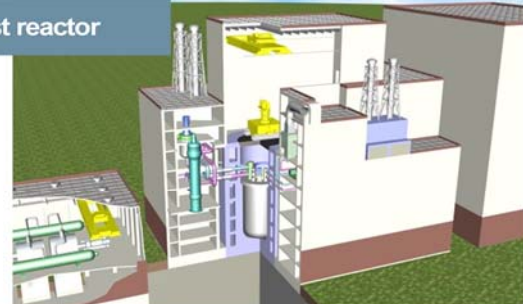
3) Initiatives for New-build and Future Reactors

- 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

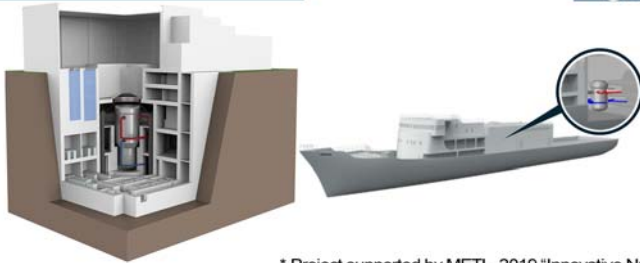
Light water reactor



Fast reactor



Small-modular reactor



High-temperature gas-cooled reactor

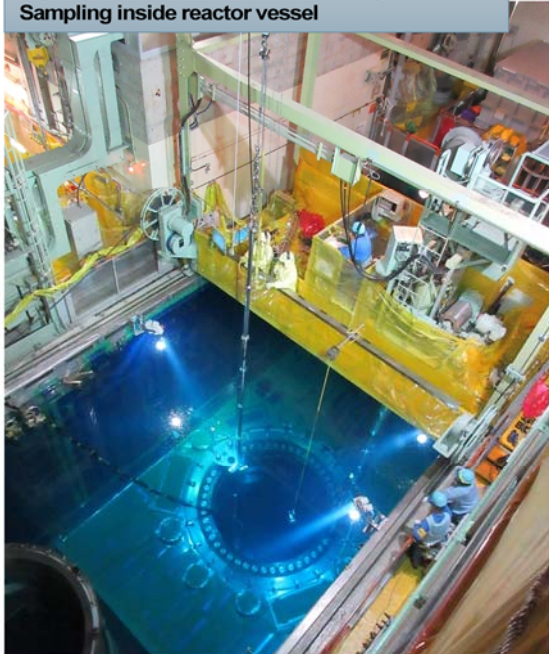


* Project supported by METI. 2019 "Innovative Nuclear Technology Development Support Projects Responding to Social Needs"
EDF: Électricité de France (French power company)

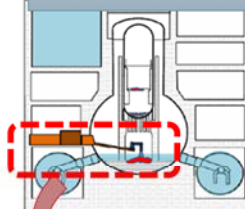
4) Decommissioning Initiatives

- 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.