MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

Energy Transition Solution for Kazakhstan with Gas Turbine

Mitsubishi Heavy Industries, Ltd.

October 2024

三菱重工

Mitsubishi Heavy Industries Group at a Glance

1884 Foundation
140 years anniversary

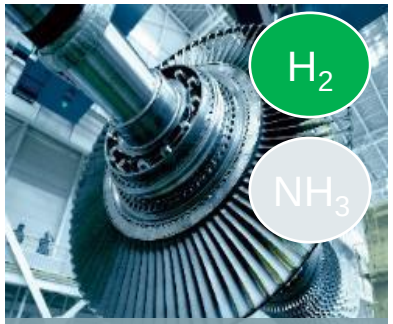
77,468 Employees
(Consolidated)

257 Group Companies
(Consolidated)

¥4.7TN ($32.5BN*) Revenue
(FY2023, consolidated)

Diverse **products**
On land, at sea, in the sky, in space

Note: The U.S. dollar revenue figure was converted from Japanese yen using the FY2023 average exchange rate, JPY 143.2/USD.



Gas turbines

Compressors


Aero engines

CO_2 capture plants

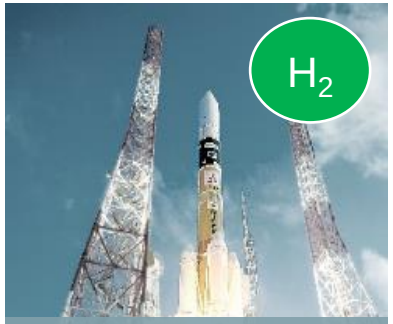
Metals machinery

Chemical plants


Transportation


Waste-to-energy


Turbochargers



Aerospace

Rocket engines


Defense

MHI Group Mission Net Zero

To achieve Net Zero CO2 emissions from its operation and entire value chain by 2040

Target Year	Reduce CO_2 emissions across MHI Group Scope 1&2	Reduce CO_2 emissions across MHI's value chain Scope 3 + reduction from CCUS
2030	-50% (compared to 2014)	-50% (compared to 2019)
2040	Net Zero	Net Zero

(Note) Scope 1&2: The calculation standard is based on the GHG Protocol.

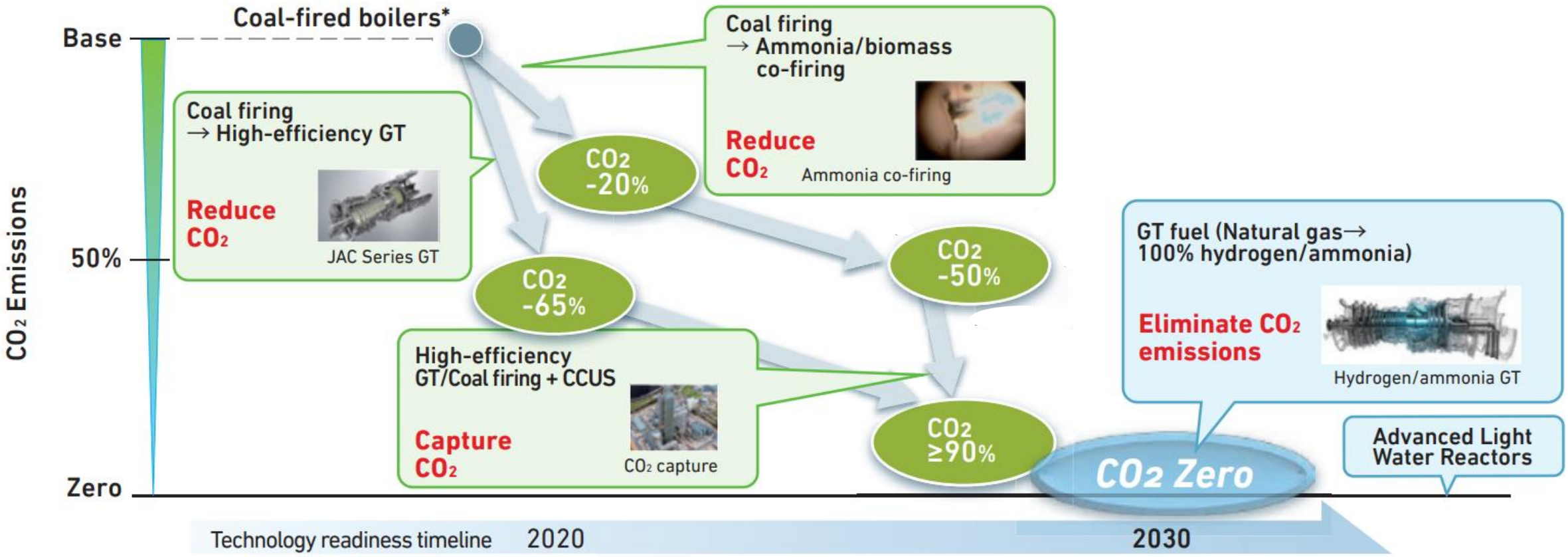
(Note) Scope 3: The calculation standard is based on the GHG Protocol.

(Note) CCUS: Carbon dioxide Capture, Utilization and Storage

Build an innovative solutions ecosystem to realize a carbon neutral future

Roadmap to Decarbonizing Existing Infrastructure

Reducing, capturing, and eliminating CO2 is one path to decarbonizing thermal power.
Another path is to reduce CO2 emissions through maximum utilization of a carbon-free energy source.



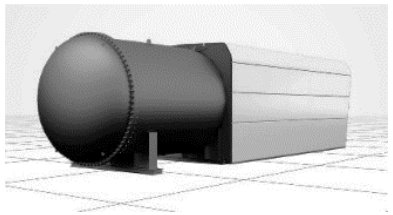
*Based on CO2 emissions from subcritical pressure coal-fired boilers

Development & Verification of Decarbonization Technology

MHI is developing and verifying decarbonization technologies to achieve carbon neutrality.
Takasago Machinery Works started the integrated verification of hydrogen production, storage and utilization.

①Nagasaki Carbon Neutral Park

CCUS*
CO_2 Capture Technology



SOEC*
Hydrogen Production

②Takasago Machinery Works

③Hitachi/Katsuta GTD

Katsuta Gas Turbine Demonstration Facility

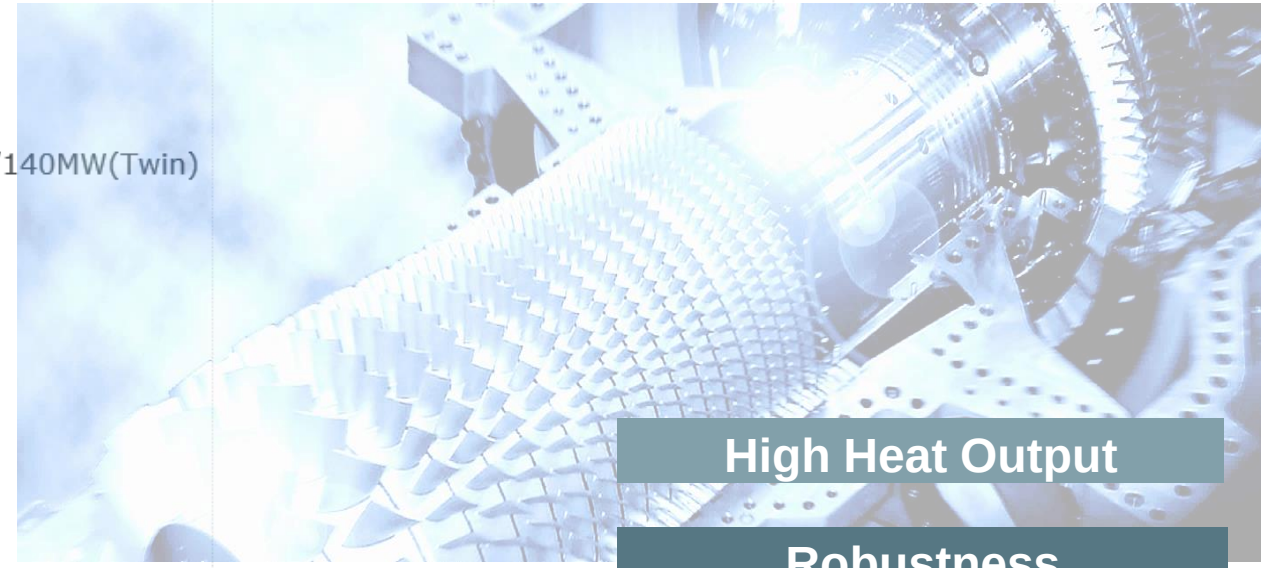
Ammonia
test facility

CCUS: Carbon dioxide Capture, Utilization and Storage SOEC: Solid Oxide Electrolysis Cell(固体酸化物形水電解)

Our Gas Turbine Line up

Model		Cycle	
PWPS	FT-8	50/60Hz	30MW(Single)/60MW(Twin)
	FT-4000	50/60Hz	60MW(Single)/140MW(Twin)
H-Series	**H-25**	**50/60Hz**	**30MW～41MW**
	H-100	**60Hz**	**105MW**
	H-100	**50Hz**	**116MW**
M-Series	M-501D	60Hz	114MW
	M-701D	50Hz	144MW
	M-501F	60Hz	185MW
	M-501G	60Hz	283MW
	M-501J	60Hz	330MW～425MW
	M-701F	50Hz	385MW
	M-701G	50Hz	334MW
	M-701J	50Hz	448MW～563MW

(MW)
0 100 200 300 400 500 600

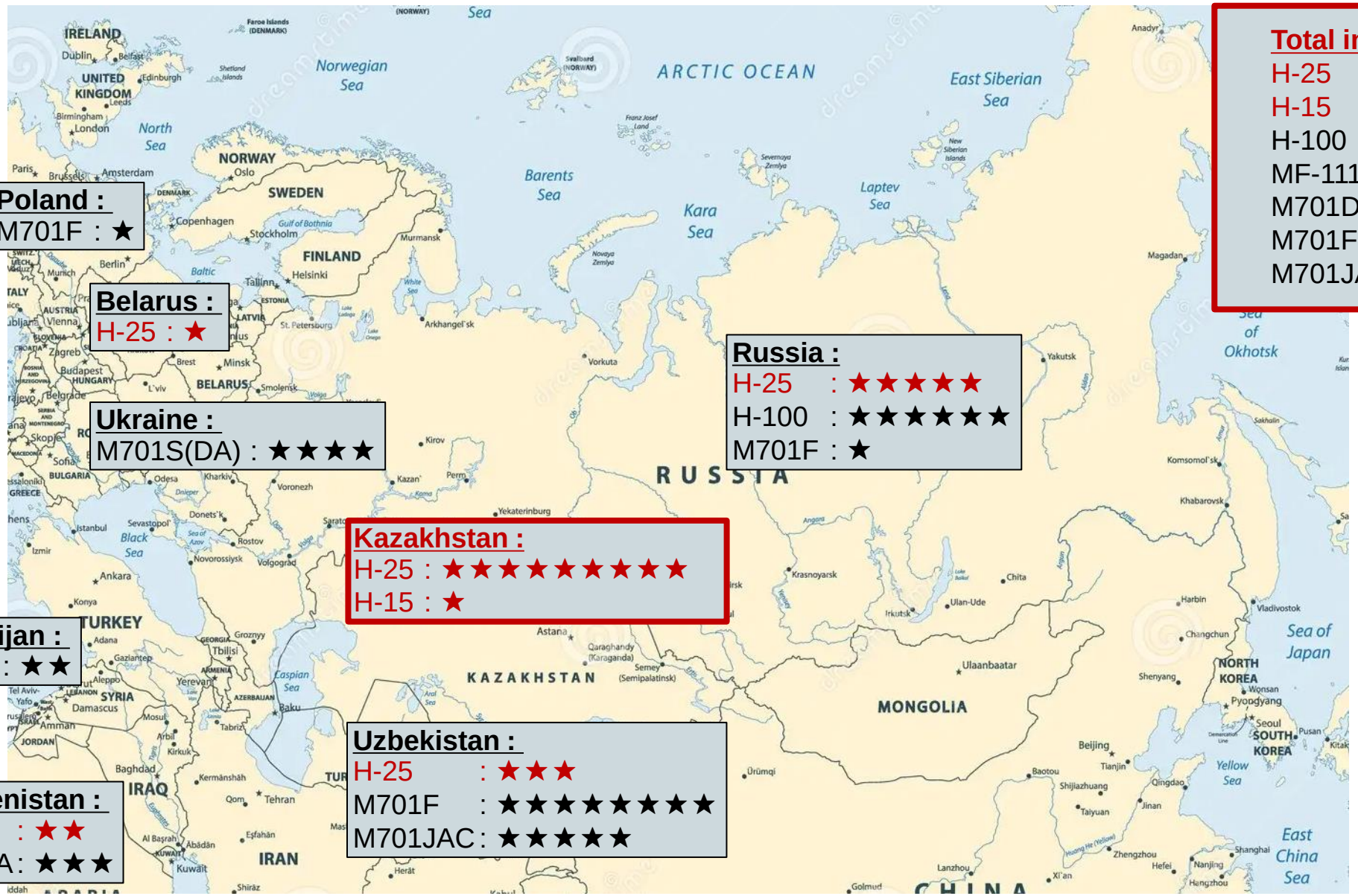


High Heat Output

Robustness

Fuel Flexibility

MHI's Gas Turbine in CIS and Eastern-Europe



Poland :
M701F : ★

Slovakia :
MF-111 : ★★

Belarus :
H-25 : ★

Hungary :
H-25 : ★★★

Ukraine :
M701S(DA) : ★★★★

Russia :
H-25 : ★★★★★
H-100 : ★★★★★★
M701F : ★

Kazakhstan :
H-25 : ★★★★★★★★★
H-15 : ★

Azerbaijan :
M701F : ★★

Uzbekistan :
H-25 : ★★★
M701F : ★★★★★★★★
M701JAC : ★★★★★

Turkmenistan :
H-25 : ★★
M701DA : ★★★

Total in Region : 56

H-25	: 23
H-15	: 1
H-100	: 6
MF-111	: 2
M701DA/S(DA)	: 7
M701F	: 12
M701JAC	: 5

as of SEP 2024

Gas Turbine Solution for CHP improvement in Kazakhstan

CHP : Combined Heat & Power

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H-25 Gas Turbine solution to improve reliability and efficiency of CHP/boiler plants in Kazakhstan through modernization.

Difficulties to switch to decarbonization all at once

【 Existing CHP/boilers 】

- Aging equipment
- Decrease of Reliability
- Emission of CO2
- Air Pollution
- Lack of Electricity

[Strategy 2060]

Gradual transition from coal to Renewable Energy, with gas as transition fuel

[Issue]

- **Major systems to be changed (New Grid and network)**
- **Huge Financing required**
- **New technology required**
- **New Cost Sharing method required**

Gas Turbine 30-41MW Solution [transition]

① **High Reliability**

② **Reduce CO2 and other emissions**

③ **Continued use of existing facilities and staff ⇒ MORE ECONOMICAL**

④ **More economical than Heat by electricity**

⑤ **Transition Finance attraction**

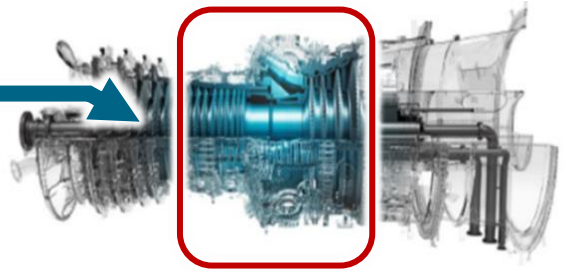
⑥ **Backup and Recovery for RE**

⑦ **H2 Ready / NH3 Ready**

H-25 Gas Turbine

Green H2/NH3 will be used as fuel in the future.The risk of seasonal fluctuations in renewable energy is also avoided. H-25 is continuously modernized to meet new goals in Japan and the world.

Combustor parts replacement only



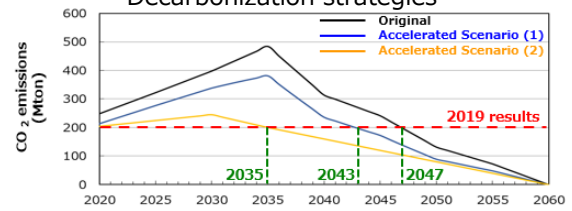
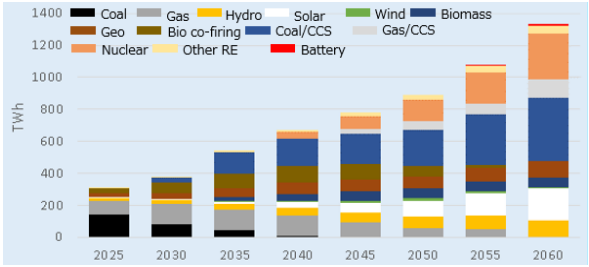
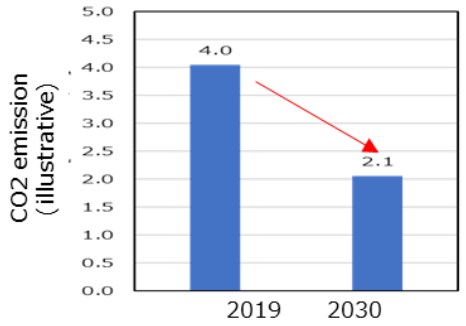
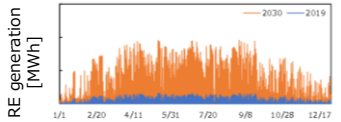
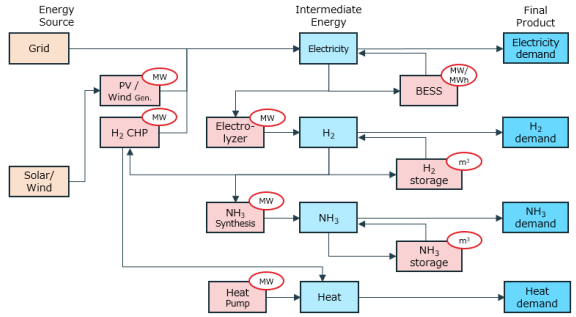
Proposal of Joint Study Utilizing Simulation Approach

Comprehensive simulation approach for Strategies, Modernization Plan, and its Evaluation

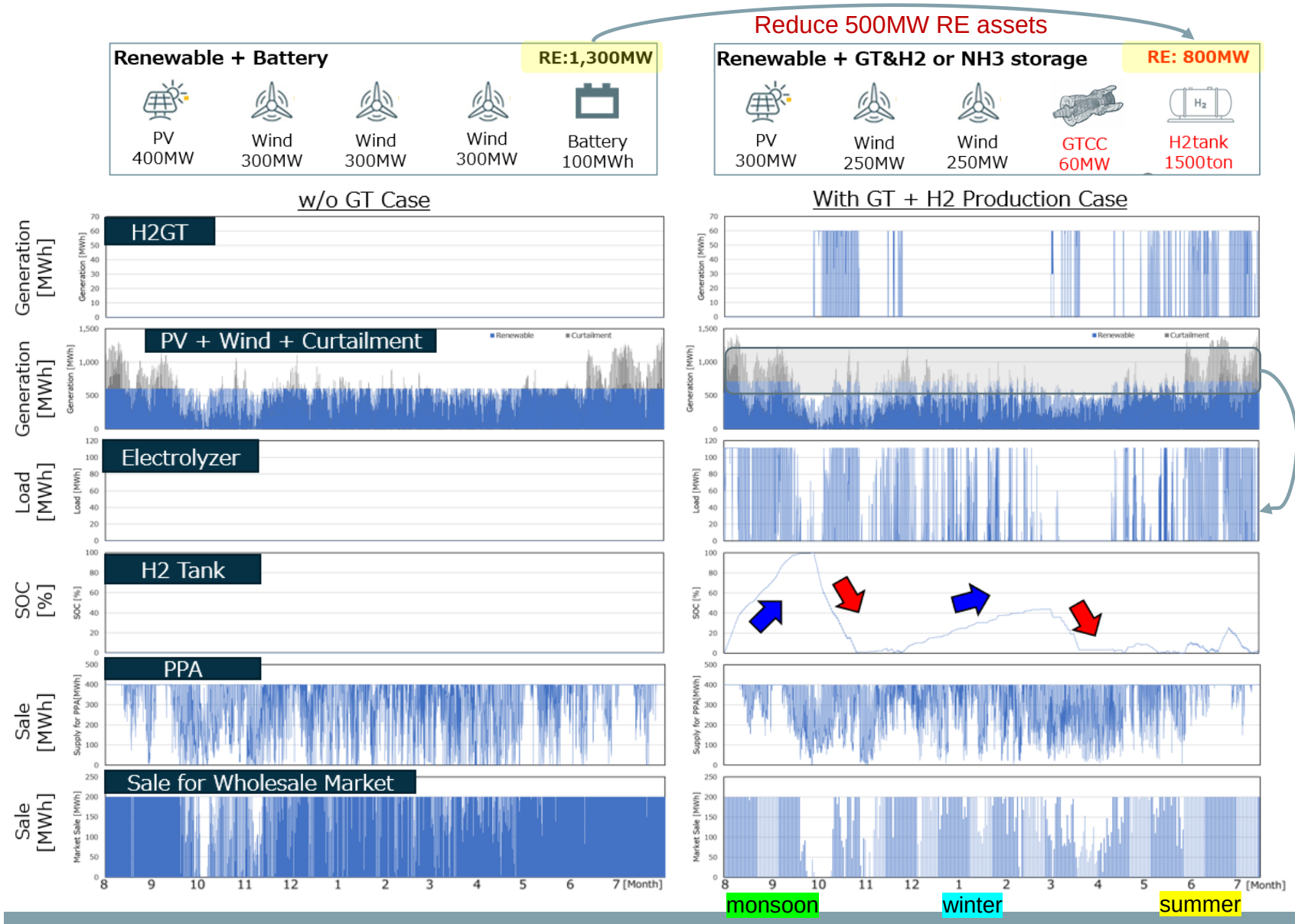
Examples of the Join Study

Solar

Wind

Item	1) Evaluation on Decarbonization Strategies	2) Utilization of Existing Facilities	3) Evaluation on Decarbonization Projects
Value-Proposition	- Forecast capacity mix under various decarbonization scenarios - Propose the decarbonization strategy to achieve the target	- Forecast utilization of each facility in future under various scenarios - Propose measures for the target plant to improve revenues and costs	- Optimize green hydrogen/ ammonia production project/plant - Propose specifications of the plant in order to minimize the total cost
Illustration	Decarbonization strategies  Capacity/generation mix  	Ex. Flexibility upgrade for a plant - Minimum load (Turn-down) - Ramp rate CO_2 emission of a whole power system  	Inputs such as RE generation profiles  Optimization capacities of each component 

H2/NH3 Gas Turbine utilized for 100% Renewable Energy



Change curtailment to H2

Ex
400MW PPA

Min.Monthly capacity factor 70%
Min. Year capacity factor 80%(ave.)

- ✓ To produce & storage H2 or NH3 using curtailment of VRE
- ✓ GT seasonal operation using H2 or NH3 during night or low wind

With GT + H2 production/storage case would be better LCOE than VRE only
※subject to the conditions

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