脱炭素に
技術と叡智
IHI

IHI Carbon Neutral Activities
- Ammonia Fuel and Others-

IHI

26th.May.2025

IHI Corporation
Carbon Solution Business Unit, Combustion Engineering Group
Takuya OKADA

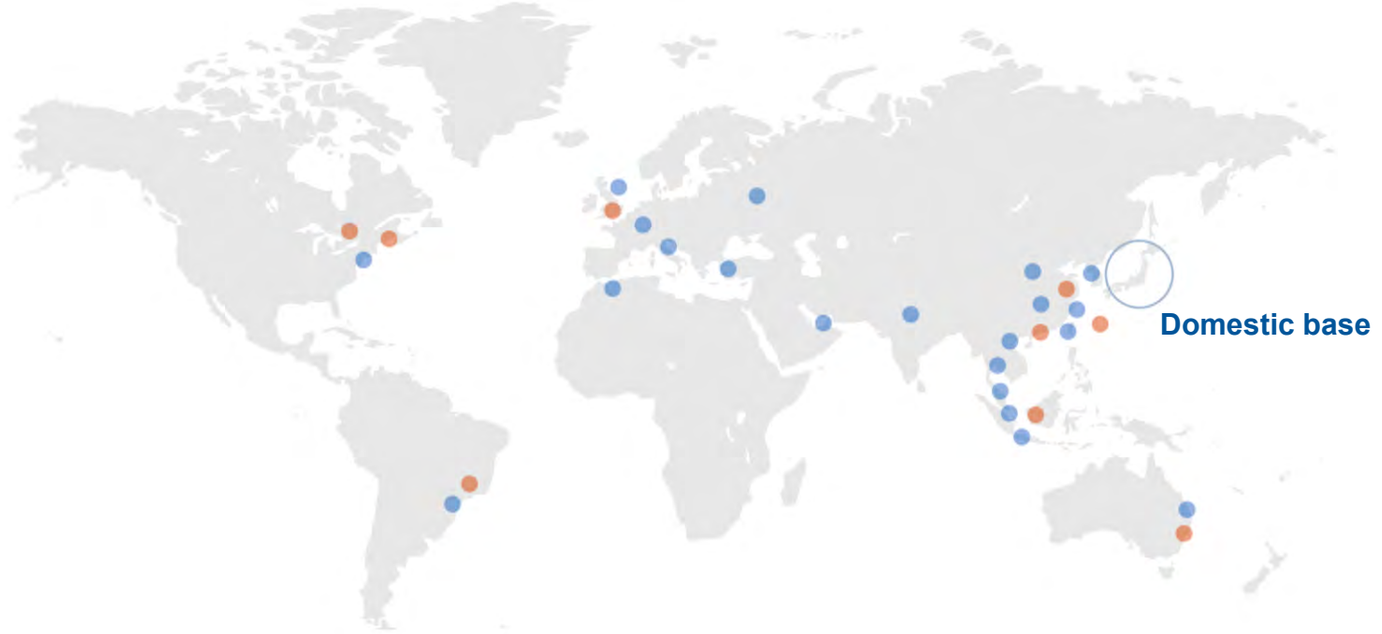
Introduction of IHI

IHI is a global company with more than 20 overseas bases and more than 100 overseas group company

Year of establishment
1853

Revenue (Consolidated)
Approx. 10 billion USD

Approx. 30,000 employees
(consolidated)



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Areas of expertise

Main products :
Carbon Solutions,
Gas Turbine/Diesel Engines/Gas Engines,
LNG Receiving Terminal, Storage Tank,
Process Plants, Equipment for Plants,
Nuclear Energy

Main products :
Compressors, Separators,
Cryogenic Product,
Turbochargers for Vehicles,
Parking System, Logistics System, etc.

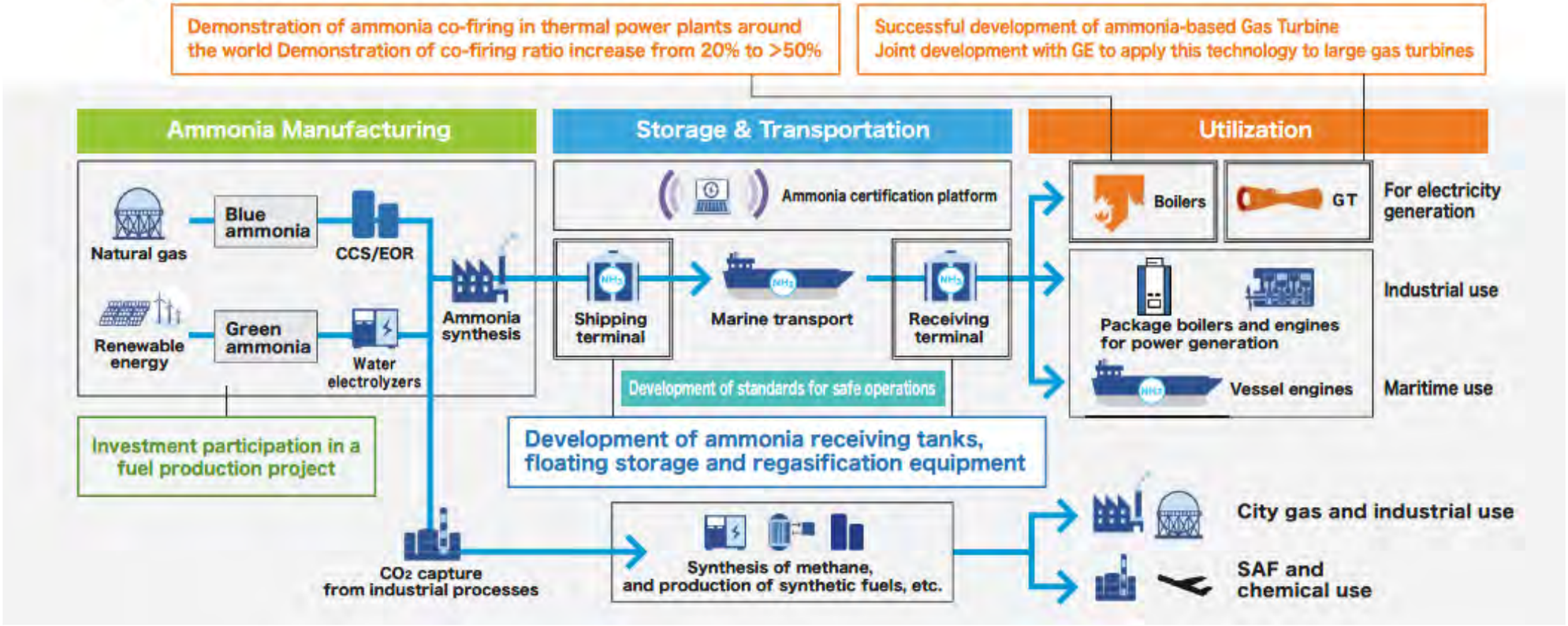
Main products :
Aero Engines, Air Traffic Control,
Rocket System and Space Exploration

Main products :
Bridges, Watergates, Shields,
Concrete Construction Materials,
Offshore Structure, Urban Development,
Security, Environment Monitoring

Our Mission

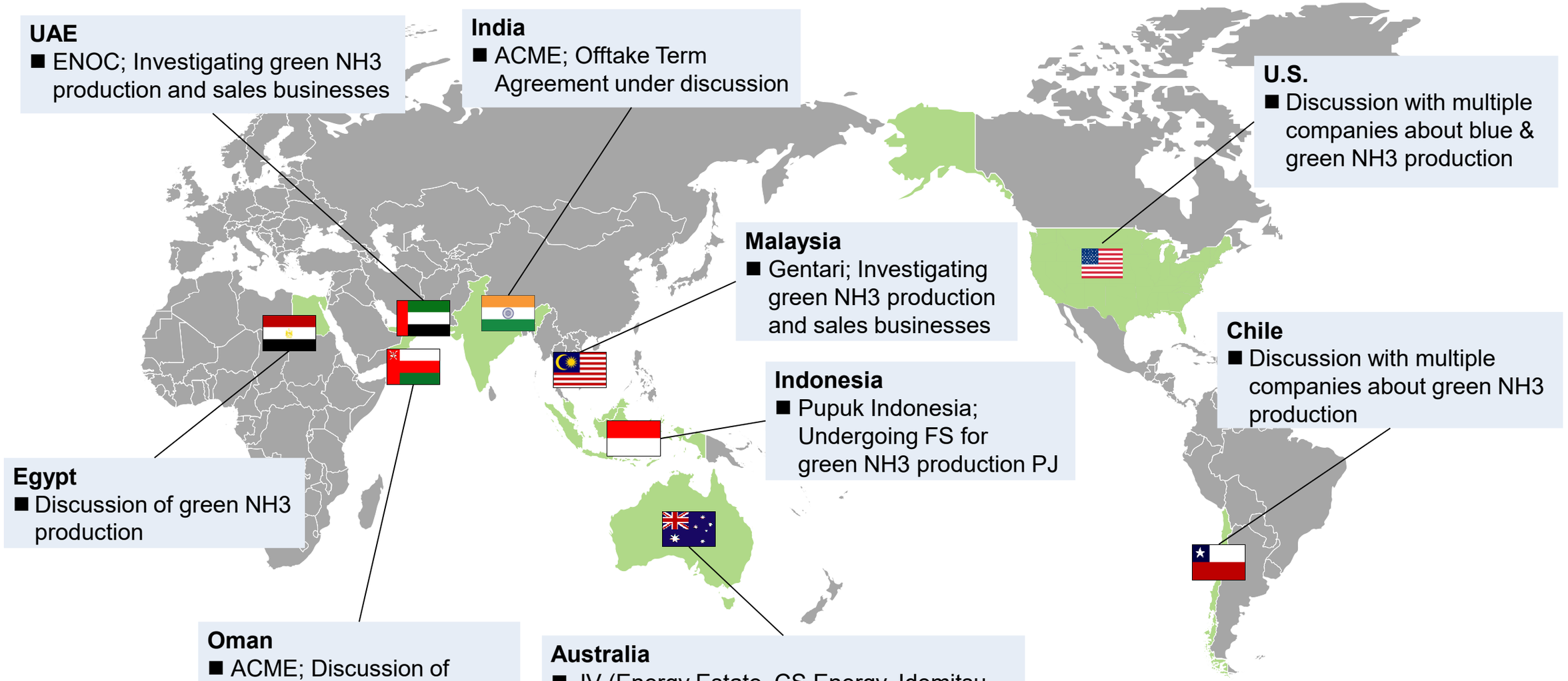
Medium-term Management Plan

- **Building it into a business that will be main pillar.**
- **We will work to create and improve our entire value chain. This includes power generation equipment such as Gas Turbine that utilizes world-leading ammonia combustion technology, as well as our storage and receiving terminals with top-tier performance.**
- **While investigating investment in fuel manufacturing projects, we will utilize our engineering capabilities to build a new business model.**



Group Management Policies 2023.pdf (ihi.co.jp)

Clean Ammonia Production Projects Over the World



UAE
- ENOC; Investigating green NH3 production and sales businesses

India
- ACME; Offtake Term Agreement under discussion

U.S.
- Discussion with multiple companies about blue & green NH3 production

Malaysia
- Gentari; Investigating green NH3 production and sales businesses

Indonesia
- Pupuk Indonesia; Undergoing FS for green NH3 production PJ

Chile
- Discussion with multiple companies about green NH3 production

Egypt
- Discussion of green NH3 production

Oman
- ACME; Discussion of Green NH3 Production PJ

Australia
- JV (Energy Estate, CS Energy, Idemitsu Australia, IHI) proceeding with FEED

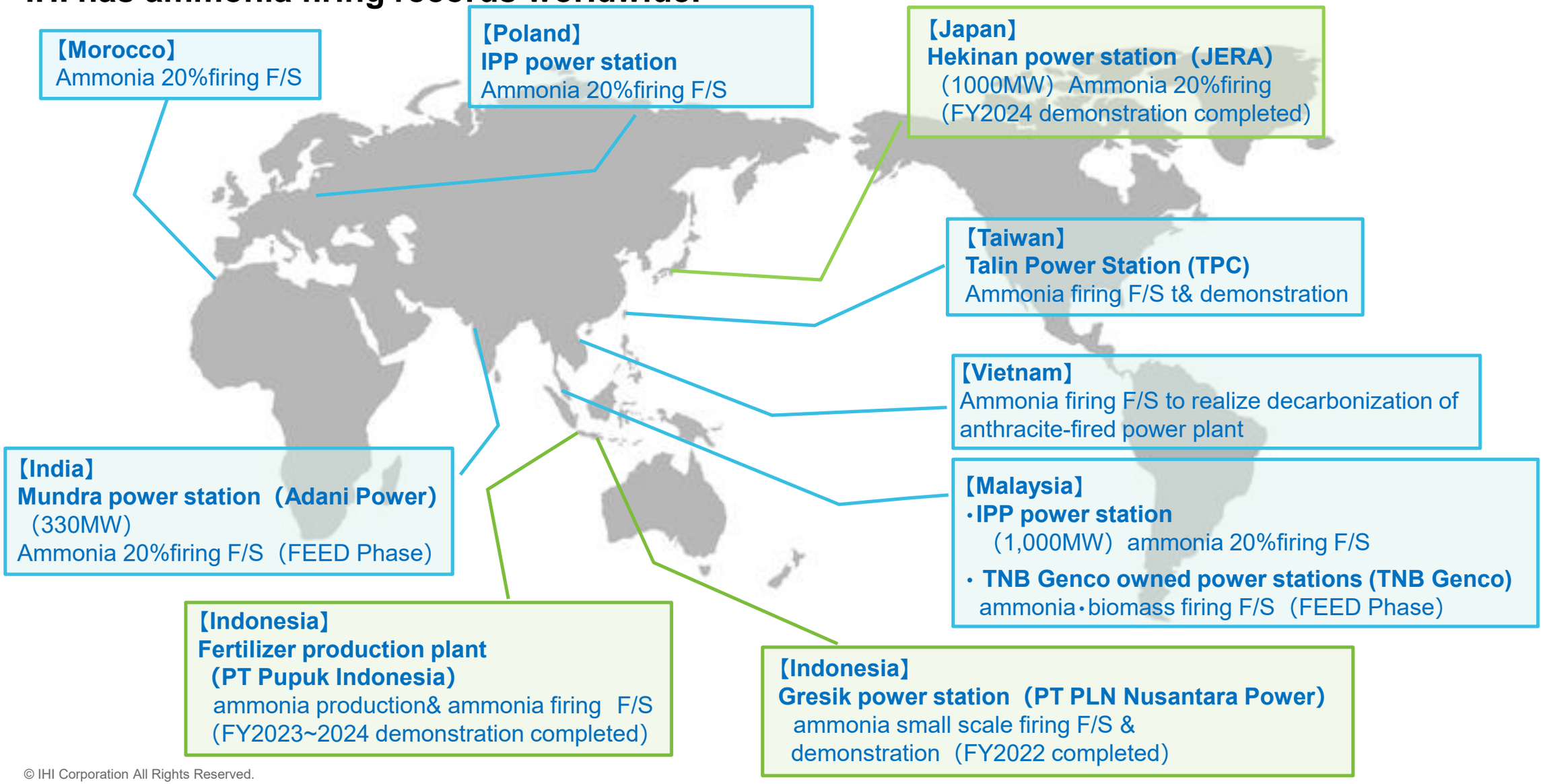
Ammonia Utilization Technologies

Wide range of ammonia utilization technologies currently in development

Field	Items		Description	Status
Power	Boiler		Developing ammonia combustion technologies for thermal power plants	Demonstration of 20% ammonia combustion at JERA's Hekinan Thermal Power Station #4 from **Apr 2024 - successfully completed Jun 2024**
	Large Gas Turbine	 9F.04 Source : GE Vernova	IHI and GE Vernova (GEV) entered into joint development agreement to apply IHI's 100% ammonia combustion technology to GEV's gas turbines (6F.03,7F and 9F)	Joint development targeting **2030**
Maritime	Recip. Engine		Developing reciprocating engines for vessels with ammonia-fueled engine	Successfully started the Engine demonstration (10% diesel, 90% ammonia) **Jul 2024,** ship to be completed by **Nov 2026**
Industry			To be used as a means for both maritime and onshore applications	Diesel engine (maritime) to be commercialized in **2027,** gas engine (onshore) in **2028**
	Small Gas Turbine	 ※Subsidized by NEDO (JPNP21020)	World's first 100% ammonia combusted gas turbines to achieve CO_2 free power generation	Durability test from **May 2024 to 2025,** to be commercialized in **2026**
	Furnace		IHI to convert existing fuel for various industrial furnaces (naphtha cracking furnace etc.) to ammonia fuel	Ammonia single-fuel burners demonstrated at naphtha cracking furnace, Idemitsu Kosan Co.,Ltd in **Feb 2024**

Global Activities for Ammonia Firing Boilers

IHI has ammonia firing records worldwide.



【Morocco】
Ammonia 20%firing F/S

【Poland】
IPP power station
Ammonia 20%firing F/S

【Japan】
Hekinan power station（JERA）
（1000MW）Ammonia 20%firing
（FY2024 demonstration completed）

【Taiwan】
Talin Power Station (TPC)
Ammonia firing F/S t& demonstration

【Vietnam】
Ammonia firing F/S to realize decarbonization of anthracite-fired power plant

【India】
Mundra power station（Adani Power）
（330MW）
Ammonia 20%firing F/S（FEED Phase）

【Malaysia】
・**IPP power station**
（1,000MW）ammonia 20%firing F/S
・**TNB Genco owned power stations (TNB Genco)**
ammonia・biomass firing F/S（FEED Phase）

【Indonesia】
Fertilizer production plant
(PT Pupuk Indonesia)
ammonia production& ammonia firing F/S
(FY2023~2024 demonstration completed)

【Indonesia】
Gresik power station（PT PLN Nusantara Power）
ammonia small scale firing F/S &
demonstration（FY2022 completed）

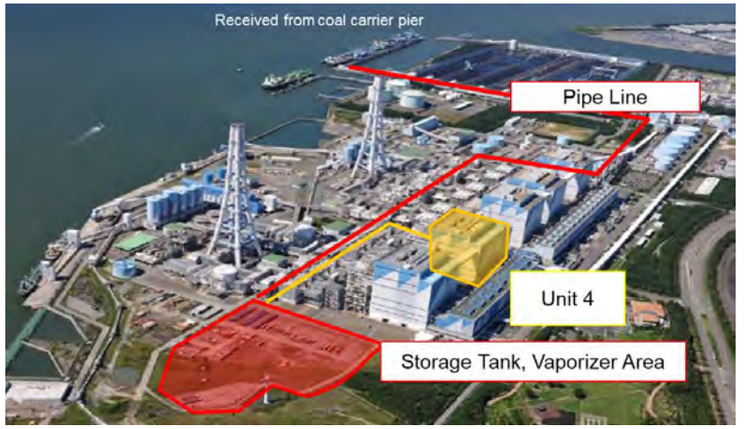
Demonstration at 1000MW Power plant in Japan

IHI and JERA Complete Fuel Ammonia Substitution Demonstration Testing at Hekinan Thermal Power Station

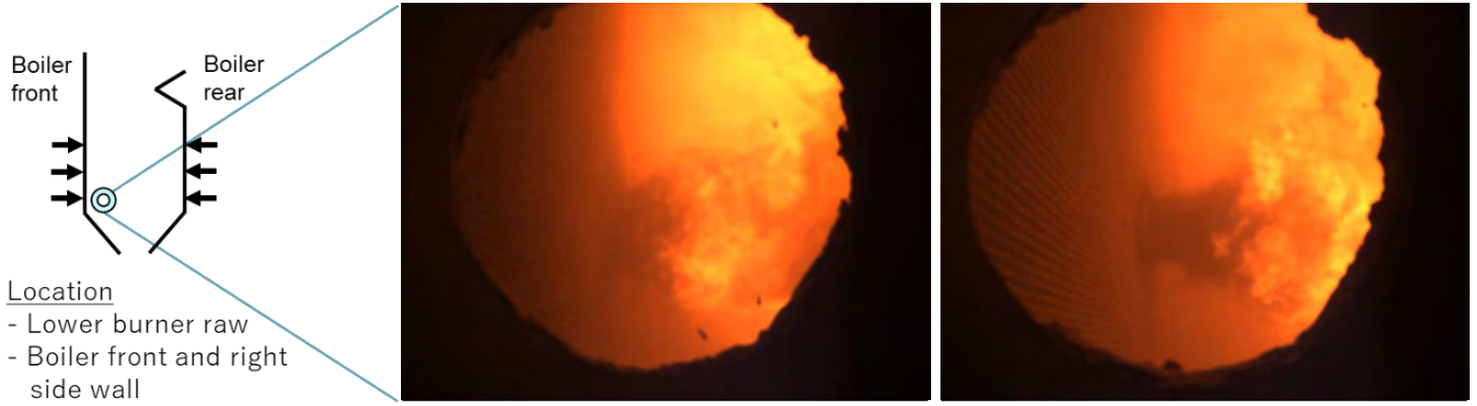
- Jun3 26, 2024 - **Press Release**

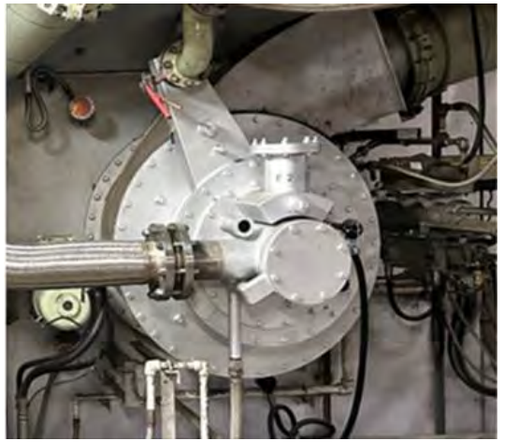
This effort has yielded favorable environmental outcomes.

- ✓ CO_2 emissions at the unit have fallen around 20%.
- ✓ NOx emissions are equal to or less than before ammonia substitution.
- ✓ SO_2 emissions are down about 20%.
- ✓ Emissions of powerful greenhouse gas N_2O have been undetectable.



JERA's Hekinan Thermal Power Station
(cited from JERA's homepage)





Test burner (total 48 burners on boiler)

※Subsidized by NEDO (JPNP16002)

IHI and JERA Complete Fuel Ammonia Substitution Demonstration Testing at Hekinan Thermal Power Station | 2024FY | News Articles

The results of the major evaluation items

The major evaluation items have all met the targets.

No.	Item	Target	Result	Evaluation of 20% Ammonia Firing
1	Main Steam/Reheat Steam Temperature	Equivalent to Coal Firing	Achieved	Steam conditions have been maintained
2	Boiler Capability Steam Generation Capacity	Equivalent to Coal Firing	Achieved	Steam generation rate have been maintained
3	Ammonia Firing Ratio	20%	Achieved	Achieved firing ratio of 20%
4	NOx	Equivalent to Coal Firing	Achieved	Achievable equivalent to Coal firing
5	Unburned Carbon in Ash	Equivalent to Coal Firing	Achieved	Can maintain the same level as Coal firing
6	N_2O	Not detected	Achieved	Below the quantitation limit
7	Unburned NH_3	Not detected	Achieved	Below the quantitation limit

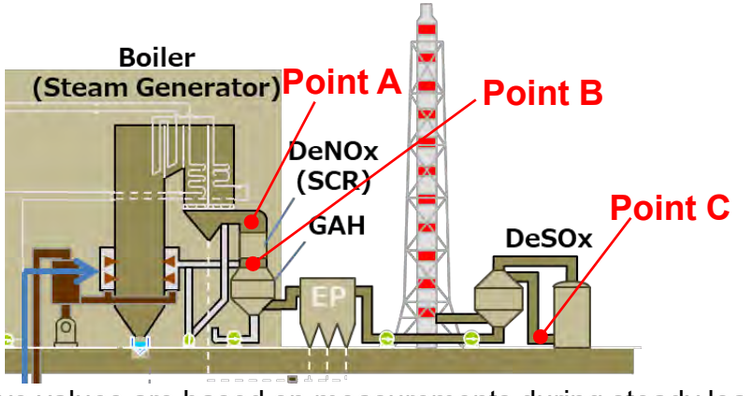
Detailed Combustion Characteristics

1) Emission (NOx, SOx) and combustibility
- ✓ Combustion characteristics and static characteristics of the boiler with 20% ammonia firing were generally equivalent to coal-only combustion
- ✓ Operation could be managed within the control range of the existing equipment.
- ✓ Boiler efficiency with 20% ammonia firing was as initially expected.
- ✓ No significant changes in unburned components were observed.

NOx		
Ammonia Firing Ratio	0% (Coal Firing)	20%
Measurement Location	DeNOx (SCR) Inlet (Point A)	
Result	134 ppm [Dry, 6%O_2basis]	106 ppm [Dry, 6%O_2basis]

SOx		
Ammonia Firing Ratio	0%	20%
Measurement Location	DeSOx (FGD) Inlet (Point C)	
Result	502 ppm [Wet]	397 ppm [Wet]

Unburned Carbon in Fly Ash		
Ammonia Firing Ratio	0%	20%
Measurement Location	DeNOx (SCR) Inlet (Point A)	
Result	1.6%	1.8%



※The above values are based on measurements during steady load operation at 1000MW.

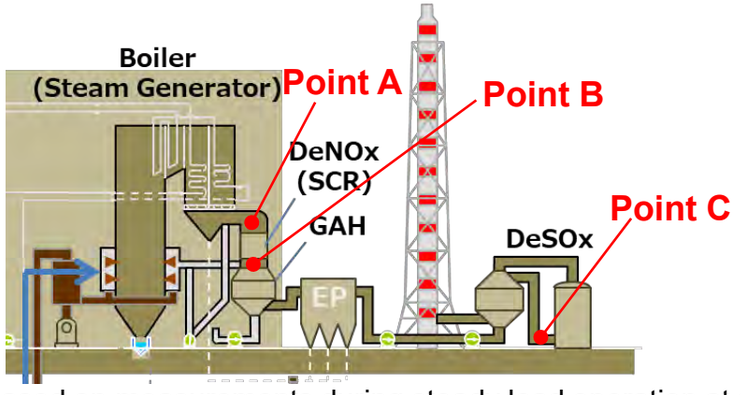
Detailed Combustion Characteristics

2) GHG (CO_2 , N_2O), Unburned NH_3
- ✓ CO_2 emissions were reduced by approximately 20% through 20% ammonia firing.
- ✓ Flue gas properties were good condition in terms of emission.

CO_2		
Ammonia Firing Ratio	0% (Coal Firing)	20%
Measurement Location	GAH Inlet (Point B)	
Result	13.4 % [Dry, 6%O_2basis]	10.8 % [Dry, 6%O_2basis]

N_2O		
Ammonia Firing Ratio	0%	20%
Measurement Location	DeNOx (SCR) Inlet (Point A)	
Result	Below Limit of Quantitation (1 ppm)	Below Limit of Quantitation (1 ppm)

Unburned NH_3		
Ammonia Firing Ratio	0%	20%
Measurement Location	DeNOx (SCR) Inlet (Point A)	
Result	Below Limit of Quantitation (0.3 ppm)	Below Limit of Quantitation (0.3 ppm)



※The above values are based on measurements during steady load operation at 1000MW.

Demonstration at 300MW Power plant in Indonesia

IHI and Indonesian Partners Complete Southeast Asia's First Green Ammonia Combustion Trial at Commercial Coal-Fired Power Plant

- April 16, 2025 - **Press Release**

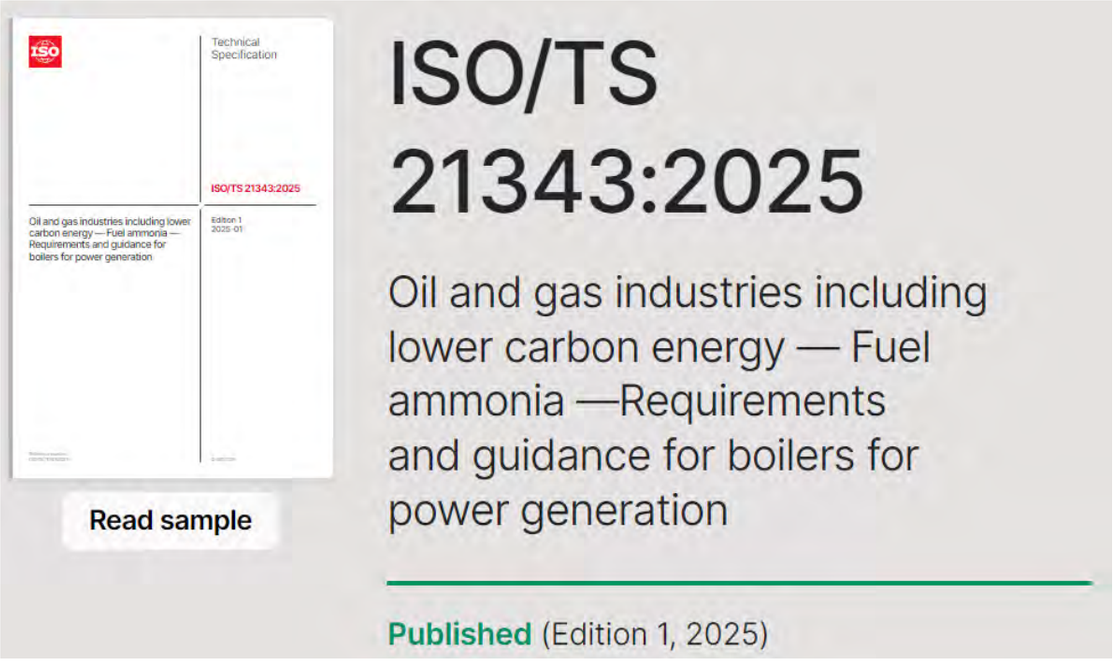
- ✓ IHI and Indonesian partners have made successful completion of Southeast Asia's first pilot combustion trial using green ammonia at a commercial coal-fired power plant
  (Labuan Power Plant, 300MW).
- ✓ The suppression of N2O and NOx emissions as planned have been confirmed.
- ✓ IHI modified an existing boiler burner –originally manufactured by another company— to IHI-designed burner capable of ammonia combustion.

IHI and Indonesian Partners Complete Southeast Asia's First Green Ammonia Combustion Trial at Commercial Coal-Fired Power Plant | 2025FY | News Articles | IHI Corporation

International standardization for ammonia utilization

■ International Standardization Activities for Fuel Ammonia: Technical Specification (ISO/TS 21343) to be issued on January 14, 2025.

ISO/TS 21343:2025 - Oil and gas industries including lower carbon energy — Fuel ammonia —Requirements and guidance for boilers for power generation



Japanese Organization
- IHI (Project Leader/Chair)
- Tohoku University (Co-Chair)
- Clean Fuel Ammonia Association
- Mitsubishi Heavy Industries

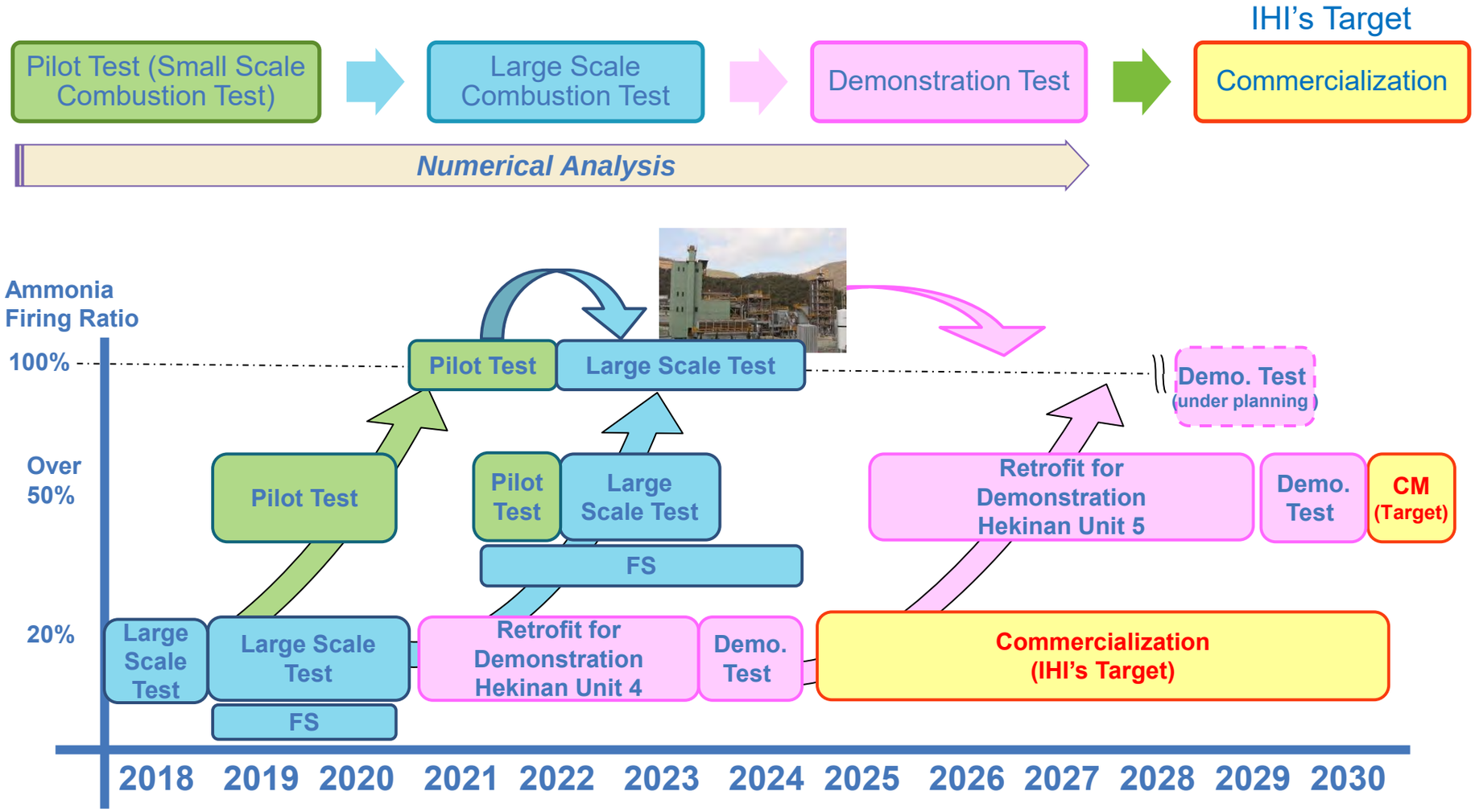
Participating Expert (Country)

Next Action: Reflecting the results of the Hekinan, switch from TS to IS.

（Remark：TS（Technical Standard / IS（International Standard）

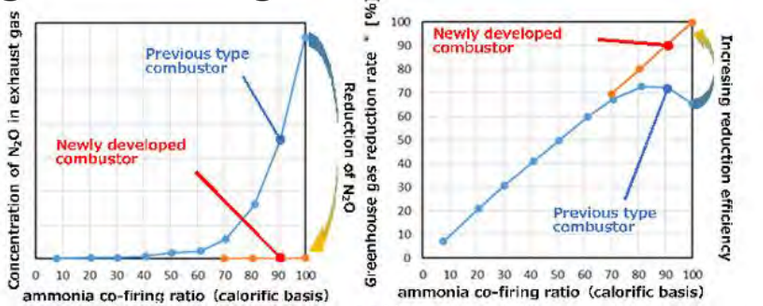
Development of over 50% and 100% Ammonia Firing Burners

■ Roadmap for Ammonia Combustion Technology Development



Ammonia Fueled Gas Turbine

2022 CO_2-free power generation achieved with the world's first gas turbine using 100% liquid ammonia –Reduction of over 99% greenhouse gases during combustion–



※Subsidized by NEDO (JPNP21020)

CO_2-free power generation achieved with the world's first gas turbine using 100% liquid ammonia
 –Reduction of over 99% greenhouse gases during combustion– | 2022FY | News Articles | IHI Corporation

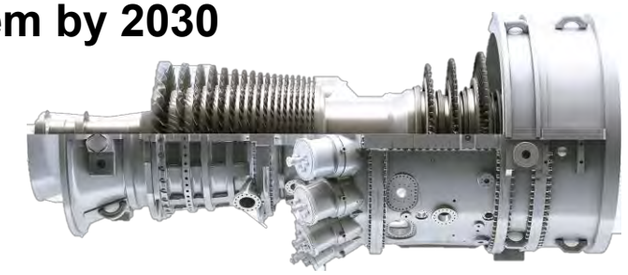
2026 IHI, Gentari sign MoU to develop global green ammonia value chain and commercial demonstration of ammonia-powered gas turbine

IHI, Gentari sign MoU to develop global green ammonia value chain and commercial demonstration of ammonia-powered gas turbine | 2023FY | News Articles | IHI Corporation

2030 GE Vernova and IHI move to the next phase of the technology roadmap aiming to develop a 100% ammonia capable gas turbine combustion system by 2030

GE VERNOVA

IHI
Realize your dreams



9F.04 : Source : GE Vernova

GE Vernova and IHI move to the next phase of the technology roadmap aiming to develop a 100% ammonia capable gas turbine combustion system by 2030 | 2023FY | News Articles | IHI Corporation

100% NH3 Firing GT at Aioi Works

IHI Advances Development of Ammonia-Fueled Gas Turbines to Realize CO_2-Free Power Generation

- April 11, 2025 - **Press Release**

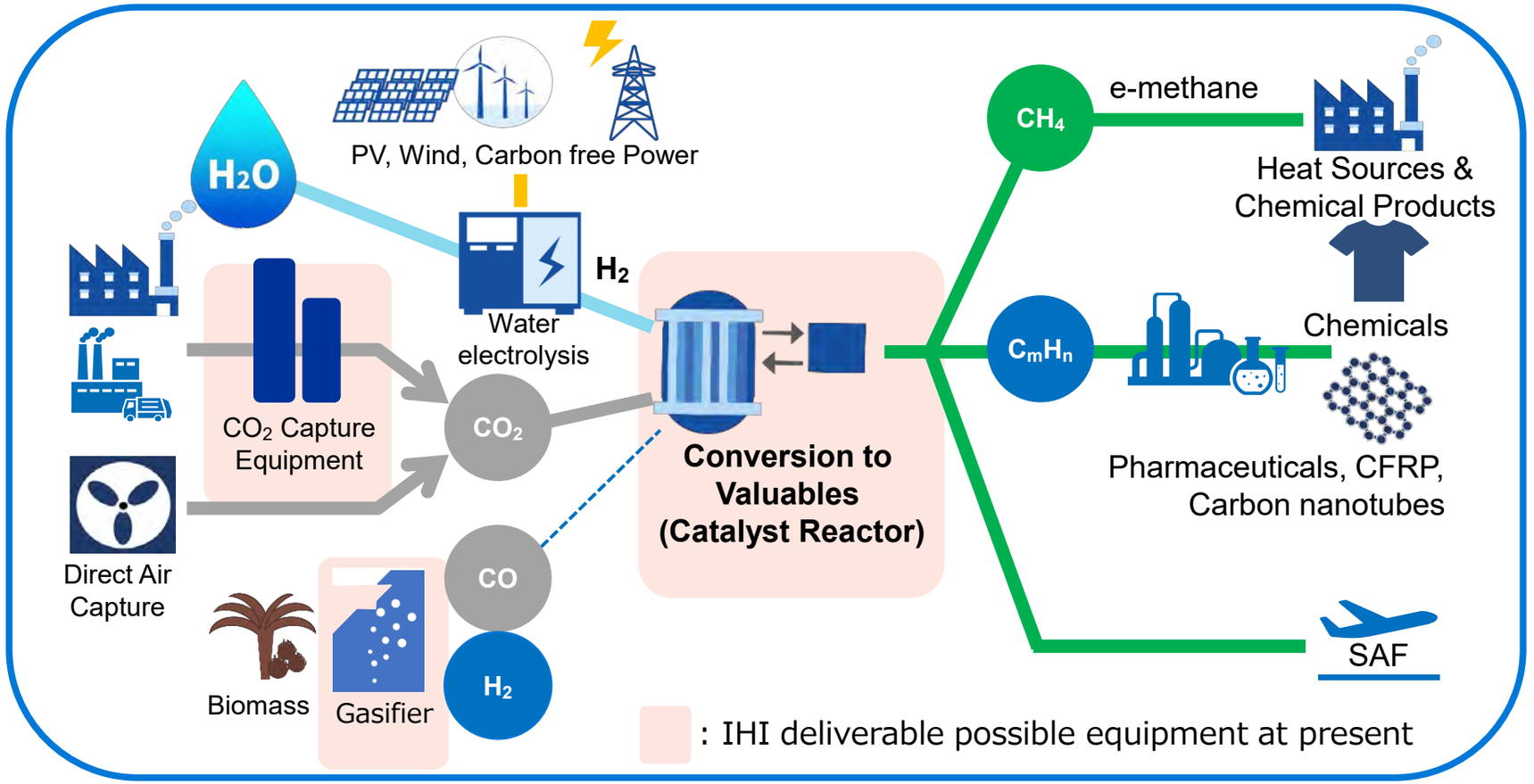
- ✓ At IHI Aioi Works, IHI is conducting durability tests on gas turbines utilizing clean ammonia.
- ✓ The suppression of N2O and NOx emissions as planned have been confirmed.
- ✓ The electricity generated during these tests is being utilized within Aioi Works facility, with the decarbonization value derived by using clean fuel ammonia to be provided to the 2025 Osaka-Kansai Expo.

IHI's 2,000kW-class gas turbine "IM270" at Aioi Works

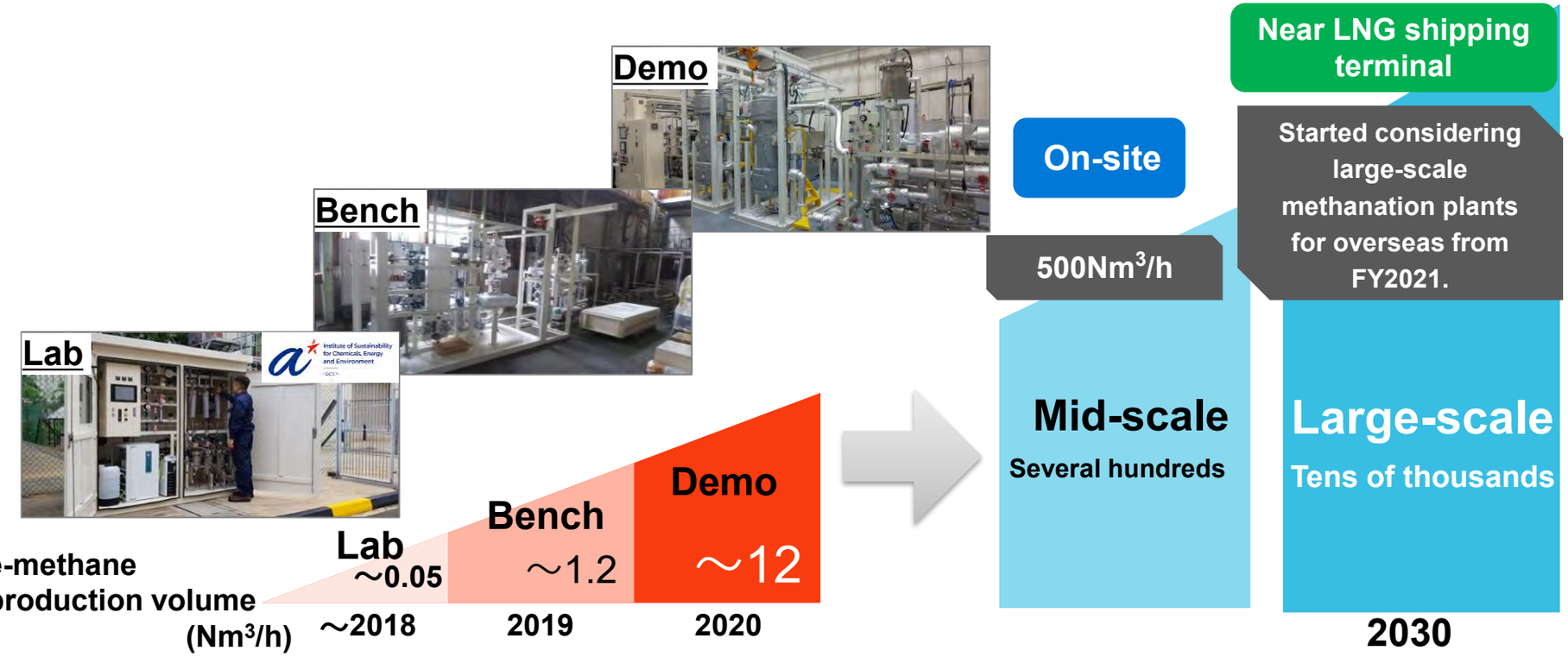
IHI Advances Development of Ammonia-Fueled Gas Turbines to Realize CO_2-Free Power Generation | 2025FY | News Articles | IHI Corporation

IHI's Solution of Carbon Recycling

- ✓ **IHI will provide carbon recycling technology to customers who carbon neutrality through fuel conversion is difficult.**
- ✓ **Carbon recycling technologies is to supply hydrocarbon-based fuel, chemicals and raw materials, not fossil fuel.**



Scale up of Methanation Process



Fully commercialized in October 2022

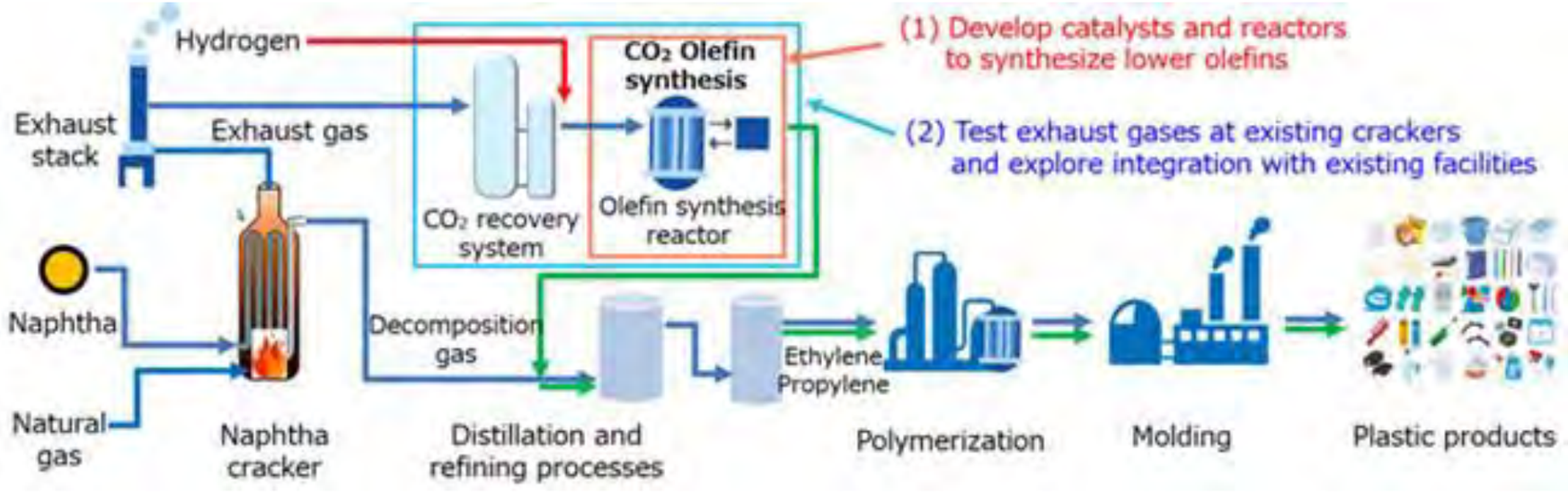
Customer	Planned delivery location	e-methane production volume at demo	Reference approx. required volume of CO_2
Soma IHI Green Energy Center	Soma City, Fukushima Pref.	12.5Nm³/h	Approx. 0.6Ton/day
T	Aichi Pref.	5Nm³/h	Approx. 0.24Ton/day
T	Yamaguchi Pref.	12.5Nm³/h	Approx. 0.6Ton/day
N	Aichi Pref.	2Nm³/h	Approx. 0.1Ton/day

IHI to Conduct Proof-of-Concept Tests at Thai Petrochemicals Plant for Sustainable Lower Olefin Synthesis Technology from CO_2 as Feedstock

-To tap CO_2 from petroleum product manufacturing process to make resin materials-

- July 04, 2023 - **Press Release**

- ✓ Small-scaled demonstration (100kg-CO_2/day) at a petrochemical plant operated by Siam Cement Group Public Company in Thailand.
- ✓ We will develop a low-grade olefin synthesis technology using CO_2 captured from the actual exhaust gas of naphtha crackers and by-product H_2 generated from other processes.



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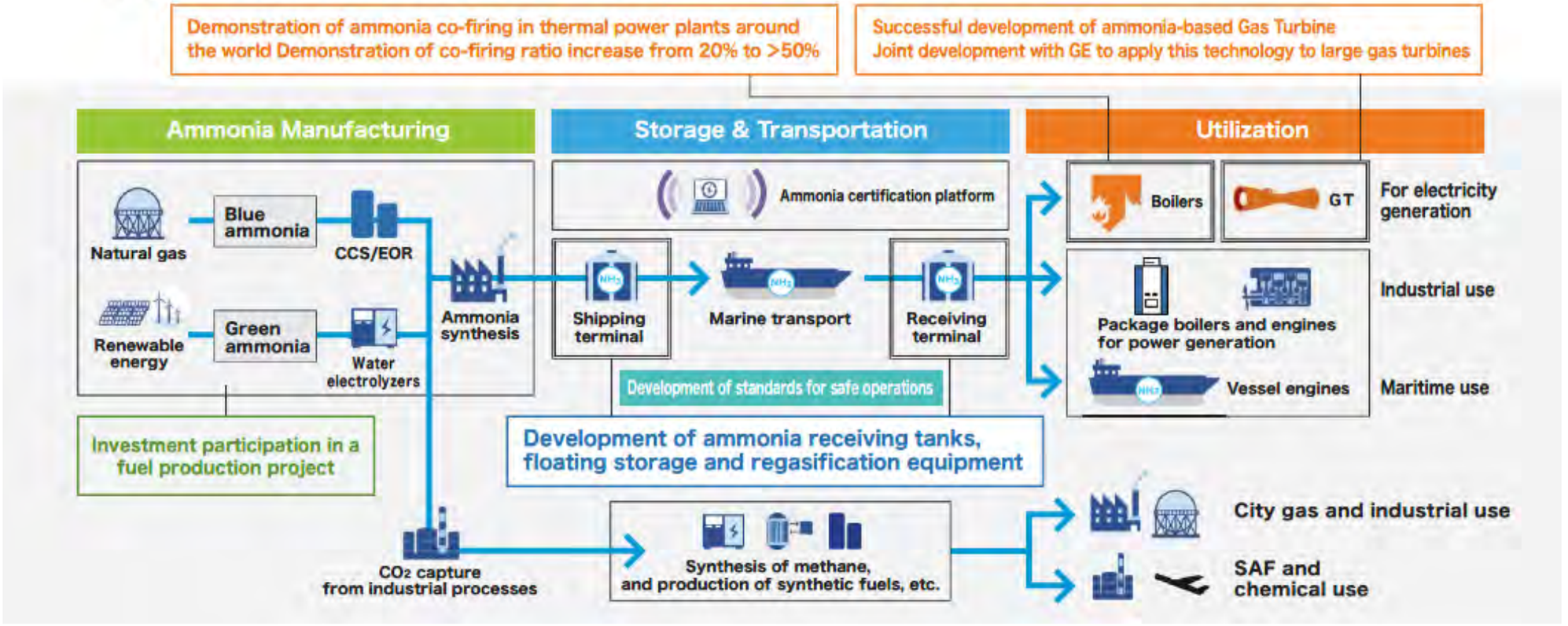
Summary

- **IHI will continue to develop and commercialize ammonia combustion technology globally, contributing to the realization of carbon neutral in thermal power plants and various industries.**
- **IHI will establish a global ammonia value chain through international collaboration.**
- **IHI will develop a variety of carbon recycling technologies, contributing to the global reduction of CO2 emissions.**



Group Management Policies 2023.pdf (ihi.co.jp)

IHI

Realize your dreams