

IHI's Solution to Achieve Carbon Neutrality

IHI

September 2nd, 2024

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Carbon Solution SBU,
Resources, Energy and Environment Business Area,

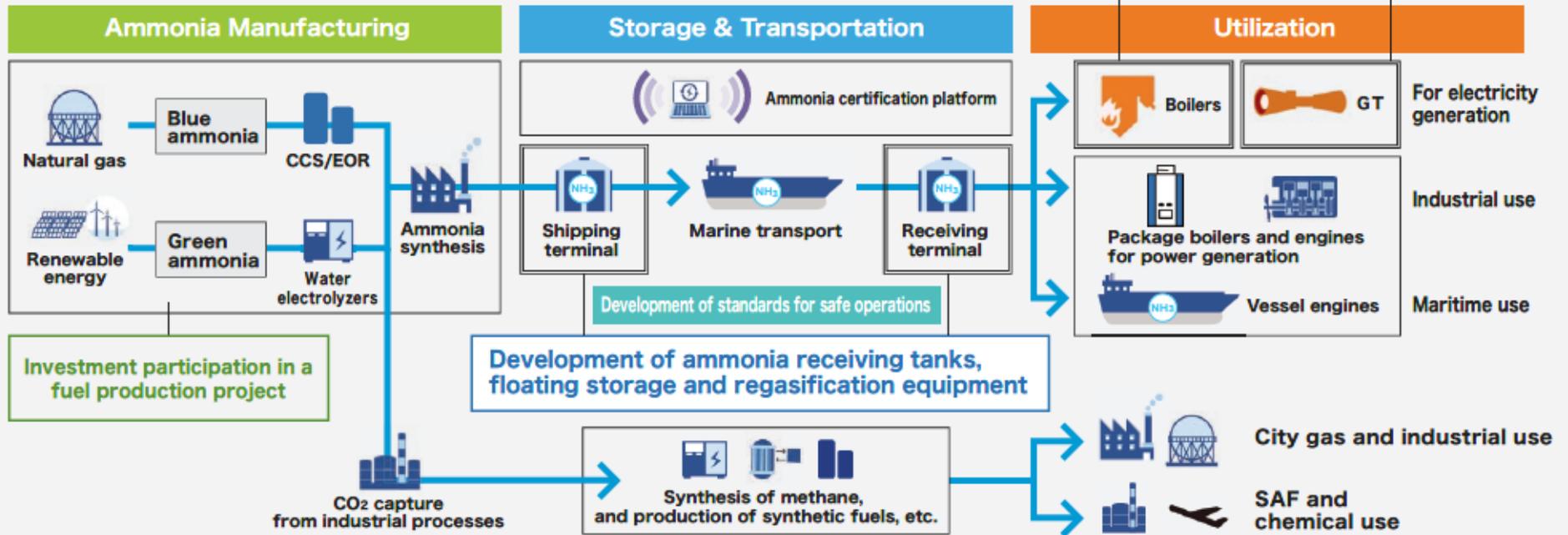
IHI Corporation

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**.

Demonstration of ammonia co-firing in thermal power plants around the world
 Demonstration of co-firing ratio increase from 20% to >50%

Successful development of ammonia-based Gas Turbine
 Joint development with GE to apply this technology to large gas turbines





Activities for Establishment of Ammonia Value Chain

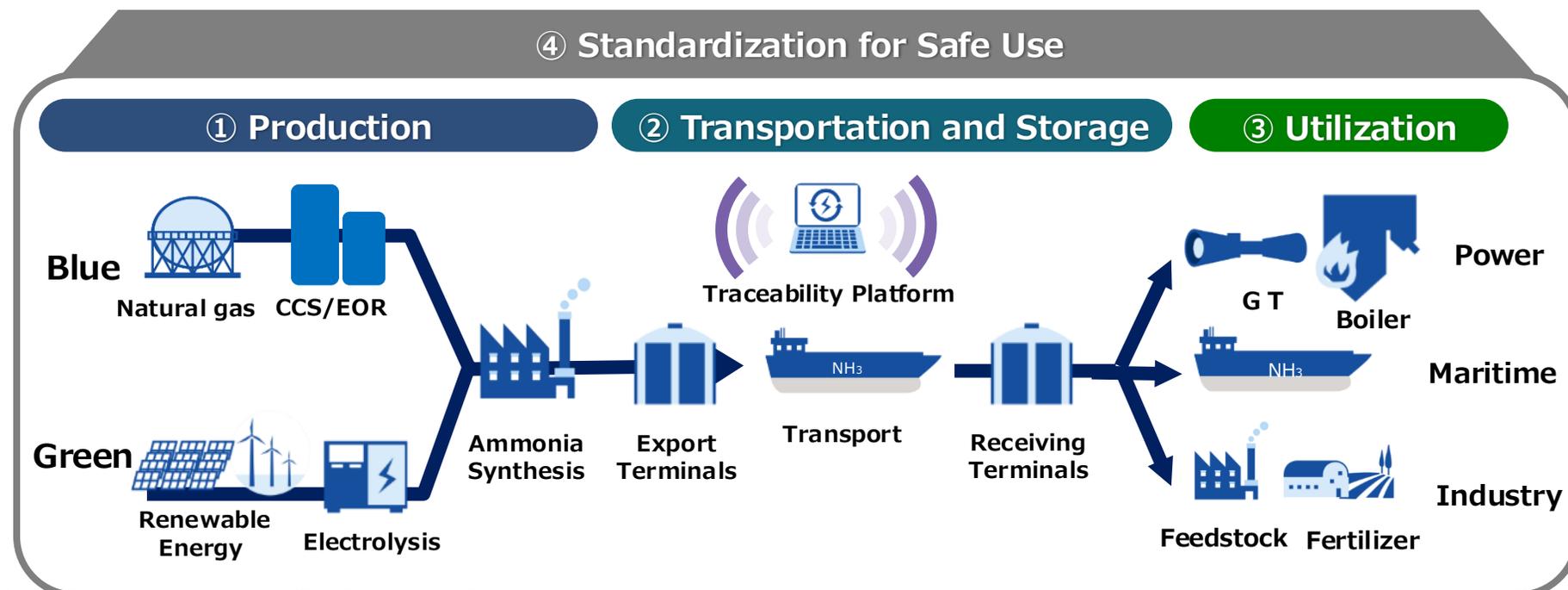
~Carbon neutrality through fuel conversion~

- ✓ Green ammonia production projects
- ✓ Ammonia utilization technologies
- ✓ Activities for thermal power
- ✓ Biomass power

IHI's mission is to provide **advanced ammonia utilization technologies** and a **reasonable price of ammonia** to partners who aim to achieve carbon neutrality.

IHI's wide range of **development activities to build an ammonia value chain include -**

- ① Ammonia Production; NH₃ Direct Synthesis
- ② Transportation and Storage; Large Capacity Tanks
- ③ Utilization; Boilers, GTs, Reciprocating Engines, Industrial Furnaces
- ④ Standardization for Safe Use



Clean Ammonia Production Projects Over the World



IHI is promoting on the feasibility of the green ammonia production projects.

UAE

- ENOC; Investigating green ammonia 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 ammonia 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

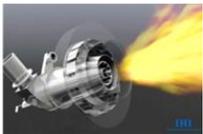
Australia

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

Updates in Technologies for Ammonia Utilization



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 Turbines  <small>9F.04 : Source : GE Vemova</small>	IHI and GE entered into joint development agreement to apply IHI's 100% ammonia combustion technology to GE's gas turbines (6F.03, 7F and 9F)	Joint development targeting 2030
Maritime	Recip. Engine  <small>Source: NYK Line JPNP21014</small>	Developing reciprocating engines for vessels with ammonia-fueled engine	Successfully started the Engine plant demonstration (10% diesel, 90% ammonia) April 2024 , ship to be completed by: - Ammonia-Fueled Tugboat Aug 2024 - Ammonia-Fueled Medium Gas Carrier Nov 2026
		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
Industry	Small Gas Turbine  <small>JPNP21020</small>	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

New-build & Retrofit of Ammonia combustion



Stepwise increase of co-combustion ratio toward zero CO₂ emissions



Fuel Ammonia Firing at Boilers

IHI has many experiences in ammonia fuel conversion FS/FEED/Demonstration for coal fired boilers around the world.

Poland (FY2022)
IPP power station
Ammonia 20% firing F/S

Morocco (FY2021)
Ammonia 20% firing F/S

India (On-Going)
**Adani Power/
Mundra power station**
Ammonia 20% firing FEED



Indonesia (FY2023)
**PT Pupuk Indonesia/
Fertilizer plant**
Ammonia production
& ammonia firing FS



Japan (FY2024)
**JERA/
Hekinan power station**
Ammonia 20% firing
demonstration



Taiwan (On-Going)
**Taiwan Power Company/
Talin Power Station**
Ammonia firing F/S & demonstration

Vietnam (On-Going)
EVN / Coal Fired Units
Ammonia firing F/S for anthracite-fired Units

Malaysia
① **IPP power station (FY2021)**
Ammonia 20% firing F/S
② **TNB Genco/Coal Fired Unit (On-Going)**
Ammonia-biomass firing FEED

Indonesia (FY2022)
**PT PLN Nusantara Power/
Gresik power station**
Ammonia small scale firing
F/S & demonstration



Some mutual discussions are on going in Central and South America and East Asia, etc.

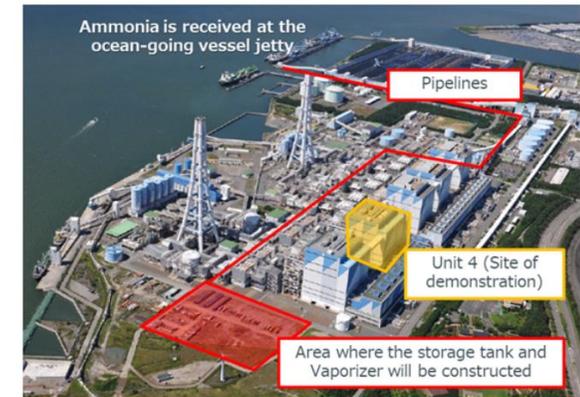
2024

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

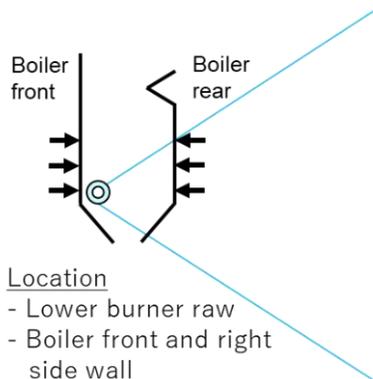
[IHI and JERA Complete Fuel Ammonia Substitution Demonstration Testing at Hekinan Thermal Power Station | 2024FY | News Articles](#)

This effort has yielded favorable environmental outcomes.

- ✓ CO₂ emissions at the unit have fallen around 20%.
- ✓ NO_x emissions are almost equal before ammonia substitution.
- ✓ SO₂ emissions are down about 20%.
- ✓ Emissions of powerful greenhouse gas N₂O have been undetectable.



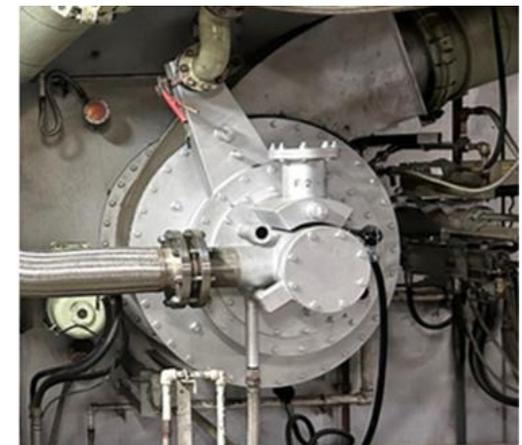
JERA's Hekinan Thermal Power Station
(cited from JERA's homepage)



Conventional fuel flame



20% Ammonia flame



Test burner

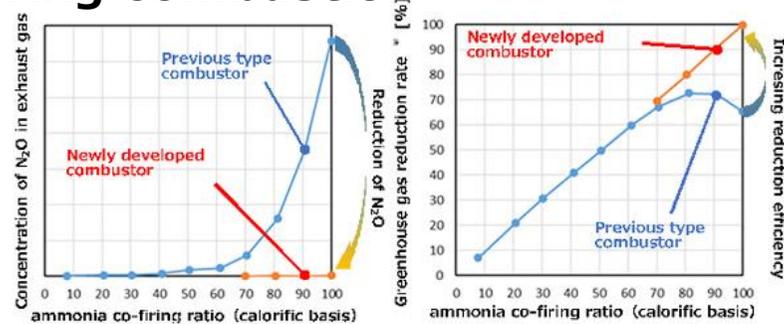
※Subsidized by NEDO (JPNP16002)

Ammonia Fueled Gas Turbine



2022

CO₂-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)

https://www.ihico.jp/en/all_news/2022/resources_energy_environment/1197938_3488.html

2026

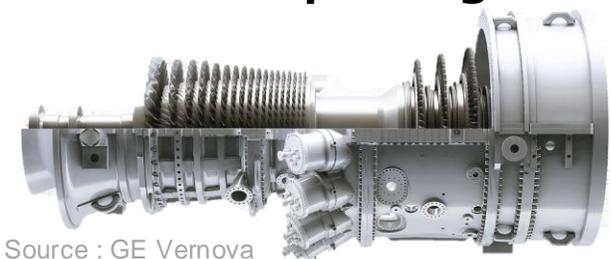
IHI, Gentari sign MoU to develop global green ammonia value chain and **commercial demonstration** of ammonia-powered gas turbine



https://www.ihico.jp/en/all_news/2023/resources_energy_environment/1200488_3523.html

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

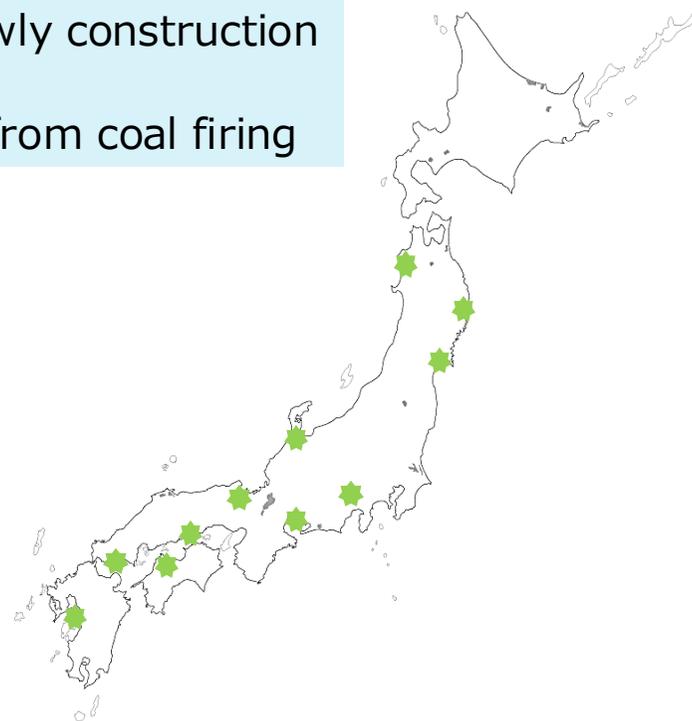
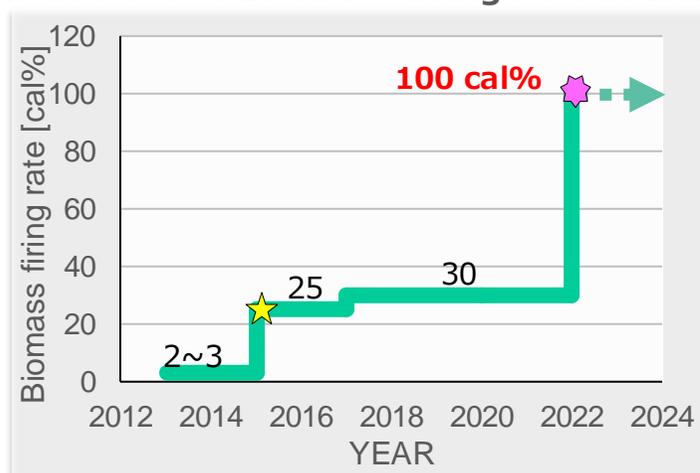


9F.04 : Source : GE Vernova

CO₂-free power generation achieved for biomass firing

- ✓ Modification for existing coal firing boiler / Newly construction
- ✓ Various firing rate
- ✓ Achieved for biomass firing with modification from coal firing

Transition of Biomass firing rate in IHI



Project	Many Ref.	A	B	C	D
Biomass firing Rate	2~3 cal%	15 cal%	30 / 42 cal%	100 cal%	95 cal% with assist gas
Output	-	500 MW	149 MW	112 MW	200 MW
Fuel	Coal, Wood Chips, Wood Pellet	Coal, Wood Pellet	Coal, Wood Pellet, Wood Chips	Wood Pellet	Wood Pellet
Year	2005~Current	2020	2015 / 2023	2022	2023



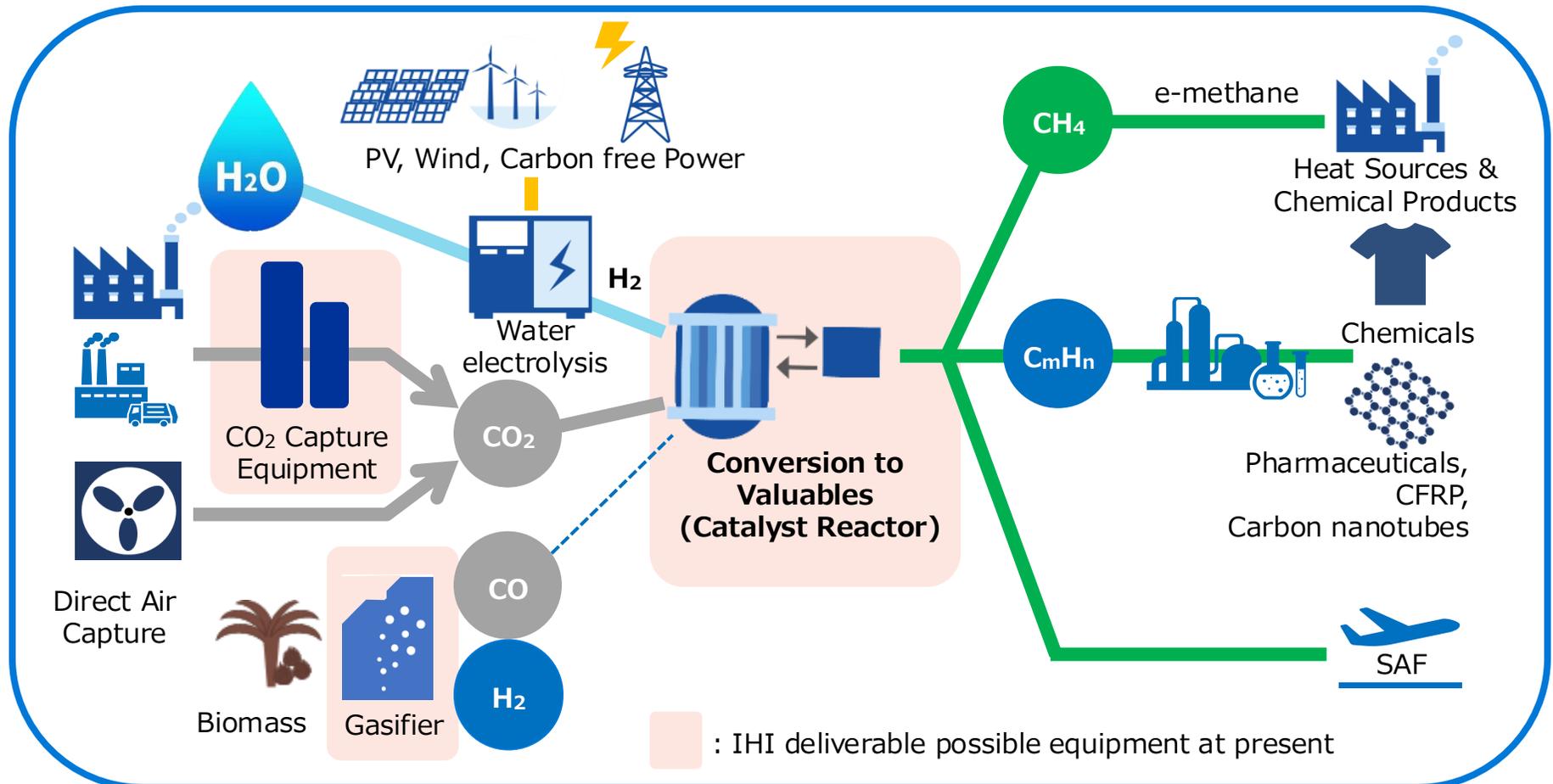
Development of Carbon Recycle Technologies

~Efforts in industries where carbon neutrality
through fuel conversion is difficult~

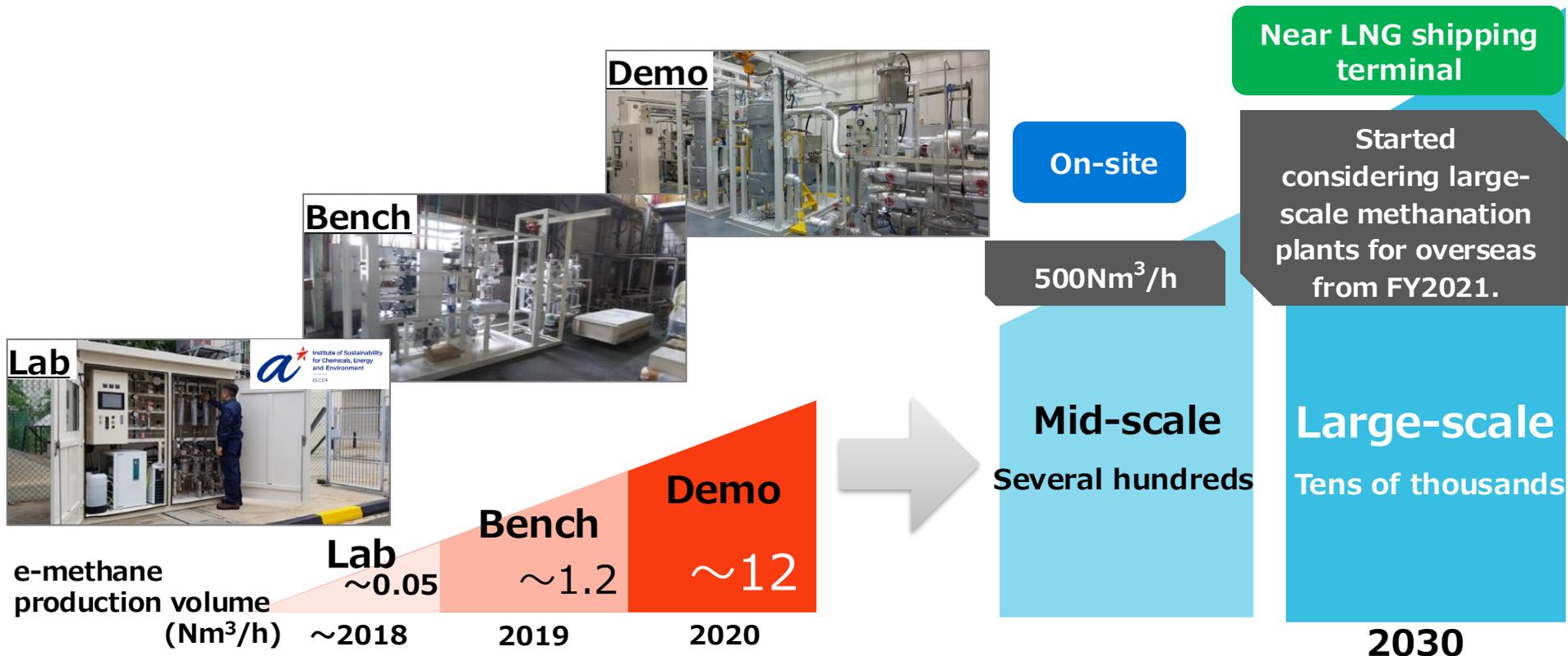
- ✓ IHI's solution
- ✓ Scale up of methanation process
- ✓ Application of carbon recycle technologies

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

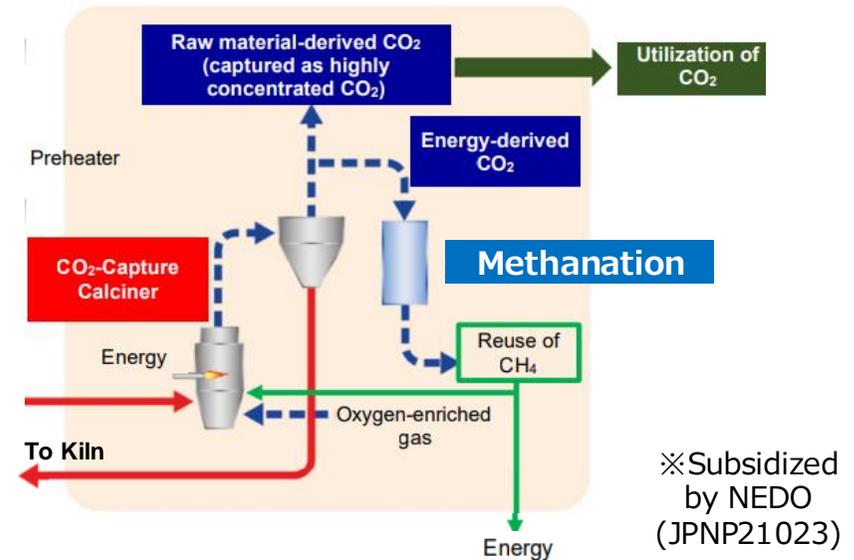


Customer	Planned delivery location	e-methane production volume at demo	Reference approx. required volume of CO ₂
Soma IHI Green Energy Center	Soma City, Fukushima Pref.	12.5Nm ³ /h	Approx. 0.6Ton/day
AA	Aichi Pref.	5Nm ³ /h	Approx. 0.24Ton/day
BB	Yamaguchi Pref.	12.5Nm ³ /h	Approx. 0.6Ton/day
CC	Aichi Pref.	2Nm ³ /h	Approx. 0.1Ton/day

*SIGC: Soma IHI Green Energy Center

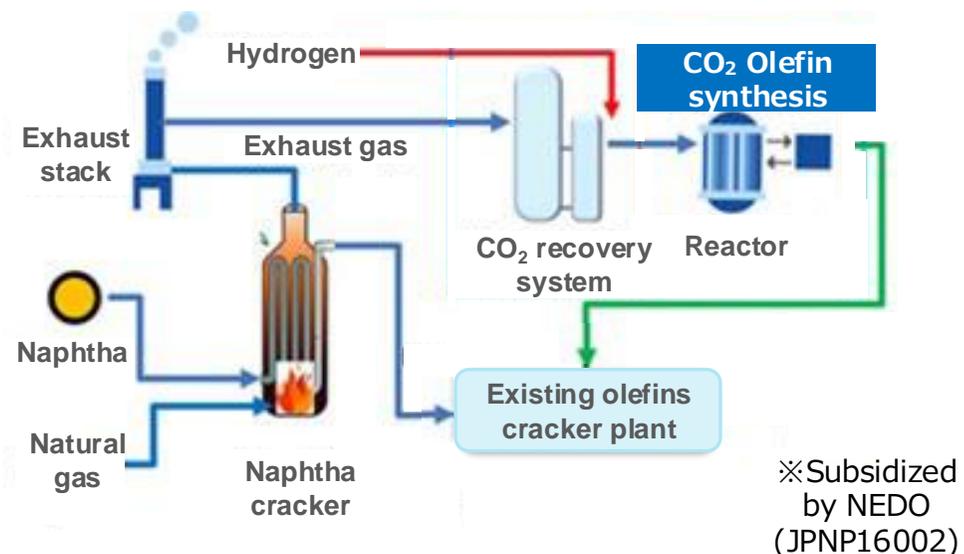
Cement Industries

- ✓ Methanation of CO₂ from CO₂-capture type calciner
- ✓ Pretreatment process of CO₂ for methanation
- ✓ Use e-methane for energy in the process in the future



Petrochemical Industries

- ✓ CO₂ capture from exhaust gas of naphtha cracker
- ✓ Olefin synthesis using by-product H₂ generated from other processes
- ✓ Mix olefin synthesis gas into existing process



[IHI to Conduct Proof-of-Concept Tests at Thai Petrochemicals Plant for Sustainable Lower Olefin Synthesis Technology from CO₂ as Feedstock | 2023FY | News Articles | IHI Corporation](#)

Concluding Comments

- ✓ **With IHI's carbon solution technologies such as fuel ammonia, biomass and carbon recycle technologies, IHI will promote R&D and social implementation toward the realization of a carbon neutral society by 2050.**
- ✓ **In order to achieve carbon neutral society, we strongly request support from the government for the social implementation and their subsequent dissemination.**
- ✓ **IHI is firmly committed to tackling the social challenge towards the realization of carbon neutral society in 2050 through the power of our technology.**



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技術と叡智

IHI

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Realize your dreams