Energy for a New Era

JERA's Decarbonization Initiatives

Hydrogen and Ammonia as an Alternative Sustainable Fuel

November 2024

JERA's Mission & Vision

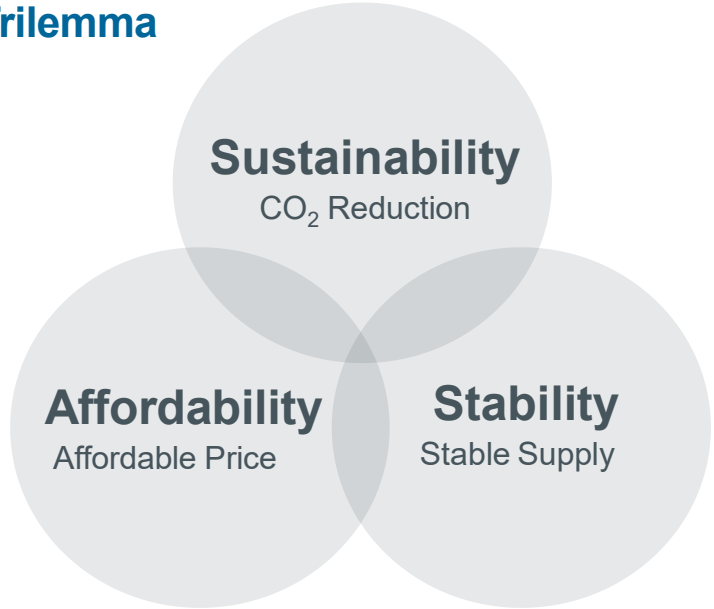
- The world's energy issue is to solve the energy trilemma- achieving sustainability, affordability and stability simultaneously.
- JERA's business model is addressing the energy trilemma by combining renewables and low greenhouse gas thermal power in a practical and responsible way.
- Expansion of cutting-edge solutions from Japan to Asia and the world.

Mission
To provide cutting edge solutions to the world's energy issues

2035 Vision
Clean energy platform of renewables and low greenhouse gas thermal power

Goal: Zero CO_2 Emissions 2050

Energy Trilemma



The intermittency of renewables, created due to natural flutuations in wind and sunlight, combined with a lack of electricity storage technology and capacity, means low greenhouse gas thermal power will play a critical role in the energy transition

JERA's Journey of Energy Transition: Aiming for the Future through Long-Term Perspective and Agile Portfolio Adaptation

- As the times change, effective solutions also evolve. JERA maintains 3 business areas (LNG, Renewables, Hydrogen & Ammonia) from a long-term perspective, agilely adapting the portfolio in accordance with the business environment.
- By 2035, JERA aims to handle over **35 million** tons of LNG, increase renewable capacity to **20 GW**, and manage approximately **7 million** tons of hydrogen & ammonia.

Changing Business Environment

Past 10 years..

- Significant growth in renewables
- Introduction of LNG in many countries

Short term horizon 2025-2030

Possible scenarios:
- Renewable growth negtatively affected by high interest rates etc.
- Demand for AI-related electricity grows
- LNG is effective as a stable transition fuel

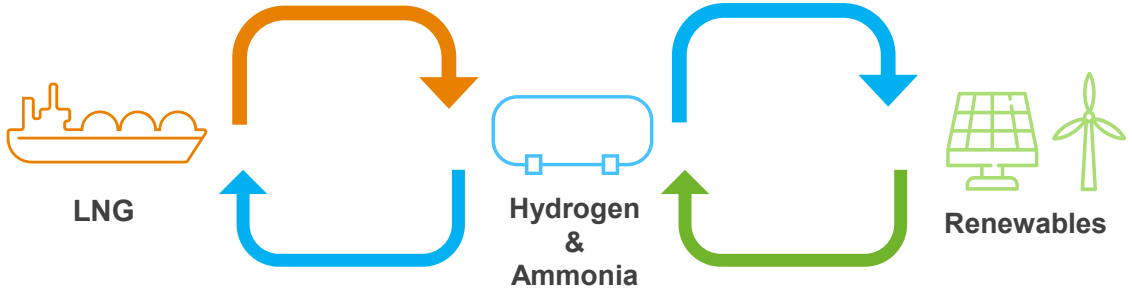
Long term horizon 2030-2040

Possible scenarios:
- Renewables will grow again
- LNG & Coal will eventually be replaced with hydrogen & ammonia, and decarbonized
- New decarbonization solution commercialized

JERA's Unique Position

Flexible decision-making operations x Common foundation of optimization and O&M x Synergy between 3 business areas

Synergy between 3 business areas:



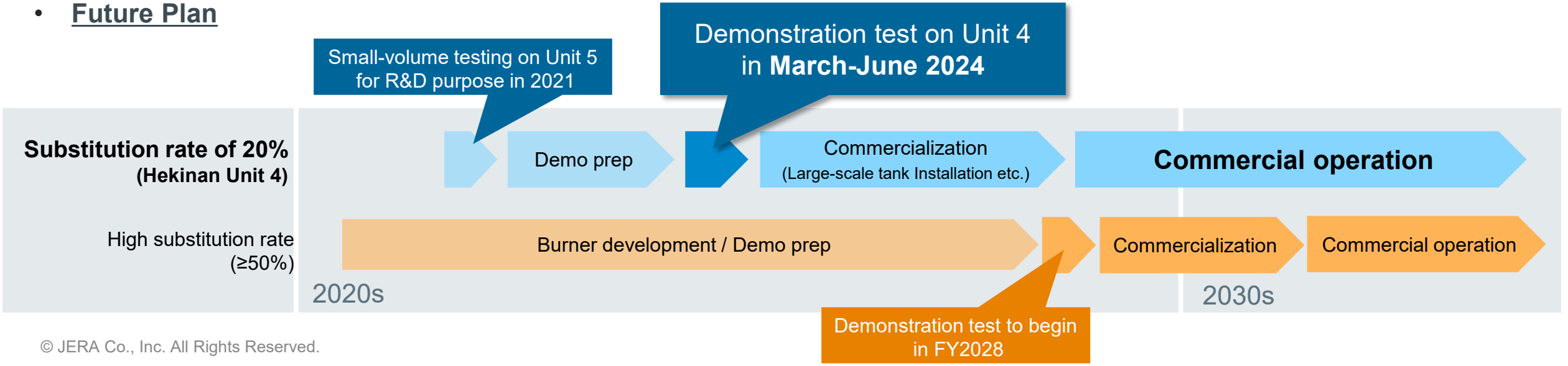
- **Blue Hydrogen & Ammonia:** Full utilization of LNG value chain i.e., gas field development (CCS), transportation, thermal power O&M capabilities, and trust relationship with oil majors
- **Green Hydrogen & Ammonia:** In addition to LNG value chain, large-scale renewable energy development, and O&M capabilities, we leverage our trust relationship with renewable players

JERA's Ammonia Fuel Substitution Demonstration Tests: Summary and Steps for Commercial Operation and High-ratio Combustion

- **World's first demonstration test** of large-volume fuel ammonia substitution (20% of heating value) at a large-scale commercial coal-fired thermal power plant funded by NEDO.

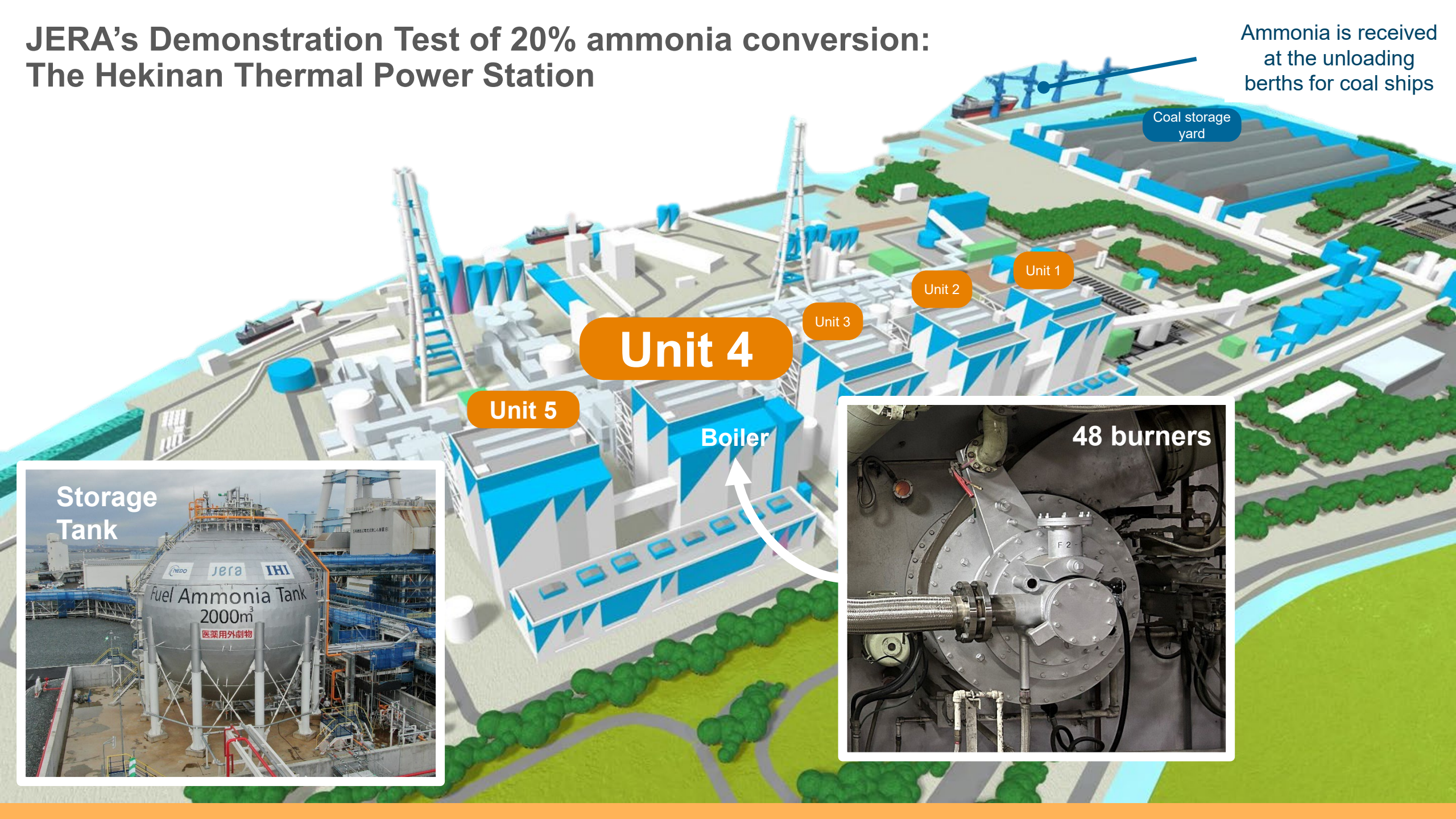
Item	Content
Project location	**HEKINAN** Thermal Power Station - Unit 4 (Output: 1GW) / **JERA,IHI**
Objectives	✓ Establish ammonia substitution technology at a large-scale commercial coal-fired power plant ✓ Evaluate both boiler heat absorption characteristics, environmental impact and operation ability
Project Concept	✓ Modify and replace all 48 existing burners for ammonia firing ✓ Construct the facilities for ammonia fuel supply and sufficient equipment for safety operation
Ammonia Usage	approx. 40,000 tons
Ammonia Receiving	Unloading arm for fuel ammonia at coal jetty for demonstration test purpose

- **Future Plan**



JERA's Demonstration Test of 20% ammonia conversion: The Hekinan Thermal Power Station

Ammonia is received at the unloading berths for coal ships



Results of Hekinan 20% ammonia generation test

Technical Specifications	
Duration of demonstration tests	2024.4.1~6.26 (including actual test days: 53 days)
Fuel ammonia power generation time	Approximately 520 hours
Fuel ammonia consumption	Approximately 31,000 tons (Total of 4 ammonia ships)
Rated Output	1,000 MW

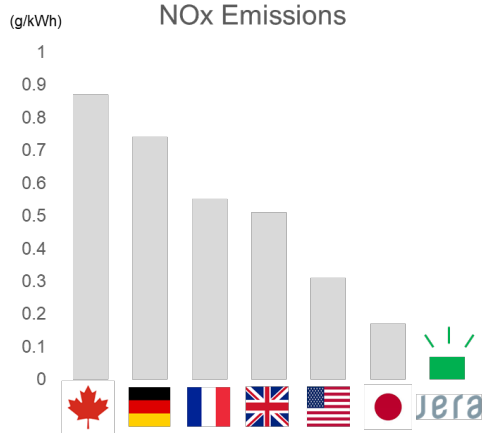
Exhaust gas characteristics

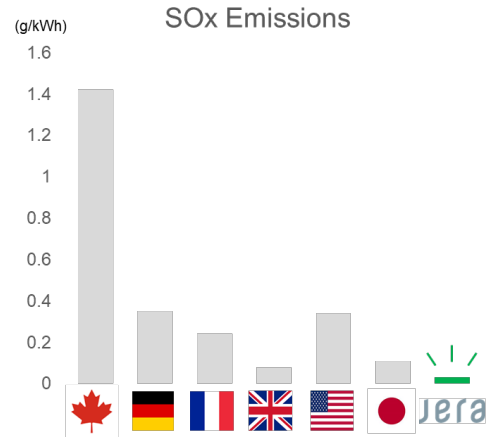
- NOx: Coal equivalent
- SOx and dust: Approx. 20% reduction
- N_2O: Not detected

Plant operational performance

- Load change rate: 1.0%/min (Coal equivalent)
- Range of load change: 400MW~1,000MW (Coal equivalent)

- NOx/SOx emissions characteristics compared to JERA's world-leading emissions profile.





JERA's efforts to support Asia's Energy Transition

- For optimal energy transition for each country in Asia, JERA signed MOU regarding decarbonization activities with various energy companies in Asia
- Purposes and targets of each MOU are mainly classified into items as follows:
- Decarbonization Roadmap, Ammonia/Hydrogen Substitution/Supply Chain, CCUS, etc.

Malaysia
- MOU signed with IHI for collaboration towards expansion of ammonia in Malaysia's energy sector to support decarbonization (2022.10)

Malaysia
- JSA signed with PETRONAS to Explore Feasibility of the Entire Carbon Capture and Storage Value Chain between Japan and Malaysia (2024.04)

Singapore - August 2022
- MOU signed with MHI and Jurong Port to jointly explore establishing 100% ammonia fired power plant combined with bunkering operations in Singapore

Thailand - January 2023
- MOU signed with EGCO for collaboration on decarbonization initiatives
- MOU signed with multiple parties for conducting feasibility study for ammonia substitution at the BLCP thermal power station

Thailand - May 2023
- MOU signed with PTT on Building a Hydrogen and Ammonia Supply Chain for Decarbonization of Thailand

Philippines - February 2023
- MOU signed under witness of President Marcos to consider ammonia substitution in Philippines to support decarbonization

Indonesia
- MOU signed with PLN and JGC regarding CCS feasibility study (2023.10)
- MOU signed with PT PLN Energi Primer Indonesia on LNG Value Chain Development (2024.02)
- Conducting "Master Plan for Energy Transition Management Project in Indonesia" in collaboration with PLN as JICA program (2024.02)

Indonesia
- MOU signed with Pertamina (Persero) to collaborate on Business Opportunity Discussion and Potential Collaboration (2023.12)

Vietnam - October 2023
- MOU signed with EVN for Cooperation on Decarbonization Roadmap

Energy for a New Era