

IHI 49th / 50th Unsecured Bonds (Transition Bonds)

All of the funds raised (excluding issuance cost) by the IHI 49th / 50th Unsecured Bonds (Transition Bonds) issued on June 6, 2022, were used for the selected projects and there is no unallocated balance as of March 31, 2023.

■ Summary of Transition Bonds

	IHI 49th Unsecured Bonds	IHI 50th Unsecured Bonds
Maturity	5 years	10 years
Amount	11 Billion Yen	9 Billion Yen
Interest rate	0.39%	0.62%
Payment date	June 6, 2022	June 6, 2022
Maturity date	June 4, 2027	June 4, 2032
Issuer rating	A- (R&I) / A- (JCR)	

■ Allocation reporting (As of March 31,2023)

Criteria	Project	Amount allocated
Electrification	Initiatives for Zero Emission Mobility	New financing:3.6 Billion Yen Refinancing:3.0 Billion Yen Subtotal:6.6 Billion Yen
Carbon Solutions	Initiatives for Ammonia Exclusive Firing and Establishment of an Ammonia Value Chain	New financing:5.5 Billion Yen Refinancing:7.8 Billion Yen Subtotal : 13.3 Billion Yen
	Realization of carbon recycling	
	Issuance cost, etc.	0.1 Billion Yen
	Total	20.0 Billion Yen

Criteria : Electrification

Project : Initiatives for Zero Emission Mobility



● Electric Turbochargers (ETC) for Fuel Cell Systems

【Overview】

R&D of Electric Turbocharger (ETC): important elements in fuel cell system of Fuel Cell Vehicle (FCV) and responsible for supplying oxygen in compressed air.

【Progress】

- [-April 2021-](#) IHI and AVL LIST GmbH (AVL), the world's largest independent company for the development, simulation and testing of powertrain systems, signed a Technology Collaboration Agreement on electric turbochargers for fuel cell systems.
- [-October 2022-](#) It was decided that IHI's ETC to be officially installed in AVL's HyTruck* fuel cell system, and to be installed in the HyTruck system which to be integrated into AVL's demo truck in 2023. AVL's HyTruck system equipped with IHI's ETC was first exhibited at the Hydrogen Technology EXPO which was held in Bremen from Oct 19th to 20th, 2022.
* AVL's development project funded by the Austrian government.
- IHI's ETC (M size: for 100kW-150kW FC system output) is under evaluation for adaptation by several FC system manufacturers of commercial vehicles, ships and vessels.

● Electrification of Aircraft Systems

【Overview】

R&D of electrification of aircraft and aircraft engine systems.

【Progress】

- [-March 2023-](#) IHI, in collaboration with Akita Prefectural University, Akita University, and local companies in Akita Prefecture, has successfully developed a prototype of a 250-kW high-power electric motor for aircraft propulsion systems. The electric motor is being developed as an electric hybrid propulsion system. This development have achieved high output (high efficiency), downsizing, and weight reduction. IHI envisages the motor would be increased to more than 1 MW and installed as an electric hybrid propulsion system in a 200-seat medium-sized passenger aircraft.

Fig.1 Fuel cell system (ETC consists of a compressor, turbine, motor, bearing, and inverter.)

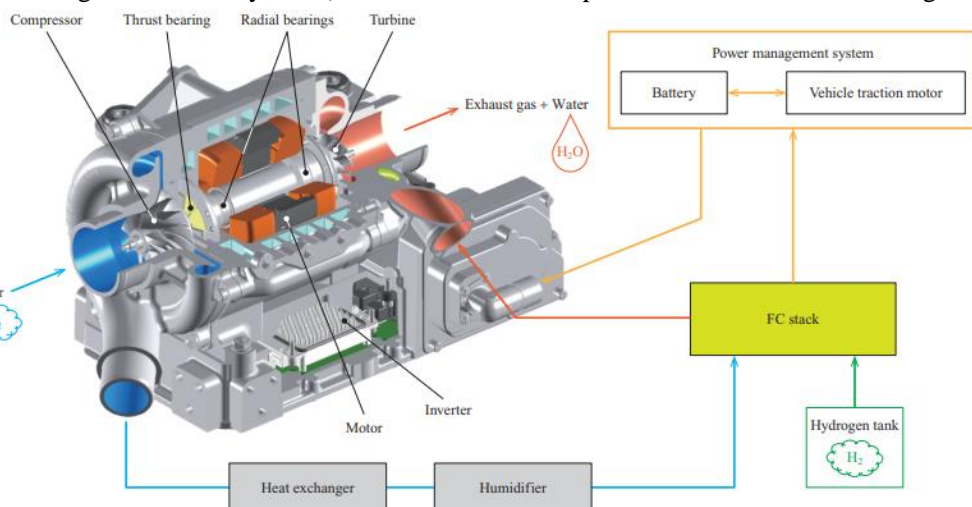


Fig.2 A prototype of a 250-kW high-power electric motor
©Akita Prefectural University



Criteria : Carbon solutions

Project : Initiatives for Ammonia Exclusive Firing and Establishment of an Ammonia Value Chain (1/2)

Development of Next Generation Green Ammonia Production Technologies

[Overview]

Development of synthesis technologies of ammonia which aims to ensure low-cost green ammonia production.

[Progress]

- [-May 2022-](#) IHI, Hokkaido University, Fukuoka University, the University of Tokyo, and metal electrode manufacturer De Nora Permelec Ltd were selected by the New Energy and Industrial Technology Development Organization (NEDO) to jointly undertake a project to innovate technology to directly synthesize carbon dioxide-free ammonia from water and nitrogen. The project will be part of the Feasibility Study Program on Energy and New Environmental Technology, which is one of a range of NEDO's feasibility study programs.



Green Ammonia Production and Sales Business Development

[Overview]

Development of large-scale ammonia storage equipment and development and expansion of ammonia supply chain.

[Progress]

- [-June 2022-](#) IHI, INPEX CORPORATION and Mitsui O.S.K. Lines, Ltd. have executed the demonstration of a clean ammonia supply chain linking the United Arab Emirates and Japan. IHI utilized the clean ammonia, transported from Abu Dhabi to Japan with an ISO tank container, to conduct a combustion experiment using an ammonia combustion turbine which is under development. (Fig.3)
- [-November 2022-](#) IHI has concluded a Memorandum of Understanding (MoU) with Emirates National Oil Company Group (ENOC), the leading integrated international oil and gas player operating across the energy sector value chain, to evaluate the feasibility of tapping the abundant solar resources of Dubai and neighboring emirates in the United Arab Emirates (UAE) to produce and sell green ammonia derived from renewables.
- [-February 2023-](#) IHI has concluded a MoU with ACME, a leading renewable energy company in India, to study and investigate the feasibility of producing and utilizing green ammonia derived from renewable energy. IHI will consider participation in green ammonia production projects, led by ACME, based in Oman, India, the USA and Egypt, as well as the use of ammonia for decarbonized power generation for in the islands and other regions. (Fig.4)

Fig.3 Ammonia production plant in Abu Dhabi



Fig.4 Signing ceremony



Criteria : Carbon solutions

Project : Initiatives for Ammonia Exclusive Firing and Establishment of an Ammonia Value Chain (2/2)

Development of the technologies for the use of fuel ammonia

【Overview】

Development of the technologies for applying ammonia to thermal power plant boilers, gas turbines, ships and vessels, etc.

【Progress】

- [October 2021](#)- IHI and JERA Co., Inc. (JERA) have begun small-volume utilization of fuel ammonia at JERA's Hekinan Thermal Power Station Unit 5. IHI and JERA are working together on a project to demonstrate large-volume utilization (20% of heating value) of fuel ammonia at a large-scale commercial coal-fired power plant. In [May 2022](#), in light of the steady progress made by the project, IHI and JERA have decided to move up the start of large-volume co-firing of fuel ammonia (20% of heating value) at Unit 4 of the power station by approximately 1 year, to 2023FY. (Fig.5)
- [May 2022](#)- IHI has succeeded to have exclusive fired ammonia while minimizing harmful emissions of nitrogen oxide at the compact combustion testing facility of the Aioi Works in Hyogo Prefecture.
- [June 2022](#)- IHI has succeeded in reducing greenhouse gases by over 99% during combustion of liquid ammonia in a 2,000-kilowatt-class gas turbine achieving truly CO₂-free power generation. (Fig.6)
- [August 2022](#)- NEDO has selected IHI and Kowa Company, Ltd., to undertake a joint study under its International Demonstration Project on Japan's Energy Efficiency Technologies. IHI and Kowa agreed to conduct the market research in India and to study the technical and economic feasibility of initiating 20% ammonia co-firing for existing coal boilers at Adani Power Mundra with a view to transitioning later to exclusive firing.
- [January 2023](#)- IHI and GE Gas Power (GE) have signed MoU to jointly develop ammonia combustion technologies for heavy duty gas turbines to generate electricity with reduced or near zero CO₂ emissions. The MoU marks a significant milestone following the announcement in June 2021 of the first MoU between IHI and GE to carry out an economic assessment for the use of ammonia as a carbon-free fuel for both existing and new gas turbines.



Fig.5 Project Schedule

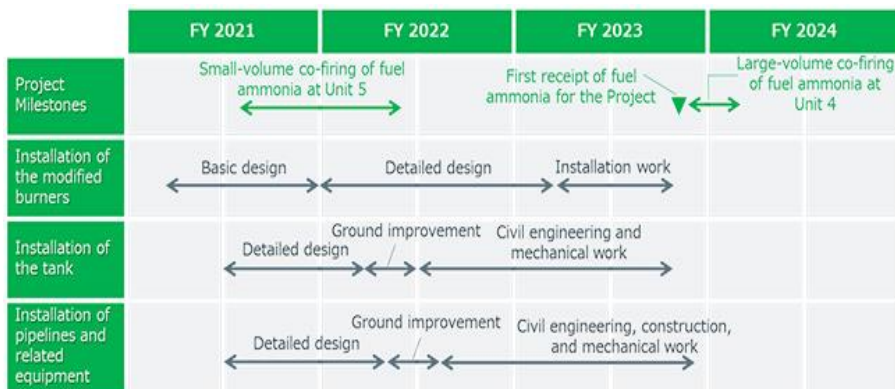
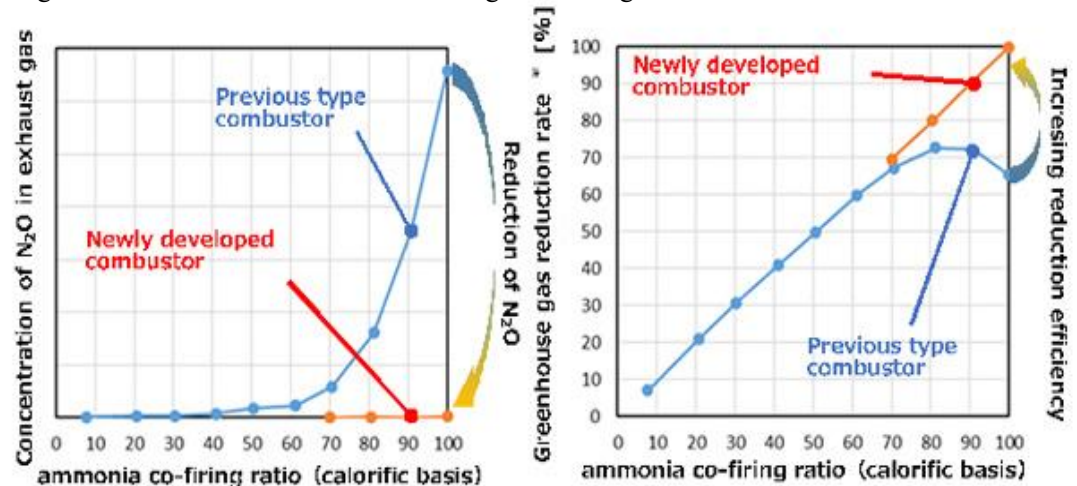


Fig.6 Gas turbine N₂O concentration and greenhouse gas reduction rate



Criteria : Carbon solutions

Project : Realization of carbon recycling



CO₂-to-fuel conversion technology (Methanation)

【Overview】

R&D and investigation of social implementation for methanation equipment which uses hydrogenation (H₂) to convert carbon dioxide (CO₂) and synthesize methane (CH₄).

【Progress】

- April 2022- IHI, TOKYO GAS CO.,LTD and the Japan Aerospace Exploration Agency (JAXA) were selected as Business Operators of “Development of innovative technology for the production of synthetic methane”, one of the “Green Innovation Fund Projects: Development of Technology for Producing Fuel Using CO₂, etc.” publicly offered by NEDO.
- October 2022- IHI launched a compact methanation machine. This carbon recycling setup uses hydrogenation to convert carbon dioxide and synthesize 12.5 normal meters cubed per hour of methane. IHI commercialized this machine in response to heavy demand for pilot operations of its methanation equipment to assess the feasibility of making factories, research institutions, and business sites carbon neutral. IHI standardized the design to cut installation costs and accelerate deliveries. (Fig.7)
- December 2022- IHI received order for the methanation machine from JFE Steel Corporation to be delivered in 2024FY which recycles 24 metric tons of carbon dioxide daily from test blast furnace gas, producing 500 normal cubic meters of methane per hour. IHI will push ahead with development that centers on upgrading catalysts, enlarging reactors, and enhancing processes to tap reaction heat effectively for the methanation machine. It also seeks to attain commercial methanation capacity in Japan and abroad of between several thousand and tens of thousands of normal cubic meters per hour by 2030.
- December 2022- IHI has concluded a MoU with PT Pertamina (Persero), Indonesia’s national energy company to explore the creation of a production through usage value chain for e-methane, aiming to make e-methane near an existing liquefied natural gas plant in Indonesia for the domestic or export markets.
- January 2023- IHI received order for the methanation machine from Toho Gas Group for Chita LNG Terminal to be delivered in 2023FY. The machine produces synthetic methane which can be used as fuel for city gas, etc.
- January 2023- IHI launched e-methane supply for vehicles which uses e-methane as fuel for the first time in Japan in the case of Soma City’s community bus in Fukushima Prefecture. The e-methane is produced by using green hydrogen produced by electricity generated by solar power generation equipment in the “Soma IHI Green Energy Centre”. Production of the e-methane and use of vehicle fuel will be demonstrated by supplying e-methane to one of the community bus.

Fig.7 Compact methanation machine



Fig.8 Scale up of methanation process

No.	Synthesized Methane	Purpose	Location	Status
1	0.05Nm ³ /h	Catalyst development, Understand characteristics of parameters	Joint research partner in Singapore	Test completed
2	1.2Nm ³ /h	Scale-up, Performance validation of catalytic reactor	IHI Yokohama Office	Test completed
3	12.5Nm ³ /h	Scale-up, Performance validation of catalytic reactor, Understand characteristics of system operations	Soma IHI Green Energy Centre (SIGC)	Test completed

