Overview of NEDO Green Innovation Fund Projects toward achieving the 2050 Carbon Neutrality “ Next-generation Ship Development ”

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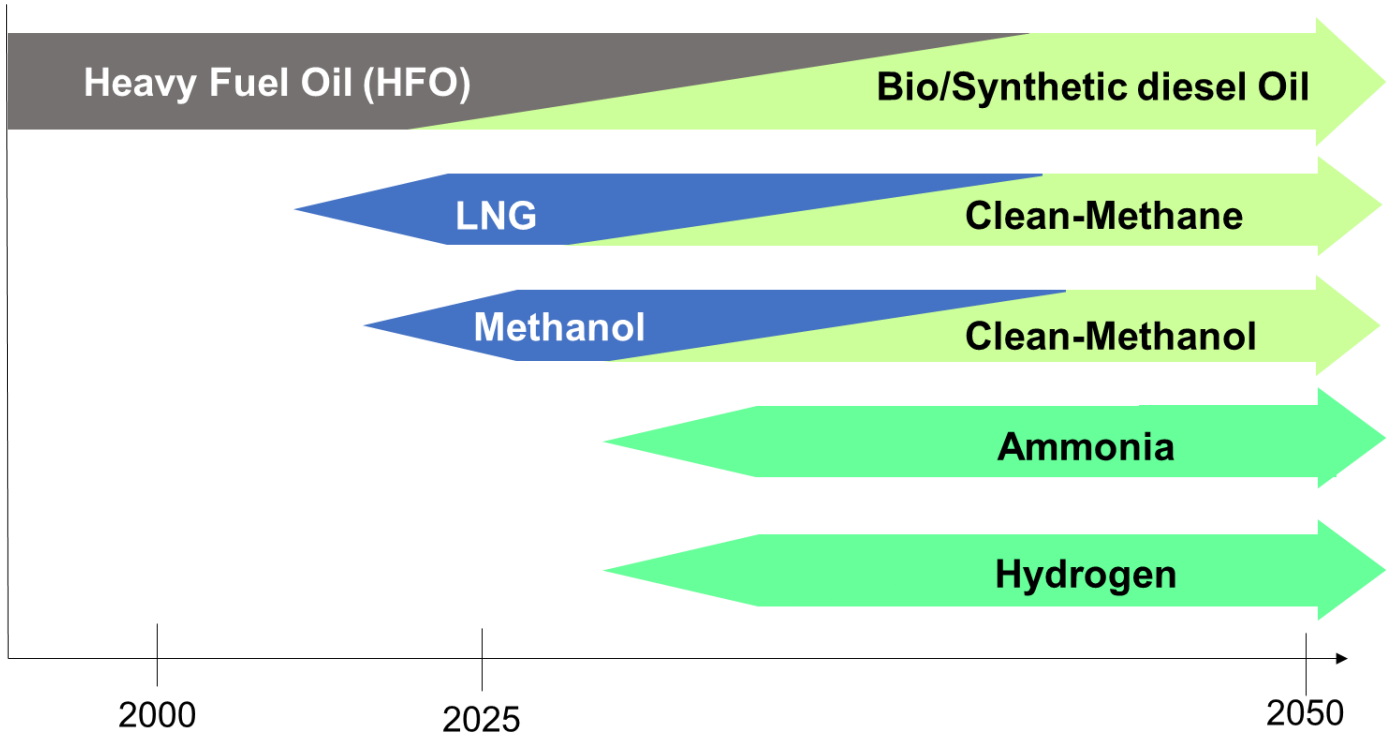
Energy Transition in International Shipping

- CO_2 emissions from international shipping **rank within top 10 largest emitter, if it were a country**.
- **Energy transition is essential** for significant GHG emissions reduction in international shipping.
- Expected to shift from **heavy fuel oil (HFO) to zero-emission fuels, such as ammonia and hydrogen**.

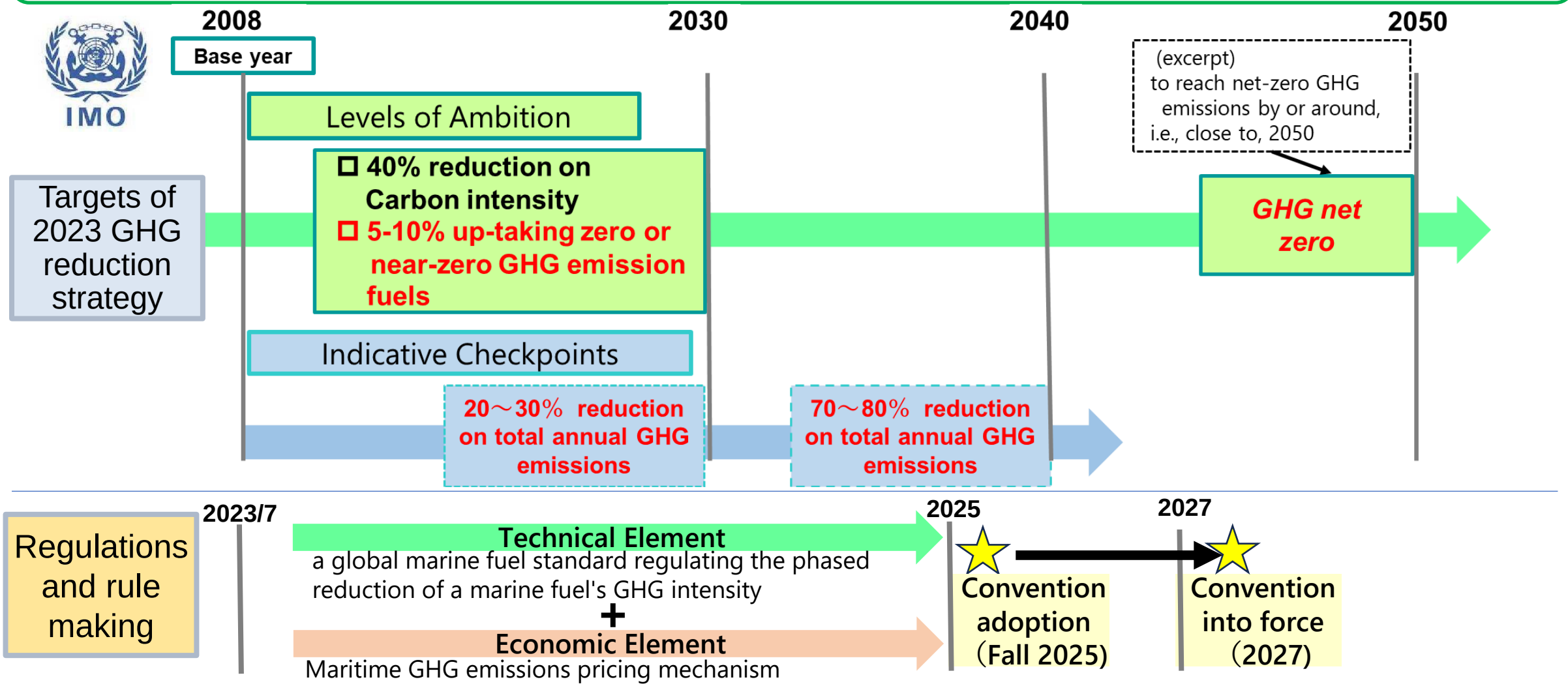
CO_2 emissions from international shipping

Converting Ship Fuels Toward Carbon Neutrality



Adopted the GHG Net Zero from International Shipping around 2050

- The IMO(International Maritime Organization) adopted the**"2023 IMO GHG STRATEGY" (2023 Strategy)** on Reduction of GHG Emissions from international shipping.



Green Innovation Fund Projects

- **In October 2020**, Japan declared that it aims to **achieve carbon neutrality by 2050**.
- And **formulated the "Green Growth Strategy through Achieving Carbon Neutrality in 2050"**.
- GI Fund creates about **2.8 trillion yen (20 billion dollars)** as budget, for continuous supports up to 10 years.

Next-generation Ship Development

Promoting this project for the world's first practical use of zero-emission ships

Total Budget :
35 billion yen
(250 million dollars)

(Source) Ministry of Economy, Trade, and Industry, Japan

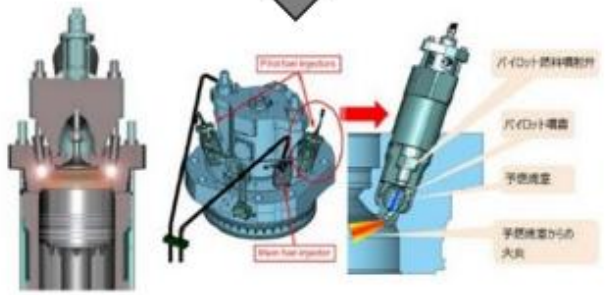
Next-generation Ship Development

- In the shipping sector, **hydrogen, ammonia, and carbon-recycled methane are expected to be used as zero-emission ship fuels**; however, their adoption will depend considerably on the fuel prices and the development of the fuel supply infrastructure.
- In this project, we will **develop and demonstrate the engine, fuel tank, fuel supply system**, and other components for next-generation ships and develop the infrastructure for ammonia fuel supply to ships, including the developing of an ammonia bunkering ship.

Hydrogen/ammonia-fueled engine

- Hydrogen: extremely flammable
- Ammonia: fire retardants, generates N_2O

Requires advanced combustion control and fuel injection technology



LNG fuel injection technology

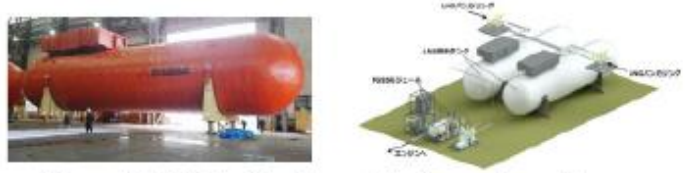
(Source) IHI Power Systems Co.,Ltd.

Fuel tank/fuel supply system

	Hydrogen	Ammonia
Volume	4.5 times	2.7 times
Boiling point	−253 °C	−33 °C
Issues	leakage, brittleness	corrosive, toxic

※Volume comparison with C heavy oil

Requires space saving, structural optimization, and material optimization



Current LNG fuel tank and fuel supply system

(Source) Mitsubishi Heavy Industries

Measures against methane slip

- Development of technology to reduce the unburned methane contained in the exhaust gas from an LNG-fueled ship.

Ship ammonia fuel supply

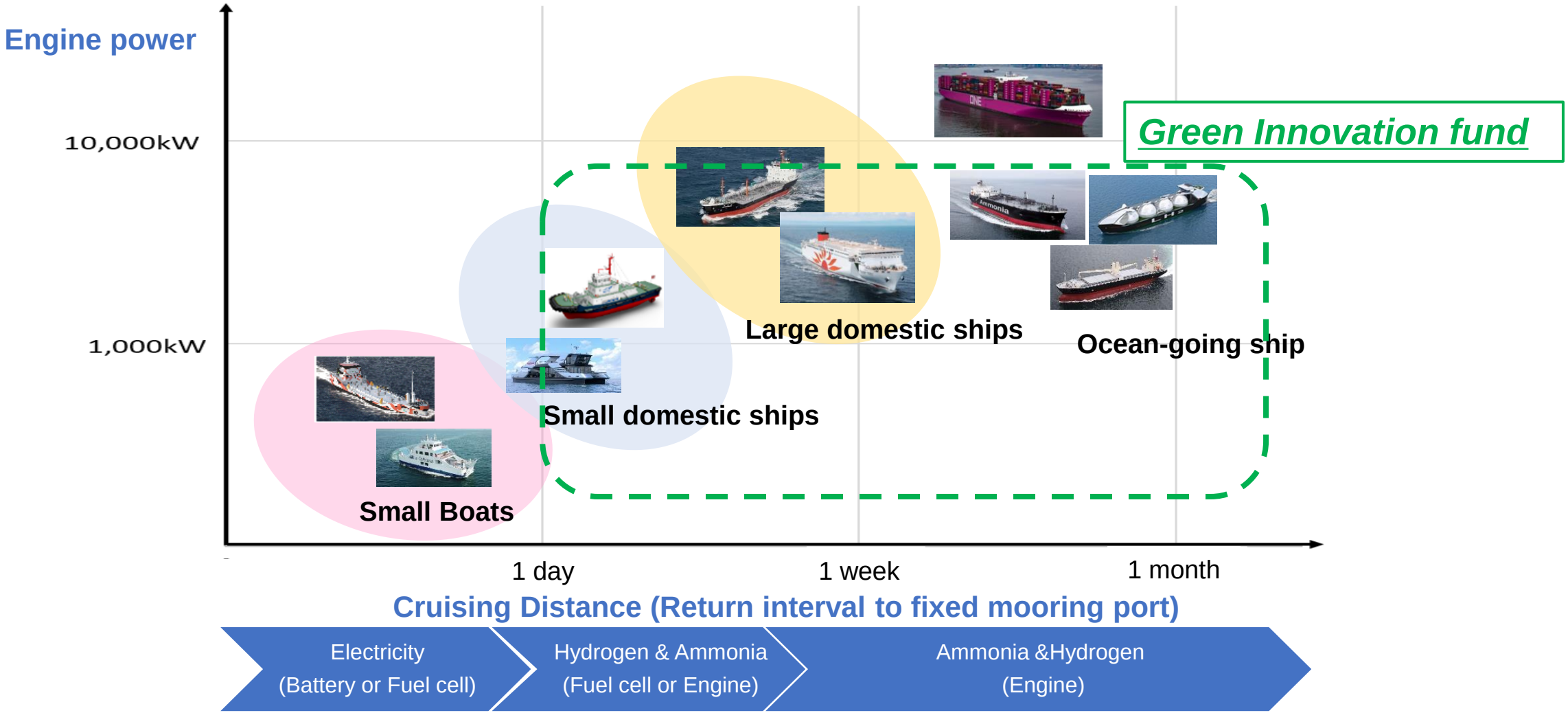
- Developed an ammonia bunkering ship that supplies fuel to ammonia-fueled ships.

Current LNG bunkering ship

(Source) Central LNG Marine Fuel Japan Corporation

The Development Target for GI Fund

- For more engine power and long cruising distance, **it is necessary to develop hydrogen and ammonia combustion engines.**



Development and Full-Scale Test Schedule

		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1. Development of hydrogen fueled ships								・Multi-purpose ship ・Oil Carrier			
Development of marine hydrogen engine and MHFS* *Marine Hydrogen Fuel System	Kawasaki, YANMAR, J-ENG	Development						DV			
								・Large-scaled liquefied Hydrogen carrier			
2. Development of ammonia fueled ships											
Development of ships with ammonia fueled domestic engines	NYK, IHI Power Systems, J-ENG, NSY	Development			DV ・Tugboat		Commercial Voyages				
		Development					DV ・Ammonia Gas Carrier		CV		
Integrated project for development and social implementation of ammonia fueled ships	ITOCHU, NSY, MITSUI E&S, K LINE, NS United Kaiun Kaisha, Ltd.	Development					DV ・Large Coal Carrier		CV		
Development of N_2O reactor installed on ammonia-fueled ships	Kanadevia, NYK				Development		DV ・Ammonia Gas Carrier		CV		
Development of peripheral equipment for constructing a supply chain using ammonia-fueled ships	ITOCHU, Fuji Electric					Development		DV	CV		
3. Preventing methane slip on LNG fueled ships											
Development of methane slip reduction technology from LNG fueled ships by catalyst and engine modification	Kanadevia, YANMAR, MOL Mitsui O.S.K. Lines	Development			DV ・Large Coal Carrier						

: GI Fund

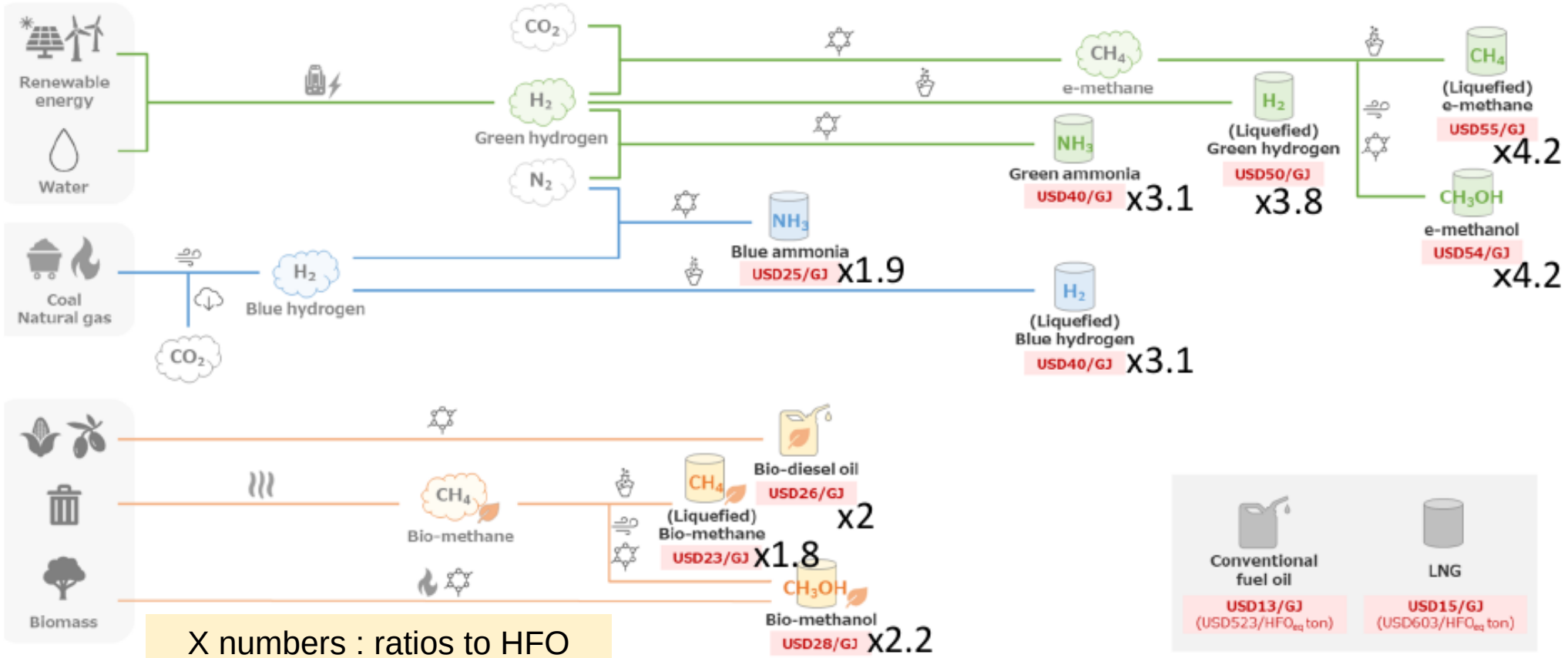
DV : Onboard & Demonstration Voyages

CV : Commercial Voyages

Future Issues （“Chicken and Egg” problem）

- Clean fuel cost reduction and fuel supply chain development (e.g., bunkering).
- Develop global consensus on economic elements (incentives, fuel charges, etc.) under discussion at IMO.

Alternative fuel production pathway costs (Costs are estimated as of 2030)



X numbers : ratios to HFO

Source; Class NK

NEDO Green Japan, Green Innovation

Green Innovation Fund Projects

Working toward a carbon-neutral future.

The driving force behind Japan's future growth is the challenge of achieving carbon neutrality.

Now is the time for Japan-A technological superpower
One world-changing innovation after another.

Working together to create a carbon-neutral future.
A new Japan is waiting in 2050.

Outline of development of hydrogen fueled ships

“ Development of marine hydrogen engine and MHFS “

MHFS：Marine Hydrogen Fuel System

Project overview and objectives

① To reduce GHG emissions from ships, **develop several type of hydrogen engines with different power ranges and applications.** We will develop and demonstrate those engines using full-scale ships.

② **Develop a marine hydrogen fuel tank and fuel supply system.** Through land-based testing, the system will be applied to several types of engines to confirm its functionality and reliability, leading to its implementation in society.

Participant companies

Bold : Lead-managing company

- **Kawasaki Heavy Industries, Ltd.**
- Yanmar Power Technology Co., Ltd.
- Japan Engine Corporation

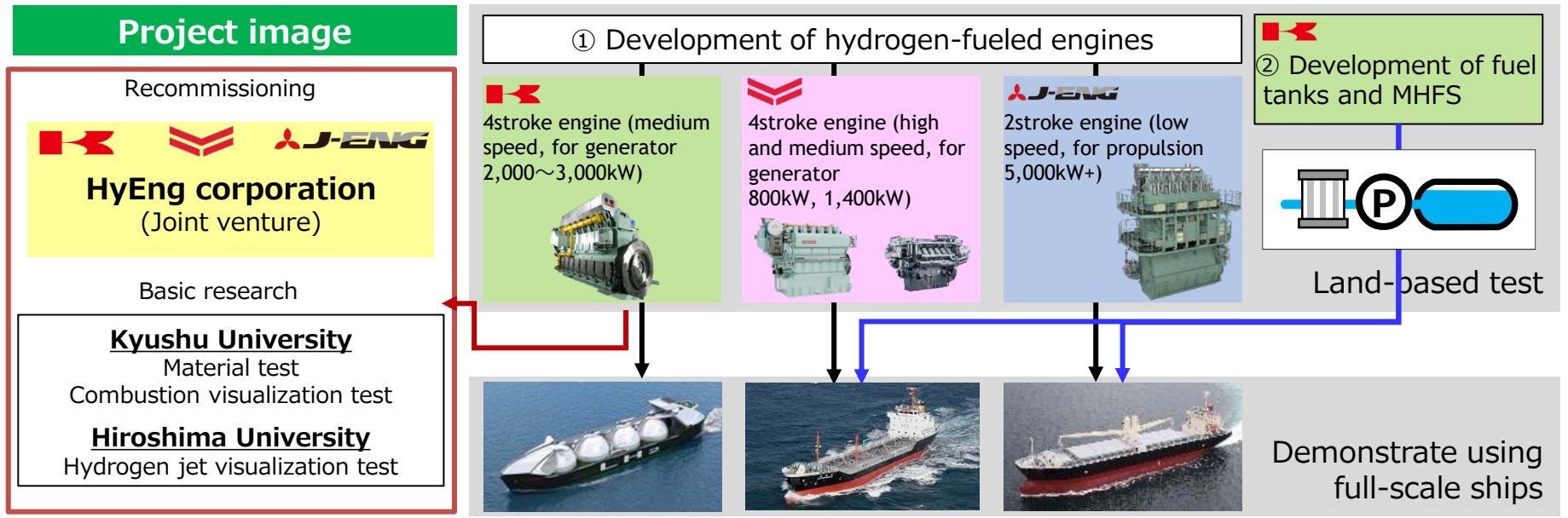
Support amount

Budget : 21 billion yen (150M USD)

Project period

10 years (FY2021-FY2030)

Project image



Outline of development of ammonia fueled ships

“ Development of ships with ammonia fueled domestic engines “

Project overview and objectives

① **Development and operation of ammonia fueled tugboats (domestic ships)**
4-stroke main engines, design of ammonia fueled ships with consideration for safety and practicality, and establishment of operation and maintenance methods for ammonia fueled ships, etc

② **Development and operation of ammonia fueled ammonia carriers (ocean-going ships)**
2-stroke main engines and domestic 4-stroke auxiliary engines, design of ocean-going ships, establishment of onboard safety systems against ammonia toxicity, etc.

Participant companies

Bold : Lead-managing company

- **NYK**
- IHI Power Systems Co., Ltd.
- Japan Engine Corporation
- Nihon Shipyard Co., Ltd.

Project period

7 years (FY2021-FY2027)

Support amount

Budget : 8.4 billion yen (60M USD)

Project image

<Ammonia Fuel Engine Development>

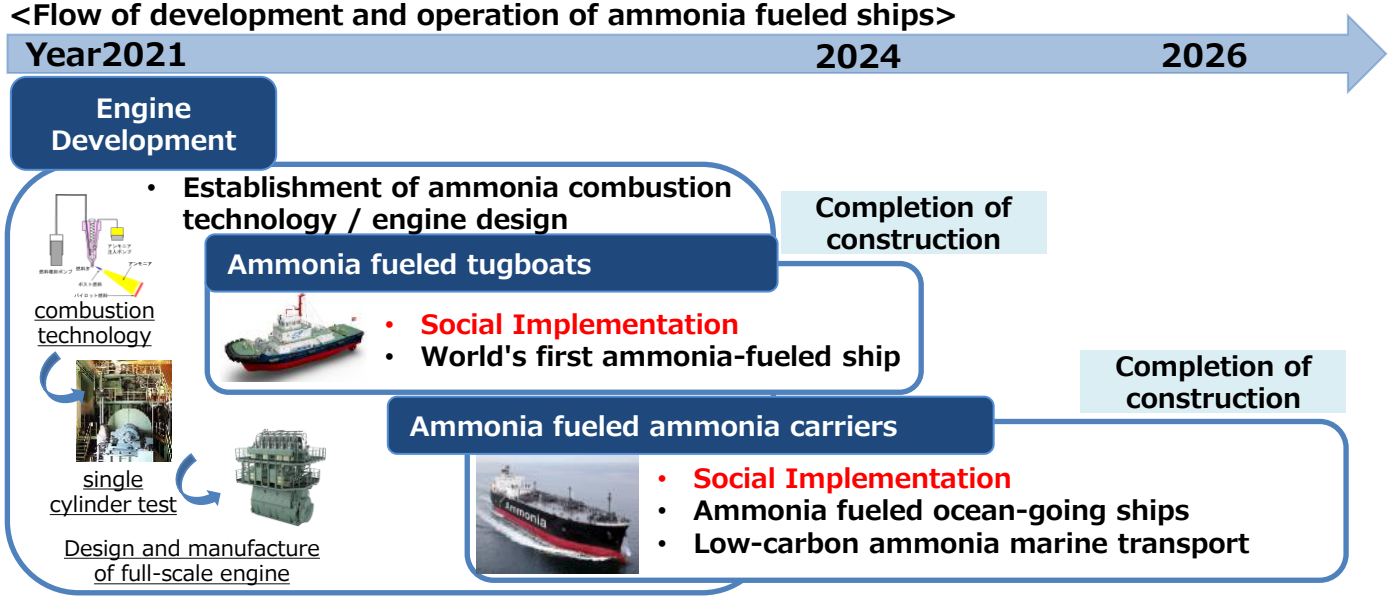
①

Use	Type	Bore dia. (mm)	Output (kW)
Main	4stroke	 280	abt 1,600

②

Use	Type	Bore dia. (mm)	Output (kW)
Main	2stroke	 500	abt 8,000
Auxiliary	4stroke	 200 ~ 250	abt 1,300

<Flow of development and operation of ammonia fueled ships>



Outline of development of ammonia fueled ships

"Integrated project for development and social implementation of ammonia fueled ships"

- The "Integrated Project" is constituted by (1) development of ammonia-fuel ship, (2) ownership and operation, (3) development of fuel supply chains, and (4) ammonia procurement.

Shipbuilding

AFV Development

NIHON SHIPYARD, ITOCHU, ClassNK, MITSUI E&S, MAN Energy Solutions, ITOCHU ENEX CO.,LTD.

Shipbuilding Contract

Shipping

Owner / Operator

ITOCHU, K LINE, NS United Kaiun Kaisha, Ltd.

Charter

Charterer

Shipper

"PILOT PROJECT"

- 200,000dwt NH_3 D/F Bulk Carriers
- 1st ship delivery in 2027 (under review)
- Followed by Container ships & others

Ammonia Fuel Supply

Singapore NH_3 Bunkering Consortium

ITOCHU, TotalEnergies, PAVILION ENERGY, MOL, Vopak, ITOCHU ENEX CO.,LTD.

* Other areas also considering

Bunkering @Singapore

Blue / Green

ITOCHU + Producer

Fuel Procurement

Fuel Production

Participant companies

- **ITOCHU**
- MITSUI E&S
- NSY
- K-Line
- NSU

Support Budget

2 billion yen (14M USD)

Project period

7 years (FY2021-FY2027)

Source; ITOCHIU Corporation