De-carbonization of Ocean-going Vessels

Ammonia Energy Association 2020 Conference

November 19th, 2020

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NYK LINE
NIPPON YUSEN KAISHA

Role of Shipping Industry in Decarbonization

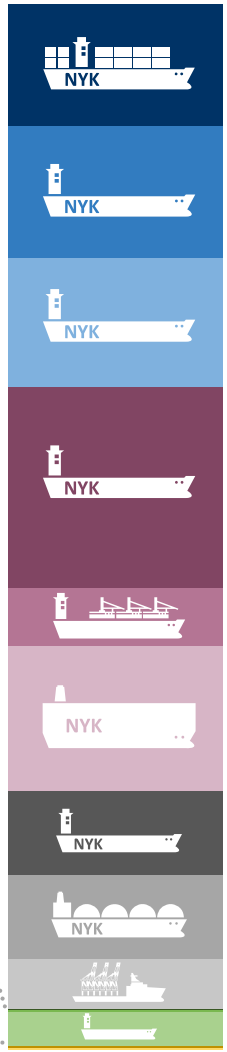
NYK Line Overview

- **Trade Name**
  Nippon Yusen Kabushiki Kaisha（NYK LINE)
- **Established**
  September 29, **1885**
- **Main Activities**
  Global logistics based on international marine transportation business, cruises, terminal and harbor transport, shipping-related services, real estate, and others
- **Paid-in Capital**
  JPY144,319,833,730 *As of March 31, 2020
- **Employees**
  35,711 (consolidated)
  1,732 (non-consolidated) *As of March 31, 2019
- **Revenues**
  JPY1,668 billions *FY2019 result
- **NYK Group Fleet**
  784 vessels *As of March 31, 2020

NYK Group Fleet and Facility

Vessel

784 vessels



- 58 container ships
- 114 capesize bulkers
- 92 panamax bulkers
- 155 handysize bulkers
- 43 wood chip carriers
- 111 car carriers
- 56 tankers
- 78 LNG carriers
- 41 multi-purpose carriers
- 28 shuttle tankers

1 others
1 cruise ships

3 FPSOs
2 FSOs
1 drillship

*For the year ended March 31, 2020

Air Freighter

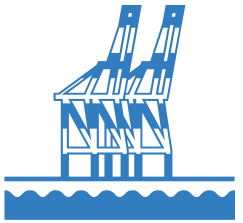
8 aircrafts

5,227 flights in 2020

Terminal

Operating at

21 ports in 2020



Logistics Center

609 locations

3.1 million m²

*As of March 31, 2020

IMO's GHG Reduction Target

- United Nations specialized organization
- Established in **1958** in London
- 174 countries (as of September 2019)

Vision	Zero emissions as early as possible in this century			
Principles	Mandatory requirements apply regardless of flag state			
Target (vs 2008)	**Fuel Efficiency (ton-mile basis)**		**GHG Emissions**	
	40% improvement by **2030**	**70**% improvement (effort) by **2050**	**Halved By 2050**	Nearly zero emissions

LNG as transition marine fuel for reducing GHG Emission

NYK has been utilizing LNG as “Transition Marine Fuel” since **2015** to reduce GHG Emissions (Emission Reduction: 20-30% of CO2, 100% of SOx, 80% of NOx)

2 LNG Bunkering Projects

- ✓ Operating world’s first purpose-built LNG bunkering vessel since 2017 in Europe
- ✓ Japan’s first LNG bunkering project was launched in Sep. 2020 in Nagoya Port

1st LNG bunkering Vessel (2017)

2nd LNG Bunkering Vessel (2020)

8 LNG-fueled Ocean-going Vessels

- ✓ 3 LNG fueled Pure Car & Truck Carriers (PCTC) on operation. First one was delivered in 2016.
- ✓ 1 LNG fueled PCTC, 3 battery hybrid LNG PCTCs and 1 LNG-fueled Coal Carrier are on order

LNG-Fueled PCTC (2016~)

LNG-fueled Coal Carrier (2023)

1 Methanol-fueled Methanol Tanker

1 LNG-fueled Tugboat

Methanol-fueled Tanker (2019)

LNG-fueled Tugboat (2015)

Roadmap to Zero Emission of International Shipping

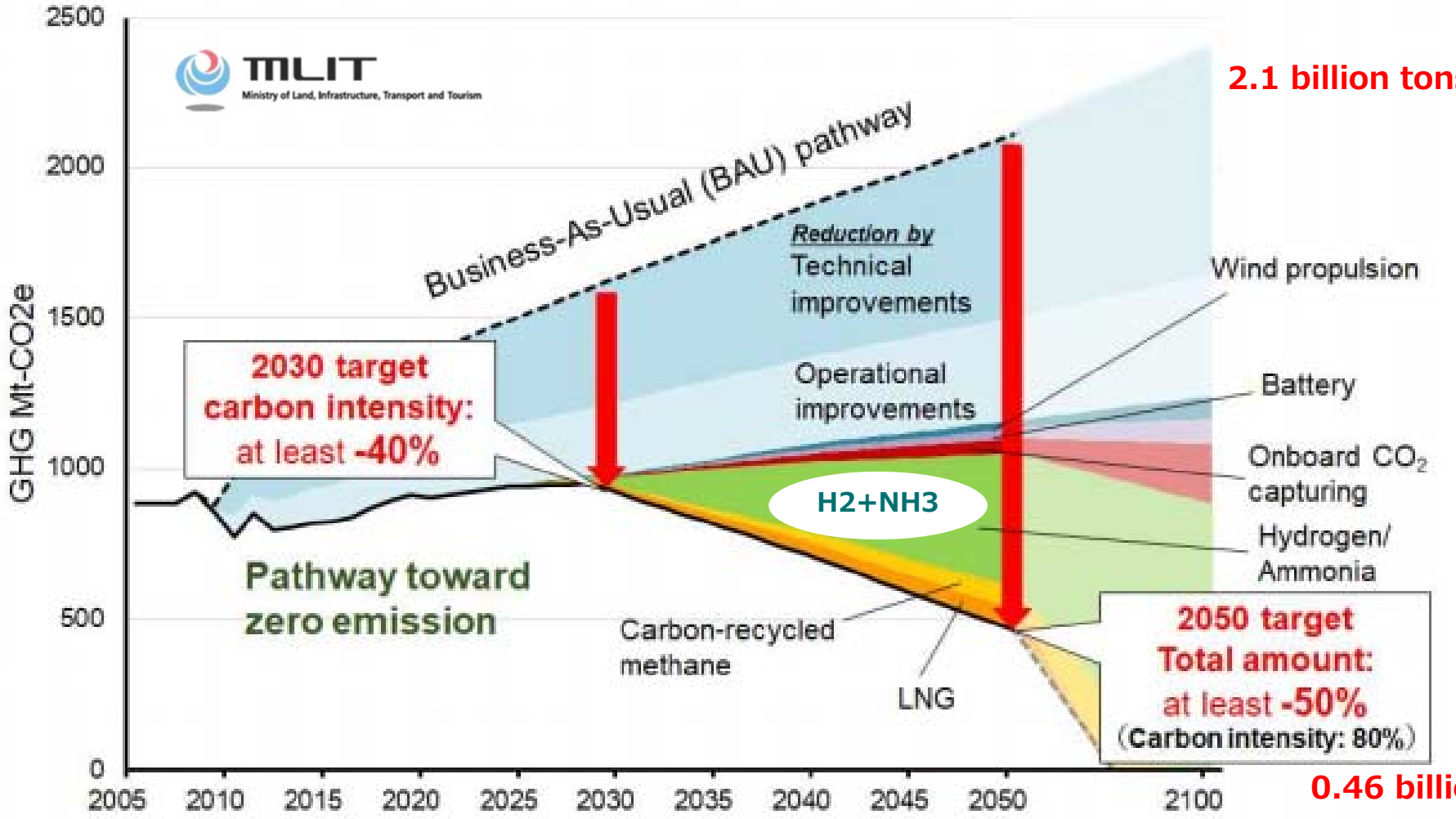


Figure 4.3.2-5: Trends in GHG Emissions and Reduction

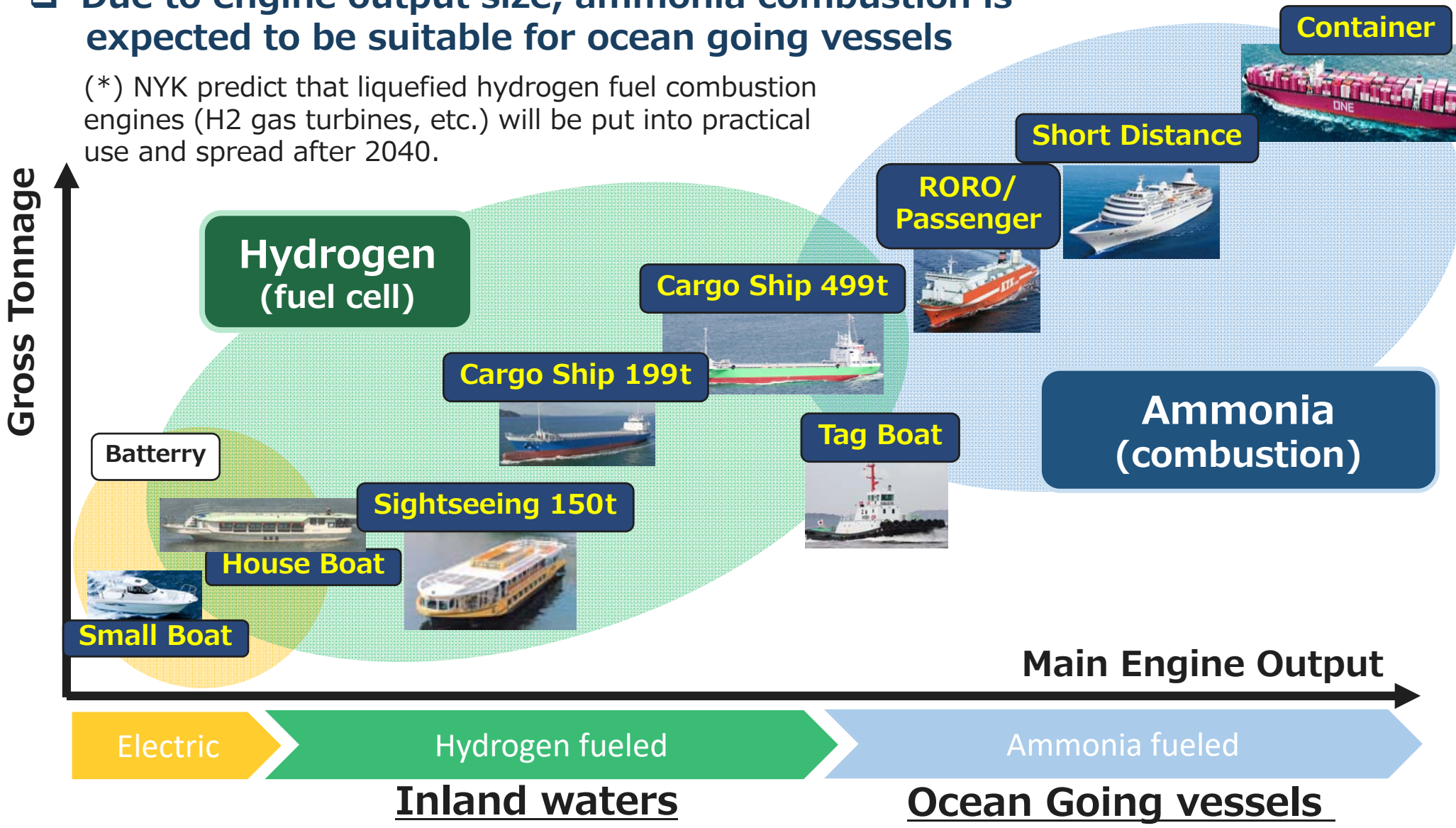
(Emission Pathway II: the Expansion of Hydrogen and/or Ammonia Fuels)

Ref: Roadmap for Zero Emissions of International Shipping (MLTI, March 2020)

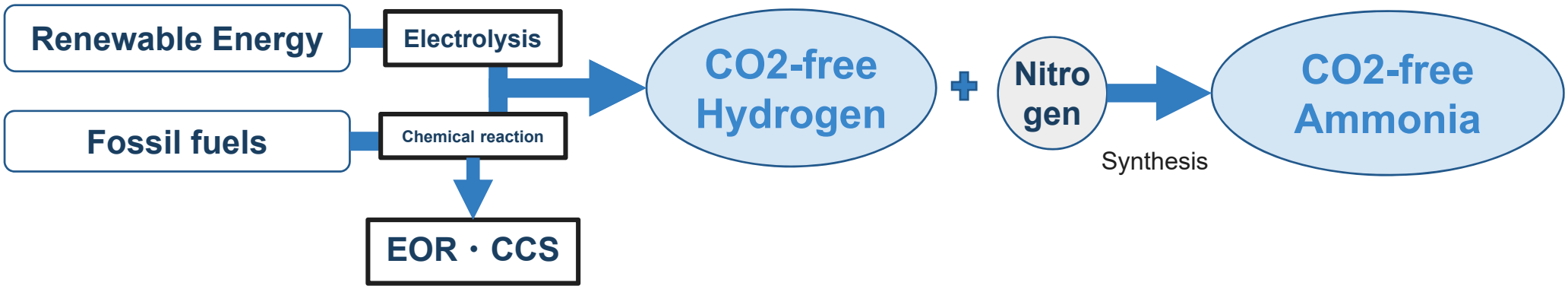
Hydrogen and Ammonia Playing Different Roles in 2030s

❑ **Due to engine output size, ammonia combustion is expected to be suitable for ocean going vessels**

(*) NYK predict that liquefied hydrogen fuel combustion engines (H2 gas turbines, etc.) will be put into practical use and spread after 2040.



Emerging CO2-free Ammonia Supply Chain for Net Zero Target



Potential Supply

- North America
- Middle East
- Australia

Potential Demand

Thermal Power Generation Fuel

Ocean-Going Vessel Fuel

Net Zero Emission Target by 2050

METI Ministry of Economy, Trade and Industry

MLIT Ministry of Land, Infrastructure, Transport and Tourism

NYK's R&D projects related to CO2-free Ammonia

NYK started following 3 joint R&D projects in Aug 2020 for use of CO2-free ammonia as an alternative fuel for vessels.

Project	Partner	Image
Ammonia-fueled Tug Boat	IHI NIGATA IHI Power Systems ClassNK	
Ammonia-fueled Ammonia Gas Carrier	JMU ClassNK	
Ammonia Floating Storage Regasification Barge		

Technical Challenges for Achieving Zero Emission

3 major challenges for achieving zero-emissions by ammonia-fueled vessels

❑ Minimization of pilot fuels

- ➢ Co-combustion with pilot fuels for flame retardancy of ammonia
- ➢ What kind of fuels will be used for pilot fuels?
- ➢ What amount of pilot fuels will be needed?

❑ NOx reduction

- ➢ More effective Selective Catalytic Reduction (SCR) for NOx reduction to achieve IMO regulations (Tier 3)
- ➢ N2O (nitrous oxide) reduction is one issue needed to be resolved

❑ Development of ammonia-fueled generator

- ➢ Not only an ammonia-fueled main engine but also an ammonia-fueled generator needs to be developed

Commercial Challenges for Ammonia Fuel

❑ 4 major commercial challenges for ammonia-fueled vessels

Fuel storage	Fuel tank will be about 3 times larger than current vessels due to heat values of ammonia
Supply chain	Bunkering infrastructure (including fuel bunkering vessels) is required
Safety	Development of international marine regulation and operational procedures for safety
Cost	Cost reduction for production, transportation, and supply is essential

Ammonia vs Other alternatives

❑ Ammonia fuel tank will be about **3** times bigger than heavy oil.
Liquid H2 fuel tank will be **4.5** times bigger.

	CO2 emissions per heating value	Volume per heating value	Remark
Ammonia	**0**	**2.72**	• NOx reduction • Toxicity • - 33℃
Liquid Hydrogen	**0**	**4.46**	• -253℃
Methanol	0.9	2.39	
LNG	0.74	1.65	
Heavy Oil	1.00	1.00	

LNG Fueled Coal Carrier (2023 delivery)

Hydrogen Supply Chain Project: AHEAD

- A full-scale demonstration project of the world's first global hydrogen supply chain

AHEAD

Advanced Hydrogen Energy Chain Association for Technology Development

CHIYODA CORPORATION

Mitsubishi Corporation

MITSUI & CO.

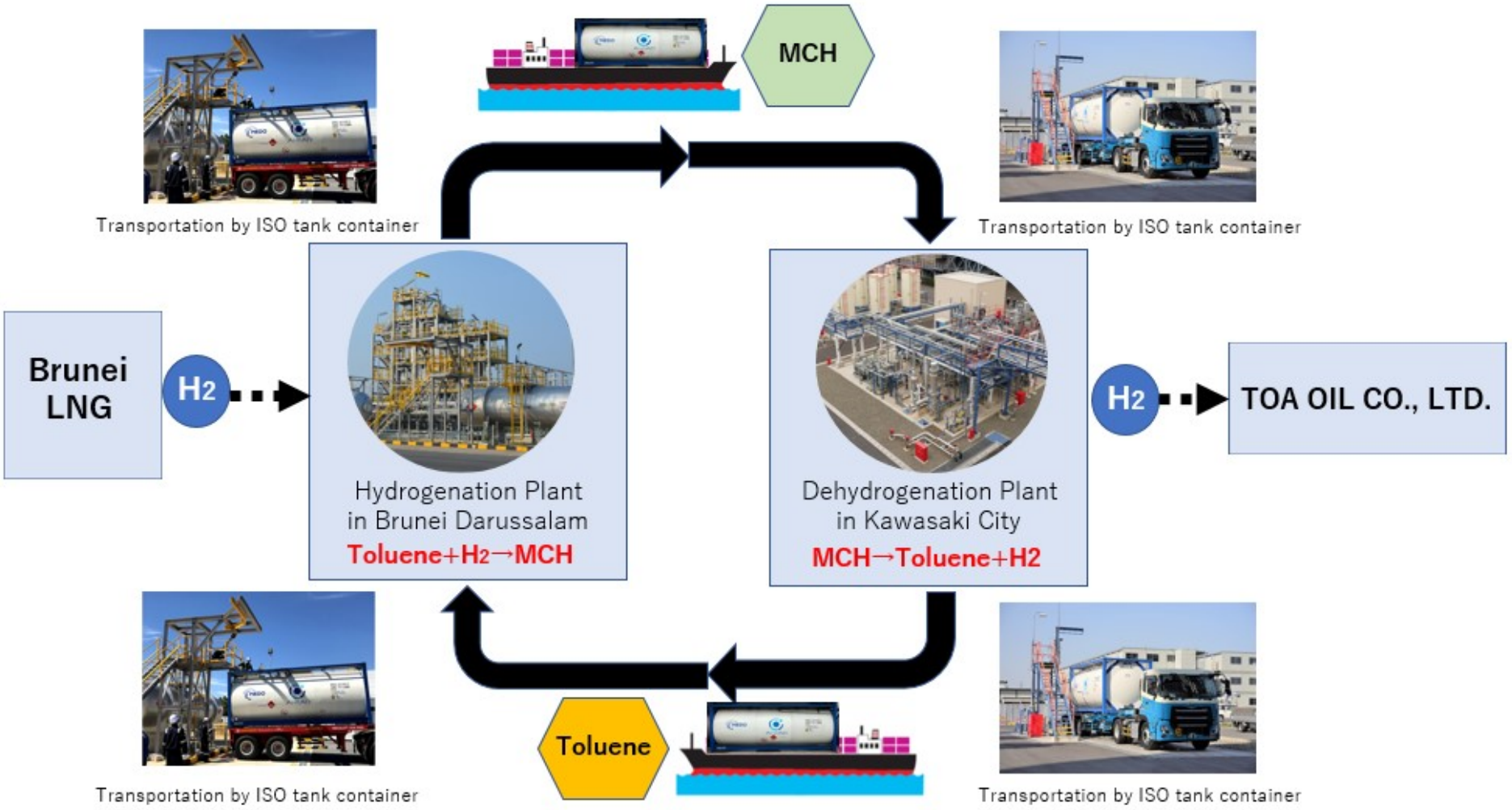
NYK LINE NIPPON YUSEN KAISHA

Supported by

NEDO New Energy and Industrial Technology Development Organization

Business scale	Max 210 tons/year
Purpose & Demo Period	Aiming at commercial supply chain operation in anticipation of commercialization About 1 year from April 2020

Hydrogen Supply Chain Project: AHEAD



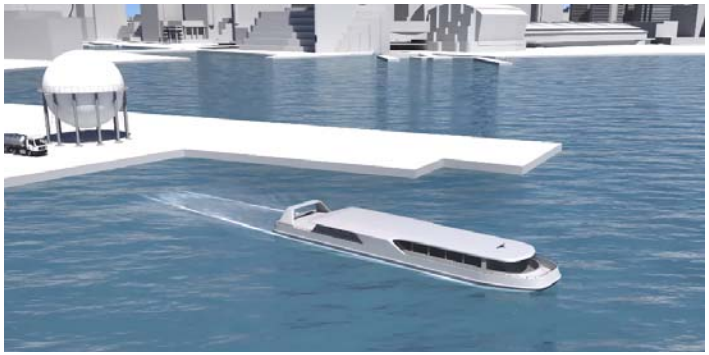
- Hydrogen and toluene are converted into a liquid substance at room temperature and normal pressure called MCH (methylcyclohexane) by chemical reaction.
- In hydrogen demand countries, hydrogen is separated into toluene and hydrogen (dehydrogenation reaction) and supplied to consumers as a gas.

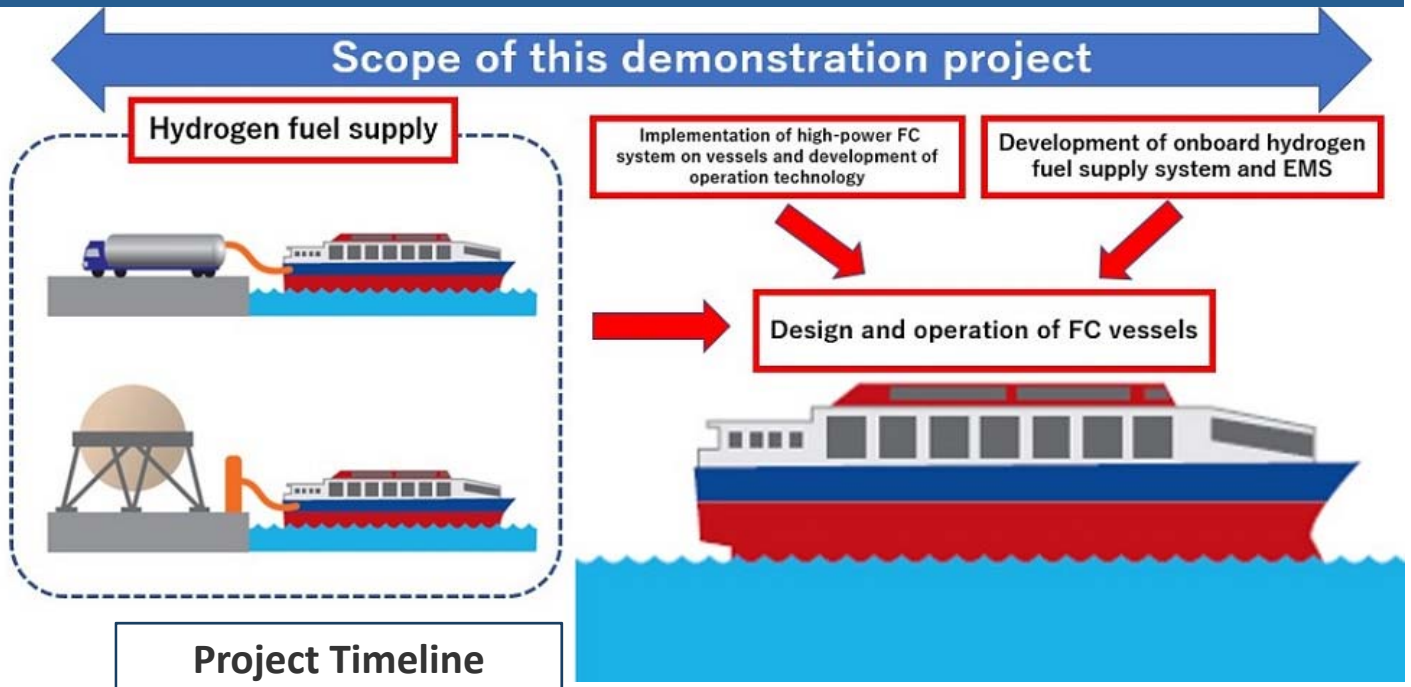
Hydrogen – Japan's First Project for High-Power Fuel Cell Vessel

- ❑ Developing a 150 ton class high-power FC vessel that functions as a mid-sized tourist ship
- ❑ Demonstrating the whole value chain of hydrogen-powered vessels

Consortium Members

NYK LINE (NIPPON YUSEN KAISHA)
TOSHIBA
Kawasaki
ENEOS
ClassNK





Project Timeline

	Item	FY2020	FY2021	FY2022	FY2023	FY2024
Common	Feasibility study					
Ship side (Vessel, FC, EMS, etc.)	Basic design					
	Detail design					
	Production/Construction/ Installation					
Shore side (Hydrogen fuel supply system)	Basic design					
	Detailed design					
	Production					
Common	Demonstration operation					

Working together for Greener Future

THE GREEN AMMONIA CONSORTIUM
一般社団法人 グリーンアンモニアコンソーシアム

AMMONIA ENERGY ASSOCIATION

Hydrogen Council

In July 2020, NYK became one of the first shipping companies to become a member of the Hydrogen Council.

Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

In July 2020, NYK became a founding member to promote decarbonization within the maritime industry by converting to alternative fuels.

Getting to Zero Coalition

GLOBAL MARITIME FORUM
FRIENDS of OCEAN ACTION
WORLD ECONOMIC FORUM

In October 2019, NYK joined the Getting to Zero Coalition to accelerate maritime shipping's decarbonization.

About us

NYK line was founded in 1885 and is one of the world's leading transportation companies. NYK Group is operating over 700 major ocean vessels, including bulk carriers, car carriers, containerships, LNG carriers, tankers and others, as well as fleets of planes and trucks. The NYK Group is based in Tokyo and has regional headquarters in London, New York / New Jersey, Singapore, and Shanghai.

For more information:

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