

16th ASEF Forum

Directions of decarbonization in international shipping and NYK's fuel transition strategy

12 Nov 2025

Takahiro Rokuroda

General Manager

Next Generation Fuel Business Group

NYK Line



#0 Directions of International Shipping



International shipping accounts for approx. 2% of global CO₂ emissions

Targets Set at MEPC* 80 (July 2023)

2030

- Reduce total CO₂ emissions by 20–30% (compared to 2008)
- Achieve 5–20% share of zero-emission fuels in energy mix

2040

- Reduce total GHG emissions by 70–80% (vs 2008)

2050

- [Achieve Net-Zero GHG emissions](#)



Approval of mid-term GHG reduction measures (April 2025)

- GHG Fuel Intensity Regulation (GFI) – [GHG emissions pricing contributions](#)
- IMO Net-Zero Fund – [Reward Scheme](#)





* MEPC : Core IMO committee responsible for marine environmental protection.

The committee meetings are held once or twice a year to update regulations such as MARPOL 73/78 Convention

Regulating GHG Emissions from Ships



Regulations currently running and/or under formulation process

	EU ETS	CBAM	Fuel EU maritime	GFI
Region	Europe 	Europe 	Europe 	Global 
Regulation/ Supporting Schemes	<ul style="list-style-type: none"> Market-based emission trading system (cap-and-trade) 	<ul style="list-style-type: none"> Carbon Border Adjustment Mechanism (linked to EU ETS) 	<ul style="list-style-type: none"> European fuel-based GHG regulation under EU 	<ul style="list-style-type: none"> Global fuel-based GHG regulation under IMO
Effective date	2024/1/1~	2026/1/1~	2025/1/1~	2028/1/1~*2
Subjects	<ul style="list-style-type: none"> GHG emissions (gCO₂eq) from EU voyages and ports 	<ul style="list-style-type: none"> Import products (e.g., fertilizers, steel, hydrogen) 	<ul style="list-style-type: none"> Vessels' fuel GHG intensity (gCO₂eq/MJ) calling at European ports 	<ul style="list-style-type: none"> Vessels' fuel GHG intensity (gCO₂eq/MJ)
Mechanism	<ul style="list-style-type: none"> Companies must surrender EU Allowances (EUA) for verified emissions. CO₂ price drives decarbonization (€70–100/t CO₂). 	<ul style="list-style-type: none"> Importers buy CBAM Certificates*1 based on embedded CO₂ emissions to align with EU ETS carbon cost. 	<ul style="list-style-type: none"> Ships exceeding GHG targets must pay FuelEU Penalty. Annual targets tighten progressively. 	<ul style="list-style-type: none"> Ships exceeding GHG targets must purchase Remedial Units (\$100–380/t CO₂eq until 2030). Annual targets tighten progressively.
Impact	<ul style="list-style-type: none"> Introduces carbon cost to shipping activities; encourages low-carbon fuel use. 	<ul style="list-style-type: none"> Prevents carbon leakage by equalizing CO₂ costs for imports. 	<ul style="list-style-type: none"> Promotes transition to low/zero-carbon fuels regionally. 	<ul style="list-style-type: none"> Promotes transition to low/zero-carbon fuels globally beyond vessel design efficiency.

*1 Price linked to EUA

*2 Adoption postponed

Pathways to Achieve IMO 2050 Goal



Post Extraordinary MEPC – Temporary Delay, Same Direction

- The Adoption at the Extraordinary MEPC has been postponed by one year
- Still, the overall direction & momentum to combat GHG remains unchanged

International Shipping requires GHG regulations at the IMO level

- A borderless industry with its emission not attributable to any specific countries/regions
- A globally consistent regulatory framework is indispensable for GHG control

Multiple Pathways to Achieve the IMO 2050 Goal

- Fuel Saving Technologies – wind propulsion & energy-saving devices
- Operational Efficiency with DX & digital tools
- Onboard CCS
- Fundamental Solution = Fuel Conversion to low-carbon / carbon-free fuels



#1 Future Fuels



Future Fuels ① Comparison of characteristics

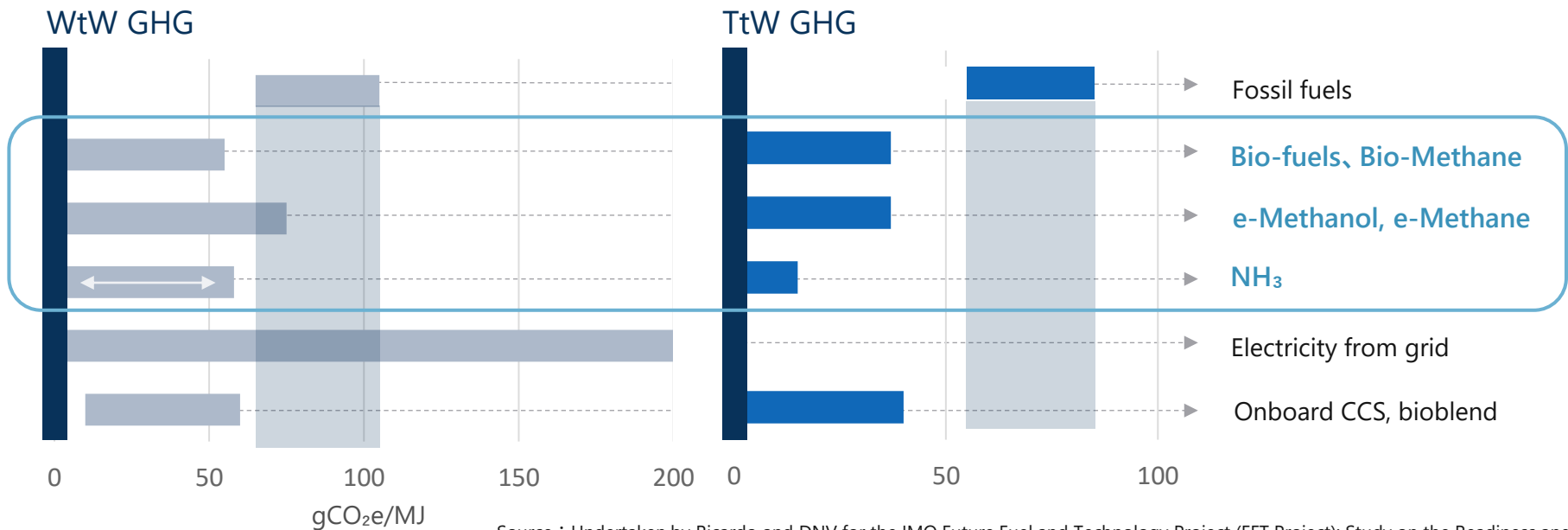
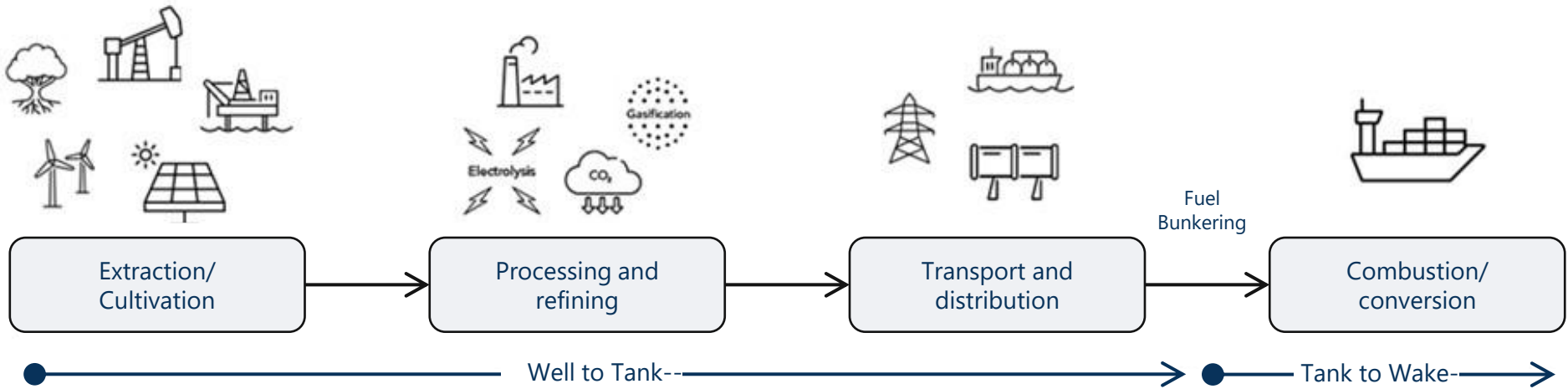
Multiple answers – need to bet on all possible options



	Low-Carbon Fuel			Zero-Carbon Fuel		
	VLSFO	LNG	Propane	Methanol	Hydrogen	Ammonia
Lower Heating Value (GJ/t)	40.4 (39.8–41.7)	48.0 (46.5–50.4)	46.3	19.9	120.0	18.8
CO ₂ Conversion Factor (CO ₂ -t/Fuel-t)	3.114	2.693	3.000	1.375	0	0
Volumetric Ratio per Heat (vs. VLSFO, liquid state)	1.00	1.63	1.62	2.39	4.42	2.86
CO ₂ Emission per Heat (CO ₂ -g/GJ)	77.38	56.10	64.79	69.10	0	0
By-product GHG & Warming Factor	-	Methane (slip) GWP:28	-	-	-	N ₂ O GWP:265
Boiling Point (°C)	200–400	-162	-42	65	-253	-33
Pilot Fuel	Not required	Required	Required	Required	Required	Required

Future Fuels ② GHG Reduction

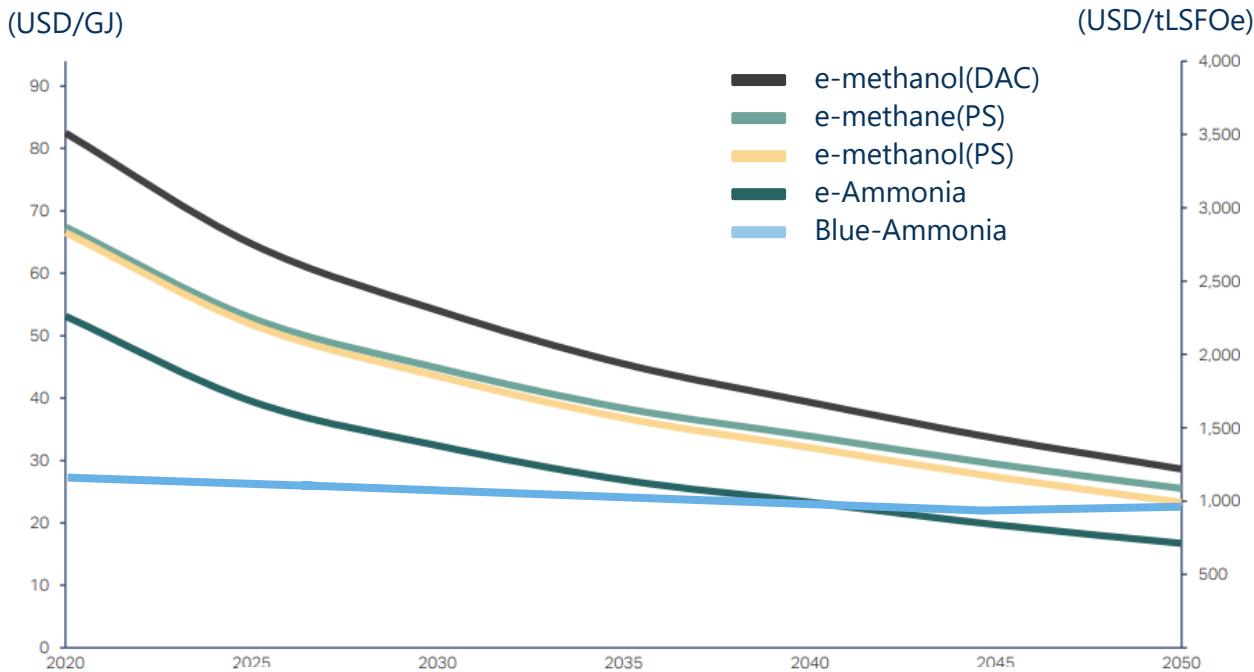
Need low carbon intensity on Well-to-Wake basis



Future Fuels ③ Affordability



The cost of H₂ will greatly define affordability of future fuels



Key Insights

- ✓ Blue H₂ is presently positioned as relatively price-effective
- ✓ Green-H₂ may outcompete Blue by 2040 or even earlier as H₂ costs fall

①

(/ton)

Material Volume Required	e-Methanol	e-Ammonia
H ₂	0.188	0.177
CO ₂	1.373	-
N ₂	-	0.822

②

(/ton)

Material Unit Cost	Now	2030	2050
H ₂	\$5,000	\$2,500	\$1,450
CO ₂	\$600	\$400	\$250
N ₂	\$160	\$160	\$160

① x ②

(/ton)

Material Procurement Cost	Now	2030	2050
e-Methanol	\$1,764	\$1,019	\$616
e-Ammonia	\$1,017	\$574	\$388

Future Fuels ④ Scalability & Availability

IEA prediction: NH₃ to play a mainstream role in marine fuel by 2050

Fuel consumption: service:



Conventional fuel oil
200 mil. tons
(93%)

216 mil. tons/year*1



Alternative fuel
16 mil. Tons *2
(7%)

The required amount for a full transition to zero-emission fuels would be...

For methanol	440 mil. tons/year
For ammonia	470 mil. tons/year
For methane/LNG	180 mil. tons/year

x 3% =
13mtpa

x 44% =
206mtpa

*1 The annual fuel consumption for ships engaged in international voyages with 5,000 gross tonnage and above (abt. 30,000 ships subject to IMO DCS) in 2023 (conventional fuel oil equivalent)

*2 Conventional fuel oil equivalent (of which 98% is LNG fuel.)

Vessel in service:



Conventional fuel ships
37,777 ships
(96%)

39,410 ships *3



Alternative fuel ships *4
1,633 ships
(4%)

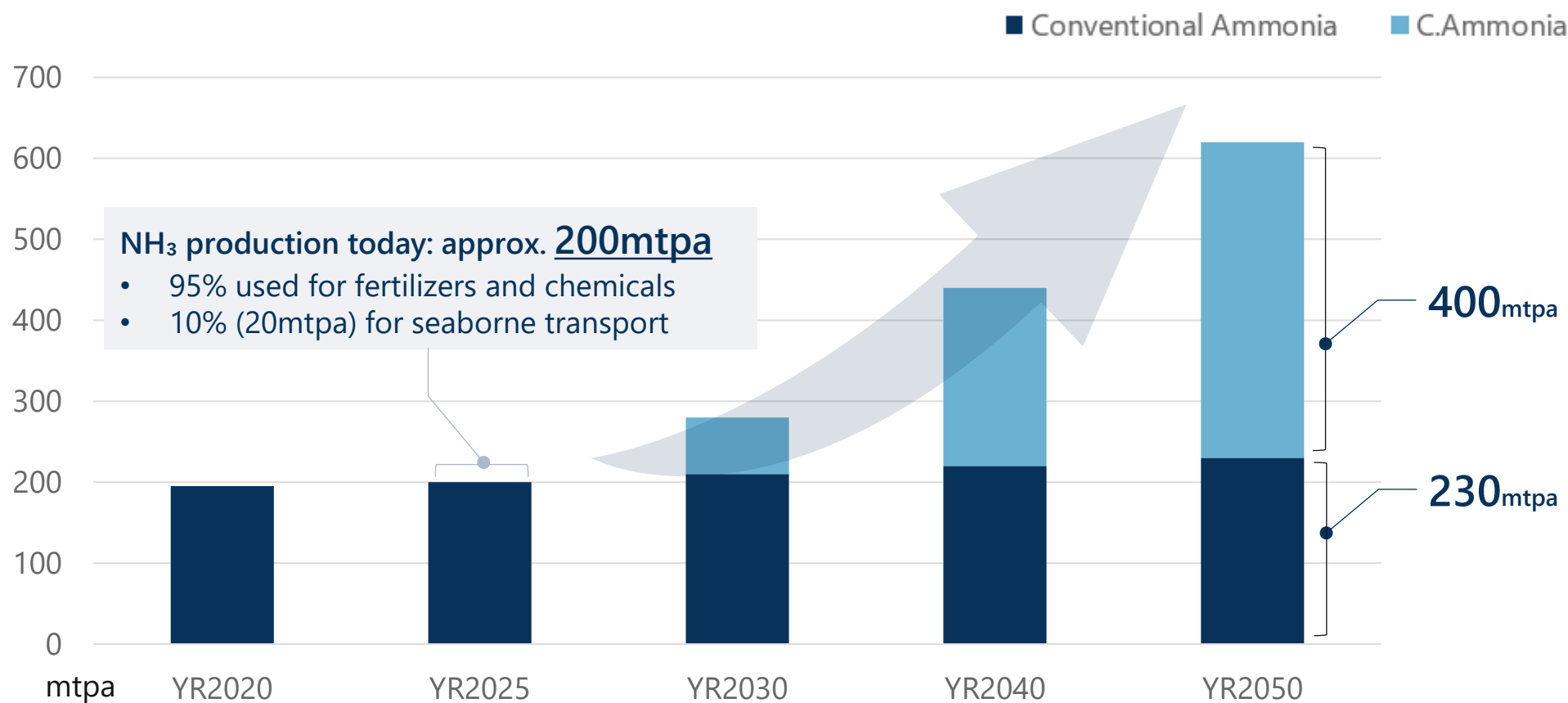
A transition of 37,777 ships to alternative fuels is necessary.
(Alternative fuel ships can use zero-emission fuels.)

*3 5,000 gross tonnage and above (as of the end of June 2025, adjusted for fractions)

*4 LNG-fueled LNG carriers included.

Future Fuels ⑤ Ammonia





- Diversified application from fertilizers/chemicals to power/marine fuels & H₂ carriers
- Enabling demand aggregation across sectors to realize economies of scale
- Abundant feedstock availability – clean H₂ and N₂
- Can leverage existing supply chain and infrastructure



Future Fuels ⑤ Support from Public Sector



Public sector's support will greatly encourage fuel transition to H₂/ NH₃

	H2 Global*1	Japanese CfD	CHPS (Oct 25 Canceled)	IRA - 45Q
Region				
Regulation/ Supporting Schemes	Supporting Schemes	Supporting Schemes	Supporting Schemes	Supporting Schemes
Effective date	Commercial Operation should start by 2027*3	Commercial Operation should start by FY2030	Commercial Operation should start by 2028*3	2023/1/1~
Applicable period	7 years from the start of operation*2	15years from the start of operation	15years from the start of operation	12 years from the start of operation
Subjects	Low-carbon hydrogen derivatives	Low-carbon hydrogen derivatives	power generation with Hydrogen/Ammonia	CO2
Mechanism	Price gap between selling price and purchase price will be covered (Double-auction mechanism)	Price gap between conventional fuels and Hydrogen derivatives will be covered	Cost gap between clean hydrogen-based power and conventional power generation will be covered	Company will obtain CO2 tax credit based on their CCUS activities

*1 Mainly Germany

*3 1st round

*2 1st round

#2 NYK's Strategies



NYK's Strategies – Fuel transition roadmap toward NZ by 2050



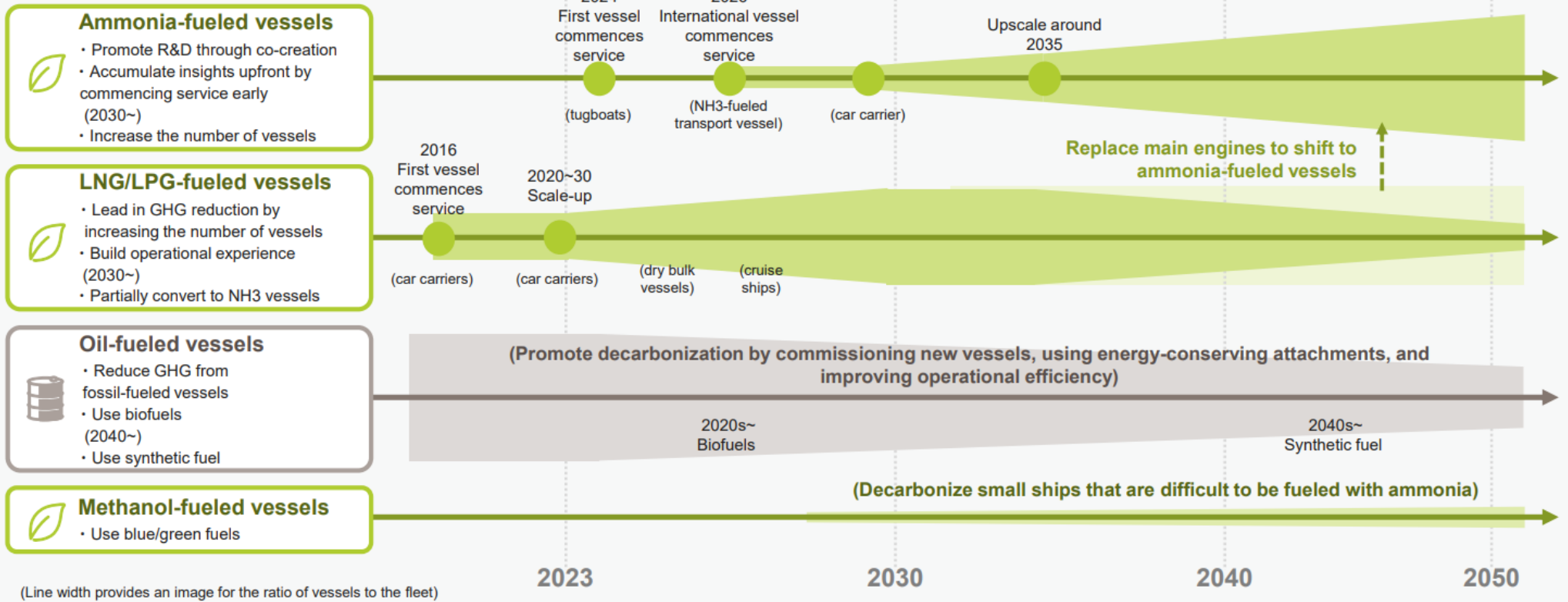
- Multiple fuels will come with varied trajectories of adoption – all within NYK's scope
- BDF/LNG will play key roles for short/mid terms

- 2030

- Maximize the use of the latest GHG reduction technology
- Expand the number of LNG-fueled vessels

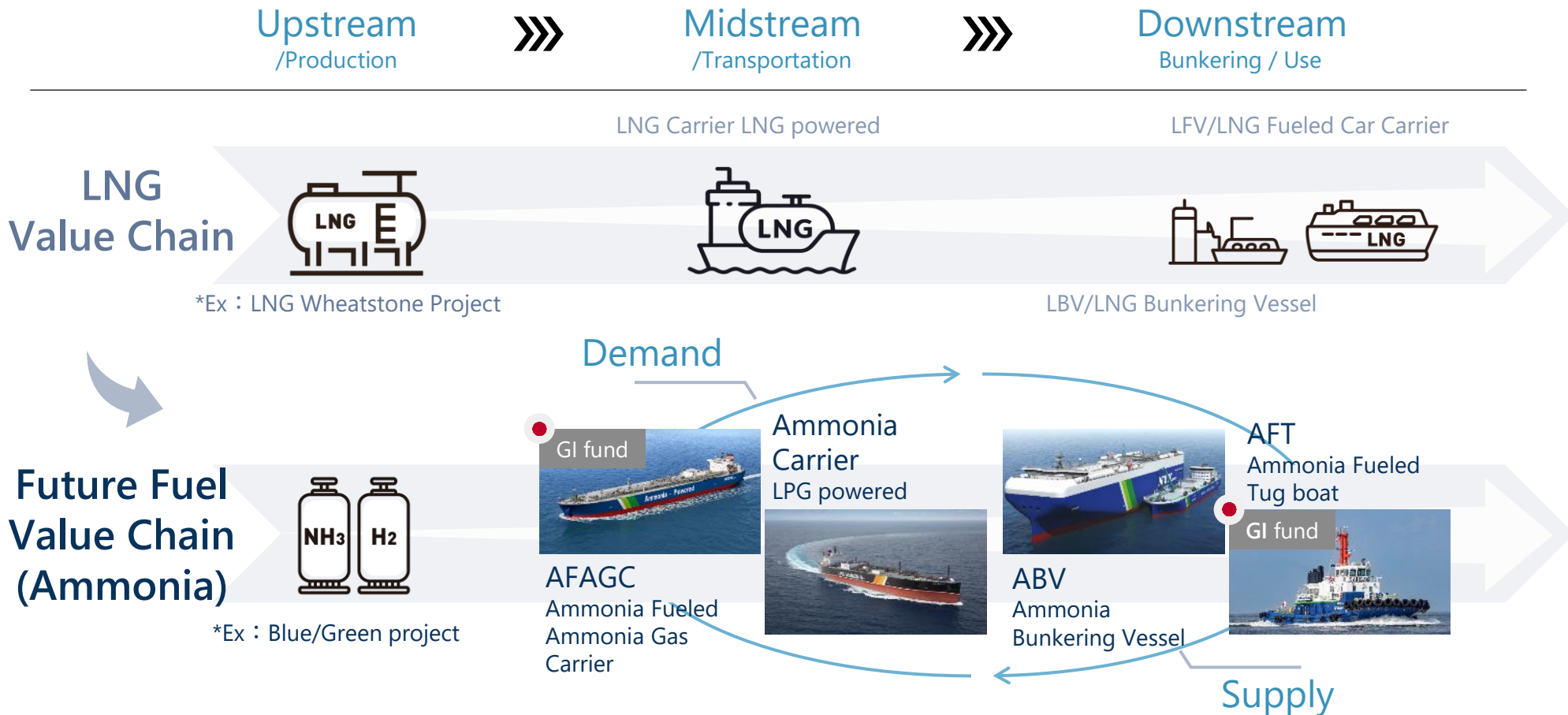
2030 - 2050

- Primarily shift to NH3-fueled vessels
- Select optimal fuels based vessel characteristics



NYK's Strategies – Value Chain Approach

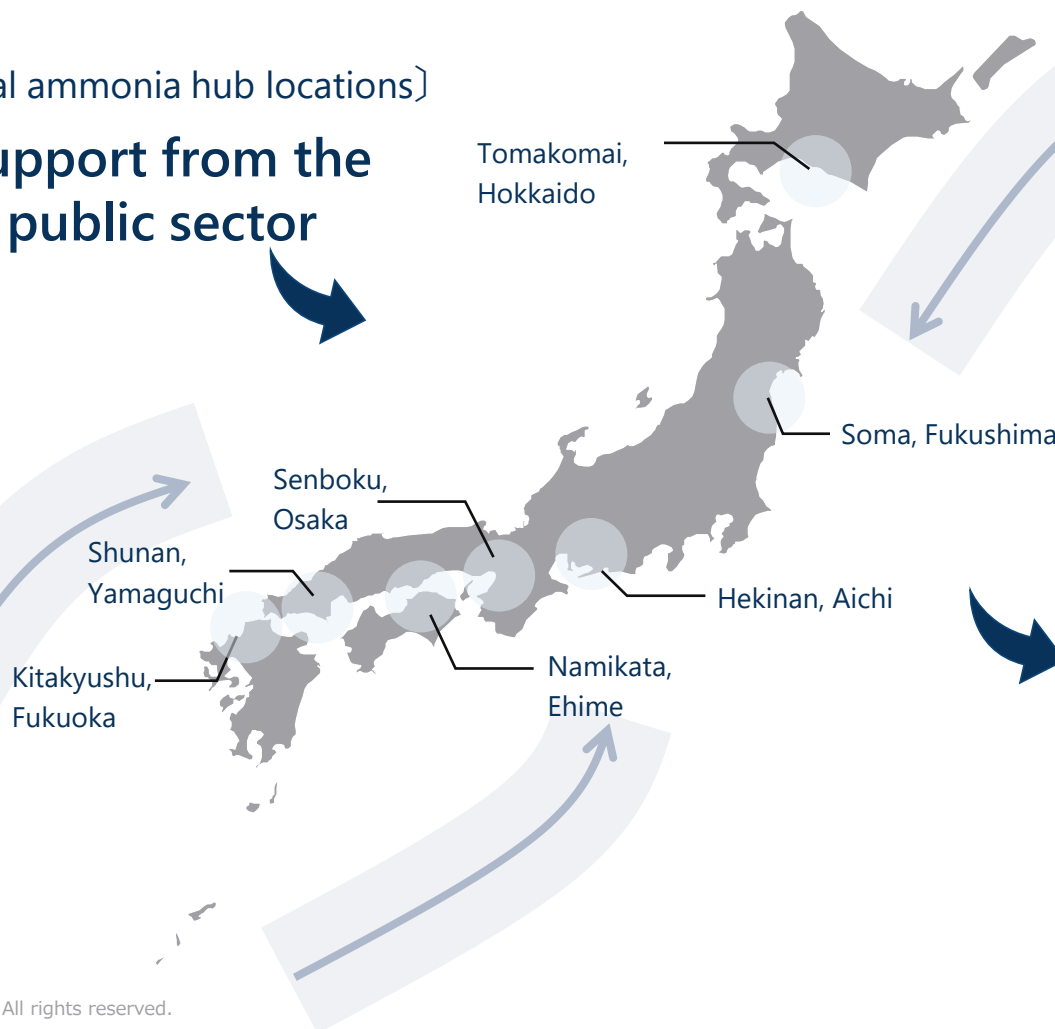
- Value Chain Approach covering up/mid/down stream
- A journey NYK has already experienced in LNG
- Establishment of clean fuel market - industries need to join forces



- Japan's stride to establish clean fuel NH₃ S/C from power sector
- Demand aggregation from ships will enhance its scale, resilience and economy

〔Potential ammonia hub locations〕

Support from the public sector



Expected events around 2030

- Establishment of new fuel NH₃ s/c
- Import of clean NH₃
- Expansion of NH₃ application to various sectors beyond power gen including shipping

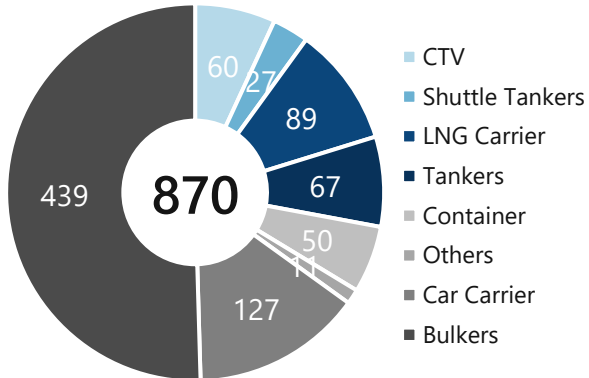
New Biz Opportunities

- Ocean transport
- Bunkering

NYK's Strategies – Midstream (Ocean Transport)



Expanding from upstream to downstream, with a focus on midstream



Seaborne NH₃ trade 20mtpa (present) → 160mtpa (2050)
 | Targeting more than 10% share
 | Further expanding with ammonia carriers

Exploration	Drilling	Development	Production / Storage	Regional Transport	Purification / Liquefaction / Storage	Transport	Customers
Investigation / Geophysical Exploration Vessel	Drillship	LNG Upstream Business (Wheatstone Project)	FPSO FSO	Shuttle Tanker	FLNG LNG Midstream Business (Cameron Project)	LNG Carriers Tanker (Petroleum / LPG/ Chemical) Coal Carriers	FSRU / FSU LNG Fuel Sales Business
		Ammonia / Hydrogen Production			Ammonia Floating Storage	Ammonia Fuel Ammonia Gas Carriers Overseas Ammonia Transport Ammonia Coastal Transport Liquefied CO ₂ Transport MCH Transport Liquefied Hydrogen Carrier	Ammonia Tugboat Ammonia Floating Storage Ammonia and Hydrogen Fuel Sales Business Current / Tidal Power Generation

NYK's Strategies – Downstream (Bunkering)

NYK is uniquely positioned with capabilities of demand creation & supply development

- One of the world's largest operating fleet – create captive fuel demand at scale
- Leveraging operational expertise, concurrently develop bunkering systems

● Demand

Japan's 1st LNG-fueled tugboat,

- "Sakigake"(Delivered in 2015)
- Reborn as an ammonia-fueled in 2024

2×World's 1st LNG-fueled PCC

- United European Car Carriers
- Delivered in 2016

Japan's 1st LNG-fueled PCC

- Delivered in 2020
- CO2 emission have been reduced by 40%

Build 20 LNG-fueled PCCs by 2028

- Most new PCCs to be LNG-fueled

World's 1st LNG-fueled Coal Carrier

- Delivered in October 2023
- 3 coal carriers by end-2025

LNG-Fueled Capesize Bulk Carriers

- Delivered in January 2024
- 5 vessels by 2025



● Supply



World 1st LNG bunkering Vessel



Green Zeebrugge

Delivered in 2017

Japan's First LNG bunkering Vessel



Kaguya

Delivered in 2020

LNG bunkering Vessel in Western Japan



KEYS Azalea

Delivered in 2024



A-tug "Sakigake"

'24/7

World's first Truck to Ship ammonia bunkering at Yokohama

- Procurement from JERA and Resonac

'24/8

Retrofitted at the Keihin Dock (NYK subsidiary)

- World's first ammonia-fueled commercial vessel
- In tug & towing operations in Tokyo Bay
- 3 mth demonstration to verify safe operation and emissions

Confirmed GHG reduction is up to about 95% (TtW)

'25/3

A-Tug project completion ceremony



Ammonia co-firing rate/GHG reduction rate (TtW basis)

M/E load	100%	75%	50%	25%
NH ₃ Co-firing rate	95.2%	94.8%	93.4%	91.1%
GHG reduction rate*	94%	94.4%	93.0%	90.3%

*GHG emission compared to Fuel Oil



Target in Nov 2026

Ammonia Fueled Ammonia Gas Carrier

NYK signed AFAGC SBC (Dec 2023)



Developed the design to obtain NK's MRS notation

*Machinery Room Safety for ammonia

Ammonia-Fueled DF main engine

(Japan Engine)

- ✓ 2-stroke engine
- ✓ Full scale engine developed & delivered to yard
- ✓ Confirmed high co-firing rate (~95%)
- ✓ Very limited amount of N₂O emissions



Ammonia-fuelled DF auxiliaries

(IHI Power System)

- ✓ 4-stroke engine
- ✓ Similar specifications and performance to the M/E of A-Tug



The real cases prove best that “ammonia works”

Approval of Basic Design for Bunkering Boom (Jul 2024)

Jointly developed with TB Global Co., featuring emergency-release system to improve safety.

Completion of the Ammonia-Fueled Tugboat (Aug 2024)

The world's first ammonia-fueled tugboat was completed, marking the start of zero-emission operation trials in ports.

Conclusion of Time-Charter Agreement for AFAGC (Feb 2025)

Signed the world's First Time-Charter Agreement for AFMGC with Yara Clean Ammonia.

Large-Scale Ammonia Ship-to-Ship (StS) Operation Achieved (Sep 2025)

Successfully conducted large-scale ammonia transfer under near-commercial conditions, confirming the feasibility of commercial StS operations.

The world's first commercial ammonia fueled engine by Japan Engine (Aug 2025)

Engine's environmental performance and safety were certified by ClassNK.



Creating Environmental Value through the Development of Ammonia Medium Gas Carrier(MGC) (Planned Nov 2026)

Building a dedicated ammonia carrier to establish a global large-scale transportation framework.

NYK's Strategies – Expand Track Records



Press Released

- Dec 06 2023

Mitsui Concludes Contract to Supply Ammonia for Co-firing Demonstration Project at Unit 4 of the JERA Hekinan Thermal Power Station



Mitsui & Co., Ltd. ("Mitsui", Head Office: Tokyo, President and CEO: Kenichi Hori) and JERA Co., Inc. ("JERA") have concluded a sales agreement covering the supply of fuel ammonia for use in ammonia co-firing trials at the JERA Hekinan Thermal Power Station (Hekinan-shi, Aichi Prefecture).

Since fiscal 2021, JERA has been implementing a demonstration project to establish technology for large-scale ammonia fuel co-firing at the Hekinan Thermal Power Station. For this demonstration project, under the said sales agreement, Mitsui will supply ammonia for use as a fuel in large-scale co-firing (co-firing rate: 20%) at Unit 4 of the Hekinan Thermal Power Station.

Dec. 06, 2023

Press Release

NYK Concludes Time Charter Agreement for Fuel Ammonia Transport

Developing a marine transportation system for future expansion of the fuel ammonia market

In October, NYK signed a time charter contract with Mitsui & Co., Ltd. (hereinafter "Mitsui"; head office: Tokyo; president: Kenichi Hori) for the transport of ammonia. The vessel Berlian Ekuator, owned and operated by NYK, will be used for the shipments.

The vessel will transport fuel ammonia to be used by JERA Co., Inc. (hereinafter "JERA") in the world's first large-scale fuel-conversion demonstration test,* which will be conducted at unit 4 of JERA's Hekinan Thermal Power Station. In June, Mitsui and JERA signed an ammonia sales and purchase agreement to be used in the demonstration test.

Fuel ammonia transportation for the trial



BERLIAN EKUATOR

SM	: NYKMS
LOA	: 169.9 m
Beam	: 27.4 m
Capacity	: about 35,500m ³
Built YR	: 2004

Key takeaways

- ✓ **Importance of Ship Management**
Thorough maintenance before discharge (Essential for older vessels)
- ✓ **Operational Knowledge**
Close coordination with terminal to optimize fuel ammonia transport to power plant.

Press Released

- Sep 24 2025

Successful Ship-to-Ship Transfer of 23,000 Tons of Liquefied Ammonia Achieved

Advancing the global ammonia supply network through STS technology

On September 2, a ship-to-ship (STS)* ammonia transfer was executed from the ammonia carrier Berlian Ekuator — owned by NYK and time-chartered by Mitsui & Co., Ltd. — to the ammonia carrier Eco Enchanted, operated by Trammo, Inc., a leading ammonia trader. The transfer was conducted in accordance with stringent safety protocols on the high seas off the coast of Ceuta, Spain.

While NYK has experience with STS transfers involving crude oil, liquefied natural gas (LNG), and liquefied petroleum gas (LPG), this marks our first operation involving liquefied ammonia.

With the support of Trammo's longstanding experience and their designated STS specialist provider, International Fender Providers Ltd.,** we successfully leveraged our advanced safety management system and refined STS operational know-how to safely transfer the entire cargo of liquefied ammonia, approximately 23,000 MT, to Berlian Ekuator.



NYK's Strategies – Expand Track Records



Press Released

- Oct 15 2025

World's First Environmental Value Created through Operation of NYK Ammonia-fueled Tugboat

Expanding the environmental contribution potential of fuel ammonia

Shin Nippon Kaiyosha obtained third-party certification on 25th September, 2025 for the environmental value¹ representing the quantified greenhouse gas (GHG) emissions reduced through the towage services² provided by the ammonia-fueled tugboat Sakigake (the "vessel").

This certified environmental value can be allocated to purchasers through the Book & Claim method³ and is expected to contribute to the reduction of Scope 3 emissions⁴ by transportation service users in the future. This is the world's first instance that environmental value derived through the operation of an ammonia-fueled vessel has received third-party validation.

Selected in October 2021 as part of NEDO's⁵ Green Innovation Fund project, "Development of ships with ammonia fueled domestic engines", Sakigake is the world's first ammonia-fueled vessel developed for commercial use. The vessel is fueled by low-environmental-impact ammonia "ECOANN,"⁶ manufactured by Resonac Corporation and provided by JERA Co., Ltd. Since its completion in August 2024, Sakigake has been providing safe and low-carbon tugboat services in Yokohama port.

GHG emissions from cargo transportation are commonly classified as Scope 3 for transport service users, requiring collaboration across the entire supply chain to reduce them. By visualizing GHG reductions in the shipping industry, this initiative paves the way for future Scope 3 emission reductions by shippers and consideration of additional GHG reduction measures, further expanding the potential environmental contribution of ammonia as a marine fuel.

Moving forward, NYK will continue to focus on developing a fuel ammonia value chain and advancing decarbonization within the shipping and marine industries. This commitment includes the development of the ammonia-fueled medium gas carrier (AFMGC), scheduled for completion in November 2026, that NYK is developing in collaboration with others.

Press Released

- Feb 10 2025



Yara Clean Ammonia

Yara and NYK Conclude World's First Time-Charter Agreement for Ammonia-Fueled Medium Gas Carrier

Yara Clean Ammonia Switzerland SA (Yara Clean Ammonia)*, a subsidiary company of Yara International ASA (Yara), the world's largest ammonia distributor, signed a time-charter contract with Nippon Yusen Kabushiki Kaisha (NYK) for an ammonia-fueled medium gas carrier (AFMGC) to be delivered in November 2026.



Signing Ceremony

Left : Csaba Laszlo, Vice President, Yara Clean Ammonia
Right : Hironobu Watanabe, Managing Executive Officer, NYK



Top Management Meeting

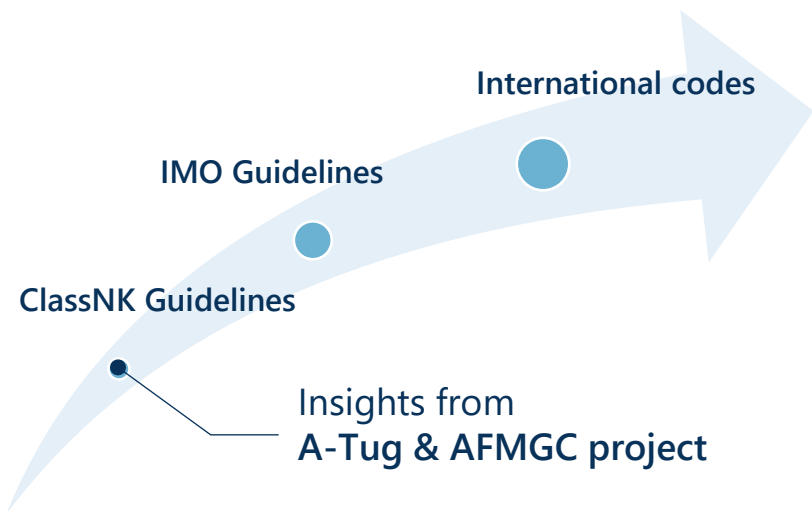
Front Left : Hans Olav Raen, CEO, Yara Clean Ammonia
Back Left : Murali Srinivasan, Senior Vice President, Yara Clean Ammonia
Front Right : Takaya Soga, President, NYK
Back Right : Tsutomu Yokoyama, Executive Officer, NYK

Objective : Prove ammonia works & to establish a new NH₃ market

- **Shipowners** to adopt ammonia as a fuel.
- **Ammonia producers** to support production of clean ammonia for bunkers.
- **Shipbuilders / Engine & Machinery manufacturers** to drive production & reduce costs.
- **Regulators** to formulate rules and regulations to govern/incentivize the use of ammonia.
- **Ports & Terminals** to invest in relevant infrastructure.
- **All Parties** to join force to create sustainable and large-scale supply chain of clean ammonia.

Strategy : "Standardization & Regulation"

- **Share** the tries/errors/lessons learned through our project with Class society & Regulators.
- **Establish** common understanding of safety & effective combustion to combat GHG emission.
- **Support** the regulators to formulate adequate rules to govern the use of ammonia as a marine fuel.



Steps	Summary
NK Guidelines	<ul style="list-style-type: none"> • Aug 2021 released "Guidelines for Ships Using Alternative Fuels". • Jul 2024 released edition 3.0.3 of the "Guidelines"
IMO Guidelines	<p><IGF></p> <ul style="list-style-type: none"> • Finalized at CCC10 (Sep.2024) • Approved at MSC109 (Dec.2024), Issued Interim Guidelines (Feb.2025) <p><IGC></p> <ul style="list-style-type: none"> • Finalized at CCC11 (Sep.2025)
International Codes	<ul style="list-style-type: none"> • To be adopted as international code in 2028

Ammonia fuel still faces challenges - join forces across all sectors

1

Supply Chain

Production, transport, and supplying infrastructure for fuel ammonia are yet to be sufficient



Establishing the Supply Chain

- Production : Development of upstream projects
- Transportation : Establishing Marine Transportation based on volume
- Supply : Develop supply facilities, including bunkering vessels

2

Shipbuilding Capacity

Need cost competitiveness backed by sufficient building capacity of AFVs



Develop Shipbuilding infrastructure for Ammonia Fueled vessels

- Sufficient capacities for Ships/Engines/Equipment/Tanks
- Incentive programs from public sectors to reinforce production lines

3

Cost Effectiveness

High CAPEX for AFVs/ABVs
Fuel ammonia still is costly, too



Establish economic viability for fuel ammonia

- Join forces with power sector to realize economies of scale in the fuel S/C
- Share decarbonization costs for Scope 3 across the entire supply chain
- Incentive programs from public sector to overcome high entry cost

4

Rules

Safety standards, GHG regulations, and incentives for new fuel are not yet established




Set safety standards

Create economic incentives for next-generation fuels

- Establish common understanding of safety element across the industry
- Fair system to measure GHG & evaluate reduction efforts

NYK's Strategies – Partnership

- No single player can solve all challenges or create a new market alone
- Collaboration across industries, NGOs/NPOs, and regulators is essential



MMMC ZCS
(Maersk Mc-Kinney Møller Center for Zero Carbon Shipping)

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

CFAA(Clean Fuel Ammonia Association)

CLEAN FUEL AMMONIA ASSOCIATION

GCMD(Global Centre for Maritime Decarbonisation)


Global Centre for MARITIME DECARBONISATION

Maritime & Port Authority of Singapore (MPA)

MPA SINGAPORE

Press Released

NYK and Singapore's MPA sign MoU to advance maritime decarbonization, digitalization and manpower development in July 2024.





免責事項

本資料は、電子的または機械的な方法を問わず、当社の書面による承諾を得ることなく複製又は頒布等を行わないようお願いいたします。

Legal Disclaimer

No part of this document shall be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of NYK Line.