Symposium on alternative low-carbon and zero-carbon fuels

Expectations from a shipowner on using ammonia as marine fuel for zero-emission ships

February 9th, 2021

Toshi Nakamura
Senior General Manager
Green Business Group
NYK Line
## Agenda

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Company introduction</td>
</tr>
<tr>
<td>2</td>
<td>GHG reduction strategy in the shipping industry</td>
</tr>
<tr>
<td>3</td>
<td>Projects of ammonia fuel</td>
</tr>
<tr>
<td>4</td>
<td>Challenges to realize ammonia fueled vessel</td>
</tr>
</tbody>
</table>
CHAPTER 1

Company Introduction
NYK Group Fleet and Facility

**Vessel**
- 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 drillship
- 1 cruise ship
- 3 FPSOs
- 2 FSOs

**Air Freighter**
- 8 aircrafts
- 5,227 flights in 2020

**Terminal**
- Operating at 21 ports in 2020

**Logistics Center**
- 609 locations
- 3.1 million m²

*For the year ended March 31, 2020

*As of March 31, 2020

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NYK’s Medium-term Strategy

“Staying Ahead 2022 with Digitalization and Green”

Promoting “Green Business” to Drive Future Growth and Create New Value as a Shipping Company

Hydrogen/Ammonia

Offshore wind power

LNG bunkering

World’s first LNG-fueled car carrier

World’s first LNG bunkering vessel

Japan’s first LNG bunkering vessel
GHG Reduction Strategy in the Shipping Industry
Introduction of H2 and NH3 is a key to CO2 reduction.

2.1 billion tons

0.46 billion-ton

Japanese maritime industry worked together with Ministry of Land, Infrastructure, Transport and Tourism.
Roadmap for Zero Emission of International Shipping by MLIT

Expected scenario of hydrogen and ammonia introduced toward 2050

Start from 2028

H2
NH3

45%

LNG

Petroleum fuel

(March 2020)

Japanese maritime industry worked together with Ministry of Land, Infrastructure, Transport and Tourism

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Clean Fuel Ammonia Association in Oct 2020

Roadmap of Ammonia Supply Chain by CFAA

**Supply**
- Natural Gas (Blue)
- Renewables (Green)

**Utilization**
- Large-scale demand for power generation
- Coal Power Plants (~1,000MW)
- GTs (~0.3MW)
- GTs (2MW~) SOFC
- ACCGT (100MW~)
- Industrial Furnaces
- Marine Engines

**2020**
- FS, Construction of Supply Chain
- Demonstration with Saudi Arabia

**2025**
- Carry out Small-scale Demo, Construction of Supply Chain for Large-scale Supply
- 0.5-1 Million ton/y for Japanese market

**2030**
- Supply of Green Ammonia
- 3-5 Million ton/y for Japanese market

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Due to engine output size, ammonia combustion is expected to be suitable for ocean-going vessels. NYK predicts that liquefied hydrogen fuel combustion engines (H2 gas turbines, etc.) will be put into practical use and spread after 2040.

NYK’s forecast for hydrogen and ammonia in 2030s

Inland waters

Ocean Going vessels

Hydrogen (fuel cell)

Ammonia (combustion)

Electric

Hydrogen fueled

Ammonia fueled

- Cargo Ship 199t
- Cargo Ship 499t
- Tag Boat
- Sightseeing 150t
- House Boat
- Small Boat
- Battery
- Cargo Carriers
- RORO/Passenger
- Container

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CHAPTER 3

Projects of Ammonia Fuel
NYK started three joint R&D projects from Aug 2020 for use of CO2-free ammonia as an alternative fuel for vessels.

<table>
<thead>
<tr>
<th>Project</th>
<th>Partner</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A-Tug</strong> (Ammonia-fueled Tug)</td>
<td>IHI Power Systems</td>
<td>![A-Tug Image]</td>
</tr>
<tr>
<td><strong>AFAGC</strong> (Ammonia-fueled Ammonia Gas Carrier)</td>
<td>NIHON SHIPYARD</td>
<td>![AFAGC Image]</td>
</tr>
<tr>
<td><strong>A-FSRB</strong> (Ammonia Floating Storage Regasification Barge)</td>
<td>ClassNK</td>
<td>![A-FSRB Image]</td>
</tr>
</tbody>
</table>
Joint R&D > Ammonia fueled tugboat

Joint R&D project to put the ammonia fueled tugboat into practical use

Shipyard → Building → NYK (Shipowner) → NYK Group (Operator)

Joint R&D

ClassNK

NYK Line

IHI Power Systems

LNG fueled tugboat “Sakigake”
built in 2015

Ammonia fueled tugboat

SOx Reduction 100%
NOx Reduction approximately 80%
CO2 Reduction approximately 30% (※Compared to heavy oil)

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Joint R&D > Use of Ammonia in Marine Transportation

Supply Chain of CO2-Free ammonia

Production | Storage | Marine Transportation | Storage & delivery | Bunkering to vessels | Marine Fuel

AFAGC
Ammonia-Fueled Ammonia Gas Carrier

A-FSRB
Ammonia Floating Storage and Regasification Barge

Stable supply chain of ammonia fuel

AFAGC: Contribute to the early realization of zero emissions for oceangoing vessels
A-FSRB: Contribute to the early introduction of ammonia fuel as an alternative to land facilities

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CHAPTER 4

Challenges to realize ammonia fueled vessel
Challenges of ammonia fueled vessel

To use ammonia as marine fuel, both technical and commercial challenges need to be overcome.

<table>
<thead>
<tr>
<th>Technical Challenges</th>
<th>Pilot fuels</th>
<th>NOx</th>
<th>Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Challenges</td>
<td>Fuel cost</td>
<td>Fuel storage</td>
<td>Fuel Supply chain</td>
</tr>
</tbody>
</table>

Working with various partners including other sectors is necessary to solve the challenges.

Power generation fuel

METI (Ministry of Economy, Trade and Industry) (2020s～)

Marine fuel

MLIT (Ministry of Land, Infrastructure, Transport and Tourism) (2028～)
LFV vs LBV “Chicken & Egg” Situation finished

It takes a long time to finish “chicken & egg” situation when introducing a new type of marine fuel.

<Example: LNG as marine fuel>

【LNG Fueled Vessels (LFV) (excluding LNG carriers) & LNG Bunkering Vessels (LBV)】

- MV Kaguya (LNG Bunkering Vessel)
- MV Green Zeebrugge (LNG Bunkering Vessel)
- MV Auto Eco/Energy (LNG Fuel PCTC)
- MV Sakigake (LNG Fuel Tug )
- Delivered LNG Bunkering Vessel

Showing delivery year of existing orders only. Future contracts will increase the number of LNG fuelled ships delivered in 2022 and onwards.
How can we establish safety requirements for toxic and corrosive ammonia fuel?

To build an ammonia fueled vessel

Liquified gas carrier? (e.g. liquified ammonia carrier?)

Yes
IGC code
Toxic fuel not allowed
Amend IMO regulation

No
IGF code
Ammonia fuel not covered
Set guidelines based on safety verification

Different types of ship need different actions.
IGC Code
The International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
• This standard is for the safe carriage by sea in bulk of liquefied gases to minimize the risk to the ship, to its crew and to the environment.
• Liquified gas carriers are not allowed to use toxic fuels. (including ammonia fuel)

IGF Code
The International Code of Safety for Ship Using Gasses or Other Low-flashpoint Fuels
• This standard is for the safe use of gas fuels.
• The current standard mainly covers LNG fuel. (not including ammonia)

There is already a new movement to optimize these standards for the use of next-generation marine fuels.
Contribution to GHG Reduction in International Shipping

Contribution to the realization of GHG reduction targets through technical development of the Japan Maritime Cluster

Multi-country approval based on alternative design

Other countries where ships call
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