LNG as a Marine Fuel
A Shipping Company’s Perspective

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History / Marine Propulsion
HISTORY / Marine Propulsion

WIND or SAILING had long been marine propulsion source since ancient times for over 4,000 years, then

COAL STEAMING developed through the Industrial Revolution took over the key role of marine propulsion from wind’s in the 19th century, then

OIL BURNING came into wide use in the 20th century, now low speed 2 stroke diesel engine is the most popular propulsion unit for larger ocean-going ships

NUCLEAR is most unlikely to become major propulsion power for merchant marine,

and THEN
Challenges / Prevention of Air Pollution
CHALLENGES Prevention for Air Pollution

**International Maritime Organization (IMO)** sets sail for air pollution act with

1. NOx Emission Standards,
2. Sulfur Content of Fuel, and
3. Greenhouse Gas Emissions

In October 2016, IMO MEPC has decided the Global Sulphur Cap will enter into force on Jan.1 2020

- **WIDE SPREAD**: The decision covering high-seas, will affect not only more than 70,000 ships but other industries i.e. oil, oil refining and energy industries
- **NOT ENOUGH TIME**: The decision hurries the industries to comply the rules in short time of period
- **FAIRNESS**: The rule should have practical and effective rule implementation to expose cheating or violation
### CHALLENGES: Prevention for Air Pollution

#### Regulations to Prevent Air Pollution

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<tbody>
<tr>
<td><strong>SOx (sulfur oxides)</strong></td>
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<tr>
<td>General sea area</td>
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<td></td>
<td></td>
<td>Sulfur content 3.5%</td>
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<td>Sulfur content 0.5%</td>
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<tr>
<td>ECA</td>
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<td>Sulfur content 1.0%</td>
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<tr>
<td><strong>NOx (nitrogen oxides)</strong></td>
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<tr>
<td>General sea area</td>
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<td></td>
<td>Tier II regulation</td>
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<td>Tier III regulation</td>
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<td>ECA</td>
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**SOx Emissions Regulations:** Sulfur content in fuel oil is controlled to reduce SOx in exhaust emissions. From 2015, the ratio level in the Emission Control Areas (ECAs*) was reduced to 0.1% or less. In October 2016, the IMO decided to reduce sulfur content in fuel oil to 0.5% or less even in general sea areas.

**NOx Emissions Regulations:** NOx in exhaust gas from engines is controlled in a step-by-step manner. Tier I regulates emission levels by rated engine rpm, targeting vessels built between 2000 and 2010. Tier II requires vessels built in 2011 or later to reduce a further 15.5-21.8% from the Tier I level. In the ECAs**, Tier III applies to vessels built in 2016 or later, requiring reduction of 80% from the Tier I level.

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*ECA-designated sea areas: (1) North America Coast – within 200 nautical miles (SOx/NOx), (2) United States Caribbean Sea (SOx/NOx), and (3) Baltic Sea and North Sea (currently SOx only. SOx/NOx in 2021 and later)*
CHALLENGES Prevention for Air Pollution

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</thead>
<tbody>
<tr>
<td>EEDI</td>
<td>Phase 0</td>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 3</td>
<td></td>
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<tr>
<td>SEEMP</td>
<td>Mandatory</td>
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<tr>
<td>DCS</td>
<td>Mandatory</td>
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In 2013, conventions related to energy efficiency (EEDI and SEEMP) were adopted as measures to reduce GHG emissions from international ocean shipping.

**EEDI:** Energy Efficiency Design Index. It is required that CO₂ emissions in theory conform to the regulations at the design stage of a newbuilding vessel. Target of reduction rate in each phase: Phase 0 = 0; Phase 1 = 10%; Phase 2 = 20%; and Phase 3 = 30%.

**SEEMP:** Ship Energy Efficiency Management Plan. Selection of an operational method for each vessel to improve energy efficiency, documentation of the action plan, and adoption of method aboard the vessel are required. SEEMP targets both newbuilding vessels and existing vessels.

In addition, IMO plans adoption of DCS to further reduce GHG emissions.

**DCS:** Data Collection System. The system is intended to report fuel consumption data from ships to the IMO, which will analyze it and set strategies toward reduction of GHG emissions, including introduction of market based measures.
Prevention of Air Pollution / Options
**FACTORS shipping company considers when selecting marine fuels**

### Economical Factors
- Fuel Price
- Logistics (Availability and Flexibility of Supply)
- Capital Investment and Operation & Maintenance Cost

### Technical Factors
- Reliability and Endurance
- Safety Assurance
- Operability and Maintainability

### Social, Political and Legal Factors
- Rule and Regulation
- Environmental Consciousness
- Social Responsibility
### Three Options to Comply Prevention for Air Pollution

<table>
<thead>
<tr>
<th><strong>Option 1</strong></th>
<th><strong>Option 2</strong></th>
<th><strong>Option 3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>“Complied Oil”</strong></td>
<td><strong>“Scrubber”</strong></td>
<td><strong>“Alternative Fuel”</strong></td>
</tr>
<tr>
<td>To use rule complied (low Sulphur) marine fuels</td>
<td>To use high Sulphur fuel oil with scrubber</td>
<td>To adopt alternative fuels such as LNG, LPG etc.</td>
</tr>
</tbody>
</table>

#### Pros

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No or small capital investment</td>
<td>Lower fuel cost expected</td>
<td>Better Compliant both SOx/NOx regulation</td>
</tr>
<tr>
<td>Supply capacity</td>
<td></td>
<td>Lower carbon emission</td>
</tr>
</tbody>
</table>

#### Cons

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher fuel cost expected</td>
<td>Supply capability</td>
<td>Limited Supply Capacity</td>
</tr>
<tr>
<td>Industrial specs not yet established (Engine system adaption)</td>
<td>Scrubber waste</td>
<td>Capital investment</td>
</tr>
</tbody>
</table>
Challenges / Prevention of Air Pollution

LNG as a Marine Fuel
LNG as a marine fuel - A shipping company's perspective” – Mitsui O.S.K. Lines

LNG as a Marine Fuel / LNG Bunkering

= Development =

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| LNG Fueled Ship (Existing, excl. LNG Carriers) | | LNG Fueled Ship (On Order, excl. LNG Carriers) |
| Gross Tonnes | <10,000 | 10,000～50,000 | >50,000 | Total | Gross Tonnes | <10,000 | 10,000～50,000 | >50,000 | Total |
| Bulker | 2 | | | 2 | Bulker | 3 | 3 |
| Container | 3 | | | 3 | Container | 12 | 9 | 17 |
| Fishing Boat | 1 | | | 1 | Fishing Boat | 1 | |
| General Cargo | 4 | | | 4 | General Cargo | 1 | 1 |
| Pass./Ferry/RORO | 35 | 8 | 1 | 44 | Pass./Ferry/RORO | 12 | 7 | 16 | 35 |
| Special | 45 | 8 | | 53 | Special | 11 | 2 | 10 | 23 |
| Tanker | 9 | 12 | 1 | 22 | Tanker | 5 | 12 | 8 | 25 |
| PCTC | 2 | | | 2 | PCTC | 2 | |
| TOTAL | **96** | **25** | **10** | **131** | TOTAL | **29** | **36** | **43** | **108** |

(Source: Clarkson)
LNG as a Marine Fuel / LNG Bunkering

= Bunkering Measures =

- Truck to Ship Bunkering
  - 25-35 cubic meter / unit
  - 25 cubic meter / hour

- Shore to Ship Bunkering
  - 100-2,000 cubic meter / unit
  - 100-200 cubic meter / hour

- Ship to Ship Bunkering
  - 2,000-7,500 cubic meter / unit
  - 1,000 – 1,500 cubic meter / hour

LNG Supply Facilities

LNG Truck

LNG Shore

LNG Bunkering Ship

LNG Fueled Ship

2nd Annual Japan Ship Finance Forum
### LNG as a Marine Fuel / LNG Bunkering

#### Applications

<table>
<thead>
<tr>
<th></th>
<th>Container Ship 20,000 TEU type Large Container Ship</th>
<th>Bulk Carrier Newcastle Max Bulk Carrier</th>
<th>Coastal Ferry</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trade</strong></td>
<td>Asia / N.Europe</td>
<td>WC Australia / China</td>
<td>Japan Inland Sea Round</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td>Fixed</td>
<td>Not Fixed but Patterned</td>
<td>Fixed</td>
</tr>
<tr>
<td><strong>Bunkering Place</strong></td>
<td>Rotterdam (Public Berth) or Singapore (Public Berth)</td>
<td>Dampier (Private Berth)</td>
<td>Osaka (Public Berth)</td>
</tr>
<tr>
<td><strong>Bunkering Interval</strong></td>
<td>Every 77 days (once a round voyage)</td>
<td>Every 30 days (once a round voyage)</td>
<td>Every 6 days (every 3 voyages)</td>
</tr>
<tr>
<td><strong>Bunkering Volume</strong></td>
<td>12,000 cbm</td>
<td>6,000 cbm</td>
<td>300 cbm</td>
</tr>
<tr>
<td><strong>Annual LNG Consumption</strong></td>
<td>57,000 cbm (abt 26,000 MT)</td>
<td>73,000 cbm (abt 33,000 MT)</td>
<td>18,000 cbm (abt 8,200 MT)</td>
</tr>
</tbody>
</table>
LNG as a marine fuel - A shipping company’s perspective” – Mitsui O.S.K. Lines

LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field / History =

- Subsea Support Vessel
- Shuttle Tanker
- FSRU (under construction)
- Ice Class LNG Carrier
  For Russian Yamal LNG Project
- Oil Tanker S/S Otowasan-Maru, 1936
- Oil Tanker, 1936
- LNG Tug Boat
- Ethan Carrier, 2016
- Subsea Support Vessel, 2016
- Shuttle Tanker, 2014
- FPSO, 2012
- FSRU, 2007
- Methanol Fueled Tanker, 2016
- Methanol Tanker, 1983
- LNG Tanker, 1983
- Chemical Tanker, 1983
- LPG Tanker, 1959
- Company, 1884
LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field (Energy Related Project) =

MOL’s Activities toward LNG as a Marine Fuel

- Formed Bunker Business Office
- Joined “Green Corridor” Joint Industrial Program
- Completed LNG Fueled Ferry Design
- Completed LNG Fuel “ME-GI” Engine Demonstrational Operation with MES
- Ordered 20,000 TEU “LNG Ready” Container Ship
- Ordered LNG Fuelled Tug Boat
- Invited to LNG Bunkering Rule Making Committee in Singapore
- Participated in Industry Groups
- Conducted Joint Study of the design of an LNG-powered coal carrier with Electric Company and Shipyards
LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field / Projects =

“Green Corridor” Joint Industrial Program

- Joint Industry Project to study feasibility of LNG-fueled Newcastlemax Bulker
- BHP, Rio Tinto, Woodside, MOL, DNV-GL, SDARI and U-Ming participate
- AIP to be granted by DNV-GL


Regular LNG Ship-to-Ship Transfer Operation

- First commercial LNG Ship-to-Ship Transfer (“STS”) operations in Japan under JAPEX operation
- Using flexible hoses between a FSU (“LNG Taurus” 125,000 m³) and a type-C shuttle vessel (“Akebono Maru” 3,500 m³)
- Total 52 cargo transfer operation completed in 2011/2012 Winter and December 2012 at Port of Tomakomai, Hokkaido Japan
LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field / Projects =

LNG Fueled Ferry Design

• “Senpaku (Ship in Japanese) Ishin” or “Innovations in Sustainability backed by Historically proven, Integrated technologies – MOL’s technology innovation program started 2009
• In project “Ishin 2”, MOL completed basic engineering and design study in 2012
• Then together with costal ferry subsidiary companies, MOL is seeking for opportunity to build LNG fuelled ferry boat


LNG Fuel “ME-GI” Engine Demonstrational Operation


• Collaborated with Mitsui Engineering and Shipbuilding (MES), held Electronically-Controlled Gas Injection Marine Diesel Engine (ME-GI) Demonstrational for Marine Use at MES site
• Demonstration for one year long was carried out and successfully completed in March 2013
LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field / Projects =

Joint Study LNG-powered coal carrier with Electric Company, Shipyard

- Joint Study of the design of an LNG-powered coal carrier to earn Approval in Principle (AIP) from Lloyd's Register
- Collaboration with Tohoku Electric Power, Namura Shipbuilding - the Japan's first joint acquisition by three companies: a cargo holder, a shipping company, and shipbuilder of an AIP for a vessel powered by LNG.
- The design ensures sufficient cargo capacity without making the hull larger by installing the LNG fuel tank at the stern
- The study is pursued based on installation of the tank cover with an eye toward preventing an onboard fire from spreading to the LNG fuel tank while streamlining inspection work.

LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field / Projects =

20,000 TEU “LNG Ready” Container Ship

- “LNG Ready” design 20,000 TEU container ship
- AIP granted for the engineering and design by DNV-GL
- Collaboration with shipyards (Samsung Heavy, Imabari Shipbuilding) and the Class (DNV-GL)
- Delivery started in 2017


LNG Fuel Tag Boat

- The first LNG-fueled tugboat in Japan conforming to the IGF code issued in January 2017
- The first LNG-fueled tugboat to escort large-scale freighters in Osaka Bay and the Seto Inland Sea
- Collaboration with Osaka Gas (supplier), Kanagawa Dockyard, Yanmer Co (Engine Maker), Nihon Tag Boat (Operator / subsidiary) and local government
- To be delivered in 2019

LNG as a Marine Fuel / LNG Bunkering
= MOL Approach to New Business Field / Projects =

TR 56 / Technical Committee for LNG Bunkering in Singapore

- Working committees lead by Singapore Government to make a rule for LNG Bunkering started in Apr 2015
- Among leading companies, MOL is a core member of WG 3

MOL participates in industry groups (NPO) in relation to energy transport, LNG operation and LNG bunkering, such as:

- International Association of Independent Tanker Owners (INTERTANKO)
- Society of International Gas Tanker and Terminal Operators (SIGHTO)
- Society for Gas as a Marine Fuel (SGMF)
- LNG Marine Fuels Institute (LMFI)
LNG as a Marine Fuel / LNG Bunkering

• LNG as a Marine Fuel is becoming “promising option” rather than “one of options” particularly to Large Container Ships, Large Bulk Carriers and Ferry Boat, because of:
  • Improvement of Logistics
  • Development of Engineering
  • Support from Government and
  • Consciousness of Environmental Issues

• In every aspects, Mitsui O.S.K. Lines is ready to go on “LNG as a Marine Fuel projects” from both user side and supply (bunkering) side.
Thank you