Opportunities and Challenges for Maritime Transport of Liquefied Hydrogen in Bulk

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HySTRA – KHI & Shell are HySTRA members
Agenda

• Regulatory landscape
• Hydrogen – A clean source of energy
• Key challenges for H2 wider uptake
• Project background
• Project Update – Design & Construction
• Novel technologies
• Ship Operation in the Coming Years
• Q & A’s
Transport sector

By 2050, maritime carbon dioxide emissions could increase between 50 – 250%.

Source: IMO 2014 study on GHG emissions

IMO - By 2050, maritime carbon dioxide emissions, in comparison to 2008 levels, are to be reduced by at least 50%.
Hydrogen – A clean source of energy

Hydrogen is a clean fuel at the point of use
Hydrogen can be produced from various sources globally
Hydrogen can be produced utilizing renewables with a low well to wake greenhouse gas footprint

H2 consumption in Fuel cell offers higher efficiency and virtually:
- Zero CO$_2$
- Zero SO$_x$
- Zero NO$_x$
- Zero Particulates

Courtesy of HySTRA
Key Challenges for Hydrogen wider uptake

- Economical production and supply
- Demand and Supply chain
- Energy by volume is lower
- Lack of Marine regs for carriage as Cargo
- Lack of Marine regs for utilization as Fuel
- Lack of H₂ related industry standards
- Large Flammable range
- Higher risk of fire/exp
- Cryogenic risks
- Extreme low temperature
- BOG management
- Smallest atom size
- Technology readiness
- Operational know how
- BOG management
- Smallest atom size
- Technology readiness
- Operational know how
Project Introduction
- CO₂ Hydrogen Energy Supply Chain (HESC)

Australia

- Surplus Renewable Energy
- Liquefaction & Storage
- CO₂ Capture Storage (CCS)
- Brown Coal
- H₂
- CO₂
- CO₂ free H₂

Japan

- Use in processes
  - Semiconductor, solar cell productions
  - Oil refining and desulfurization
- Transportation equipment
  - Refueling station
  - Fuel cell vehicles
- Distributed power generation
  - Hydrogen gas turbines and engines, fuel cells etc.
- Power plants
  - Combined cycle power plants

Transport & Storage

Pilot chain

Liquefied Hydrogen Container
Liquefied Hydrogen Carriers
Liquefied Hydrogen Storage Tanks
## Project Update
- **1,250m³ Liquefied Hydrogen Carrier (LH2C)**

### Ship Specifications

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<th>Details</th>
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<tbody>
<tr>
<td><strong>L x B x D</strong></td>
<td>ab. 110m x ab. 20m x ab. 11m</td>
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<tr>
<td><strong>GT</strong></td>
<td>ab. 8,000</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>ab. 13.0 knots</td>
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<tr>
<td><strong>flag/Class</strong></td>
<td>Japan/ClassNK</td>
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### CCS Specifications

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<tr>
<td><strong>Capacity</strong></td>
<td>ab. 1,250 m³ (No. of Tank: 1)</td>
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<tr>
<td><strong>Type</strong></td>
<td>IMO Independent Tank Type C</td>
</tr>
<tr>
<td><strong>Press /Temp</strong></td>
<td>0.4MPaG/20K(-253 degree C)</td>
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<tr>
<td><strong>Insulation</strong></td>
<td>Vacuum Multi-layer Insulation + KPS</td>
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<tr>
<td><strong>BOGM</strong></td>
<td>Pressure Built-up (Retention)</td>
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### Diagram

- **Loading Station**
- **Vent Mast**
- **Diesel-Electric Prop. System**
- **CCS + Tank Cover**
- **CM & M + GCU RM**s
- **VIP**
Novel technologies & philosophies

- Cargo containment system, VIP
- Cargo equipment – Compressor, pump, Vaporiser/heater, GCU
- Level measurement / TPS
- Relief valves, bellows, gaskets etc.
- Instrumentation (P,T, Vacuum, fusible plugs, flame sensor)
- Cargo vent mast, Cargo Manifold
- Marine loading arm & connection piece
- Cargo venting & emergency jettisoning
- Ships Ventilation, Gas and fire detection, Fire fighting philosophy
- Purging and sampling philosophy
- Earthing and bonding philosophy
- Hazardous area classification
Project Update
- Hull Construction

- Hull construction laid down on 12 June 2019, to be launched on December 2019 at KHI Kobe Shipyard.
Ship operation

- **Normal Operations**
  Loading
  Seagoing
  Unloading

- **Pre/Post dry dock ops**
  Warm up
  Inerting (H2 to N2)
  Aeration (N2 to air)
  Inerting (Air to N2)
  Gasification (N2 – H2)
  Cool down (GH2 to LH2)
Ship operation additional considerations & Demo test plan

**Existing LNGC Practice**
- Vapour return arrangement
- Emergency shut down 1/2
- Level/temp/pressure monitoring
- Manned Cargo Operations

**Additional considerations** (LNGC +)
- No open purging/drainage or testing at manifold
- Introduction of double-wall design with monitoring
- Monitoring rate of change of temperature in VIP
- Steps for ensuring VIP integrity prior operations
- Monitoring PSV’s and TRV’s leaks and/or lifting
- Emergency preparedness for LIN/LOX formation

**Demonstration stage test plans**
- Demonstration of safe and sustainable carriage of LH2 in bulk via the pilot LH2C
- Development of LH2 cargo handling operation manual for ship and terminal
- Demonstration of the performance of cargo tank vacuum multi-layer insulation
- Data collection and sharing for Marine rule development