Way to Decarbonization – Kawasaki Hydrogen Road

Submitted by: Kawasaki Heavy Industries
for APEC21

Way to Decarbonization

Kawasaki Hydrogen Road

September 9th, 2021

Kawasaki Heavy Industries, Ltd.

Changing forward
Our Products

- Ships/Marine
- Rolling stock
- Aerospace
- Energy/Plants/Environment
- Motorcycles and Engines
- Precision Machinery
Agenda

1. KHI's activities for Hydrogen Supply Chain

2. About Hydrogen Trading rules
KHI Group Hydrogen Products

1. KHI's activities for Hydrogen Supply Chain

Production

- Water Electrolysis System
- Liquefier Plant
- Liquefied Hydrogen Tanks

Storage

- Liquefied Hydrogen Carrier

Utilization

- Fuel Cell Train
- High pressure Hydrogen Gas Valve
- Compressed H2 Trailer Trucks

Transport

- Hydrogen Gas Engine
- Hydrogen Gas turbine
- Hydrogen Boiler

Realization of Products with Corporate Technology Synergy
Toward large volume hydrogen utilization essential for decarbonization

Energy system only with renewables and battery storage has a limit for energy scale, facility cost and applications.

Liquefied hydrogen enables large amount, long-distance, long-term transportation and storage of energy and connects multiple sectors.

With extremely wide range of industries involved in hydrogen supply chain and demand field, hydrogen is highlighted worldwide due to creating a virtuous cycle for environment and economy.

Kawasaki Heavy Industries contributes to achievement of decarbonization as the sole company in the world that owns the whole hydrogen supply chain technology for production, transportation, storage and utilization.
CO2-Free Hydrogen Resources in the World

- Hydrogen can produce from various sources and procure from many economies → **Contribute to energy security**
- Large amount, long-distance, long-term transportation and storage of energy and sector integration are possible with hydrogen → **Contribute to resilience**

**Wind Power • Hydro Power • Natural Gas H₂**

**Hydro Power H₂**

**Oil & Natural Gas H₂**

**Solar Power H₂**

**Wind Power H₂**

**Coal**

**Large Amount, Stable Procure, Low Cost**

**Australian Victorian Coal with CCS**
Concept of CO2-free Hydrogen Chains

Stable energy supply while suppressing CO2 emissions

Producing economy (Australia)
- Production of hydrogen at low costs from unused resources (Victorian coal) and/or abundant recyclable energy
- Affordable renewable energy
- Liquefaction/loading
- Victorian coal
- CCS (CO2 capture/storage)
- CO2-free hydrogen

Liquefied hydrogen cargo ship

Liquefied hydrogen containers

Liquefied hydrogen storage tanks

Utilizing economy (Japan)
- Process uses
  - Semiconductor and solar battery manufacture
  - Oil refinement, desulfurization, etc.
- Transport equipment
  - Hydrogen stations
  - Fuel cell vehicles etc.
- Distributed power plants
  - Hydrogen gas turbines
  - Hydrogen gas engines
  - Fuel cells etc.
- Electrical power plants
  - Combined Cycle power generators etc.

production

transport / storage

utilization
Demonstration of Hydrogen Supply Chain
Australia and Japan

1. KHI's activities for Hydrogen Supply Chain

- Starting in June 2021, the carrier docked at the liquefied hydrogen receiving terminal and beginning demonstration tests using hydrogen.
- In FY 2021 the carrier will make the first round trip between Australia and Japan.

"Suiso Frontier“ arriving at the terminal

Presented by HySTRA

(As of January 2021)
1. KHI's activities for Hydrogen Supply Chain

2. About Hydrogen Trading rules
## Different situations in Europe and Japan

<table>
<thead>
<tr>
<th>Europe</th>
<th>Japan / Korea / Chinese Taipei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Population density</td>
<td>High population density</td>
</tr>
<tr>
<td>= Low energy consumption density</td>
<td>= High energy consumption density</td>
</tr>
<tr>
<td>Many regions rich in renewable energy.</td>
<td>Low energy self-sufficiency rate</td>
</tr>
<tr>
<td>= Distributed renewable energy</td>
<td>= need energy import</td>
</tr>
<tr>
<td>Existing vast NG pipeline system</td>
<td>Strict regulation on gas pipeline</td>
</tr>
<tr>
<td>= Hydrogen pipeline available</td>
<td>= hard to inject H2 into pipeline</td>
</tr>
</tbody>
</table>

![Diagram illustrating hydrogen trading rules in Europe and Japan](image)

- **Europe**
  - Local Hydrogen / Power grid
  - House heating

- **Japan / Korea / Chinese Taipei**
  - Large scale H2 supply chain
  - Power Plant

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Different situations in Europe and Japan

In Japan or some regions,
- Enhancement of energy security is very important
- Difficult to increase capacity of renewable energy due to its high population and limited habitable(living) area

Population density ranking
- Austria: 70
- Germany: 35
- Denmark: 58
- Norway: 162
- Japan: 22
- UK: 30
- France: 63
- Korea: 138
- USA: 180
- Canada: 184
- Australia: 4

Renewable Power introduction per Land Area (TOE/y/km²)
- Austria: 143.7
- Germany: 114.0
- Denmark: 104.1
- Norway: 102.3
- Japan: 94.3
- UK: 67.1
- France: 34.7
- Korea: 21.7
- USA: 14.7
- Canada: 9.8
- Australia: 1.1

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Future European hydrogen transport infrastructure

- European hydrogen transport will be based on pipeline system.
- This system is very similar to NG transport system.
- These will be newly constructed and conversion of NG pipeline.

European Hydrogen Backbone
https://gasforclimate2050.eu/sdm_downloads/european-hydrogen-backbone/
Overseas transportation is necessary

- Perhaps the world's first hydrogen supply chain may begin between Australia and Japan.
- Japan may also import hydrogen from the Middle East.
- Europe and the United States also plan to import the shortage in the region from overseas.
Supply Chain Structure (Australia and Japan)

- GHG Responsibility -

Hydrogen Supply Chain

Process Area
GHG Responsibility

LNG Supply Chain

Process Area
GHG Responsibility

Transfer GHG responsibility?
Universal rules are yet to be determined.
Supply Chain Structure (Australia and Japan) — Hydrogen Environmental Property —

Process Area

Australia

Maritime

Japan

GHG Protocol
CertifHy (G.O.system)
IPHE
TF H2PA

Hydrogen Environmental Property

Scope2
Scope1
Scope3

Not including Transportation footprint

Which scope is appropriate?

Universal rules are yet to be determined.

2. About Hydrogen Trading rules

Not including Transportation footprint
About hydrogen trading rules

- There is no overseas trading rules of GHG responsibility for hydrogen production and transportation.
  
  We need to establish the trading rules by commercial hydrogen supply chains beginning.

- The scope of hydrogen environmental property requirements can change depending on the economy or region.
  
  We want flexible trading rules of hydrogen property can be selected options which scope of GHG to count

- Maritime GHG (CO2, CH4, N2O etc.) has a great impact on emission footprint of a clean energy.
  
  It is important to take whole supply chain into account for the footprint.
Kawasaki, working as one for the good of the planet

“Global kawasaki”