

The 31st Clean Coal Day International Symposium

Kawasaki's Challenge toward Carbon Neutrality - International Supply Chain of Hydrogen derived from Brown Coal -

Sep 6th, 2022

Kawasaki Heavy Industries
Eiichi HARADA



Growing Expectations for Hydrogen

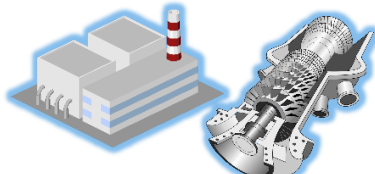
H₂

De-carbonization

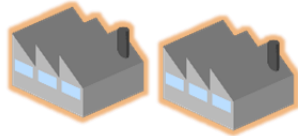
Contribution to De-carbonization

- "Ultimate clean energy" which emits no CO₂ when used
- **Key technology applied in various sectors: "Power generation", "Mobility" and "Industries"**
- Compensate for fluctuations in renewable energies

Wide Range of Applications



Power Generation



Industry



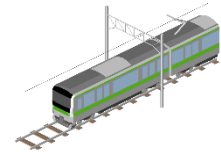
Cars/Motorcycles



Industrial Vehicles



Large vehicles (Buses, Trucks)



Rolling stock (Non-electric section)



Ships



Aircraft

Growing Expectations for Hydrogen

H₂

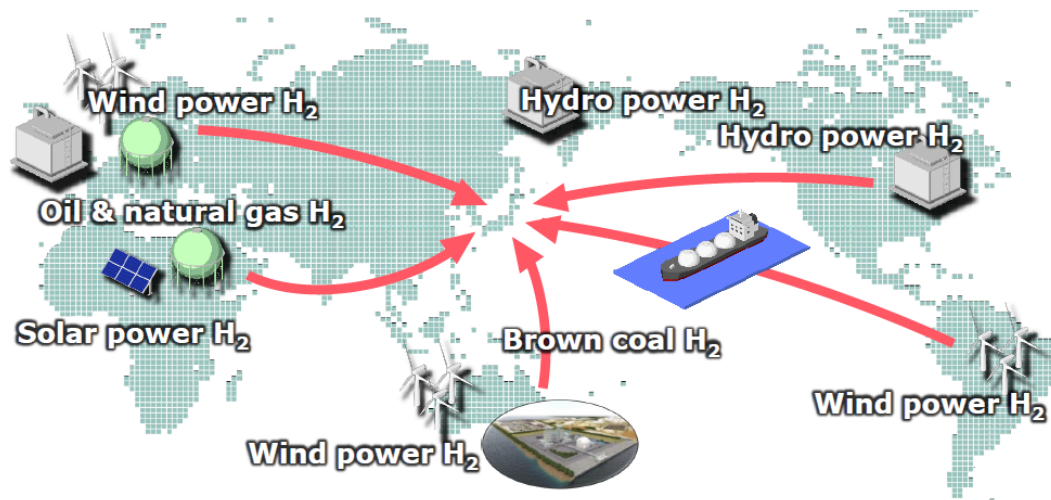
Energy Security

Contribution to Energy Security

- Production possible from a variety of sources
- Production possible in multiple geographies
- Mass, long-term, long-distance transportation and storage possible

Japan's low energy self-sufficiency rate

Soaring energy price due to Ukraine crisis



Growing Expectations for Hydrogen

H₂

Economic Growth

Contribution to Economic Growth

- Wide range of relevant industrial fields
- Leading the world in terms of technologies and international standards
- Improving Japan's industrial competitiveness

by further enhancing hydrogen technologies

World's first achievements



Technical demonstration of an international supply chain



Hydrogen fueled power generation demonstration in a city area

International standards



Approval of safety requirements by IMO



ISO of cargo loading/unloading system

Growing Expectations for Hydrogen

De-carbonization



Energy Security



Key Driver
to Accelerate

Economic Growth

Growing Expectations for Hydrogen

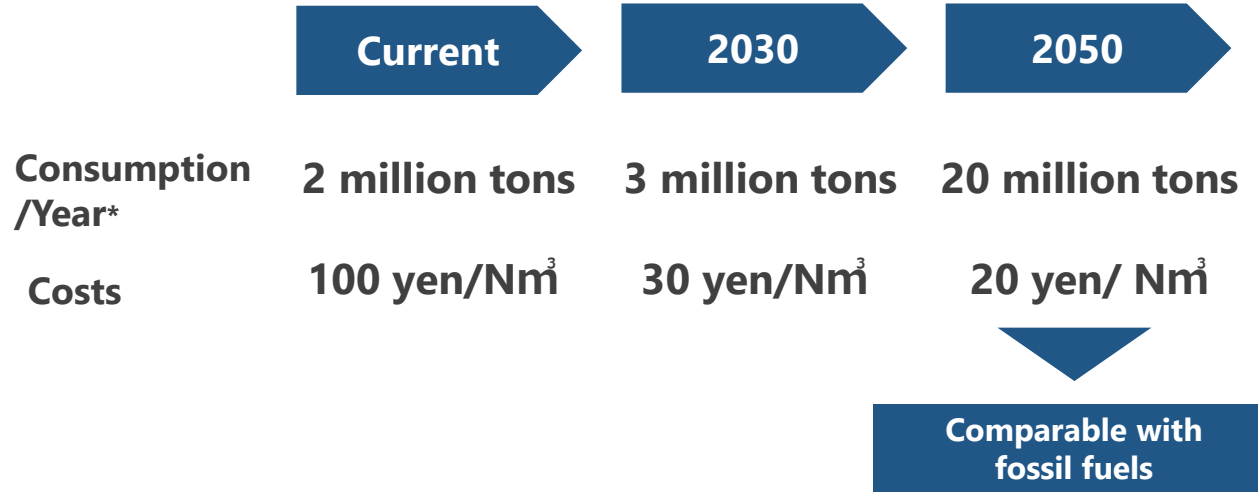
De-carbonization

Energy Security

Economic Growth



Hydrogen Targets set by Japanese Government – Green Growth Strategy –



Source : <https://www.meti.go.jp/press/2020/12/20201225012/20201225012-2.pdf>

* including consumption of ammonia

Kawasaki and Hydrogen

Kawasaki: Leading technologies

Only One in the World

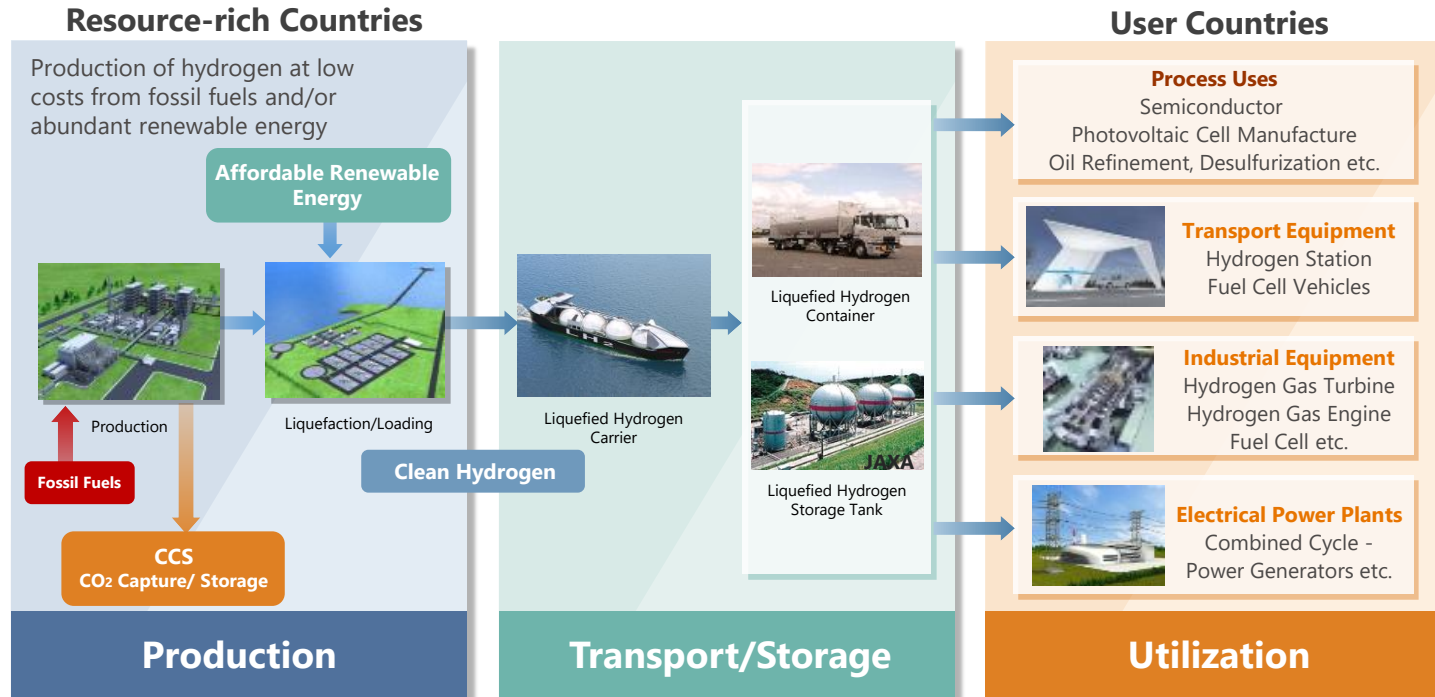
from "production" to "storage", "transportation" and "utilization" of hydrogen

Hydrogen-related products of Kawasaki Group



International Hydrogen Supply Chain

Concept: Producing and liquefying clean hydrogen overseas and transporting it to Japan by sea

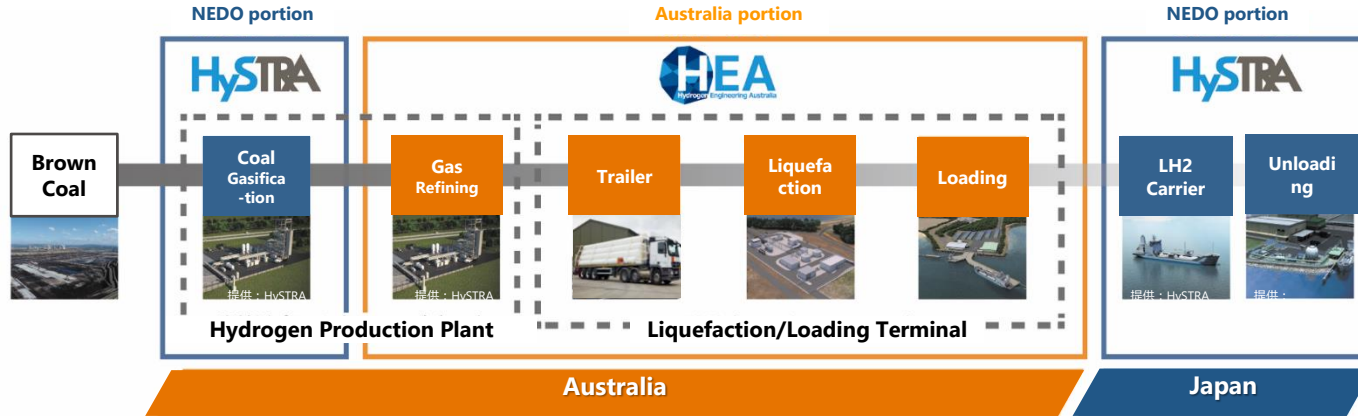


International Hydrogen Supply Chain

Hydrogen Energy Supply Chain (HESC) Pilot Project

World's
First

Working with project partners, supported by Japanese, Australian and Victorian governments



HySTRA

【CO2-free Hydrogen Energy Supply-chain Technology Research Association】
Iwatani, Kawasaki, Shell Japan, J-Power, Marubeni, ENEOS, KLINE

HEA
Hydrogen Engineering Australia

【Hydrogen Engineering Australia】
Kawasaki, J-Power, J-Power Latrobe Valley, Iwatani,
Marubeni, Sumitomo, AGL

Supported by NEDO (New Energy and Industrial Technology Development Organization)

International Hydrogen Supply Chain

Combining Australia's unused resource "brown coal" and "CCS" to produce clean hydrogen in large quantities at low cost



+

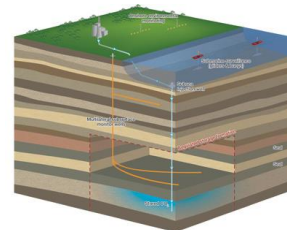


Hydrogen production from
low-grade/low cost brown coal

CO₂ Capture and Storage
(CarbonNet Project)

CCS image

Carbon-neutral path for future use of coal resources



International Hydrogen Supply Chain

Mass transportation/storage possible by liquefying hydrogen at -253°C

- Liquefaction at a cryogenic temperature of -253°C → $1/800^{\text{th}}$ the volume of gas
- High-performance insulation technology (double-shelled/vacuum insulated tank)
→ Long-term storage equivalent to LNG
- High purity/No need for refining → Suitable for a wide range of applications
from FCVs to industrial furnaces simply by evaporation



LH2 Storage Tank
at Tanegashima Space Center



Japan's biggest LH2 Tank
at Kobe LH2 Terminal



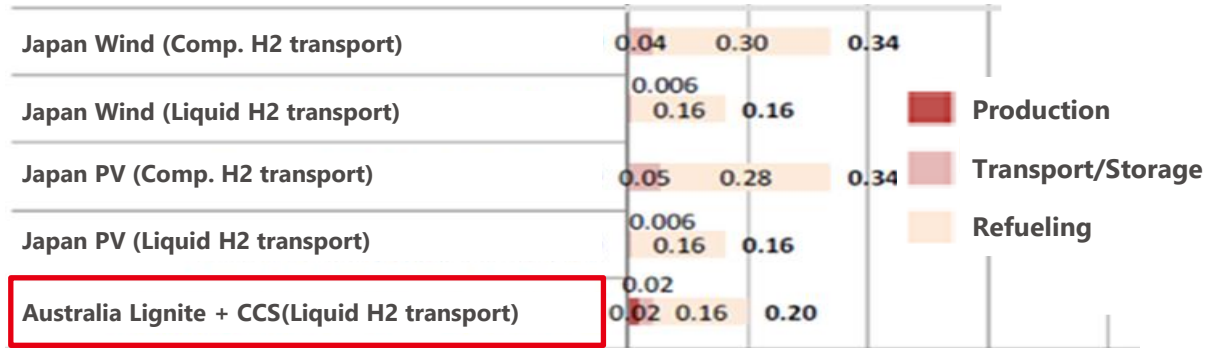
Large-scale LH2 Carrier
(to be built)



International Hydrogen Supply Chain

CO₂ Footprint : Well-To-Tank CO₂ emission per 1Nm³-Hydrogen [kg-CO_{2e}/Nm³-H₂]

CO₂ emissions of brown coal-derived and renewable energy-based hydrogen are comparable



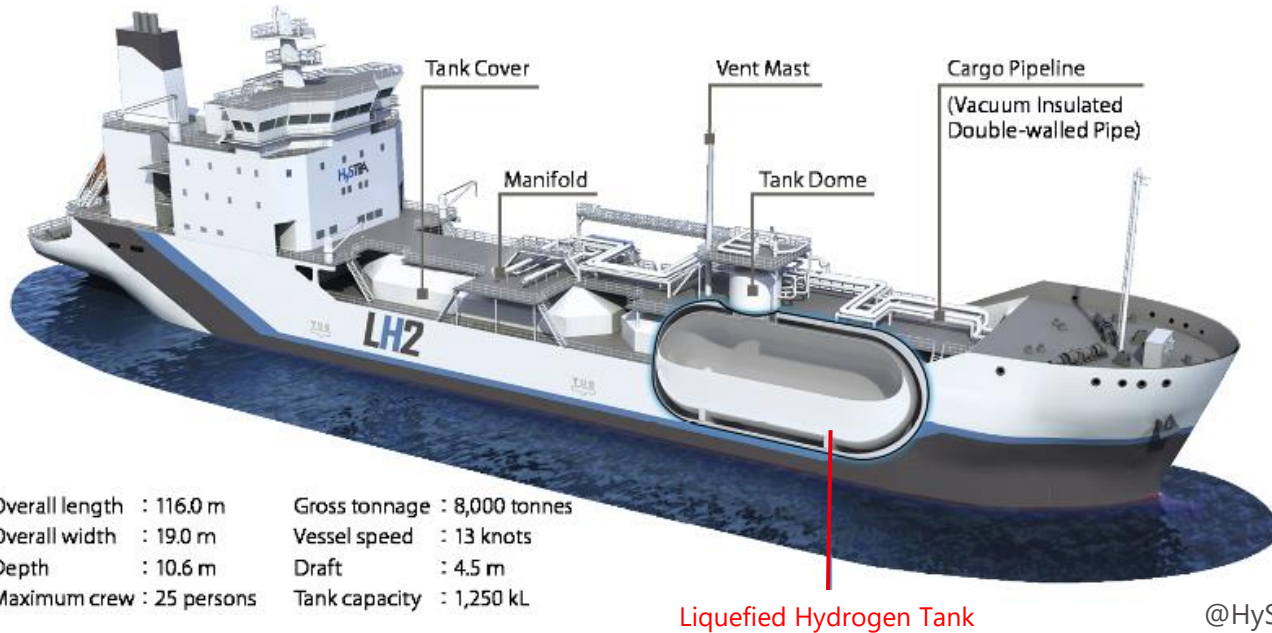
(CCS : CO₂ Capture and Storage)

Life Cycle Assessment by Mizuho Information & Research Institute
Ref: <https://www.mizuho-ir.co.jp/publication/report/2016/pdf/wttghg1612.pdf>

International Hydrogen Supply Chain

Liquefied Hydrogen Carrier "Suiso Frontier" Kawasaki built

World's
First



International Hydrogen Supply Chain

Liquefied Hydrogen Terminal "Hy touch Kobe" Kawasaki built

World's
First



International Hydrogen Supply Chain

Successful completion of the pilot project
transporting hydrogen produced/liquefied in Australia to Japan by sea

World's
First

Departed Japan in Dec 2021, arrived in Australia in Jan 2022, and returned to Japan in Feb 2022



Hydrogen Road Video (英)



HySTRA

T-L1

液化水素貯槽

HySTRA

未利用褐炭由来水素大規模海上輸送サプライチェーン構築実証事業
日豪サプライチェーン完遂 記念式典

Utilization of Hydrogen

Demonstration of power generation in a city area using hydrogen transported from Australia

In June 2022 electricity was generated using hydrogen transported from Australia with “Suiso Frontier” and supplied in a city area

Model case in which hydrogen “production”, “transportation”, “storage”, and “utilization” were seamlessly connected into an integrated supply chain

HySTRA, Kawasaki, Obayashi, Kansai Electric Power, City of Kobe



Transporting hydrogen from terminal



Filling a storage tank with hydrogen



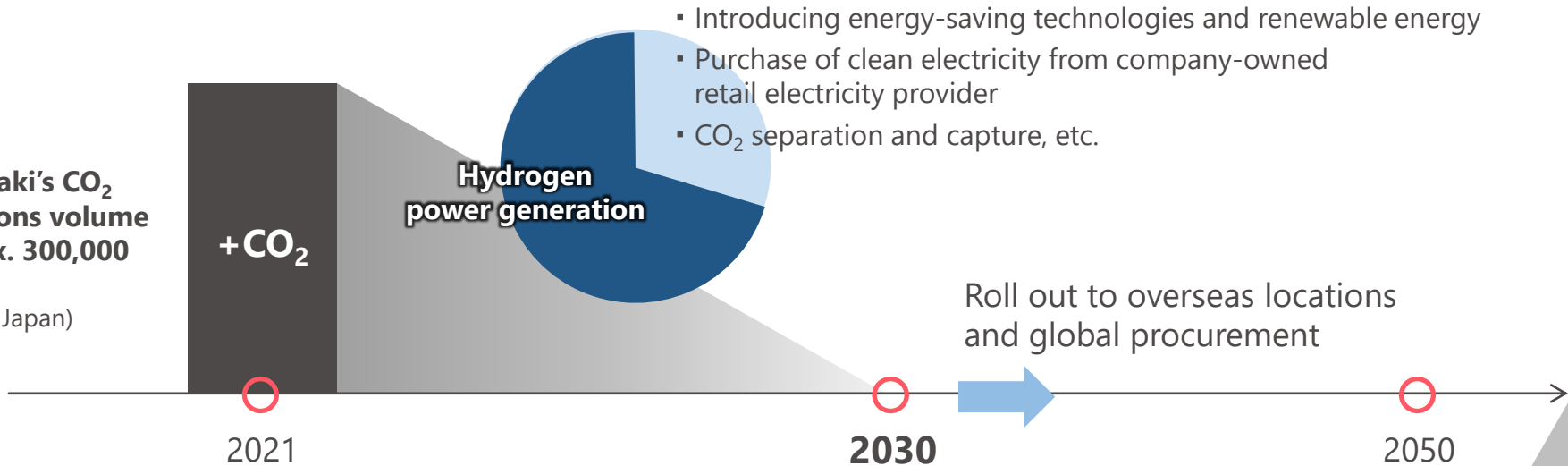
Hydrogen CGS demonstration plant

Utilization of Hydrogen

Kawasaki's Zero Emission Plant : Reducing CO₂ Emissions from our Business Activities

Our Target: To achieve **standalone carbon neutrality in 2030 through initiatives centered on **hydrogen power generation****

Kawasaki's CO₂ emissions volume approx. 300,000 t/year (sites in Japan)



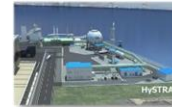
International Hydrogen Supply Chain

Pathway from pilot demonstration to commercialization

2021-2022

**Pilot
Demonstration**

Phase to demonstrate technical, safety and operational viability
of hydrogen production using brown coal
and marine transportation over long distances



Mid-2020s

**Commercial
Demonstration**

Phase to determine economic probability before commercialization
using commercial-sized facilities
(in minimum configuration)



Around 2030

**Commercial
-ization**

Phase of a profitable business
economically self-sustaining from equipment installation to operation



International Hydrogen Supply Chain

Liquefied Hydrogen Supply Chain Commercialization Demonstration

Adopted by NEDO Green Innovation Fund in August 2021

Large-scale demonstration to transport tens of thousands of tons/year to be conducted by Japan Suiso Energy[※], ENEOS, and Iwatai Corporation



川崎重工業株式会社（代表取締役社長執行役員 橋本 博洋、以下「川崎重工業」）の100%子会社の日本水素エネルギー株式会社（代表取締役社長 藤田 英一、以下「日本水素」）を親会社として、ENEOS株式会社（代表取締役社長 佐藤 隆夫、以下「ENEOS」）と伊藤忠商事株式会社（代表取締役社長 藤田 英一、以下「伊藤忠商事」）の3社は、国立研究開発法人エネルギー・産業技術総合研究所（以下「NEDO」）が主催する「グリーンイノベーション基金事業」の採択企業として、本事業の商用化実証を行うこととして、「液化水素サプライチェーン」の商用化実証（以下「本事業商用化実証」）を採択され、採択されました。

本事業商用化実証は、2020年12月25日に経済産業省が採択決定した「2050年カーボンニュートラルに向けたグリーン成長戦略」に示される、積極的な脱炭素化戦略を促し、産業連関や社会経済の実現を促すこと、及び成長産業に結びつけていく（経済産業省の成長戦略）の一環を担うことと期待されています。

本事業商用化実証では、カーボンニュートラルを実現する本業の事業機会を創出し、CO₂フリー水素サプライチェーンの構築に貢献する目的の一環として、百数十トン規模の水素製造・輸送・貯蔵の商用化実証を世界に先駆けて行い、水素製造・液化・出荷・輸送・受入までの一連の商用化実証の成功をアピールし、需要創出を行います。具体的には、16万m³（4万m³×4基）クラスの液化水素タンクを転載する液化水素船約3万m³クラスの船隻約10隻の船隻と、48基の船隻（48基×10隻）の船隻を転載する20万m³以上の船隻を転載する20万m³クラスの船隻約10隻の船隻と、2020年10月17日の採択決定以来、船隻転載コスト、船隻転載コスト削減の両方を削減します。なお、水素製造、輸送、貯蔵、船隻転載のうえに、本事業商用化実証の目的、仕様・要件などは、様々な関係者との協議を通して決定してまいります。

日本水素と川崎重工業、ENEOS、伊藤忠商事は、水素事業でエネルギー・関連事業で自社が持つべき技術や知見を創出し、川崎重工業が持つ豊富な事業経験とコスト削減に向けて連携、採択された本事業商用化実証の商用化実証（本事業商用化実証）を推進し、本事業商用化実証の成功を促すことと期待されています。

日本の2050年までのカーボンニュートラル実現への貢献に向けて商用化する本事業商用化実証の成功を促すことと期待されています。



※Wholly-owned company by Kawasaki

Source : https://www.nedo.go.jp/news/press/AA5_101471.html

International Hydrogen Supply Chain

Kawasaki will contribute to lower supply costs by scaling-up facilities

Transport



Suiso Frontier: 1,250m³ @HySTRA

128 times

Transport



Large-scale Carrier : 160,000m³

Storage



Storage Tank at Hy touch Kobe: 2,500m³

20 times

Storage



Large-scale Storage Tank: 50,000m³

Closing

The completion of the Japan-Australia supply chain pilot project is a significant step forward

in opening the way for hydrogen to play a key driving role in
“de-carbonization” “energy security” and “economic growth,

and

also in paving the way for a carbon-neutral path of coal utilization.

**Kawasaki will continue to work with public and private sector partners
to establish an international liquefied hydrogen supply chain.**

- Kawasaki is working on scale-up of transportation and storage facilities (liquefied hydrogen carrier and liquefied hydrogen terminal) in preparation for the commercialization demonstration.
- Kawasaki will also collaborate with the demand side, such as hydrogen power generation, for which large-scale demand is expected.

Aiming for a society where hydrogen is used as commonly as current fossil fuels