IEA Low-carbon Gas Day

International Hydrogen Supply Chain

March, 25, 2022

Motohiko NISHIMURA

Kawasaki Heavy Industries, Ltd.

Kawasaki
Powering your potential

Products of Kawasaki Heavy Industries

Energy System & Plant Engineering

Motorcycle & Engine

Precision Machinery & Robot

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.

Initiative by Global Companies

Hydrogen Council

- A global CEO-level initiative with a united vision and long-term ambition for hydrogen to foster the energy transition.
- Composed of 130 leading companies from energy, transportation, manufacturing industry, trading and financial sectors.
- Launched during the 2017 World Economic Forum in Davos

CEO event at Versailles, France, 2020

Concept of a CO_2-free Hydrogen Chain

Producing country (Australia,･･･)

Utilizing country (Japan)

Production of hydrogen at low costs from unused resources and/or abundant renewable energy

Affordable renewable energy

Liquefaction/ loading

Fossil fuel: Natural gas coal .....

CCS (CO_2 capture/storage)

Liquefied hydrogen carrier

CO_2-free hydrogen

Liquefied hydrogen containers

Liquefied hydrogen storage tanks

Process uses
Semiconductor and photovoltaic cell 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

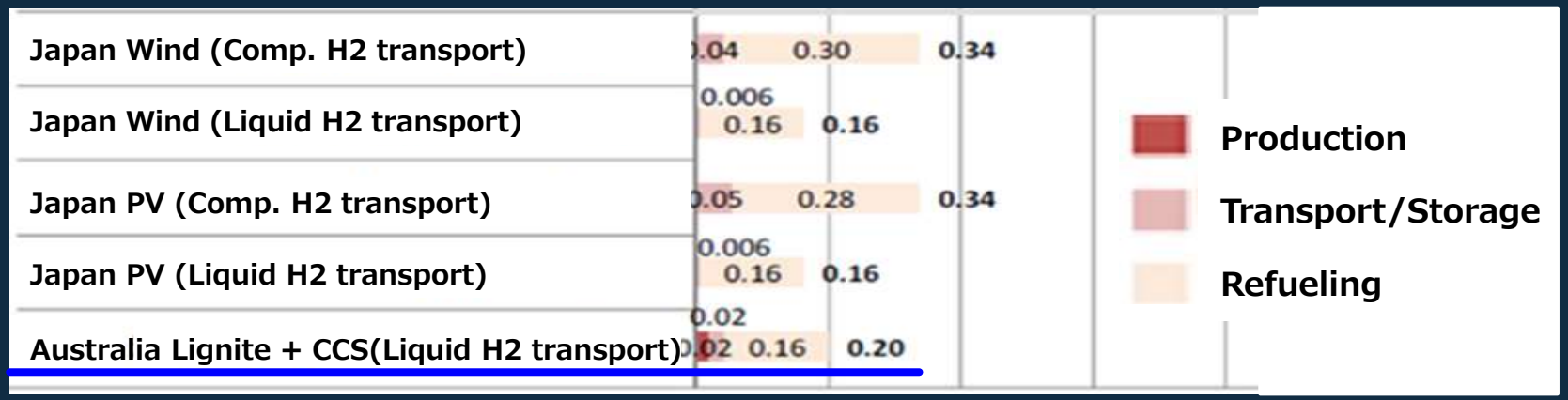
transport / storage

utilization

CO_2 Footprint of Hydrogen

- **CO2 emissions of Lignite(Brown coal) derived and renewable energy based hydrogen are comparable**

Well-to-Tank CO2 emission per 1Nm^3-Hydrogen [kg-CO_2e/Nm^3-H_2]



LCA by Mizuho Information & Research Institute

Ref: https://www.mizuho-ir.co.jp/publication/report/2016/pdf/wttghg1612.pdf

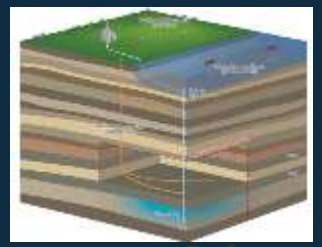
CCS・CO_2 Storage

（CCS：CO_2 Capture and Storage）

- The Victorian Government and Commonwealth Government promote CarbonNet Project
- After Studying Pipe Lines, Completion of drilling an offshore appraisal well(OAW) on 24 January 2020
- Driving for Commercialization in cooperation with Japan and Australia Project

Reference：METI

CCS Image



Reference：CO2CRC HP

Reference：Carbon Net HP

Robust Progress by Working with Australian Government

- Talks between Japanese PM Suga and Australian PM Morrison held in Tokyo, **hydrogen project in Victoria state** announced in joint statement (Tokyo, Nov 17, 2020)

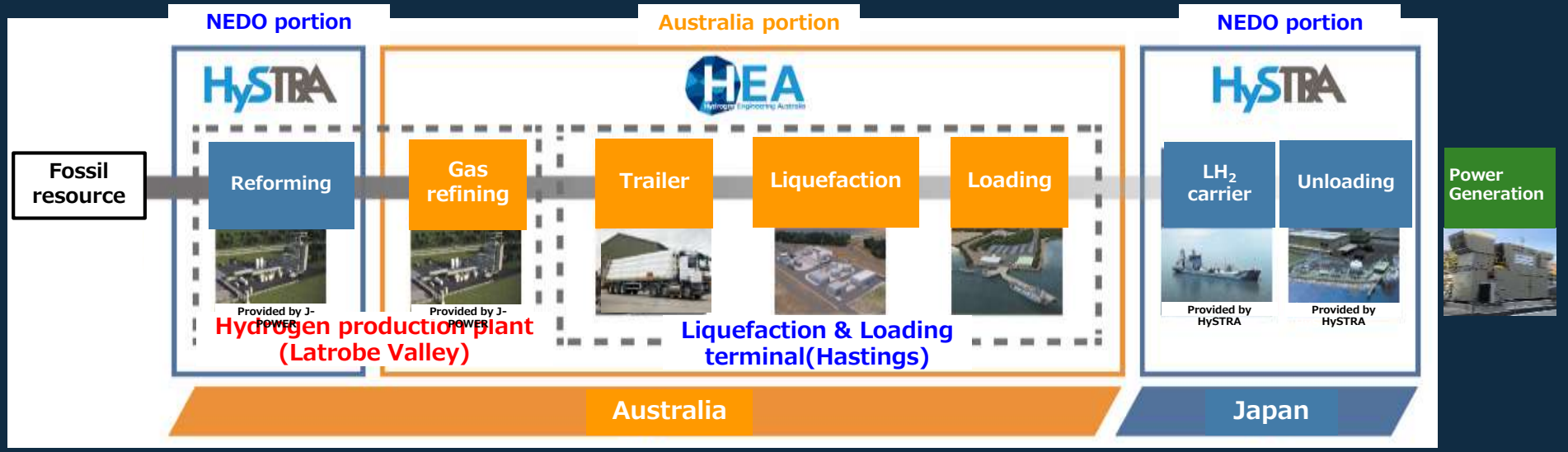
- On the next day (Nov 17), PM Morrison participates in talks with Japanese businesspeople at roundtable discussion about hydrogen, pledges cooperation in making brown-coal hydrogen project a reality

20. The Leaders concurred to continue close cooperation to ensure secure and reliable energy supply including LNG and to reduce emissions through new and emerging low-emissions technologies and supply chains, including hydrogen, Carbon Capture, Utilization and Storage (CCUS) and Carbon Recycling (CR). **They welcomed the progress made to date on the Hydrogen Energy Supply Chain project in the state of Victoria in Australia**. The Leaders concurred to advance hydrogen cooperation to support national and global transitions to a resilient, low emissions economy. In this context, Prime Minister Morrison acknowledged the recent announcement by Prime Minister Suga that by 2050, Japan will aim to reduce greenhouse gas emissions to net-zero, that is, to realize a carbon-neutral, decarbonized society. Prime Minister Suga acknowledged that Australia is implementing a Low Emissions Technology Roadmap to reach net zero emissions as soon as possible, and has already reduced emissions by 14% since 2005.

From MOFA website (Japan-Australia Leaders' Meeting Joint Statement)

Pilot Project Structure

Kawasaki is working with a number of partners on the pilot project supported by the governments of Japan and Australia.



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

*NEDO : New Energy and Industrial Technology Development Organization

Status of the Pilot Demonstration Project

Hydrogen Production (Australia)

Land Transportation and Liquefaction(Australia)

Maritime Transportation

Length	116m	Speed	13knot
Width	19m	Cargo	1,250m3
Crew	25person	Propulsion	Diesel Electric

© HySTRA

Unloading and Strage

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Status of the Pilot Demonstration Project: Hydrogen Transportation

Steps in Scale Up of Hydrogen Use and Transportation

Production

Hydrogen production and liquefaction

Transportation

Liquefied hydrogen carrier

Storage

Liquefied hydrogen tank

Utilization

Hydrogen power generation and mobility

Technical Demonstration

2020

Scale-up

Commercial Demonstration

Transportation Volume **28,000t/y** (provisional value)

2025

Supported by Green Innovation Fund

Commercialization

Transportation Volume **225,000t/y**

2030

Approval in Principal for Large-Scale Transportation of Liquefied Hydrogen

Kawasaki Develops Cargo Containment System for Large Liquefied Hydrogen Carrier with World's Highest Carrying Capacity—AiP(Approval in Principal) Obtained from ClassNK, April 2021.

NIPPON KAIJI KYOKAI

Document No: KF-211HE0599R Date: 28 April 2021

Approval in Principle

KAWASAKI HEAVY INDUSTRIES, LTD.
Cargo Containment System for 160,000m3 Liquefied Hydrogen Carrier

Nippon Kaiji Kyokai (ClassNK) has examined the documents specified in the annex to this letter based on the current Society's Rules and Guidance for the Survey and Construction of Steel Ships *"Part N, Ships Carrying Liquefied Gases in Bulk"* incorporating *"the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)"*, *"Guidelines for Liquefied Hydrogen Carriers"* incorporating *"INTERIM RECOMMENDATIONS FOR CARRIAGE OF LIQUEFIED HYDROGEN IN BULK (RESOLUTION MSC.420 (97))"* and other related requirements, and found the design is feasible as basic concept.

Accordingly, Approval in Principle is hereby granted.

Conditions on this approval are set out in the annex to this letter and to be fully taken into account.

(M. Aoki)
General Manager of Hull Department
NIPPON KAIJI KYOKAI

AiP certificate

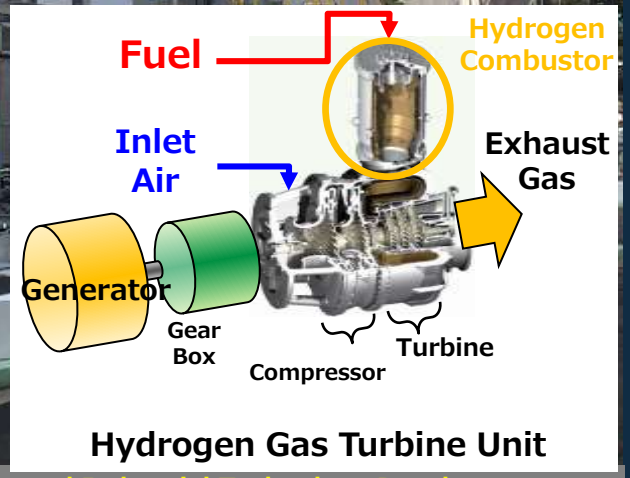
Large liquefied hydrogen carrier (cargo carrying capacity: image of 40,000 m3 × 4 tanks)

Hydrogen Gas Turbine

(Kobe Port Island)

Power and heat supply system using pure hydrogen, natural gas and mixture of these as a fuel. (Power Generation: 1 MW class)

Partners: Obayashi, Kawasaki, Kobe City, KEPCO, Iwatani, Kenes, Osaka University



Hydrogen Gas Turbine Unit

CGS=Co-generation System

Supported by NEDO

*NEDO : New Energy and Industrial Technology Development Organization

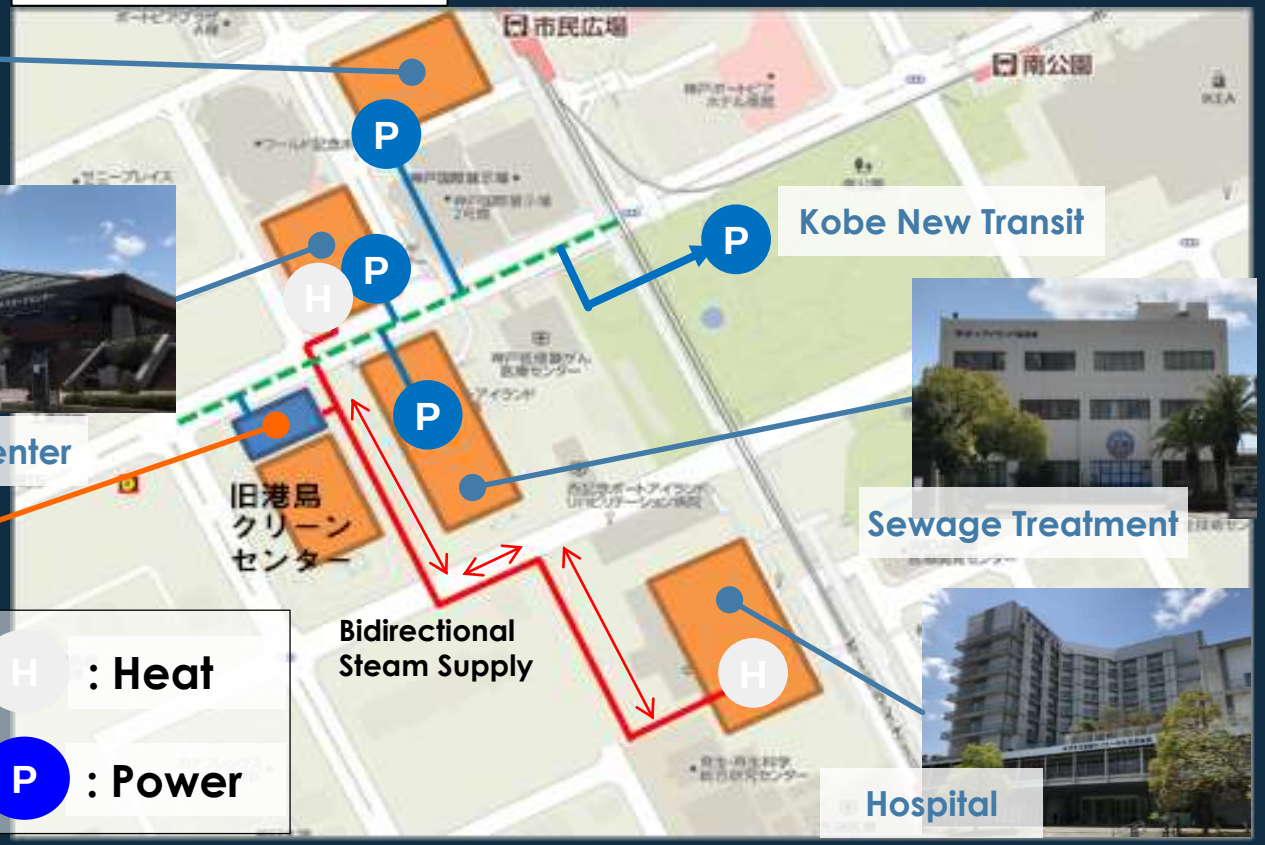
Heat and Power Delivery Demonstration

Exhibition Center

Sport Center

Hydrogen GT

Energy Delivery (As of Nov. 2018)



■ Energy delivery capability
Electric Power : Approx. 1,100 kW
Heat : Approx. 2,800 kW

■ Heat and power supply at the urban area using a hydrogen fueled gas turbine has been achieved in April 2018 (World first!).

Hydrogen Supply Chain for Decarbonization

1 Stable Supply

- Hydrogen from fossil fuel linked with CCS will realize vast and affordable energy supply

→ **Contribute energy security**

2 Environmental

- No CO_2 emissions when used

→ **“Carbon Neutrality"**

3 Economy

- Decarbonization brings Industrial growth

→ **Creating job opportunity**

- Hydrogen production started from fossil fuel shifted to the renewables in the future

→ **Sustainability**

4 Clean Hydrogen implementation in Japan

- Start from 420,000 ton/year in 2030　200 billions ton/year in 2050

Further Development of Hydrogen-Related Products/Businesses

Liquefied Hydrogen Supply Chain

Energy Solution & Marine Engineering Company

Hydrogen Valves For FCV

Precision Machinery & Robot Company

Fuel Cell Vehicles

Rolling Stock Company

Kawasaki Heavy Industries, Ltd.

Hydrogen Vehicles

Motorcycle & Engine Company

Aerospace Systems Company

Hydrogen Aircraft Engines

Hydrogen Power Generation