Gastech | Hydrogen | Climatetech

Kawasaki's technology to establish hydrogen supply chain

Luis Quadrante

Kawasaki Heavy Industries(UK), Ltd.

Kawasaki

Powering your potential

カワる、サキへ。

Changing forward

Introduction

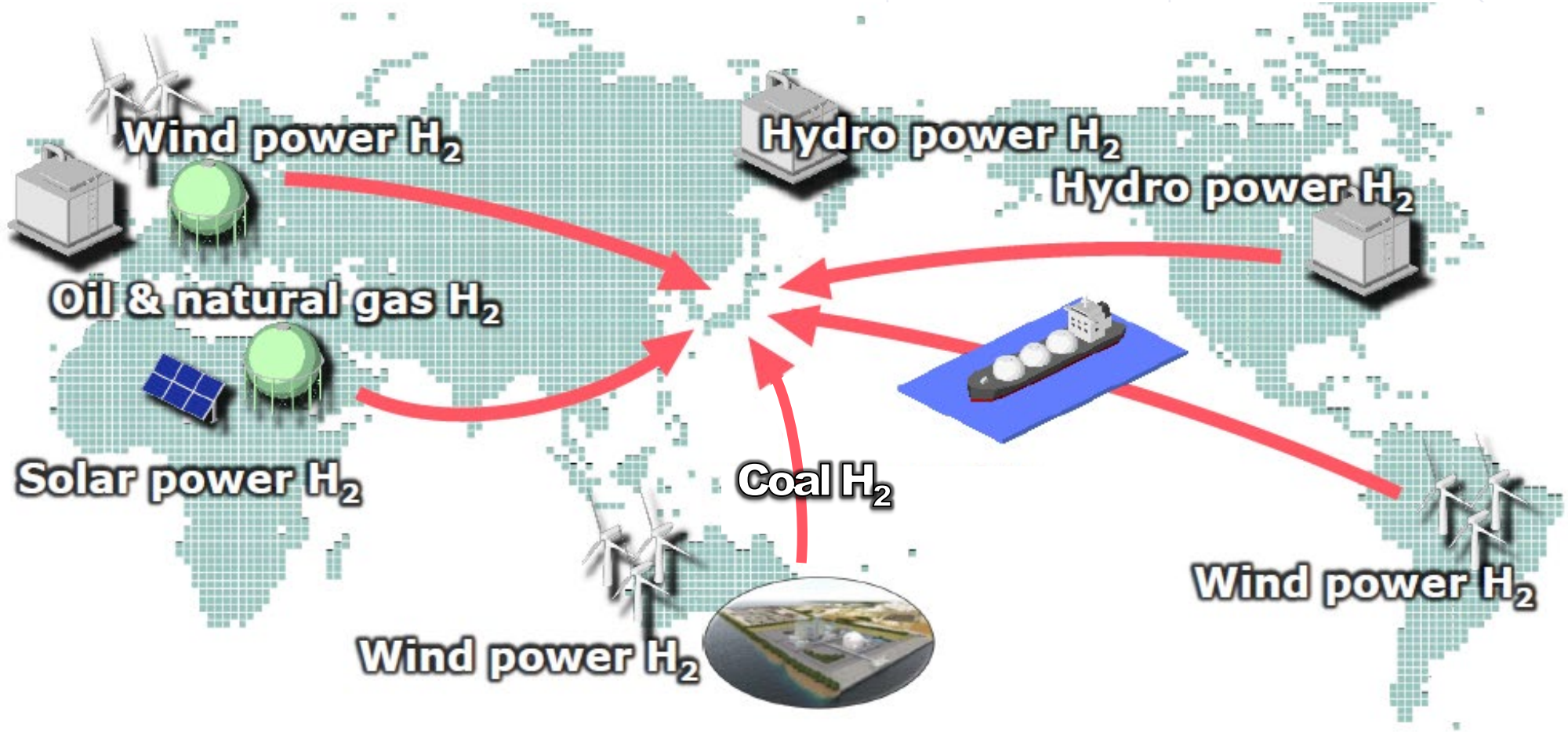
Ⅰ. Outline of hydrogen supply chain

Ⅱ. Demonstration by pilot project

Ⅲ. Establishment of commercial scale hydrogen supply chain

Hydrogen supply chain

Hydrogen can be produced from various sources and procured from many countries.
By liquefying hydrogen, it can be transported in larger amount and longer distance compared to electricity transmitted through a global power grid.



Concept of CO_2-free hydrogen supply chain
– production, transportation, storage and utilization -

Stable energy supply while suppressing CO_2 emissions

Producing country (Australia, ・・・)

Utilizing country (Japan)

Production of hydrogen at low costs from affordable renewable energy and/or fossil fuel with CCS

Fossil fuel: Natural gas Coal…

CCS (CO_2 capture /storage)

Affordable renewable energy

H_2 Production

Liquefied hydrogen cargo ship

Liquefied hydrogen containers

Liquefied hydrogen storage tanks

LH_2 transport / storage

Process uses
Semiconductor, Oil refinement, etc.

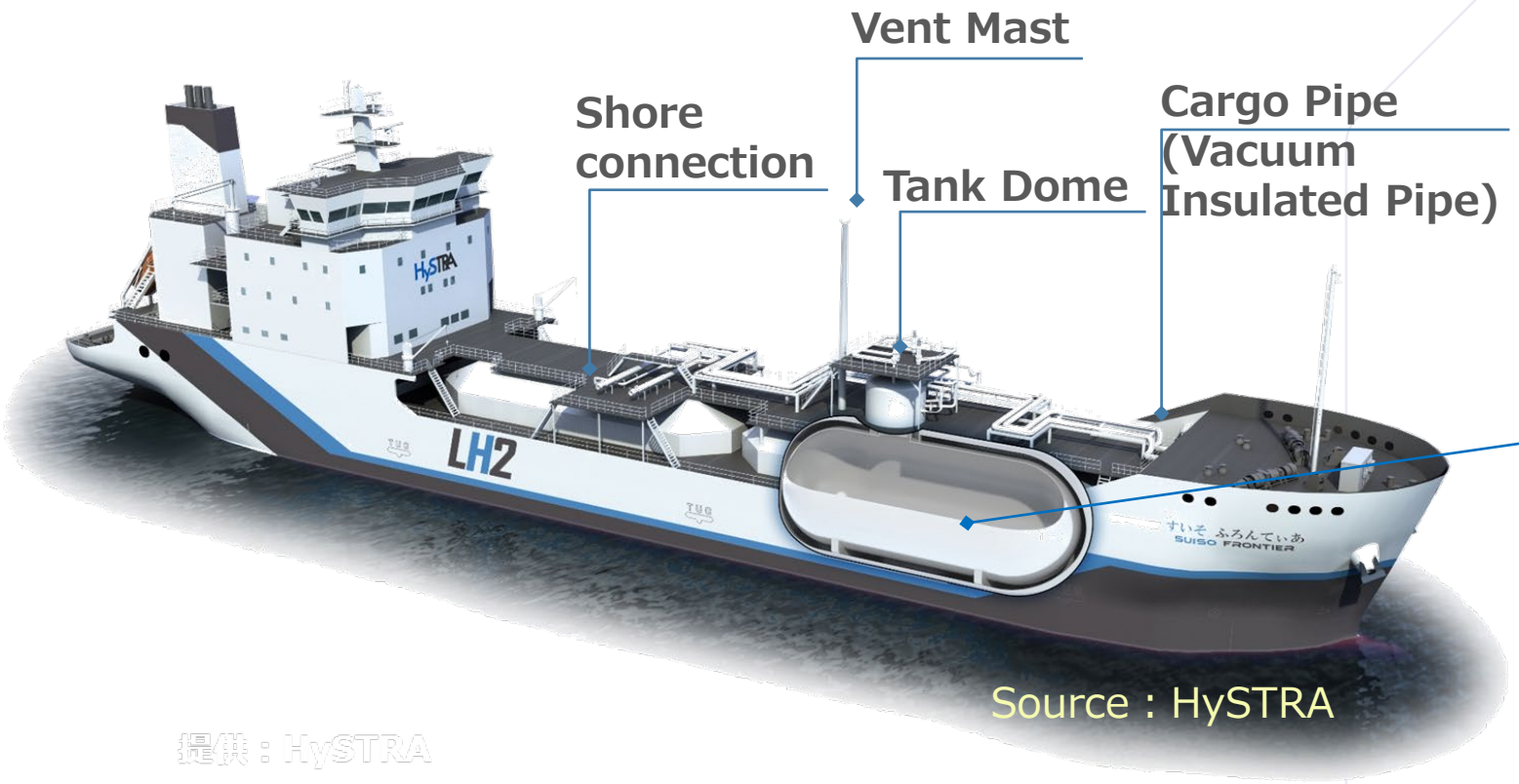
Transport equipment

Distributed Power plants

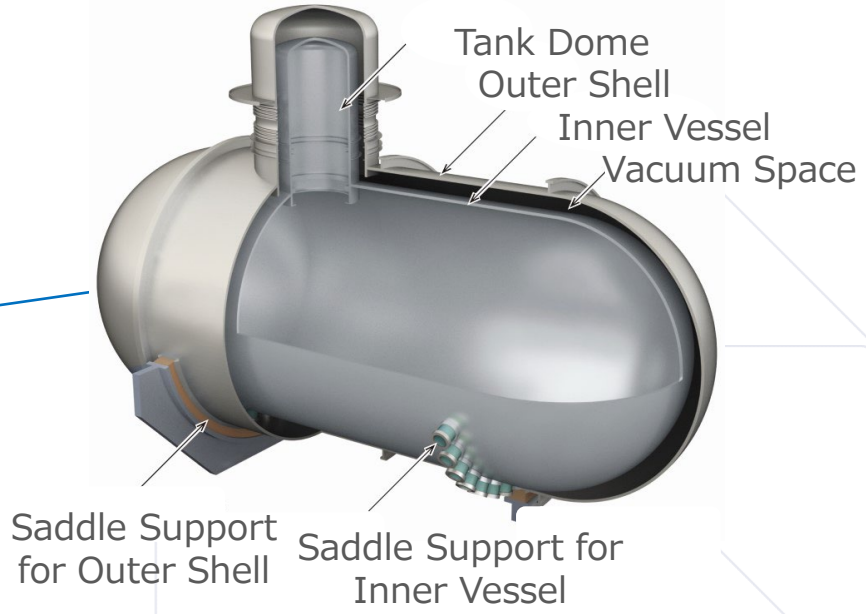
Electrical power plants

H_2 utilization

The world's first LH_2 carrier "Suiso Frontier"



Cargo Containment System (1,250m³)



Vacuum Insulated Double Shell Structure

■ Length o.a.	116.0 m	■ Propulsion	Oil fired diesel electric
■ Breadth	19.0 m	■ Service speed	abt. 13 knots
■ Class/Flag	NK/Japan	■ Complement	25 persons

This presentation is based on results obtained from a project subsidized by the New Energy and Industrial Technology Development Organization (NEDO).

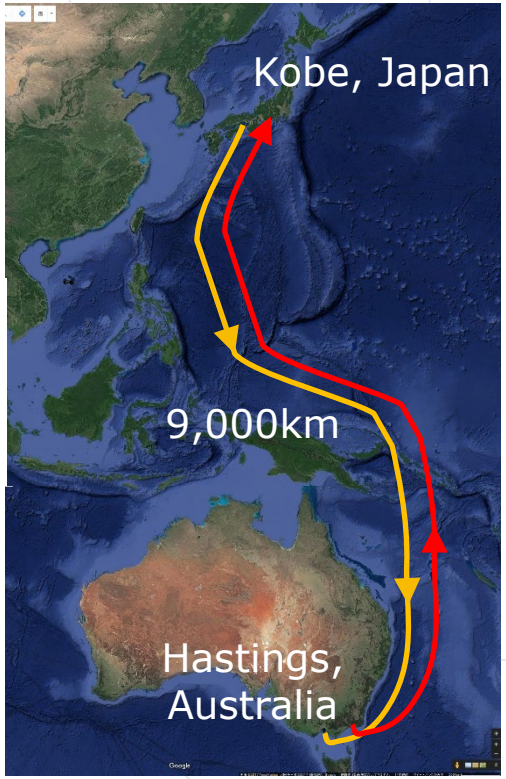
Demonstration by pilot project

■ Demonstration I

- Loading and unloading tests at LH_2 terminal
- Full load trial voyage in Japan

■ Demonstration II

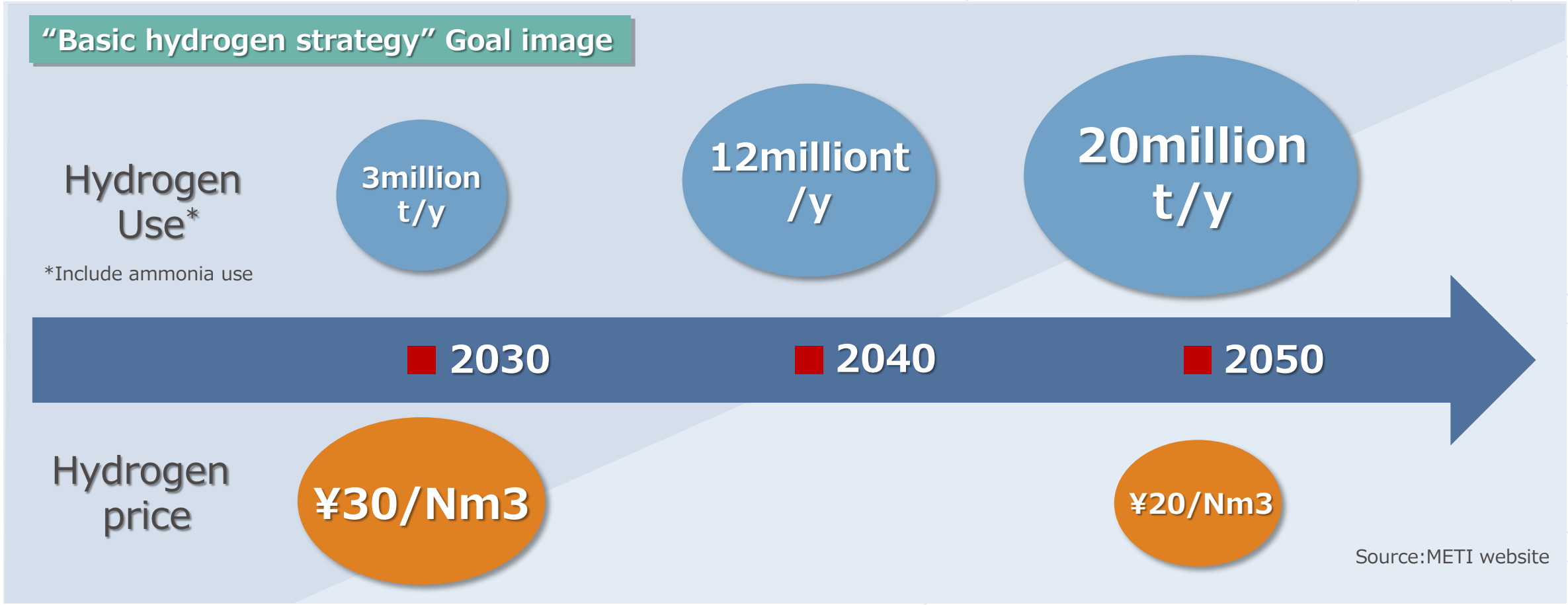
Verification of long-distance transportation technology



Source : HySTRA

This presentation is based on results obtained from a project subsidized by the New Energy and Industrial Technology Development Organization (NEDO).

Hydrogen Strategy in Japan



Japanese government has established a **Green Innovation Fund** to support the development of carbon neutral technologies, including hydrogen technology in order to achieve its target in 2050

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

Suiso Frontier

Scale up

2020

Hy-touch Kobe

Co-generation System

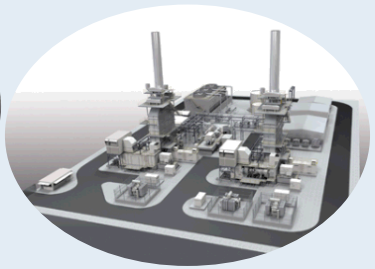
Commercial Demonstration

Large scale LH_2 carrier x 1ship

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

Supported by JP. Gov. Green Innovation Fund

2025



Commercialization

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

Large scale LH_2 carrier x 2ship

2030

Price: **Appx ¥30**/Nm^3

LH_2 supply chain for commercialization demonstration project

- Selected sites for “Liquefied Hydrogen Supply Chain Commercialization Project”
  - **Export site : Port of Hastings (Victoria, Australia)**
  - **Receiving site : Kawasaki Coastal Area (Kanagawa Pref., Japan)**
- A MOU was signed to advance the establishment an LH_2 supply chain between Japan and Australia at the Asia Zero Emission Community (AZEC) on 3rd March, 2023.

AZEC Public-Private Investment Forum

Agreement for transportation of the liquefied hydrogen

- There are no rules or regulations for liquefied hydrogen carriers at present. (Liquefied hydrogen is not described in IGC)
- Agreement on safety is required to transport the liquefied hydrogen by IGC code. In June 2023, Japan and Australia have agreed on the transport requirements for Large scale LH_2 carrier
- This agreement may be followed to “New” Interim Recommendations.

Japan-Australia Maritime Bureau meeting in June, 2023

Source:MLIT website

Australian Government
Australian Maritime Safety Authority

Ministry of Land, Infrastructure, Transport and Tourism

MINUTE (2023)
Concerning requirements to be applied to the carriage of liquefied hydrogen in bulk

On 11th January 2017, the Australian Maritime Safety Authority (hereinafter "AMSA") and Maritime Bureau, Ministry of Land Infrastructure, Transport and Tourism of Japan (hereinafter "JMB") confirmed agreement of the suitable conditions for pilot ship carrying liquefied hydrogen in bulk in accordance with 1.1.6.1 of the IGC code as those specified in IMO Resolution MSC.420(97) - INTERIM RECOMMENDATIONS FOR CARRIAGE OF LIQUEFIED HYDROGEN IN BULK.

This time, AMSA and JMB confirmed new safety measures for carriage of liquefiec hydrogen in bulk (hereinafter "the safety measures for liquefied hydrogen carrier") as attached in the annex are suitable in accordance with 1.1.6.1 of the IGC code.
The safety measures for liquefied hydrogen carrier specifies suitable conditions for the carriage of liquefied hydrogen for the following design:
Cargo containment systems of independent cargo tanks using vacuum insulation; and
Cargo containment systems of independent cargo tanks using insulation materials and hydrogen gas in the inner insulation spaces.

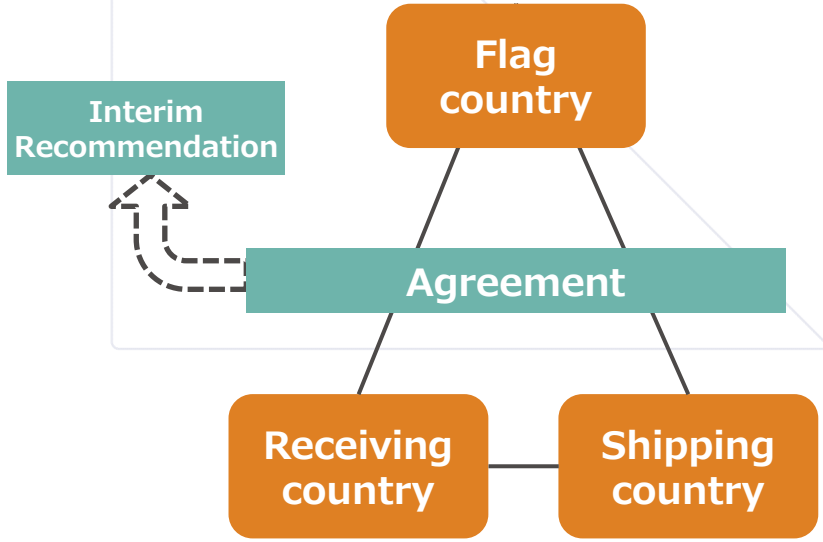
This non-legally binding memorandum covers the design and construction of ship as safe long-distance overseas carriage of liquefied hydrogen in bulk between Australia and Japan.

16th June 2023

Mr. Stephen McMeeking
Manager
Ship Inspections and Registration Operations
Australian Maritime Safety Authority
AUSTRALIA

Mr. CKETANI Mitsuhiro
Director of Dangerous Goods Transport Office
Inspection and Measurement Division
Maritime Bureau
Ministry of Land, Infrastructure, Traesport and Tourism
JAPAN

Image of Agreement



Rule and Guidelines for liquefied hydrogen carrier

■ Revised works for Interim Recommendation are ongoing for CCC9.

MSC.420(97)

Interim recommendations for carriage of liquefied hydrogen in bulk

(adopted on November 2016)

ClassNK was established their Guideline.

(issued on March 2017)

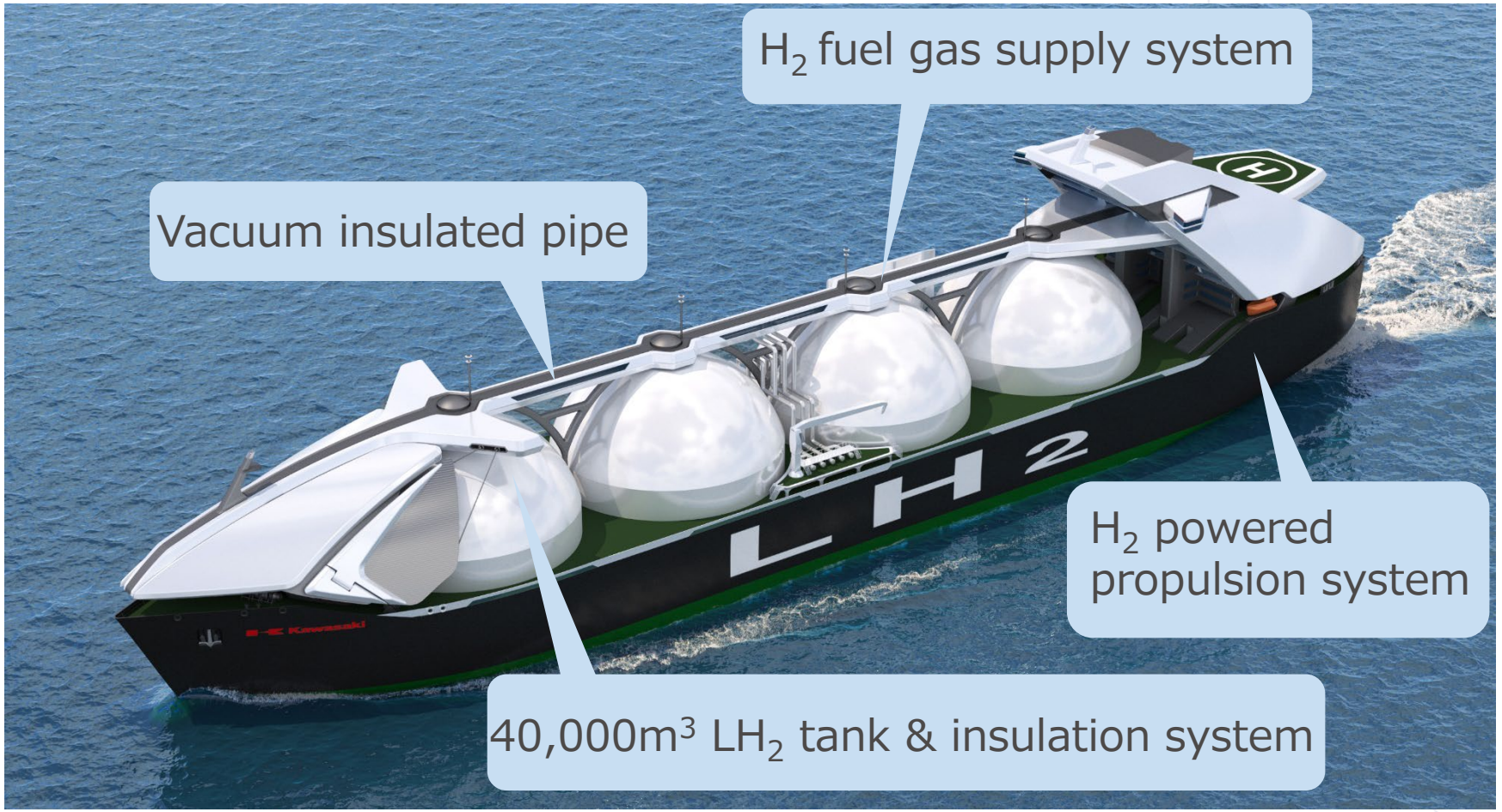
Revised study was started from CCC8 in September 2022

A draft revised version will be reported to CCC9 in September 2023 and Japan will participate and lead the discussions at the IMO

160,000m3 Liquefied Hydrogen Carrier

■ Length o.a.	346.0 m	■ Service speed	ab. 18 knots
■ Breadth	57.0 m	■ Complement	50 persons
■ Depth	28.0 m	■ Class/Flag	NK/Japan

ClassNK issued Approval in Principle (AiP) for 160,000m³ LH_2 Carrier in April, 2022.



ClassNK
NIPPON KAIJI KYOKAI

Document No. KF-22HE04387
Date: 19 April 2022

APPROVAL IN PRINCIPLE

160,000m3 Liquefied Hydrogen Carrier
developed by KAWASAKI HEAVY INDUSTRIES, LTD.

THIS IS TO CERTIFY THAT Approval in Principle is granted to KAWASAKI HEAVY INDUSTRIES, LTD.

The AiP is for the design concept of the captioned vessel including the following systems:

- Cargo Containment System
- Cargo Handling System
- Dual Fuel Main Boiler using Boil-Off Gas

The AiP is based on the current Society's Rules and Guidance for the Survey and Construction of Steel Ships (hereinafter "the Rules") and Guidelines *"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 relevant requirements as applicable.

The documents/drawings specified in the Annex to this letter have been reviewed and it is examined that the conceptual design of the systems is feasible for the intended application.

Conditions on this approval are set out in the Annex to this letter.
For final approval of the vessel, a complete set of documentation is to be approved by the Society in accordance with the relevant Rules.

Akio Usami
General Manager of Hull Department
NIPPON KAIJI KYOKAI

Form CLS (21.01)

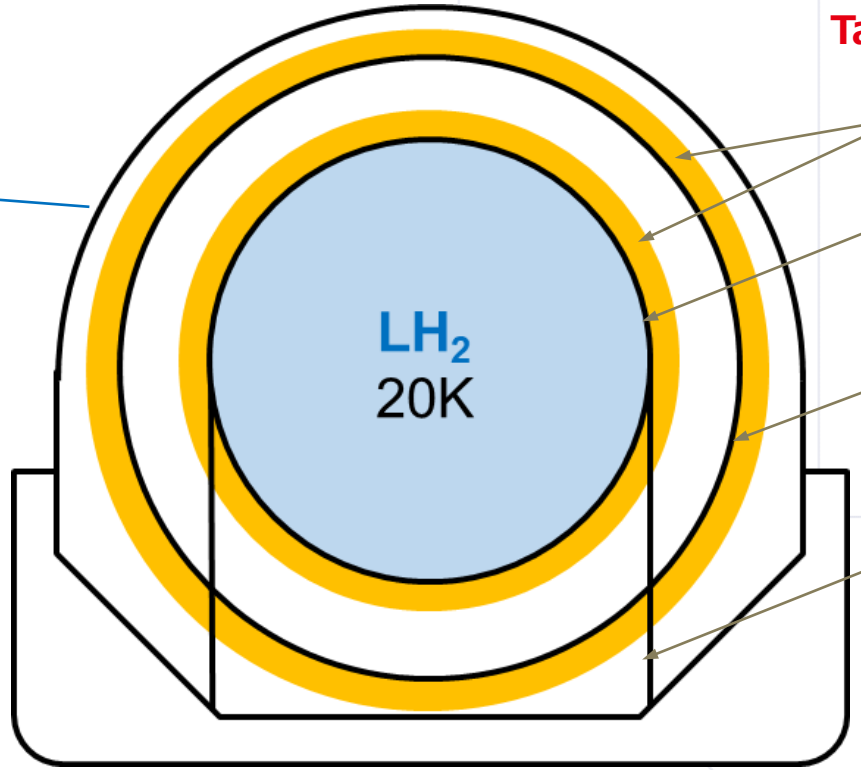
AiP Certificate

Novel technologies for cargo containment system

- **"CC61H" type - Newly developed double shell structure CCS**
  - AiP obtained from ClassNK in April, 2021
  - Large amounts tank that enables transportation of cryogenic liquefied hydrogen (-253degC)
  - High-performance heat insulation system that mitigates boil-off gas

160,000m3 LH_2 carrier

CC61H type CCS



Tank capacity : abt. 40,000m3

Insulation material

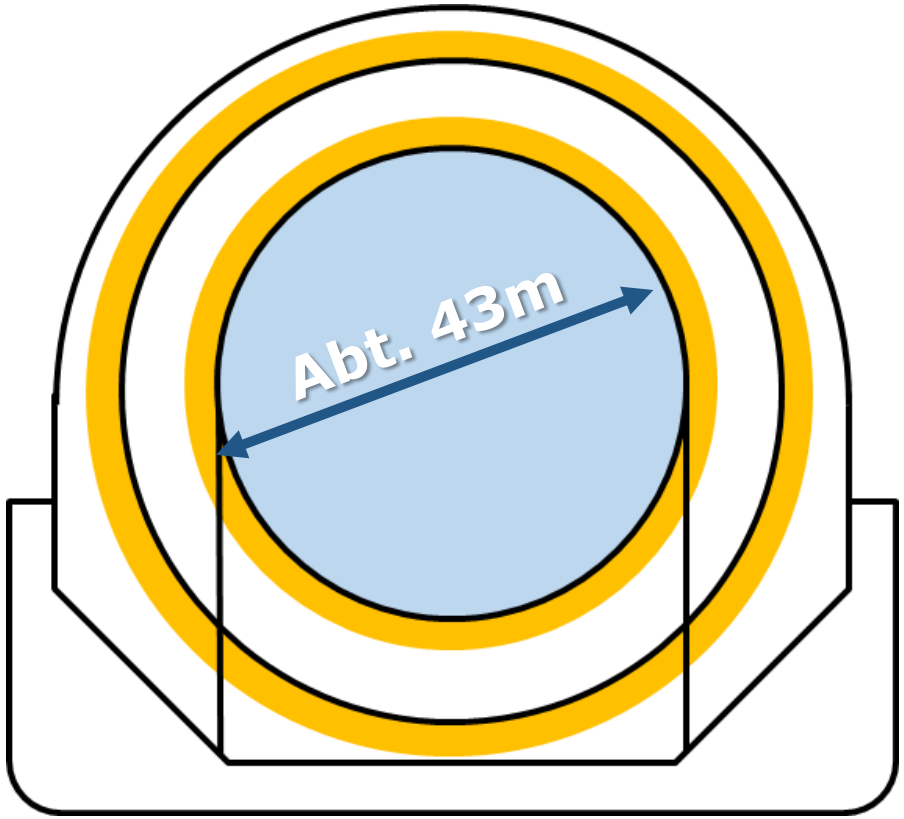
Inner shell

Outer shell

Support structure

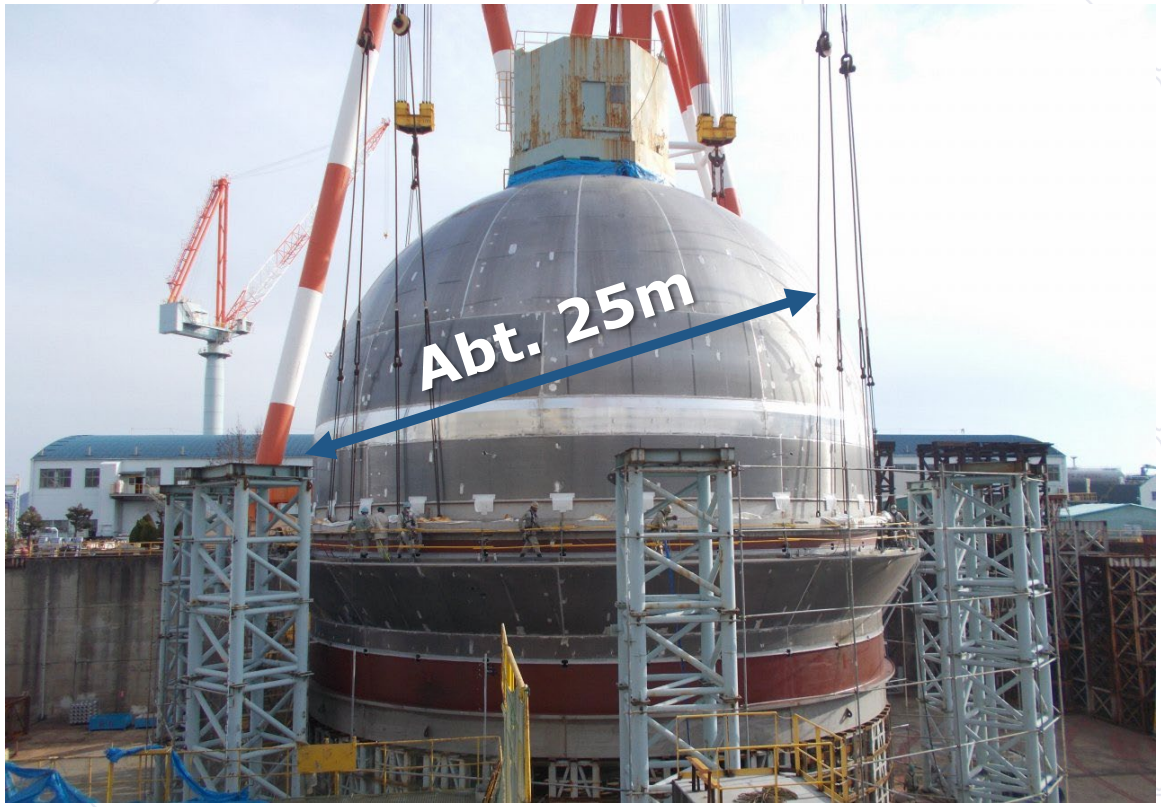
Novel technologies for cargo containment system

Full scale tank



Scale down

Functional demo tank



- ✓ **Construction of half diameter of functional demo tank was completed**
- ✓ **Establishment of construction procedure of double shell structure**

This presentation is based on results obtained from a project subsidized by the New Energy and Industrial Technology Development Organization (NEDO).

Novel technologies for cargo containment system

- ✓ Enhanced insulation performance by cool-down test
- ✓ Deformation of double shell structure at cold condition

This presentation is based on results obtained from a project subsidized by the New Energy and Industrial Technology Development Organization (NEDO).

Novel technologies for cargo handling system

- New equipment related to hydrogen cargo handling has been developed in cooperation with many vendors.
- Vacuum insulated pipe is adopted to cargo piping of 160,000m3 LH2 carrier same as Suiso Frontier
- In accordance with Interim Recommendation and Guidelines for LH2 carriers of ClassNK, system related to hydrogen such as cargo handling system is based on risk assessment.

Risk assessment overview

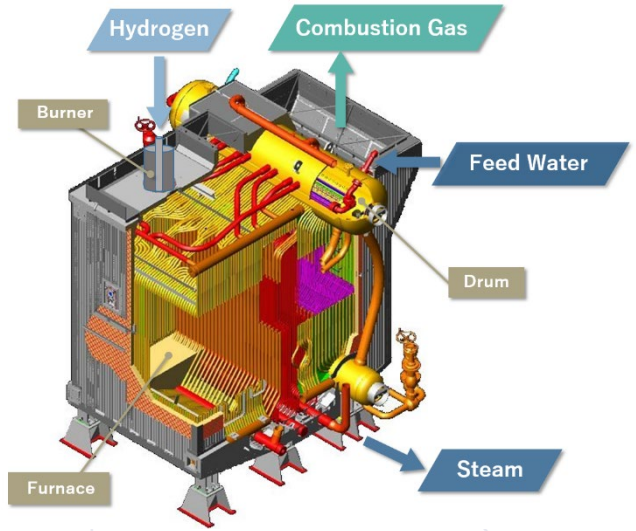
(*) HAZID for cargo containment system and propulsion system had also been carried out

For system	Cargo handling system HAZID* had been carried out in 2022 and AiP obtained from ClassNK in April, 2022
For Equipment	Technology Qualification (TQ) is carried out with Vendors, ClassNK and KHI

Novel technologies for propulsion system

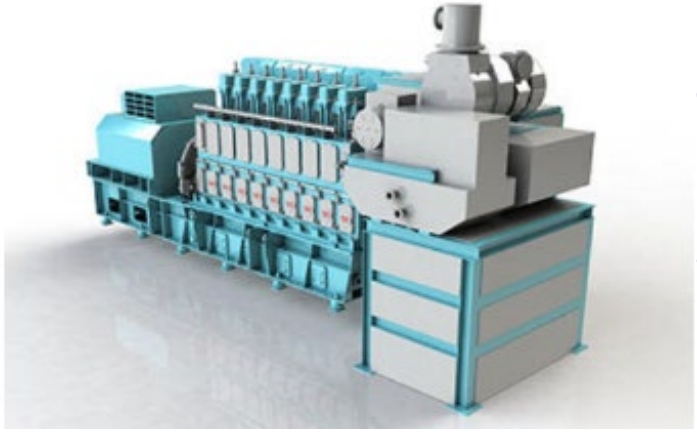
■ Newly developed dual fuel main boiler for main propulsion system

- Units : Two units / ship
- Steam generation : 70t/h/unit
- Fuel : 100% Hydrogen to 100% low-sulfur marine gas oil (flexible)
- AiP of propulsion system including dual fuel boiler obtained from ClassNK in April, 2022



■ Newly developed dual fuel diesel engine for electric power plant

- Dual fuel with hydrogen and low-sulfur marine gas oil
- Power output : 2,400kWe (by Hydrogen)
- Cylinder dia : 300mm
- AiP obtained from ClassNK in November, 2022
- Supported and subsidized by Japanese Government



This presentation is based on results obtained from a project subsidized by the New Energy and Industrial Technology Development Organization (NEDO).

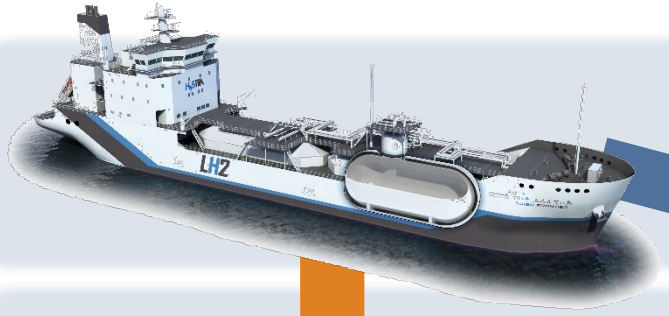
Expansion of LH_2 Carrier Lineup

- Various size of LH_2 carrier can be developed in accordance with market needs
- Developed by using the technologies and expertise obtained through the development of Suiso Frontier and large-scale LH_2 carrier

1st STEP
small ship Development

2nd STEP
Large ship development

Next STEP
Expansion of Lineup



Scale up

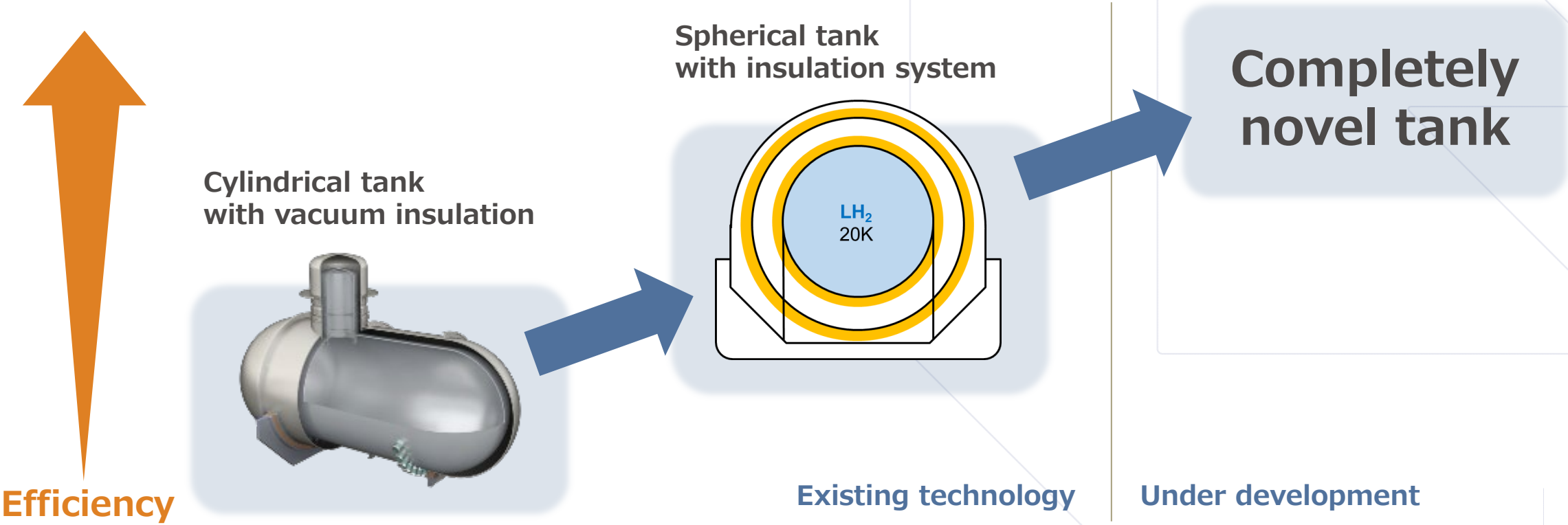
Feedback from Suiso frontier

Feedback from Large-scale LH_2 carrier

LH_2 carrier suitable for market needs

Challenge to improve transportation efficiency

- KHI has completed the development and demonstration of **small cylindrical tank**
- The development of **large spherical tank** has also been completed and under demonstrated.
- To improve transportation efficiency, KHI started development of **completely novel tank** by supported from NEDO.



Keys to the Future

1 Hydrogen supply chain

- Hydrogen can be produced from wide range of countries and energy sources
- Liquefied hydrogen carrier is one of key components to establish hydrogen supply chain, because it is possible to transport a large amount of hydrogen

2 Pilot project

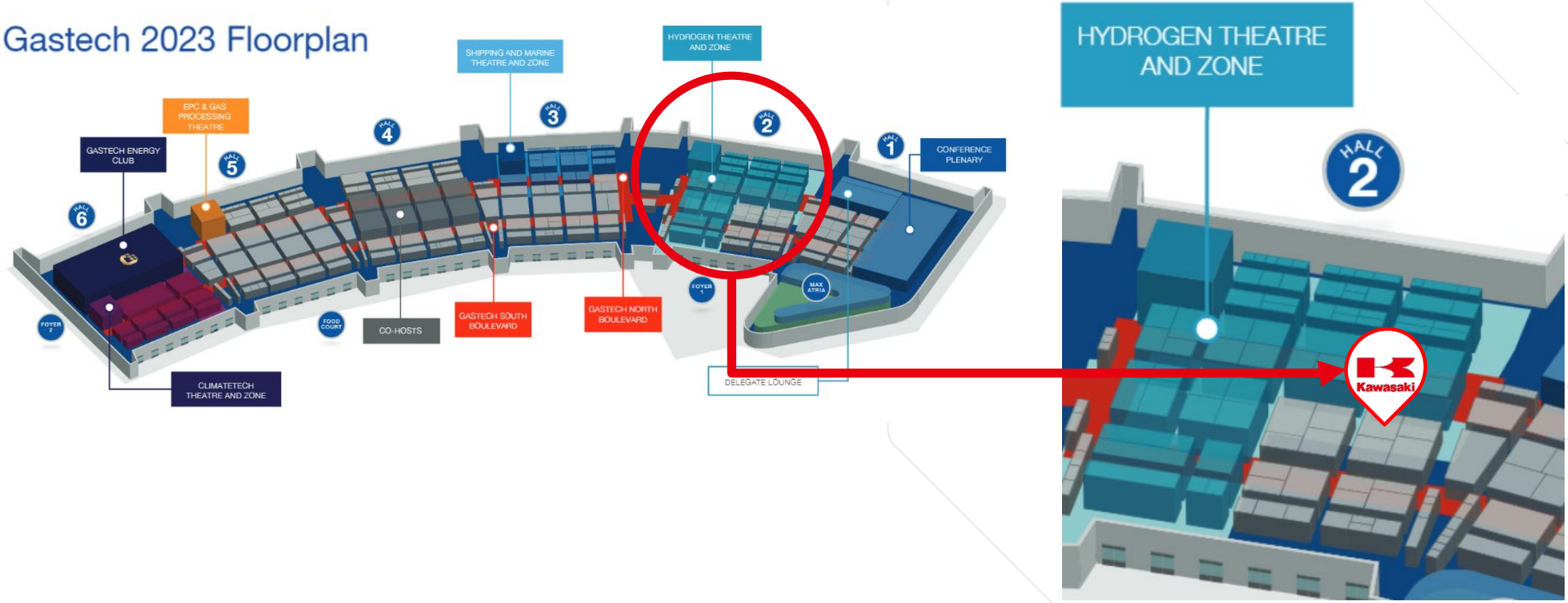
- Kawasaki demonstrated long-distance marine transportation of liquefied hydrogen by “SUISO Frontier”
- Cargo handling operation procedure for liquefied hydrogen was established by loading and unloading operations with terminals

3 Establishment of commercial scale chain

- Scale up of the ship is essential to reduce hydrogen cost
- Wide range of technologies to achieve scale up of the ship will be available soon
- Kawasaki can provide various size of LH_2 carrier from small size to large size in accordance with market needs

Booth information

For further information and ship model of 160k LH_2 carrier and others, please visit our booth **"A154"** in Hydrogen Area



New Values

A Safe and Secure
Remotely-Connected Society

Trustworthy Solutions for the Future

Cross Over

Energy and Environmental Solutions

"Near-Future" Mobility

Frontier