LH_2 Supply Chain Development

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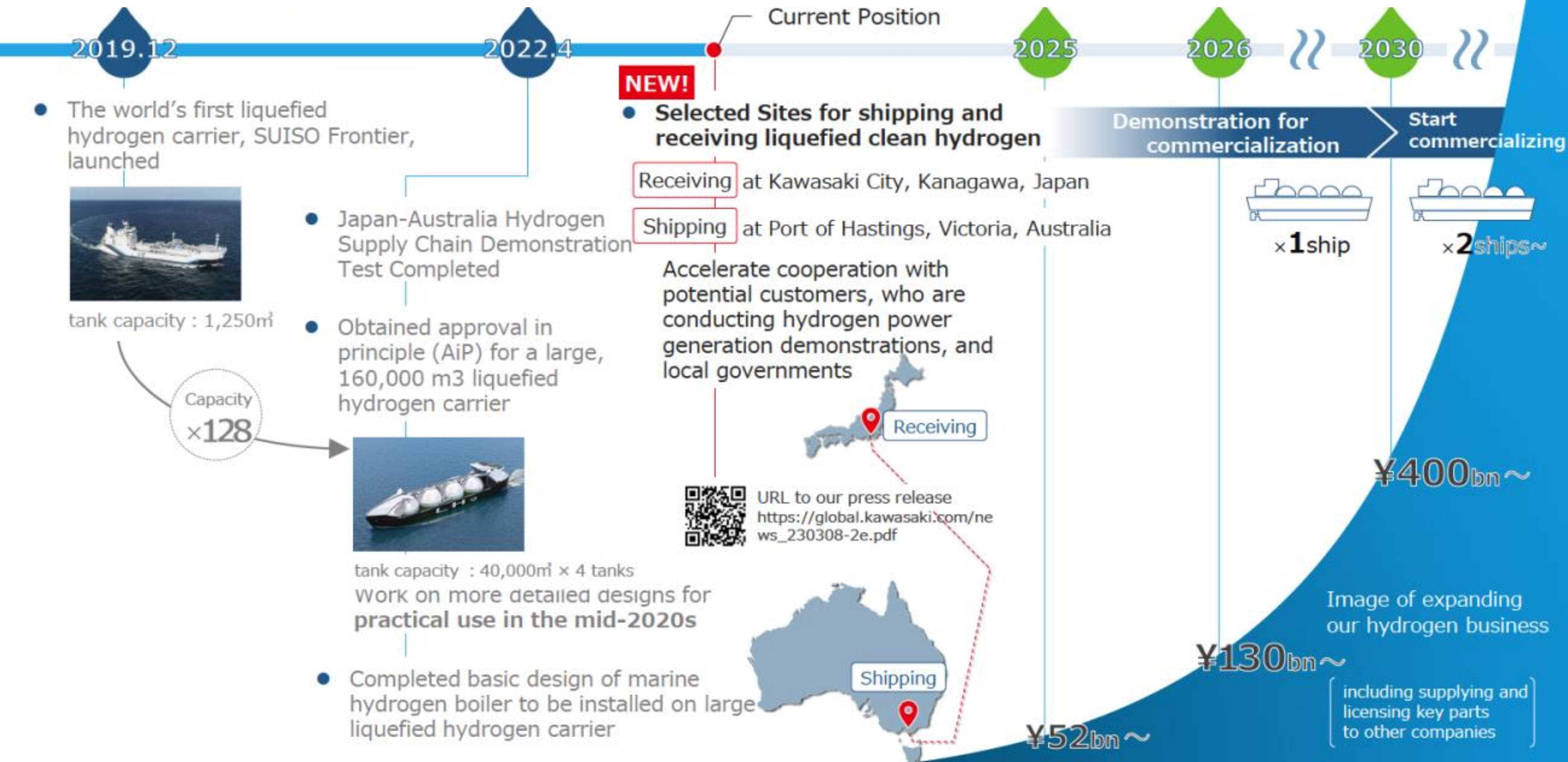
KHI's LH2-related Track Record and Milestone toward 2030s



Large-scaled LH_2 Carrier

June 2023
Completed technological development for a cargo containment system (CCS) to be used in large LH_2 carriers.

April 2022
Obtained AiP (approval in principle) for Large 160,000 m^3 LH_2 Carrier from Nippon Kaiji Kyokai (ClassNK).

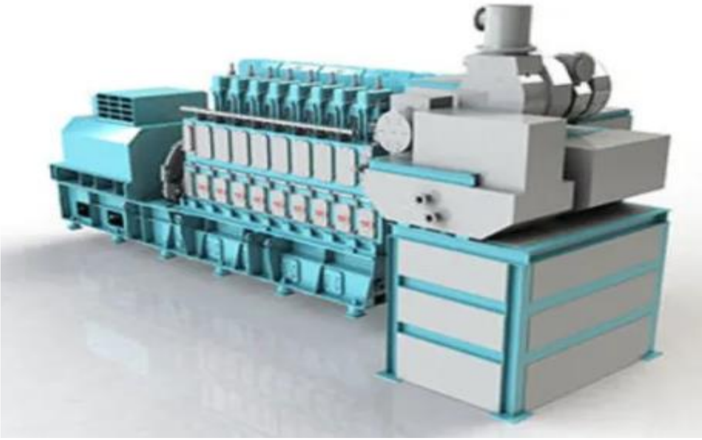
Measures in Marine Transportation

In addition to scaling up of facility side, operational measures to enhance **efficiency** are also ongoing.

⇒ Effective use of BOG enables to maximize the delivery volume by minimizing CO2 emission.

H_2-Fueled Vessel Propulsion System

KHI established JV with Yanmar and J-Eng in 2021 to develop and aim to complete lineup for various applications.



AiP for Dual Fuel Generator Engine Using Hydrogen Gas as Fuel

KHI got ClassNK's Aip for the above engine and related machinery systems & arrangements for 160,000m3 LH2 Carrier (November 2022)

The dual fuel generator engine can switch between hydrogen and low-sulfur fuel oil flexibly, and when hydrogen fuel is selected, boil-off gas naturally evaporated from the ship's liquefied hydrogen cargo tanks is used as the main fuel at a calorie - based mixed ratio of 95% or higher to generate and supply electricity in board,

which is expected to reduce greenhouse gas emissions from the ship significantly.

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Japan's Hydrogen Unit Cost Reduction Target

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Main Contribution

H2 Production& CCS	H2 Liquefaction	Loading base	LH2 Carrier
			

*CIF Cost

2030 (1st commercial scale)	14.7 JPY/Nm^3	9.4 JPY/Nm^3	3.2 JPY/Nm^3	2.5 JPY/Nm^3	▶ 30 JPY/Nm^3
	770 t/day	1,000 t/day	200k m^3	225k t/year	

2050 — Market development will make further cost down. → 20 JPY/Nm^3

Source: the Ministry of Economy, Trade and Industry "Future hydrogen policy issues and directions of response: Interim arrangement (draft),"

The Issue of Prevailing “Cost Comparison” Argument

- Is the typical argument such as “The issue with LH2 is the energy loss and costs that buyers will incur when transporting it over even moderate distances.” fair enough?

- LH2’s advantages such as “non-toxicity”, “high-purity” and “no-greenhouse gas” elements are often ignored as “taken for granted” in the prevailing argument, but those can save huge cost behind the scene. The benefit of the cryogenic heat utilization (-253℃) @demand side is also seldomly referred.

- While NH3 option is said to be described as “valid utilization and co-existence with the existing coal facilities”, risk-management cost for “transporting huge volume of NH3 to power plant sites, etc. throughout the demand countries and then storing it for later use over long storage periods” is often neglected.

- Also, in case of ammonia as a hydrogen energy carrier, additional facility and energy-related costs to extract H2 and that for safety/security management during the storage and transportation until the final consumption points should properly be incorporated into the argument for “apple to apple” cost comparison.

- By achieving the ongoing facility-enlargement and operational measures such as the effective use of BOG during the voyage, we believe that the LH2 option becomes to have the advantageous position since having less costs factors until its ultimate use at the consumption end thanks to the above-mentioned elements.

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