11:10-11:30 May 5(CEST time) Dissemination conference of PRESLHY project

World’s first ocean going liquid hydrogen carrier

Shoji Kamiya
Kawasaki Heavy Industries, Ltd. Japan

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Powering your potential

Outline

1. Concepts of CO_2 free hydrogen energy supply chains

2. LH2 carrier and its safety requirements

3. LH2 loading / unloading terminal

4. Numerical analyses & Experiments on hydrogen safety

5. Summary

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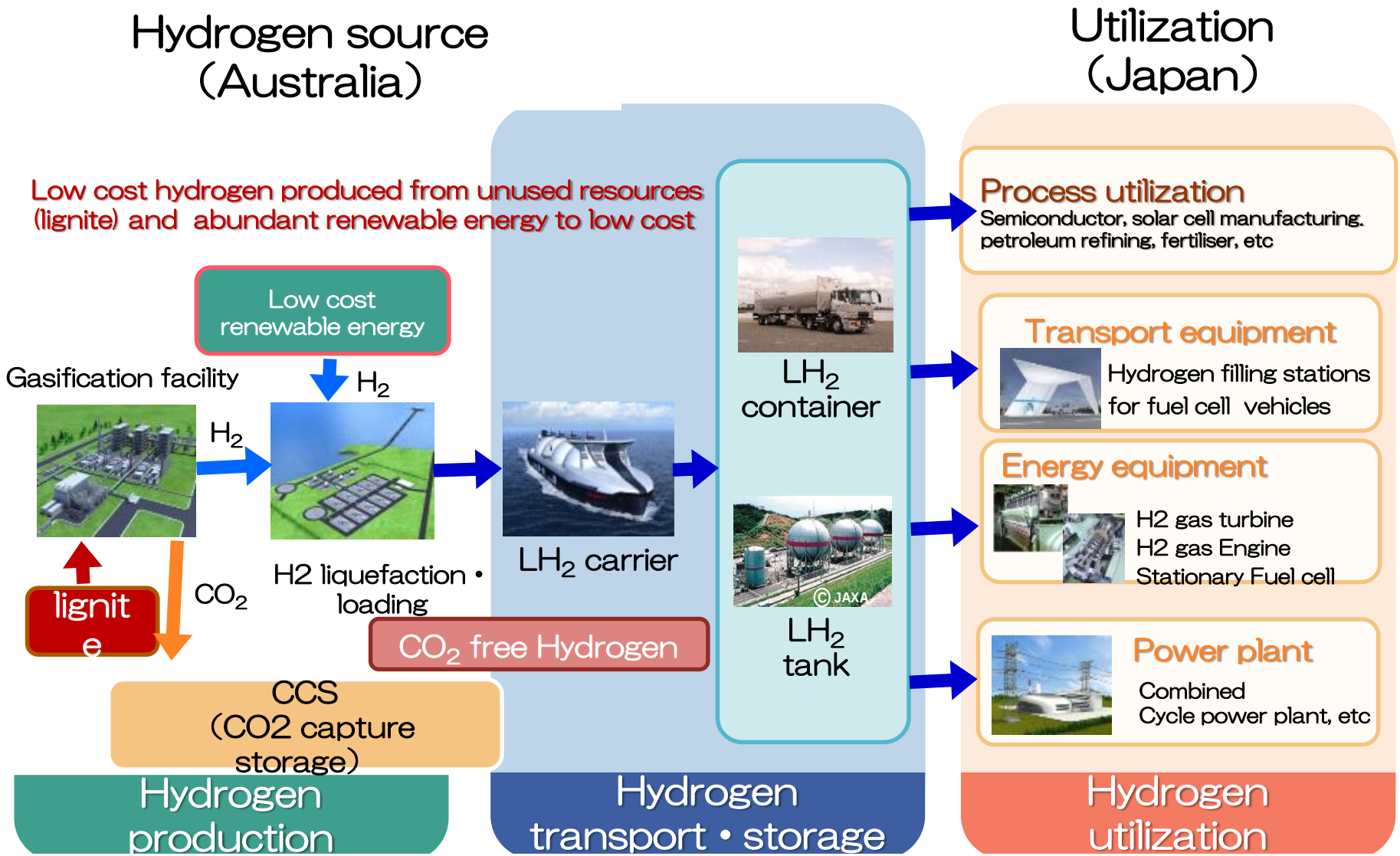
Concepts of CO_2 free hydrogen energy supply chains



Source : M. Nishimura et al, Activities for Realization of International Liquefied Hydrogen Energy Supply Chain. Kawasaki Technical Review No.182 (2021),etc

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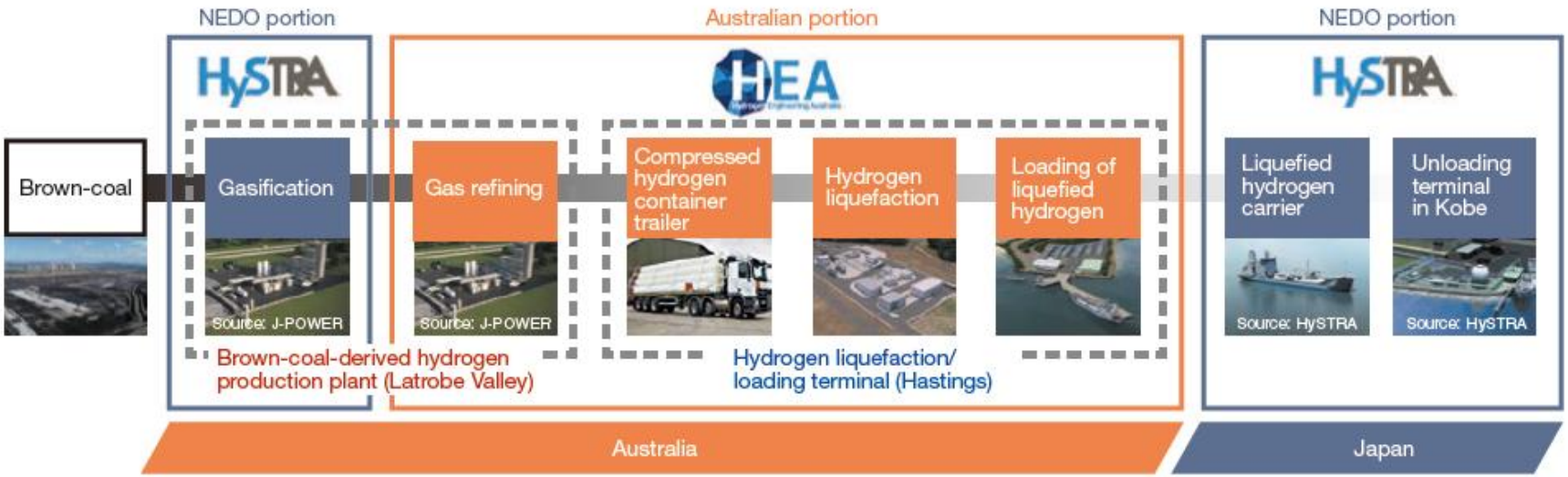
Japan–Australia pilot demonstration project



Development
- **-Coal gasification technology**
- **-Technology of long distance transportation of large mass LH2**
- **-LH2 loading and unloading technologies**

HySTRA : CO2-free Hydrogen Energy Supply Chain Technology Research Association
・Iwatani, ・Kawasaki, ・SHELL Japan, ・J- power, ・Marubeni ・ENEOS , ・Kawasaki Kisen
HESC : Hydrogen Energy Supply Chain
・Kawasaki, ・J-power, ・Iwatani, ・Marubeni, ・Sumitomo , ・SHELL, ・A G L

Source : HySTRA home page http://www.hystra.or.jp/news/
HESC(Hydrogen Energy supply chain) home page https://hydrogenenergysupplychain.com/about-hesc/

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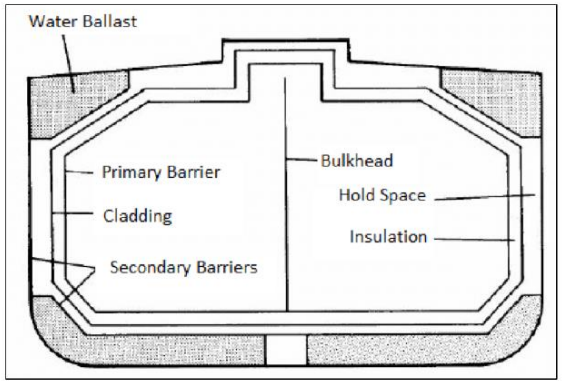
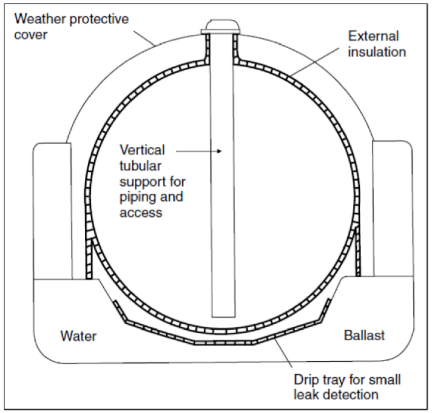
Typical types of independent tanks of LNG carriers as per IMO, IGC

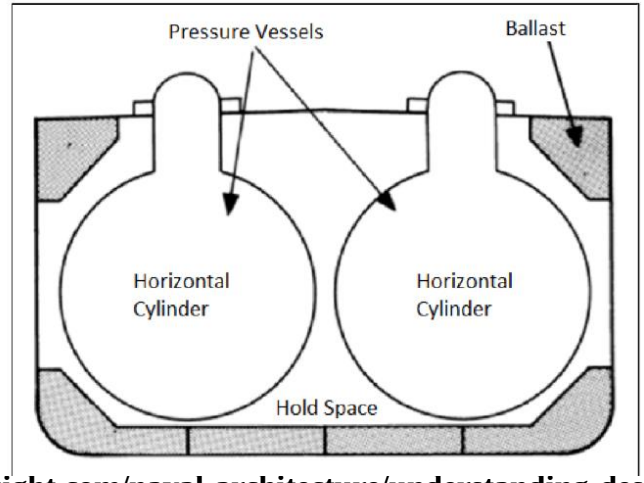
Type 'A' tank



Type 'B' tank



Type 'C' tank



A Pilot LH2 carrier adopted Type 'C ' tank as cargo containment system .

-IMO: International Maritime Organization
-IGC code :
The International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

Source : https://www.marineinsight.com/naval-architecture/understanding-design-liquefied-gas-carriers/Understanding the design of liquefied gas carriers

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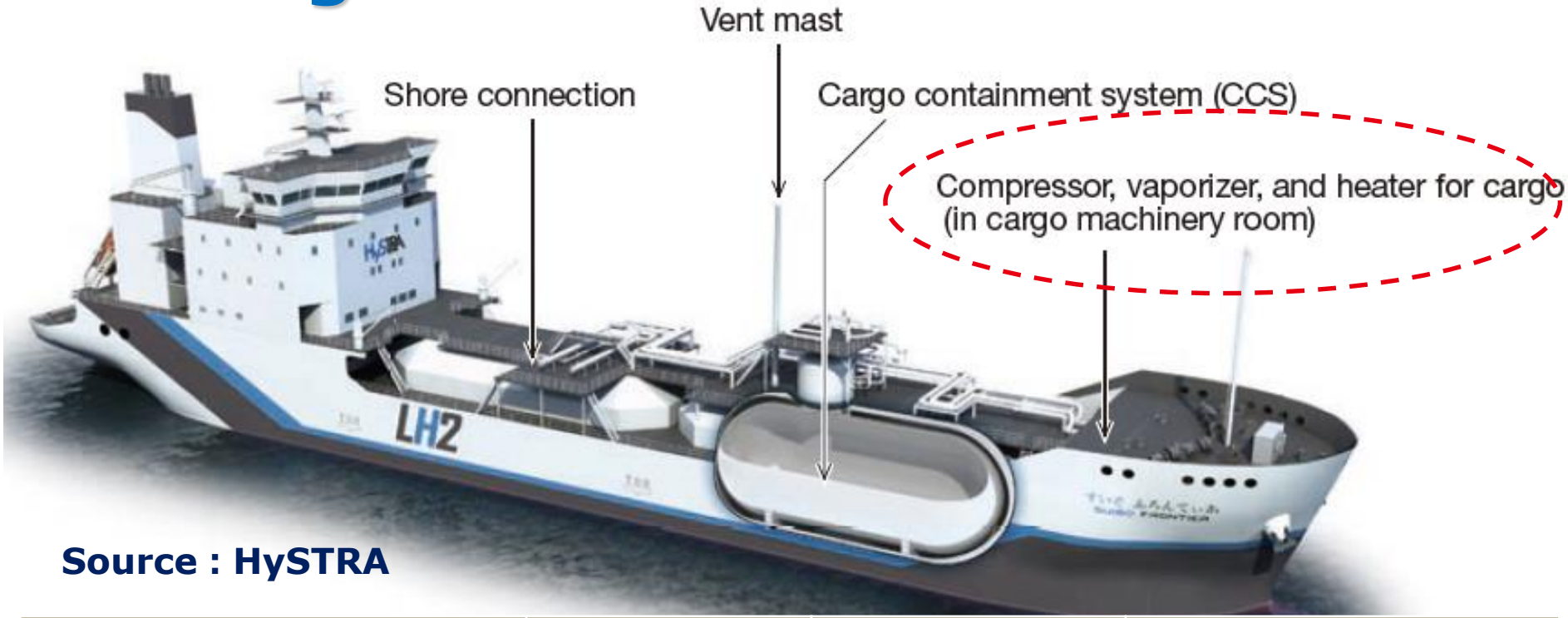
Image of a Pilot LH2 carrier



Source : HySTRA

Items	Specification	Items	Specification
Length overall	116.0m	Propulsion system	Diesel power generation / electric propulsion
Length between perpendiculars	109.0 m	Cruising speed	Ab.13 knots (24km/h)
Width	10.6 m	Crew	25 persons
Full draft	4.5 m	Class	NK
Gross tonnage	Ab. 8,000 ton	Flag	Japan
Cargo tank capacity	Ab. 1250 m^3 x1	Ship owner	HySTRA

Source :
--O. Muragishi et al; Hydrogen Transportation-Development of liquefied hydrogen Carrier, Kawasaki Technical Review No.182(2021) etc

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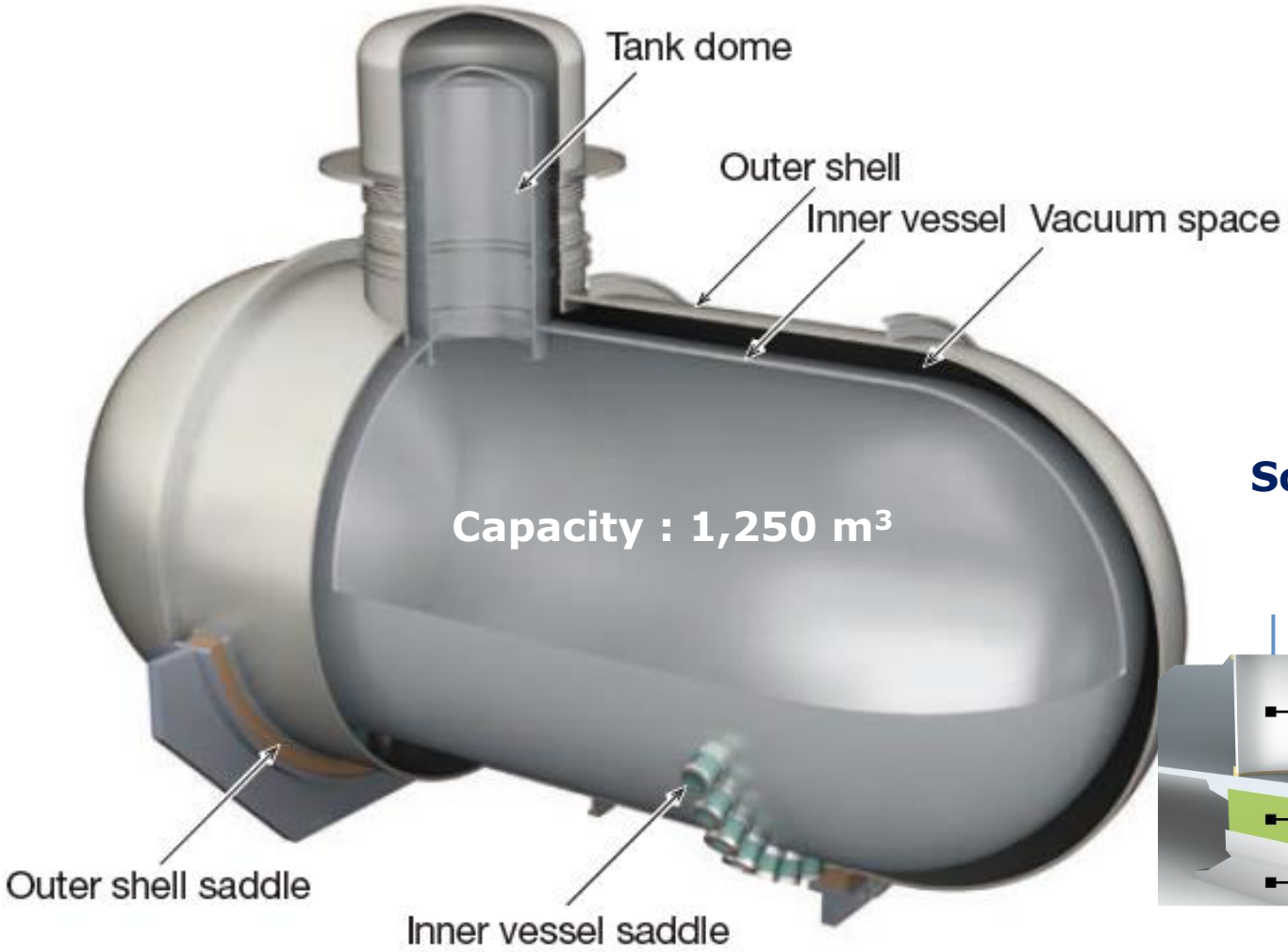
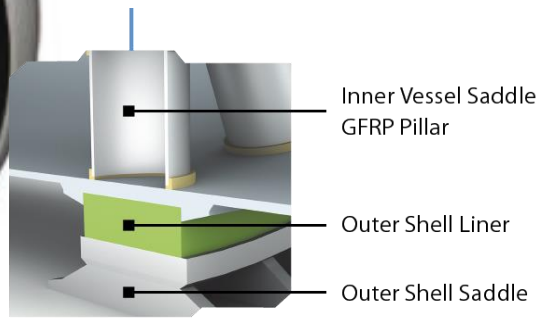
Cargo containment system of a pilot LH2 carrier



Source : HySTRA



Source:

- **O.Muragishi et al; Hydrogen Transportation-Development of liquefied hydrogen Carrier, Kawasaki Technical Review No.182(2021)**
- **HySTRA (CO2-free Hydrogen Energy Supplely –chain Technology Research association) brochure (Feb. 2020)**

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Special requirements (e.g.) for LH_2 carrier safety

1) Thermal insulation and its materials of a cargo tank, cargo process piping, pressure vessels and equipment
   - Thermal insulation for reducing heat ingress. Measures against liquid air

2) Vacuum insulation system for a cargo containment system
   - Measures against vacuum degradation

3) Design, arrangement of cargo process piping , pressure vessels and equipment
   - Arrangement and joints considering thermal expansion and contraction

4) Pressure relief for cargo tanks
   - Consider scenarios of blowing in a tank and piping

5) Vent systems for a cargo containment system
   - Avoiding above design pressure and static electricity. Proper stack height

6) Measurement of temperature and gas concentration, gas detection and fire detection
   - Standard of gas and flame detectors and proper their locations

7) Risk assessment
   - Qualitative and quantitative analyses by HAZID, HZAOP, FMEA

Source :
--CLassNK ; Guidelines for liquefied Hydrogen Carriers (2017)

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Launching of a LH_2 carrier(SUISO FRONTIR (Dec. 2019)

Source : HySTRA

LH2 carrier under outfitting (May 2020)

Source : O. Muragishi et al; Hydrogen Transportation-Development of liquefied hydrogen Carrier, Kawasaki Technical Review No.182(2021) etc

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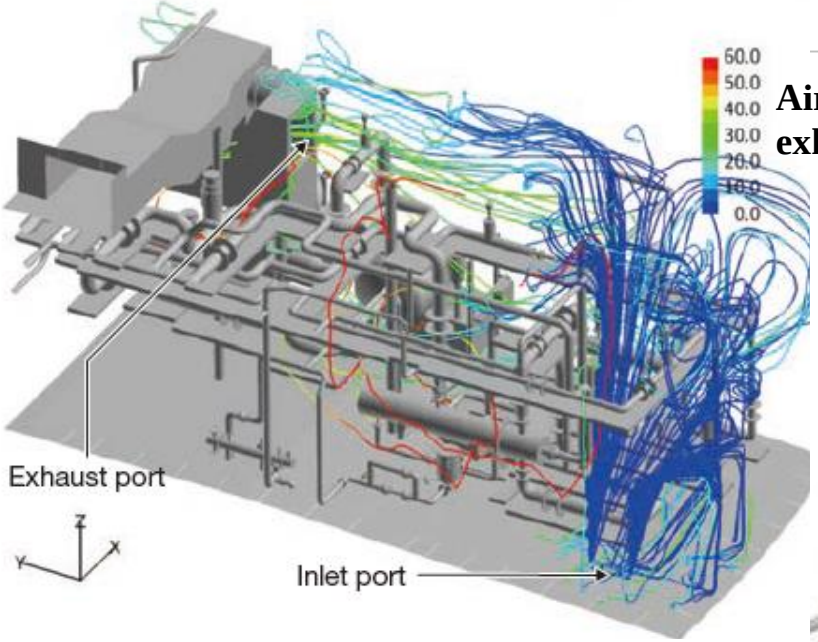
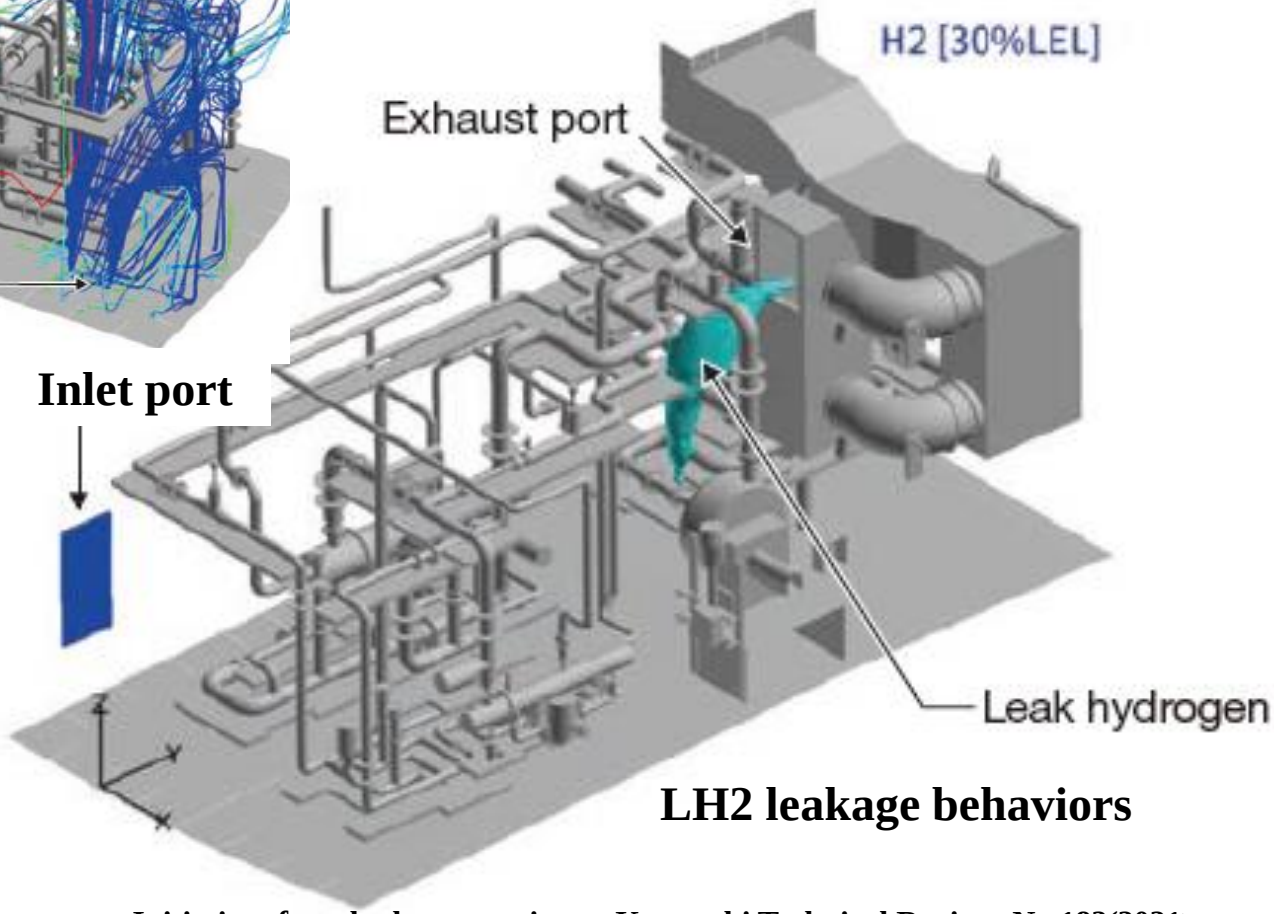
Ventilation flow analyses for a machinery room



Air residual time(sec) from the inlet to exhaust port

Ventilation flow behaviors



LH2 leakage behaviors

Source :K. Kanbe et al; Product Safety Assessment Initiatives for a hydrogen society, Kawasaki Technical Review No.182(2021)

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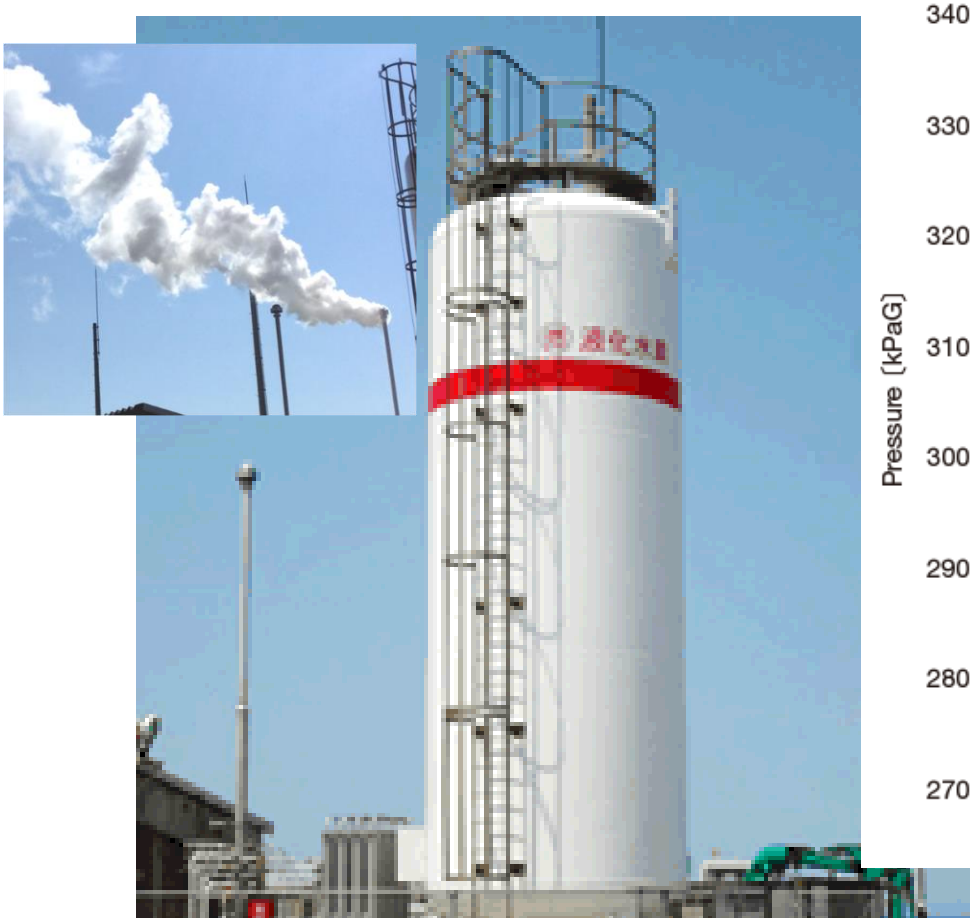
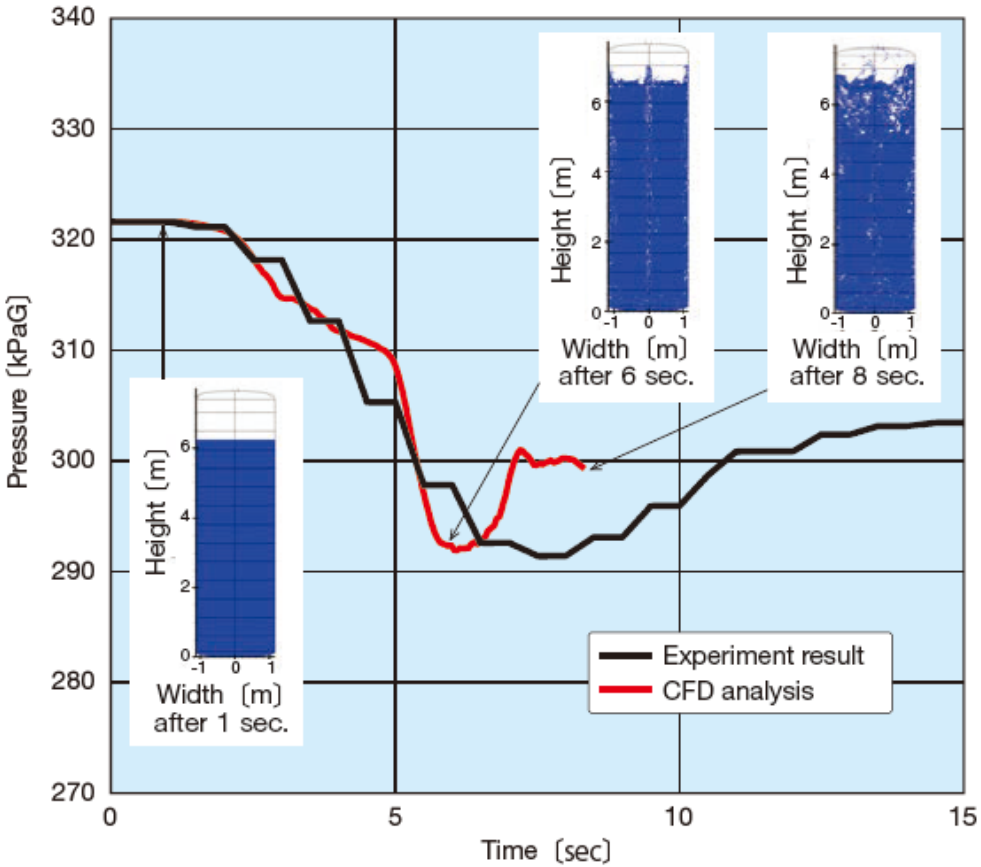
Rapid depressurization experiment using a 30m³ LH2 tank





Pressure behaviors after rapid pressure release

Cooperative research by Tokyo University & JAXA(Japan Aerospace Exploration Agency)

Source :

-K. Kanbe et al; Product Safety Assessment Initiatives for a hydrogen society, Kawasaki Technical Review No.182(2021)

-K.Tani, et al, Prediction of pressure reduction rate in 30m3 liquid hydrogen tank based on experimental and numerical analysis ,ICHS 2019

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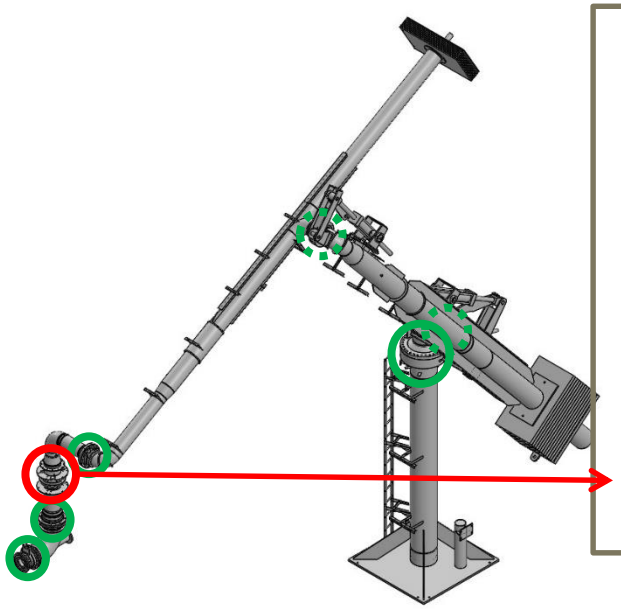
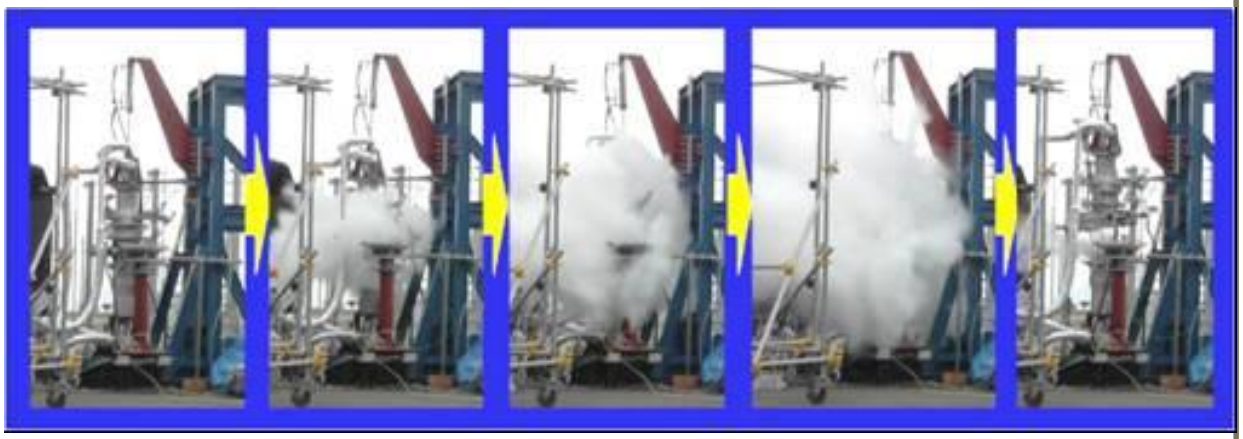
Quick release test of ERS using LH_2

- ERS(Emergency Release System)
- Swivel joints





This work was supported by Council for Science, Technology and Innovation (CSTI), Cross-ministerial Strategic Innovation Promotion Program (SIP), “Energy Carriers” (Funding agency: JST).

Source : A. Inomata ; Development of transfer arms for marine transportation of liquefied hydrogen,
The 2nd International Workshop on Liquefied Hydrogen Technology (Oct. 2018)

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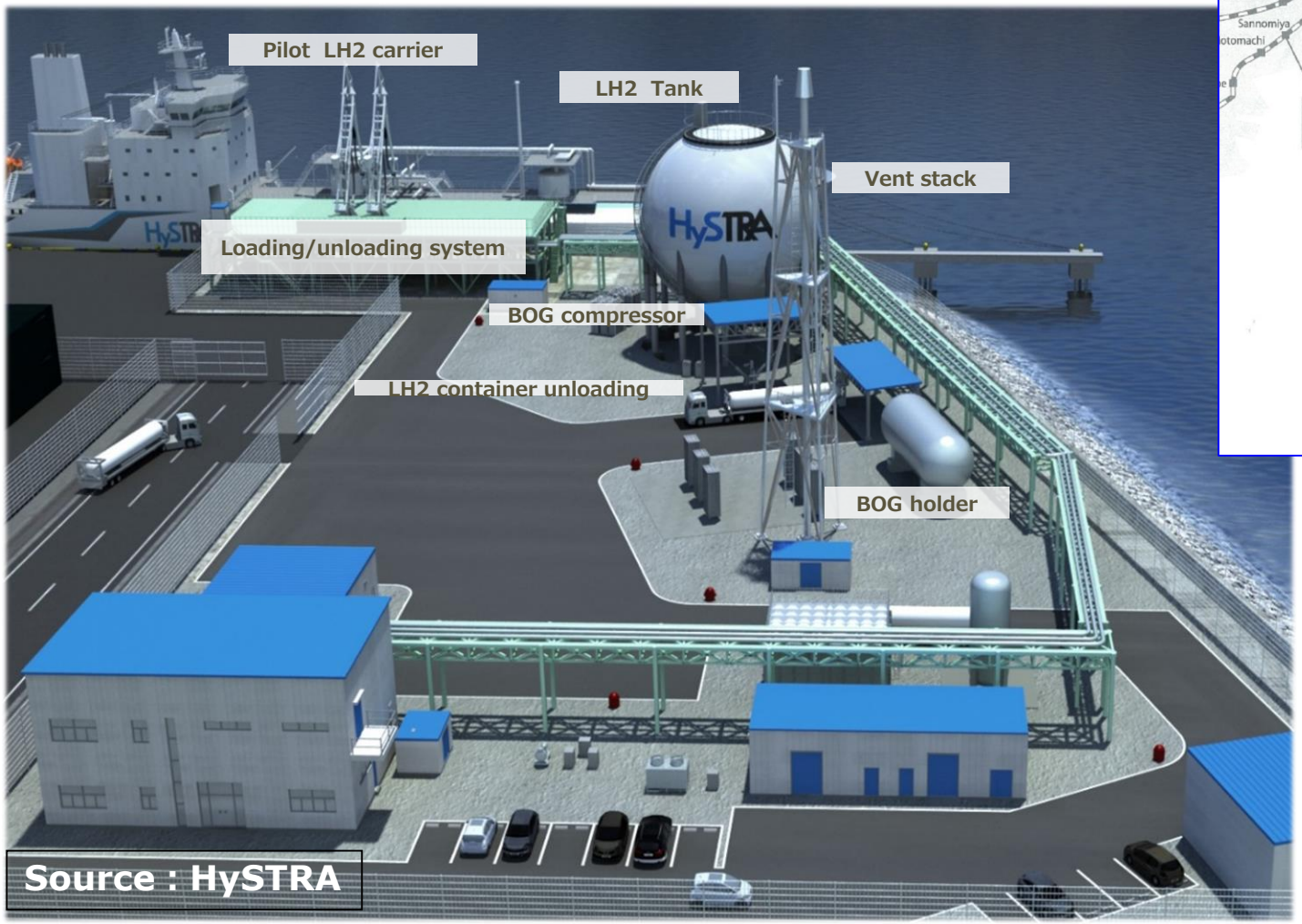
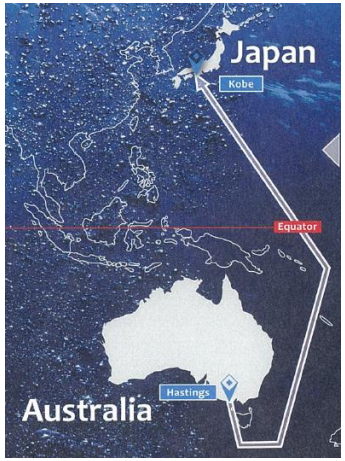
Pilot LH2 unloading terminal (Kobe)





Source:

- **HySTRA (CO2-free Hydrogen Energy Supplely –chain Technology Research association) brochure (Feb. 2020)**

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Pilot LH2 unloading terminal （Kobe）

Source : HySTRA

LH2 tank spec. ・Structure and Capacity : Double–shell spherical tank, 2,500 m^3
・Thermal insulation : Vacuum perlite insulation
・Outer dia. of a tank : ab.19m
・Boil off rate : less than 0.1 % /day

Source :M. Nishimura et al, Activities for Realization of International liquefied Hydrogen chain. Kawasaki Technical Review No.182 (2021)

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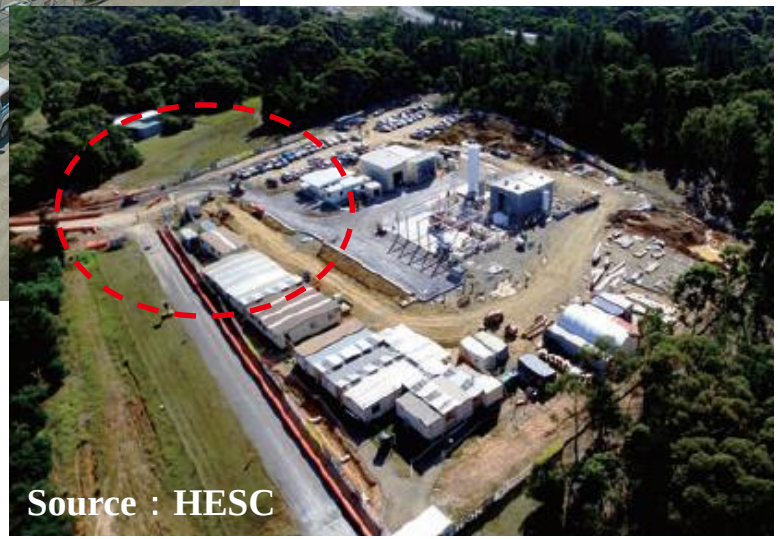
Hydrogen liquefaction terminal at the port of Hasting in Australia

Source：HESC (Hydrogen Energy Supply Chain)



Source：HESC

Source :
M. Nishimura et al, Activities for Realization of International liquefied Hydrogen chain. Kawasaki Technical Review No.182 (2021)

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Summary

1) We are developing LH2 carriers toward establishing a CO2 free hydrogen energy supply chain till 2030.

2) At the first step, we have developed a pilot LH2 carrier with 1250 m^3 as per IMO Interim Recommendation (NK guideline).

3) The CCS(Cargo Containment System) of a pilot LH2 carrier adopted the independent type tank ‘C’ with thermal vacuum insulation.

4) We are adjusting equipment of CCS after the preliminary experiment using LN2.

5) The pilot LH2 carrier will do trial sail on the Japan coast, and sail to Australia in 2021.

6) We have conducted numerical analyses and experiments besides safety requirements of NK guideline.

7) We have completed LH2 terminals of Japan and Australia.

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