Commercialization Barriers and Issues for Large Scale Hydrogen Infrastructures

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Commercialization Barriers and Issues for Large Scale Hydrogen Infrastructures

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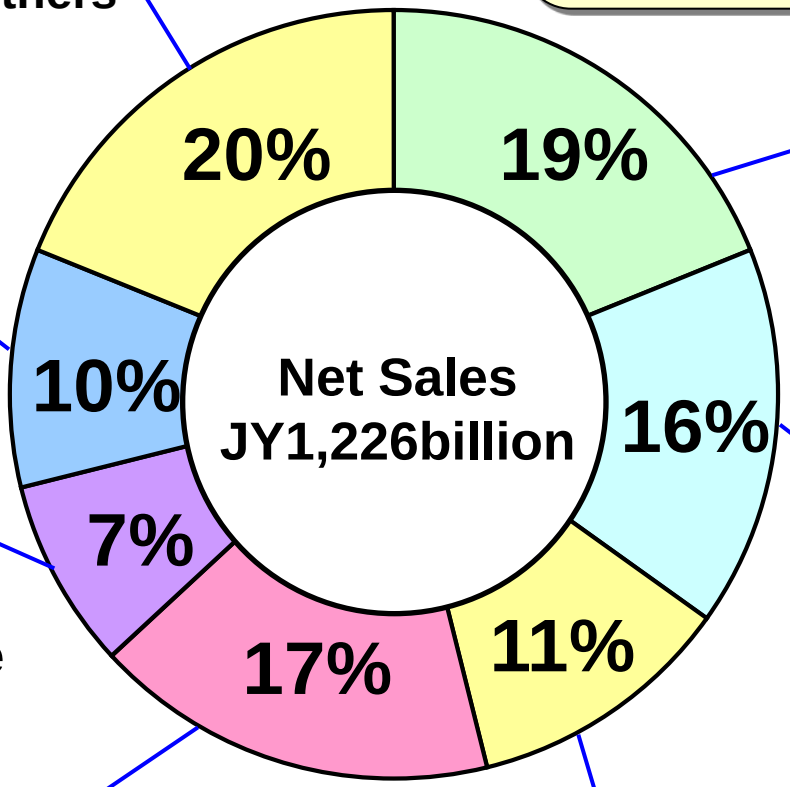
KHI Corporate data

Founded：1878
Paid-in Capital JY104 billion
Employees 32,706
Head offices: Tokyo, Kobe

Ship building

Hydraulic components, others



Motorcycle & Engine

Plant & Infrastructure

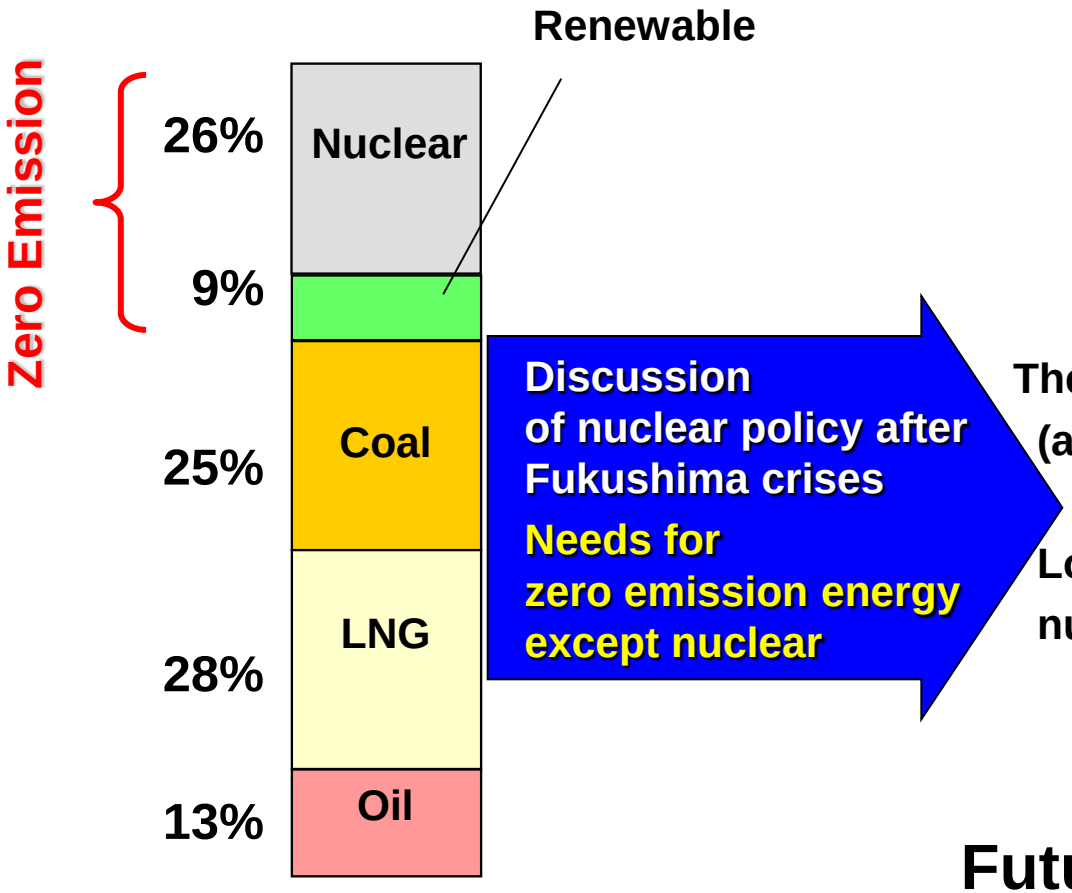
Aerospace

Gas Turbines & Machinery

Rolling Stock

（April, 2010 ~ March, 2011）

Japan's Future's Energy Plan ?



Current breakdown of Japan's energy

Discussion of nuclear policy after Fukushima crises

Needs for zero emission energy except nuclear

The energy and environmental strategy (announced in Sept.14,2012)

Lowering the nation's reliance on nuclear energy to zero in the 2030s

Future's Basic Energy Plan of Japan ?

Why CO2 free hydrogen?

Need for CO2 free energy in the world

① Nuclear energy

② Renewable energy

③ Hydrogen energy

CO2 Free Hydrogen corridor

(import hydrogen from resources countries)

Hydrogen sources :

-Renewable energy (Wind, sunlight)

-Fossil sources with carbon capture at the production location

CO2 free hydrogen chain of KHI

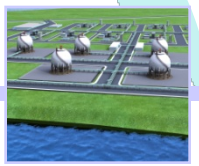
Australia

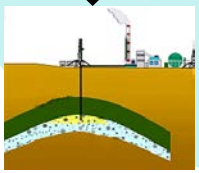
Japan

Hydrogen Production

Brown coal gasification

Hydrogen base



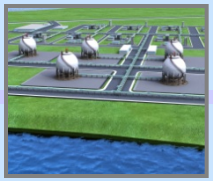


CO_2 Storage

Maritime transport

Hydrogen carriers

Hydrogen base



Hydrogen Use

Use in processes
Semiconductor and solar cell production, oil refining and desulfurization, etc.

Electric power plants
Combined cycle power plants, etc.

Co-generation
Hydrogen gas engines, gas turbines, boilers, fuel cells, etc.

Transportation equipment
Fuel cell vehicle, Hydrogen station, etc.

Kawasaki's products related to Hydrogen chain

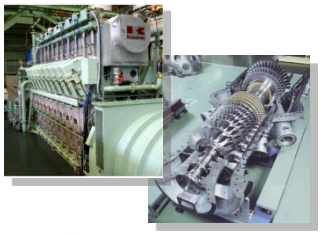
Fertilizer plant

LNG base

Liquid hydrogen tank (Rocket launch system)

LNG carrier

Hydrogen lorry & container



Gas engine Gas turbine

LNG power plant

Advantages of CO2 free hydrogen chain

1. **Zero emission**
   It is zero emission like renewable energy

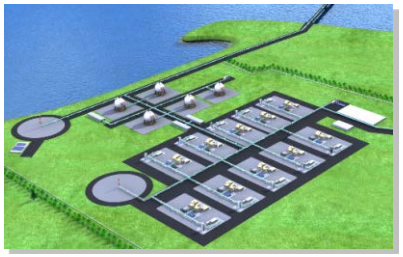
2. **Massive and stable utilization**
   We can use it in massive whenever and wherever we like
   (Renewable energy is relatively small scale and not stable supply)

3. **Lower cost**
   It is cheaper than renewable energy

Hydrogen production cost estimated by FS

CIF cost
30 yen/Nm³

Hydrogen carrier	9%
Loading base	11%
Hydrogen liquefaction	33%
Hydrogen production	29%
ccs	10%
Brown coal	8%



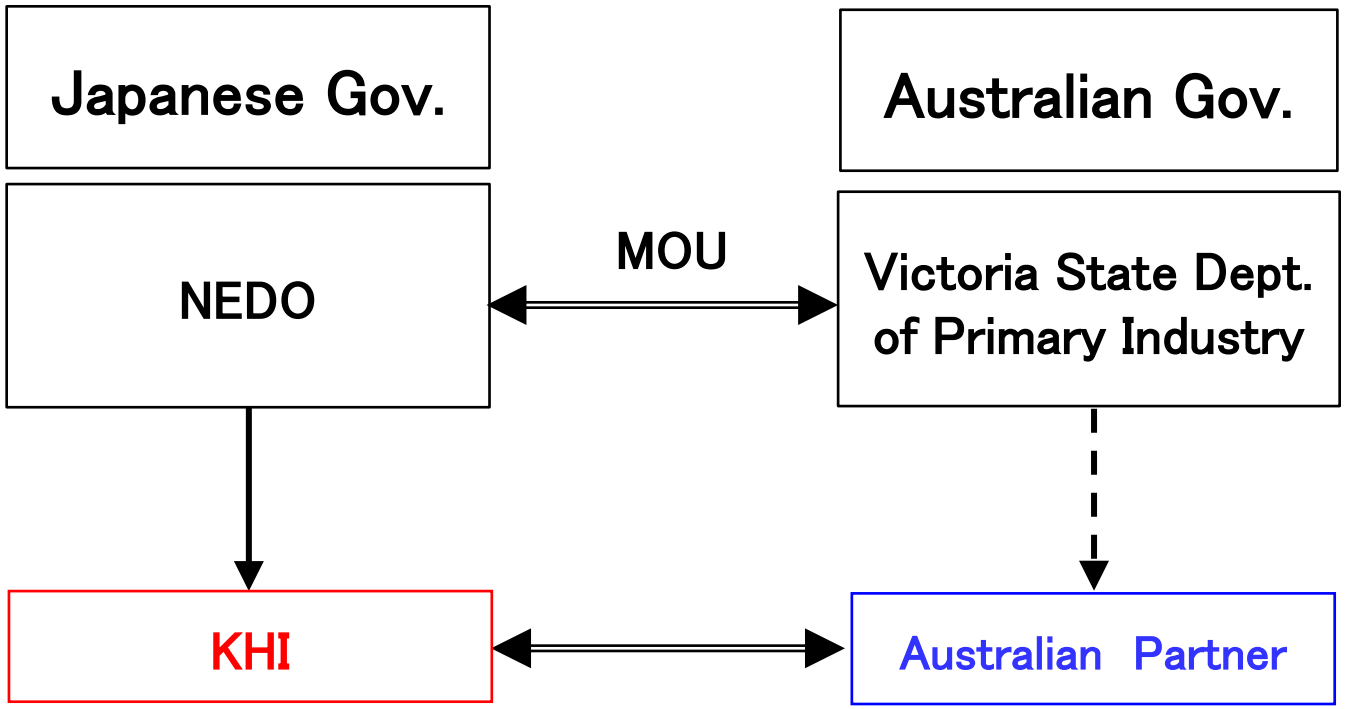
Arrival hydrogen:
225,400t / year(2.5 billion Nm3)

FCV (Fuel Cell Vehicle): 3 million

Hydrogen power plant : 650 MW

CIF cost =Hydrogen cost +Insurance + Freight

Feasibility Study (FS) for Commercial Chain （Japan-Australia joint study）



Execution scheme of FS

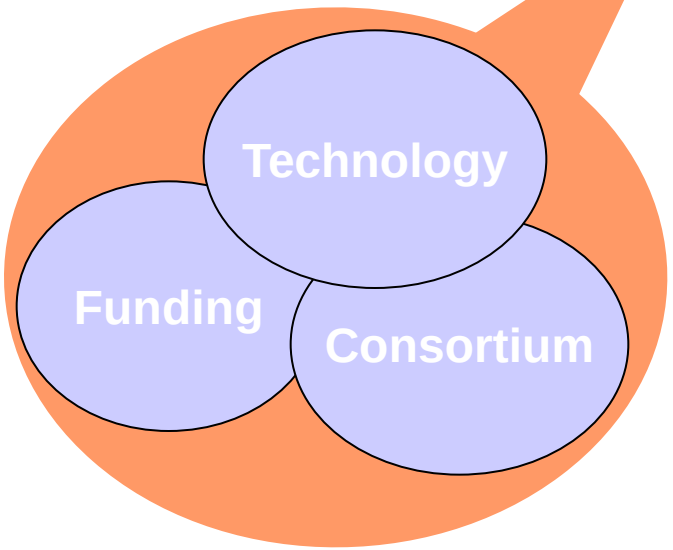
Schedule of hydrogen chain development

Year	'10	'11	'12	'13	'14	'15	'16	'17	'18 ~ '24	'25	'30
Pilot chain	R&D FS Basic engineering				Construction				Operation		Commercialization
Demo. chain					Planning				Engineering Construction		

Pilot decision

Pilot chain operation

Demo. Chain operation



10t/day hydrogen

770t/day hydrogen

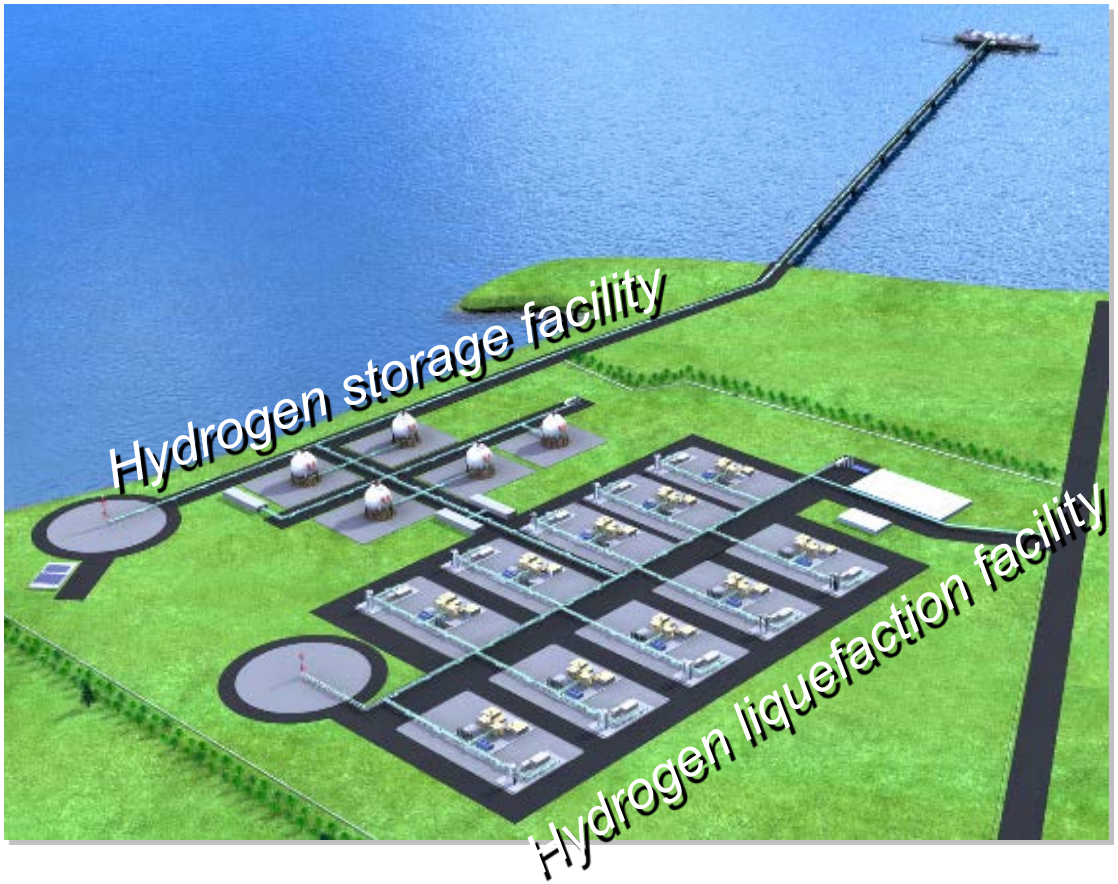
Large scale hydrogen facilities for hydrogen chain

EX. Hydrogen loading base and carrier in 2025

Hydrogen liquefaction
Capacity:770t/day

Hydrogen storage facility
50,000m³ ×5 tanks

Liquid Hydrogen carrier (2 ships)
Loading Hydrogen:
238,500t／year



Large scale hydrogen facilities' specifications

Year	2017	2025
Project	**Pilot chain**	**Demo chain**
Hydrogen liquefier	**10 ton/day**	**770ton /day** **(50 ～100ton/day/1 unit)**
Liquid hydrogen storage tank	**Capacity :3,000m^3** **1 unit** **Sphere tank** **Vacuum insulation** **BOG:0.1%/day**	**Capacity: 250,000m^3** **50000m3 x 5 units** **Sphere or cylindrical tank** **Vacuum insulation** **BOG:0.1%/day**
Liquid hydrogen carrier	**Capacity: 2500 m^3** **(1,250m3 x 2 unit)** **Cylindrical tank** **TYPE C(IGC code)** **Vacuum insulation**	**Capacity: 160,000m^3** **(40,000m3 x 4 units)** **Sphere tank** **TYPE B(IGC code)** **Vacuum insulation panel** **BOG:0.2%/day**

Safety and design code on a large scale LH2 storage

1 Liquid hydrogen technologies of the rocket Lunch system(JAXA)

The system was designed and manufactured according to High Pressure Gas Safety law (HPGS) of Japan

and voluntarily standard taken into consideration on hydrogen

- LH2 tank(540m3):

Safety distance is 167m from the liquid oxygen tank according to the standard blast –wave pressure stipulated in the USA Air Force.

-Vent stack and burn pond - Gas & fire detector system ,

- Deluge & fire extinguishing system、- Emergency shut down system

2 Accidents of large scale liquid hydrogen and its measures

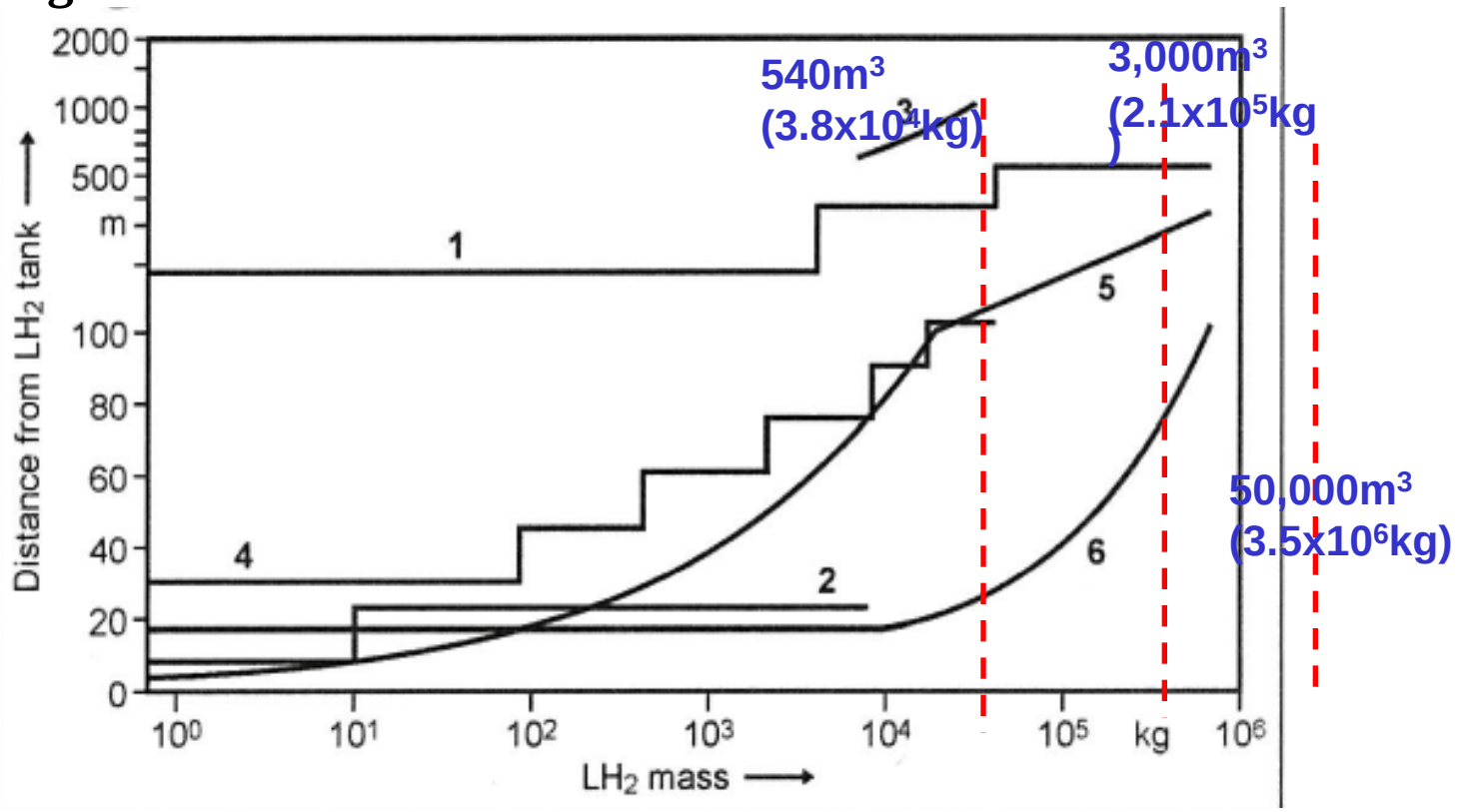
- For example , liquid hydrogen intentionally released

HPGS stipulates a dike of a tank in case of its capacity above 500ton

- Optimized safety distances

Safety distance according to regulations or codes

Quantity –distance relationship between LH2 storage systems and inhabited buildings as a function of LH2 mass



1 US Dep. Defense Instruction No. 4145.21 (1964)
2 National Fire Protection Association (NFPA), Boston (1973)
3 US Army Material Command Safety Manual No. 385-224 (1964)
4 Burean of Mines, Pittsburgh (1961)
5 German Fed. Ministry of the Interior, Bonn (1974) (nuclear power plants) for liquefied gases
6 High-Pressure Gas Control Legislation, Japan (category I)

Reference : " Safety Consideration on liquid hydrogen" p54 , Karl Venfonder (Juelich)(2008)

Safety and design code on a LH2 carrier

1 Conceptual design of a LH2 carrier and their elementary development

- Large bulk transportation is not covered by any existing codes

- In the EQHHP(EU) & the WE-NET (Japan), liquid hydrogen carriers were considered , based on IGC code published IMO

IGC : International code for the Constructing and Equipment of Ships Carrying Liquefied Gases in bulk

IMO: International Maritime Organization

- Test of spilling Liquid hydrogen on ground or water

- Test of cloud dispersion from vent and its ignition

- Performance test of various thermal insulation

2 More discussion and related experiments must be engaged with authorities

- Evaluate more specifically hazards

- Evaluate their consequence on the design

Conclusion

-In Japan, the large mass hydrogen energy may be introduced in the medium and long –term, as a solution to energy issue

-Their scales will be equivalent to the existing LNG energy chain

- Large scale LH2 storage and transportation is not covered by any existing regulations, code, and standards

-International code, standards for large scale hydrogen shall be standardized

EX Safety distance (LH2 quantity- Distance relationship)

-Evaluate current standards and codes related to H2 and improve them

EX. Re-asses the scientific basis of them

- Risk assessment of typical accidents

-Reliable rules or standards for modeling or reducing the effect of hydrogen explosion

- Conduct experimental examinations on accident cases

Thank you for your attention!