

# Japan's movement for Hydrogen society and global hydrogen supply chain

Kawasaki Heavy Industries, Ltd.



# Contents

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1. Overview of Hydrogen Supply Chain
2. Project status
3. Hydrogen Utilization

# Our Products

**Ships/Marine**



**Rolling stock**



**Aerospace**



**Energy/Plants/  
Environment**



**Motorcycles and Engines**



**Precision Machinery**

# Hydrogen related Products



**Fertilizer Plant**



**Rocket Base for JAXA  
(LH2 tanks, supply system)**



**LH2 tanks**



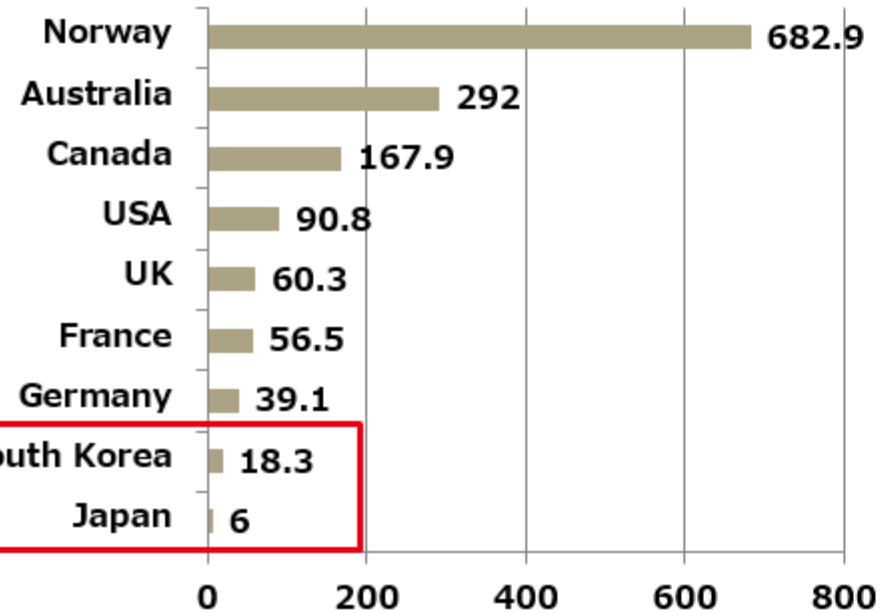
**LH2 container trucks**



**Compressed H2 trailer  
trucks**

# Different situations in Europe and Japan

Primary energy self-sufficiency ratios (%)



Population density ranking

70

35

58

162

22

30

63

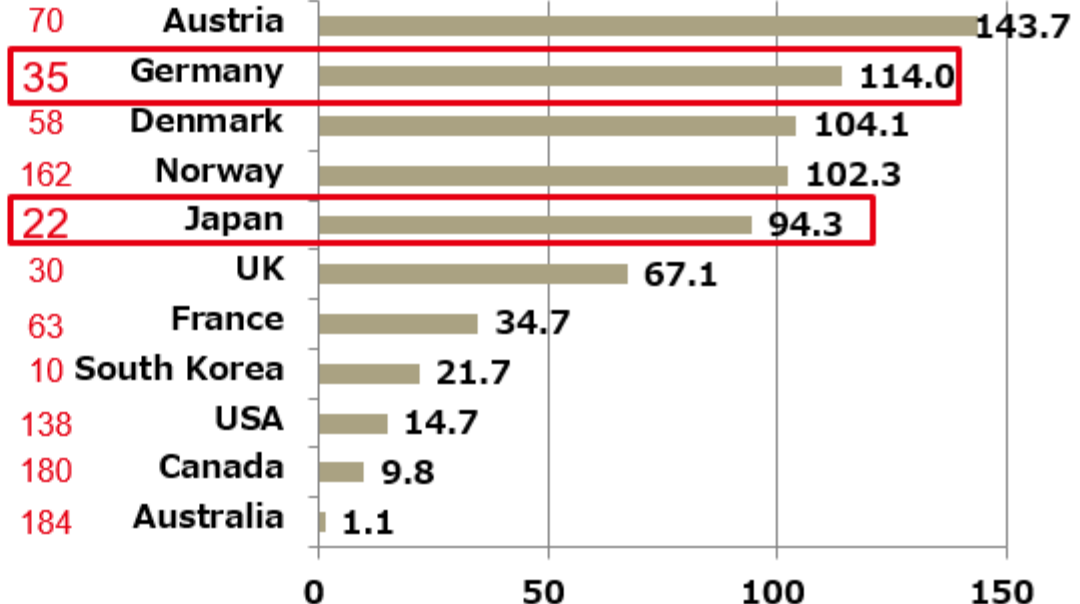
10

138

180

184

Renewable Power introduction per Land Area (TOE/y/km<sup>2</sup>)



In Japan or some regions,

- Enhancement of energy security is very important
- Difficult to increase capacity of renewable energy due to it's high population and limited land space

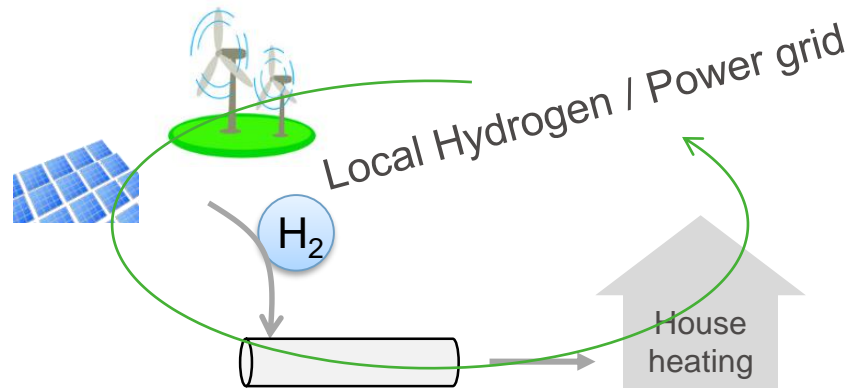
# Different situations in Europe and Japan

## Europe

Low Population density  
= Low energy consumption density

Distributed renewable power  
+ Hydrogen as an energy buffer

No strict regulation on pipeline  
= injection to pipeline available

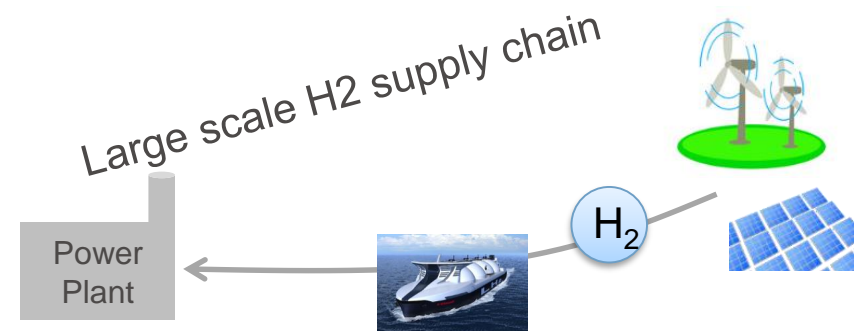


## Japan/Korea/Taiwan

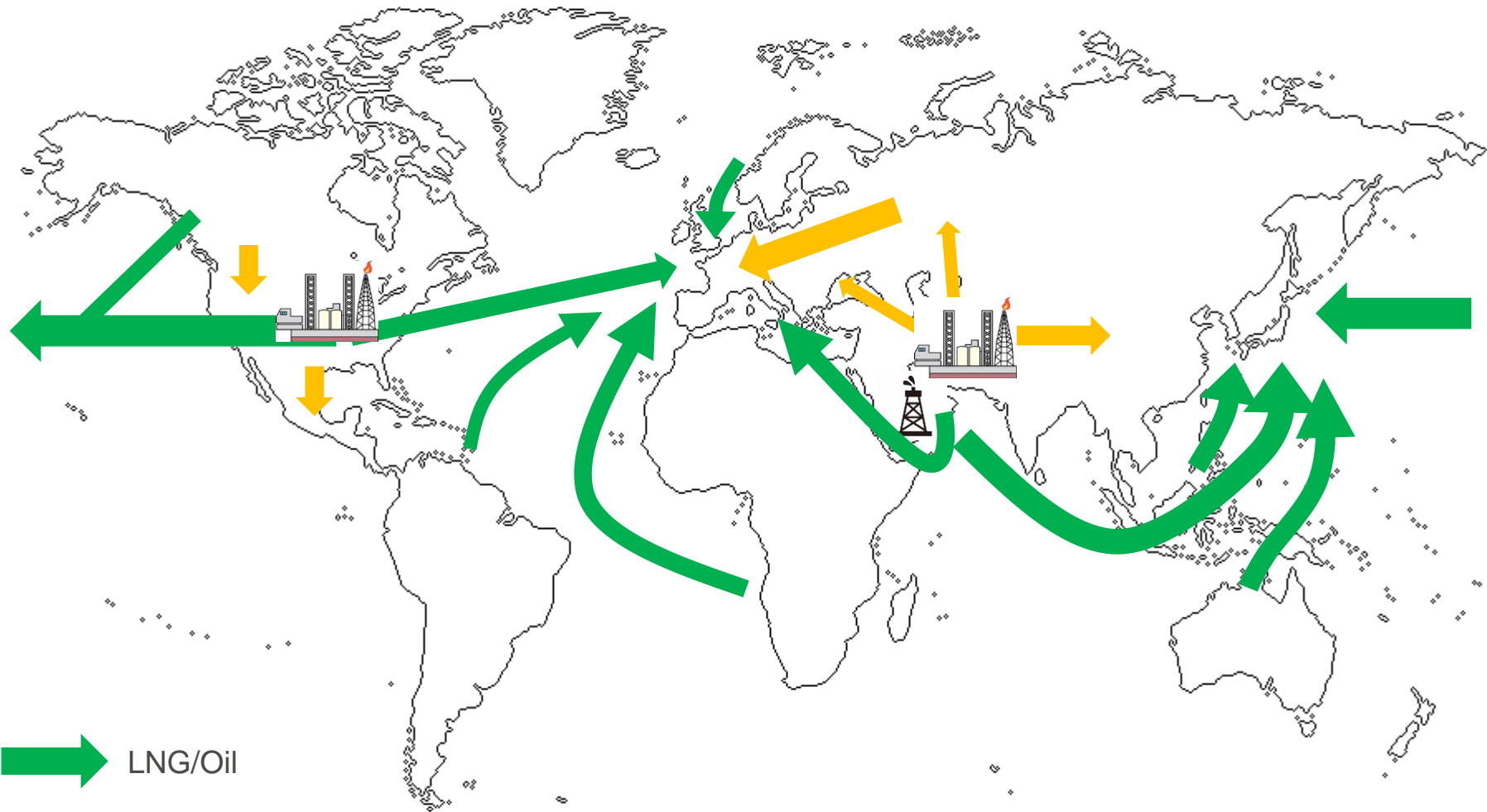
High population density  
= High energy consumption density

Centralized power generation by gas turbine (fueled by fossil or Hydrogen)  
= need energy import

Strict regulation on gas pipeline  
= hard to inject H2 into pipeline



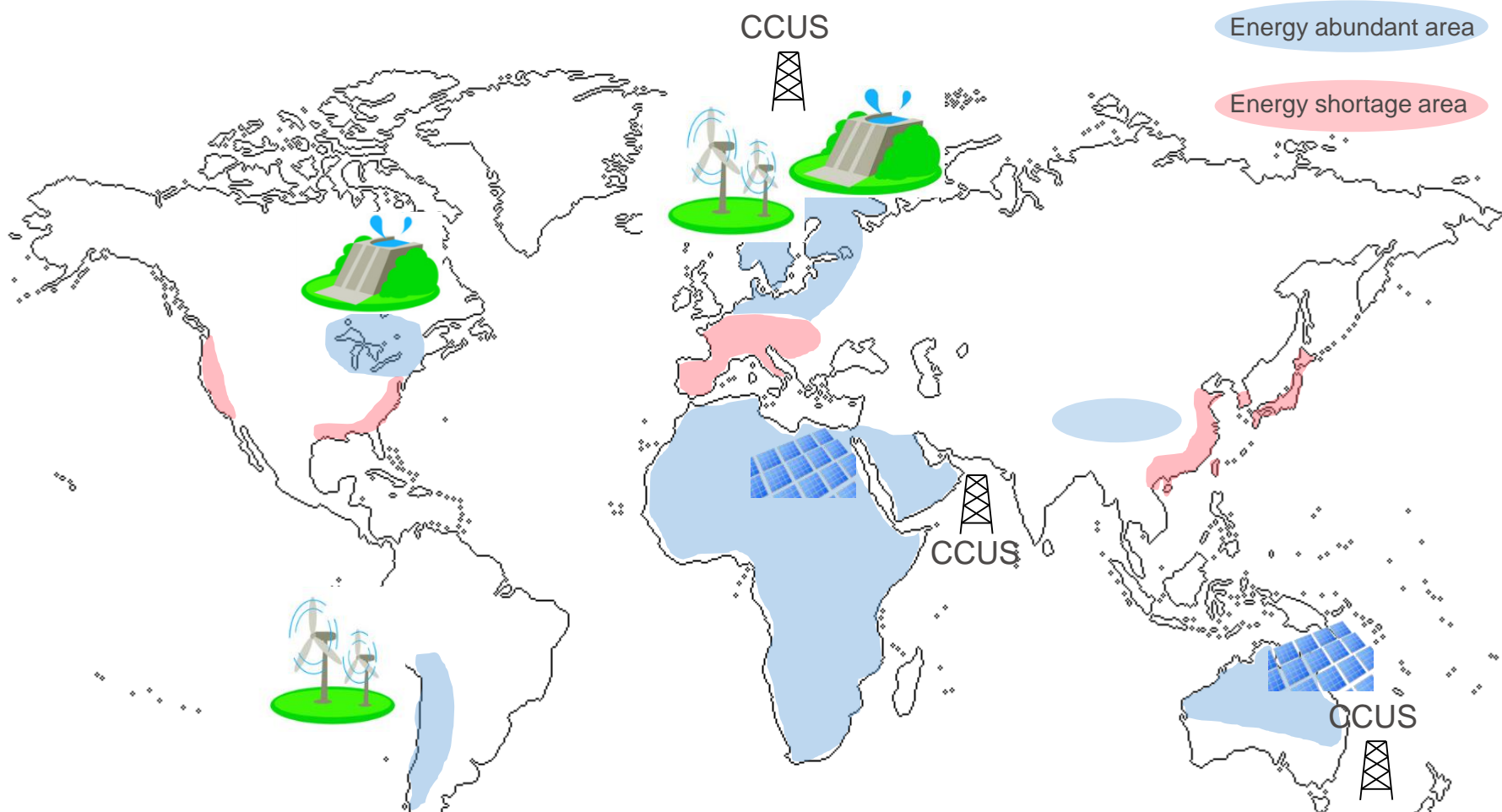
# Energy Distribution



➔ LNG/Oil

➔ Pipeline

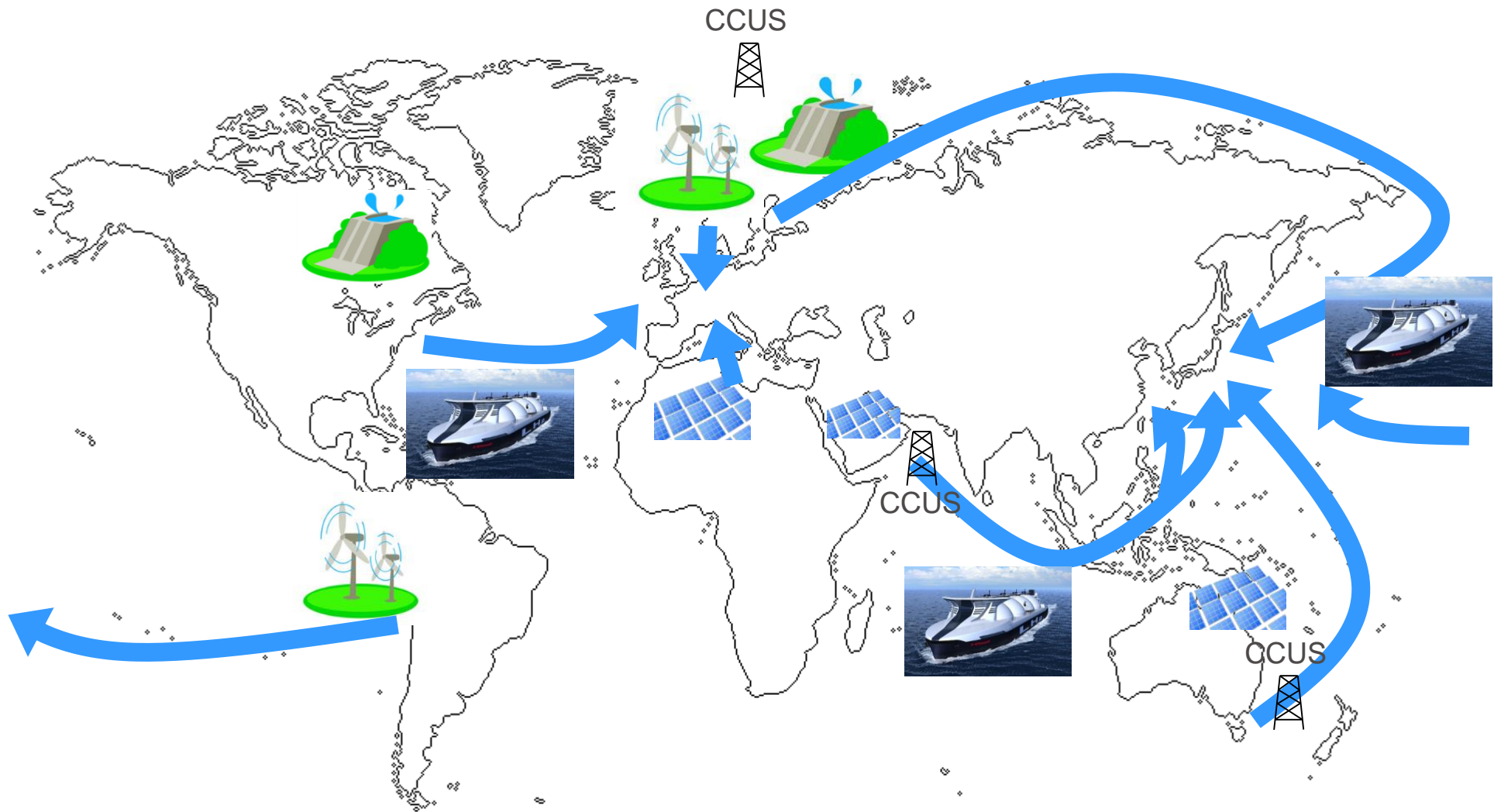
# Energy Distribution



## How will be the energy distribution 2050?

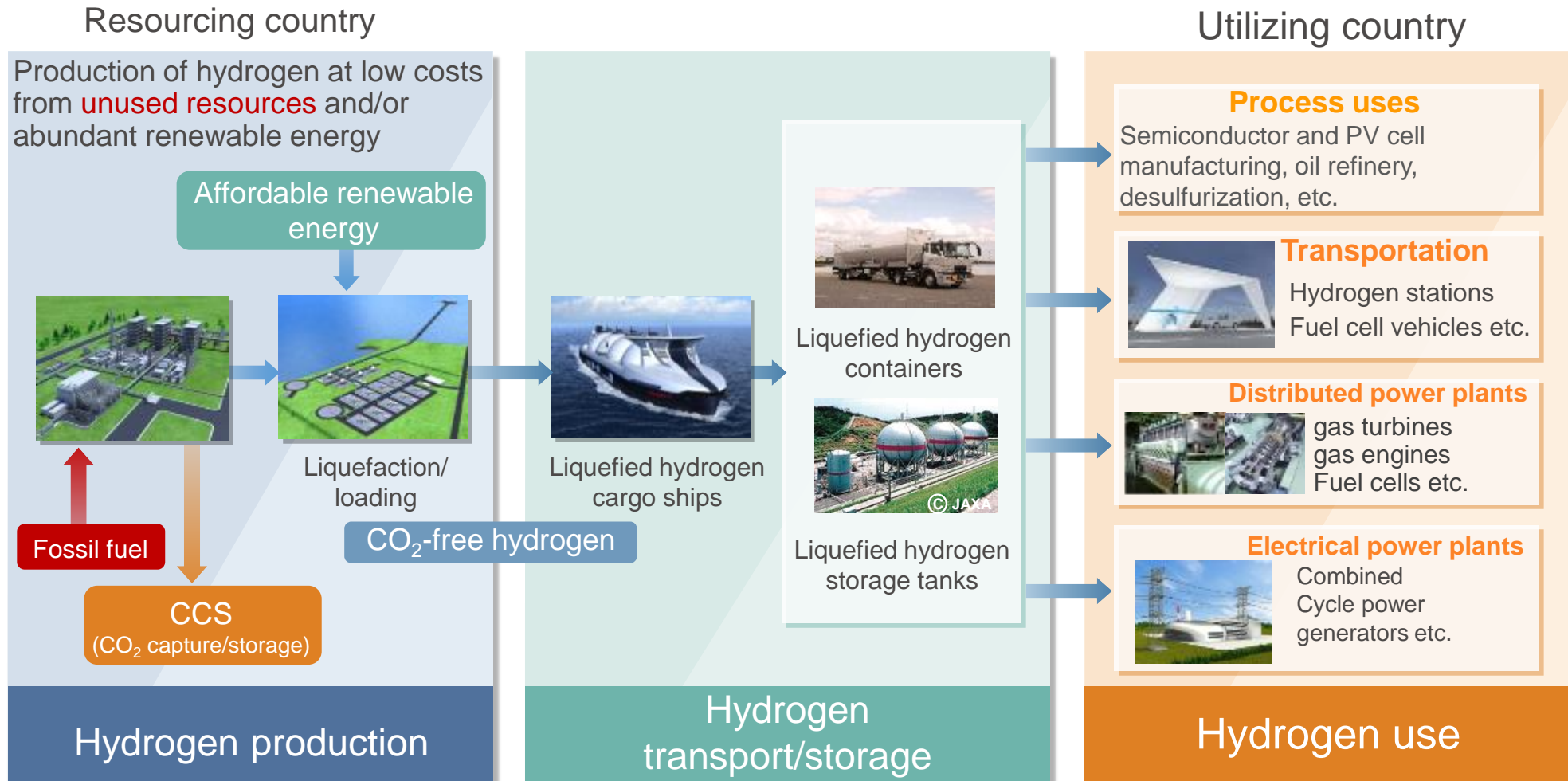


# Expected CO<sub>2</sub>-free H<sub>2</sub> Supply chain



# Concept of CO<sub>2</sub>-free Hydrogen Chains

Stable energy supply while suppressing CO<sub>2</sub> emissions



# Journey for commercialization

2020  
Pilot Demo



1,250m<sup>3</sup> Ship x1

Mid 2020s  
Commercial Demo



Commercial scale  
Technology confirmation

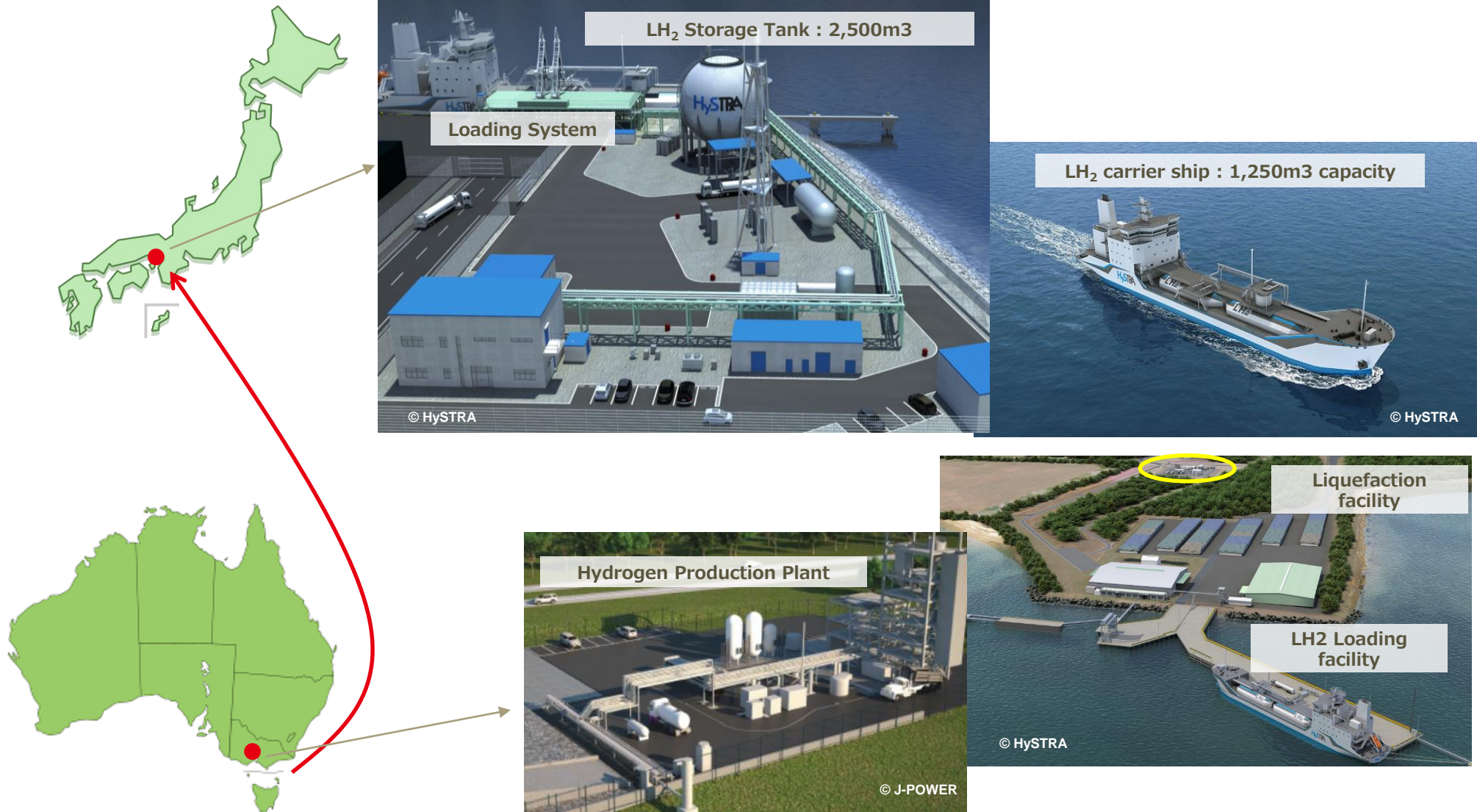
2030  
Full Commercial



160,000m<sup>3</sup> Ship x2  
Commercial Supply chain

Technical & social  
demonstration

# Pilot Demonstration 2020

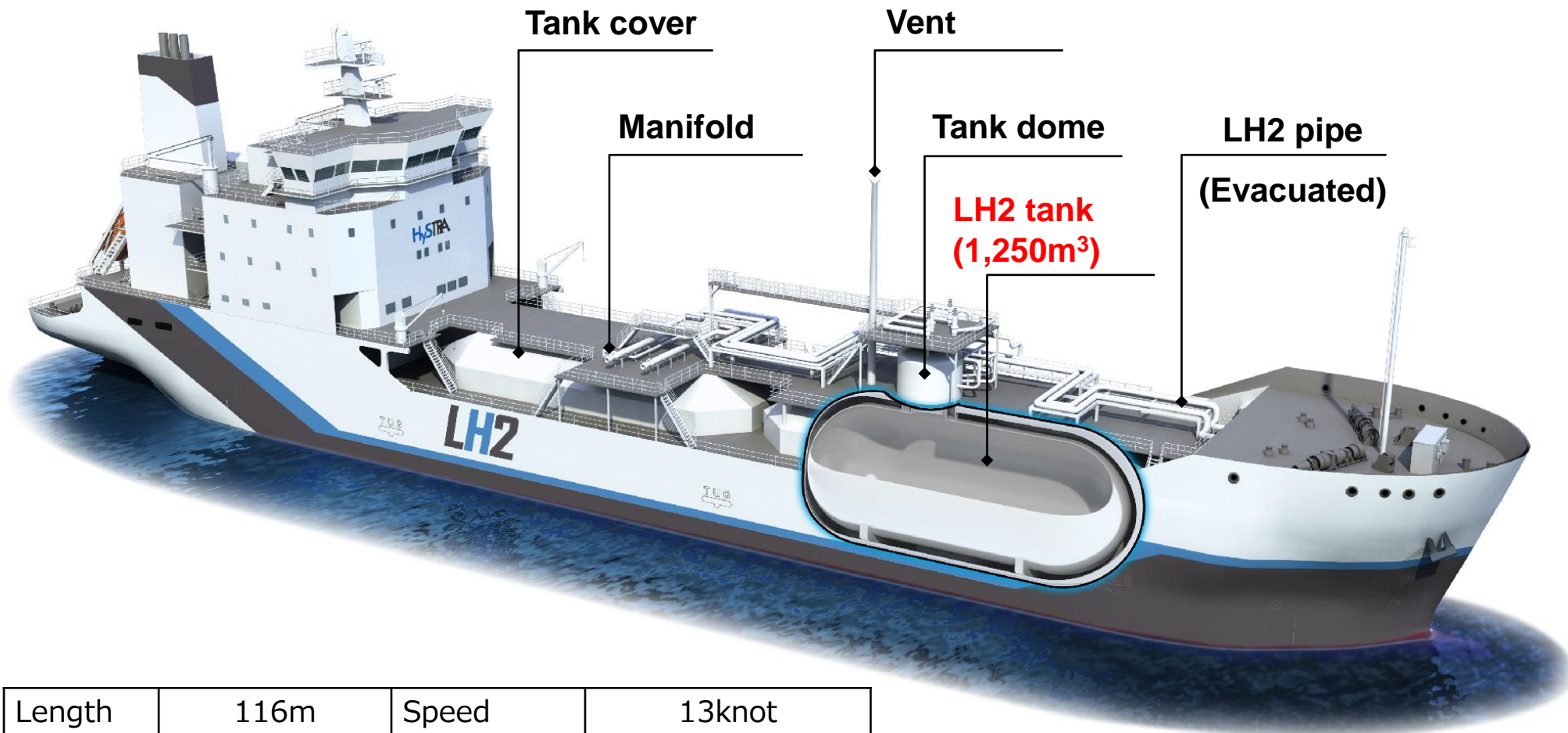


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# Current situation - LH2 cargo Ship -

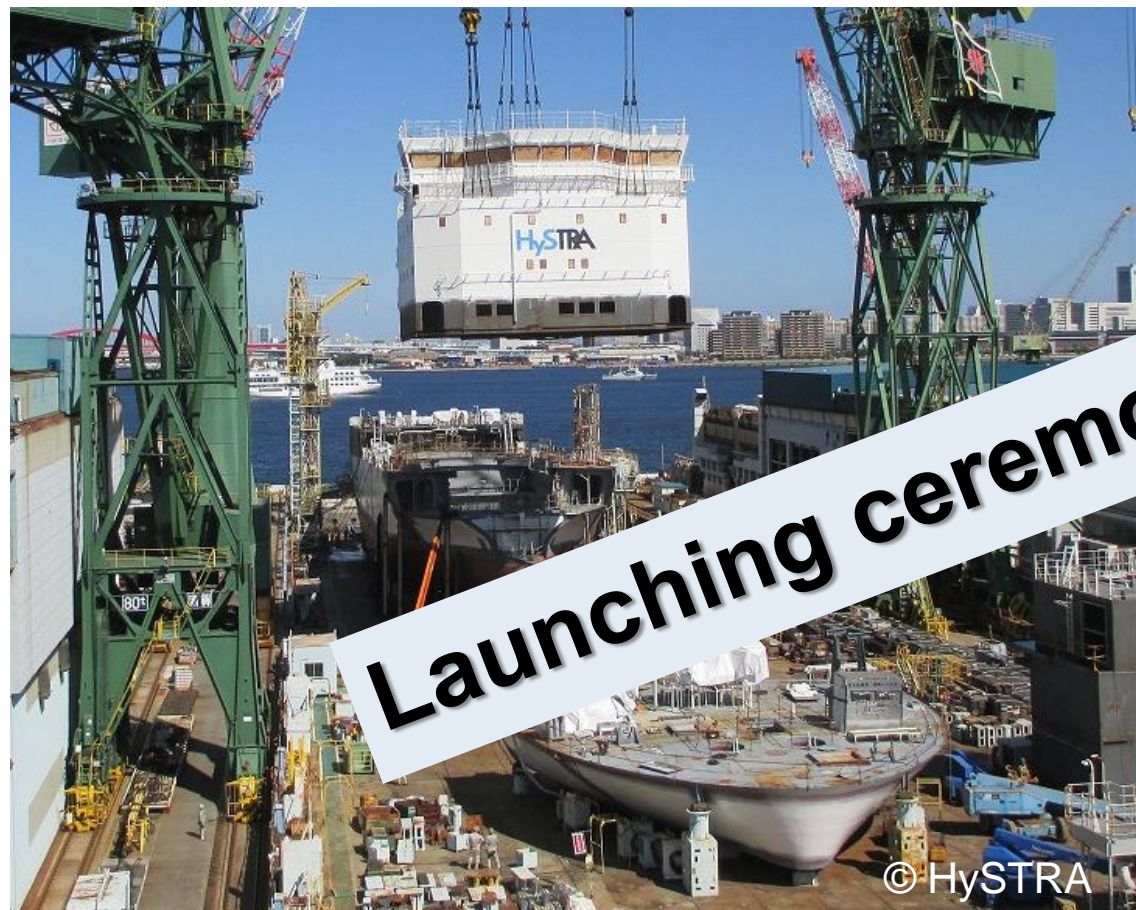


Length	116m	Speed	13knot
Width	19m	Distance	21,000km
People	25	Propulsion	Diesel electric

© HySTRA

1knot = 1.852km/h

# Current situation - LH2 cargo Ship -



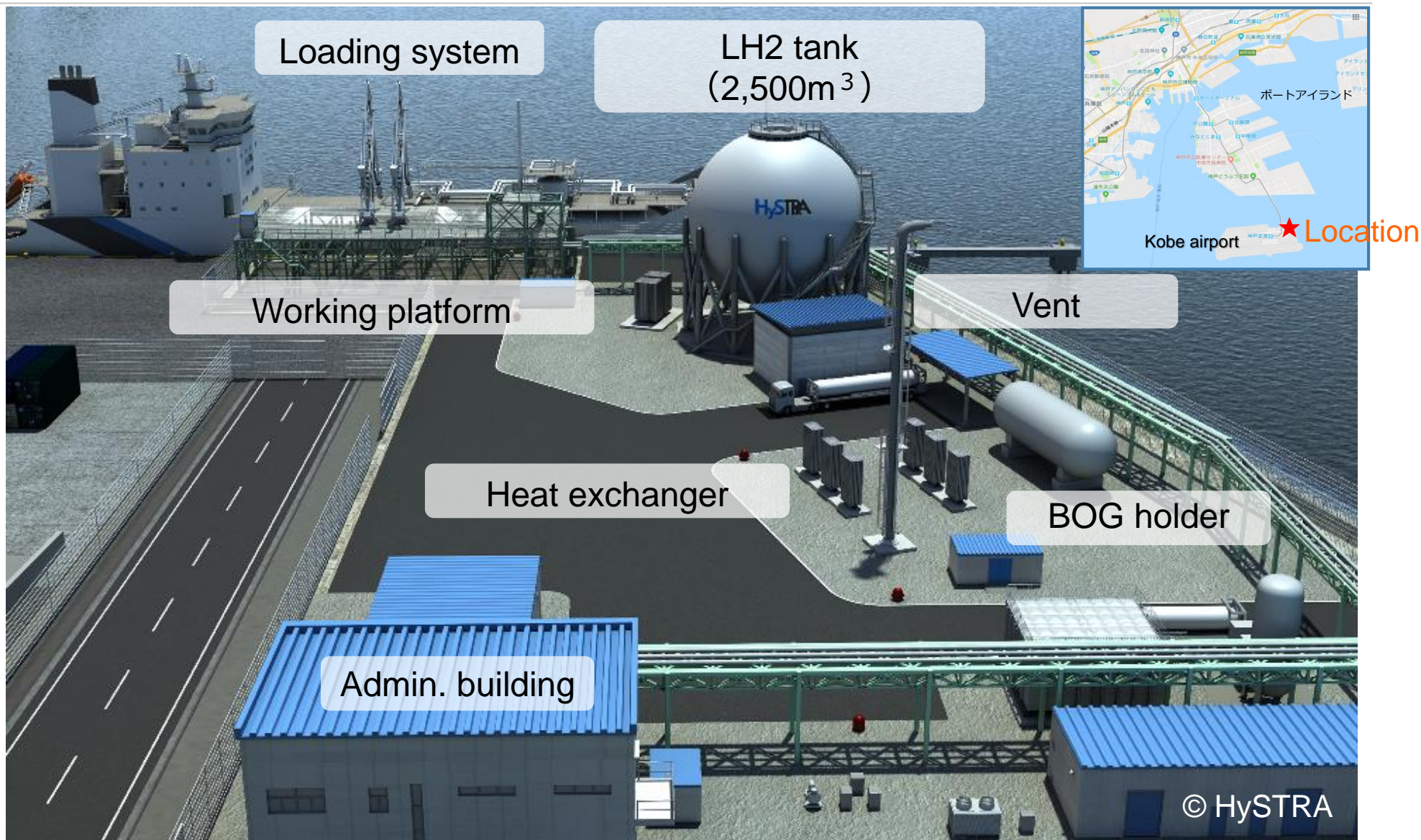
**Launching ceremony Tomorrow !**

© HySTRA

© HySTRA

(as of Sept.2019)

# Current situation – Receiving terminal -





# Current situation – Receiving terminal -



(As of July 2019)

Working platform

LH2 tank

BOG holder

Heat exchangers

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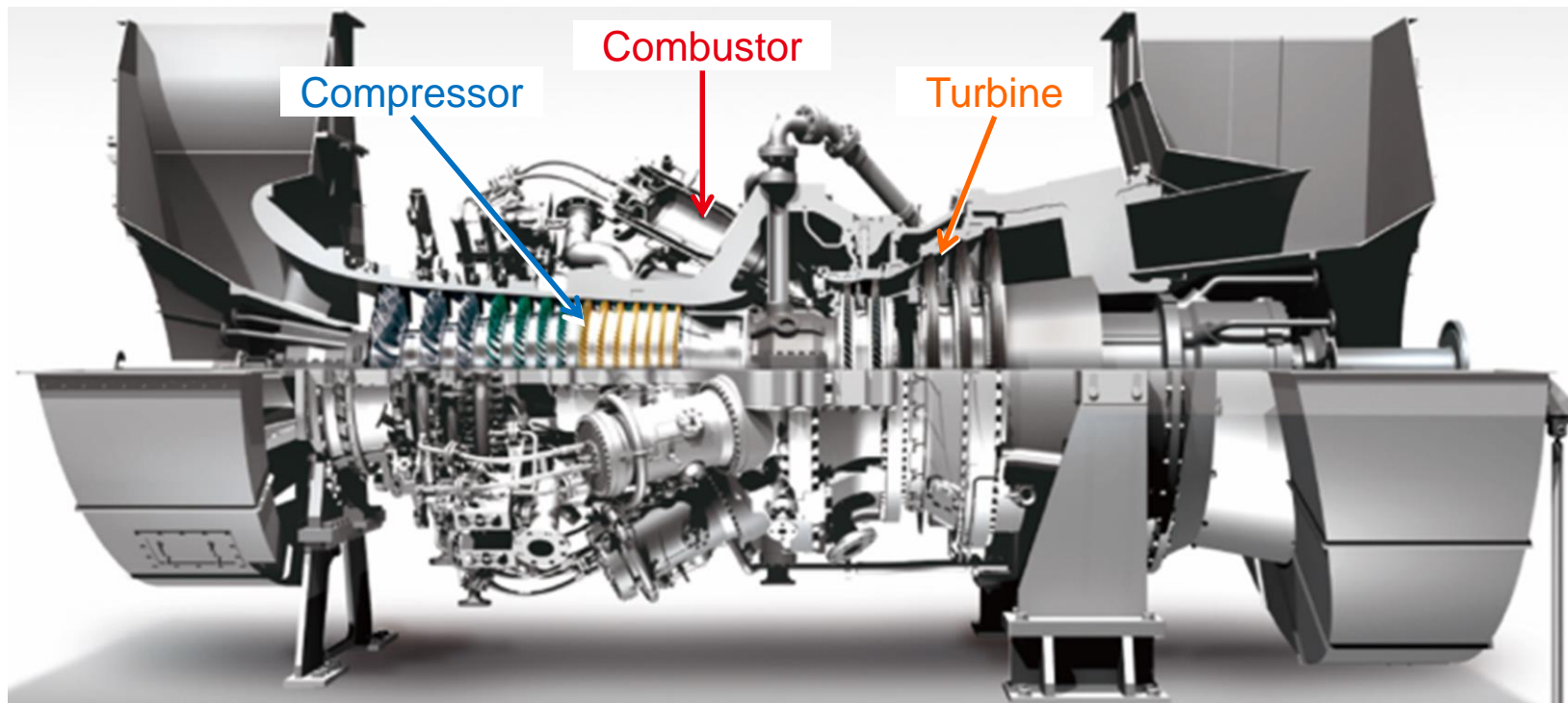
# Hydrogen Gas Turbine

Production

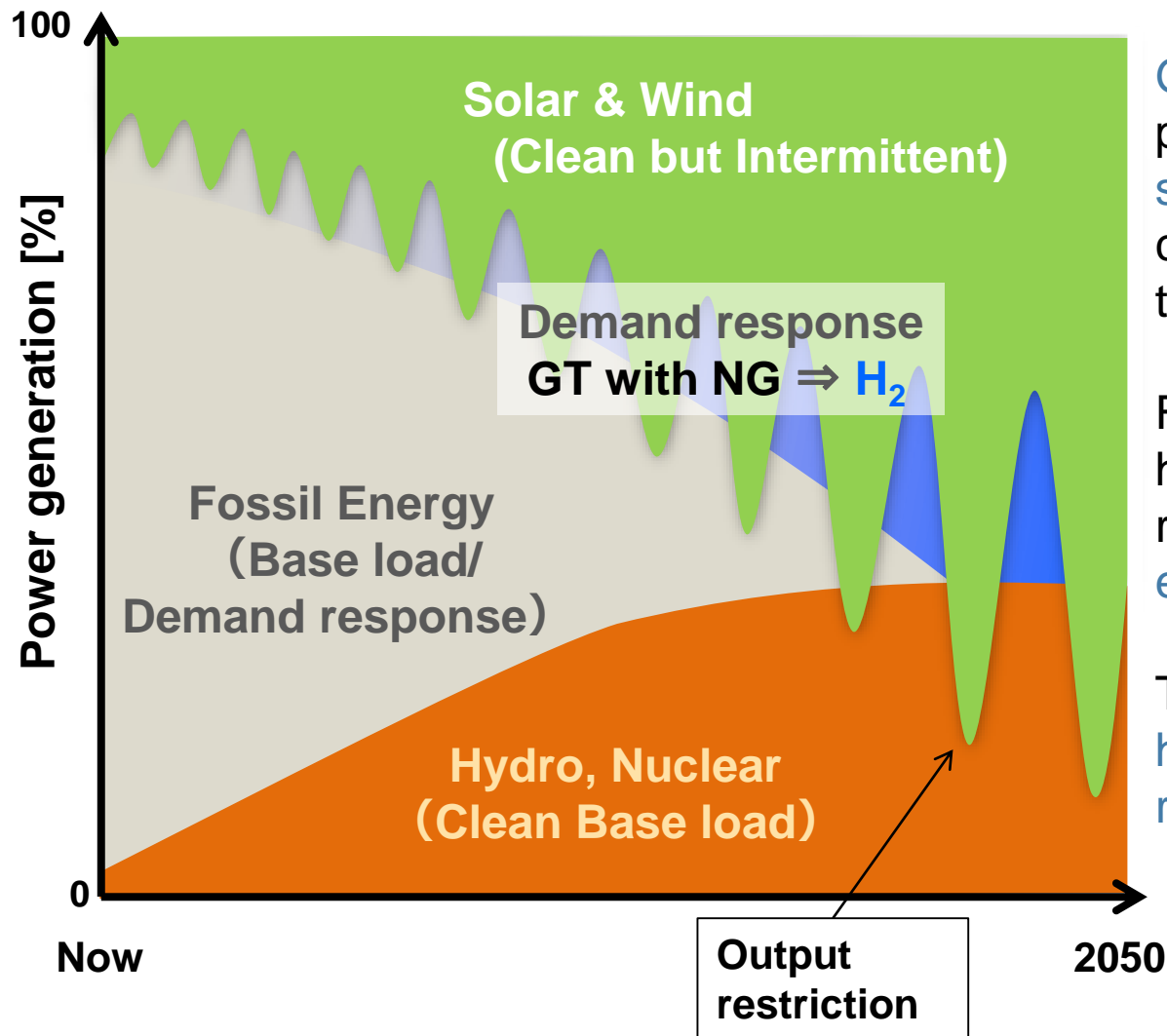
Transport/Storage

Utilization

Application to hydrogen by exchanging combustor only,  
no modification of compressor and turbine



# Solutions to Increase CO<sub>2</sub>-free Powers



Gas turbine(GT) power generation will play an important role to **enhance stability** of the electricity grid, by compensating intermittent power from the renewable energies.

Fuel change from natural gas(NG) to hydrogen can also regulate fluctuation of renewable energies **without CO<sub>2</sub> emission**.

This will be a **good combination** with hydrogen production from excessive renewable power.

# Hydrogen Combustion Issues

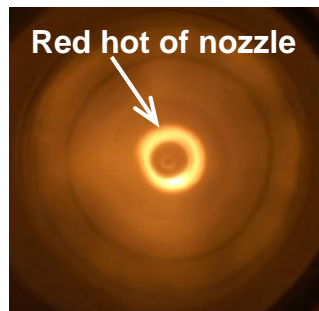
- Higher combustion temperature than that of natural gas (hot spot in the combustion chamber)

➔ Higher NO<sub>x</sub> emission

- Higher flame propagation velocity than that of natural gas

- Shorter flame quenching distance

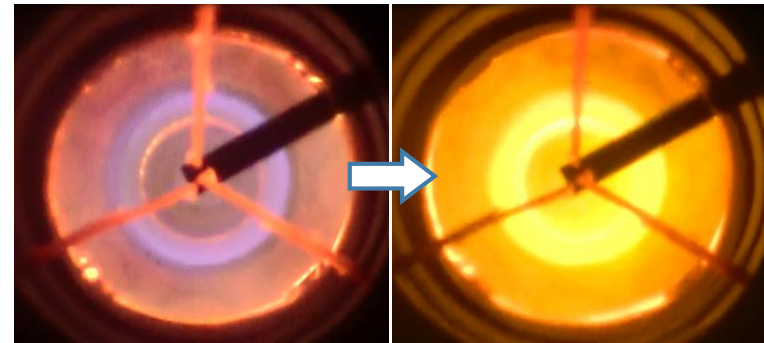
➔ Structural burnout, flash back



Hydrogen  
fueled



The nozzle after test



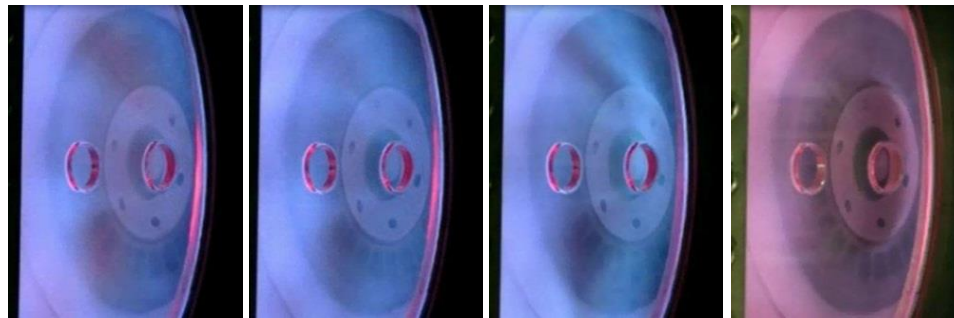
Flash back with pre-mixed combustion

# Fuel Flexible Low NOx Combustion

Flame behavior (Visualization test)

Pure natural  
gas

Pure  
hydrogen

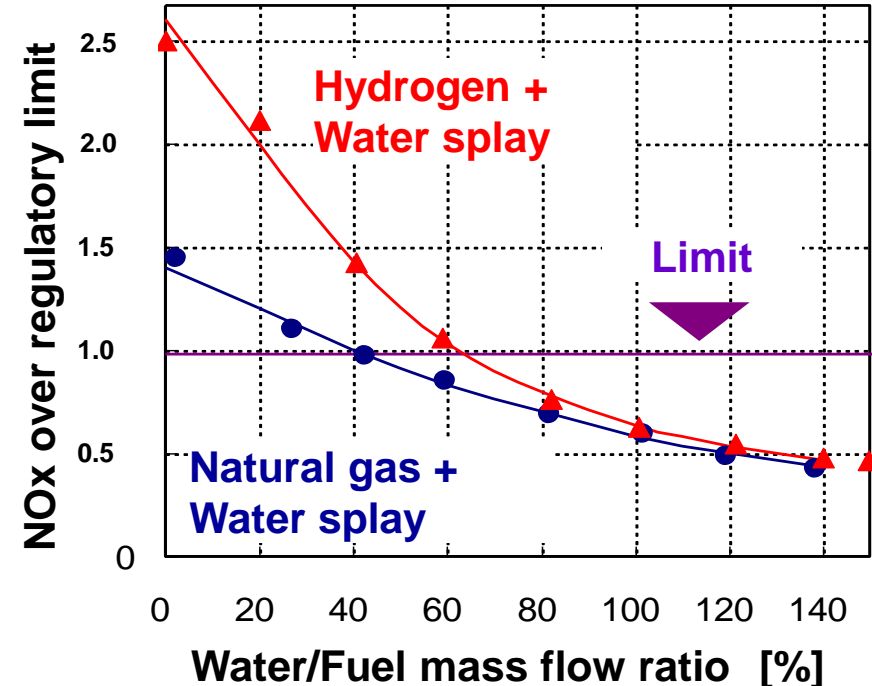


Natural gas 100%  
Hydrogen 0%

60%  
40%

20%  
80%

0%  
100%



- Succeed in 100% hydrogen power generation in urban site
- NOx suppressed less than the limit with water injection

Supported by NEDO

# Hydrogen Power Station in Kobe

Power and heat management system using hydrogen and natural gas as a fuel.

Power Generation: 1 MW class

Partners: Obayashi (Leader), Kawasaki,  
Kobe City, KEPCO, Iwatani, Kenes,  
Osaka University(~FY2018)

Period: FY2016~FY2019



Supported by NEDO



Hydrogen Power Station

# Heat and Power Delivery in the Demonstration



Exhibition Center



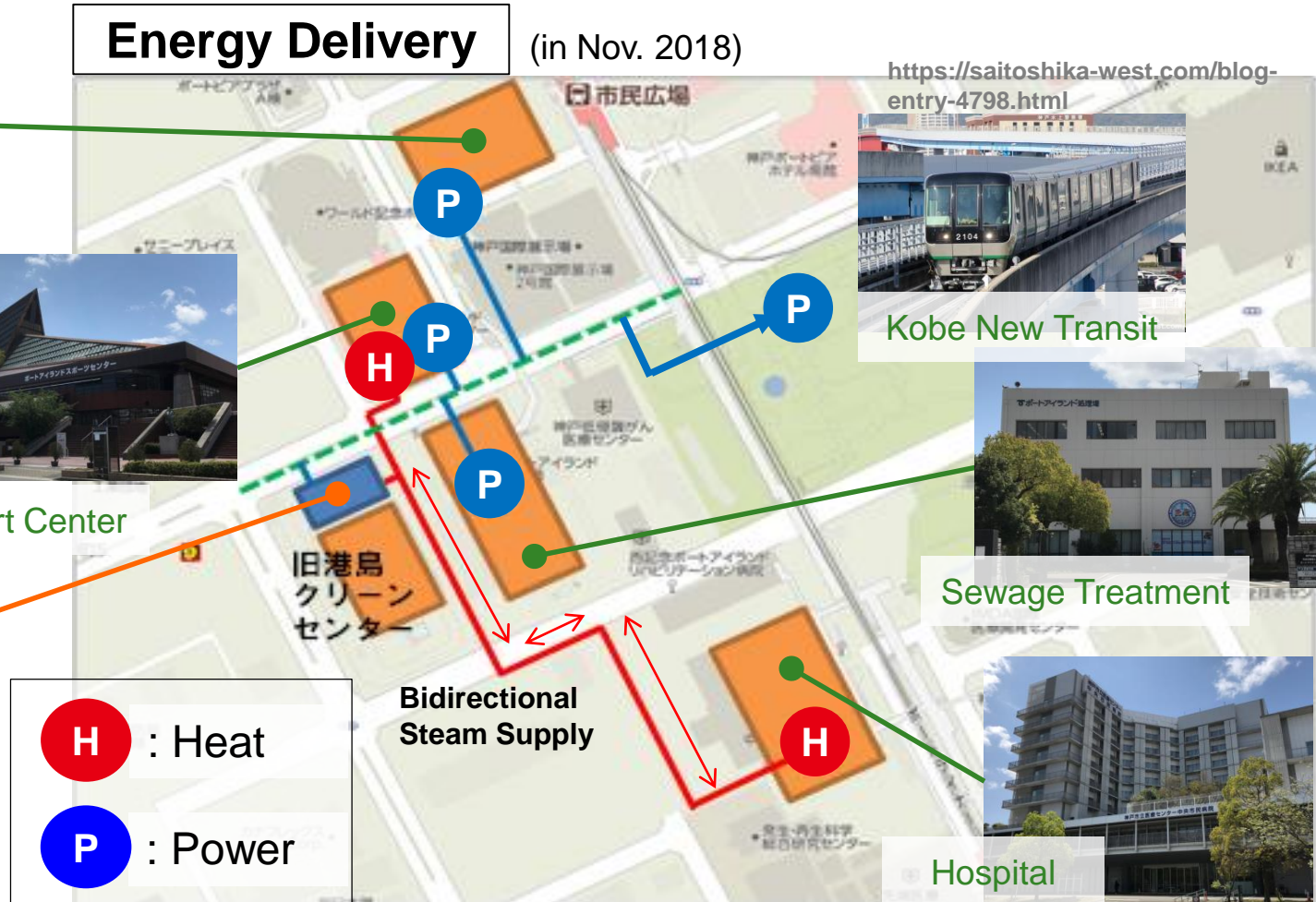
Sport Center



Hydrogen GT

## Energy Delivery

(in Nov. 2018)

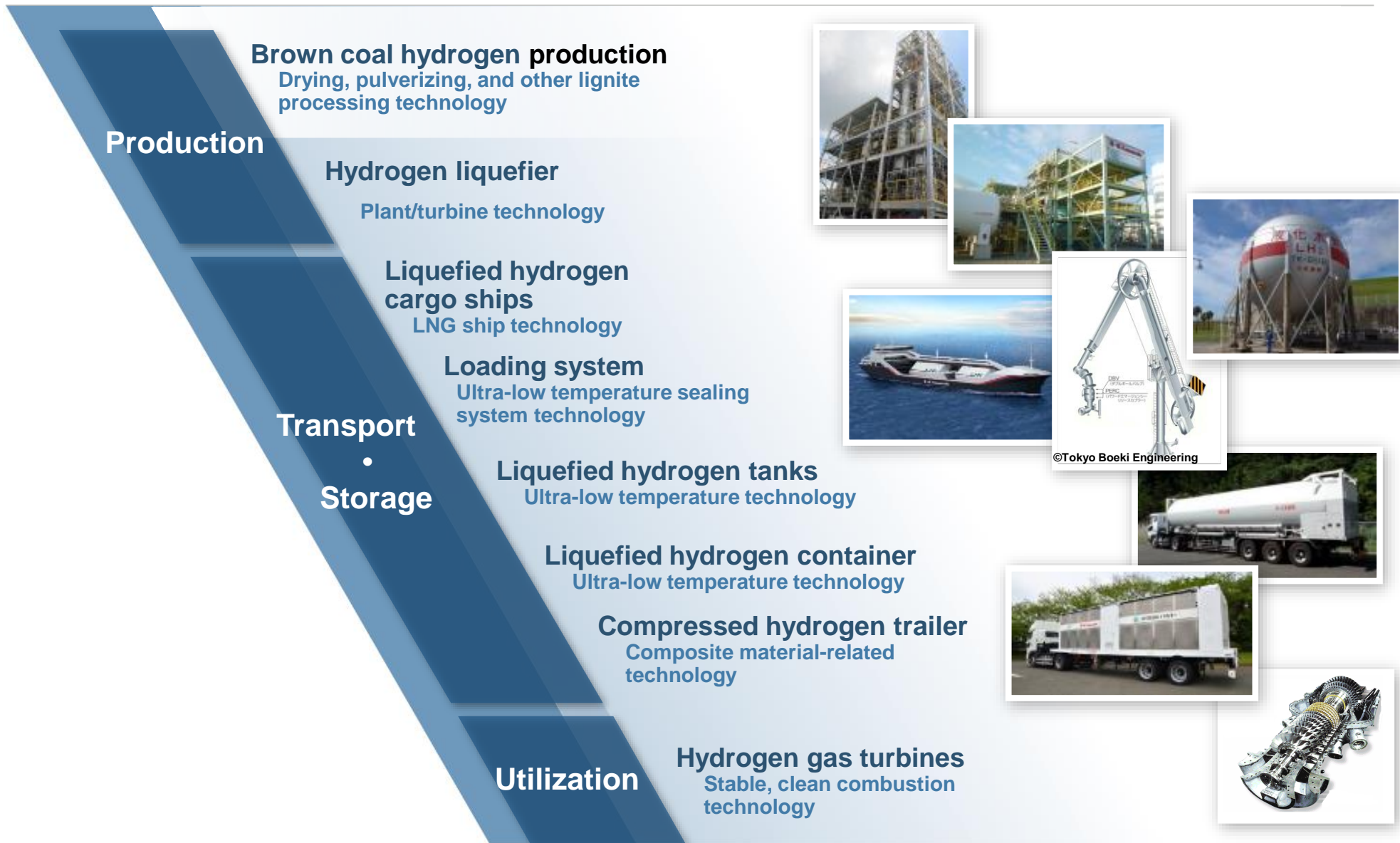


- Energy delivery capability  
 Electric Power : Approx. 1,100 kW  
 Heat : Approx. 2,800 kW

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



# Hydrogen Infrastructure Technologies



# Evaporation of Liquefied Gas



**LH2**



**LN2**

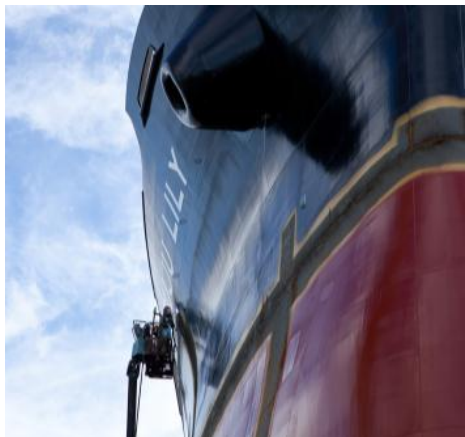


**LNG**

<b>Humidity</b>	<b>15%</b>	<b>Wind speed</b>	<b>1.6m/s</b>
Atm.	995.5 hPa	Direction	NE

<b>Humidity</b>	<b>24%</b>	<b>Wind speed</b>	<b>1.3m/s</b>
Atm.	995.2 hPa	Direction	ENE

<b>Humidity</b>	<b>24%</b>	<b>Wind speed</b>	<b>3.1m/s</b>
Atm.	995.3 hPa	Direction	WNW



# One Kawasaki Land. Sea. Air. worldwide

