Hydrogen Energy Supply Chain from Australia to Japan

International CCS Value Chain Developments Panel

2019 Carbon Capture, Utilization, Storage, and Oil & Gas Technologies Integrated Review Meeting

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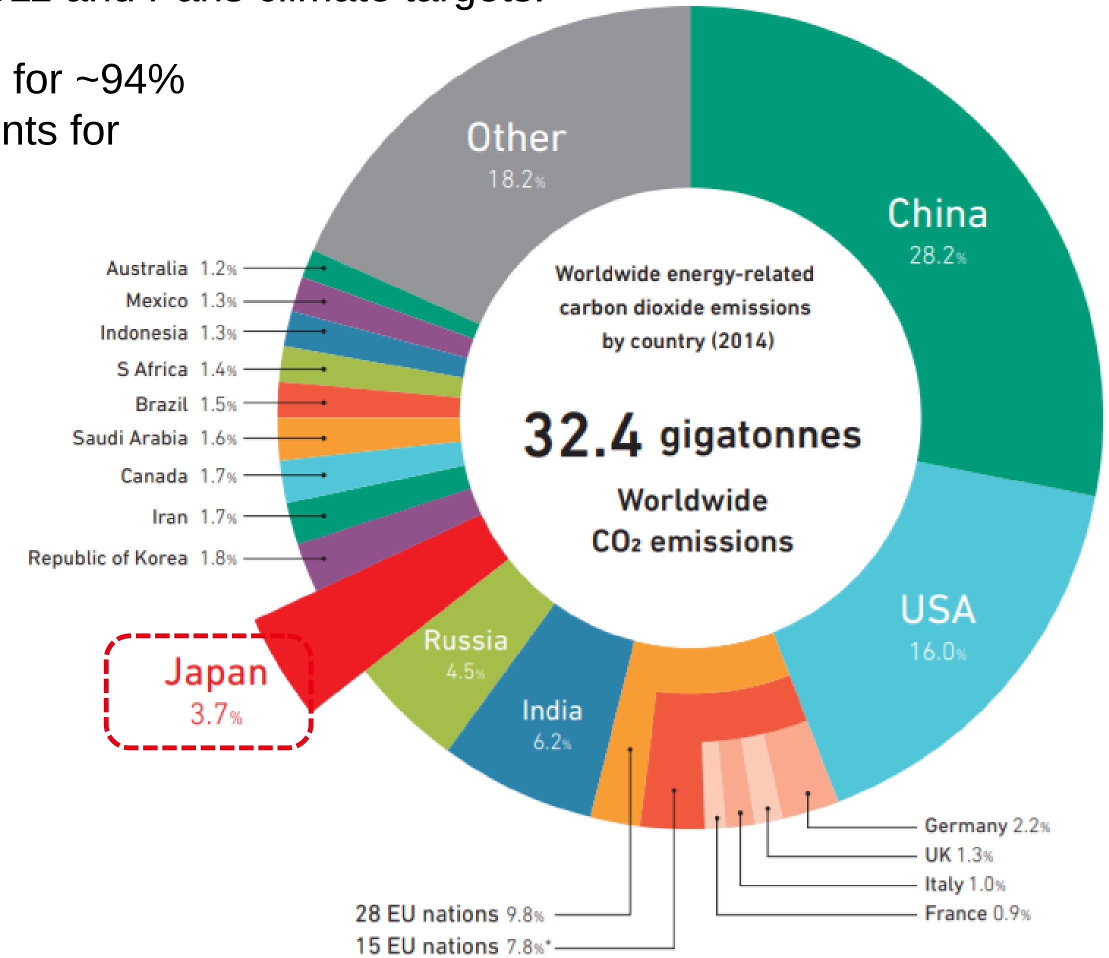
Rationale for a Japanese hydrogen strategy

- Japan is facing real challenges regarding energy security and emissions reductions, subsequent to the Fukushima nuclear accident in 2011 and Paris climate targets.
- Japan depends on overseas fossil fuels for ~94% of its primary energy supply[1] and accounts for ~3.7% of worldwide CO2 emissions[2].

6-7% *Japan's energy self-sufficiency rate (2nd lowest among OECD countries)[1]*

94% *Japan's dependence on overseas fossil fuels for its primary energy supply[1]*



[1] *Basic Hydrogen Strategy, Ministry of Economy, Trade and Industry (METI)*
[2] *Annual report on the environment in Japan 2017 – Ministry of the Environment, Japan*

Source: Annual report on the environment in Japan 2017 – Ministry of the Environment, Japan

Japan’s Strategic Road Map for Hydrogen 2019

		Goals in the Basic Hydrogen Strategy		Set of targets to achieve	Approach to achieving target
Use	Mobility	FCV 200k/2025 800k/2030	2025	● Price difference between FCV and HV (¥3m → ¥0.7m) ● Cost of main FCV system (FC ¥20k/kW → ¥5k/kW Hydrogen Storage ¥0.7m → ¥0.3m)	• Regulatory reform and developing technology
Use	Mobility	HRS 320/2025 900/2030	2025	● Construction and operating costs (Construction cost ¥350m → ¥200m Operating cost ¥34m→¥15m) ● Costs of components for HRS (Compressor ¥90m → ¥50m Accumulator¥50m → ¥10m)	• Consideration for creating nation wide network of HRS • Extending hours of operation
Use	Mobility	Bus 1,200/2030	Early 2020s	● Vehicle cost of FC bus (¥105m → ¥52.5m) ※In addition, promote development of guidelines and technology development for expansion of hydrogen use in the field of FC trucks, ships and trains.	• Increasing HRS for FC bus
Use	Power	Commercialize by 2030	2020	● Efficiency of hydrogen power generation (26%→27%) ※1MW scale	• Developing of high efficiency combustor etc.
Use	FC	Early realization of grid parity	2025	● Realization of grid parity in commercial and industrial use	• Developing FC cell/stack technology
Supply	Fossil Fuel +CCS	Hydrogen Cost ¥30/Nm3 by 2030 ¥20/Nm3 in future	Early 2020s	● Production: Production cost from brown coal gasification (¥several hundred/Nm3→ ¥12/Nm3) ● Storage/Transport : Scale-up of Liquefied hydrogen tank (thousands m^3→50km^3) Higher efficiency of Liquefaction (13.6kWh/kg→6kWh/kg)	• Scaling-up and improving efficiency of brown coal gasifier • Scaling-up and improving thermal insulation properties
Supply	Green H2	System cost of water electrolysis ¥50,000/kW in future	2030	● Cost of electrolyzer (¥200,000m/kW→¥50,000/kW) ● Efficiency of water electrolysis (5kWh/Nm3→4.3kWh/Nm3)	• Demonstration in model regions for social deployment utilizing the achievement in the demonstration of Namie, Fukushima • Development of electrolyzer with higher efficiency and durability

Source: The Strategic Road Map for Hydrogen and Fuel Cells Ministry of Economy, Trade and Industry (METI), 2019

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Global leader in hydrogen technology

We are building the foundations of a hydrogen market

Global leader in hydrogen technology

Fertilizer Plant (Hydrogen production)

H-II rocket fuel hydrogen storage tank

Liquid hydrogen storage tank

Liquid hydrogen container

High pressure hydrogen gas trailer

H2 Gas Turbine

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HESC Project - Overview

- The HESC Project is a world-first initiative to establish an integrated supply chain for sustainable hydrogen, produced from Victorian brown coal in the Latrobe Valley, Victoria, to be exported to Japan.

- The HESC Project will be developed in two phases:
  - **Pilot Phase:** The **pilot phase** will demonstrate a fully integrated supply chain between Australia and Japan by 2021.
  - **Commercial Phase:** The **commercial phase** will be operational targeted in the 2030s.

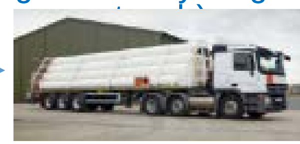
Pilot Phase

AGL Loy Yang, Latrobe Valley Victoria, Australia

SC1-A – Brown coal gasification
(Japanese funded)

SC2 – Gas Refining

SC3 – Transport
(pressurized gaseous hydrogen



BlueScope Western Port Port of Hastings Victoria, Australia

SC4 – Hydrogen liquefaction

SC5 – Hydrogen loading base

Brown Coal exported to Japan

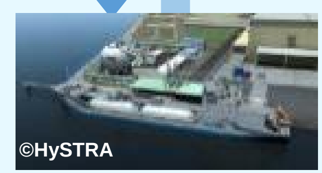
SC6 – Liquefied hydrogen carrier
(Japanese funded portion)

Kitakyushu, Japan

C1-B – Brown coal gasification (20t/d EAGLE II facility)
(Japanese funded portion)

Kobe, Japan

SC7 – Liquefied hydrogen unloading terminal
(Japanese funded portion)



Project Timeline

CCS solution required!

Completed (2017)
Front End Engineering Design (FEED) study for Australian portion

2017 - 2018
Regulatory approvals completed and Final Investment Decision (FID) for pilot plant

2019
Commence construction of pilot facilities in Australia

2020 - 2021
Pilot Operations and delivery of hydrogen to Japan

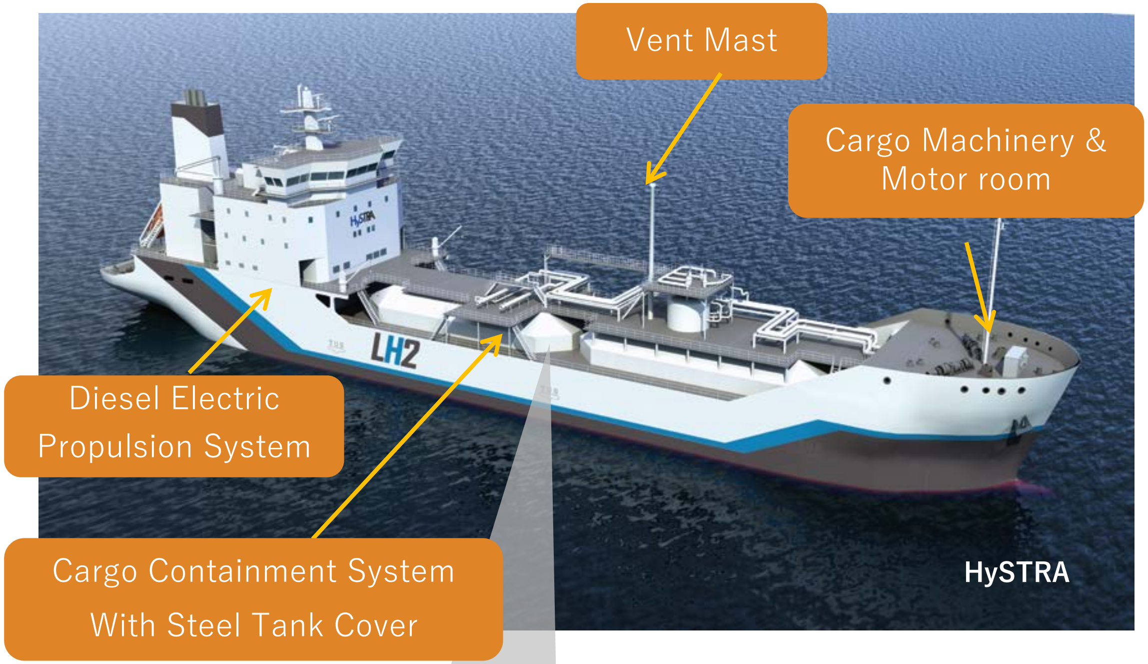
2018 - 2021
Development of a commercialisation plan for the HESC

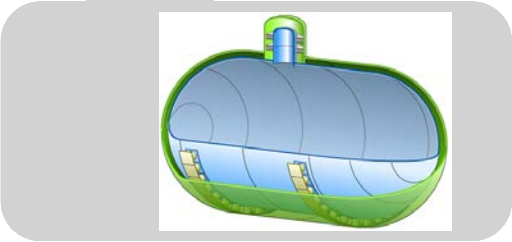
2021 – 2030s
Planning, construction and commissioning of the commercial plant

2030s
Full commercial operations

Indicative timeline and milestones

Liquefied Hydrogen Carrier Ship

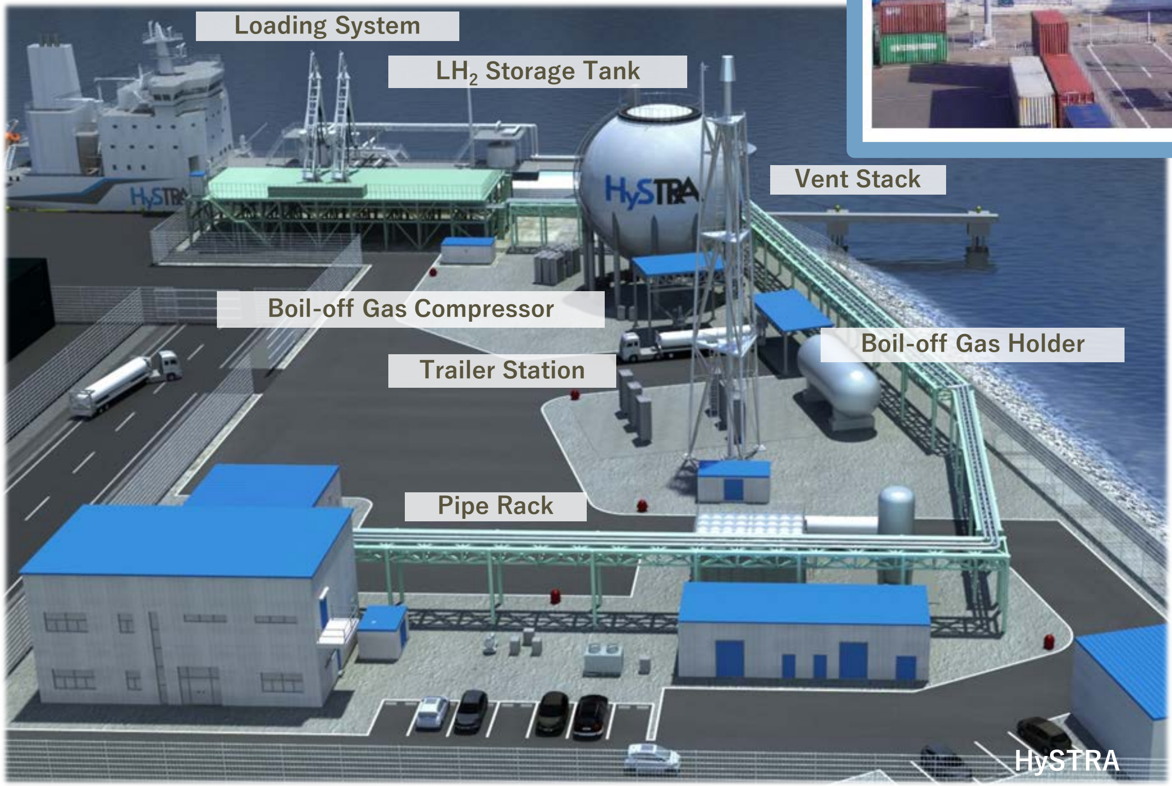




LH2 Loading Terminal in Hastings

as of July 2019

LH2 Unloading Terminal in Kobe



as of July 2019

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The HESC Project will require a CCS solution

- The HESC Project concept was developed by linking the two strategic advantages of Victoria – abundant brown coal resources and suitable geological formations for CCS.

- CCS is critical to the ability of the HESC Project to supply low-emissions hydrogen.

- The Australian and Victorian Governments' CarbonNet Project presents a prospective CCS solution for the HESC Project.

Issues for CCS and solution

- One of the key issues preventing the wide scale adoption of CCS is the limited number of suitable locations.
- The key characteristics of sites suitable for CCS include:
  - Existence of cap rock
  - No geologic fault
  - Proximity between CO_2 source and CO_2 sequestration site

HESC + CCS (CarbonNet)

Some of the relevant characteristics of the HESC Project that make it suitable to be combined with CCS include:

- Hydrogen will be produced from fossil fuels in close proximity to a suitable location for CCS sequestration
- CO_2 generated from hydrogen production can be sequestered at low cost (through minimization of CO_2 transportation costs)
- Clean hydrogen produced in mass quantities can be transported to consumers

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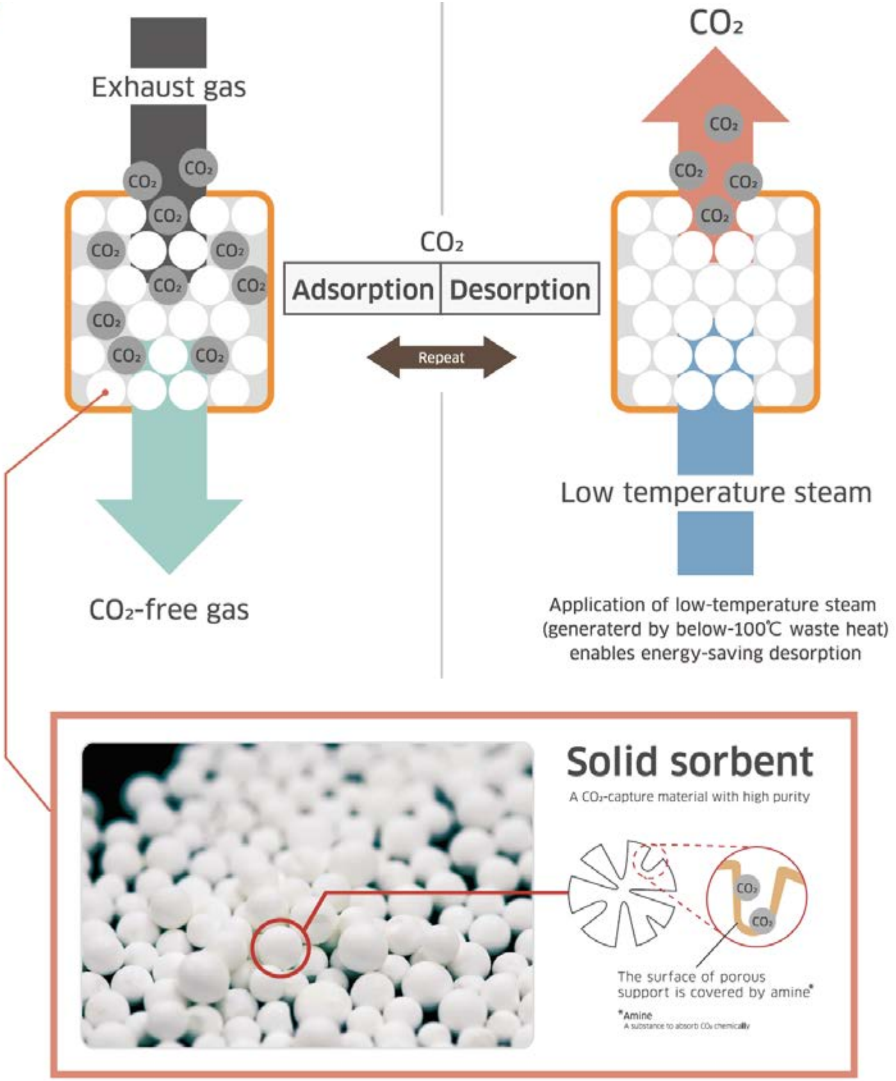
CO_2 capture with low energy consumption



Japan – USA Collaboration Project on CCS

- Collaboration project between Japan (KHI and Japan Coal Energy Center) and USA (the State of Wyoming) is on going
- Feasibility Study for environmental impact assessment of amine solid sorbent have been conducted from FY 2018

Implementation Structure

MOE Ministry of the Environment

Commission

Project Support

JCOAL Japan Coal Energy Center

MOU

Wyoming

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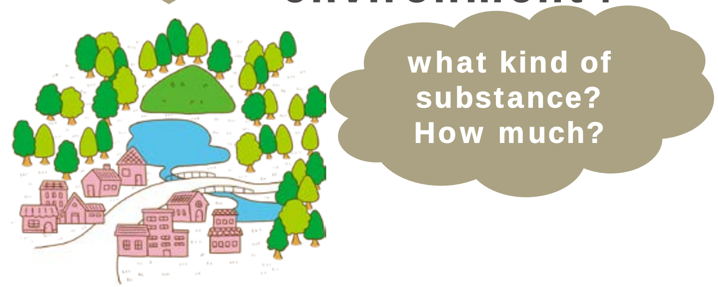
Effect on the environment?



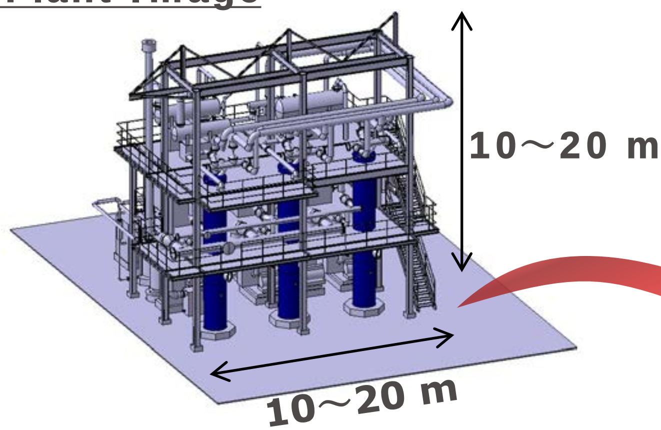
Acknowledgments

This Feasibility Study is supported by Ministry of the Environment, Japan.

Demonstration Test Plan at ITC

The ITC (Integrated Test Center) in Dry Fork Station in the state of Wyoming provides space for KHI to conduct environmental impact assessment test

Test Plant Image



Dry Fork Station
(Coal Fired Power Generation)
Electricity Generated : 400 MW

Schedule (Plan)

FY2018:Feasibility Study (Done)
FY2019~20:Design of Test Plant
FY2021~22:Construction and Demonstration Test

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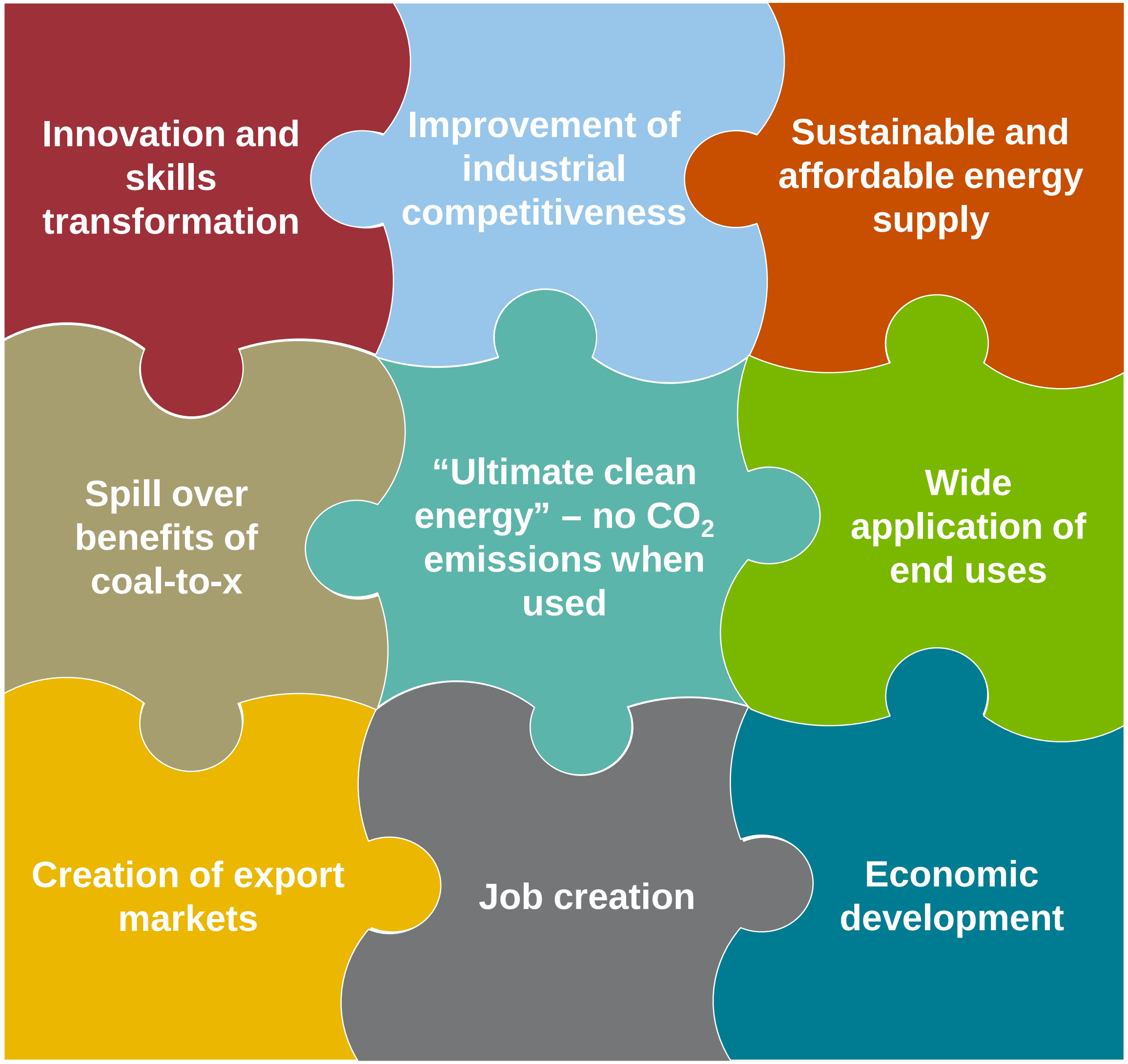
Advantages of Low Emissions Hydrogen Supply Chains



Thank you for listening

Kawasaki, working as one for the good of the planet

"Global Kawasaki"

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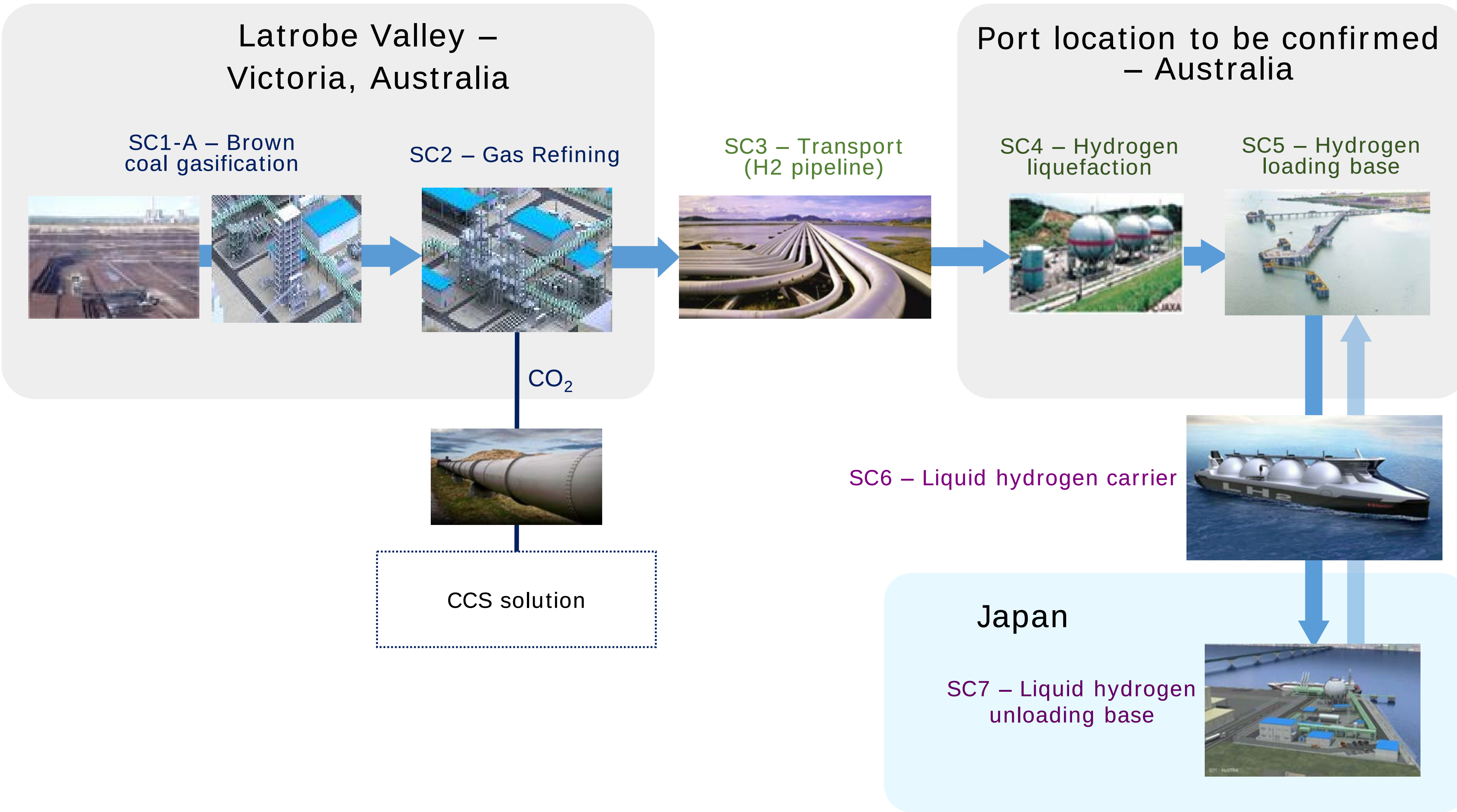
Commercial Phase



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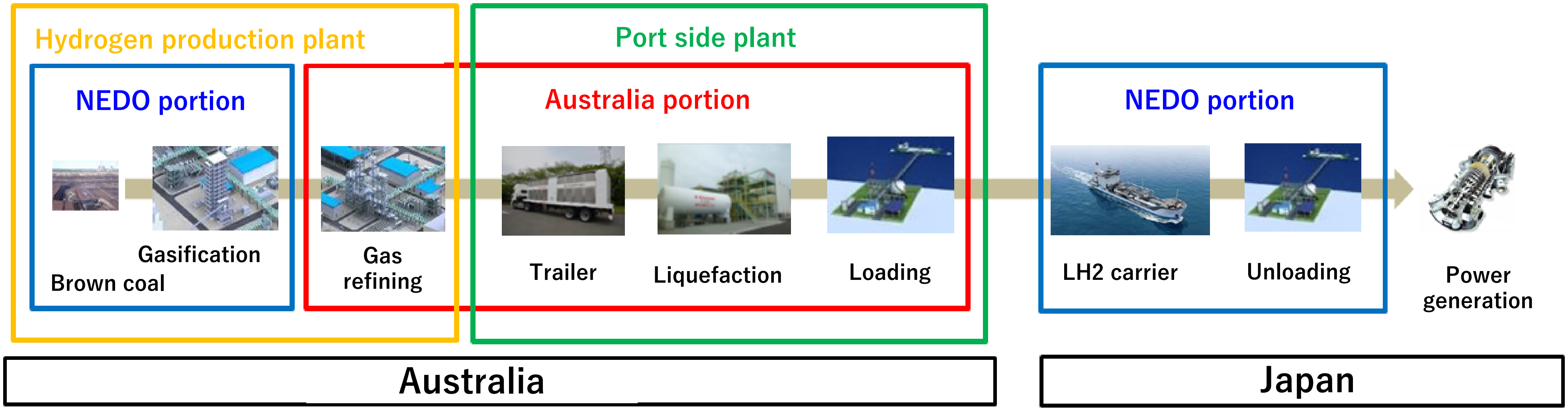
Project Structure



NEDO portion: gasification in Australia, H2 carrier and unloading terminal in Japan supported by NEDO, performed by HySTRA

Australia portion: gas refining and loading terminal in Australia supported by Australian Governments

Hydrogen Production Plant: gasification and gas refining in Latrobe Valley

Port side plant: trailer, liquefaction and loading terminal in Hastings