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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1. Japan’s Basic Hydrogen Strategy
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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\(^2\).

\(^{1}\) Basic Hydrogen Strategy, Ministry of Economy, Trade and Industry (METI)
\(^{2}\) Annual report on the environment in Japan 2017 – Ministry of the Environment, Japan
### Japan’s Strategic Road Map for Hydrogen 2019

#### Goals in the Basic Hydrogen Strategy

<table>
<thead>
<tr>
<th>Use</th>
<th>Mobility</th>
<th>2025 Set of targets to achieve</th>
<th>Approach to achieving target</th>
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</table>
| FCV 200k/2025 800k/2030 | HRS 320/2025 900/2030 | • Price difference between FCV and HV (¥3m → ¥0.7m)  
• Cost of main FC system  
  - Hydrogen Storage: ¥0.7m → ¥0.3m  
  - FC: ¥20k/kW → ¥5k/kW  
• Construction and operating costs  
  - Construction cost: ¥350m → ¥200m  
  - Operating cost: ¥34m → ¥15m  
• Costs of components for HRS  
  - Compressor: ¥90m → ¥50m  
  - Accumulator: ¥50m → ¥10m  
• Vehicle cost of FC bus (¥105m → ¥52.5m) | • Regulatory reform and developing technology  
• Consideration for creating nation wide network of HRS  
• Extending hours of operation  
• Increasing HRS for FC bus |

| Use          | 2020 Commercialize by 2030 | Efficiency of hydrogen power generation (26% → 27%)  
  *1MW scale  
• Developing of high efficiency combustor etc. |

| Use          | 2025 Early realization of grid parity | Realization of grid parity in commercial and industrial use  
• Developing FC cell/stack technology  
| Supply       | Early 2020s Fossil Fuel +CCS | Production: Production cost from brown coal gasification  
  (¥several hundred/Nm³ → ¥12/Nm³)  
• Storage/Transport: Scale-up of liquefied hydrogen tank  
  (thousands m³ → 50km³)  
  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       | 2030 Green H2 | System cost of water electrolysis (¥50,000/kW in future)  
• Demonstrating in model regions for social deployment utilizing the achievement in the demonstration of Namie, Fukushima  
• Development of electrolyzer with higher efficiency and durability  |

| Supply       | 2030 System cost of water electrolysis (¥50,000/kW in future) | Cost of electrolyzer (¥200,000/m²/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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Join Us on the Hydrogen Road

Kawasaki Technology Paving the Way for the Hydrogen Road.

Hydrogen Production
- Producing clean, low-cost hydrogen from various resources.

Hydrogen Transportation & Storage
- Transportation/storage technology to help disseminate hydrogen energy.

Hydrogen Use
- Sustainable future realised by hydrogen energy.

Global leader in hydrogen technology

We are building the foundations of a hydrogen market
Global leader in hydrogen technology

2. KHI’s Hydrogen Capabilities

- 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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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.
3. Hydrogen Energy Supply Chain (HESC) Project

Pilot Phase

AGL Loy Yang, Latrobe Valley, Victoria, Australia

- SC1-A – Brown coal gasification (Japanese funded)
- SC2 – Gas Refining

Brown Coal exported to Japan

Kitakyushu, Japan

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

BlueScope Western Port
Port of Hastings, Victoria, Australia

- SC3 – Transport (pressurized gaseous hydrogen)
- SC4 – Hydrogen liquefaction
- SC6 – Liquefied hydrogen carrier (Japanese funded portion)

Kobe, Japan

- SC7 – Liquefied hydrogen unloading terminal (Japanese funded portion)
3. Hydrogen Energy Supply Chain (HESC) Project

Project Timeline

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

- **2019**
  Commence construction of pilot facilities in Australia

- **2018 - 2021**
  Development of a commercialisation plan for the HESC

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

- **2020 - 2021**
  Pilot Operations and delivery of hydrogen to Japan

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

- **2030s**
  Full commercial operations

*Indicative timeline and milestones*

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Liquefied Hydrogen Carrier Ship

3. Hydrogen Energy Supply Chain (HESC) Project

- Vent Mast
- Cargo Machinery & Motor room
- Diesel Electric Propulsion System
- Cargo Containment System With Steel Tank Cover
- Outer Tank
- Inner Tank

HySTRA
LH2 Loading Terminal in Hastings

as of July 2019
3. Hydrogen Energy Supply Chain (HESC) Project

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.
4. The HESC Project and Carbon Capture and Storage (CCS)

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:
  o Existence of cap rock
  o No geologic fault
  o Proximity between CO2 source and CO2 sequestration site

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
• CO2 generated from hydrogen production can be sequestered at low cost (through minimization of CO2 transportation costs)
• Clean hydrogen produced in mass quantities can be transported to consumers
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5. KHI’s CCS capabilities

**CO₂ capture with low energy consumption**

Kawasaki CO₂ Capture

KCC

![CO₂ capture process diagram](image)

**Solid sorbent**

A CO₂ capture material with high purity

The surface of porous support is covered by amine

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5. KHI’s CCS capabilities

**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

Commission

JCOAL

Project Support

KCC commercial plant image

**Effect on the environment?**

what kind of substance? How much?

**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.

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

5. KHI’s CCS capabilities
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Advantages of Low Emissions Hydrogen Supply Chains

- Innovation and skills transformation
- Improvement of industrial competitiveness
- Sustainable and affordable energy supply
- Spill over benefits of coal-to-x
- “Ultimate clean energy” – no CO₂ emissions when used
- Wide application of end uses
- Creation of export markets
- Job creation
- Economic development

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Thank you for listening

Kawasaki, working as one for the good of the planet

“Global Kawasaki”

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3. Hydrogen Energy Supply Chain (HESC) Project

**Commercial Phase**

**Latrobe Valley – Victoria, Australia**
- SC1-A – Brown coal gasification
- SC2 – Gas Refining
- SC3 – Transport (H2 pipeline)
- SC4 – Hydrogen liquefaction
- SC5 – Hydrogen loading base
- CO₂
- CCS solution

**Port location to be confirmed – Australia**
- SC6 – Liquid hydrogen carrier
- SC7 – Liquid hydrogen unloading base

**Japan**
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

Australia

Japan