カワる、
サキへ。
Changing forward

Kawasaki's Challenge to Carbon Neutrality

Aiming to build an international liquefied hydrogen supply chain

April 2025

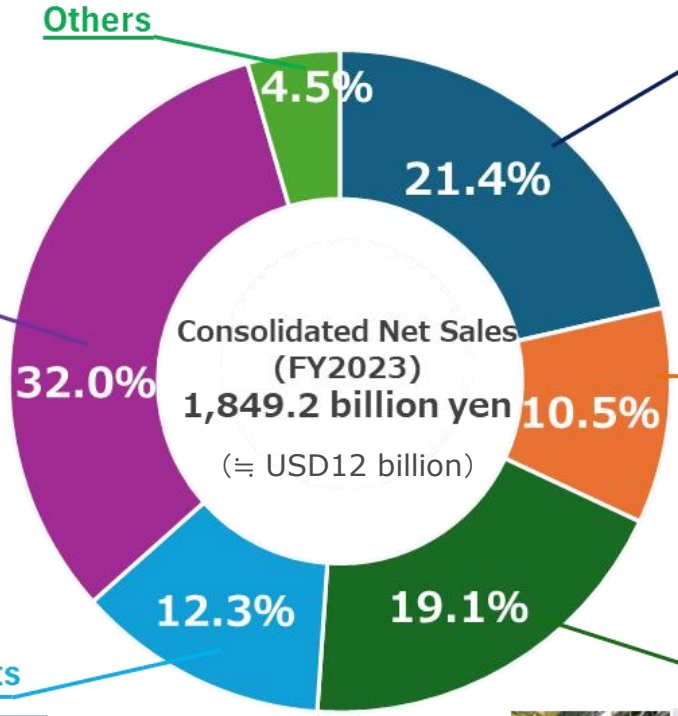
Kawasaki Heavy Industries, Ltd.

Kawasaki
Powering your potential

Contents

Kawasaki's Business Segment & Revenue Ratio

Kawasaki Heavy Industries is a Japanese multinational manufacturer with a history of nearly 150 years that produces not only motorcycles, but also a wide range of industrial products, including ships, rolling stocks, engines, robots, compressors, boilers, aerospace etc.



Kawasaki Hydrogen Products

Hydrogen Gas Engine

Water Electrolysis System

Hydrogen Liquefier Plant

Liquefied Hydrogen Tanks

Production

Storage

Liquefied Hydrogen Loading Arm

Hydrogen Gas Turbine

Hydrogen Boiler

Utilisation

Realising technological synergies across products

Transport

Liquefied Hydrogen Carrier

Fuel Cell Train

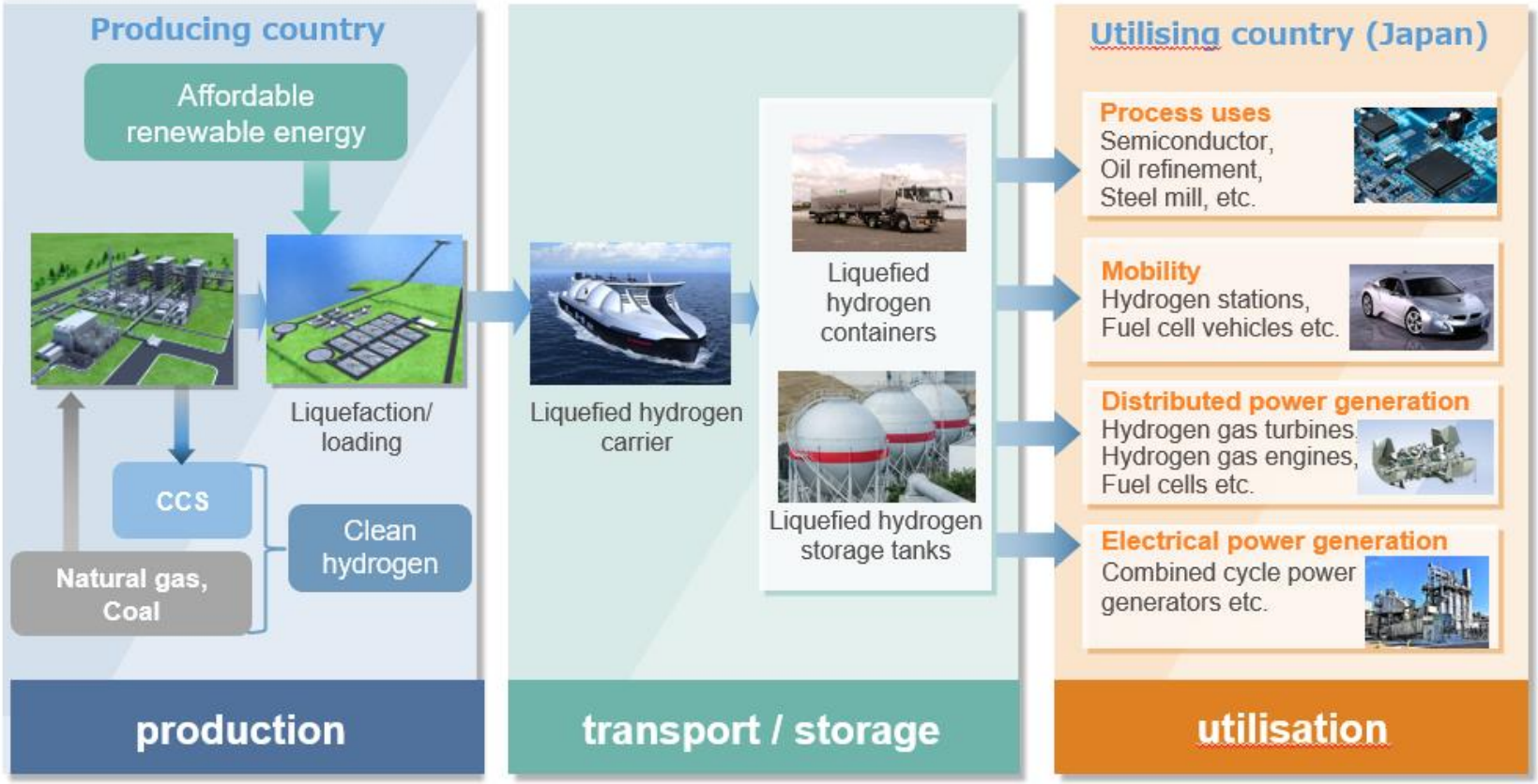
High-pressure Hydrogen Regulator

Centrifugal Hydrogen Compressor

Compressed H_2 Trailer Trucks

Liquefied Hydrogen Container

Concept of a Long-haul Liquefied Hydrogen Supply Chain



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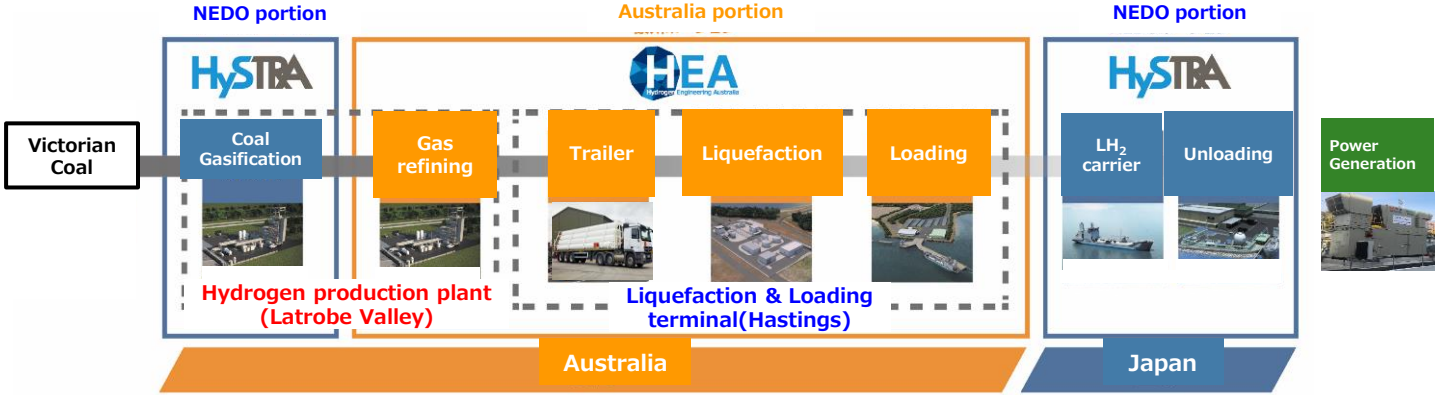
Hydrogen Energy Supply Chain (HESC) Pilot Project

Kawasaki is working with a number of partners on the pilot project supported by the governments of Japan and Australia.



HySTRA

CO2-free Hydrogen Energy Supply-chain Technology Research Association

Iwatani, Kawasaki, Shell Japan, J-Power, Marubeni, ENEOS, KLINE

Supported by NEDO

HEA Hydrogen Engineering Australia

Hydrogen Engineering Australia

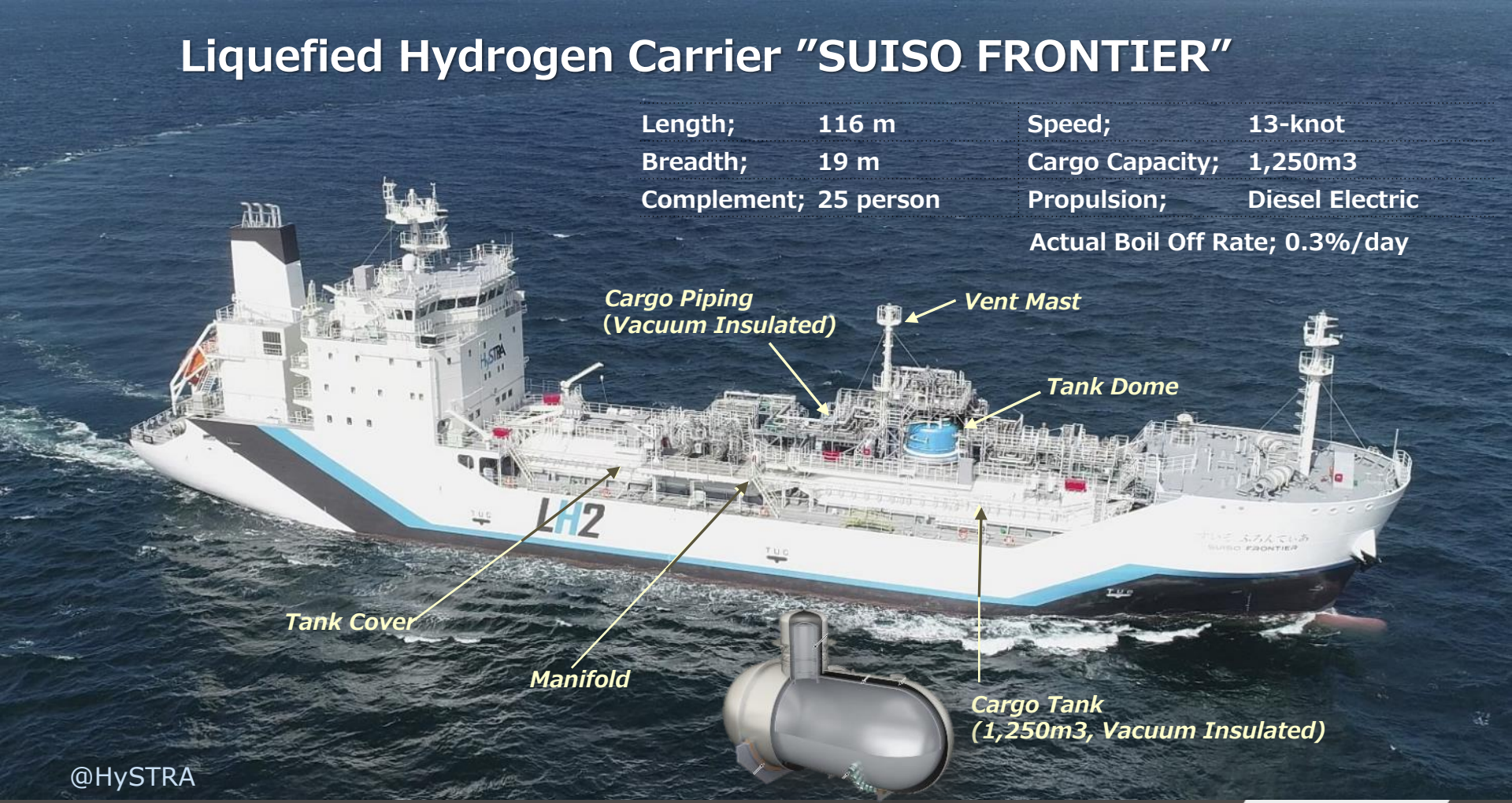
Kawasaki, J-Power, J-Power Latrobe Valley, Iwatani, Marubeni, Sumitomo, AGL

***NEDO : New Energy and Industrial Technology Development Organization**

Liquefied Hydrogen Carrier "SUISO FRONTIER"

Length;	116 m	Speed;	13-knot
Breadth;	19 m	Cargo Capacity;	1,250m3
Complement;	25 person	Propulsion;	Diesel Electric

Actual Boil Off Rate; 0.3%/day



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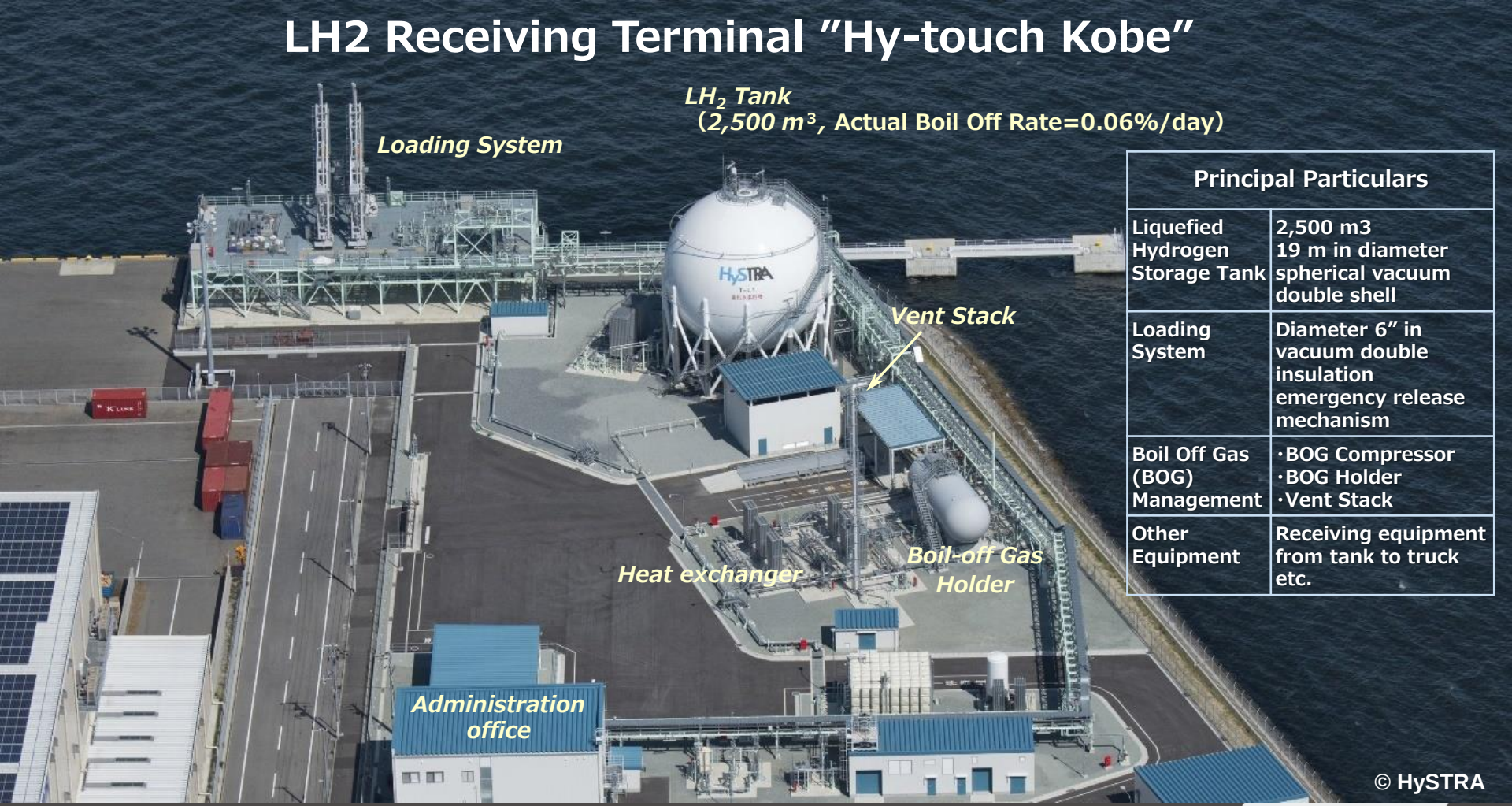
LH2 Receiving Terminal "Hy-touch Kobe"



Principal Particulars	
Liquefied Hydrogen Storage Tank	2,500 m3 19 m in diameter spherical vacuum double shell
Loading System	Diameter 6" in vacuum double insulation emergency release mechanism
Boil Off Gas (BOG) Management	·BOG Compressor ·BOG Holder ·Vent Stack
Other Equipment	Receiving equipment from tank to truck etc.

© HySTRA

Liquefaction Plant at Hastings, Australia

Hydrogen Liquefier

Administration office

Gas Hydrogen Receiving Facility

LH2 Container Setting Space

© HySTRA

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Large-Scale Demonstration Hydrogen Supply Chain Commercialisation Demonstration Project

Green Innovation Fund (Supported by Japanese Government, METI and NEDO)

METI:Ministry of Economy, Trade and Industry

Participants

Japan Suiso Energy, Ltd., ENEOS Corporation, and Iwatani Corporation

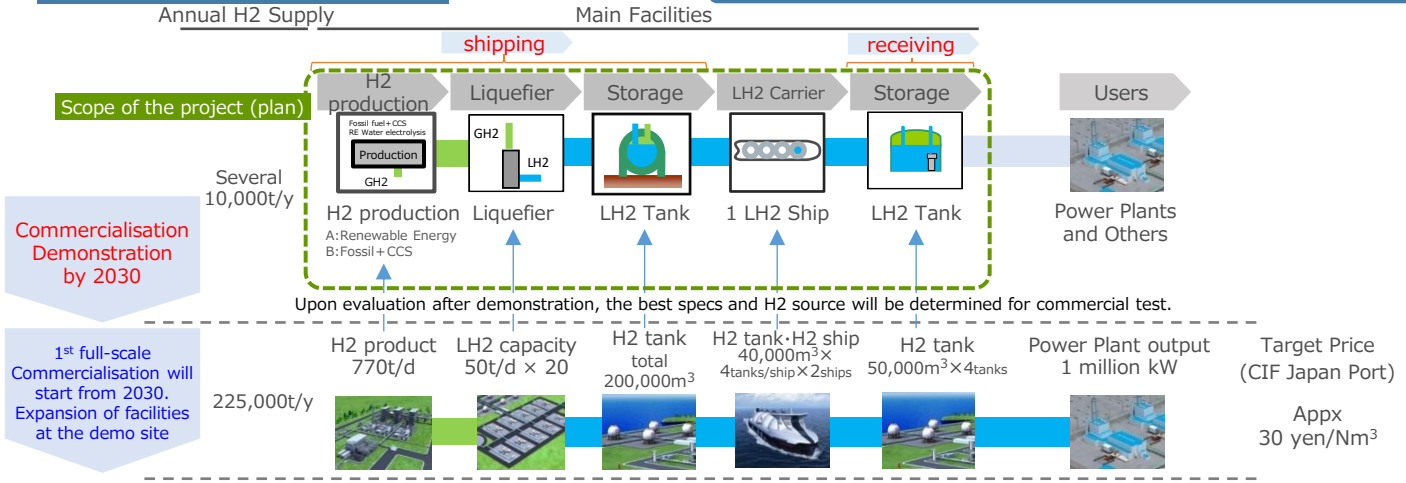
Investment

Total Investment* : Appx. USD 2.7 billion
Government support : Appx. USD 2.0 billion**

1US$=110¥

*Including the development of an innovative technology to further enhance liquefaction efficiency worked by Kawasaki Heavy Industries, Ltd.
**Including the amount of incentive reward. Expected to be rationalised in accordance with the progress of the project through stage-gate process.

Overview



Development of Scaling-Up on LH2 Facilities

Pilot scale

1,250m³

2,500m³

Commercial scale

40,000m³ class

160,000m³ class

50,000m³ class

200,000m³ class

Roadmap - Liquefied Hydrogen Supply Chain in Japan

2015 2020 2025 2030 2040～

Pilot Demonstration (Completed in 2023)

Demonstration of hydrogen production from brown coal and long-haul marine transportation (approximately 1/100th the commercial scale)

Demonstration test for Commercialisation

- Manufacture commercial-scale (large-scale) equipment/facilities
- Assess the feasibility of commercialisation, including economics (one step away from commercialisation)

Commercial Chain Operation

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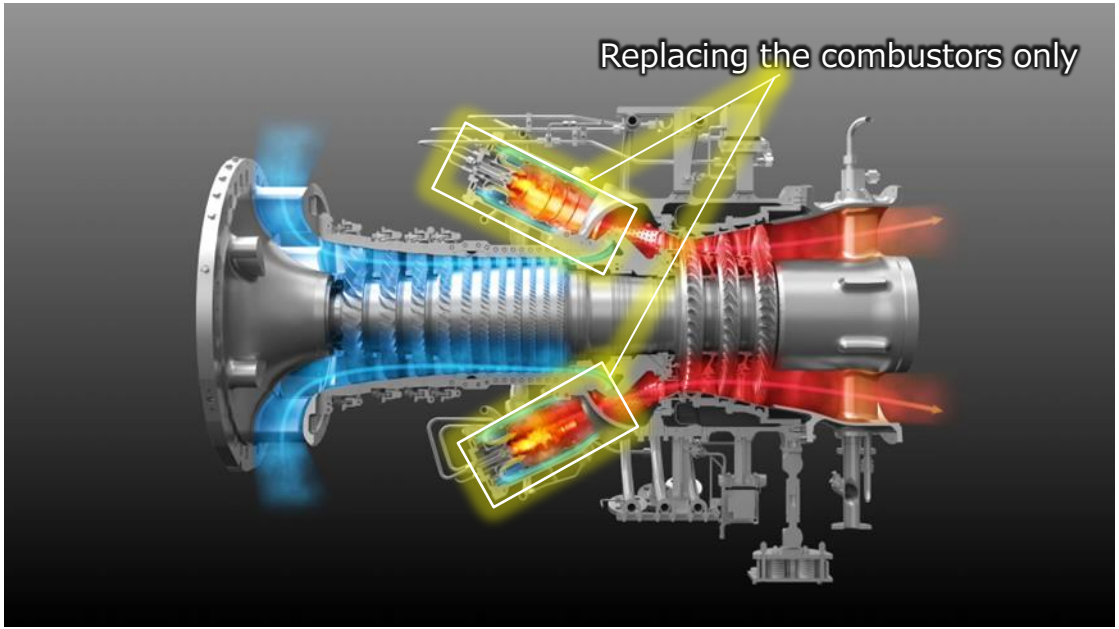
Use of hydrogen energy in gas turbine power generation



Hydrogen mixed combustion
0%～100%

Partial modification only

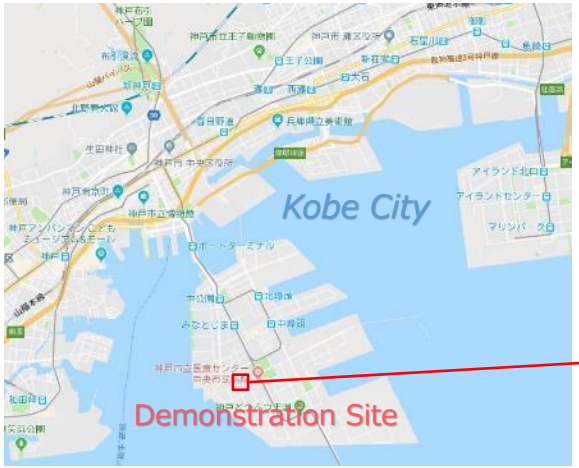
The modification cost is
approx. **10%**
of the total price of the gas turbine engine

Achieving
Carbon-free Electricity
through hydrogen-only combustion

(Space for explosion-proofing is a prerequisite.).

Hydrogen Co-generation System Demonstration

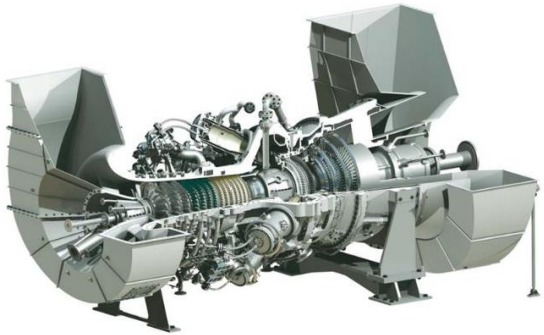
- Co-generation system (CGS) with 1 MW class hydrogen gas turbine has been installed in city area (Kobe Port Island)
- Demonstration of supplying electricity and heat generated from hydrogen to a local area



Hydrogen Power Generation Demonstration Projects in Europe

RWE Kawasaki

Kawasaki started the demonstration project of 100% hydrogen fuelled power generation with a major German energy company **RWE**



Performance Data @ ISO Conditions *				
Output Power	Electrical Efficiency	Fuel Consumption	Exhaust Gas Mass Flow	Exhaust Gas Temperature
34 380 kW	40.3%	85 300 kW	92.6 kg/s	502°C

*based on natural gas

Kawasaki L30A

Location: Lingen, Land Niedersachsen, Germany

Contents

Expanding hydrogen fuel to Mobility

- Know-how to burn hydrogen safely and cleanly developed through hydrogen power generation
- Pursuing Kawasaki's combustion technology further, leading the world in mobility internal combustion engine

Development of Hydrogen-Fueled Vessel Propulsion System * 1

Complete lineup for various applications by around 2026

Hydrogen Aircraft Core Technology Development Project* 2

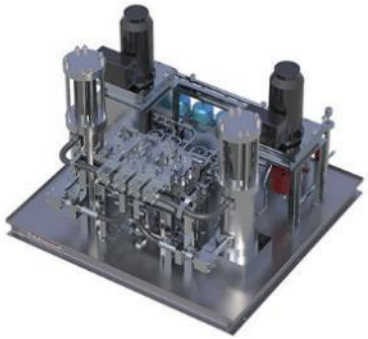
Promote development in anticipation of full-scale launch after 2035

Joint Research on Hydrogen Engines

Domestic two- and four-wheel manufacturers collaborate to develop hydrogen engine

*1 NEDO Green Innovation Fund Project "Development of a Hydrogen Fuel Ship Propulsion System" (about 21.9 billion yen in subsidies)
(Yanmar Power Technologies to be Adopted in Consortium with Japan Engine Corporation)
*2 NEDO Green Innovation Fund Project "Core Technology Development for Hydrogen Aircraft" (grant: about 18 billion yen)

Hydrogen Compressors



https://global.kawasaki.com/en/corp/newsroom/news/detail/?f=20250212_5975

■ for **Hydrogen Pipeline**

Kawasaki Multi-stage Compressor

Centrifugal Type, Vertical Split Gas Tight Casing housing, Multi-stage Beam Style

- ✓ Flow Rate; 500,000 Nm^3/hr
- ✓ Inlet Pressure; 30 barA
- ✓ Outlet Pressure; 60 barA
- ✓ Pressor Ratio; 2.0+(plus)
- ✓ Market Launch; 2026

■ for **Hydrogen Refuel Station**

High-capacity hydraulic booster compressor for heavy duty FCVs at large-scale hydrogen refuel stations

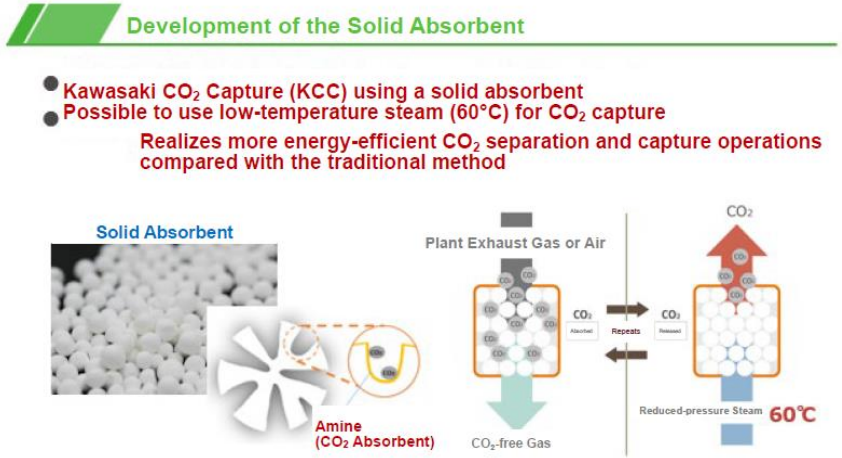
- ✓ Flow Rate; 600 Nm^3/h (at intake pressure of 20MPa)
- ✓ Discharge Pressure; 82 MPaG
- ✓ Type; Single-stage compression

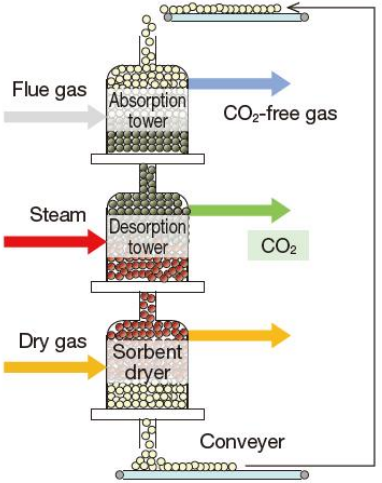
※ Under development; Booster type large compressor for heavy duty vehicles with a flow rate of 1,000 Nm^3/h or more.

Energy-Saving CO2 Separation and Capture System KCC (Kawasaki CO2 Capture)

- Product overview: Technology for separating and capturing CO2 from combustion exhaust gas using solid absorbent materials.
- Features: Uses a newly developed solid absorbent material with amine supported on a porous body.

  By using low-temperature steam (approximately 60°C), CO2 separation and capture is achieved with less energy than conventional methods.





System Flow

Bench Scale Test Machine

Currently, KCC is working with RITE and KEPCO in a NEDO project to conduct practical testing at a 40t/d level

Large-Scale DAC

Kawasaki promotes **CO2 capture business from the atmosphere** through large-scale DAC facilities.
(Approx. 500,000 - 1million t - CO2 / year)

DAC image of 1 million t - CO2 / year

Recent Topics

Daimler Truck and Kawasaki signed MoU to jointly study the optimization of liquefied hydrogen supply chains

- In June 2024, Daimler Truck, one of the world's leading commercial vehicle manufacturers, and Kawasaki have signed a MoU to study the establishment and optimization for the supply of liquefied hydrogen
- The MoU aims to expand the use of liquefied hydrogen in road freight transport, and will also consider LH_2-terminals, large- and medium-sized overseas shipping and large-scale liquefied hydrogen storage

"Our initiative with Kawasaki underlines the comprehensive view and activities Daimler Truck is pursuing to make economically priced green liquefied hydrogen a reality for our customers"

Mr. Martin Daum
Chairman of the Board of Management and CEO of Daimler Truck

Developing hydrogen-related products for decarbonization

- Launch of energy-saving hydraulic hydrogen compressors for hydrogen stations
  - Hydrogen gas compression control technology
  - Rotation control pumps system "ECO SERVO"

→ Energy Saving

Recent Topics

World's first public run of a hydrogen engine motorcycle

- On July 20, Kawasaki Motors conducted the world's first public run of a hydrogen ICE (internal combustion engine) motorcycle developed by a mass-production motorcycle manufacturer at Suzuka Circuit in Japan
- A step forward toward a future where riders can contribute to carbon neutrality while enjoying the unique feeling of an ICE
- Research and development aimed at practical application in early 2030 are underway

It's not about "which wins". Our goal is carbon neutrality.

We, Kawasaki Motors, also developing EV・HEV*2. We would like to create a carbon-neutral world with hydrogen-fueled engines.

We hope to realize a world where everyone is realizing carbon neutrality without anyone knowing it, while valuing the "FUN" such as the heartbeat and acceleration of the engine.

Message from ***KAWASAKI***

https://youtu.be/UgZeYBiGqtA

Our Press Release URL
https://global.kawasaki.com/en/corp/newsroom/news/detail/?f=20240722_6039

Recent Topics

Kawasaki Successfully Completes Small, Hydrogen-fueled Aircraft Engine Test

- Tokyo, October 17, 2024 — Kawasaki Heavy Industries, Ltd. Kawasaki Heavy Industries announced that it has successfully completed operational test of a small, 100% hydrogen-fueled aircraft engine as part of a New Energy and Industrial Technology Development Organization (NEDO) Green Innovation Fund project.

- The project's goal is to develop hydrogen combustion technologies for hydrogen aircraft engines. For this latest operational test, a standard jet-fuel-type, small aircraft engine made by Kawasaki was equipped with the newly developed hydrogen combustor and other equipment. The test was conducted at rocket testing centre of the Japan Aerospace Exploration Agency (JAXA) in Japan. Only hydrogen fuel was used for a full test of engine operations, starting with ignition followed by engine spool-up, steady-state operation, spool-down and stoppage. The success of the test confirmed the feasibility of stable hydrogen-fueled engine operation.

- It was carried out as part of development operations for the one of three development subjects kicked off in 2021, encompassing development of hydrogen aircraft engine combustor and system technologies. The remaining two subjects, which consist of liquefied hydrogen fuel storage tank development and hydrogen-aircraft architecture concept research, are also proceeding as planned.
  Based on the results of this latest test, Kawasaki will continue with the development of core hydrogen aircraft airframe and engine technologies. The project adopts a ten-year core technology development period starting in 2021, and verification ground testing for evaluating the feasibility and performance of the completed and integrated system is slated for 2030.

Recent Topics

CB&I and Kawasaki signed a Strategic Collaborative Agreement for promoting commercial-use liquefied hydrogen supply chain

• CB&I, a wholly owned unrestricted subsidiary of McDermott, and Kawasaki Heavy Industries, Ltd. (“Kawasaki”) announced their signing of a strategic agreement for promoting a commercial-use liquefied hydrogen supply chain and realising a zero carbon-emission society.
The signing ceremony took place at Gastech Exhibition & Conference in Houston on September 18, 2024.

• Both companies will use their specialised know-how to provide infrastructure that will enable commercial-scale international Liquefied Hydrogen supply chains in order to help achieve carbon neutrality.
By leveraging Kawasaki’s combined expertise to deliver large-scale Liquefied Hydrogen infrastructure solutions, Kawasaki and CB&I are removing barriers, driving down costs and enhancing scalability across the entire supply chain.

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