Obayashi and Hydrogen & CCUS Technologies
Some Approaches for Decarbonization

大林組の水素・CCUSに関する取り組み
脱炭素化に向けて

March 12, 2021

Topics for today

Climate Change Global Warming

Decarbonization

SDGs
ESG
CSR

Renewable Underuse Energies

・Solar ・Wind ・Biomass
・Small-scale Hydro ・Geothermal etc.

Storage, Transportation, Adjustment of supply & demand

Conservation

・Zero Energy Building
・Micro/community grid
・Demand control

CCUS

・CO2 Microbubble Storage System

Carbon Pricing

・Differentiation from Fossil Fuels (Internalization of External Economies)

Nuclear

・SMR

Hydrogen

Production

・Fossil Fuels + CCS
・Bi-product H2 + Refining
・Water Electrolysis
・(Photocatalyst)
・(Hydrogen Fermentation)

Transportation

・Gas (35MPa - 70MPa)
・Liquid (LH2, -253°C)
・Ammonium (NH3)
・Methanation (CH4)
・Organic Hydride(MCH)
・Formic Acid (CHCOOH)
・Hydrogen Occlusion Alloy
・Pipeline

Utilization

・Mobility
・Power generation
・Raw materials

・Burner (Heat)
・Engine (Kinetic - Electricity)
・Turbine (Kinetic – Heat, e)
・Fuel Cell (E – Kinetic, Heat)

Battery (Electricity)

・APB ・VPP ・Consignment service

Other Methods

・Pumping-up power plant
・Heat storage ・Compressed air

OBAYASHI

Obayashi Corporation at a glance

Establishment
1892

Number of employees
14,993

Overseas offices
21 Cities

Years of business
129 years

Net sales
JPY 2,073 bn

Number of group companies
120


Technical Research Institute


Tokyo HQ

Over the last 129 years, Obayashi has proudly built capabilities to provide services for the entire construction value chain:

Research & Development → Urban Planning (Real Estate Investment) → Design (Arch., Structure, MEP) → Civil Construction → Building Construction → Maintenance → Renewal

Four Business Domains

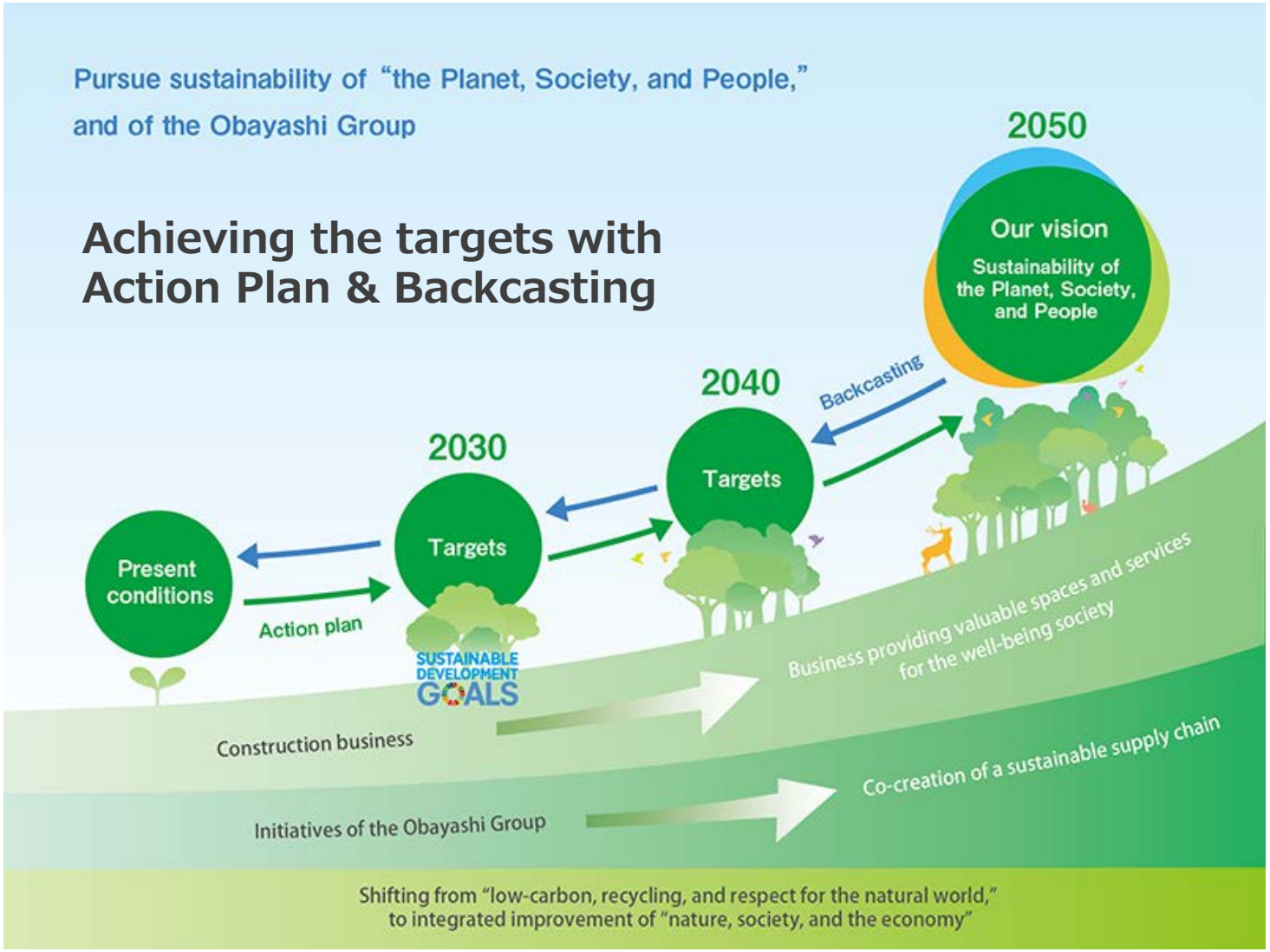
Building Construction

Civil Engineering

Real Estate Development

New Businesses (Renewables, PPP)

■ Obayashi's vision towards zero CO_2 emission for a sustainable society

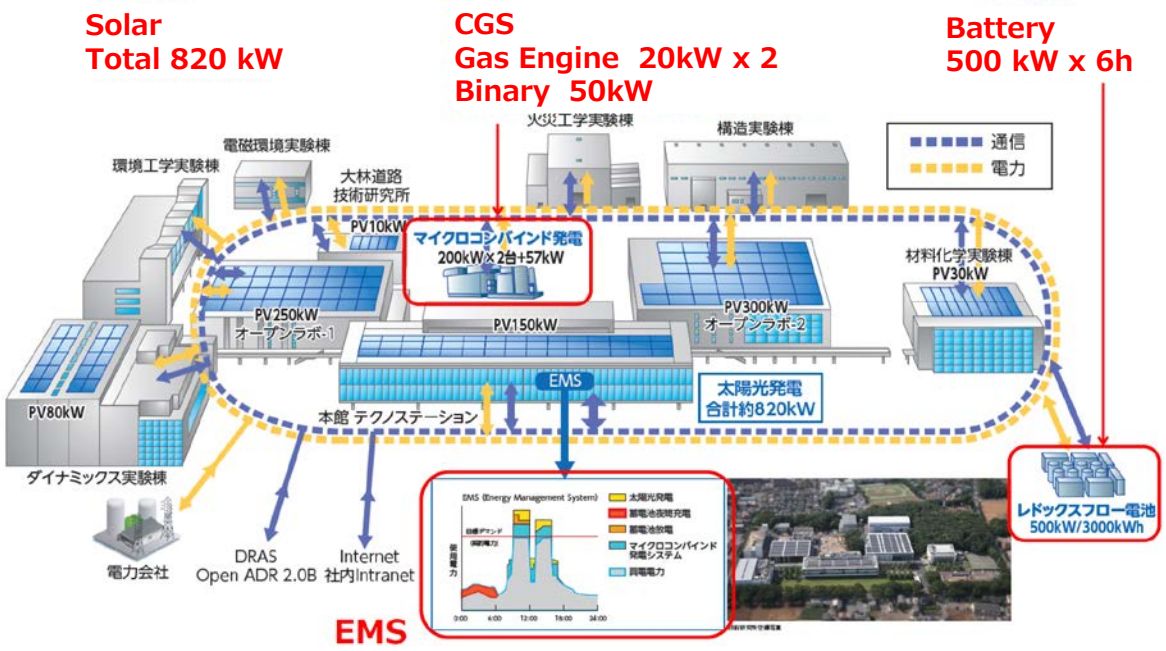


2040-2050 Targets

De-Carbonization
Achieve zero CO_2 emissions in the entire Obayashi Group

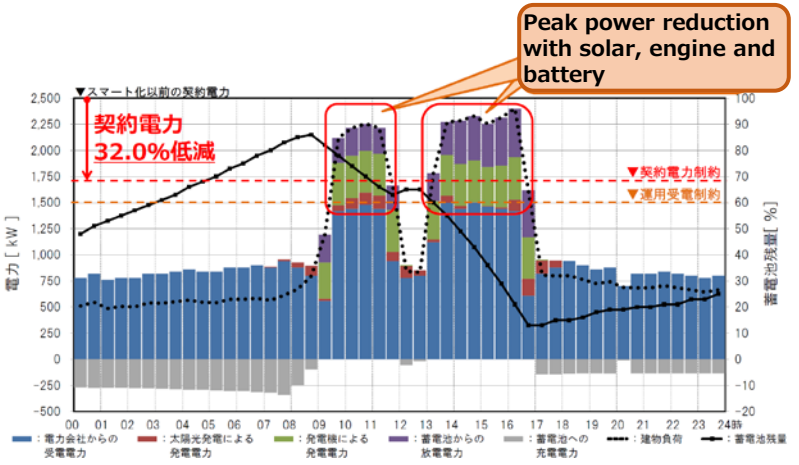
Provide valuable Spaces and services
Achieve a society designed for well-being

Co-creation of a sustainable supply chain
Achieve with people in our business



Energy management & BCP system with micro-power grid

- Combination of solar, battery & gas engine
- Provide stable power in blackout
- EMS with user participation enabled power demand reduction by 32%



Techno Station

The main building of Obayashi Technical Research Institute (Tokyo) , was awarded as a finalist in the category of Leadership in Sustainable Design and Performance of the Asia Pacific Regional Network Leadership Awards in Green Building (APNA) of the World Green Building Council (WorldGBC).

Renewable Energy

- In 2012, Obayashi embarked on renewable energy businesses. Since then, we have expanded our renewables portfolio, spanning from Solar, Biomass to Wind.
- Currently operating 44 plants in 30 domestic sites with the total capacity of 154MW:
  - SOLAR 28 sites, 133MW
  - BIOMASS 1 site, 6MW
  - WIND 1 site, 15MW (plus 1 under construction)
  - GEOTHERMAL Multiple survey projects
- **We have considerable experience/know-how in all aspects of renewable energy business value chain.**

Develop
- Search and acquire/lease land
- Obtain licenses / permits
- Negotiate grid connection

Design &EPC
- Design
- Engineering / Procurement / Construction

O&M
- Operation
- Sale of electricity
- Maintenance

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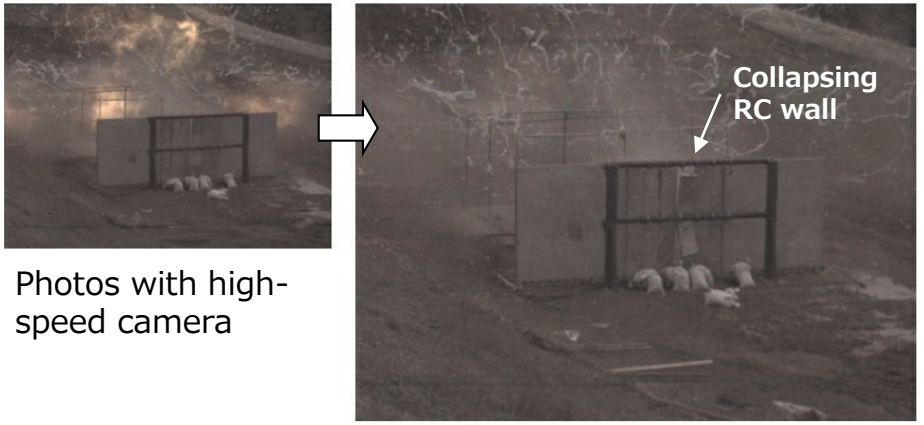
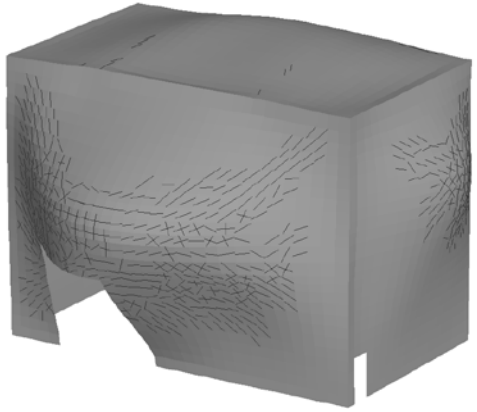
Hydrogen Technology: Structural analysis (Trigger)

Structural analysis of RC Structure against Hydrogen Explosion around year 2000

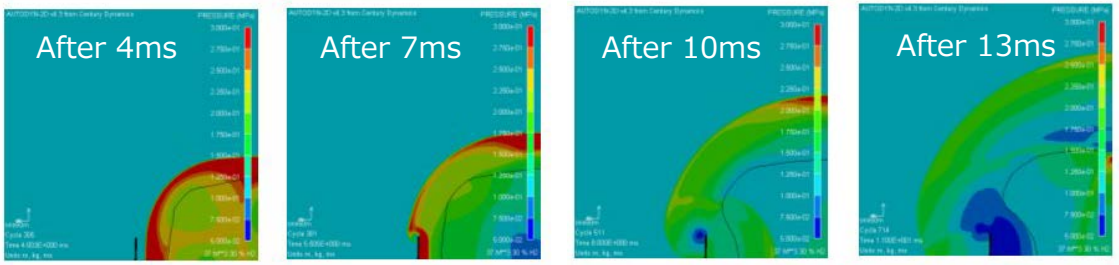
Hydrogen explosion field experiment



Photos with high-speed camera



FEM analysis of RC structure



Computer simulation of blast wave

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Construction of Hydrogen related facilities

- Upper left
  Iwatani R&D Center (Hyogo, 2013)
- Upper Right
  Air Liquide Tokyo Innovation Campus
  (Kanagawa, 2018)
- Bottom Right
  Hydrogen Energy Test & Research Center, 2nd phase (Fukuoka, 2014)

Hydrogen Refueling Stations

- **Obayashi is one of the first companies tapping into hydrogen potential in Japan.**
  - Obayashi as a Design-Builder completed a number of Hydrogen Refueling Stations.

Iwatani Hydrogen Refueling Station in Tokyo, 2015

Opening Ceremony, Prime Minister Shinzo Abe attended

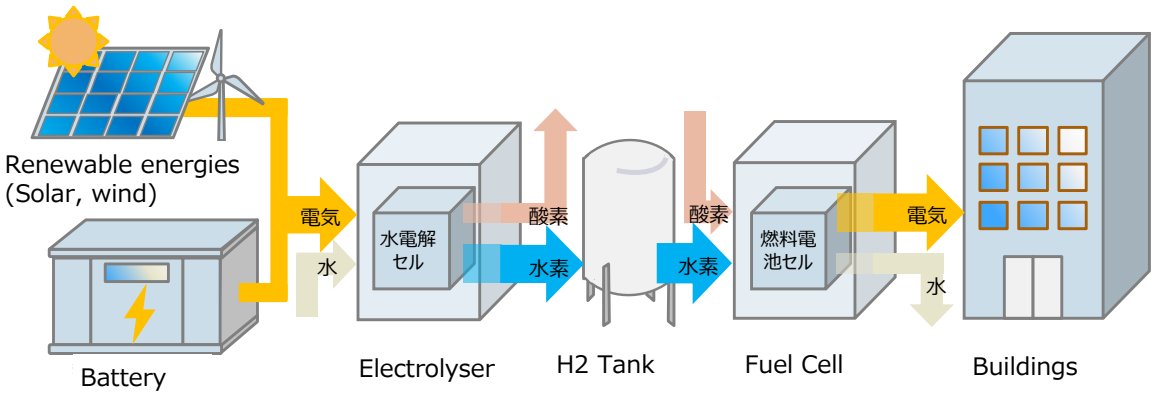
Hydrogen Refueling Station
at Kansai Airport, 2017

Hydrogen Refueling Station
In Nagoya, 2015

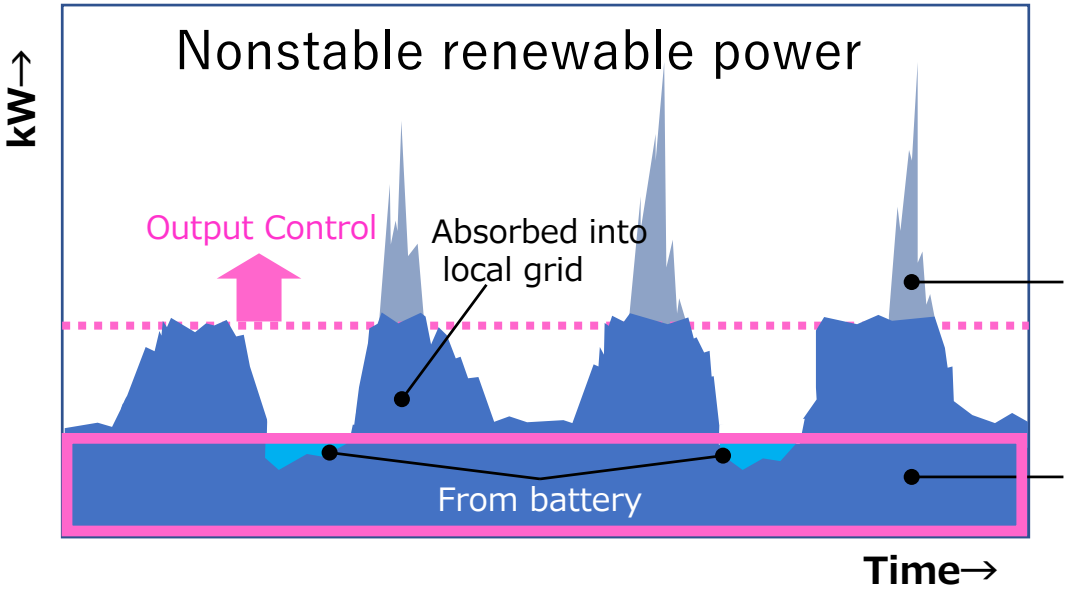
Toyota MIRAI Showroom at Iwatani
Station in Tokyo, 2015

High-Efficient CO_2 Free Hydrogen Production

Hydrogen production EMS with renewable energy



Subsidized from Tokyo Pref.



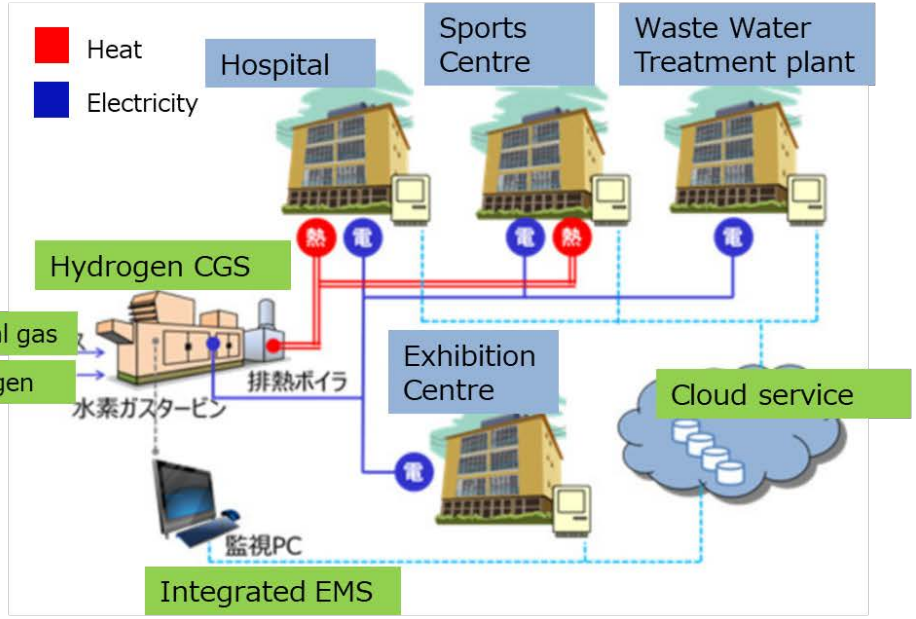
Stable and optimal electrolyser operation increases overall plant efficiency, decreasing hydrogen production cost.

Low Efficiency
Hydrogen production with
surplus power

High Efficiency
Hydrogen production with
stable (base) power

Hydrogen Co-Generation System Smart Community in Kobe

Heat and power supply at the urban area, from hydrogen fueled gas turbine engine has been achieved in April 2018 (World first!)



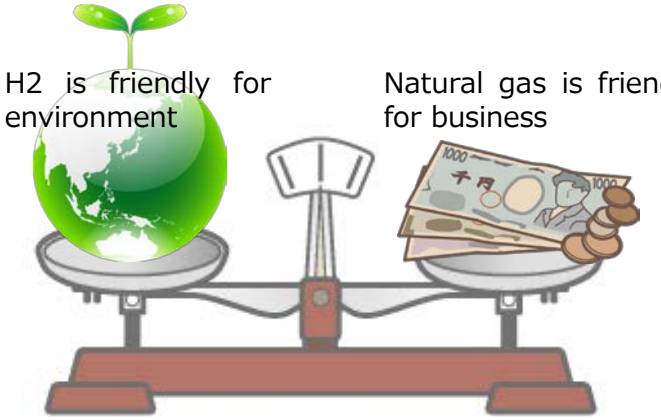
- Hydrogen fueled Co-Generation System (Hydrogen CGS) with gas turbine engine.
- Hydrogen CGS generates electricity and heat which are supplied to 4 public buildings in the area.
- Operation is monitored by cloud-based EMS.

Joint Project with Kawasaki Heavy Industries from 2015

Supported by New Energy and Industrial Technology Development Organization (NEDO)

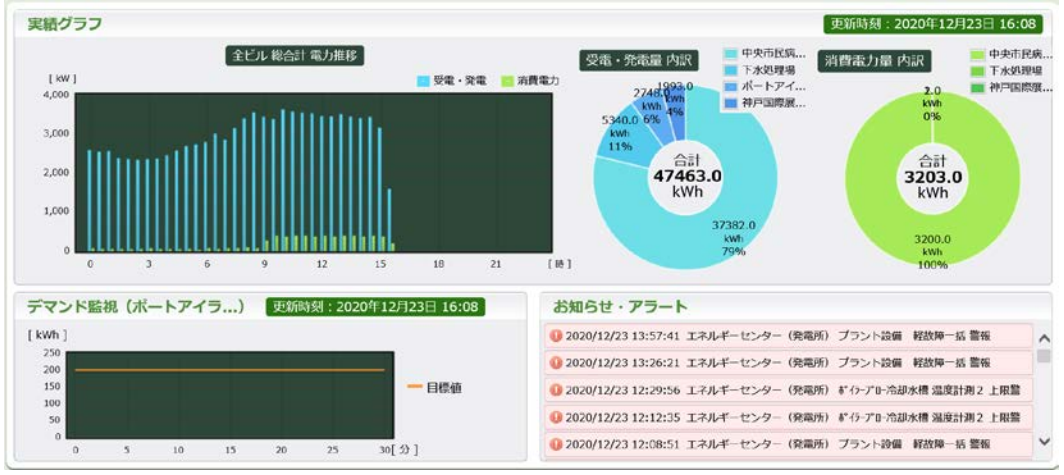
Optimal blend ratio of hydrogen and natural gas is essential for both economically and environmentally.

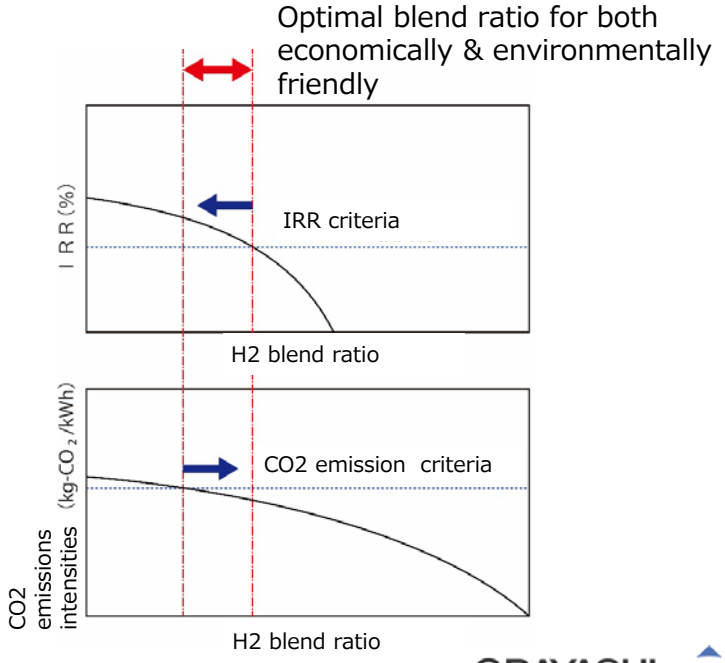
Trade-off between H2 & Natural Gas



And in future…

CGS operation needs to be flexible against daily/hourly price changes at H2 spot markets.



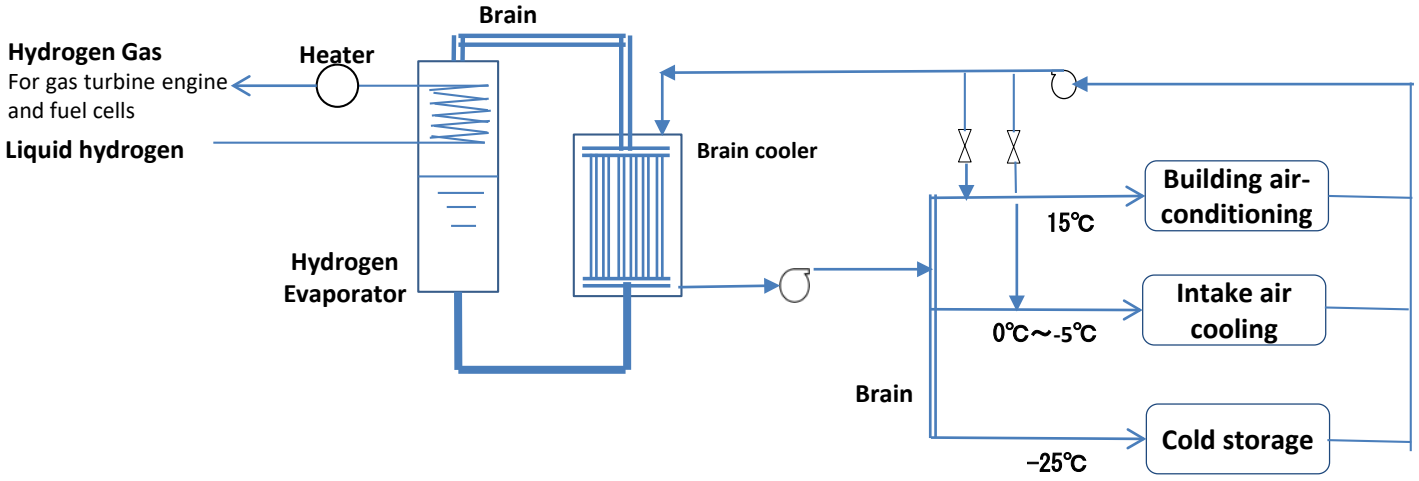


Effective use of cold heat increases overall energy performance of liquid hydrogen

Unused cold energy from liquid hydrogen
Huge energy is needed in liquefaction, but no energy is extracted from liquid hydrogen in simple evaporating process.

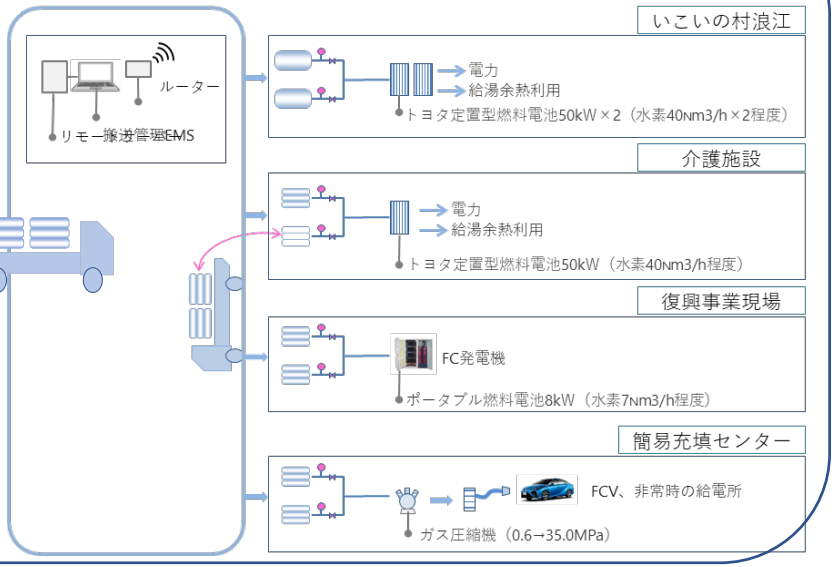
Hydrogen CGS with the cold heat utilization system
It provides not only electricity, hot heat but also cold heat, too.

Cold heat
-- for intake air cooling technology, increases gas turbine engine output.
-- for cold storages, freezes food, vaccines and others.
-- for building air conditioning.



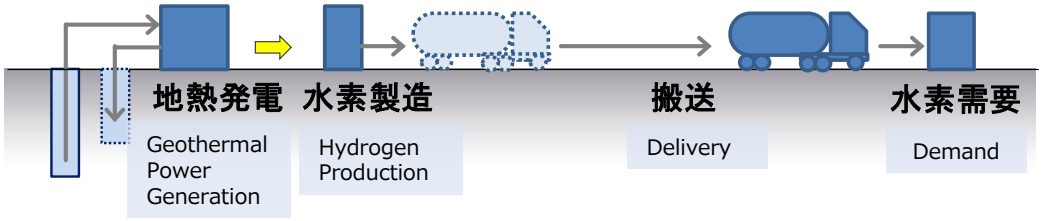
■ Our Green Hydrogen Projects in Japan

Solar origin Hydrogen SC Project in Fukushima



- The project focuses on establishing efficient delivery system of hydrogen to optimize hydrogen supply chain.

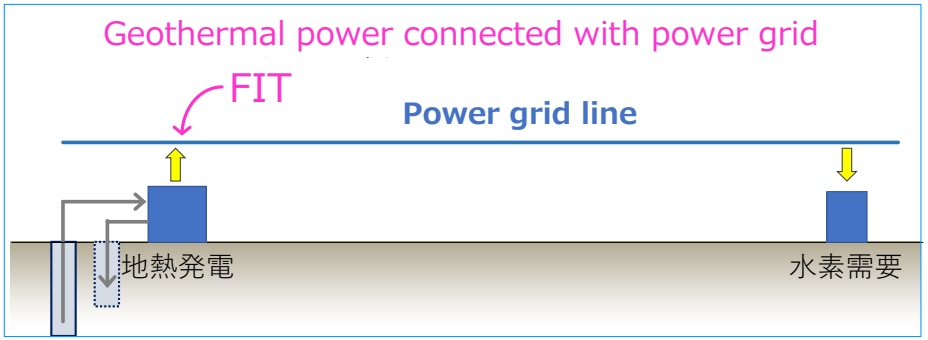
Geothermal origin Hydrogen SC Project in Oita

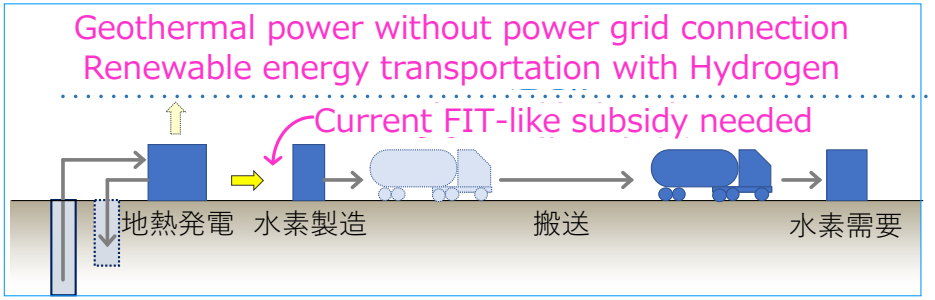


- This pilot plant produces hydrogen through electrolysis using electricity generated from geothermal heat.
- Through this R&D project, we are aiming to build a hydrogen supply chain in Japan.

Geothermal origin Hydrogen SC Project in Oita

Hydrogen expands possibilities of developing geothermal energy in remote area where power grid connection is limited.

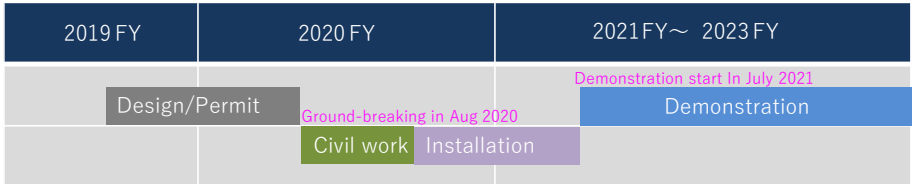




Overview

Total Power	125kW×2 (One generator for the demonstration)
H2 Production	10Nm^3/h
Construction	August 2020 – June 2021
Demonstration	July 2021 – March 2024

Schedule



Potential hydrogen users

Hydrogen research institutes
Hydrogen fueling stations
Industries

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Solar origin Hydrogen SC Project in Fukushima

Overview

- This project aims to increase hydrogen usage by installing FCs and a simple fueling station.
- Solar origin hydrogen will be supplied from Fukushima Hydrogen Research Field (FH2R) with cylinder bundles and tube trailers.
- Hydrogen supply chain optimization system generates best delivery plan and route which reduces carbon emission.

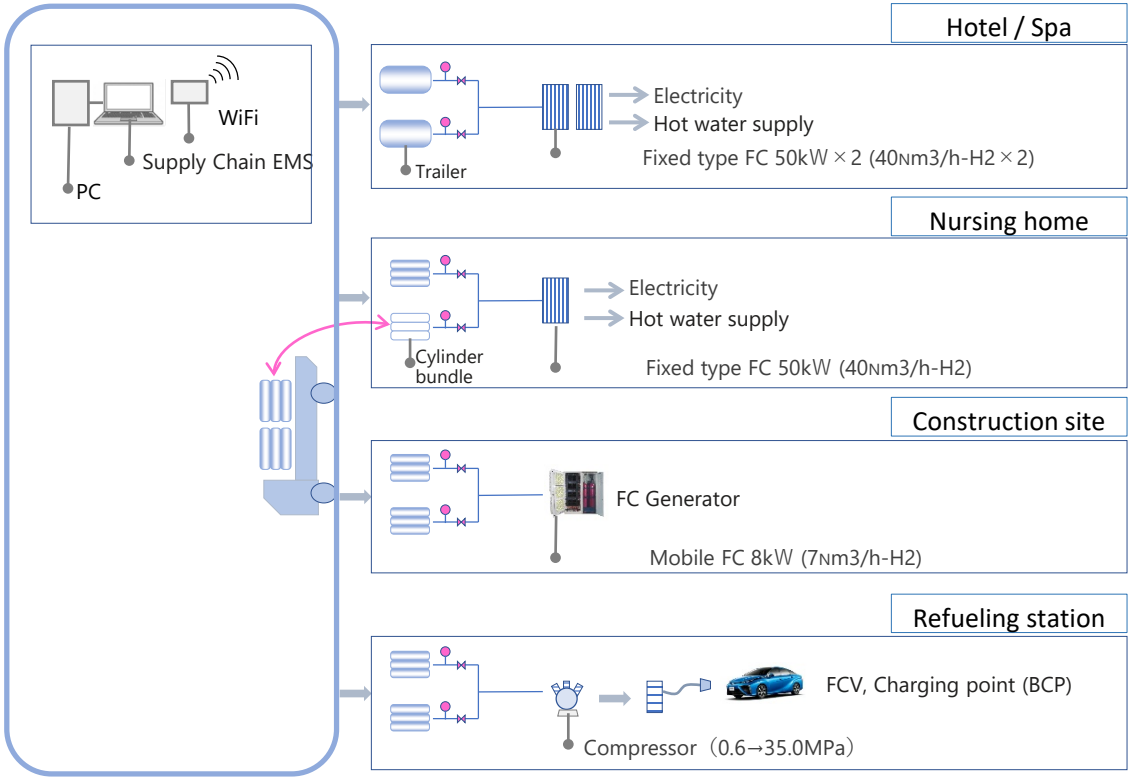
Schedule

2020FY	2021FY	2022 FY
Planning・FS	Engineering / Installation	Demonstration

Ministry of the Environment commissioned project

System configuration

Hydrogen production plant (10MW) from solar power, “Fukushima Hydrogen Research Field (FH2R)”

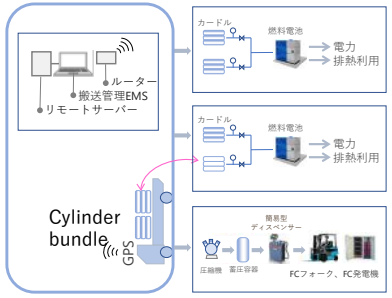


Future expansion image

- By installing FCs and FCVs in the area, small supply chain will grow into large chain.
- Management of large supply chain with several production plants and stock & supply bases, is not simple.
- The optimization of SC system becomes more important.

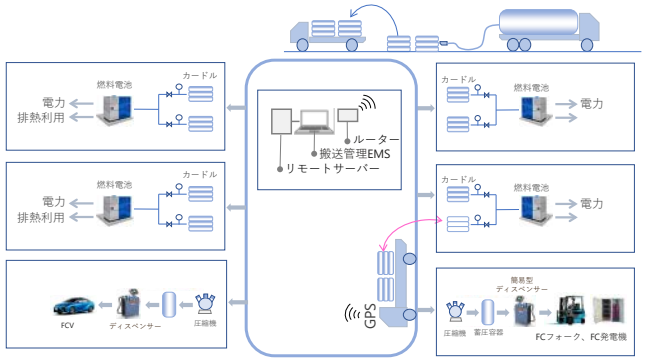
Step 1

Increases hydrogen consumption by installing FCs. Hydrogen will be delivered with cylinder bundles



Step 2

FC installations stimulate potential hydrogen demand, and tube trailers will be used for larger volume hydrogen delivery.



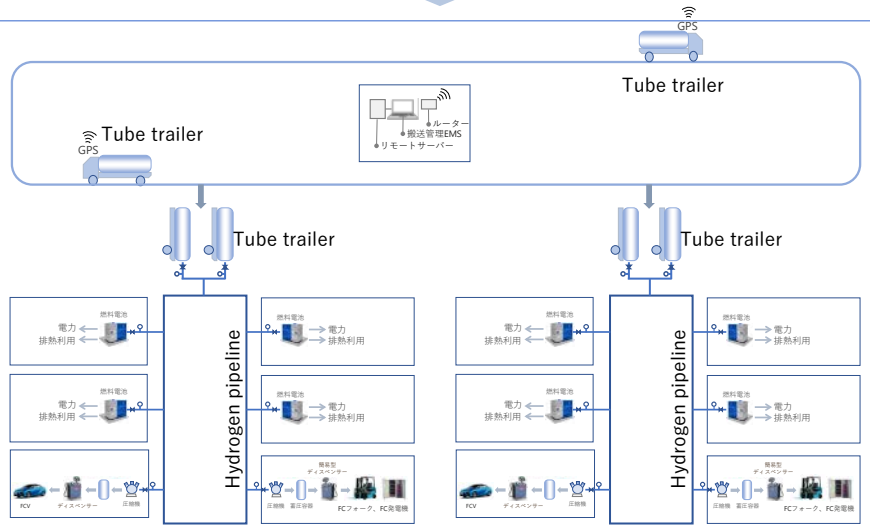
Step 3

As more FCs & FCVs are added to the community, hydrogen pipeline will be installed at some urbanized/populated area.

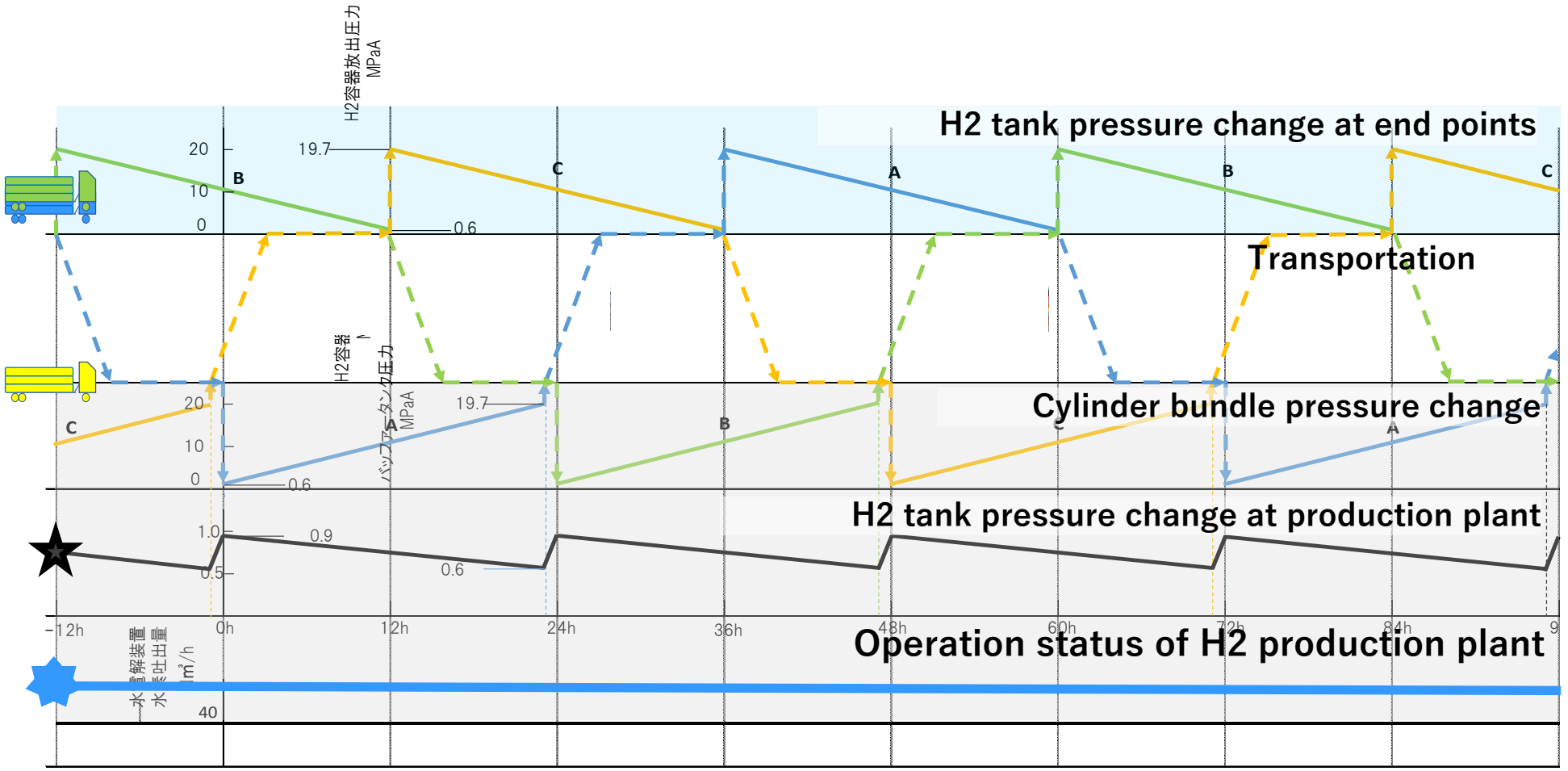
For lager demand, new production plants will be also added.

Tube trailers will be deployed from hydrogen plants to hydrogen stock and supply bases.

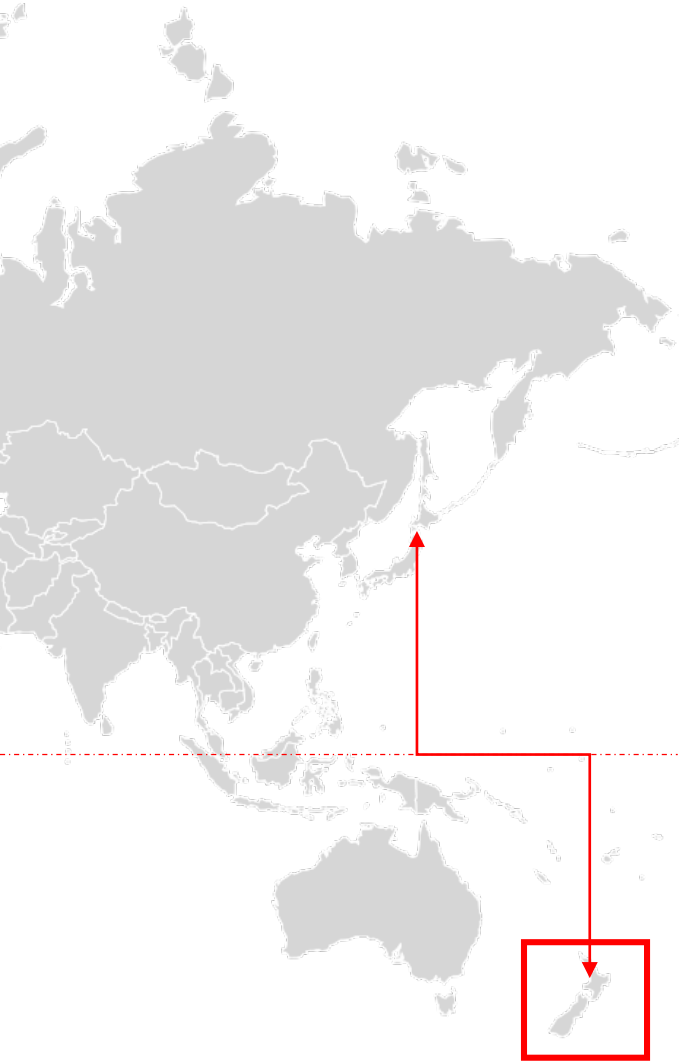
New hydrogen production plants



Necessity of Optimizing Supply Chain System



Green Hydrogen Supply Chain Demonstration in New Zealand



New Zealand

- Population 4.95 million
- Capital Wellington Pop. 0.5 million
- Business Auckland Pop. 1.7 million

Taupo

- Lake resort town in North Island with 22 thousand population
- Location of 100MW scale geothermal power plants
- Location of between Auckland and Wellington is ideal for hydrogen refueling station

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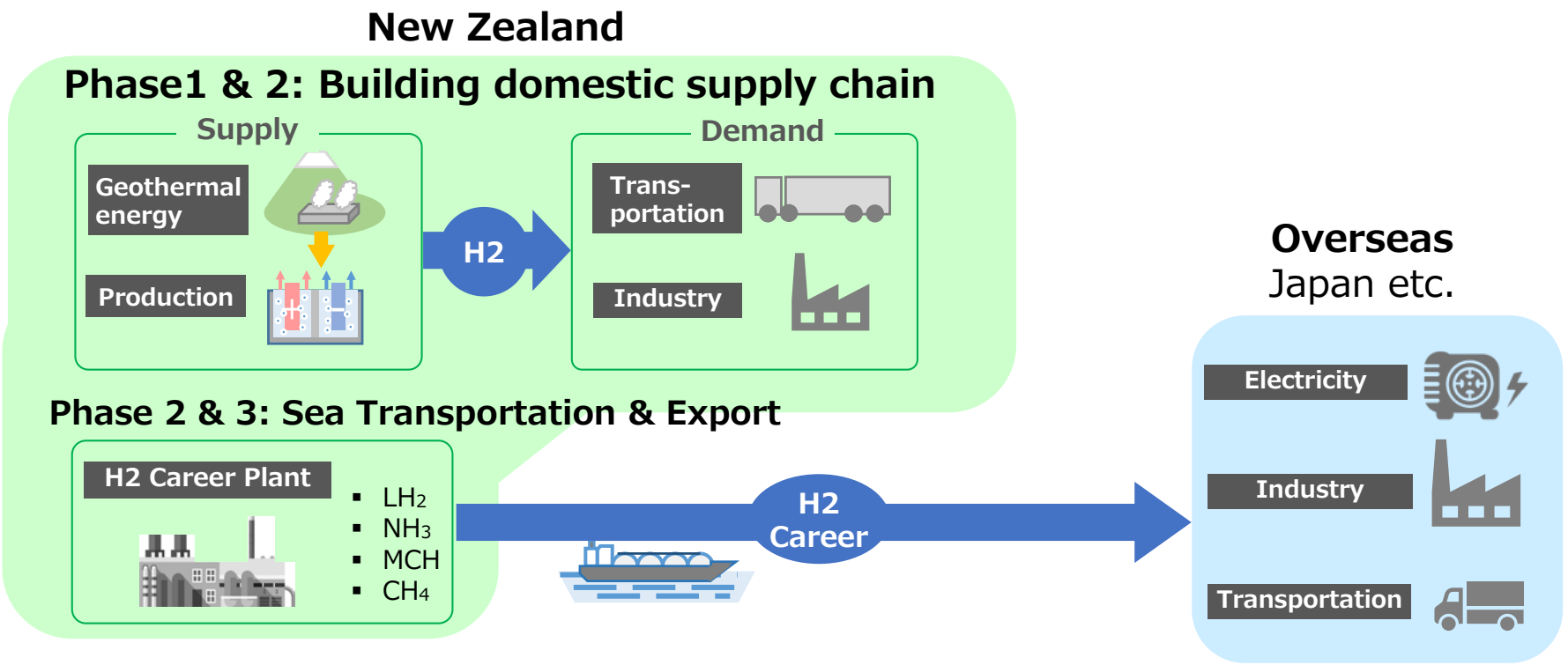
Three phases of the project



Project Phases

FY 2018- FY 2025-

Phase 1
Demonstration of Green Hydrogen Supply Chain in NZ

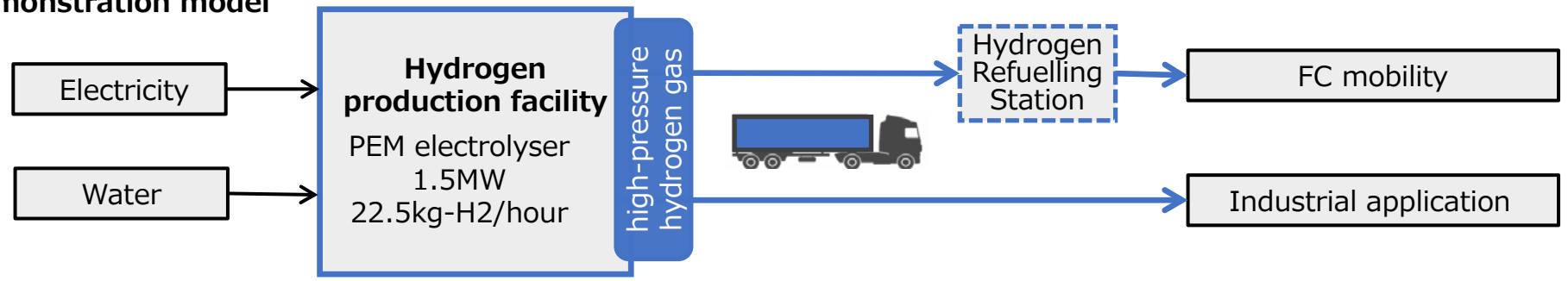
Phase 2
Demonstration of Sea Transportation

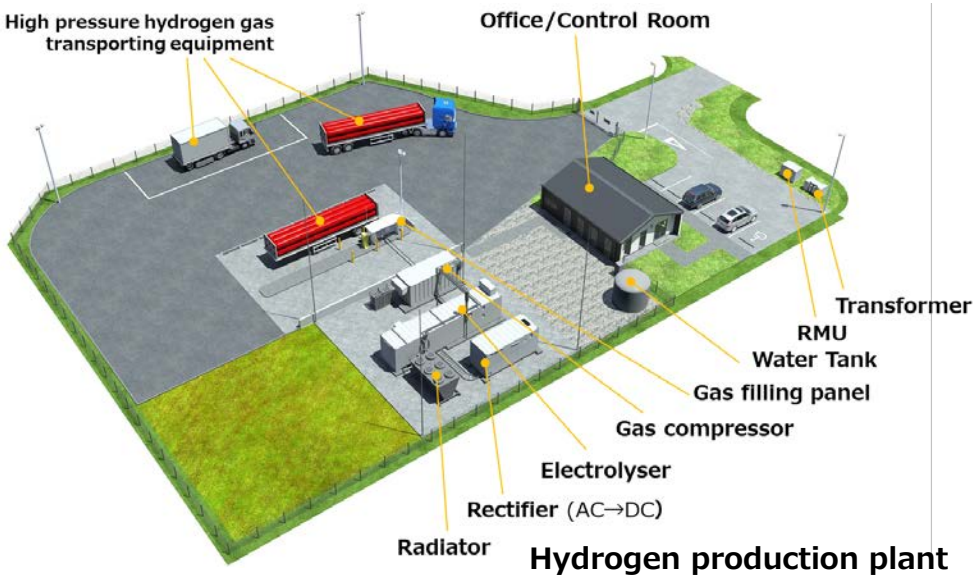
Phase 3
Scaling up & Export Business

NZ Green H2 SC Demonstration / Phase1: Building SC in NZ

- **Obayashi have launched a pilot project that aims to develop a green hydrogen supply chain in New Zealand with our local partner Tuaropaki Trust.**
- **The implementing body of this project is Halcyon Power Limited, a JV between Tuaropaki and Obayashi. Halcyon undertakes production and transport of high pressure hydrogen gas for users in New Zealand.**

Demonstration model





Hydrogen production plant

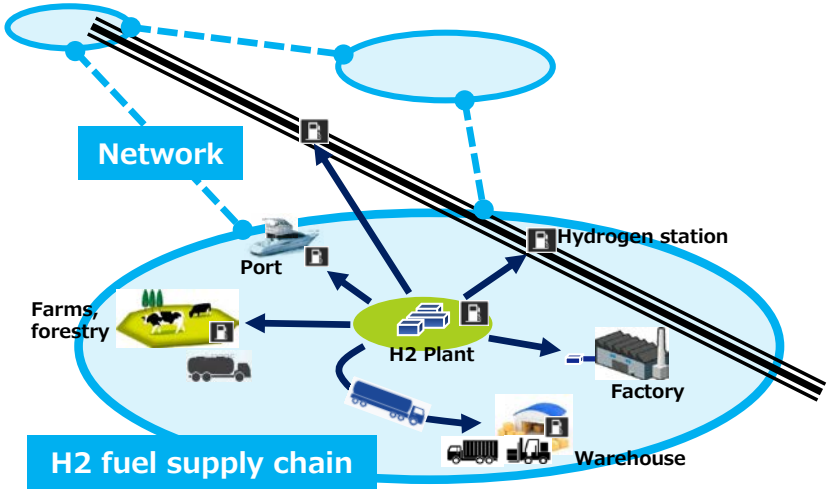


Image of green hydrogen supply chain in New Zealand

NZ Green H2 SC Demonstration / Phase1: as of 2020/12/20

Entrance gate

General view

PM Ardern visit（2020/09/10）

Power conditioner, Electolyser, Gas compressor

Inside production container

Gas filling panel
Note: FCV filling facility installed at other point

Up and Running in April 2021

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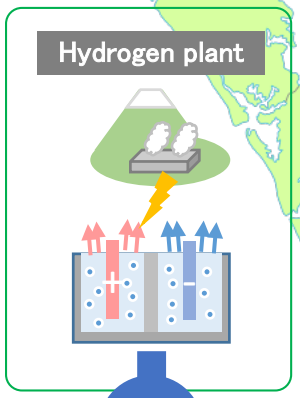
Sea transport demonstration from New Zealand to Japan



H_2

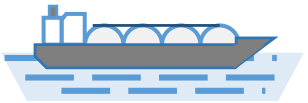
Hydrogen Career Plant

New Zealand

- LH_2
- NH_3
- MCH
- CH_4

Phase 2: Sea Transportation

LH2 tanker / Chemical tanker



Overseas

Japan etc.

Electricity | Transportation

Industry | Logistics

Project Phases

2018-	2025-	
Phase 1 Demonstration of Green Hydrogen Supply Chain in NZ	**Phase 2** Demonstration of Sea Transportation	**Phase 3** Scaling up & Export Business
R & D		Commercialization

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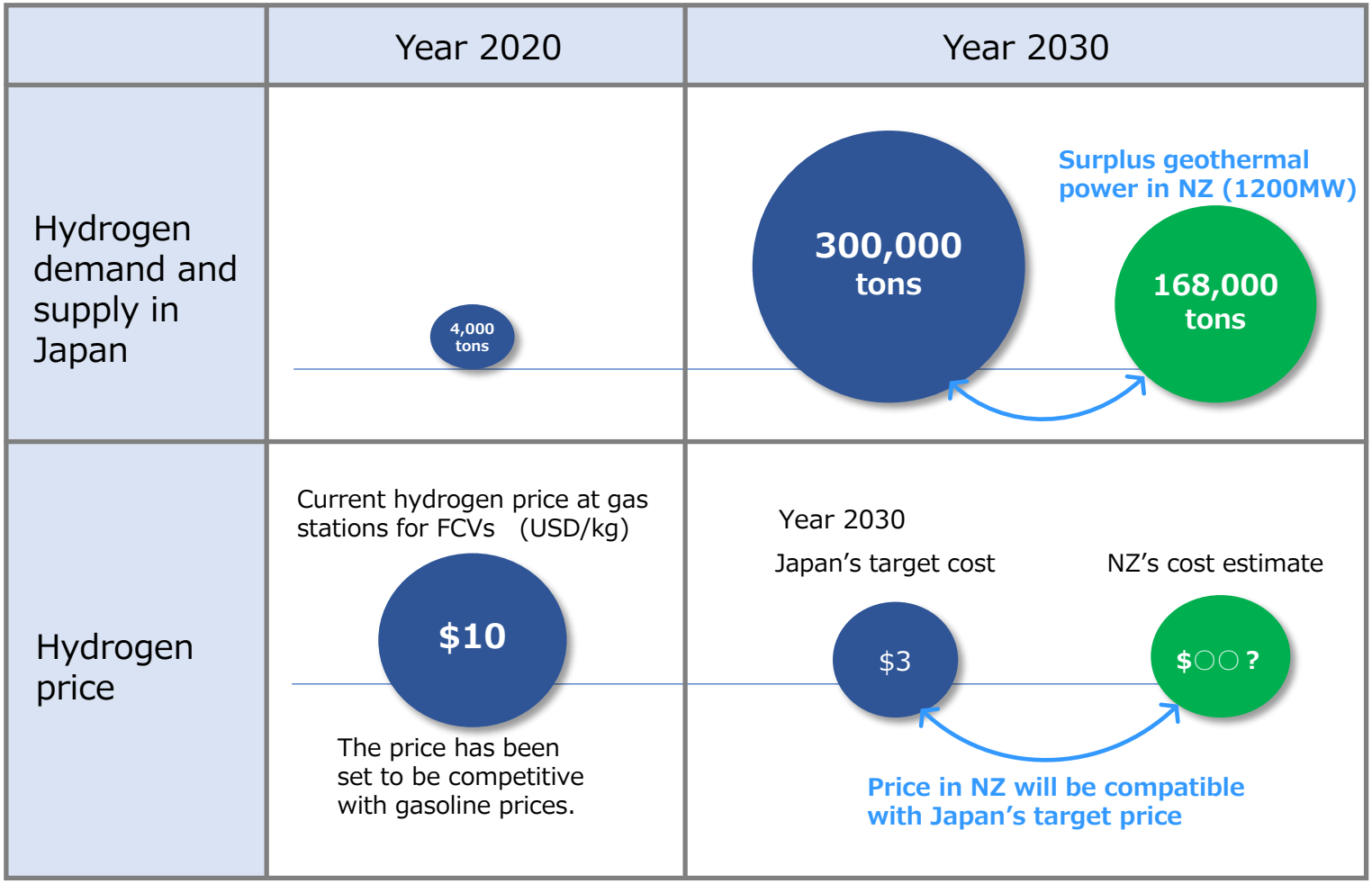
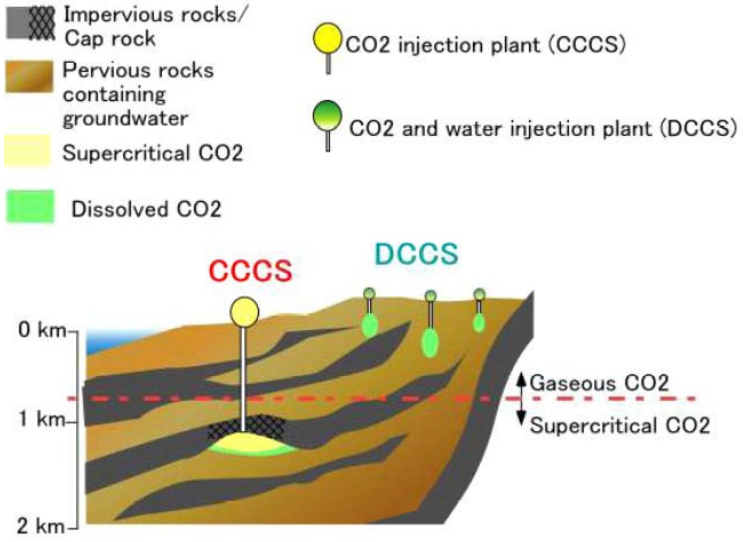
A half of demand in Japan could be covered with NZ's geothermal green H2.
-- An oil importing country now might be a fuel exporting country in 2030 --



CO_2 Microbubble Storage System (CMS)

- **An alternative carbon storage technology to CO_2 Capture and Storage (CCS).**
- **The CMS stores CO_2 dissolved water that is generated using a microbubble, by replacing it with groundwater in shallow ground.**
- **One storage unit can hold 150,000t-CO_2, and 10 units are estimated to exist in Japan.**

Two Types of CCS

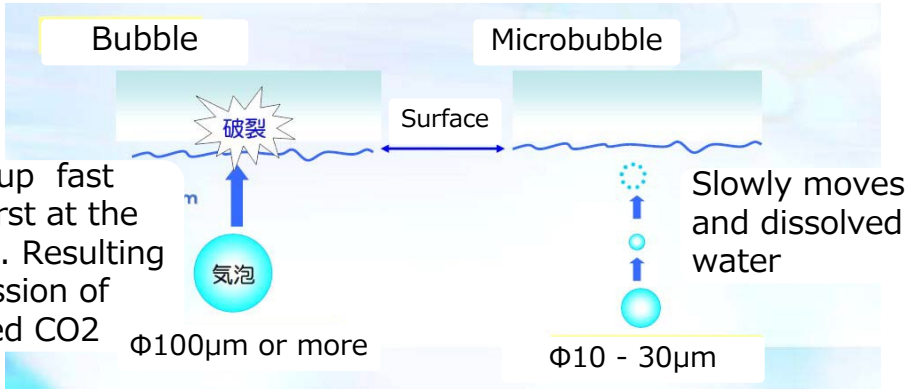


CCCS (Concentrated CCS)
Sore high-pressure & temperature supercritical state CO_2 at -800m deep.

DCCS (Distributed CCS)
Sore low-pressure CO_2 dissolved water at -300m deep where no groundwater use.

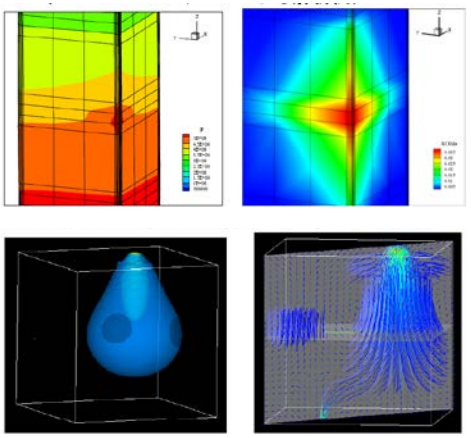
Source: AIST Nishio (2009)

Microbubble



Moves up fast and burst at the surface. Resulting re-emission of captured CO2

Slowly moves up and dissolved in water



Computer Simulation of dissolved CO_2 density

Pressure test equipment