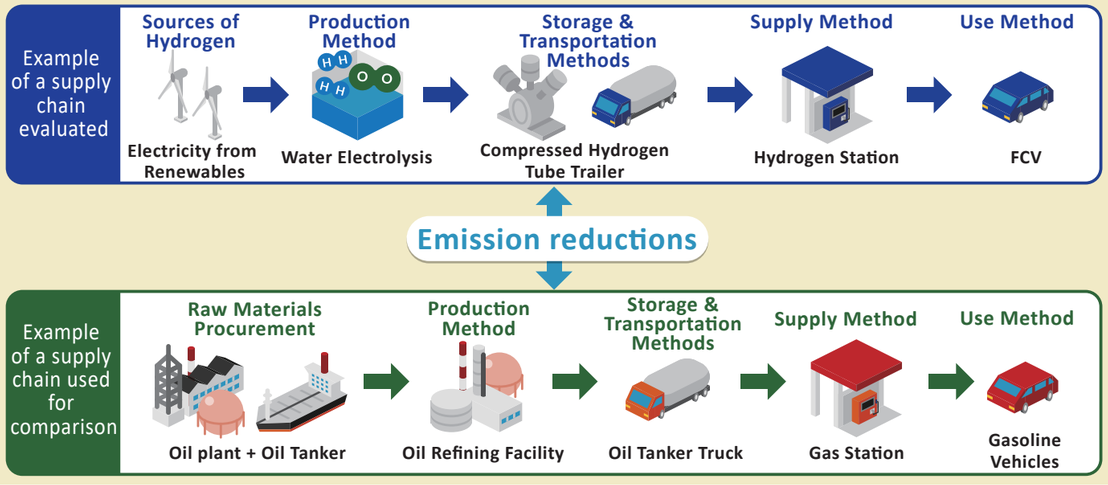
Guidelines and tools for calculating greenhouse gas emission reductions

Ⅰ LCA Guidelines

It is crucial to confirm that the use of hydrogen energy contributes to reducing greenhouse gas emissions in the whole supply chain, not only when hydrogen is used as fuel. LCA Guidelines help to calculate greenhouse gas reductions in the supply chain. These reductions are calculated by subtracting the greenhouse gases emitted by a conventional energy supply chain from those emitted by a hydrogen-based supply chain.



Greenhouse gas emission calculation method

Volume of Activity × Emissions Per Unit = GHG Emission

■Volume relates to the scale of business
➤ Each organization in the supply chain calculates their activity volume based on their expense sheet or design values
<Example values>
-Ectricityconsumption -Fuel consumption for transportation
-Amount of waste products

■Greenhouse gas emissions per unit of activity
➤Use values in publicly available information
<Example values>
-Greenhouse gas emissions per 1kWh of electricity
-Greenhouse gas emissions per 1L of fuel
-Greenhouse gas emissions per 1t of garbage burned

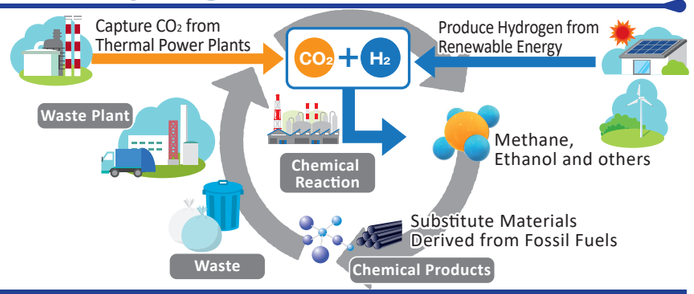
Ⅱ Tool for calculating emission reductions

In order to support the guidelines above, MOE created a tool for calculating greenhouse gas emission reductions in hydrogen supply chains as a part of the Ministry's 2016 project to evaluate and validate CO_2 reductions in hydrogen use. This tool automatically calculates hydrogen supply costs and CO_2 emission reductions in each stage of the hydrogen supply chain: production, transportation, supply, and use. The tool (an Excel file), its manual, and example calculations are available on the MOE website.

➤ **https://www.env.go.jp/seisaku/list/ondanka_saisei/lowcarbon-h2-sc/support-tool/ (Japanese only)**

CO_2 capture and utilization with hydrogen

Hydrogen derived from renewable energy sources can be used to produce chemicals without the use of fossil fuels by reacting it with CO_2 recovered from thermal power plants. This technology is called Carbon Dioxide Capture and Utilization (CCU) and it is attracting attention as an important technology for creating a decarbonized society.



Contact Information: Climate Change Projects Office, Climate Change Policy Division,
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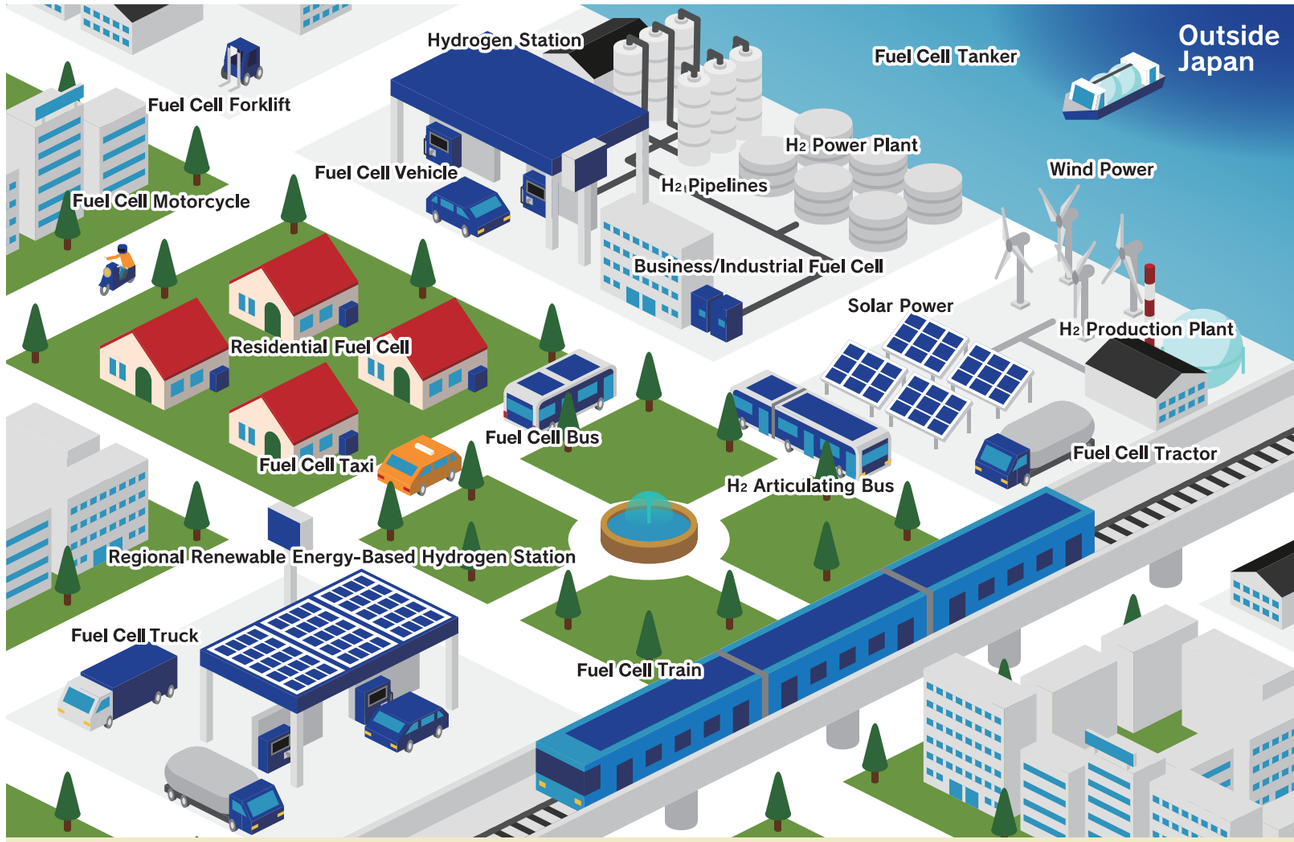
Ver.2021.03.15

環境省
Ministry of the Environment

Projects for the Creation of a Hydrogen Society

Hydrogen fuel does not generate any CO_2 when used, and fuel cells allow efficient extraction of electricity and heat. In addition, the use of renewable energy during the production of hydrogen fuel is expected to lead to total decarbonization from production to use. Hydrogen plays an important role in the creation of a decarbonized "hydrogen society," a society that uses hydrogen as a common energy source. Hydrogen has a big role to play in our society, and various hydrogen utilization projects are currently underway.



What is hydrogen?

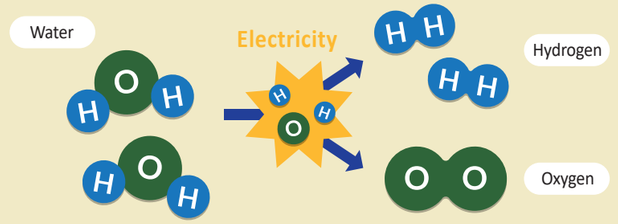
Hydrogen gas is the lightest gas on Earth and is made up of two hydrogen (H) atoms, expressed with the molecular formula H_2. Hydrogen atoms form bonds with various elements and is found in a variety of chemical compounds, such as water and fossil fuels. This characteristic makes it possible to produce H_2 from various resources. For example, hydrogen can be produced by methods such as electrolysis of water (H_2O) to generate hydrogen (H_2) and oxygen (O_2) gas.

Water electrolysis

By electrolyzing water

▼

Hydrogen and oxygen are produced

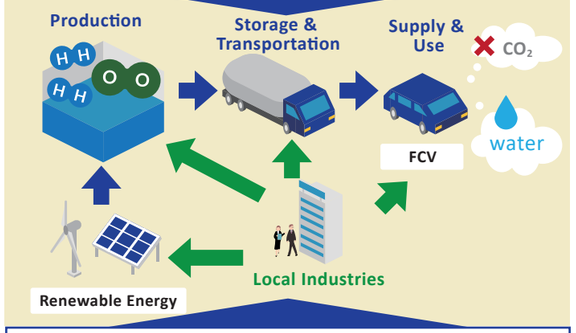


What are benefits of using hydrogen as an energy source?

Hydrogen is being used as an energy source to break free from our carbon society, with initiatives underway both in Japan and globally. Hydrogen also has the following properties.

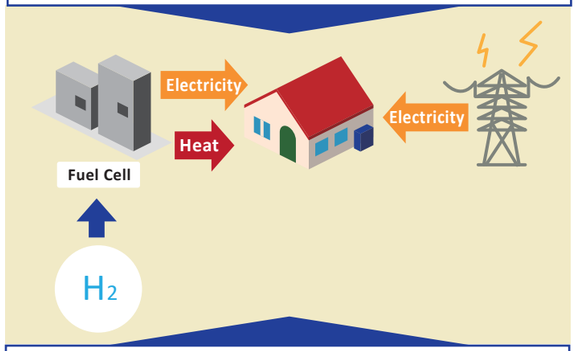
Hydrogen fuel is environmentally friendly

Since hydrogen fuel does not emit CO_2 when used to generate electricity, it can reduce our impact on the environment. Hydrogen produced from renewable energy sources are expected to further reduce CO_2 emissions.



Hydrogen fuel is helpful in emergencies

Stockpiling hydrogen fuel in advance can allow fuel cells to supply energy in times of emergency such as natural disasters, where access is cut off to traditional power sources.



Hydrogen fuel can revitalize local economies

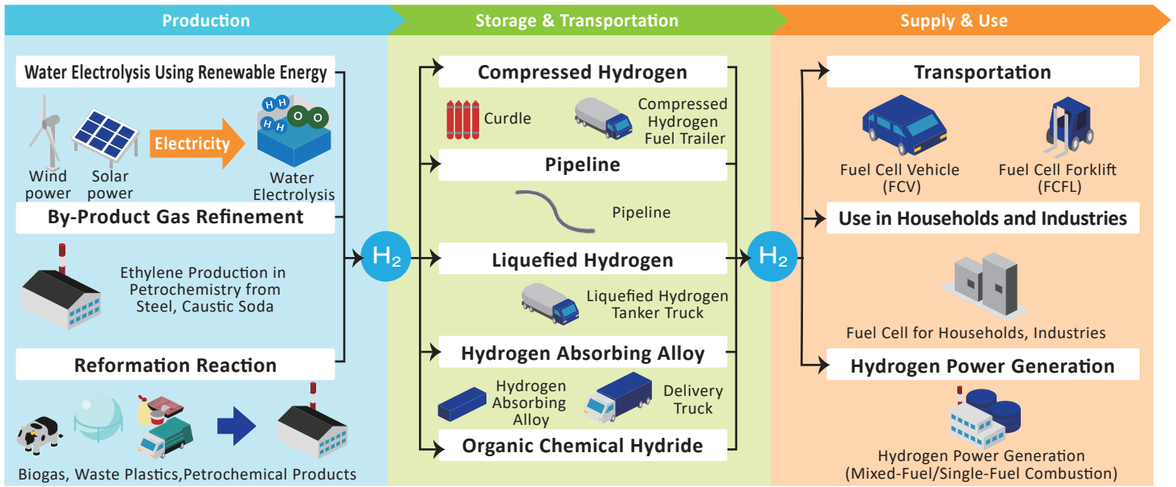
Hydrogen fuel produced from locally-generated energy sources and used within the same area will increase the number of local business opportunities, leading to local revitalization.

Hydrogen fuel can supply both electricity and heat

Hydrogen fuel cells generate not only electricity, but also heat. This enables effective usage of energy.

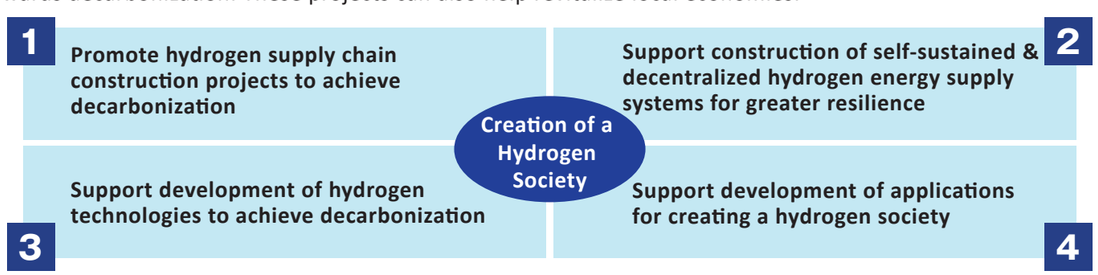
What is a decarbonizing supply chain?

To achieve decarbonization through hydrogen fuel, it is necessary to take consistent measures from production to storage, transportation and use.



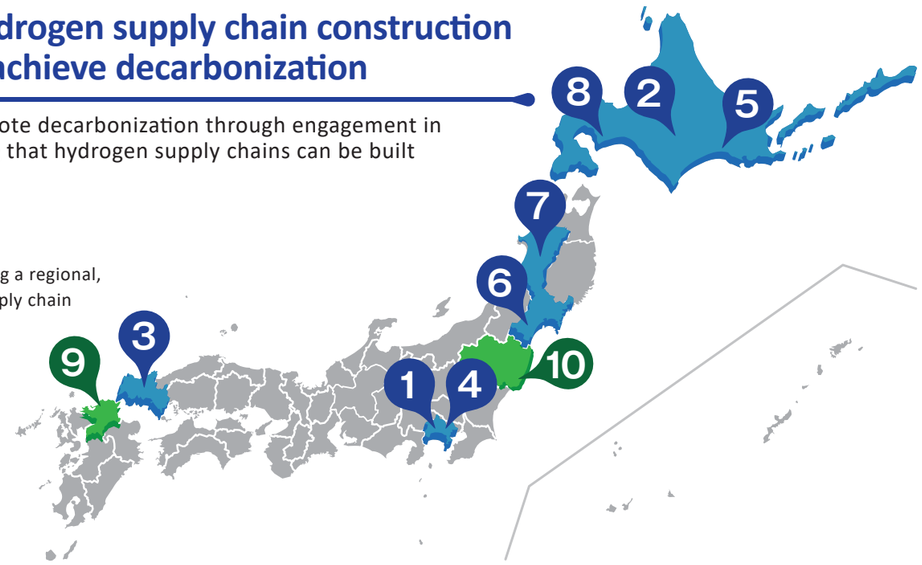
Projects for the creation of a hydrogen society

The Ministry of the Environment (MOE) is engaged in a variety of hydrogen-utilization projects in their efforts towards decarbonization. These projects can also help revitalize local economies.



1 Promote hydrogen supply chain construction projects to achieve decarbonization

The MOE aims to promote decarbonization through engagement in projects demonstrating that hydrogen supply chains can be built using local resources.



1 A hydrogen-station free direct supply of renewable hydrogen to fuel cell forklifts *Project completes in fiscal 2020

■PJ Name: Introduction of fuel cell forklift at Keihin Coastal Area and demonstration of clean hydrogen utilization model construction
■Demonstration: Keihin Coastal Area ■Primary partner: Toyota Motor Corp.
■Municipalities: Kanagawa Prefecture, Yokohama City, and Kawasaki City

Production

Hydrogen is produced through water electrolysis using wind power, which is generated at a wind power plant called Hama Wing.

With a storage battery system, electricity can be supplied even when there is little or no wind.

Storage & Transportation

Stored in a tank and then compressed, the hydrogen fuel is delivered by a simplified hydrogen fueling vehicle to sites where it will be used.

Supply & Use

The hydrogen fuel is supplied to FC forklifts at a fruit/vegetable market, distribution warehouses, and refrigerated warehouses.

2 Beyond dairy products: hydrogen production from livestock manure

■PJ Name: The hydrogen energy supply chain demonstration project from livestock manure
■Demonstration: Shikaoi Town and Obihiro City, Hokkaido ■Primary partner: Air Water Inc. ■Strategic partners: Kajima Corp., Nippon Steel Pipeline & Engineering Co., Ltd., and Air Products Japan K.K. ■Municipalities: Hokkaido, Shikaoi Town, and Obihiro City

Production

Hydrogen is produced from biogas originating from livestock manure.

Storage & Transportation

Compress the hydrogen fuel for delivery.

Put the hydrogen fuel into simplified hydrogen fueling vehicles for delivery.

Put the hydrogen fuel into curdles for delivery.

Supply & Use

The hydrogen fuel is supplied to FCVs and FC forklifts from the hydrogen station on the project operation site.

Pure hydrogen fuel cells at a sturgeon farm and Obihiro Zoo. These facilities use the hydrogen fuel to generate electricity and heat.

3 Making use of byproduct hydrogen with various transportation means

■PJ Name: Project to build a model of regional cooperation and local energy production/consumption using high purity waste hydrogen from caustic soda production ■Demonstration: Shunan City and Shimonoseki City, Yamaguchi Prefecture ■Primary partner: Tokuyama Corp.
■Strategic partners: Tosoh Corp., Yamaguchi Prefecture, Shunan City, and Shimonoseki City

Production

Hydrogen is effectively collected using buffer drums and pipelines that connect companies. The gas is then utilized in 4 different supply chains (SCs) using distinct hydrogen-delivery systems.

Storage & Transportation

The hydrogen fuel is delivered to a nearby swimming club from a caustic soda plant through pipelines.

The hydrogen fuel is compressed and delivered to a roadside station in tanks.

©Iwatani

The hydrogen fuel is liquefied and transported to a hydrogen station in Shunan and a refueling facility in Shimonoseki by tanker truck.

Supply & Use

It is used to supply electricity and heat produced with a pure hydrogen fuel cell at the swimming club.

A pure hydrogen fuel cell at the roadside station supplies electricity and heat using the hydrogen for this facility.

It is supplied to FCVs, FCFLs, pure hydrogen fuel cells and pure hydrogen boilers. Fuel cells and boilers are installed at markets and ports.

4 A hydrogen hotel running on used plastics

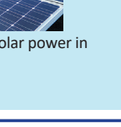
■PJ Name: Low-carbon hydrogen demonstration project of waste plastics regional circular model
■Demonstration: Kawasaki City, Kanagawa Prefecture ■Primary partner: Showa Denko K.K ■Municipality: Kawasaki City

Production

Waste plastics

Reused Plastic Fuels (RPF)

Hydrogen is produced from plastic waste.



Storage & Transportation

The hydrogen produced at the Showa Denko Kawasaki Plant is transported to the sites where it will be used by pipeline or using a compressed hydrogen tube trailer.

Supply & Use

Power generated by a hotel's pure hydrogen fuel cell (left photo) is used in various ways such as for lighting in guest rooms and in a plant factory (right photo) .

It is also supplied to FCVs at a hydrogen station.

5 Boosting regional renewable potential: hydrogen production from small-hydro power

*Project completes in fiscal 2020

■PJ Name: Expanding the use of hydrogen produced from a small hydropower plant and establishing a hydrogen utilization model suitable for the local characteristics of Hokkaido ■Demonstration: Shiranuka Town and Kushiro City, Hokkaido ■Primary partner: Toshiba Energy Systems & Solutions Corp. ■Strategic partner: Iwatani Corp. ■Municipalities: Hokkaido, Kushiro City, and Shiranuka Town

Production

Hydrogen is produced through water electrolysis using small-scale hydropower.

Storage & Transportation

Stored in a tank and then compressed, the hydrogen fuel is delivered in high-pressure gas tanks to sites where it will be used.

Supply & Use

The hydrogen fuel is supplied to a pure hydrogen fuel cell installed at a heated indoor swimming pool, and then used as electricity and heat.

6 Safe delivery of renewable hydrogen to households using hydrogen-absorbing alloy cartridge

■PJ Name: Project to demonstrate a low-carbon hydrogen supply chain using fuel cells and the existing logistics network in Tomiya, Miyagi Prefecture
■Demonstration: Tomiya City, Miyagi Prefecture ■Primary partner: Hitachi, Ltd. ■Strategic partner's: Marubeni Corp., Miyagi Coop., and Tomiya City

Production

Hydrogen is produced by solar power in Tomiya.

Storage & Transportation

The hydrogen fuel is stored in hydrogen-absorbing alloy cartridges and transported to the sites using the existing logistics of Miyagi Coop.

Supply & Use

The hydrogen is supplied through hydrogen-absorbing alloy cartridges.

For greater resilience, a hydrogen mixed-combustion engine generator is used to supply electricity to auxiliary facilities necessary for hydrogen production.

7 Making use of existing infrastructure: mixing renewable hydrogen with town gas

■PJ Name: Project to demonstrate the production of hydrogen from electrolysis using wind power, as well as the supply and use of hydrogen mixed with municipal natural gas ■Demonstration: Noshiro City, Akita Prefecture ■Primary partner: NTT Data Institute of Management Consulting, Inc.
■Strategic partner: Dainichi Machine and Engineering Co., Ltd. ■Municipality: Noshiro City

Production

Hydrogen is produced using electricity generated by a wind power plant in Noshiro, Akita.

Storage & Transportation

After being mixed with a gas similar to town gas, the hydrogen is temporarily stored in gas holders or tanks. The hydrogen-mixed gas is then supplied through gas pipelines to the sites where it will be used.

Supply & Use

The gas mixture is used in stoves, heaters, boilers and other commercial gas devices in demonstration households to test the device's compatibility with the gas.

The gas mixture is used in home-use fuel cells installed at municipal facilities.

8 Renewable hydrogen delivery with hydrogen-absorbing alloy tank and effective heat utilization

■PJ Name: Project to demonstrate a low-pressure hydrogen delivery system to promote hydrogen use in buildings and city infrastructure
■Demonstration: Muroran City, Hokkaido ■Primary partner: Taisei Corp. ■Strategic partners: Muroran City, Kyushu University, Muroran Institute of Technology, Tomoe Shokai Co., Ltd., and Kita Koudensha Corp.

Production

©The Muroran Minpo Co. Ltd.

This project uses electricity generated by wind power facilities in Muroran, Hokkaido, to produce hydrogen.

Storage & Transportation

The hydrogen is delivered by a vehicle-mounted hydrogen-absorbing alloy tank, and stored in a stationary hydrogen-absorbing alloy tank.

Supply & Use

A pure hydrogen fuel cell installed at a hot spring facility generates electricity and heat. Unused excess heat is used to extract hydrogen from the fuel cell alloy.

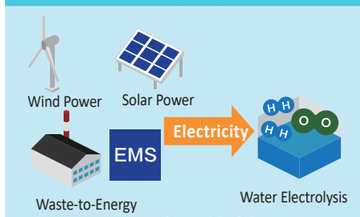
A pure hydrogen fuel cell installed at a welfare facility generates electricity and heat. Excess heat from the fuel cell is used to extract hydrogen from the alloy.

9 Using waste-to-energy and local renewable energy for green hydrogen

*Project adopted in fiscal 2020

■PJ Name: Project to demonstrate green hydrogen production and supply using local renewable energy in Kitakyushu City
■Demonstration: Kitakyushu City, Fukuoka City and Kurume City, Fukuoka Prefecture ■Primary partner: Kitakyushu Power Co., Ltd.
■Strategic partners: IHI Corp., Fukuoka Oxygen Co., Ltd., ENEOS Corp. ■Municipalities: Fukuoka Prefecture and Kitakyushu City

Production



An Energy Management System (EMS) is used to efficiently adjust surplus power from various renewable energy sources and produce hydrogen at a low cost.

Storage & Transportation

The compressed hydrogen fuel is transported by curdles.

The hydrogen fuel is transported through pipelines.

Supply & Use

The hydrogen fuel is supplied to FCVs from hydrogen stations and to FCFLs from simplified hydrogen fueling vehicles.

The hydrogen fuel is used to generate electricity and heat using pure hydrogen fuel cells in demonstration households and museums.

10 A city-building hydrogen supply chain that achieves recovery and decarbonization

*Project adopted in fiscal 2020

■PJ Name: Project to construct and demonstrate a low-cost renewable hydrogen supply chain using an operation optimization system
■Demonstration: Namie Town, Fukushima Prefecture ■Primary partner: Obayashi Corp. ■Municipality: Namie Town

Production

Renewable hydrogen produced at the Fukushima Hydrogen Energy Research Field (FH2R) is used.

Storage & Transportation

Optimized delivery of compressed hydrogen fuel by curdles.

Supply & Use

The hydrogen fuel is used to generate electricity and heat using fuel cells in the town's facilities.

The hydrogen fuel is supplied from simplified hydrogen fueling vehicles.

*These images are for illustration purposes only.

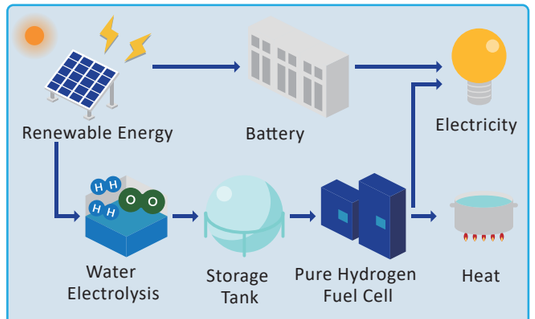
2 Support construction of self-sustained & decentralized hydrogen energy supply systems for greater resilience

The MOE supports construction of self-sustained & decentralized hydrogen energy supply systems for greater resilience. The system generates electricity and heat using hydrogen in the event of a disaster.

Self-sustained & decentralized hydrogen energy supply system

End User

The MOE supports the introduction of FC buses and FC forklifts, the popularization of which is expected to contribute a reduction in the mobility sector. Both of them are equipped with an emergency power supply function.



Self-sustained & Decentralized Hydrogen Energy Supply System

Column **Example of Stationary Fuel Cell Utilization**

When Hokkaido Eastern Iburi earthquake occurred in 2018, the self-sustain function of stationary fuel cell worked successfully. It also supplied electricity to the facilities with using fuel cell vehicles and fuel cell forklifts

Stationary Fuel Cell kept the breeding facility operation

Sturgeon breeding facility

Image courtesy of Environmental Conservation Center of Shikaoi Town

Case 1 (2018 MOE subsidy program)
Hydrogen-Based Autonomous Energy Supply System "H2 One™"
Mizuho-Toshiba Leasing Co., Ltd., Asahi Group Holdings, Ltd., Asahi Brewery in Ibaraki prefecture

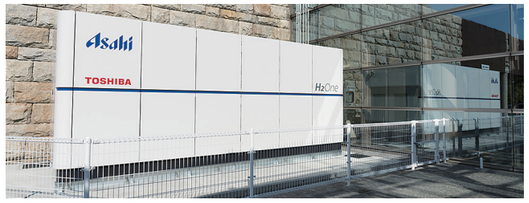


Image courtesy of Toshiba Energy Systems & Solutions Corp.

Case 2 (2019 MOE subsidy program)
Hydrogen Based Accumulator System "Hydro Q-BiC"
Design plan of the New Headquarters Building, Hokuriku Branch, Shimizu Corp. with "Hydro Q-Bic" equipped

Image courtesy of Shimizu Corp.

3 Support development of hydrogen technologies to achieve decarbonization

The MOE supports development of hydrogen utilization technologies that will reduce CO_2 emissions reduction and lead to the realization of a decarbonized society.

Hydrogen-absorbing alloy

R & D

Developed a hydrogen-absorbing alloy, which allows for low-pressure, high-density hydrogen storage, for a cost reduction, and improved its absorption and emission efficiency.
■Primary partner: NASU DENKI-TEKKO CO., LTD.
■Strategic partner: Ashikaga University
■Implemented from fiscal 2017 to 2019

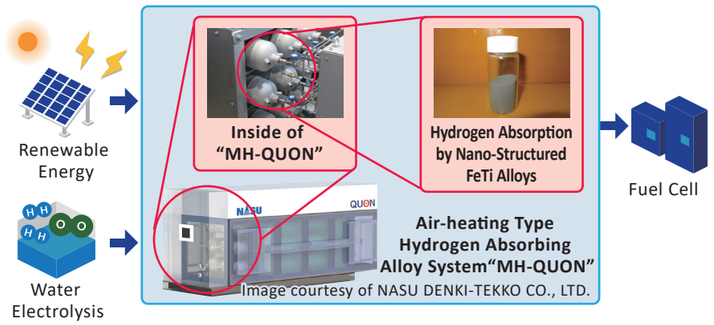


Image courtesy of NASU DENKI-TEKKO CO., LTD.

Column **Benefits of Hydrogen-absorbing Alloys**

A hydrogen-absorbing alloy can store hydrogen and allow for its handy carrying.

The alloy can be carried by hand. No special tool or qualification are required

Loading hydrogen-absorbing alloy cartridges

Image courtesy of Hitachi, Ltd.

4 Support development of applications for creating a hydrogen society

The MOE supports the development and implementation of applications in the transportation and other sectors.

Fuel cell power supply vehicle and fuel cell based mobile power generator

R & D

The MOE supports the development of fuel cell power supply vehicles and fuel cell based mobile power generators that can utilize hydrogen derived from renewable energy sources.
The power to run the vehicle's motors and its electronics is provided by fuel cells, so the vehicle contributes to decarbonization. The vehicle is equipped with a hydrogen tank capable of a maximum range of approximately 100 km for one-way travel (200 km for round-trip travel), and capable of supplying electricity continuously for approximately 72 hours. It can supply electricity in the event of a disaster, thereby enhancing resilience in securing an energy source.

■Primary partner: Denyo Co., Ltd.
■Strategic partner: Toyota Motor Corp.
■Implemented from fiscal 2019

Image courtesy of Denyo Co., Ltd.

FC Vessel

R & D

Developed a water-and salt-proof FC unit for vessels, and demonstrated at sea.
■Primary partner: Toda Corporation
■Strategic partners: Nagasaki Institute of Applied Science, Nippon Kaiji Kyokai
■Implemented from fiscal 2014 to 2015

Image courtesy of Toda Corp.

Stationary FC

R & D

Developed a control system for connected multiple 100kW units, for the downsizing of the stationary FC, and improvements of its durability and power output.
■Primary partner: Toshiba Energy Systems & Solutions Corporation
■Implemented from fiscal 2018

Image courtesy of Toshiba Energy Systems & Solutions Corp.

FC Forklift

R & D End User

Supported R&D of a FC forklift for its potential to reduce costs and its improvement of energy efficiency and durability, leading to its commercialization in 2016.
Supports the introduction of forklifts, which boast both environmental friendliness and convenience (about 3 min. of refilling time).
■Primary partner: Toyota Industries Corp.
■Implemented from fiscal 2014 to 2016

Image courtesy of Toyota Industries Corp.

FC Garbage Truck

R & D

Developed an FC garbage truck, tested its basic performances, and identified optimal uses in actual garbage collection.
■Primary partner: Flat Field Co., Ltd.
■Strategic partners: Waseda University Academic Solutions Corp., Techmation Co., Ltd.
■Implemented from fiscal 2015 to 2017

Image courtesy of Flat Field Co., Ltd

FC Truck

R & D

Tested a FC truck's basic performances and practicality, and demonstrated on public roads for its mass production.
■Primary partner: Tokyo R&D Co., Ltd.
■Implemented from fiscal 2016 to 2019

Image courtesy of Tokyo R&D Co., Ltd.

FC Bus

R & D End User

Supported R&D of a FC bus for the improvement of its power performance, reliability and durability, leading to its commercialization in 2017.
Supports the introduction of the FC buses, which boast both environmental friendliness and comfort.
■Primary partner: Hino Motors, Ltd.
■Strategic partner: Toyota Motor Corporation
■Implemented from fiscal 2013 to 2015

Image courtesy of Toyota Motor Corp.

Column **Example of Fuel Cell Bus Utilization**

When Chiba Prefecture, Japan was struck by the typhoon in 2019, fuel cell bus successfully supplied electricity as an emergency power source.

Fuel cell bus supplied electricity to home appliances and mobile phones

Fuel Cell Bus

Image courtesy of Toyota Motor Corp.