Tools for supporting operationalization

1. 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.

Example of a supply chain evaluated by the LCA Guidelines

- **Sources of Hydrogen**
  - Electricity from Renewables
  - Water Electrolysis

- **Production Method**
  - Compressed Hydrogen Tube Trailer

- **Supply Method**
  - Hydrogen Station

- **Use Method**
  - FCV

Emission reductions

Example of a supply chain used for comparison in the LCA Guidelines

- **Raw Materials Procurement**
  - Oil plant + Oil Tanker

- **Production Method**
  - Oil Refining Facility

- **Storage & Transportation Methods**
  - Oil Tanker Truck

- **Supply Method**
  - Gas Station

- **Use Method**
  - Gasoline Vehicles

Method of calculating greenhouse gases

- **Volume of Activity**
- **Emissions Per Unit**

GHG Emission

What is hydrogen?

Hydrogen is the lightest gas on earth and is shown as H2 in the world of chemistry. When a hydrogen atom, the most abundant chemical substance in the universe, bonds with another hydrogen atom, H2 is produced. On earth, hydrogen atoms bond with many other elements and exist in the form of chemical compounds such as water or fossil fuels, which makes it possible to produce hydrogen atoms from various kinds of resources. The most common way to produce hydrogen is to electrolyze water (H2O), thereby generating hydrogen (H2) and oxygen (O2).

Water electrolysis

By electrolyzing water

Hydrogen and oxygen are produced

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**Benefits of using hydrogen as energy**

1. **Reduce the amount of energy consumption**
   Fuel cells, which produce electricity by reacting hydrogen with oxygen, can achieve even greater energy efficiency when the reaction’s by-product heat is also used, leading to a reduction in energy consumption.

2. **Decarbonize fuels**
   Although the amount of CO₂ emitted in hydrogen production varies depending on the sources of hydrogen, hydrogen can contribute to the decarbonization of fuels since no CO₂ is emitted when it is used.

### Examples of sources of hydrogen

- **Renewable Energy**
  - Electrolyze water using wind power
  - Water Power

- **Biogas**
  - Reform biogas produced from livestock manure or sewage sludge
  - Refining

- **Industrial By-product**
  - Refine hydrogen by-product of caustic soda production

3. **Promote the use of renewable energy**
   Since renewables are unstable, mechanisms to store excess electricity or supply it when there is a shortage are needed. Hydrogen is one such mechanism because it can store energy for a long period of time.

### Projects for constructing a low-carbon hydrogen supply chain

- **Demonstrating a regional, low-carbon hydrogen supply chain**
  - The MOE aims to promote decarbonization through large-scale use of hydrogen as part of the Ministry’s medium- to long-term global warming countermeasures. With this in mind, the MOE is engaged in projects to construct low-carbon hydrogen supply chains in various regions.

### A hydrogen-station free direct supply of renewable hydrogen to fuel cell forklifts

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

### Beyond dairy products: hydrogen production from livestock manure

- **PJ Name**/The Hydrogen Energy Supply Chain Demonstration Project from Livestock Manure
- **Demonstration Area**: 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.

**Program (fiscal 2018)**

- **Projects for constructing a low-carbon hydrogen supply chain**
  - Promoting a hydrogen-based society through the use of renewable energy
    - Demonstrating a regional, low-carbon hydrogen supply chain

- **Support for adoption of low-carbon hydrogen technologies**
  - Using renewable energy-based hydrogen to promote the decarbonization of community infrastructure
  - Development of Self-sustained & Decentralized Hydrogen Energy System

- **Support for development of low-carbon hydrogen technologies**
  - Low-carbon Technology Research and Development Program
  - Feasibility Study on FC Vessel Technology

- **Tools for supporting operationalization**
  - Promoting a hydrogen-based society through the use of renewable energy
    - Evaluation and validation of CO₂ emissions reduction in hydrogen use
Making use of byproduct hydrogen with various transportation means

- **Production**: The hydrogen is produced by electrolyzing water with high-purity byproduct hydrogen from a small hydroelectric plant.
- **Storage & Transportation**: The hydrogen is delivered to a nearby swimming pool from the byproduct plant through pipelines.
- **Supply & Use**: The hydrogen is used at the swimming pool to generate electricity and heat.

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

- **Production**: The hydrogen is produced via electrolysis using wind power, as well as the supply and use of hydrogen mixed with municipal natural gas.
- **Storage & Transportation**: The hydrogen is stored in hydrogen-absorbing alloys and transported to the cities. Taking advantage of existing logistics networks, the delivery also involves the delivery of other goods.
- **Supply & Use**: The hydrogen is supplied through hydrogen-absorbing alloy cartridges.

A hydrogen hotel running on used plastics

- **Production**: 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.
- **Storage & Transportation**: The hydrogen stored at the ECO Hydrogen Station in Kawasaki is supplied to FCVs at the hotel.

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

- **Production**: The gas is supplied to FCVs at a hotel.
- **Storage & Transportation**: The hydrogen supplied to FCVs at the hotel.

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

- **Production**: The hydrogen is produced by electrolyzing water with electricity generated by a small-scale hydroelectric plant.
- **Storage & Transportation**: The gas is supplied to a pure hydrogen fuel cell installed at a heated indoor swimming pool and then used as electricity and heat.

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

- **Production**: This project uses electricity generated by wind power facilities in Muroran, Hokkaido, to produce hydrogen.
- **Storage & Transportation**: The hydrogen is stored in a stationary hydrogen-absorbing alloy tank.
- **Supply & Use**: A pure hydrogen fuel cell at a hot spring facility generates electricity and heat from the hydrogen. Exhaust heat at the facility is utilized to extract the hydrogen from the alloy.
2 Support for adoption of low-carbon hydrogen technologies

The MOE renewable-energy-based hydrogen infrastructure, as well as hydrogen mobility, to promote low-carbon hydrogen.

**Support for Hydrogen Mobility**
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.

**FC Forklift**
- 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).

**FC Bus**
- 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.

**Support for Hydrogen Infrastructure**
The MOE subsidizes hydrogen stations that supply hydrogen to FCVs, and decentralized hydrogen energy systems that supply power and heat. These systems allow self-sustained energy supply in times of disaster, and reduce the loss of energy in transmission and distribution.

**Self-sustained & Decentralized Hydrogen Energy Supply System**
- Supports the introduction of hydrogen energy supply systems, which consist of a battery, a water electrolyzer, or hydrogen storage tank.
- Aims to develop renewable energy storage and use models with hydrogen, which can accommodate different regional circumstances.

**Renewable-energy-based Hydrogen Station**
- Confirmed the effectiveness of renewable-energy-based hydrogen station units, which can generate hydrogen and also supply it to FCVs.
- Supports the introduction and maintenance of renewable-energy-based hydrogen stations.

3 Support for development of low-carbon hydrogen technologies

The MOE supports the development of low-carbon hydrogen technologies for a large scale CO2 reduction.

**Development of Hydrogen Storage Technologies**
The MOE supports the development of safe and cost-efficient hydrogen storage technologies.

**Hydrogen-absorbing Alloy**
- 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
  - Implementation from fiscal 2017

**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 is required.
  - Loading of hydrogen-absorbing alloy cartridges

**Development of Hydrogen Usage Technologies**
The MOE supports the development of hydrogen mobility for decarbonizing transportation.

**FC Truck**
- 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.
  - Implementation from fiscal 2016

**FC Garbage Truck**
- Developed an FC garbage truck, tested its basic performances, and identified optimal uses in actual garbage collection.
  - Primary partner: Flat Field Co., Ltd.
  - Implementation from fiscal 2015 to 2017

**FC Vessel**
- Developed a water- and salt-proof FC unit for vessels, and demonstrated at sea.
  - Primary partner: Toda Corporation
  - Implementation from fiscal 2014 to fiscal 2015

**Stationary FC**
- 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
  - Implementation from fiscal 2018