Provisional Translation

Summary of the Strategic Road Map for Hydrogen and Fuel Cells

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Agency for Natural Resources and Energy

Summary of the Strategic Road Map for Hydrogen and Fuel Cells (1)
— Overview —

Significance of realizing a hydrogen society

1. Energy conservation	Making use of fuel cells to realize high energy efficiency, leading to achievement of dramatic energy conservation
2. Energy security	Hydrogen is a resource that could enhance energy security if the following advantages are leveraged and the applicable scope of the resource is expanded: [i] the ingredients of hydrogen are highly interchangeable with other materials, and hydrogen can be manufactured with various methods from many kinds of substitute materials, such as various primary energy sources including unutilized energy resources (e.g., by-product hydrogen, crude oil associated gas and lignite) and renewable energy; and [ii] in the future, such energy may be procured inexpensively from regions with low geopolitical risk, and utilizing hydrogen manufactured from renewable energy in Japan may also increase the energy self-sufficiency rate in the future.
3. Reducing environmental burdens	When used as an energy source, hydrogen does not emit carbon dioxide. Taking advantage of this characteristic, combining the technology for manufacturing hydrogen with a carbon capture and storage (CCS) process, or with making use of hydrogen derived from any renewable energy, will lead to the reduction of environmental burdens and even to the full elimination of carbon dioxide.
4. Promoting industries and revitalizing regional economies	Japan has strong global competitiveness in the field of fuel cells. For example, Japan has filed the world's largest number of patent applications for the technology—five times the number of those filed by second or lower-placed countries—, leaving other countries far behind. In addition, Japan's regional resources, e.g., renewable energy, can be utilized to manufacture hydrogen for fuel cells.

Future direction for the measures for realizing a hydrogen society

- To realize a hydrogen society, related systems will be formulated on a large scale, which may be accompanied by changes in the current social structure, and long-term, continuous measures for realizing such a society will be taken. In addition, the imbalance between supply side and demand side issues will be resolved, while academia, government and industry will collaborate to proactively engage in measures for utilizing hydrogen.
- To achieve this goal, Japan will aim to achieve a hydrogen society through the following step-by-step process:
  - **Phase 1 (Dramatic expansion of hydrogen use)** : Dramatically expanding the use of stationary fuel cells and fuel cell vehicles, which are in the process of being realized, leading to the successful acquisition of a global market in the field of hydrogen and fuel cells, in which Japan leads the world;
  - **Phase 2 (Full-fledged introduction of hydrogen power generation/Establishment of a large-scale system for supplying hydrogen)** : Further expanding the demand for hydrogen, while widening the scope of hydrogen sources to include unutilized energy, so as to establish a new secondary energy structure in which hydrogen will be added to existing resources, namely electricity and heat (gas); and
  - **Phase 3 (Establishment of a zero-carbon emission hydrogen supply system throughout the manufacturing process)** : Combining the technology for manufacturing hydrogen with a CCS process, or with making use of hydrogen derived from a renewable energy resource, so as to establish a zero-carbon-emission system for supplying hydrogen throughout the manufacturing process.

Phase 1
Dramatic expansion of hydrogen use (Full-fledged introduction of fuel cells into society)

2020 — Conveying to the world the information on the potential of hydrogen by taking advantage of the 2020 Summer Olympic Games in Tokyo

2030

2040

Release onto the market: residential fuel cells in 2009; Fuel cell vehicles in 2015

2017
Releasing fuel cells for commercial and industrial use onto the market

Around 2020
Achieving a reduction of hydrogen price to a level equal to or lower than that of fuels for hybrid vehicles

Around 2025
Fuel cell vehicles: Achieving a reduction of vehicle prices to the level of hybrid vehicles of the same class and price range

Phase 2
Full-fledged introduction of hydrogen power generation/ Establishment of a large-scale system for supplying hydrogen

Accelerating development and demonstration
Establishing a strategic partnership with hydrogen-suppliers overseas
Realizing inexpensive hydrogen , anticipating growth in demand

Mid 2020s
-Plant delivery price of hydrogen from overseas: 30 yen/Nm3
-Building up a commercial-based domestic system for efficiently distributing hydrogen

Around 2030
-Full-fledged operation of manufacturing, transportation and storage of hydrogen derived from unutilized energy resources imported from overseas
- Full-fledged introduction of hydrogen power generation for power-producing business

Phase 3
Establishment of a zero-carbon emission hydrogen supply system throughout the manufacturing process

Systematic development and demonstration of such a system, based on its potential for development

Around 2040
Full-fledged operation of manufacturing, transportation and storage of zero-carbon emission hydrogen, by combining the manufacturing technology with a CCS process or with making use of domestic and overseas renewable energy

Market scale of the equipment and infrastructure businesses related to hydrogen and fuel cells in Japan
Approx. 1 trillion yen in 2030 → Approx. 8 trillion yen in 2050

Summary of the Strategic Road Map for Hydrogen and Fuel Cells (2)
— Chart for all fields—

Note: Pink arrows refer to initiatives led by the government and blue arrows refer to initiatives led by the private sector.

Around 2015 | Around 2020 | Around 2030 | Around 2040

Utilization of hydrogen

Phase 1: Dramatic expansion of the hydrogen use (full-fledged introduction of fuel cells into society)

Stationary fuel cells

Current situation

Brought to the market in 2009 with more than 70,000 disseminated

Residential use

Achieving a cost reduction allowing a user to recoup the investment within 7 or 8 years

Achieving a cost reduction allowing a user to recoup the investment within 5 years

Supporting introduction of such fuel cells → Further dissemination of commercially-viable fuel cells for residential use

Commercial and industrial use

Releasing such fuel cells for commercial and industrial use to the market in 2017

Demonstration for commercialization and reviewing regulations → Further dissemination of commercially-viable fuel cells for commercial and industrial use

Fuel cell vehicles

Current situation

Releasing passenger cars onto the market by 2015; buses by 2016

Achieving a reduction of vehicle price to the level of hybrid vehicles of the same class and price range

[i] Supporting businesses introducing such vehicles
[ii] Developing technology for reducing costs and enhancing the durability of such vehicles → Further dissemination of commercially-viable fuel cell vehicles (aiming at the world's quickest dissemination of the vehicles)

Phase 2 : Full fledged introduction of hydrogen power generation/Establishment of a large-scale system for supplying hydrogen

Hydrogen power generation

Determining specific directions for hydrogen power generation

Launching the full-fledged introduction of hydrogen power generation for in-house power generation

Launching the full-fledged introduction of hydrogen power generation for power-producing business

Development and demonstration of gas turbines for hydrogen power generation and other related technology → Full-fledged introduction of hydrogen power generation for in-house power generation

Full-fledged introduction of hydrogen power generation for power-producing business

Transportation and storage

Current situation

Only a small amount of hydrogen is distributed as industrial gas in the form of high-pressure hydrogen gas or liquefied hydrogen.

* Most of the hydrogen is now used in-house for refining petroleum.

Domestic situation

Achieving a reduction of hydrogen price to a level equal to or lower than that of fuel for gasoline-powered vehicles

[Hydrogen stations]
[i] Developing inexpensive hydrogen stations (STs)
[ii] Further reviewing related regulations
[iii] Advancing efforts by stakeholders according to their shared roles (roles for ST improvement and management) → Further development of commercially-viable hydrogen STs

Reorganizing the shared roles and directions for improving STs among stakeholders

Achieving a reduction of hydrogen price to a level equal to or lower than that of fuels for hybrid vehicles

[Distribution]
Development and demonstration concerning the domestic distribution of hydrogen in the form of liquefied hydrogen and organic hydride → Building up a commercial-based domestic system for efficiently distributing hydrogen

Overseas situation

Achieving plant delivery price of hydrogen from overseas at ¥30/Nm3

Full-fledged operation of manufacturing, transportation and storage of hydrogen derived from unutilized energy resources imported from overseas

Accelerated reduction of the hydrogen price due to the full-fledged introduction of hydrogen power generation for power-producing business

Full-fledged operation of manufacturing, transportation and storage of zero-carbon emssion hydrogen

Development and demonstration of how hydrogen should be transported from overseas and stored in Japan in the form of liquefied hydrogen and organic hydride → Full-fledged operation of manufacturing, transportation and storage of hydrogen derived from unutilized energy resources imported from overseas

Full-fledged manufacturing, transportation and storage of zero-carbon emission hydrogen

Manufacturing

Current situation

Manufacturing hydrogen from fossil fuels, e.g., naphtha and natural gas

Development and demonstration of manufacturing hydrogen from unutilized energy resources imported from overseas, e.g., by-product hydrogen, crude oil associated gas and lignite

Phase 3: Establishing a system for supplying hydrogen, in which carbon dioxide emissions are fully eliminated throughout the manufacturing process

Development and demonstration concerning manufacturing of zero-carbon emission hydrogen by making use of renewable and other

Summary of the Strategic Road Map for Hydrogen and Fuel Cells (3)
— Stationary fuel cells (Distributed co-generation systems) —

Note: Pink arrows refer to initiatives led by the government and blue arrows refer to initiatives led by the private sector.

Around 2015 | Around 2020 | Around 2030 | Around 2040

Utilization of hydrogen

Disseminating 1.40 million stationary fuel cells for residential use
Achieving a cost reduction allowing a user to recoup the investment within 7 or 8 years

Disseminating 5.30 million stationary fuel cells for residential use
Achieving a cost reduction allowing a user to recoup the investment within 5 years

Disseminating pure-hydrogen fuel cells to limited regions

[Residential use]

Supporting introduction of such fuel cells

Studying smooth trading of electricity generated by fuel cells

Further dissemination of commercially-viable fuel cells for residential use

Expanding the use in Japan (expanding targets from newly-built independent housing to housing complexes and even to existing housing)

Further developing sales of fuel cells overseas (expanding targets from Europe to other regions)

- Further price reduction brought about by economies of scale
- Further price reduction brought about by streamlining and standardizing processes for installing and maintaining such fuel cells

[Commercial and industrial use]

Developing technology for reducing cost and enhancing durability of solid oxide fuel cells (SOFCs) and other types

Demonstration for commercialization and reviewing necessary regulations
- Demonstrating fuel cells by applying a variety of electrical loads under different weather conditions
- Reviewing necessary regulations

Expanding autonomous dissemination of fuel cells for commercial and industrial use
- Further price reduction brought about by economies of scale
- Further price reduction brought about by streamlining and standardizing processes for installing and maintaining such fuel cells

In 2017: Bringing stationary fuel cells for commercial and industrial use to the market

Transportation and storage

Demonstrating a hydrogen supply chain that will be established in specific regions in collaboration with communities
- Demonstrating through collaboration with municipalities and local enterprises, e.g., utilizing hydrogen in the 2020 Summer Olympic Games in Tokyo

Transporting hydrogen by hydrogen pipelines to certain regions, e.g., transporting the resource to the neighborhood of hydrogen STs

Converting city gas or LP gas which are supplied through city gas pipelines or LP gas containers, to hydrogen, via extraction equipment

Manufacturing

Full-fledged operation of manufacturing, transportation and storage of hydrogen derived from unutilized energy resources imported from overseas countries

Full-fledged operation of manufacturing, transportation and storage of zero-carbon emission hydrogen

Summary of the Strategic Road Map for Hydrogen and Fuel Cells (4)
—Fuel cell vehicles + Hydrogen STs —

Note: Pink arrows refer to initiatives led by the government and blue arrows refer to initiatives led by the private sector.

Around 2015 | Around 2020 | Around 2030 | Around 2040

Utilization of hydrogen

[Fuel cell vehicles]

Releasing passenger cars onto the market by 2015

Releasing busses onto the market by 2016

Achieving a reduction of vehicle price to the level of hybrid vehicles of the same class and price range

Supporting businesses to introduce such vehicles
- Shifting targets from official and company to private vehicles step by step
- Utilizing hydrogen for taxis and busses

Developing technology to reduce cost, enhancing durability and improving fuel efficiency performance of fuel cell vehicles
- Cost reduction by reducing platinum used and other means
- Improving durability and fuel efficiency performance so as to make fuel cells durable when such fuel cells are applied to vehicles for business use

Harmonizing the global standards and the domestic laws and regulations for fuel cell vehicles, as well as realizing mutual recognition agreements of such vehicles between Japan and other countries

Demonstrating a hydrogen supply chain that will be established in specific regions in collaboration with communities
- Demonstration of potential supply chain through collaboration with municipalities and local enterprises, e.g., utilizing hydrogen in the 2020 Summer Olympic Games in Tokyo

Further dissemination of commercially-viable fuel cell vehicles (aiming at the world's quickest dissemination of the vehicles)

Transportation and storage

[Hydrogen STs]

Achieving a reduction of hydrogen price to a level equal to or lower than that of fuel for gasoline vehicles

Developing 100 STs

Achieving a reduction of hydrogen price to a level equal to or lower than that of fuels for hybrid vehicles

Achieving a reduction of the hydrogen ST cost to the commercially-viable level, namely, to half of the current cost (cost for ST improvement and management)

Improving environments for commercial use

Developing inexpensive STs
- Establishing standard specifications
- Package-unit / Movable type
- Simplified type

Further reviewing of regulations + Measures for safety and security

1) Expanding the areas in which STs are installed
2) Strategic development of STs depending on the extent to which fuel cell vehicles (FCVs) are disseminated in the areas
Example: Installing mobile or simplified STs in the areas where the FCV market is still immature

Further business expansion of commercially-viable hydrogen STs

Reorganizing the shared roles and directions for improving STs among stakeholders

Prior improvement of STs

Advancing efforts by stakeholders according to their shared roles, concerning improvement and management of hydrogen STs

[Distribution]

Development and demonstration concerning the domestic distribution of hydrogen, e.g., liquefied hydrogen and organic hydride

Building up a commercial-based domestic system for efficient distribution of hydrogen

Full-fledged supply of hydrogen derived from unutilized energy resources imported from overseas countries

Full-fledged operation of manufacturing, transportation and storage of zero-carbon emission hydrogen

Manufacturing

Utilization of existing reformers and/or by-product hydrogen from refineries and steelworks etc.

Summary of the Strategic Road Map for Hydrogen and Fuel Cells (5)
— Utilization of hydrogen power generation + hydrogen derived from unutilized energy—

Note: Pink arrows refer to initiatives led by the government and blue arrows refer to initiatives led by the private sector.

Around 2015 | Around 2020 | Around 2030 | Around 2040

Utilization of hydrogen

Measures to be implemented in a unified manner
(*Determining and implementing specific policies, jointly with power-facilities manufacturers, power producers, and hydrogen-supply businesses)

Launching the full-fledged introduction of hydrogen power generation for in-house power generation

Launching the full-fledged introduction of hydrogen power generation for power-producing business

Improving the environment for hydrogen power generation for in-house power generation

Development and demonstration of the technology
- Improving the mixture ratio of hydrogen and power generation efficiency
- Reducing NOx and other measures

Formulating related systems

Full-fledged introduction of hydrogen power generation for in-house power generation

Improving the environment for hydrogen power generation for power-producing businesses

Development and demonstration of the technology
Improving the mixture ratio of hydrogen and power generation efficiency/Reducing NOx and other measures

Formulating related systems

Preparing the commercial-based development of hydrogen power generation for power-producing businesses
Environmental assessment/Designing, procuring and constructing power plants

Full-fledged introduction of hydrogen power generation for power-producing businesses

Transportation and storage

Development and demonstration concerning the domestic distribution of hydrogen in the form of liquefied hydrogen and organic hydride
- Demonstrating the ideal approaches to transporting and storing hydrogen in the form of liquefied hydrogen and organic hydride

Building up a commercial-based domestic system for efficiently distributing hydrogen

Achieving ¥30/Nm3 delivery price of hydrogen from overseas

Accelerated reduction of the hydrogen price due to expanded capacity of facilities and enhanced efficiency of transportation, brought by the full-fledged introduction of hydrogen power generation for business

Full-fledged operation of manufacturing, transportation and storage of hydrogen derived from unutilized energy resources imported from overseas countries

Full-fledged operation of manufacturing, transportation and storage of zero-carbon emission hydrogen

Development and demonstration of proper transportation methods from overseas and storage in Japan in the form of liquefied hydrogen and organic hydride
- Developing systems for storing and loading hydrogen / Formulating regulatory systems for storing and loading hydrogen
- Developing hydrogen transport vessels / Formulating the related maritime systems
- Establishing strategic partnerships with hydrogen-suppliers overseas

Full-fledged operation of manufacturing, transportation and storage of hydrogen derived from unutilized energy resources imported from overseas countries

Full-fledged operation of manufacturing, transportation and storage of zero-carbon emission hydrogen

Manufacturing

Developing and demonstrating methods for manufacturing hydrogen from unutilized energy imported from overseas
- Manufacturing hydrogen from crude oil associated gas, lignite and other unutilized energy sources
- Establishing strategic partnerships with hydrogen-suppliers overseas

Development and demonstration concerning manufacturing of zero-carbon emission hydrogen by making use of renewable and other energy
- CCS processes in hydrogen-suppliers overseas
- Establishing an inexpensive method for stable manufacturing of hydrogen derived from domestic and overseas renewable energy, including photocatalysis technology and technology for manufacturing ammonia
- Demonstration concerning the Power-to-Gas technology, a process for leveling supply of unevenly-distributed energy and fluctuation of energy supply by manufacturing hydrogen from electricity derived from renewable energy