IPHE Country Update: Japan

Shinya KAWAMURA

Deputy Director
Hydrogen and Fuel Cells Strategy Office
Agency for Natural Resources and Energy
METI, Japan

27th IPHE Steering Committee Meeting Hamburg, Germany, April 27 - 28, 2017

New Initiatives on Hydrogen and Fuel Cell

Policy Speech by Prime Minister to Diet Session (20th January 2017)

"*The hydrogen energy is a trump card for energy security and global warming mitigation measures.* ***The world's first electric power supply will be started using a hydrogen generator in Kobe by spring 2018****. We will challenge to* ***transport a large amount of hydrogen using the world's first liquefied hydrogen carrier*** *and we will build hydrogen supply chain covered from production through to transport and consumption. For realizing these challenges, we will proceed with the* ***reformation by sorting out all regulations*** *among ministries."*

Ministerial Council on Renewable Energy, Hydrogen and Related Issues (11th April 2017)

Prime Minister Shinzo Abe attended the first meeting of the Ministerial Council on Renewable Energy, Hydrogen and Related Issues on April 11, 2017, and stated *"****Japan will be the first in the world to realize a hydrogen-based society****. I request relevant ministers to formulate the* ***basic strategy within this year****. In particular, I would like relevant ministers to accelerate the* ***establishment of hydrogen refuelling stations****, and* ***streamline regulations*** *on them, and to formulate* ***a common scenario toward the building of supply chains and the full-scale introduction of hydrogen power generation.****"*

Revised Points of the Hydrogen / FC Strategy Roadmap

Phase 1: Installation Fuel Cell (Current-)

1. Stationary FC

- ✓ Clarifies price targets of residential FCs ⇒ disseminates without government support by around 2020
  - ■ PEFC: 800,000 yen by 2019
  - ■ SOFC: 1,000,000 yen by 2021

2. Fuel Cell Vehicles

- ✓ Sets the goals of market introduction
  - ■About 40,000 FCVs by 2020, 200,000 by 2025, 800,000 by 2030
- ✓ Aims at introducing FCVs in main market segment (price range) by around 2025

3. Hydrogen Refueling Stations

- ✓ Sets the goals of installations and self-sustaining business
  - ■About 160 stations by FY2020, 320 by FY2025
    *Needs around 900 stations in case of 300Nm3/h refueling capacity by 2030
  - ■Self-sustaining business of HRSs by the late 2020s

Thereafter establishes adequate amount of stations in response to the spread of FCVs

Phase 2: H2 Power Plant/ Mass Supply Chain (Realized in the late 2020s)

4. Hydrogen Power Plant

- ✓ reflects a report by study group on H2 power plant (March 2015) , embodies the description

Phase 3: CO_2-free Hydrogen (Realized in around 2040)

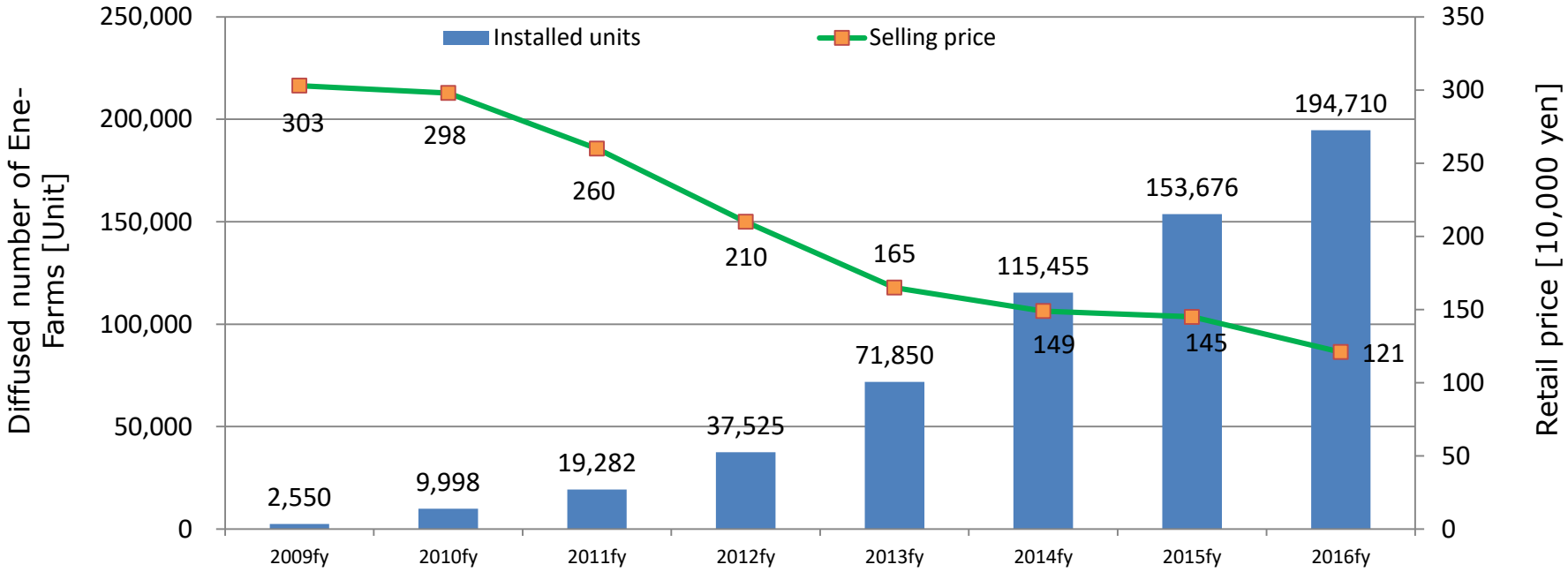
5. Hydrogen derived from Renewable Energy

- ✓ States to launch a working group which handles technical and economic issues regarding introduction of CO2-free Hydrogen concluded in March 2017.
- ✓ Describes the promotion of advanced initiatives such as the reform 2020 project and Fukushima new energy society initiative

Residential Fuel Cells

Goals in the road map	Progress
• Establish the self-sustaining market of "Ene-Farms" at the early stages, and disseminate 1.4 million units by 2020, and 5.3 million units by 2030.	Over 190,000 units diffused. (*As of March 2017)
• For the retail price of "Ene-Farms" (including construction cost for installation), aim at the price that can recover the investment within 7 or 8 years (PEFC: 0.8 million yen, SOFC: 1 million yen) by 2020, and within 5 years by 2030.	Average retail price of Ene-Farms (Including construction cost for installation) is about 1,210,000 yen. Payout time is about 15 years. * Excluding support by subsidized charge

Changes in the diffusion number and retail price



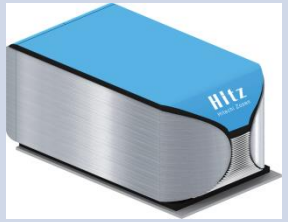
* Based on determination subsidization base

(As of the end of March 2017)

Demonstration of SOFC units for Business and Industry

Goal in the Roadmap	Progress
• For business and industry use, aim at launching SOFC cogeneration type in 2017.	• Demonstrations have been progressing in several models steadily, and expected to be launched in 2017.

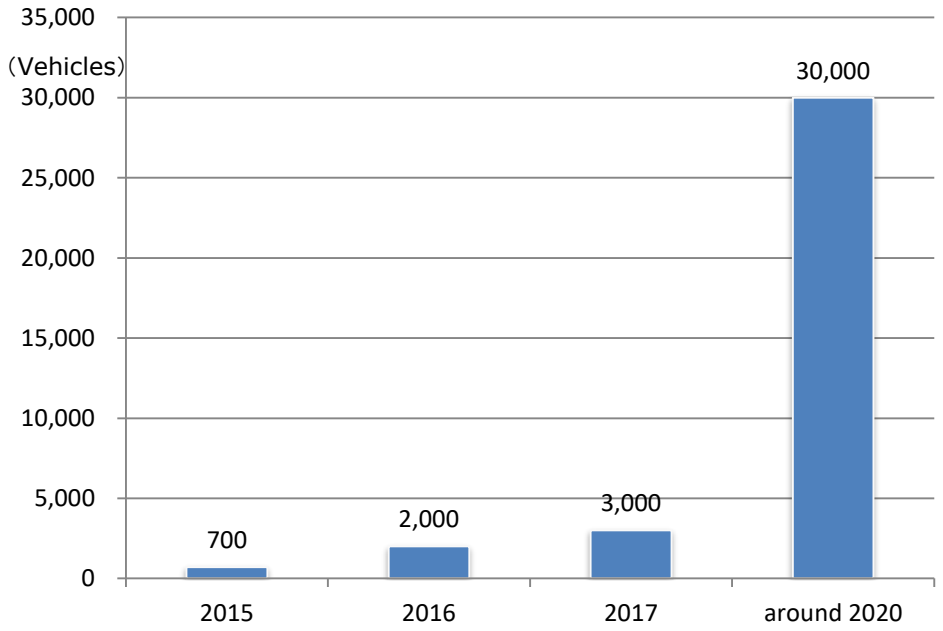
Development and Demonstration of SOFC units for business and industry

Manufacturer	Denso	Miura	Fuji Electric	Hitachi Zosen	Mitsubishi Hitachi Power Systems (MHPS)
	Demonstration model				
Appearance					
Output	5 kW	5 kW	20 kW	50 kW	250 kW
Electrical generation efficiency (target value)	(under consideration)	50 %	50 %	50 %	55 %
Total efficiency (target value)	(under consideration)	90 %	(under consideration)	80 %	73% (hot water) 65% (steam)
Major envisioned demand	Barbers and hair salons, small stores, family restaurants		Gym, welfare facilities, hospitals, small buildings		Data centers, large buildings, and hotels

Goals of Fuel Cell Vehicles for Dissemination

Goals in the Roadmap	Progress
• Launch FCVs onto the market by 2015, and aim at the market introduction as around 40,000 FCVs by 2020, 200,000 by 2025, 800,000 by 2030.	• Toyota began selling its Mirai in December 2014. • Honda began selling its Clarity Fuel Cell in March 2016. • In September 2015, Toyota announced the estimated global sales of FCVs around 2020 as 30,000 or higher.
• Aim at realizing the price of FCVs having price competitiveness equivalent to that of hybrid vehicles at the same class by around 2025.	• The retail price of Toyota Mirai and Honda Clarity Fuel Cell are both around 7million yen. Further efforts to reduce costs for FC system and platinum catalyst are promoted.

Toyota's expected global sales of FCVs (Single year)



Honda's Clarity Fuel Cell

Auto manufacturer	Honda Motor
Car's name	Clarity Fuel Cell
Retail price (including tax)	7,660,000 yen
Launch	March 2016

Progress of Hydrogen Refueling Stations for Goals㊀

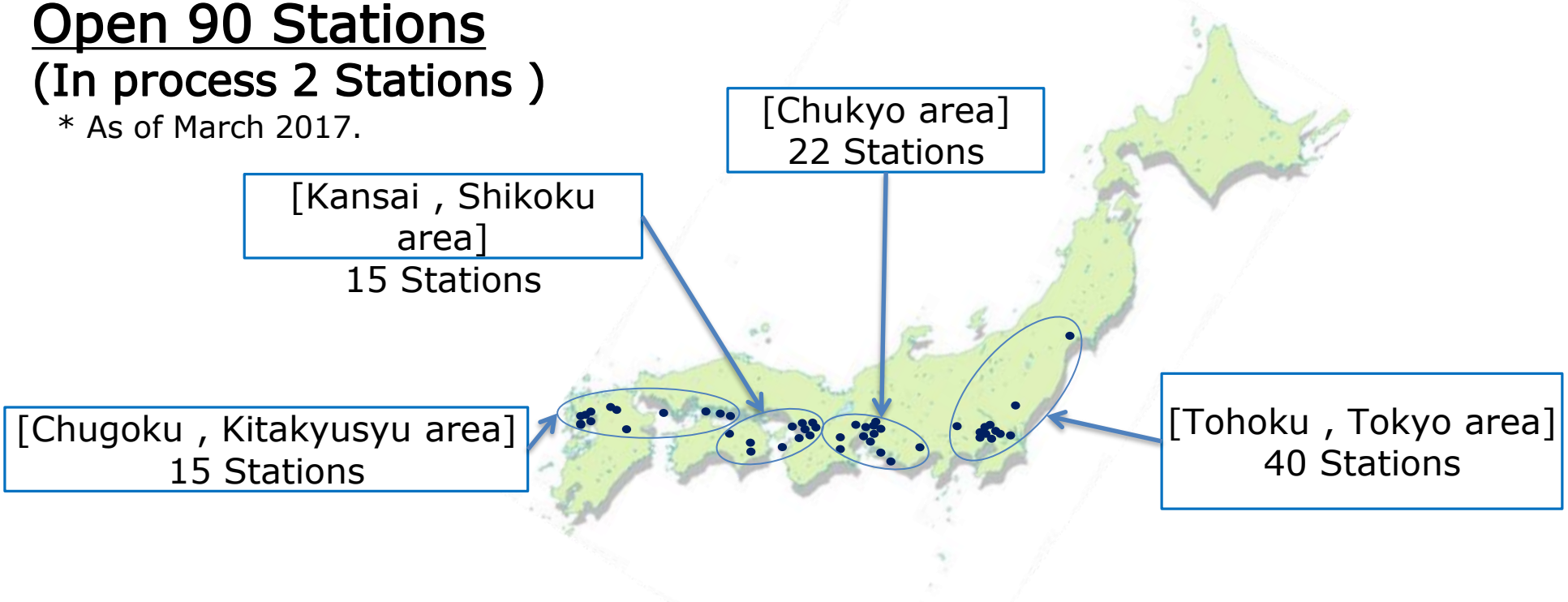
Goals in the Roadmap	Progress
• Ensure about 160 HRSs in FY2020 and 320 in FY2025.	• 90 HRSs are commercially available and 2 in process. (*As of March2017)
• For the price of hydrogen, aim at offering at the same or lower price as compared with the fuel cost of gas vehicles in 2015, and as compared with the fuel cost of hybrid vehicles by around 2020.	• In HRSs currently opened, the price of 1,000-1,100 yen/kg, which is close to the fuel cost of hybrid vehicles, is strategically set.

Map of Hydrogen refueling stations

Open 90 Stations

(In process 2 Stations)

* As of March 2017.



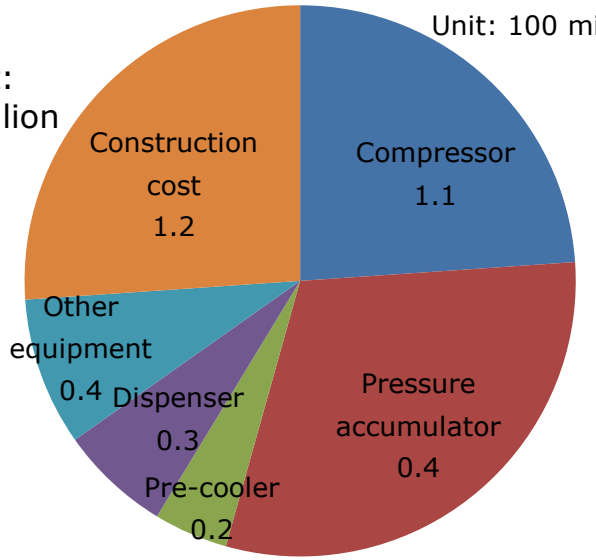
Progress of Hydrogen Refueling Stations for Goals㊀

Goals in the road map	Progress
㊀ Aims at reducing the installation cost into a half of the current cost by around 2020.	• Costs for installation: About 360 million yen * Average of actual benefit of grant money (as of the end of 2015) (fixed off site , 300Nm^3/h) * Meanwhile, please note various facility expenses that are not covered by the support will be needed in addition to the above.
㊁ Manufacturers providing equipment constituting the station aim at realizing lower equipment cost having competitiveness against manufacturers in Europe.	
㊂ Aims to reduce the annual operating cost of hydrogen refueling station (except for depreciation expense) to closer to 20 million yen level.	• Operating cost About 40 million yen * Average amount of grant money applied (as of FY 2015) (fixed off site 300Nm^3/h)

Breakdown of costs for installation of hydrogen refueling station

Total cost for establishment: About 360 million yen

Unit: 100 million yen

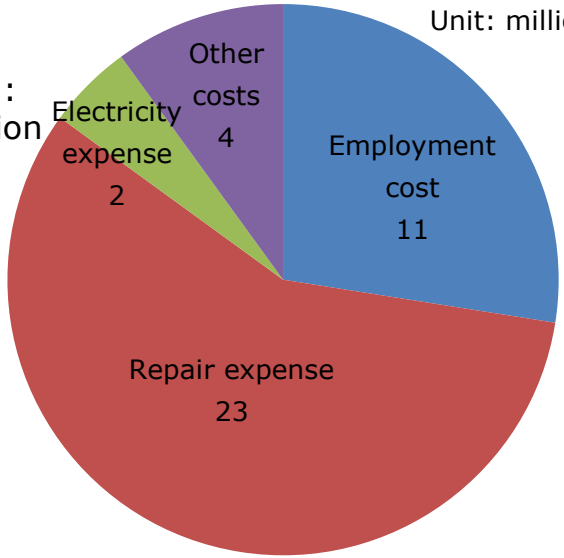


* Average of actual benefit of grant money (as of the end of 2015) (fixed off site , 300Nm^3/h)
* Meanwhile, please note various facility expenses that are not covered by the support will be needed in addition to the above.

Breakdown of operating cost of hydrogen refueling station

Total cost for management : About 40 million yen

Unit: million yen



* Average amount of grant money applied (as of FY 2015) (fixed off site 300Nm 3/h)
* Meanwhile, please note various facility expenses that are not covered by the support will be needed in addition to the above.

[Source] Created by the Agency for Natural Resources and Energy based on amount of grant money applied for projects for installation of hydrogen supply facility and reported amount of actual benefit.

Establishing an Inexpensive, Stable Supply System

Production of hydrogen: Conversion into hydrogen carriers → **Transportation of hydrogen carriers** → **Storage of hydrogen carriers** → **Takeout of hydrogen**

Hydrogen sources in foreign countries

Lignite | Associated gas | By-product hydrogen

Production of hydrogen: Gasification, reforming of steam, etc.

Refinement of hydrogen

Conversion into hydrogen carriers

Hydrogen (Combined with toluene) → MCH (CH_3)

Hydrogen → Liquefaction → Liquefied hydrogen

Organic hydride

Hydrogen is combined with toluene into methylcyclohexane.
→ Hydrogen in this state can be compressed to a volume equal to 1/500 of the volume under normal pressure.

Technology has been established.

- Transportation under normal temperature and normal pressure

→ Use of chemical tankers

Technology has been established.

- Storage under normal temperature and under normal pressure

→ Use of petroleum tanks, etc.

It is necessary to adopt large-scale dehydrogenation equipment and to achieve high efficiency in dehydrogenation.

Liquefied hydrogen

Hydrogen is liquefied by being cooled to -253°C.
→ Hydrogen in this state can be compressed to a volume equal to 1/800 of the volume under norm pressure.

It is necessary to develop hydrogen ships.

It is necessary to adopt large-scale hydrogen tanks and to reduce boil off.

Technology has been established.

Use of hydrogen:

Hydrogen power generation,

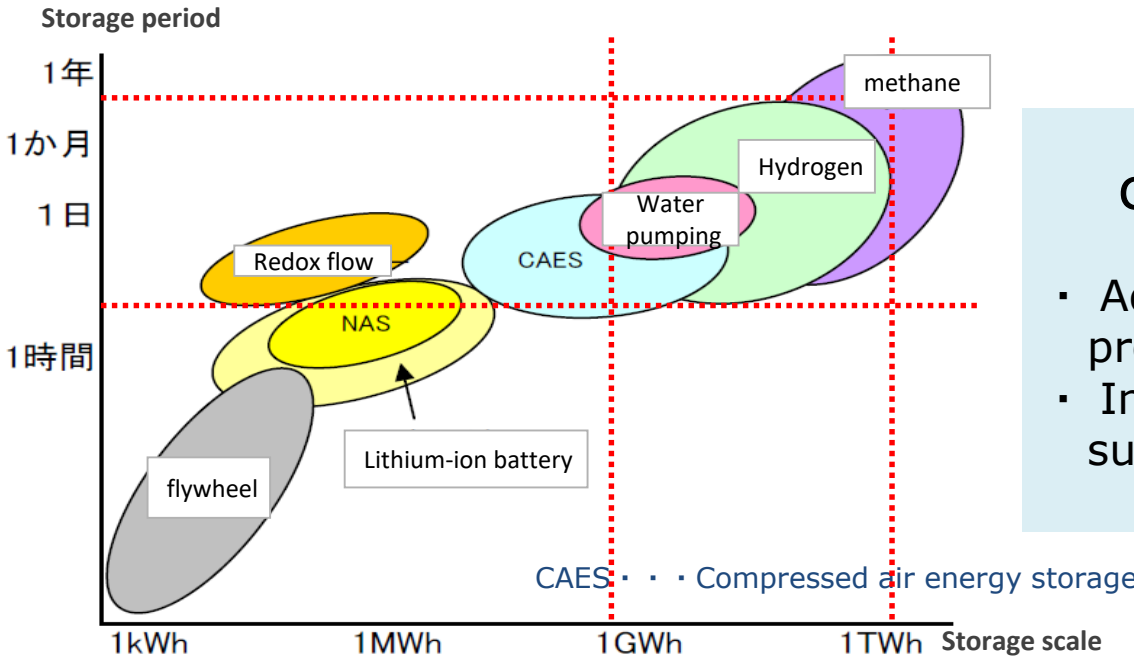
fuel cells,

Industrial gas, etc.

Characteristics of Power to Gas (P2G) Technology ～Hydrogen Derived from Renewable Energy～

It is considered that a complex system of water electrolysis and hydrogen tank has high potential of application to the area of large scale and prolonged energy storage for the good reason that the complex system has small loss over time and high expandability such as hydrogen tank as compared with competing storage battery technologies in terms of advantage.
It is expected that P2G can be a promising item as a countermeasure against problems related to power system interconnection during introduction and expansion of renewable energy in Japan in the future.

Positioning of various electric power storage technologies



CAES・・・Compressed air energy storage

Characteristics of energy storage using hydrogen (P2G)

- Advantageous to large scale and prolonged energy storage
- Impact from environmental conditions such as geography and geology is small

[Source] Fuji Keizai

Budget for Hydrogen and Fuel Cells in FY 2017

Phase 1 Installation Fuel Cell — Focus on implementation from the present

Phase 2 H2 Power Plant/ Mass Supply Chain — Realized in the late 2020s

Phase 3 CO2-free Hydrogen — Realized in around 2040

Disseminate stationary FCs

Subsidies for Stationary FCs
[9.36 billion yen]

Promote the accelerated introduction and cost reduction of Ene-farm. From FY 2017, support for stationary FC for business and industrial use is added .

ENE·FARM

Disseminate FCVs

Subsidies for HRSs
[4.5 billion yen]

Support HRS installations and promote creating new FCV demand.

Support for FCVs
[Included in 12.3 billion yen]

Build a H2 supply chain

Demonstrations for global H2 supply chain
[4.7 billion yen]

Demonstrate how hydrogen can be produced from untapped overseas energy resources, transported in the form of liquefied hydrogen or organic hydride, and used to generate power. Implement P2G field tests, etc.

R&D of FC, etc.

R&D of FCs
[3.1 billion yen]

Conduct R&D for better performance and lower costs of FCs, and demonstrate stationary FCs for business use

Stationary FC for business use

R&D of HRSs
[4.1 billion yen]

Develop technologies for lower costs and safety of HRSs, and collect data for reviewing regulations.

R&D of H2 production, transport and storage

R&D for producing, transporting and storing H2 derived from renewable energy
[1.0 billion yen]

Develop technologies of high efficiency water electrolysis units, tanks for storing liquefied hydrogen, etc. with the use of renewable energy sources.

Challenges to be considered based on current situation

～Excerpt from the document on 8th council for a Strategy for Hydrogen and Fuel Cells～

- Checking the progress of Hydrogen / FC Strategy Roadmap, issues to be considered should be focused, and efforts for realizing Hydrogen Society should be more accelerated.

	Issues to be specifically considered	Main Actions
Phase 1	**Ene-Farms** ➢ Cost reduction of instruments and **further expansion of market**	✓ Clarification of market to be reached and elaboration of steps to be addressed
	FCV／Hydrogen Refueling Stations ➢ Expansion of FCV sales which is not currently fulfilled purchase demand, and planning for **installation of FCV to volume zone** ➢ **Enhancement of review of regulations** for reduction of CAPEX and OPEX toward self-sustaining business ➢ **Establishment of new framework** for strategic deployment and enhancement of construction of Hydrogen Refueling Stations	✓ Expansion of production of FCV, enhancing sales and discontinuous efforts for cost-reduction of FCV ✓ Consideration of regulation to be reviewed and action-planning ✓ Agreeing basic items among relevant players by mid-2017 and setting framework within 2017
Phase 2	**Hydrogen Power Generation** ➢ **Strategic scenario** for full-scale installation of hydrogen power generation after 2030 ➢ **Steady implementation of demonstration for global hydrogen supply chain** for realizing hydrogen power generation	✓ Study for considering the target of installation of hydrogen power generation, based on effect of Paris Agreement and anticipating requirement of further reduction of CO2 in a long-term ✓ Proper project management of demonstration for global hydrogen supply chain by NEDO
Phase 3	**CO2-free Hydrogen** ➢ **Consideration of system** for promoting utilization of CO2-free Hydrogen ➢ Enhancement of **demonstration for Power-to-gas**	✓ From the view point of expansion of utilization of CO2-free Hydrogen, discussion on definition of CO2-free Hydrogen and design of institutional arrangement ✓ Setting up the demonstration project for CO2-free Hydrogen by NEDO

Japanese Contribution to IPHE

- FCDIC (Fuel Cell Development Information Center in Japan) celebrates its 30th anniversary. Congratulatory Addresses for the commemorative from Chair and Executive Director of IPHE.
- 5th International Meeting by Voluntary Organization.Closing address from Chair of IPHE.

Congratulation to the Fuel Cell Development Information Center from the International Partnership for Hydrogen and Fuel Cells in the Economy

On behalf of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), we are very pleased to congratulate the Fuel Cell Development Information Center (FCDIC) on its 30th anniversary. FCDIC has had a considerable impact on the development and deployment of fuel cells in Japan and around the world. Japan is the world leader with the first generation of commercial fuel cell electric vehicles and more than 200,000 combined heat and power units installed in homes, more than in any other country in the world. The contribution of FCDIC to the successful development of fuel cell technology capabilities is impressive.

Sustained research, development, and demonstrations by industry and governments have led to early market deployment in Asia, North America, and Europe. Hydrogen technologies are expected to help the green revolution in the Energy and Transport sectors. The ambition of the IPHE is to help the development of fuel cell and hydrogen (FCH) technologies at the world level, with the sharing of information amongst the eighteen partner countries and the European Commission. Partner countries collaborate to advance the commercialization of FCH technologies in an effort to help address environmental objectives, and to grow the hydrogen economy.

We would also like to congratulate the FCDIC for its 30 years of dedicated service to the fuel cells community. The work and strong commitment by the FCDIC is important in helping accelerate the cost-effective transition in the use of FCH to enhance the security and efficiency of energy systems, to help address environmental objectives, and to grow the economy.

Bernard Frois
Chair of the IPHE

Tim Karlsson
Executive Director of the IPHE