IPHE Country Update: Japan

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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

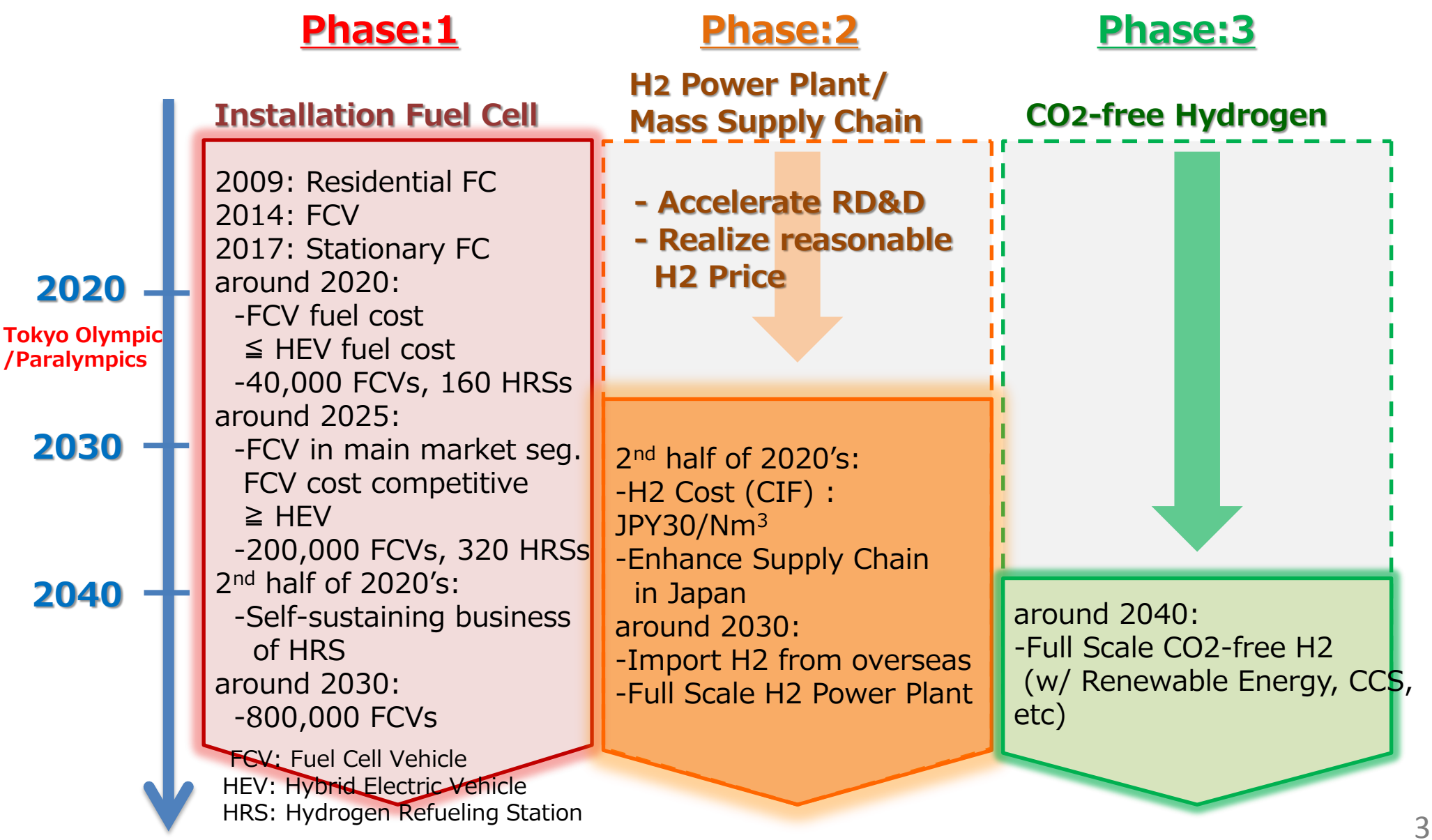
Phase 3: CO_2-free Hydrogen (Realized in around 2040)

5. Hydrogen derived from Renewable Energy

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

Hydrogen / FC Strategy Roadmap

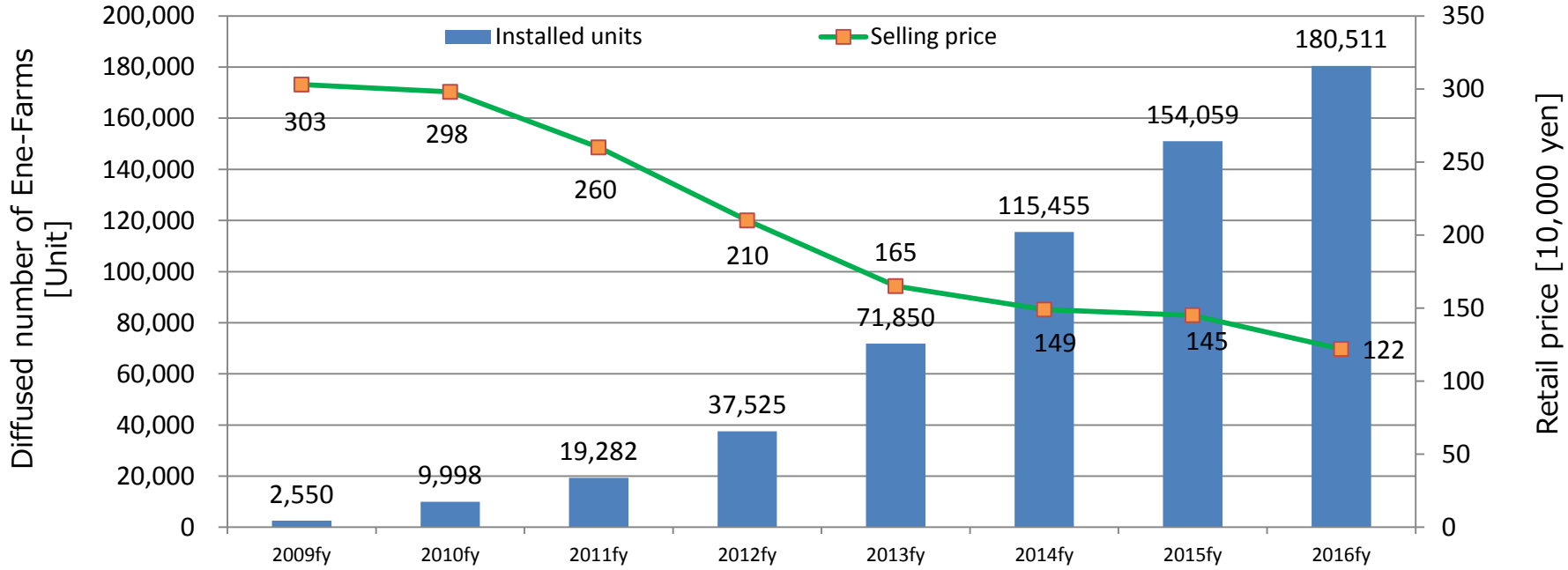
➢ Step by Step approach to realize Hydrogen Society



[Residential Fuel Cells] Progress in Goals in the Road Map

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 180,000 units diffused. (*As of September 2016)
• 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 1,220,000 yen. Payout time is about 15 years. * Excluding support by subsidized charge

Changes in the diffusion number and retail

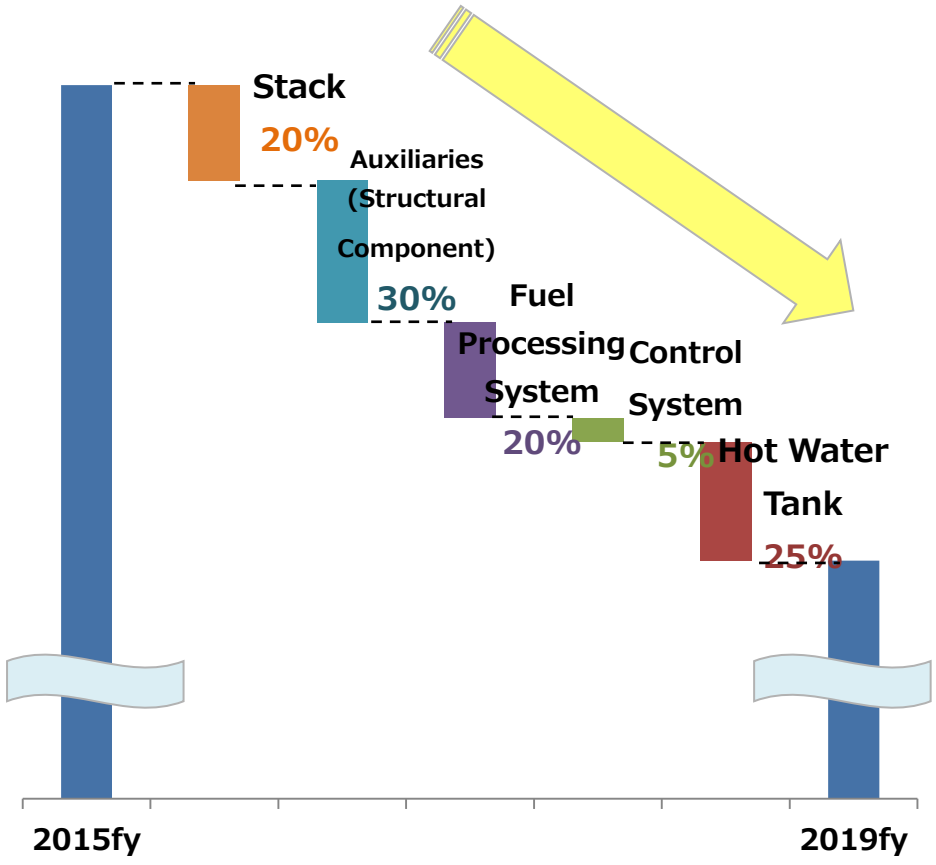


* Based on determination subsidization base

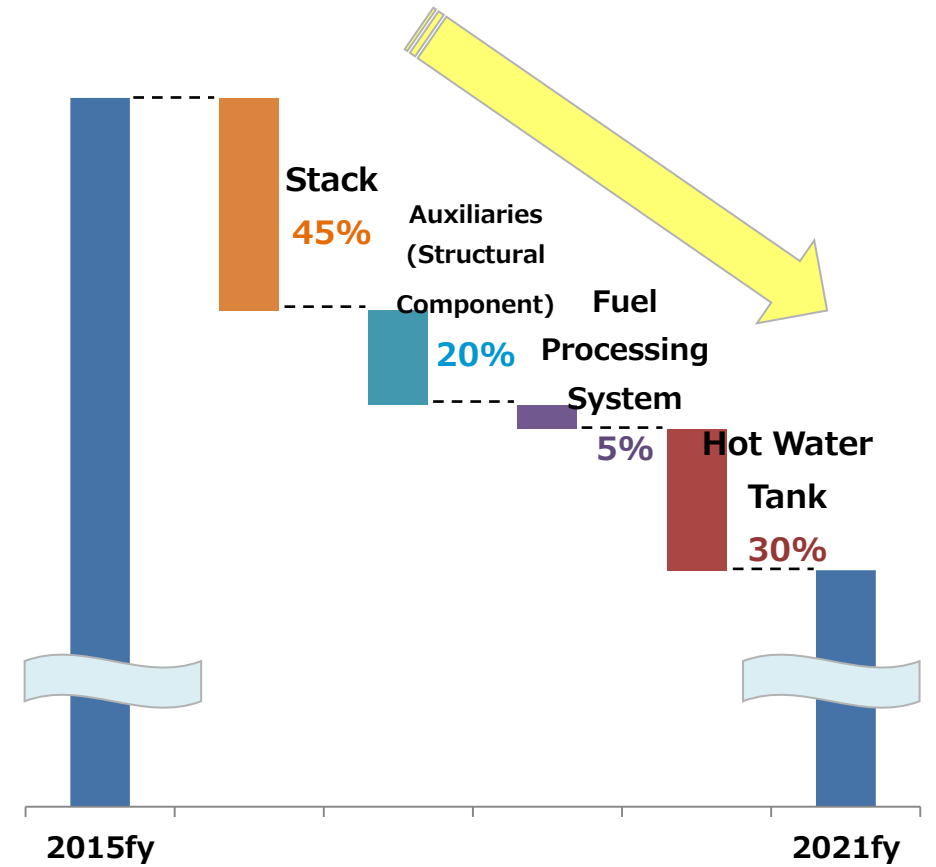
(As of the end of January)

[Residential Fuel Cells] Breakdown of Cost Reduction

Reduction of system cost (PEFC)



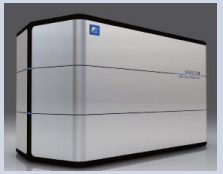
Reduction of system cost (SOFC)



[Stationary Fuel Cells] Demonstration toward Market Introduction

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.

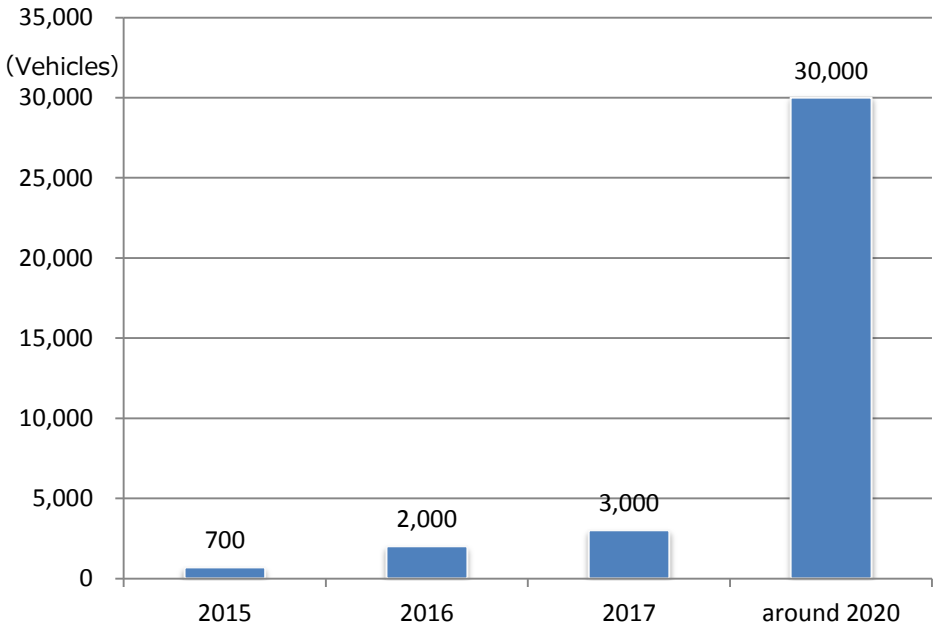
Development and Demonstration of SOFC units for business and industry

Manufacturer	Denso	Miura	Fuji Electric	Hitachi Zosen	Mitsubishi Hitachi Power Systems (MHPS)	(Reference) Bloom Energy
	Demonstration model					Business model
Appearance						
Output	5 kW	5 kW	20 kW	50 kW	250 kW	200 kW
Type	Cogeneration (under consideration)	Cogeneration	Cogeneration (under consideration)	Cogeneration	Cogeneration	Mono-generation
Electrical generation efficiency (target value)	50 %	50 %	50 %	50 %	55 %	50 – 60 % (Actual performance)
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	

[Fuel Cell Vehicles] New Goals of 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 new release

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

[Hydrogen Refueling Stations] Progress in Goals in the Road Map ①

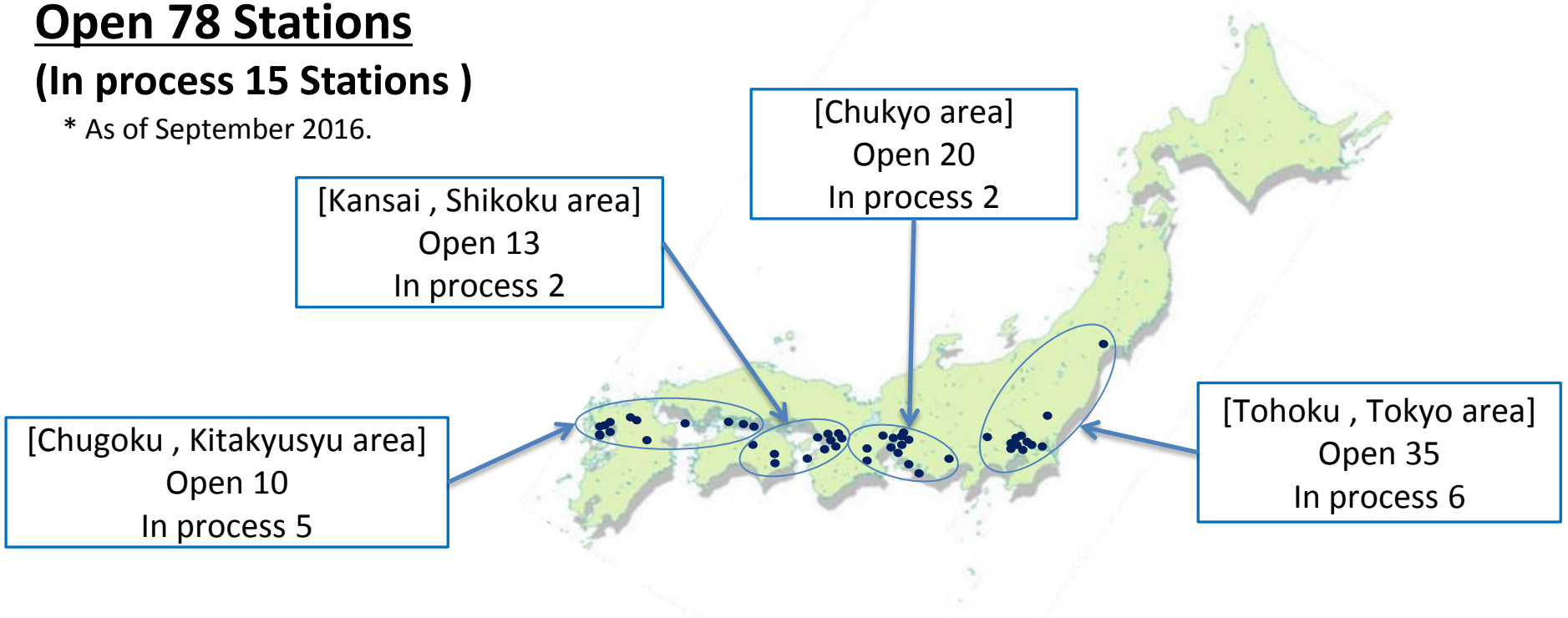
Goals in the Roadmap	Progress
• Ensure about 160 HRSs in FY2020 and 320 in FY2025.	• 78 HRSs are commercially available and 15 in process. (*As of September 2016)
• For the price of hydrogen, aim at offering at the same or lower price as compared with the fuel cost of gas vehicles in 2015, and as compared 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 78 Stations

(In process 15 Stations)

* As of September 2016.



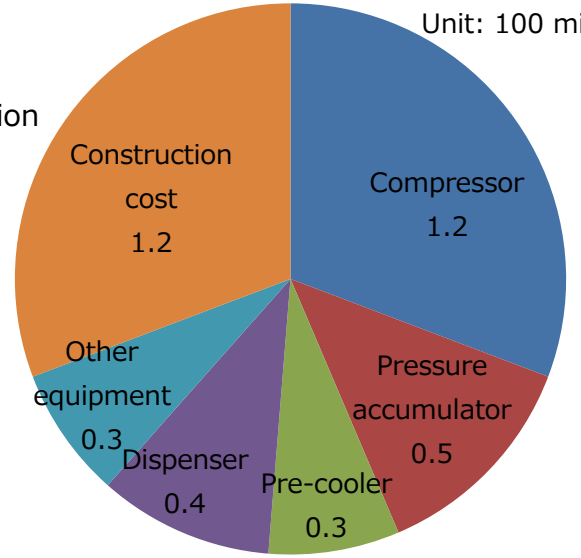
[Hydrogen Refueling Stations] Progress in Goals in the Road Map ②

Goals in the road map	Progress
① Aims at reducing the installation cost into a half of the current cost by around 2020.	• Costs for installation: About 390 million yen * Average of actual benefit of grant money (as of the end of 2014) (fixed off site , 300 N m³/h) * Meanwhile, please note various facility expenses that are not covered by the support will be needed in addition to the above.
② Manufacturers providing equipment constituting the station aim at realizing lower equipment cost having competitiveness against manufacturers in Europe.	
③ 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 47 million yen * Average amount of grant money applied (as of FY 2015) (fixed off site 300 N m³/h)

Breakdown of costs for installation of hydrogen refueling station

Total cost for establishment: About 390 million yen

Unit: 100 million yen

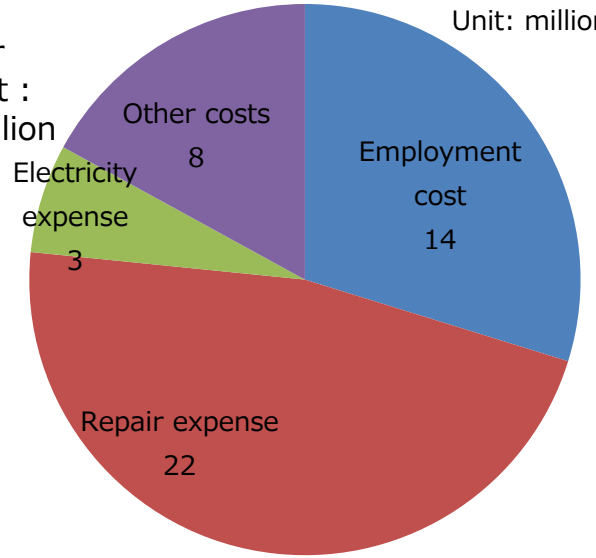


* Average of actual benefit of grant money (as of the end of 2014) (fixed off site , 300 N m³/h)
* Meanwhile, please not various facility expenses that are not covered by the support will be needed in addition to the above

Breakdown of operating cost of hydrogen refueling station

Total cost for management : About 47 million yen

Unit: million yen



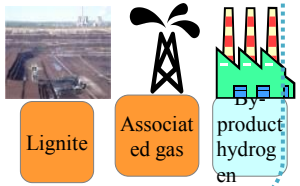
* Average amount of grant money applied (as of FY 2015) (fixed off site 300 N m3/h

[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.

[Hydrogen Supply Chain]
Establishment of an Inexpensive, Stable Hydrogen Supply System

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

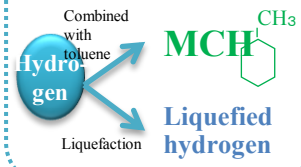
Hydrogen sources in foreign countries



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

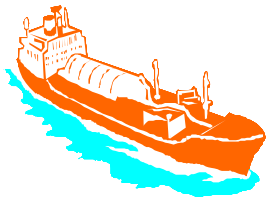
Refinement of hydrogen

Conversion into hydrogen carriers



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.

[Hydrogen Supply Chain]
Demonstration project for hydrogen supply chain

Theme	Project	Participants	Duration	Purpose
Demonstration project for establishment of hydrogen supply chain based on unused-energy-derived hydrogen	(1) Demonstration project for establishment of large-scale hydrogen marine transportation supply chain derived from unused brown coal	-Kawasaki Heavy Industries, Ltd -Iwatani Corporation -Electric Power Development Co. Ltd	2015～2020	Demonstration of brown coal gasification, marine transportation and loading
	(2) Demonstration of the hydrogen supply chain by chemical hydride method utilizing unused energy	-Chiyoda Corporation	2015～2020	Demonstration of scale up for hydrogenation /de-hydrogenation plant and operability of hydrogen chain using Toluene-MCH cycle
Technology development of systems using hydrogen	(3) Development of Smart Community technology by utilization of hydrogen CGS(Co-Generation System)	-Obayashi Corporation -Kawasaki Heavy Industries,Ltd	2015～2017	Demonstration of hydrogen firing or co-firing on GT cogeneration and energy system configured hydrogen power generation
	(4) R&D on Gas turbine for co-firing of hydrogen-natural gas for low-carbon footprint power generation	-Mitsubishi Hitachi Power Systems , Ltd. -Mitsubishi Heavy Industries, Ltd	2015～2018	Development of applicable gas turbine by natural gas /hydrogen co-firing in existing power generation plant

Budget for Hydrogen and Fuel Cells in FY 2016 (METI)

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 Residential FCs [9.5 billion yen]

Promote the accelerated introduction of ENE-FARMs. Promote lower cost through mass production.

ENE·FARM

Disseminate FCVs

Subsidies for HRSs
[6.2 billion yen]

Support HRS installations and promote creating new FCV demand.

Support for FCVs
[Included in 15 billion yen]

Build a H2 supply chain

Demonstrations for global H2 supply chain [2.8 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
[3.7 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
[4.15 billion yen]

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

Construct of H2 energy network

Construction of a H2 energy network
[Included in 4.5 billion yen]

Build a network that effectively connects multiple hydrogen applications in the region.

R&D of H2 production, transport and storage

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

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