Hydrogen and Fuel cell utilization in Japan

and

NEDO's R&D activity for

Hydrogen and Fuel cell technology

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Japan's Policy on Hydrogen Energy

Action to realize "Hydrogen Society"; at Strategic Energy Plan *(updated by Cabinet on April 11th ,2014)*

(1) Promote of Stationary FC

(2) Create of preferable market conditions for FCVs commercialization

(3) Develop new application toward wider H2 utilization (H2gas-based power generation, etc)

(4) Develop large-scale hydrogen supply chain (production/storage/delivery)

(5) Develop H2/FC Roadmap toward "Hydrogen Society"

Strategic Road Map for Hydrogen and Fuel Cells

3 Phases toward "Hydrogen Society"

Phase 1: Expand utilization of fuel cell (Present -)

- Acceleration of dissemination micro-CHP (ENE･FARM)
- Market introduction of fuel cell for commercial / industry use
- FCV: Price equivalent to the hybrid vehicle
  (Hydrogen price: around 2020 / Vehicle price: around 2025)

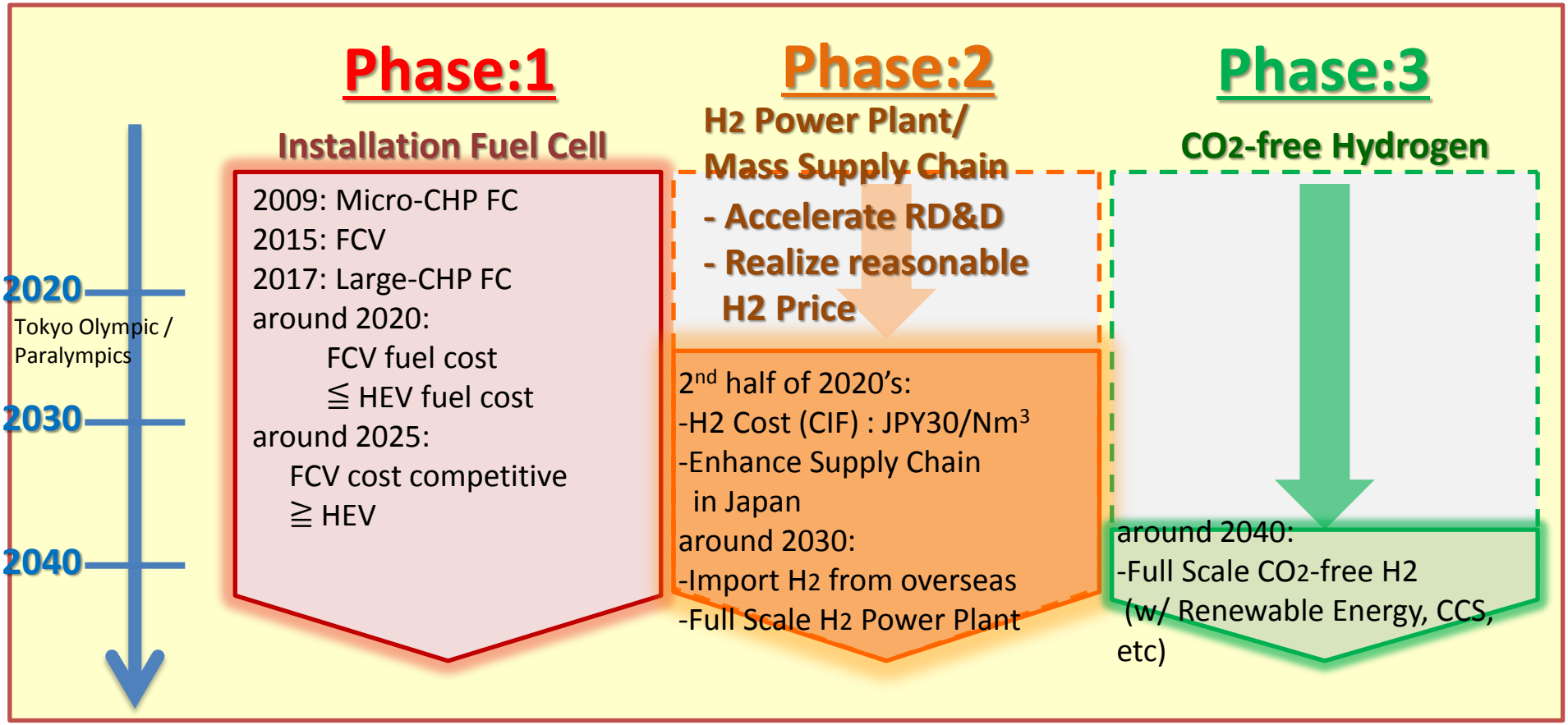
Phase 2: Establish hydrogen supply chain with unused energy from overseas (second half of 2020's -)

- Develop efficient transport / storage technology with chemical hydride, liquid hydrogen
- Market introduction on hydrogen power plant (2030)

Phase 3: Establish CO2-free hydrogen supply chain (2040 -)

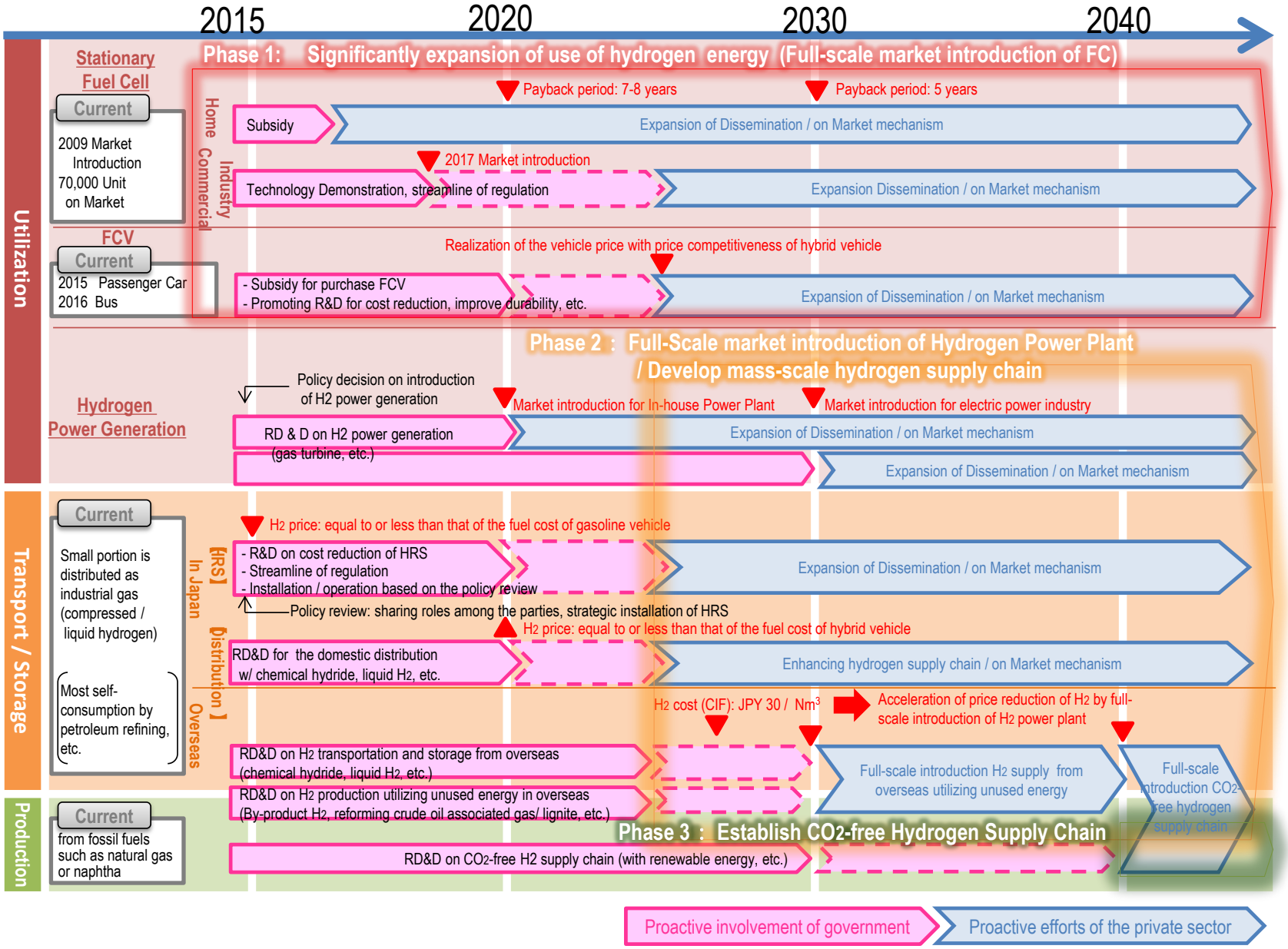
- Develop hydrogen production technology with renewable energy, CCS

Step by Step approach to realize Hydrogen Society



Create New Market on Hydrogen / Fuel Cell (Japan)

US$ 10 billion (2030) ⇒ US$ 80 billion (2050)


2015
2020
2030
2040
Utilization
Stationary Fuel Cell
Current
2009 Market Introduction 70,000 Unit on Market
Home Commercial Industry
Phase 1: Significantly expansion of use of hydrogen energy (Full-scale market introduction of FC)
Payback period: 7-8 years
Payback period: 5 years
Subsidy
Expansion of Dissemination / on Market mechanism
2017 Market introduction
Technology Demonstration, streamline of regulation
Expansion Dissemination / on Market mechanism
FCV
Current
2015 Passenger Car
2016 Bus
Realization of the vehicle price with price competitiveness of hybrid vehicle
- Subsidy for purchase FCV
- Promoting R&D for cost reduction, improve durability, etc.
Expansion of Dissemination / on Market mechanism
Phase 2 : Full-Scale market introduction of Hydrogen Power Plant / Develop mass-scale hydrogen supply chain
Hydrogen Power Generation
Policy decision on introduction of H2 power generation
Market introduction for In-house Power Plant
Market introduction for electric power industry
RD & D on H2 power generation (gas turbine, etc.)
Expansion of Dissemination / on Market mechanism
Expansion of Dissemination / on Market mechanism
Transport / Storage
Current
Small portion is distributed as industrial gas (compressed / liquid hydrogen)
Most self-consumption by petroleum refining, etc.
In Japan
[HRS]
[Distribution]
Overseas
H2 price: equal to or less than that of the fuel cost of gasoline vehicle
- R&D on cost reduction of HRS
- Streamline of regulation
- Installation / operation based on the policy review
Expansion of Dissemination / on Market mechanism
Policy review: sharing roles among the parties, strategic installation of HRS
H2 price: equal to or less than that of the fuel cost of hybrid vehicle
RD&D for the domestic distribution w/ chemical hydride, liquid H2, etc.
Enhancing hydrogen supply chain / on Market mechanism
H2 cost (CIF): JPY 30 / Nm3
Acceleration of price reduction of H2 by full-scale introduction of H2 power plant
RD&D on H2 transportation and storage from overseas (chemical hydride, liquid H2, etc.)
Full-scale introduction H2 supply from overseas utilizing unused energy
Full-scale introduction CO2-free hydrogen supply chain
RD&D on H2 production utilizing unused energy in overseas (By-product H2, reforming crude oil associated gas/ lignite, etc.)
Production
Current
from fossil fuels such as natural gas or naphtha
Phase 3 : Establish CO2-free Hydrogen Supply Chain
RD&D on CO2-free H2 supply chain (with renewable energy, etc.)
Proactive involvement of government
Proactive efforts of the private sector

Budget volumes (in FY 2015 budget request)

Phase 1

Significantly expansion of use of hydrogen energy (Full-scale market introduction of FC)

Focus on implementation from the present

Phase 2

Full-Scale market introduction of Hydrogen Power Plant / Develop mass-scale hydrogen supply chain

Realize in the late 2020s

Phase 3

Establish CO2-free Hydrogen Supply Chain

Realize in 2040s

Promote of stationary FCs

Subsidies for supporting introduction of micro-CHP (ENE-FARMs) [15 billion yen]

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

Promote of FC vehicles

Subsidies for building HRS [11 billion yen]

Support the building of HRS. Partially subsidize activities for creating new demand, etc.

Support for introducing FCV [Included in 30 billion yen]

Build a hydrogen supply chain

Demonstrations for building a supply chain of hydrogen imported from untapped overseas energy resources [3.8 billion yen]

Demonstrate how hydrogen can be produced from unused overseas energy resources, e.g., by-product hydrogen, lignite, etc., transported in the form of liquid hydrogen or chemical hydride, and used to generate power.

R&D of fuel cells, etc.

Technology development and demonstration of FCs [4.0 billion yen]

Conduct R&D to enhance performance and lower costs of FCs, and demonstrate commercial applications of FCs.

FCs for commercial application

Technology development for hydrogen fueling stations, etc. [4.5 billion yen]

Develop technologies to lower costs of HRS, enhance safety and security and collect data so as to review regulations.

Construct a hydrogen energy network

Construct a hydrogen energy network [Included in 3.0 billion yen]

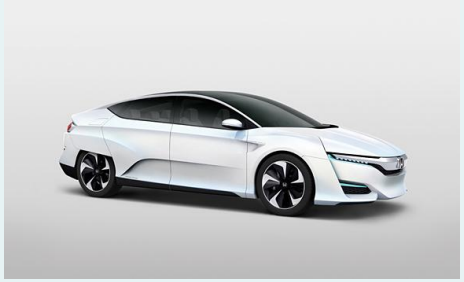
Build a network that effectively connects multiple hydrogen applications in the region.

Develop hydrogen production, transport and storage technologies

Developm technologies for producing, transporting and storing hydrogen derived from renewable energy sources [1.75 billion yen]

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

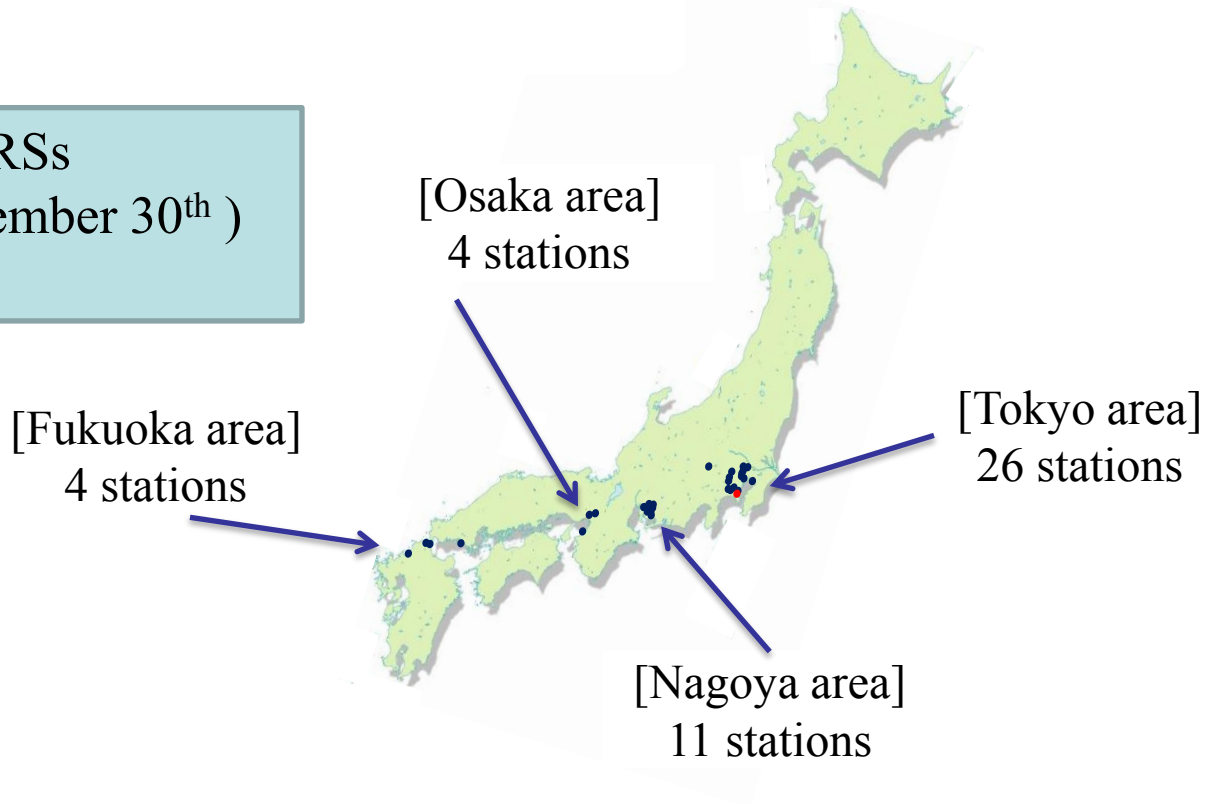
FCV and HRS are on start line of Commercial

FCV	HRS
■ **TOYOTA** Toyota Motor Corporation will launch its new FCV, "Mirai" in Japan on December 15th , 2014.  ■ **HONDA** Honda has unveiled its new FCV CONCEPT. (launch within FY2015) 	■ **Iwatani** Japan's first commercial HRS has opened in Amagasaki on July 14th , 2014, and second one has opened in Kitakyushu on October 22nd , 2014.  ■ **JX Nippon Oil & Energy** JX's First commercial HRS is going to open in December, 2014 and total 11 HRSs will open by the end of March, 2015. 

Promotion of HRS Installation

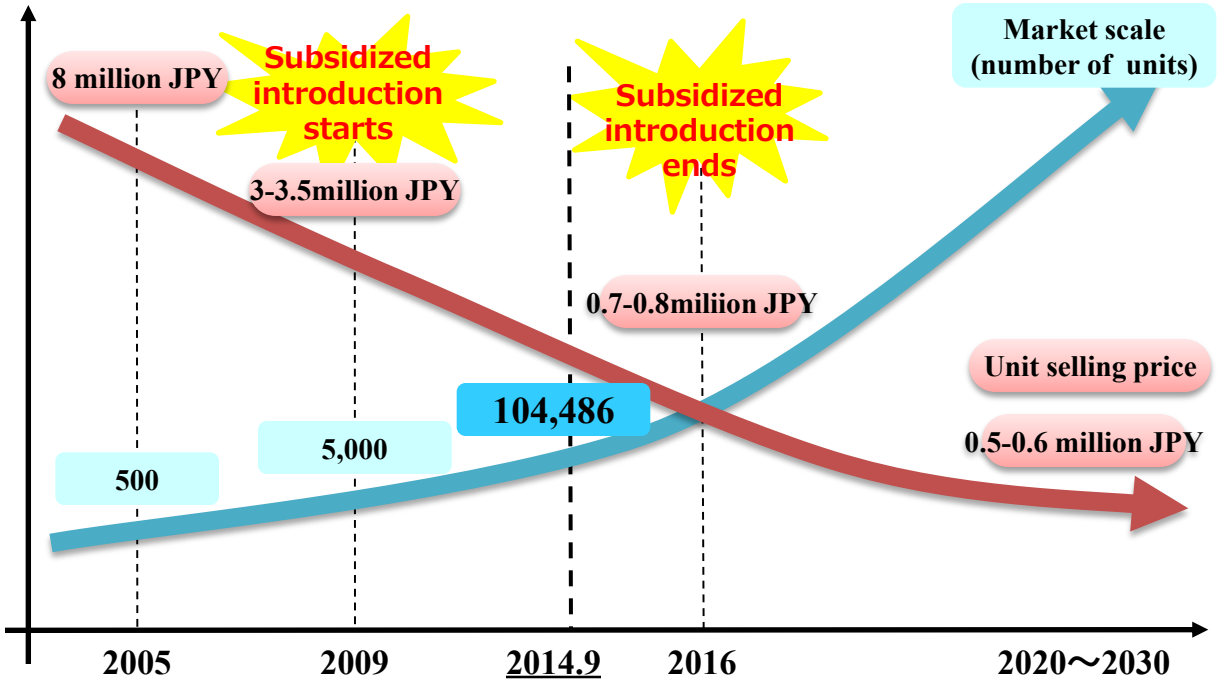
- Prior to market introduction of FCVs, 100 HRSs will be installed in four major metropolitan areas.
- METI subsidizes about 50 % of HRS installation cost (7.2 billion yen in FY2014)

Status of HRSs
(as of November 30th)
45 stations



Residential FCs ("ENE-FARM")

Large-scale validation → Market creation with policy support → Establishment of self-sustained market



- **Total units installed: 104,486 (as of 2014.9)**
- **Target: 1.4million units by 2020 5.3million units by 2030**

ENE·FARM

NEDO's Program for Hydrogen Infrastructure

Item 1: Streamlining Regulations

"Regulation Reform Plan" (Cabinet approved in June 2013) etc.
- 25 items were identified as priority
  (e.g. Location, Distance, Materials, Transport)

Item 2: R&D on low cost equipment for HRS

e.g. Accumulator, Compressor, Pre-cooler, Reformer

Item 3: Code and Standard

e.g. Quality, Metering, Fueling, Inspection

Item 4: Safety

e.g. HRS reliability Database, Social acceptance

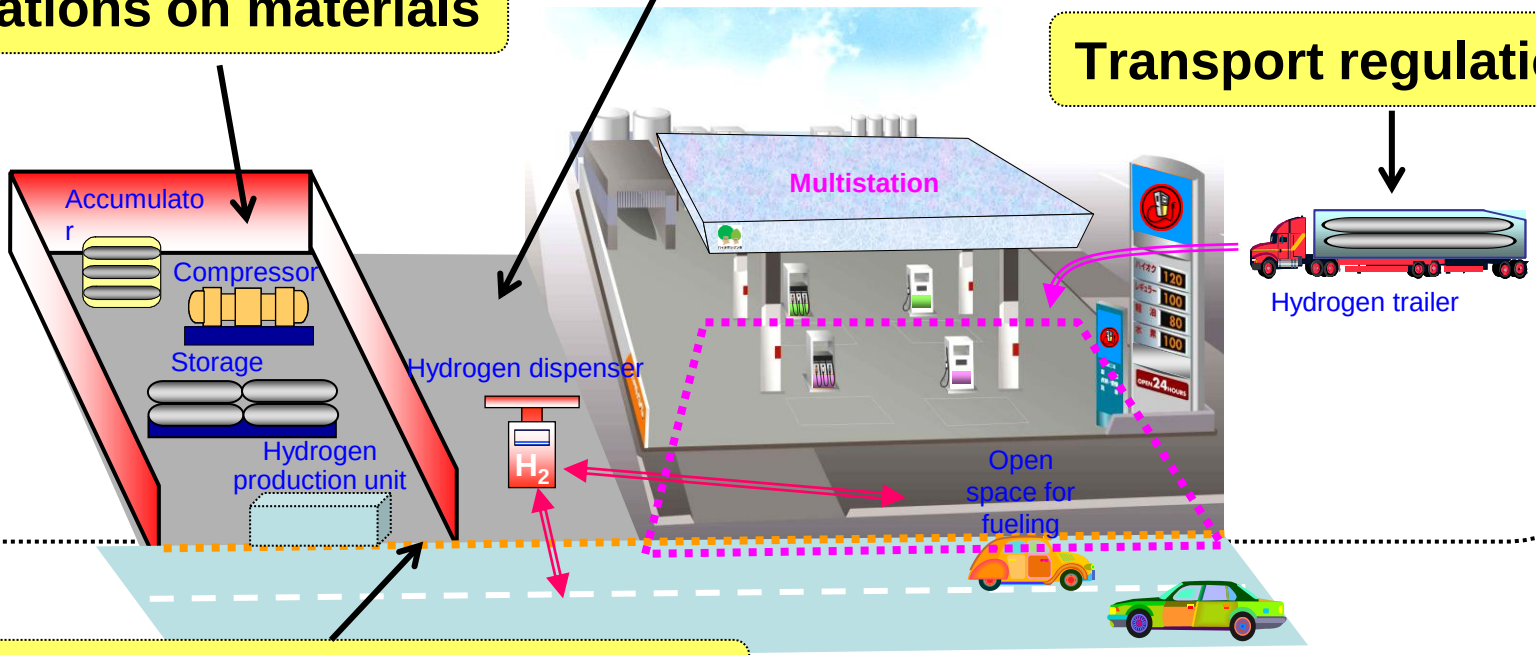
Item 1: Streamlining Regulations for HRS

Regulations on operations

Regulations on location

Regulations on materials

Transport regulations

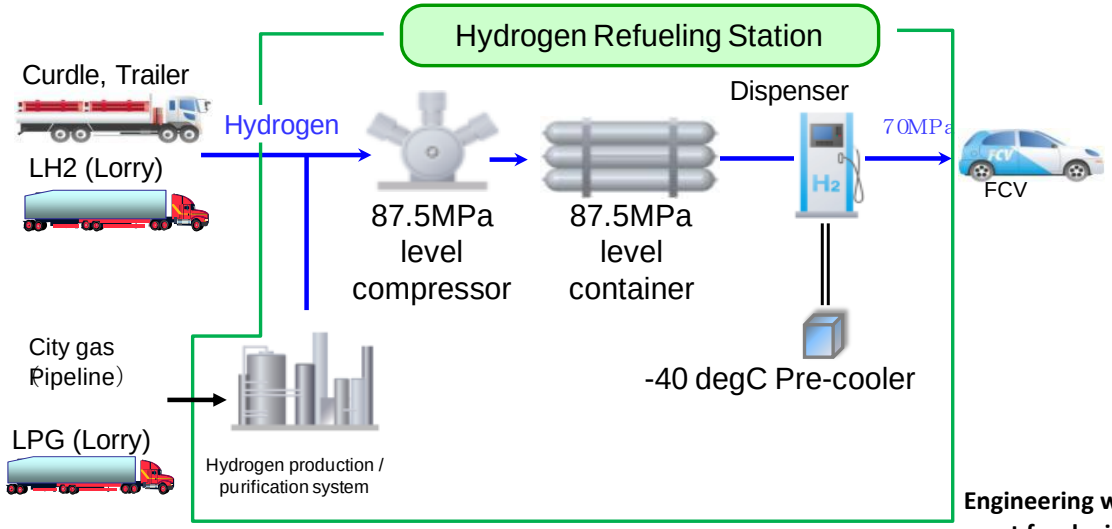


Clearance/distance regulations

Other traffic regulations

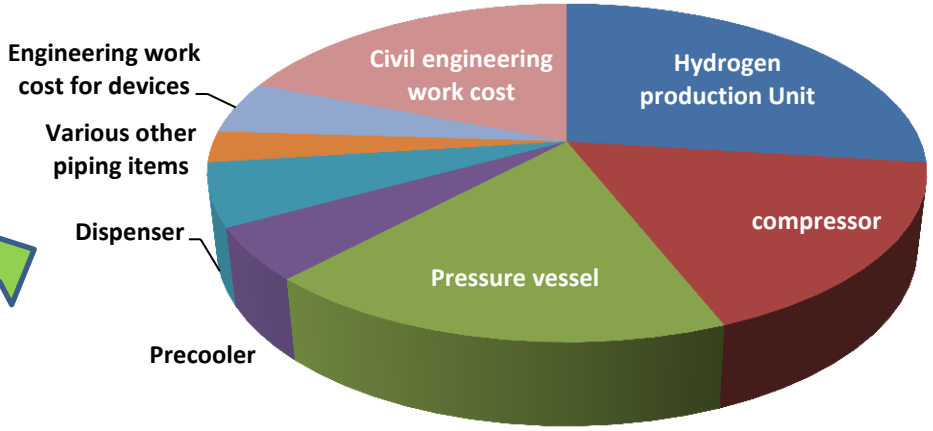
Item 2: R&D on low cost equipment for HRS

-The present cost of supply equipment is about € 3.5 million, which is a major problem.
-The goal is to lower the cost of H2 refueling stations.
-Cost reduction can be achieved by deregulation, mass production and simplification of system components.



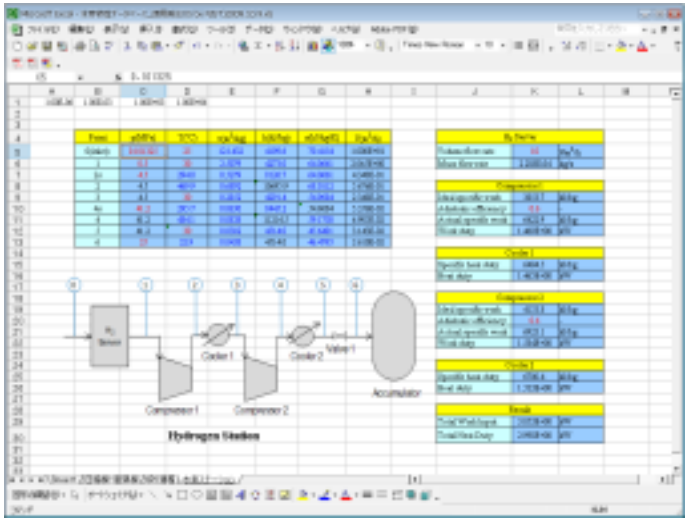
Cost breakdown for hydrogen refueling station

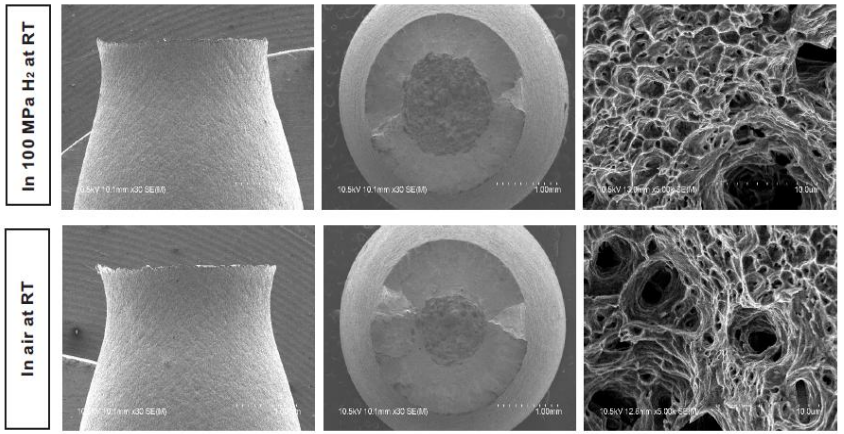
Example of medium-scale on-site costs



Item 3: Code and Standard

Kyushu Univ. as COE of Hydrogen





Item 4: Safety

Safety

- Hardware & system
- Training

Awareness

- Education
- Hands-on Opportunity

Added Value

Social system-based introduction
(Smart Community projects)

NEDO's Program for Fuel Cell

Item 1: Basic technology

e.g. Analysis to enhance MEA performance, Accelerating durability test method , Low precious metal catalyst

Item 2: Basic Production technology

e.g. Technology for mass production, Quality management technology, Demonstration for commercial applications

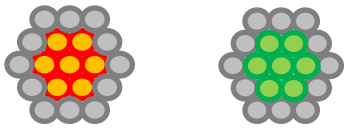
Item 3: Next generation technology

e.g. High performance Fuel Cell components and materials for next generation

Item 1: Basic technology

-Development of highly-active core-shell catalysts
in order to substantially reduce platinum used in PEFC cathode.

Two-layer structure (precious metal core)



Pt
Au
Pd

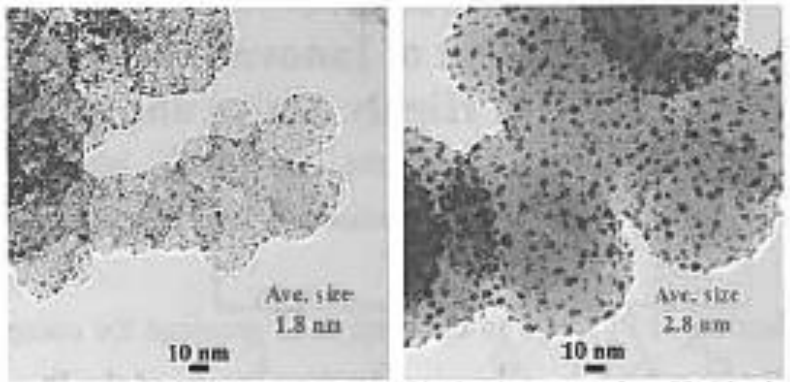
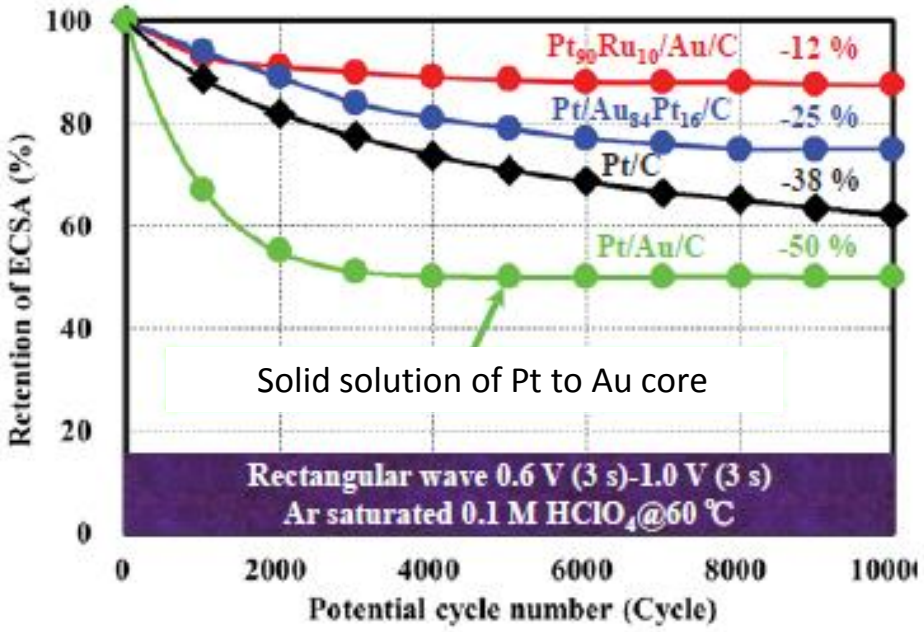


Fig. 2. TEM images of Au/C cores (DDT/$NaBH_4$).

New synthesis method using DDT ($C_{12}H_{25}SH$)/$NaBH_4$ resulted in smaller particle size and good dispensability.



Au core catalyst shows poor durability, though Au-alloy Shows good durability but lower mass-activity.

Item 2: Basic Production technology

"Demonstrative study of 5 kW SOFC system for business use"
Objective: to demonstrate performance, clarify issues and feedback to design of 5 kW-class system through field tests.

Outlook of 5 kW-class system

FY 2013	FY 2014	FY 2015
1000 h operation	5000 h operation	5000 h operation
5 systems	+ 2 systems	+ 2 systems
$\eta_e > 48\ \%$ $\eta_{total} > 90\ \%$	←	$\eta_e > 50\ \%$ $\eta_{total} > 90\ \%$

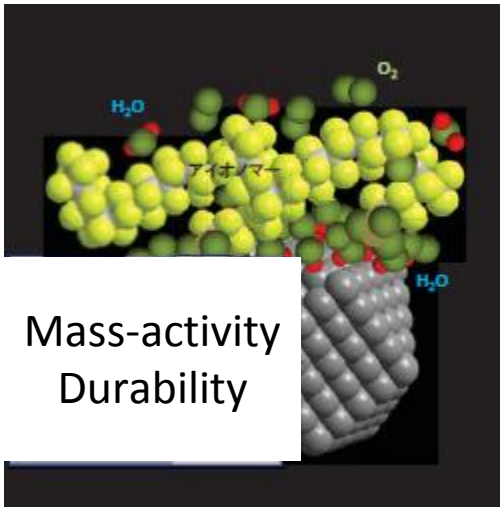
Improve stacks& BOPs

-Start with 5 systems and exchange cell stacks and BOP every year.
- 4 systems added in FY 2014 and 2015.

Estimated market: total 750 MW (in Japan)

Item 3: Next generation technology

- PEFC analysis in order to propose design guidelines for FCVs.



ORR reaction mechanism

- A new beam line constructed at Spring-8 in Dec 2012, for in-situ, real time observation of electro-chemical reactions in electrodes.
- The highest time and space resolutions in the world, used exclusively for FC-related researches

Thank you for your kind attention

Grazie per la vostra cortese attenzione