JHFC Project Activities in FY 2009

(Supported by NEDO)

Presented for IPHE Forum
September 21-22, Shanghai

Jinichi Tomuro
(ENAA, Japan)

Contents

1. The situation surrounding FCVs
   - Energy trends in Japan
   - The trends on FCV hydrogen infrastructure in Japan and abroad
   - Merits and positioning of FCVs
   - Trends in other next generation vehicles
   - Positioning of JHFC with NEDO related projects

2. The progress of JHFC in 2009
   - JHFC activities: up to now, objectives from this point, enhancement of the structure
   - Results achieved with FCV driving performance, hydrogen refueling, fuel economy etc.
   - The research results of primary technologie verifications

3. Summary and intended measures for 2010
   - Summary of 2009
   - Clarification of technical issues to be verified for commencement of FCV hydrogen infrastructure expansion
   - Intended measures for 2010

Energy Trends in Japan

At the Summit of the heads of state and government on climate change held at the United Nations headquarters in September 2009, Prime Minister Hatoyama announced that Japan intends to reduce its CO_2 emissions by 25% below 1990 levels by 2020.

Basic Act on Energy Policy

Basic Energy Plan (2003)

Basic Energy Plan (2007)

Energy requirement forecast for 2030 (2005)

Discuss the view of energy supply-demand structure for 2030, and study mid-long term energy strategy.

New national energy strategy (2006)

Mid to long term (-2030) national energy strategy focusing on energy security

Improvement Target:
energy saving 30%,
oil dependence (whole) 40%,
oil dependence (transport) 80%,
nuclear power ratio 30-40%

Next generation vehicle fuel initiative (2007)

"Next generation battery"
"Hydrogen･Fuel cell"
"Clean diesel"
"Biofuel"
"ITS"

50 beautiful stars (2007) (Cool Earth 50)

Proposed to reduce CO_2 to 50% by 2050

Technical strategy milestones

Select the technologies highly demanded for national and private sectors.

Long term energy need expectation (2008)

For achieving the target of "New national energy strategy", clarify Japan's vision of energy demand-supply structure assuming that cutting edge energy technologies are progressed and implemented "utmost".

Summit in Toyako / Hokkaido (2008)

G8 agreed to share the target of reducing global production to 50% at least, by 2005, with UNFCCC contracting states.

UN conference on climate change (2009)

Declared to reduce 25% of CO_2 by 2020 compared to 1990

Trends in abroad about FCV / Hydrogen Infrastructure

The efforts to introduce FCV / Hydrogen are distinctively more active in the EU / USA member countries and states than their respective governments.

Europe	• The automobile manufacturers announced LoU, and particularly the infrastructure manufacturers on the receiving end announced MoU, and the test scenario regarding the introduction of hydrogen stations was developed with the H_2 Mobility consortium. • In the EU within FP7, the FCH-JU (= FCH-JTI) commences with the development of NextHyLight (the successor to HyLight) or H2 Move Scandinavia (demonstration in Oslo) etc. and development is progressing.
U.S.A.	• Although the DOE Secretary Chu greatly reduced the hydrogen budget, congress resisted and succeeded in obtaining the same budget level as the previous year. However, there remains a concern regarding governmental support. • CaFCP and the government of New York state are outlining a plan for the introduction and development of FCV stations commencing in 2015. • In the Canadian provinces of BC etc. the emphasis is on the further expansion of the FC bus fleet.

Trends in Japan for FCV / Hydrogen Infrastructure 2009

1. FCV

①Heads of the Japanese car manufacturers mentioned the 2015 targets.

②Domestic leasing of the new FCV has commenced.

③Japanese car manufacturers participate in the aforesaid European LoU.

2. Hydrogen Infrastructure

① Opening of three Cooperative Hydrogen Stations (keep on increasing)

- Started operation in Kita-Kyushu, Kyushu University &in Nikko in September 2009

② Founding of the Research Association of Hydrogen Supply / Utilization Technology (HySUT)

- On July 31st, 2009
  In preparation for the year 2015 when propagation is predicted to begin, a research association was founded by 13 Japanese domestic infrastructure companies (oil, gas, equipment manufacturers), engaged in undertaking field tests.

FCV and Eco-cars Feature Comparisons

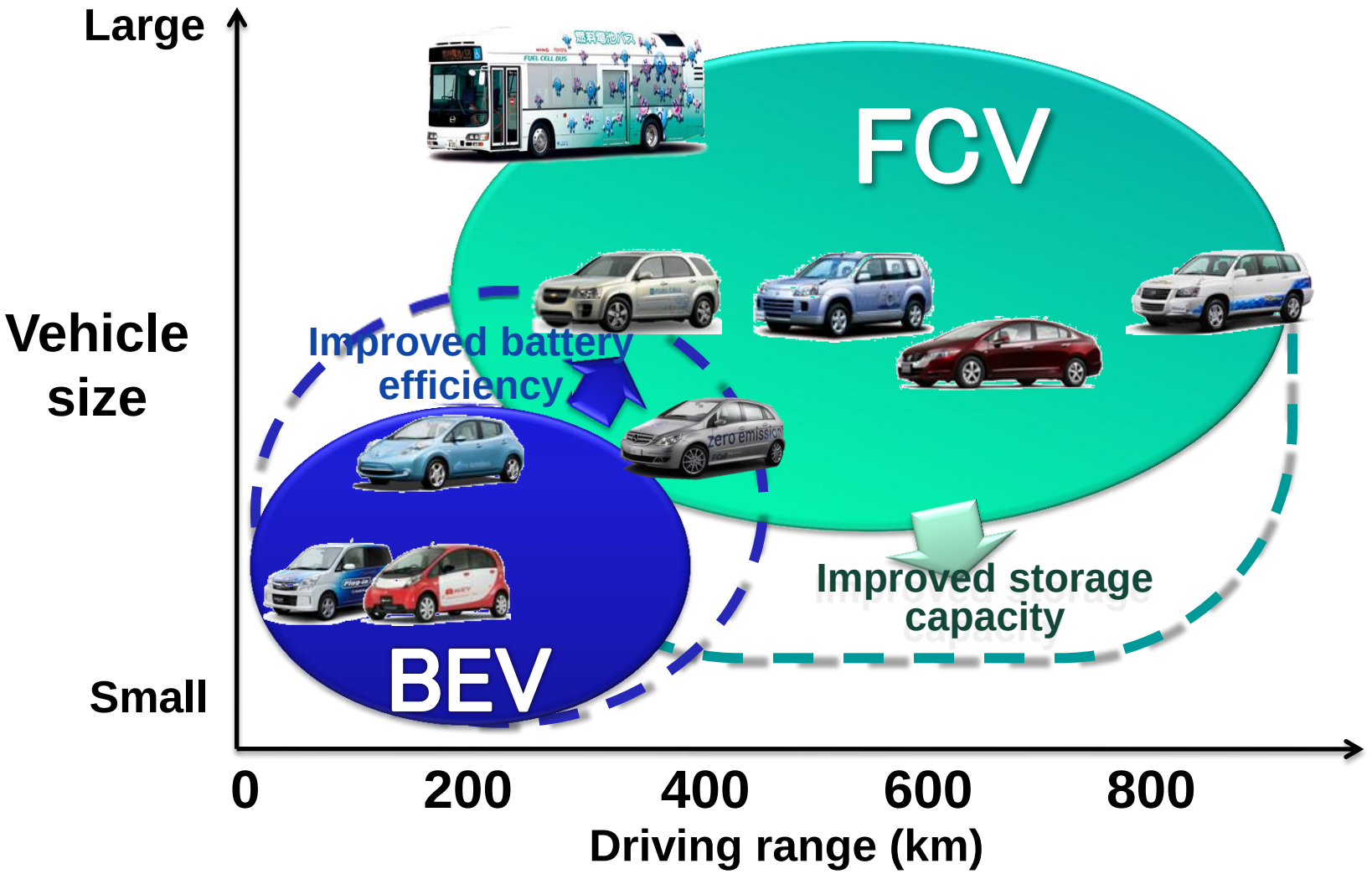
- FCV and BEV are most promising in aspects of CO_2 emission and energy sustainability.
- FCV has a major problem in vehicle cost and infrastructure improvement.
- BEV has a major problem in battery performance improvement.

★ → ★★★★★
(poor) → (very good)

Item	FCV	BEV	PHEV	HEV	ICE (gasoline)
CO_2 emission	★★★★★	★★★★★	★★★★	★★★	★
Cold district performance	★★★★ (-30°C)	★★ (Battery degradation)	★★★★	★★★★★	★★★★★
Driving range	★★★★★ (10-15 mode ~830km)	★★ (~160km)	★ (for EV, 30km) ★★★★★ (EV+HV)	★★★★★	★★★★★
Vehicle cost	★	★★	★★	★★★★	★★★★★
Durability (Performance degradation)	★★★★ (Stack 10years)	★★ (Battery)	★★★ (Battery)	★★★★★	★★★★★
Filling, charging, or refueling time	★★★★ (5 min)	★ (Normal charge 8hr) ★★ (Quick charge 20min)	★ (Normal charge 4hr) ★★★★★ (Refueling gasoline)	★★★★★	★★★★★
Infrastructure availability	★	★★★	★★★★	★★★★★	★★★★★
Energy sustainability	★★★★★	★★★★★	★★★★	★★	★

Segmentation of FCV and BEV

- FCV can replace existing gasoline vehicle in aspects of vehicle size and driving range.
- For small and short-distance applications, BEV and FCV can coexist to spread more widely.



Trends in Other Next Generation Vehicles (Japan)

The new estimate of long-term energy requirements issued by METI in August 2009 predicts that by 2020, 50% of new cars will be the next generation vehicles such as FCV

	Manufacturer	2008	2009	2010	2011	2012	
Electric cars	Mitsubishi		→				**Launch in 2009**
	Fuji Heavy Industries		→				**Launch in 2009**
	Nissan			→			**Launch in 2010**
	Toyota					→	**Launch by 2012**
Plug-in hybrids	Toyota		→				**Launch in 2009**
Biofuel	Members of the PAJ		→				**Launch by makers from 2009**

Information regarding cars is based on makers' reports.

Information regarding biofuel is from PAJ web site.

NEDO Fuel Cells / Hydrogen Technology Development Project

–2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012

Polymer electrolyte fuel cell

(2005-2009) Development of strategic technologies for applying polymer electrolyte fuel cell:
- Basic common issue solution technology (degradation analysis, etc.)
- Element technology (MEA, catalyst, stack, etc.)
- Basic produce technology (1/2 cooperative study)
- Next generation fuel cell (Utilize university researchers)

Brand new operation

Develop promotion technology for applying polymer electrolyte fuel cell (tentative)

(2008-2014) Basic material study for hi-performance cell integrating degradation mechanism analysis and nano technology (HiPer-FC)

(2005-2007) Study of advanced fuel cell science (METI operation)

(2008-2009) (FC-Cubic) Study of advanced fuel cell science

(2005-2008) Large scale demonstration of fixed fuel cell

Hydrogen supply & utilization technology

(2002-2005) (JHFC-1) (METI operation)

(2006-2008) (JHFC-2) Fuel cell system demonstration (METI)

(2009-2010) (JHFC-2) NEDO business

(2003-2007) Develop technologies for hydrogen safe use

(2008-2012) Develop technologies for hydrogen produce, transport, storage systems

(2005-2009) Improvement of common infrastructure for hydrogen society

partially integrated

(2006-2012) Base study of advanced hydrogen science

(2007-2011) Base study of advanced hydrogen storage material

Positioning of JHFC with NEDO Hydrogen Supply & Utilization Technology

Intended milestones for the propagation of FCV and hydrogen infrastructure by 2015
(Creation of a new industry, knock-on effects from the increase of competition in the industry are expected)

Establishment of Codes & Standards for Hydrogen Economy Society

(Evaluation of safety, revision of standards)

Regulation･Standardize

Evidence in society

Establishment of a hydrogen society

Evidence in technology

+

JHFC

Japan Hydrogen & Fuel Cell Demonstration Project

(Feedback, evidence from the results obtained by NEDO)

Technology development

+

Development of Technologies for Hydrogen Production, Delivery and Storage Systems

(Establish a hydrogen supply technology with high efficiency at low cost)

Fundamental Research Project on Advanced Hydrogen Science

Advanced Research on Hydrogen Storage Materials

(High density storage technology, quality, hydrogen embrittlement etc.)

Fundamental, Basic research

Contents

1. The situation surrounding FCVs
   - Energy trends in Japan
   - The trends on FCV hydrogen infrastructure in Japan and abroad
   - Merits and positioning of FCVs
   - Trends in other next generation vehicles
   - Positioning of JHFC with NEDO related projects

2. The progress of JHFC in 2009
   - JHFC activities: up to now, objectives from this point, enhancement of the structure
   - Results achieved with FCV driving performance, hydrogen refueling, fuel economy etc.
   - The research results of primary technologie verifications

3. Summary and intended measures for 2010
   - Summary of 2009
   - Clarification of technical issues to be verified for commencement of FCV hydrogen infrastructure expansion
   - Intended measures for 2010

Results of JHFC-2 until FY 2008

The followings have been achieved by the operation of fuel cell vehicles and hydrogen infrastructure.

1. Demonstrated the utilization benefits mainly by 35MPa vehicles
2. Implementation of improvement and standardization work derived from topics and data
3. Clarification of energy efficiency and costs for facilities and operations etc.
4. Verification of improvement of the awareness level from the promotional / educational activities
5. Demonstrated that the performance at low temperatures of FCV equals that of ICE etc.
6. Demonstrated the low energy efficiency (fuel consumption) of FCV, or the efficiency in the reduction of environmental pollution
7. Begun 70MPa refueling (in the second half of last year)

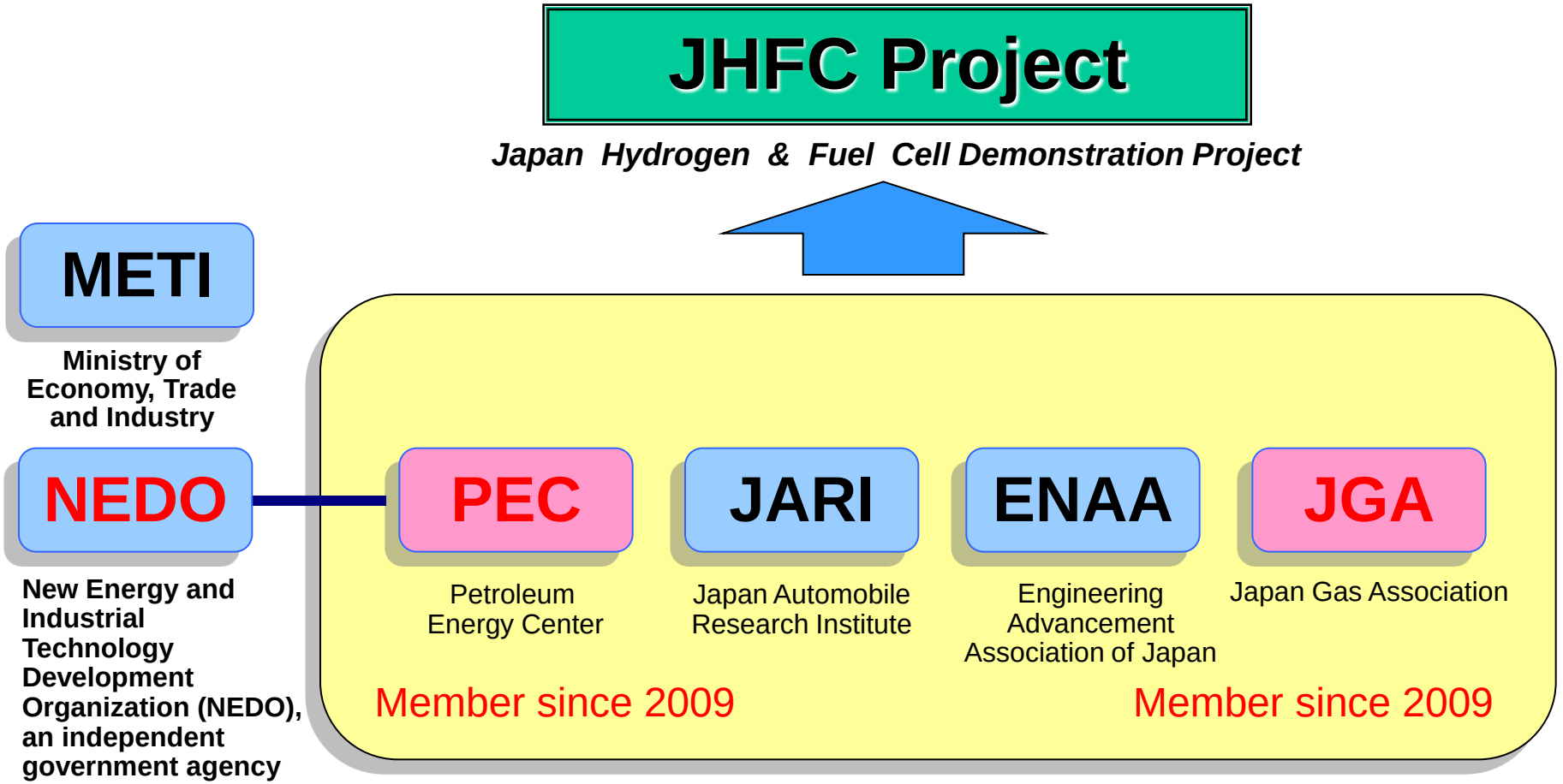
The JHFC-2 Targets (for 2015)

Our priorities from 2009 onwards

1. Suggested infrastructure model for commercialization
2. Clarification of effective counter-measures for common areas of concern relating to vehicles and infrastructure (such as best refueling pressure)
3. Development of an actual plan concerning safety verification of hydrogen infrastructure, reexamination of regulations
4. Strengthen co-operation with other operators of hydrogen-based systems and feedback the results of demonstrative research
5. Measures for the promotion of system acceptance and education (⇨ development of strategic promotional measures) , research, clarification of the regional points of emphasis
6. Clarification of the technical items to be verified required for the commencement of propagation in 2015

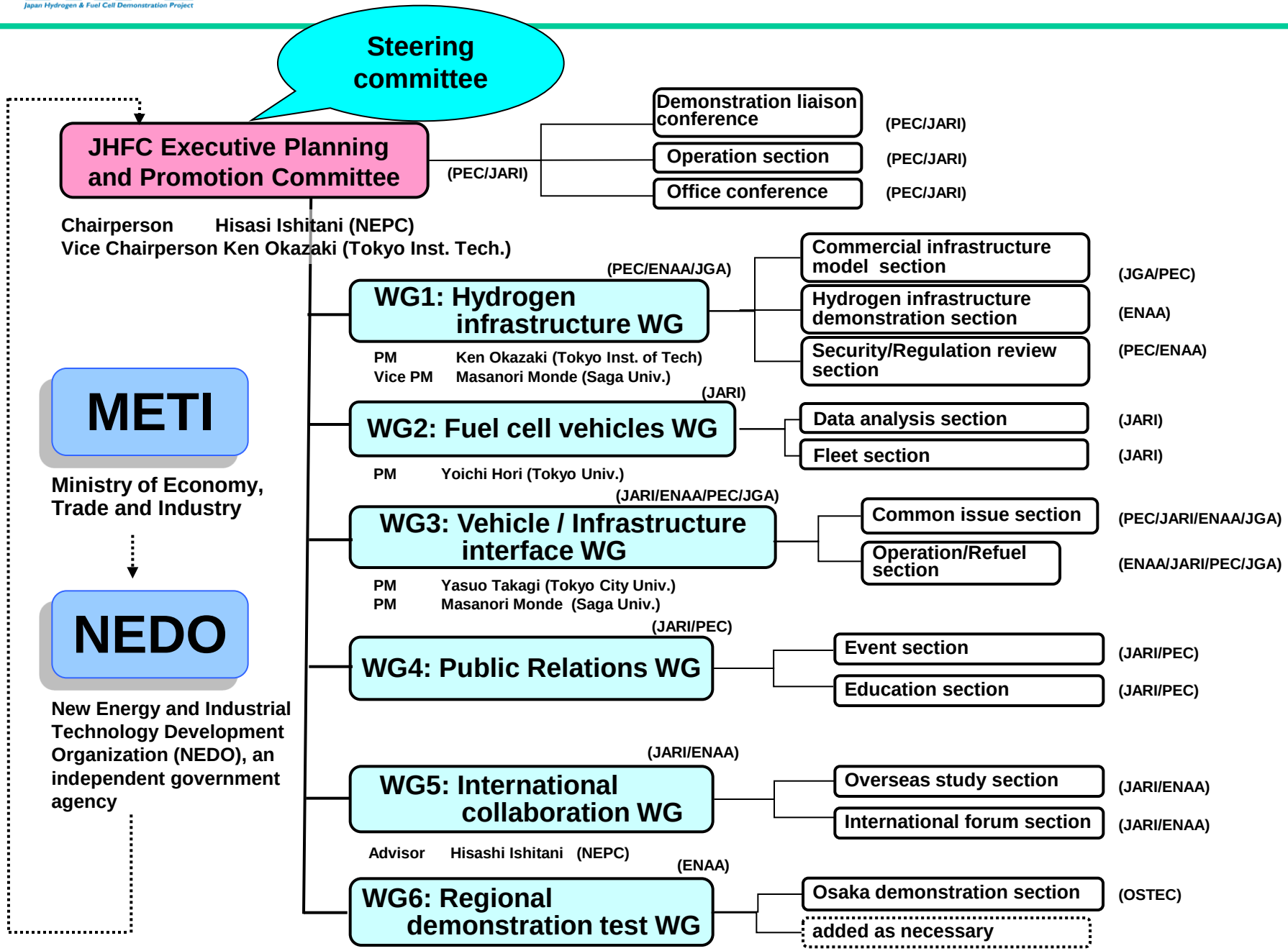
FY 2009 Enhancement of Organization

Under the framework of new NEDO supported projects, the 2 existing groups were complemented and 4 core groups were constituted under the umbrella of the JHFC.



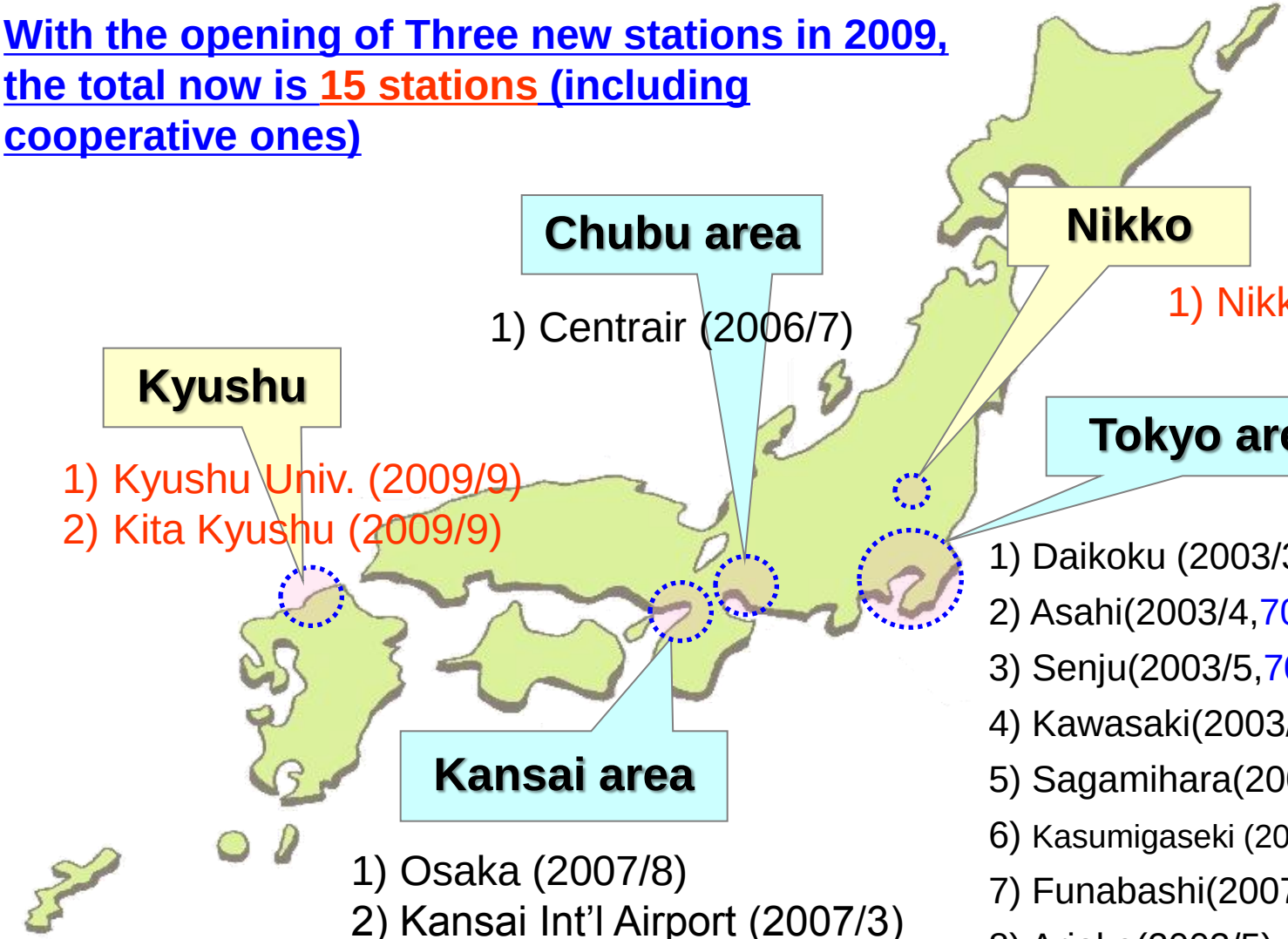
1st phase: FY 2002-2005 2nd phase: FY 2006-2010

2009 Promotion Structure (6 WGs, 12 Committees)



The Increasing JHFC Hydrogen Stations

With the opening of Three new stations in 2009, the total now is 15 stations (including cooperative ones)



Chubu area

1) Centrair (2006/7)

Nikko

1) Nikko (2009/9)

Kyushu

1) Kyushu Univ. (2009/9)
2) Kita Kyushu (2009/9)

Tokyo area

1) Daikoku (2003/3,70MPa:2008/12)
2) Asahi(2003/4,70MPa:2009/2)
3) Senju(2003/5,70MPa:2008/9)
4) Kawasaki(2003/8)
5) Sagamihara(2004/4)
6) Kasumigaseki (2002/12,70MPa:2009/2)
7) Funabashi(2007/6)
8) Ariake(2003/5)
9) Ichihara(2006/12)

Kansai area

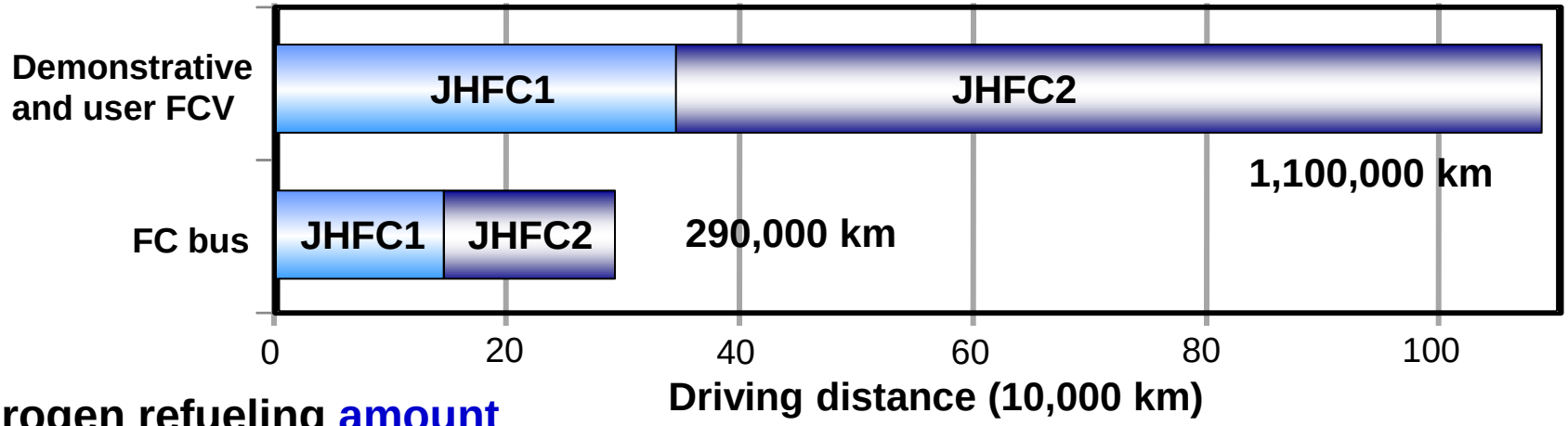
1) Osaka (2007/8)
2) Kansai Int'l Airport (2007/3)

Total Driving Distances / Hydrogen Refueling Amount Results

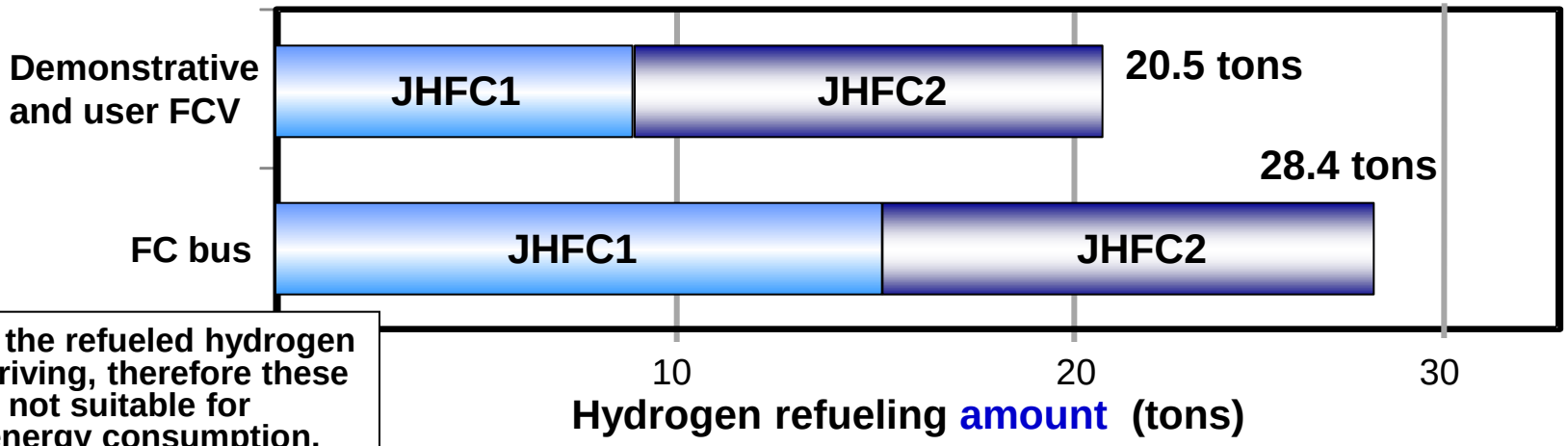
December 2002 ~ December 2009 in total

Car: Total driving distances 1,100,000 km, hydrogen refueling amount 20.5 tons
Bus: Total driving distances 290,000 km, hydrogen refueling amount 28.4 tons

① Driving distances



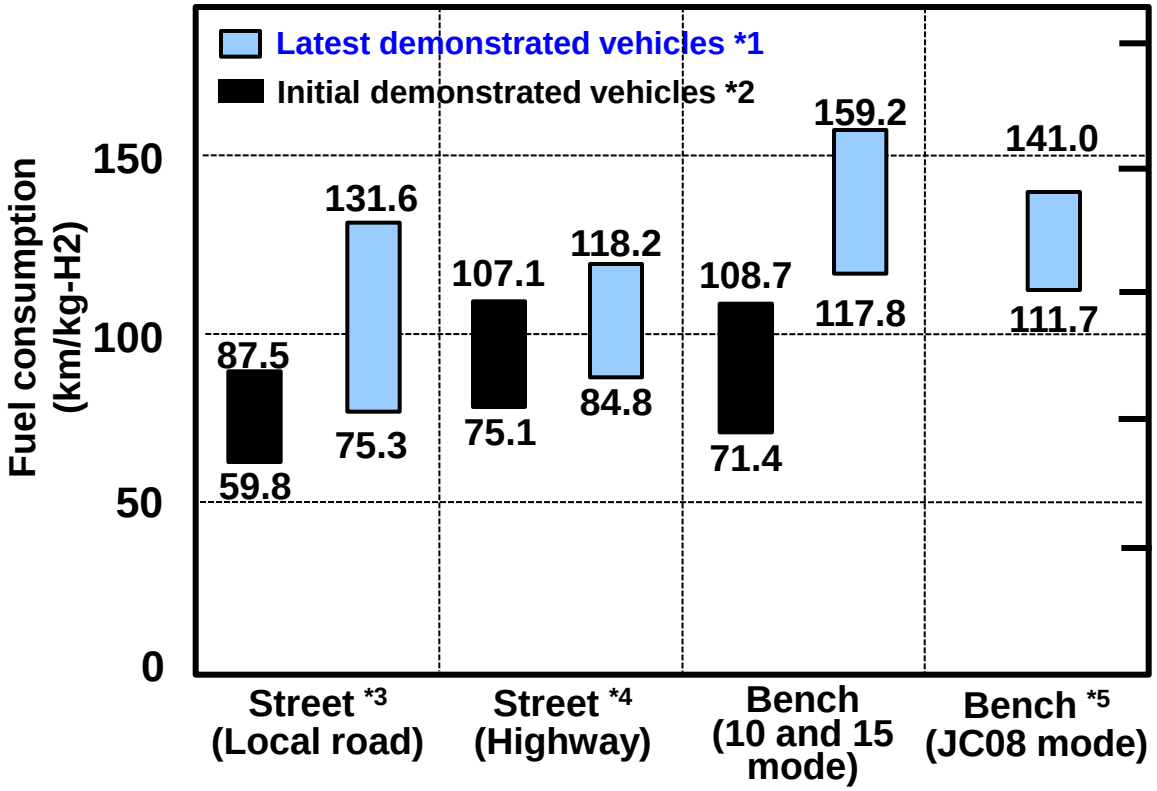
② Hydrogen refueling amount



Note: Not all the refueled hydrogen is used for driving, therefore these numbers are not suitable for calculating energy consumption.

Result of Street Fuel Economy Test

- **Latest demonstrated vehicles have improved fuel economy steadily in both local road and highway.**

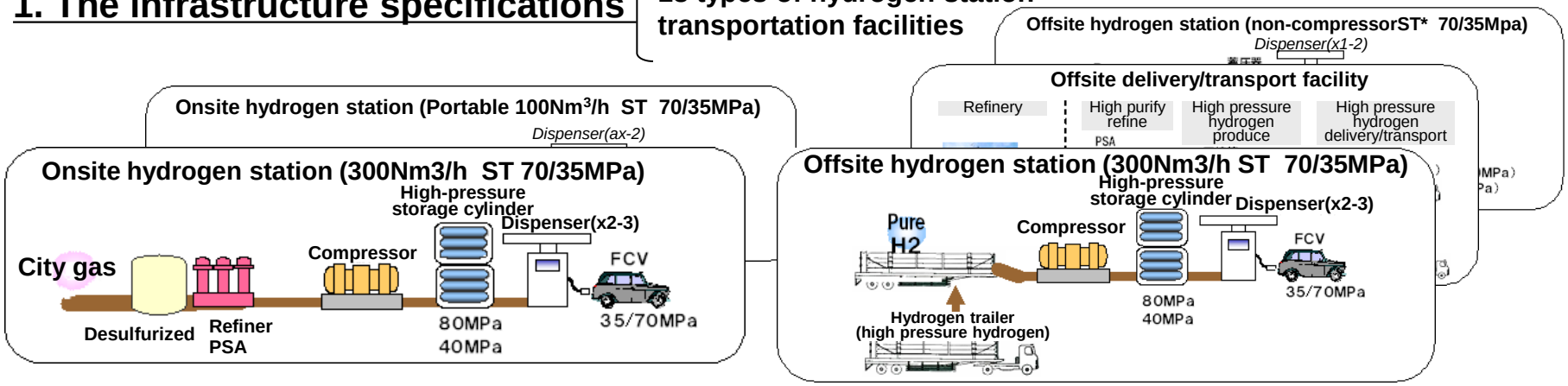


Results of the Primary Technology Verification (1)

Infrastructure models for commercial use (Propagation in 2015)

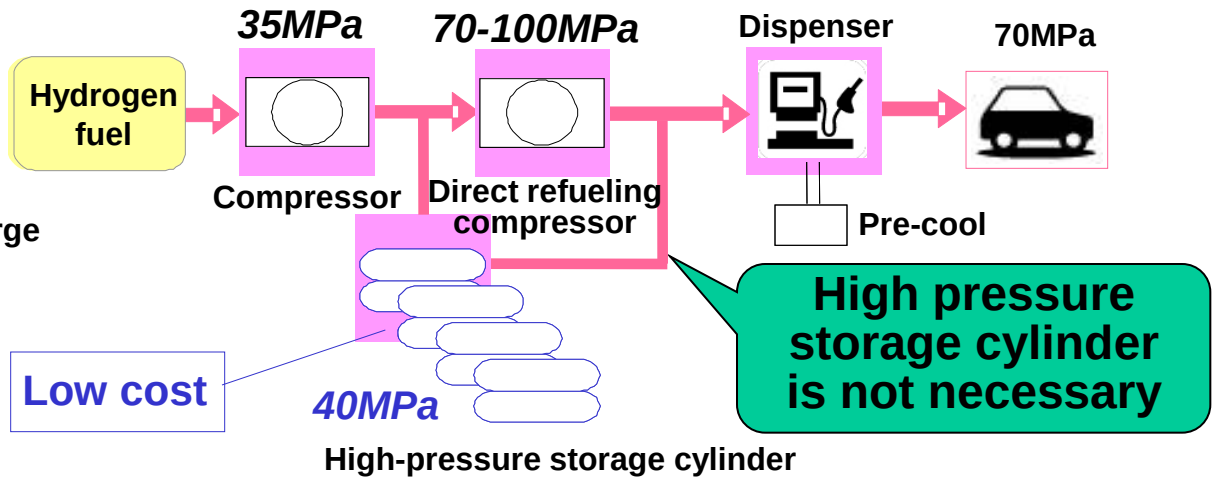
1. The infrastructure specifications

13 types of hydrogen station transportation facilities



2. A specification of a method for direct refueling by compressor (Method of refueling directly from the compressor into FCV)

- Verification in addition to the conventional "Cascade"
- While it has the benefit that the expensive high pressure storage cylinder becomes unnecessary, a large capacity compressor is required



Results of the Primary Technology Verification (2)

Example of an approximate estimate of hydrogen / infrastructure costs (on-site)

(costs during the first phase of propagation 2015~20)

(Conditions for rough estimate) Improvement of costs targeting the main cost reduction factors in the development of equipment, revision of regulations, etc.

Name	Cost reduction rate (vs. current)	Description
Hydrogen producer	50%	Target value of NEDO to produce/transport/storage Pr
Compressor	30%	Maker hearing & CNG station result are used
Hi-pressure storage cyl.	20%	Cost study section hearing
Dispenser	50%	Target value of NEDO to produce/transport/storage PJ
Pre-cooler	20%	Target cost reduction of NEDO cost structure study WG
Others (Const. fee, etc.)	30%	CNG station results are used

Costs \ Hydrogen station		35MPa (Cascade)	70MPa (Cascade)	70MPa (Direct refueling)
Station construction costs (100 Mil. Yen)	300Nm^3/h (on site)	2.9	6.8	3.8
Hydrogen costs* (Yen/Nm^3)	100% supply Base (365 days * 13 hours)	70	110	80

(Information) Driving range costs for gasoline (Note) (JPY 105/L) (JPY 165/L) (JPY 120/L)

(Note) Estimation of fuel consumption FCV: approx. 10km/Nm^3 with H_2, HEV: approx. 15km/L with gasoline

⇨ **Continuation of verification for further cost reductions is necessary**

*** Material city gas: JPY 44/Nm^3**

Results of the Primary Technology Verification (3)

Key Regulation Review Tasks Regarding Hydrogen Infrastructure

Concept of Key Rank

- **Special A:**
  Points that will cause serious problems for the propagation if not revised by 2015

- **A:**
  Points that will cause problems due to high costs etc. for the commercial operation if not revised by 2015.

- **B:**
  Points that at the commencement of propagation might become mandantory

Rank	Key Task		Statute
Special A	Development of 70MPa Laws		High Pressure Gas Safety Act
	• Revision of Safety Distance		High Pressure Gas Safety Act
	• Revision of Safety Administrator Resident Obligations		High Pressure Gas Safety Act
	• Allows Establishing Stations Alongside the Gasoline Stands		Fire Service Law
	• Expansion of Area Where Hydrogen Stands Can Be Built on		Building Standards Act
	More Steel Materials Sanctioned for Use	Review Regulations Regarding Steel Materials	High Pressure Gas Safety Act
	Review of Design Standards (Pressure Resistance Coefficient)		High Pressure Gas Safety Act
	Wider Scope for Compound Vessels in Vessel Regulations (for Transportation)		High Pressure Gas Safety Act
	Increase Hydrogen Storage in Urban Area		Building Standards Act
	Rectify inconsistencies regarding the Safety Distance among CNG and Hydrogen Stands		High Pressure Gas Safety Act
A	Extension of the overhaul inspection period, simplify the safety inspection		High Pressure Gas Safety Act
	Wider Scope for Compound Vessels in Vessel Regulations (for Transportation)		High Pressure Gas Safety Act
	Further Revision on Safety Distance		High Pressure Gas Safety Act
	Permit Reformer's Unattended Hot Air Operation		Fire Service Law
	Review of Explosion-proof Performance Criteria		High Pressure Gas Safety Act
	Installation of High-pressure storage Cylinders, Compressors, etc. on Canopies.		High Pressure Gas Safety Act / Fire Service Law
B	Parallel installing of dispensers		Fire Service Law
	Refuel FCV on public roads		High Pressure Gas Safety Act / Road Traffic Law
	Review reference temperature / consistency with overseas		High Pressure Gas Safety Act

Note) Hatched area: Items require a new test method or data acquisition.

Results of the Primary Technology Verification (4)

Results of the efficiency measurement of 70MPa stations (4 stations)

Station \ Refueling pressure	35MPa	70MPa
	HHV (LHV) %	HHV (LHV) %
Senju On-site (City gas steam reforming)	64.0 (60.0) %	62.1 (58.0) %
Yokohama / Daikoku On-site (Desulfurized gasoline steam reforming)	56.5 (50.5) %	55.6 (49.6) %
Yokohama / Asahi On-site (Naphtha steam reforming)	66.4 (59.3) %	64.0(57.0) %
Kasumigaseki On-site (High pressure steam storage)	–	96.2(95.3) %

From 35MPa ⇨ 70MPa, the efficiency drops by 1~2 points.

Reasons for the decrease in efficiency from 35MPa ⇨ 70MPa

Increase in electricity consumption: ① High pressure compressor (80MPa)

② Pre-cooling equipment (only in Senju, Yokohama / Asahi, Kasumigaseki*1)

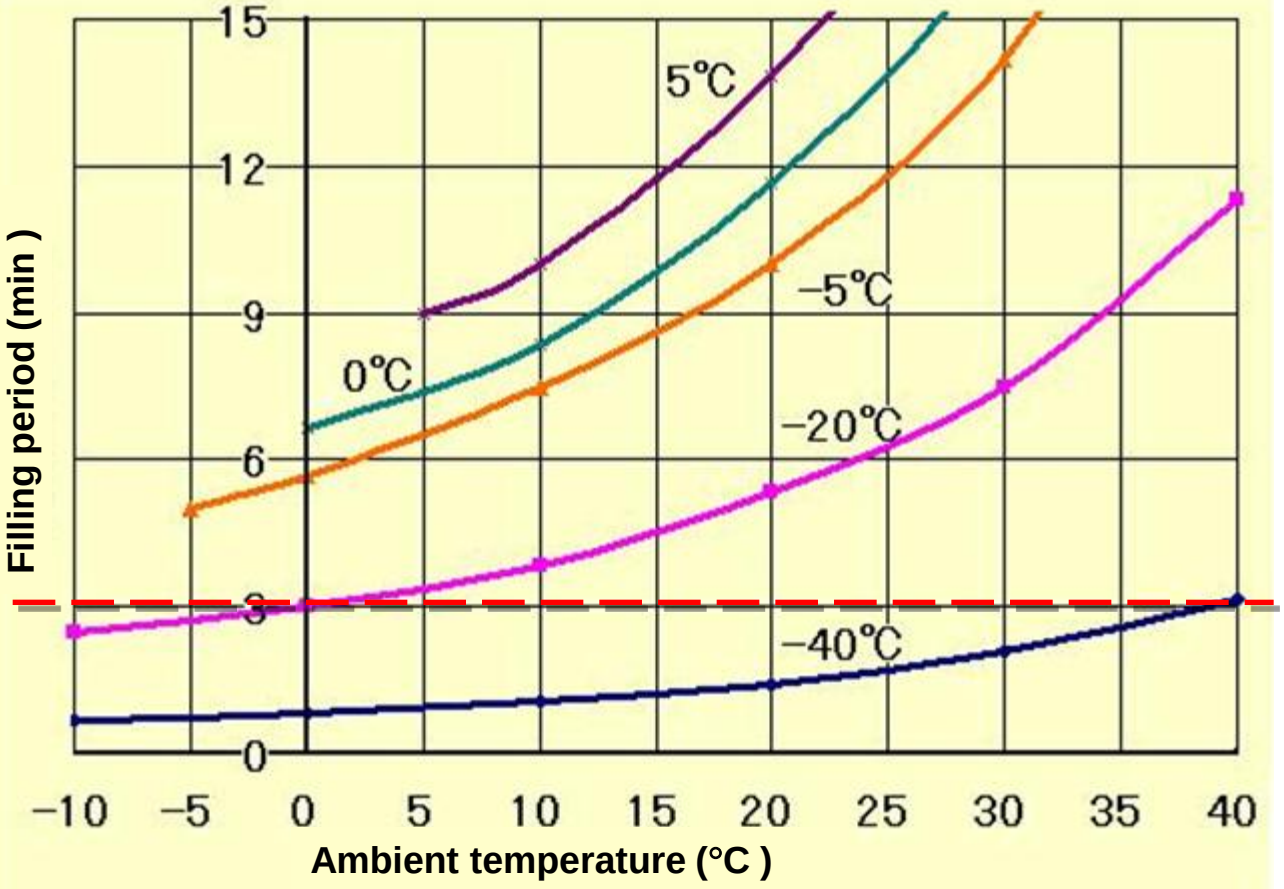
***1: The pre-cooling equipment in Kasumigaseki is a liquid nitrogen cooling system**

Study of Pre-cooling (Simulation Results)

Conclusion: 70MPa/3 minute-refueling requires -40°C specification (capability)
(-20°C pre-cooling cannot refueling in 3 minutes at 0°C or above)

- **Analyzing method:**
  MONDE simulation
- **Study condition**

tank	: Type4
internal volume	: 157 L
end temperature	: 85°C
end pressure	: 70MPa
initial pressure	: 2MPa



Relation between ambient temperature and filling period according to pre-cooling temperature

Results of the Primary Technology Verification (6)

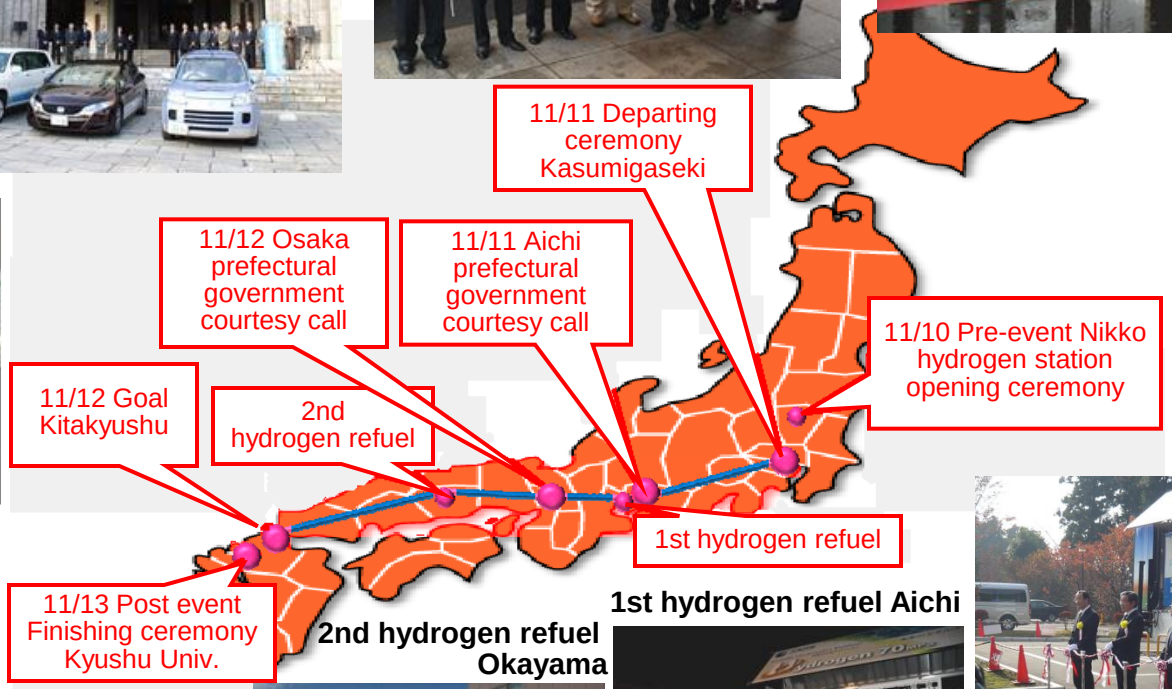
Verification of 2 refuelings in a 1100 km long distance drive

Kasumigaseki

Aichi

Osaka

Kita Kyushu



Nikko

Kyushu Univ.

2nd hydrogen refuel Okayama

1st hydrogen refuel Aichi

Contents

1. The situation surrounding FCVs
   - Energy trends in Japan
   - The trends on FCV hydrogen infrastructure in Japan and abroad
   - Merits and positioning of FCVs
   - Trends in other next generation vehicles
   - Positioning of JHFC with NEDO related projects

2. The progress of JHFC in 2009
   - JHFC activities: up to now, objectives from this point, enhancement of the structure
   - Results achieved with FCV driving performance, hydrogen refueling, fuel economy etc.
   - The research results of primary technologie verifications

3. Summary and intended measures for 2010
   - Summary of 2009
   - Clarification of technical issues to be verified for commencement of FCV hydrogen infrastructure expansion
   - Intended measures for 2010

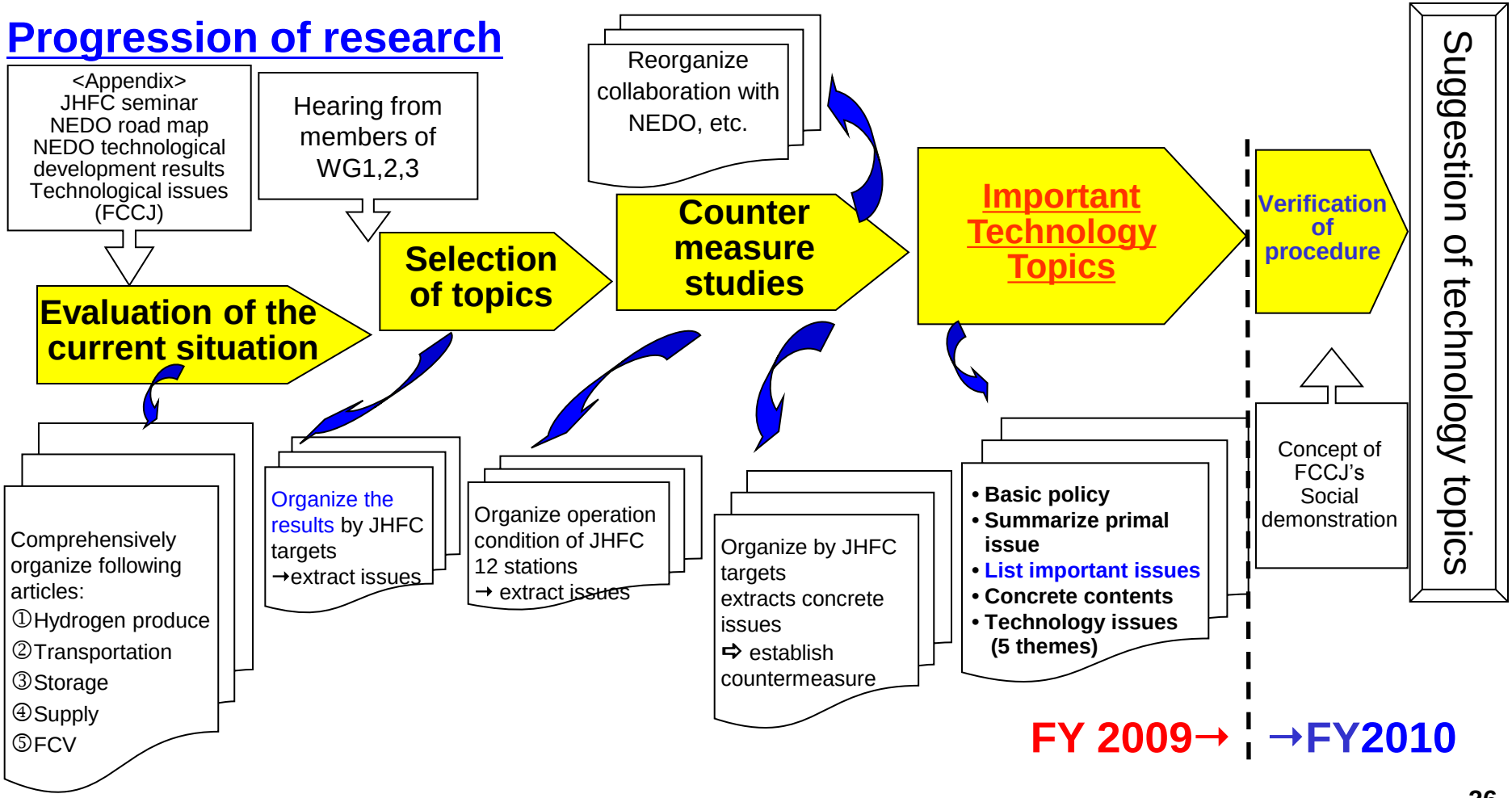
Summary of 2009

- JHFC promotes the valuation of FCV / infrastructure technology towards the scenario “Beginning of the propagation in 2015” on schedule.
- The verification of important topics like “Infrastructure model for commercial use”, “Revision of regulations / laws”, etc. has also been intensively promoted.
- During the advancement of verification of 70MPa vehicles, new topics have been found and the necessity for the development of new technologies as well as their verification has been acknowledged.
- The further improvment with FCV fuel consumption has been shown. Furthermore, with the “1,100 km long range driving” test, the range of gasoline vehicles has been verifiably equaled.
- In Japan, there is a new development in the FCV / hydrogen operation field because of the construction of three cooperating stations and the Research Association of Hydrogen Supply / Utilization Technology.
- In America and Europe, with the introduction of the BEV･PHV stage, a new phase of introductory promotion for hydrogen / fuel cell vehicles can be seen.

Clarification of technical issues to be verified for commencement of FCV hydrogen infrastructure expansion

Objective: Suggestion of technology topics to be verified concerning FCV / hydrogen infrastructure and selection of those with a high priority for tests until 2015.
Summary of the contents and procedure for these topics.

Progression of research



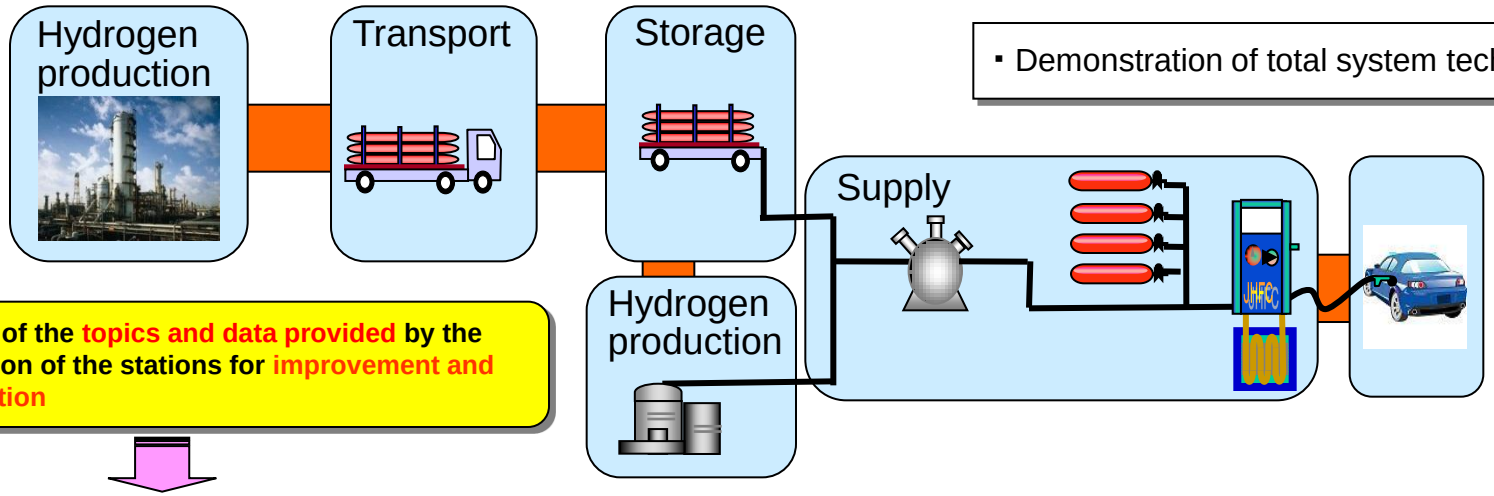
Clarification of technical issues to be verified for commencement of FCV hydrogen infrastructure expansion

[JHFC-2] [Result by FY 2008]

- Verification of FCV's high energy performance (fuel consumption), lesser environmental pollution
- Verification that FCV's low temperature performance equals that of gasoline
- Gathering driving data on public roads, utilization of analysis results for the development of FCV vehicles

- Verification of steady increase in popularity level due to propagation and educational activities

- Demonstration of total system technology



- Application of the topics and data provided by the administration of the stations for improvement and standardization

- Demonstration of high frequency/operation, durability

- Verification of safety, safe supply and practical driving with emphasis on 35MPa vehicles
- Recommencement of technology tests for 70MPa (second half of 2008)

- Specification of energy efficiency, facility costs, transportation costs etc. of different kinds of hydrogen stations

- Demonstration of lower-cost station technology

- Demonstration of “70MPa” technology

- Demonstration of “70MPa Full refueling” technology

Clarification of technical issues to be verified for commencement of FCV hydrogen infrastructure expansion

Summary and results of important technology issues that must be verified by 2015

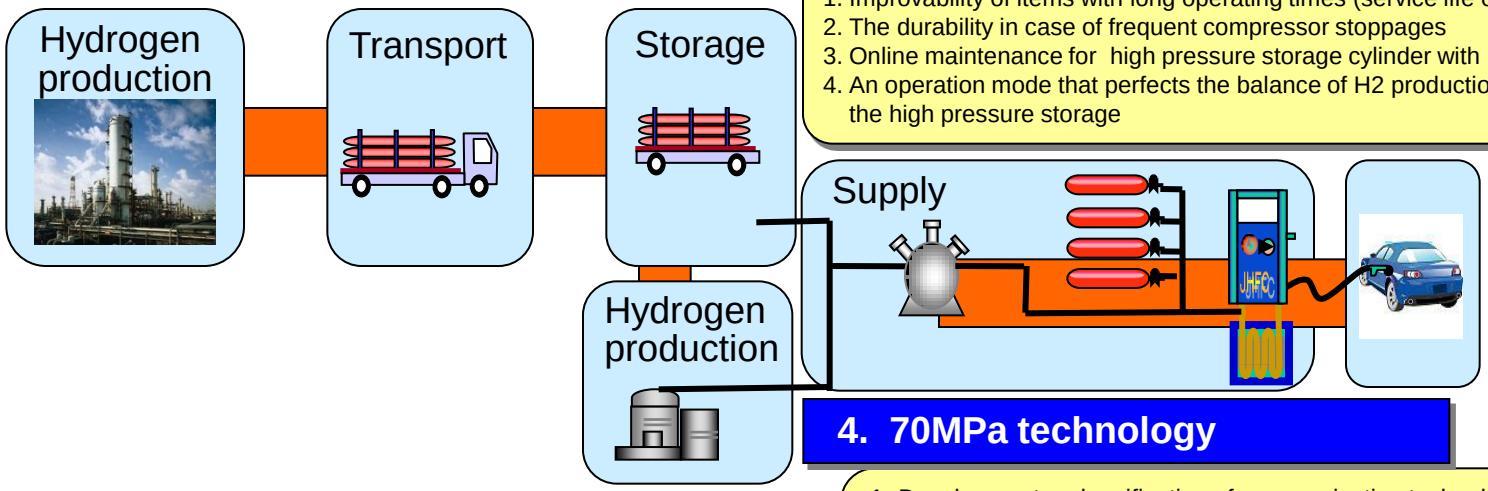
1. Overall system technology

1. Technology for the continuation of refueling or large quantity refueling of vehicles at peak times
2. The station's consequent off site performance with H2 production, transportation, storage, refueling, driving
3. A valid infrastructure model for commercial use for each type

Important technology issues

2. High frequency / operation, durability

1. Improvability of items with long operating times (service life of catalytic converter etc.)
2. The durability in case of frequent compressor stoppages
3. Online maintenance for high pressure storage cylinder with NDT technology
4. An operation mode that perfects the balance of H2 production, supply and volume of the high pressure storage



3. Lower-cost station technology

1. Verification of the cascade (70MPa)
2. Verification of direct compression cascade
3. Cost reduction of the high-pressure storage cylinder (70MPa)
4. Development and verification of compound containers (above 40MPa)
5. Cost reduction of planning, fundamental construction, installation

4. 70MPa technology

1. Development and verification of communication technology
2. Verification of 3 minute refueling
3. Verification of pre-cooling (realisation at -40 °C)
4. Verification of sudden discharge of the coupler, valves or other accessories
5. Revision of regulations

5. 70MPa full refueling technology

1. Development and verification of a steel high-pressure storage cylinder for a 70MPa full refueling
2. Revision of regulations for 70MPa full refueling

Our To Do List for 2010

1. Finalization of the JHFC activities up to now
2. Strategic activities for the promotion of awareness, propagation in Japan and abroad by holding international JHFC seminar, etc.
3. Propagation of necessary technology proofs for communication and direct refueling methods, etc.
4. Explanation of technical issues to be verified, revision of regulations, etc. on the road to commencement of propagation in 2015

- **Reference Materials**

(Documentation Material) JHFC Participating Vehicles

Toyota FCHV-adv

Nissan X-TRAIL FCV

Honda FCX Clarity

Suzuki SX4-FCV

Mercedes Benz
A-Class F-Cell

GM Equinox

Mazda Premacy RE Hybrid

Toyota/Hino FCHV-BUS

(Documentation Material) JHFC Participating Companies

Automaker: 8

TOYOTA

NISSAN

HONDA

Mercedes-Benz

GM

HINO

SUZUKI

mazda

Energy & Infra. Maker: 17

ENEOS

TOKYO GAS

Iwatani

JAPAN AIR GASES

TAIYO NIPPON SANSO
The Gas Professionals

Nippon Steel Corporation

KURITA

SINANEN

ITOCHU ENEX CO.,LTD.

TOHO GAS

OSAKA GAS

KANSAI

JOMO

KURIMOTO, LTD.

1 co-operative corporation

IDEMITSU

9th JHFC International Seminar

Date

Feb 28(Mon.) -Mar 1 (Tue.), 2011

Place

Tokyo International Forum

Hall B7

(Chiyoda-ku, **Tokyo**, near Yuraku-cho)

http://www.jhfc.jp/e/news/event/2010/002/index.html

For more information, visit our website.

http://www.jhfc.jp/e/

THANK YOU!