Overview of Scenario, Roadmap and R&D projects of Hydrogen and FCV in Japan

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New Energy and Industrial Technology Development Organization (NEDO)

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Framework for R&D of Hydrogen and Fuel Cells under METI & NEDO in Japan

Policy planning
Hydrogen and Fuel Cell Promotion Office
METI (Ministry of Economy, Trade and Industry)

R&D program planning, funding and managing
NEDO

R&D Project
Companies, Universities, National Labs etc.
FCCJ: Fuel Cell Commercialization Conference of Japan
FCCJ was established on March 19, 2001 as a conference to study and discuss at a nongovernmental level the commercialization and commercialization of fuel cells. FCCJ’s major activities include making proposals regarding verification tests for fuel cell vehicles, hydrogen infrastructure and stationary fuel cells; identifying technological development issues for fuel cells and creating and proposing roadmaps; discussing fuel cell introduction scenarios and making proposals to the ministries concerned regarding standardization and review of regulations.
FCCJ press release on July 4, 2008

Leading automakers in and outside Japan and Japanese energy companies have agreed on a scenario which sees commercialization of fuel cell vehicles (FCVs) and hydrogen stations beginning in 2015.

They have also identified the challengers facing future energy diversification and post-Kyoto Protocol talks.

Under METI (Ministry of Economy, Trade and Industry), activities for overcoming the challenges are being accelerated through the Japan Hydrogen & Fuel Cell Demonstration Project, through promotion of technology development programs led by NEDO (New Energy and Industrial Technology Development Organization), through investigations into a large scale pilot project, and through other unique initiatives by individual energy automobile companies.
Commercialization of fuel cell vehicles and hydrogen stations to commence in 2015

Major member companies of the FCCJ board
Toyota Motor, Honda Motor, Nissan Motor, General Motors Asia Pacific (Japan), Mercedes-Benz Japan, Nippon Oil, Tokyo Gas, Osaka Gas, Idemitsu Kosan, Cosmo Oil, Japan Energy, Showa Shell Sekiyu

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Commercialization Scenario for FCVs and H₂ Stations

**Phase 1**
Technology Demonstration

- **[JHFC-2]**
- 2010
- • Solving technical issues and promotion of review regulations (Verifying & reviewing development progress as needed)

**Phase 2**
Technology & Market Demonstration

- **[Post JHFC]**
- 2011
- • Verifying utility of FCVs and H₂ stations from socio-economic viewpoint

**Phase 3**
Early Commercialization

- **[Starting Period]**
- 2015
- **[Expansion Period]**
- 2016
- • Expanding production and sales of FCVs while maintaining convenience of FCV users
- • Reducing costs for H₂ stations and hydrogen fuel
- • Continuously conducting technology development and review of regulations

**Phase 4**
Full Commercialization

- **[Profitable business Period]**
- 2025
- 2026
- • Contribute to diversity of energy sources and reduction of CO₂ emissions

**Target commercialization start of FCV to general public**

- **Year 2015**
- Approx. 1,000 H₂ stations*
- Approx. 2 million FCVs*

**Increase numbers of FCV and H₂ stations based on profitable business**

- **Year 2025**
- Increase of FCV numbers through introduction of more vehicle models
- Costs for H₂ station construction and hydrogen reach targets, making the station business viable.
  (FCV 2,000 units/station)

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NEDO’s Mission and Approach

Mission
As Japan’s largest funding agency promoting research and development as well as the diffusion of energy, environmental, and industrial technologies, NEDO has a crucial mission to carry out.

- Addressing energy and global environmental challenges
- Enhancement of industrial competitiveness

Approach
Based on the goals of outcome oriented and user friendly operation, NEDO, a professional research and development management organization, employs a Plan-Do-See (PDS) approach.

- Promotion of R&D through “Selecting and Focusing”
- Flexible and agile project management through rigorous evaluations
## FY2010 Budget for R&Ds of Hydrogen and Fuel Cells managed by NEDO (in million Yen)

<table>
<thead>
<tr>
<th>R&amp;D program</th>
<th>Duration</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R&amp;D program of PEFC</strong></td>
<td>FY2010-FY2014</td>
<td>5,100</td>
</tr>
<tr>
<td><strong>R&amp;D program of hydrogen production, delivery, storage and refueling system</strong></td>
<td>FY2008-FY2012</td>
<td>1,350</td>
</tr>
<tr>
<td><strong>R&amp;D of hydrogen storage material</strong> (HYDROSTAR project, Leader: Dr. Akiba)</td>
<td>FY2007-FY2011</td>
<td>900</td>
</tr>
<tr>
<td><strong>R&amp;D of hydrogen embrittlement and tribology</strong> (HYDROGENIUS project, Leader: Prof. Murakami)</td>
<td>FY2006-FY2012</td>
<td>1,000</td>
</tr>
<tr>
<td><strong>D of FCV and refueling station</strong> (JHFC project, Chair of Steering Comm.: Dr. Ishitani)</td>
<td>FY2006-FY2010</td>
<td>870</td>
</tr>
<tr>
<td><strong>R&amp;D program of SOFC</strong></td>
<td>FY2008-FY2012</td>
<td>800</td>
</tr>
<tr>
<td><strong>D of residential SOFC</strong></td>
<td>FY2007-FY2010</td>
<td>662</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>10,682</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Vehicle size</th>
<th>Driving range (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>0-200</td>
</tr>
<tr>
<td>Small</td>
<td>200-400</td>
</tr>
<tr>
<td></td>
<td>400-600</td>
</tr>
<tr>
<td></td>
<td>600-800</td>
</tr>
<tr>
<td></td>
<td>800-1000</td>
</tr>
</tbody>
</table>

Innovated battery performance

Innovated fuel storage

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Objectives of JHFC Phase 2

1. To clarify remaining issues under the actual using conditions.
2. To collect data to develop regulations, codes and standards.
3. To formulate and implement public relations and educations for dissemination and promotion.
4. To verify the energy savings (fuel economy) and environmental impact.
5. To identify technology and policy trends of FCV’s, fuel cell powered small vehicles and hydrogen ICV’s as well as hydrogen infrastructures.
Features of JHFC Phase 2

Fleet tests by third parties

Increase of hydrogen users (not limited to FCV’s but small FC carriers and hydrogen ICV’s)

Area extension (metropolitan Tokyo, Nagoya and Osaka)

Operation of FC buses and hydrogen station in Centrair Airport region

Operation of FC wheel chairs, FC carts and FC-assisted bicycles and operation of hydrogen stations for them in Osaka region
Important points

- Progress
  8-year operation without serious accidents
  Various outreach activities
  Demonstrating technical advances

- Challenges
  70 MPa infrastructure technologies
  Cost reduction (vehicles and stations)
  Codes and standards
Organizational Framework of JHFC

JHFC consists of demonstrations of FCVs and hydrogen stations financially supported by NEDO & METI. From FY2009 on, PEC and JGA, representing oil industries and city gas industries respectively, have been involved in JHFC.

METI : Ministry of Economy, Trade and Industry
NEDO : New Energy and Industrial Technology Development Organization
PEC : Japan Petroleum Energy Center
JARI : Japan Automotive Research Institute
ENAA : Engineering Advancement Association of Japan
JGA : The Japan Gas Association
Steering of Current JHFC Phase 2

Planning and Promotion Committee

 WG1 : Hydrogen Supply Infrastructure
  Chairperson : Prof. Takeshi Okazaki
  Vice Chairperson : Prof. Masanori Monde

 WG2 : Fuel Cell Vehicle
  Chairperson : Prof. Youichi Hori

 WG3 : Interface Area between Vehicle and Infrastructure
  Chairperson : Prof. Yasuo Takagi
  Vice Chairperson : Prof. Masanori Monde

 WG4 : Promotion of Awareness
  Co-Leader : Mr. Noriaki Osao
  Co-Leader : Mr. Katsumi Yoshida

 WG5 : International Collaboration
  Advisor : Prof. Hisashi Ishitani
  Leader : Dr. Shogo Saegusa

 WG6 : Demonstration in Local Areas
  Leader : Mr. Jin-ichi Tomuro
## JHFC Participating Companies

### Auto manufacturers: 8

<table>
<thead>
<tr>
<th>Toyota</th>
<th>Nissan</th>
<th>Honda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercedes-Benz</td>
<td>GM</td>
<td>Hino</td>
</tr>
<tr>
<td>Suzuki</td>
<td>Mazda</td>
<td></td>
</tr>
</tbody>
</table>

### Energy & Infra. Related companies: 16

<table>
<thead>
<tr>
<th>Eneos</th>
<th>Sinanen</th>
<th>Itochu Enex Co., Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osaka Gas</td>
<td>Kansai</td>
<td>Jomo</td>
</tr>
<tr>
<td>Japan Air Gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIYO NIPPON SANSO The Gas Professionals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nippon Steel Corporation</td>
<td>Kurita</td>
<td></td>
</tr>
</tbody>
</table>

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JHFC Participating Vehicles

6 FCVs, FC Bus and Hydrogen ICV have been participating

- Toyota FCHV-adv
- Nissan X-TRAIL FCV
- Honda FCX Clarity
- Mercedes Benz A-Class F-Cell
- GM HydroGen3
- Suzuki SX4-FCV
- Mazda RX-8 Hydrogen RE
- Toyota/Hino FCHV-BUS

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

![Graph showing fuel consumption results for different modes and types of vehicles.

- **Street** (Local road):
  - Latest demonstrated vehicles: 87.5 km/kg-H2
  - Initial demonstrated vehicles: 59.8 km/kg-H2

- **Street** (Highway):
  - Latest demonstrated vehicles: 131.6 km/kg-H2
  - Initial demonstrated vehicles: 75.3 km/kg-H2

- **Bench** (10 and 15 mode):
  - Latest demonstrated vehicles: 107.1 km/kg-H2
  - Initial demonstrated vehicles: 108.7 km/kg-H2

- **Bench** (JC08 mode):
  - Latest demonstrated vehicles: 118.2 km/kg-H2
  - Initial demonstrated vehicles: 111.7 km/kg-H2

Gasoline equivalent fuel consumption (km/L):

- **Street** (Local road) :
  - Latest demonstrated vehicles: 87.5 km/kg-H2
  - Initial demonstrated vehicles: 59.8 km/kg-H2

- **Street** (Highway) :
  - Latest demonstrated vehicles: 131.6 km/kg-H2
  - Initial demonstrated vehicles: 75.3 km/kg-H2

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## Current cost of Major Components

<table>
<thead>
<tr>
<th></th>
<th>Current cost (million yen)</th>
<th>Parameter(^\text{*) dependence}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reformer</td>
<td>150 – 186</td>
<td>No</td>
</tr>
<tr>
<td>Compressor</td>
<td>50 – 110</td>
<td>Yes (strong)</td>
</tr>
<tr>
<td>High-pressure storage cylinders</td>
<td>39 -</td>
<td>Yes (very strong)</td>
</tr>
<tr>
<td>Dispenser</td>
<td>15 -</td>
<td>Yes (fairly strong)</td>
</tr>
<tr>
<td>Pre-cooler</td>
<td>17 -</td>
<td>Yes (fairly strong)</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>roundly 300 -</strong></td>
<td>Yes</td>
</tr>
</tbody>
</table>

Construction, piping and wiring costs are extra.

\(^{\text{*)}}\) Parameter: filling pressure, filling period, filling method

Results cannot be directly compared with those previously disclosed in the JHFC product.

Further cost reduction is definitely necessary.
## Cost Reduction Feasibility

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reformer</td>
<td>Simplified system, reduction of parts. Target is 50% of current cost.</td>
</tr>
<tr>
<td>Electrolizer</td>
<td>Key components (electrode, separator), power supply, rectifier.</td>
</tr>
<tr>
<td>Compressor</td>
<td>Cylinder type, oil-driven booster, &amp;c.</td>
</tr>
<tr>
<td>High-pressure storage cylinders</td>
<td>Large-scale cylinder, mass production through standardization, cost reduction using material other than steel, number reduction through the combination of cascade and compressor-drive filling.</td>
</tr>
<tr>
<td>Dispenser</td>
<td>Target is 50% of current cost.</td>
</tr>
<tr>
<td>Common (parts &amp; equipments)</td>
<td>Imported parts, similar equipment widely used.</td>
</tr>
<tr>
<td>Others</td>
<td>Layout optimization, cost reduction of general installation at the site.</td>
</tr>
</tbody>
</table>

Investigation to be continued.
Commercialization Scenario for FCVs and H₂ Stations

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**Phase 3**
Early Commercialization
- 2015
- Increasing of FCV numbers through introduction of more vehicle models

**Phase 4**
Full Commercialization
- 2025
- Year 2025: Increase numbers of FCV and H₂ stations based on profitable business
- Year 2026: Costs for H₂ station construction and hydrogen reach targets, making the station business viable. (FCV 2,000 units/station)

- Determine specifications of commercial type H₂ stations
- Begin building commercial type H₂ stations
- Period in which preceded H₂ station building is necessary

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* Precondition: Benefit for FCV users (price/convenience etc.) are secured, and FCVs are widely and smoothly deployed
### FCV

<table>
<thead>
<tr>
<th>year</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>vehicle efficiency % (HHV / LHV)</td>
<td>45 / 55</td>
<td>51 / 60</td>
<td>51 / 60</td>
<td>more than 51 / 60</td>
</tr>
<tr>
<td>durability (hour)</td>
<td>2,000</td>
<td>5,000</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>FC system cost (million. Yen)</td>
<td>more than 10</td>
<td>1</td>
<td>0.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Cost estimated on the assumption that annual production of FCV is 0.5 million.

### Hydrogen Station

<table>
<thead>
<tr>
<th>year</th>
<th>2010</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>station cost (M yen) (300 Nm³/h)</td>
<td>1,000 (70MPa)</td>
<td>400 (70MPa)</td>
<td>200-300</td>
<td>150</td>
</tr>
<tr>
<td>hydrogen cost (yen/Nm³)</td>
<td>120</td>
<td>90</td>
<td>70</td>
<td>60</td>
</tr>
</tbody>
</table>