Fuel Cell Technologies in the Japanese National Innovation System

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Outline

1. Motivations for Fuel Cells
2. Main Actors for FC R&D
3. "Roadmap" for PEFCs
4. R&D Funding Programs
5. Conclusion

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Motivations for FCs

- Energy policy aspects:
  - Energy security
    - Due to scarcity of natural resources, technology-intensive energy supply systems are needed.
    - First choice: Nuclear.
    - Among technologies including IGCC and renewables, fuel cell is moving up the notches to the second.
  - Environmental issues
    - Regional environmental issues such as acid rain (SOx, NOx), water pollution, etc. are not important so much in Japan. They have been resolved in 1970s.
    - The global environmental issue, that is "climate change," attracts the attention. – How to attain the target given by the Kyoto protocol.

Motivations for FCs (Cont'd)

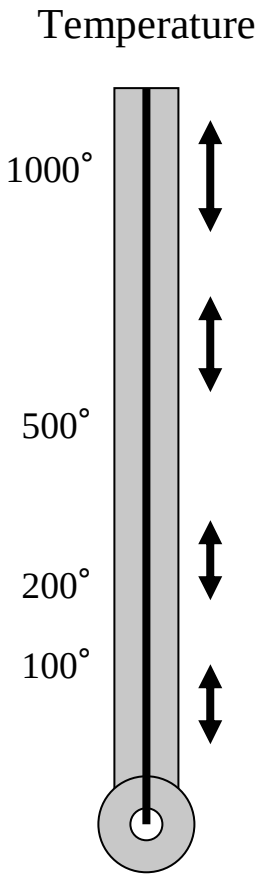
- Industrial policy aspects:
  - Industrial policy target is to seek competitive positions in the global economy.
    - Science & technology is a source of nation's competitive advantage.
  - Governmental entities want to take initiatives for R&D within the country.
    - Governmental entities are competing for leading positions vis-à-vis industries.
    - METI (formerly, MITI) has been in the leading position, even after the complete restructuring of ministries in January 2001.
    - Within METI, bureaus, agencies, research institutions, and affiliates are competing each other.

Advantages of Fuel Cells

Fuel cell technology:

1. facilitates energy conservation / improves efficiency,
   - Efficiency: about 48% (FCVs), over 80% with heat use (Stationary FC)
2. diversifies primary energy sources,
   - Hydrogen can be made from not only petroleum and natural gas but also any renewables.
3. helps build flexible energy systems,
   - FCs are small, on-site generation and storage devices.
4. reduces impacts on the environment.
   - Less CO2; No SOx, NOx.
5. A new technology can create new industries and jobs, and contribute to national competitive advantages.

Types of FCs



Types	Typical Size / Efficiency	Typical Usage	R&D Phase
Solid Oxide Fuel Cell (SOFC)	kW ~ 10MW 47~59%	Commercial use, industrial use, and power utilities.	Basic research
Melton Carbonate Fuel Cell (MCFC)	kW ~ 100MW 41~54%	Industrial use and power utilities.	Basic research
Phosphoric Acid Fuel Cell (PAFC)	kW ~ MW 35~42%	Commercial use and industrial use.	Market penetration
Polymer Electrolyte Fuel Cell (PEFC)	kW ~ 250kW 30~40%	Automobile, residential use, commercial use, and portable batteries.	Practical use and commercialization

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Main Actors for FC R&D

- Government
  - Ministry of Economy, Trade and Industry (METI. formerly known as MITI)
  - The Agency of Natural Resources and Energy (ANRE), part of METI
  - Ministry of Land, Infrastructure and Transport (MLIT)
- Semi-governmental organization
  - New Energy and Industrial Technology Development Organization (NEDO), an affiliate of METI
- Public Research Institutions
  - National Institute of Advanced Industrial Science and Technology (AIST), part of METI. Formerly, The Agency of Industrial Science and Technology.
- Private Firms
  - Firms in a consortium called the Fuel Cell Commercialization Conference of Japan (FCCJ)

METI's Initiatives

- Basic research activities directed by METI
  - 1981: The "Moonlight Plan" engaged in:
    - PAFC: Performance tests (200kW and 1000kW)
    - MCFC: Development of prototype-plants (1000kW)
    - SOFC: Basic research (2~3kW)
    - The main achievement: Developed PAFCs with the practical size of 200kW.
  - 1992: The "New Sunshine Plan"
    - succeeds the Moonlight Plan.
    - starts R&D efforts on PEFC.

METI's Initiatives (Cont'd)

- R&D for practical use of PEFCs
  - R&D activities (mainly, R&D funding programs) have been centered around PEFC in a past few years.
  - Why?
    - In 2001, two reports are submitted to the Director General of The Agency of Natural Resources and Energy of METI.
      - The first report: "Study Group Report on Commercialization of Fuel Cell Technology." (January 2001)
      - The second report: "PEFC & Hydrogen Energy Technology Development Strategy." (August 2001)
    - They suggested that emphasis be made upon PEFC.

Networking

- The Agency of Natural Resources and Energy (ANRE) of METI created a private committee to advise the Director General on fuel cell commercialization strategies in December 1999.
  - The private committee to the Director General of ANRE is called "Policy Study Group for Fuel Cell Commercialization."
  - The committee is not based on legislation of the Diet, but on administrative decision of the Director General, thus is called "private."
  - However, the committee's recommendations, which appear in two reports in 2001, are expected to reflect official perspectives of ANRE.

The Advisory Committee

- The committee consists of 28 representatives from academia, industries, and public institutions.
  - University professors: 9
  - Automobile manufacturers: 4
  - Petroleum suppliers: 3
  - Electric utilities: 3
  - Electronics manufacturers: 3
  - Gas utilities: 2
  - Raw material products manufacturers: 1
  - National research institutes: 1
  - New Energy and Industrial Technology Development Organization (NEDO) : 1
  - Journalists: 1

Committee's Recommendations

- Two reports to the Director General in 2001
  - analyzed technical and regulatory hurdles against commercialization of PEFCs,
  - estimated timeframes to market penetration as well as R&D activities required, and
  - offered a “roadmap” and technology policy targets.
- METI's policy toward FC R&D afterward basically follows these recommendations.
- The first report also motivated the creation of a non-profit organization; a consortium of 134 firms in the country.

Non-Profit Consortium

- The Fuel Cell Commercialization Conference of Japan (FCCJ), March 2001.
  - consists of 134 member firms and individuals,
  - chaired by Chairman and CEO of Toshiba Corporation, one of Japanese leading electronics manufacturers.
  - The purpose and objectives:
    - to focus upon strategic issues regarding the commercialization and widespread use of fuel cells,
    - to facilitate opportunities for member firms to discuss these issues, and
    - to influence governmental policies.
  - published a report to make recommendations to the government in July 2001.

Consortium Members

- Chairman from Toshiba corporation
- 4 Vice Chairs from
  - Petroleum supplier (Japan Petroleum)
  - Gas utility (Tokyo Gas)
  - Automobile manufacturer (Toyota Motors)
  - Consumer electronics (Matsushita)
- Member organizations:
  - Board members: 23 firms
  - General members: 61 firms
  - Associate members: 39 firms
  - Advisory members: 12 industry associations and 2 individuals

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"Roadmap" for PEFCs

- They share information and "Roadmap" for the commercialization of PEFCs.
  - Policy makers
    - METI
    - The Agency of Natural Resources and Energy (ANRE) of METI
  - Academia
    - Universities
    - National and public research institutions (inc. NEDO)
  - Industries
    - Member firms in the Advisory Committee
    - Member firms in the consortium (FCCJ)

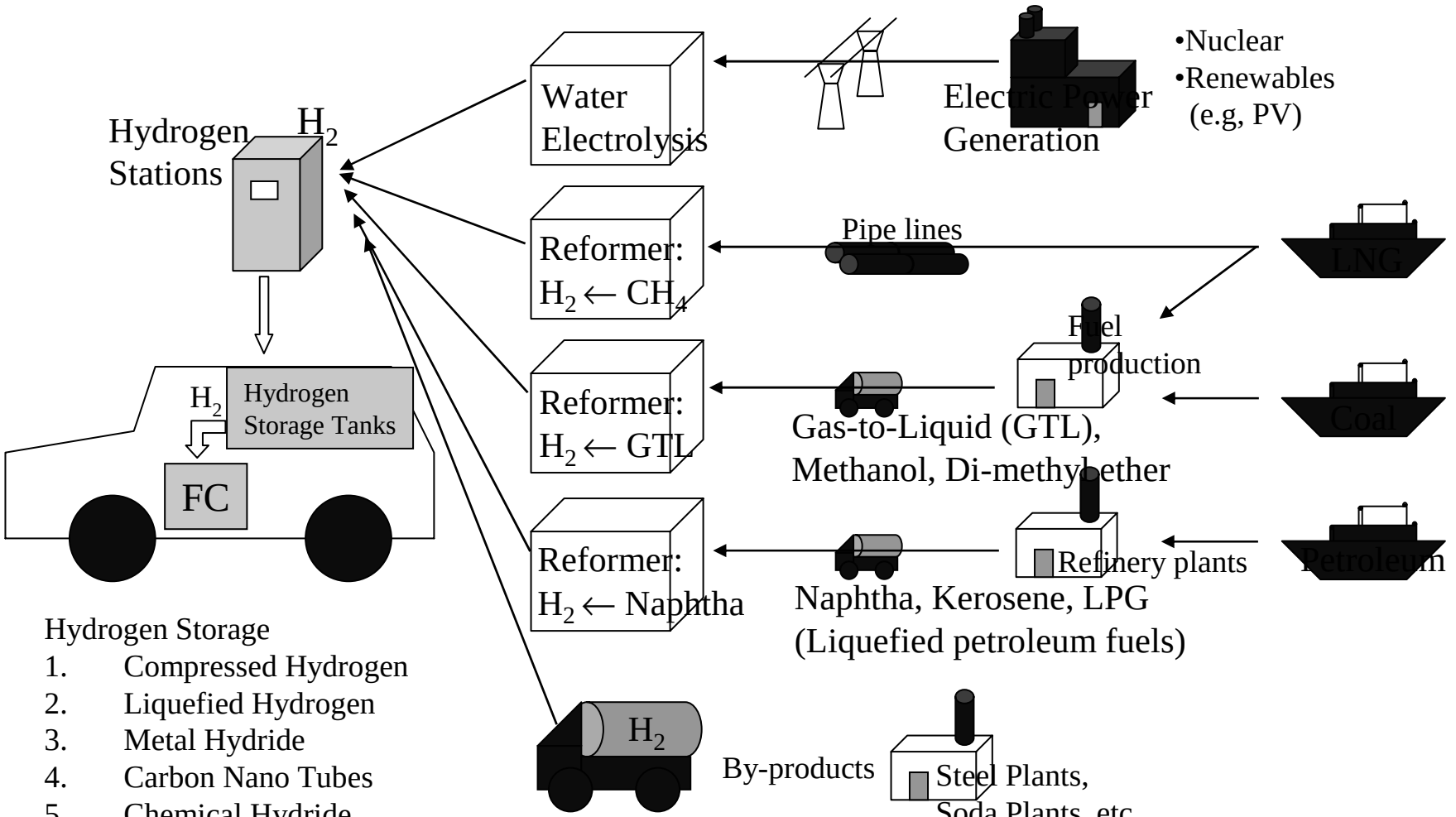
"Roadmap" for PEFCs (Cont'd)

- Phase I (2000~2005): start-up
  - creating and implementing a consistent FC R&D strategy,
  - demonstrating prototype devices, and
    - not only testing technological aspects, but also
    - inquiring social acceptance.
  - identifying fuel quality requirements.
- Phase II (2005~2010): market penetration
  - starting efforts for market penetration, and
  - starting building fuel supply infrastructure for FCVs.
  - Target: 50,000 FCVs in Japan; 2.1GW generated by stationary FCs.
- Phase III (after 2010): diffusion
  - expanding supply infrastructure for the widespread use of FCVs, and
  - expecting markets to grow by itself.
  - Target: 5 million FCVs in Japan; 10GW generated by stationary FCs.

Infrastructure for FCVs

- Widespread use of fuel cell vehicles (FCVs) will be impossible if not for fuel supply infrastructure.
- FCV R&D and the development of fuel supply systems must go together.
- Two types of fuel supply systems have been considered:
    - The choice might be much more important than the development of individual vehicles.
  - Hydrogen Loading Type
  - Fuel Loading Type

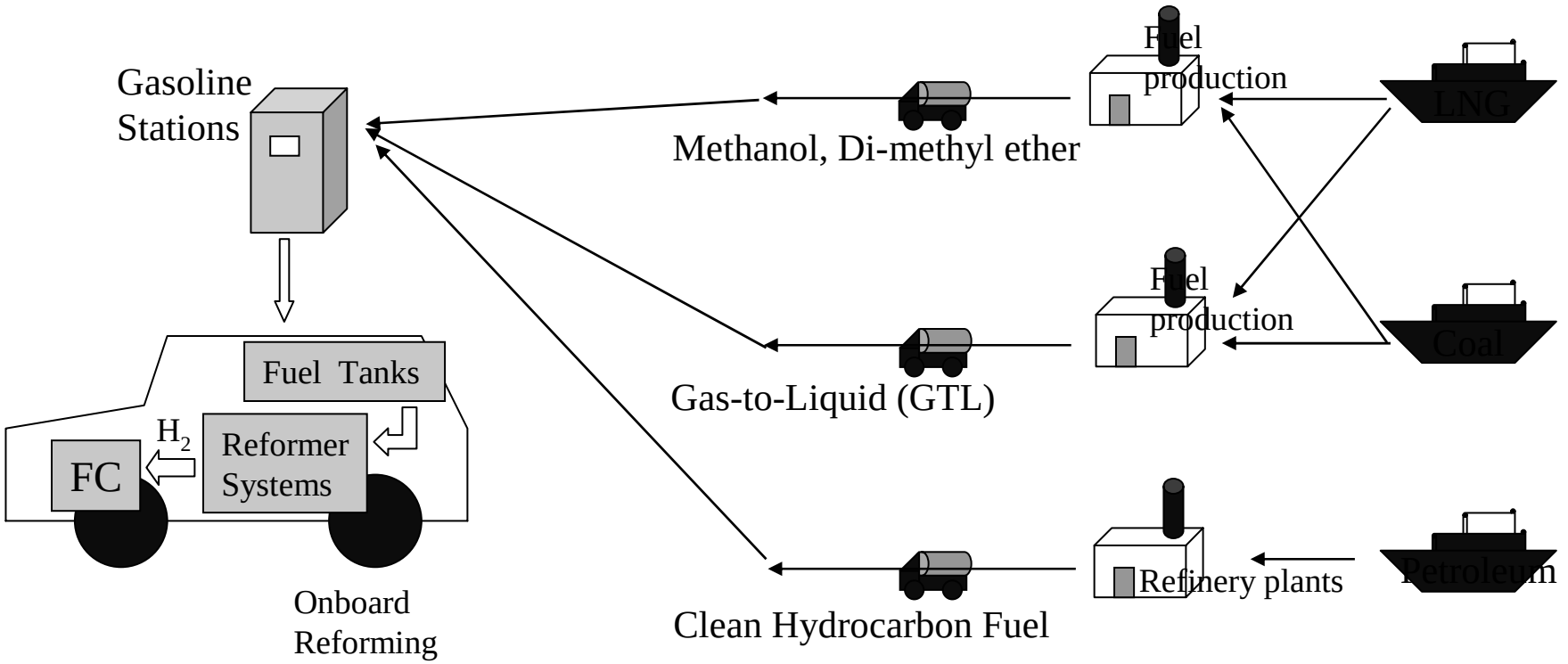
Hydrogen Loading Type



Hydrogen Storage

1. Compressed Hydrogen
2. Liquefied Hydrogen
3. Metal Hydride
4. Carbon Nano Tubes
5. Chemical Hydride

Fuel Loading Type



Key Technologies for FCVs

- Components of FC, common to both vehicles and stationary FCs:
  - Membrane, electrode, catalyst, and separator.
- Reforming technology, esp. suitable to FCV-onboard reforming:
  - efficient reforming of liquid hydrocarbon fuels such as clean gasoline and gas-to-liquid (GTL)
- GTL production technology:
  - Producing GTL from natural gas contributes to substitution of petroleum.
- Hydrogen storage for hydrogen supply systems:
  - Not only storage, transportation is also a key factor.

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R&D Funding Programs (1)

- Basic Research for PEFC
  - The Agency of Industrial Science and Technology and NEDO:
    - R&D on High Efficiency Energy System Technologies for Transportation and Commercial Sectors (one of projects in the New Sunshine Plan)
      - Terms: FY1992-2000
      - Budget: 440 million US$ (New Sunshine Plan total, FY2000).
  - METI (formerly, MITI) and NEDO:
    - "International Clean Energy System Technology Utilizing Hydrogen" Project; known as "World Energy Network Project" (WE-NET Project)
      - Terms: WE-NET Phase II (FY1999-2003)
      - Budget: 14 million US$ (FY2000); 23 million US$ (FY2001)
      - Main organizations that conduct the projects include: the Engineering Advancement Association of Japan, etc.

(1US$=120yen)

R&D Funding Programs (2)

- Commercialization of PEFC
  - METI (formerly, MITI) and NEDO:
    1. Development and Demonstration of Platform Technology for Commercialization of Fuel Cell
       - Terms: FY1999
       - Budget: (NA)
    2. Development of Technologies for the Commercialization of Highly Efficient Fuel Cell Systems
       - Terms: FY2000-FY2001
       - Budget: 14 million US$ in FY2001
    3. Ground Work Project for Diffusion of Fuel Cells, part of a national S&T project called the "Millennium Project."
       - Terms: FY2000- FY2001
       - Budget: 11 million US$ (FY2000)
       - Main organizations that conduct the projects include: Japan Automobile Research Institute (JARI), Japan Gas Association (JGA), etc.

R&D Funding Programs (3)

- Commercialization of PEFC
  - METI (formerly, MITI) and NEDO:
    4. Research and Development of PEFC Technologies
       - Terms: FY2002-FY2004 (scheduled)
       - Budget: 26 million US$ (FY2001)
       - Main organizations that conduct the projects include: the Japan Automobile Research Institute (JARI), the Japan Gas Association (JGA), etc.
  - Ministry of Land, Infrastructure and Transport (MLIT) :
    - "Low-emission car for next generation" development and promotion project
      - Terms: FY2002-FY2003
      - Budget: 13 million US$

R&D Funding Programs (4)

- Commercialization of PEFC
  - The Agency of Natural Resources and Energy (ANRE):
    - Fuel Cell Demonstration Test Program
      - Terms: FY2002-FY2004 (scheduled)
      - Budget: 21 million US$ in FY 2002

      The program comprises of two projects:
      - Project on fuel cell vehicles (FCVs) and hydrogen supply stations, and
      - Project on stationary fuel cells and co-generation systems.

      Main organizations that conduct the projects include:
      - FCVs and hydrogen: Japan Electric Vehicle Association (JEVA) and Engineering Advancement Association of Japan (ENAA)
      - Co-generation: New Energy Foundation (NEF).

Fuel Cell Demonstration Test Program: Details (1)

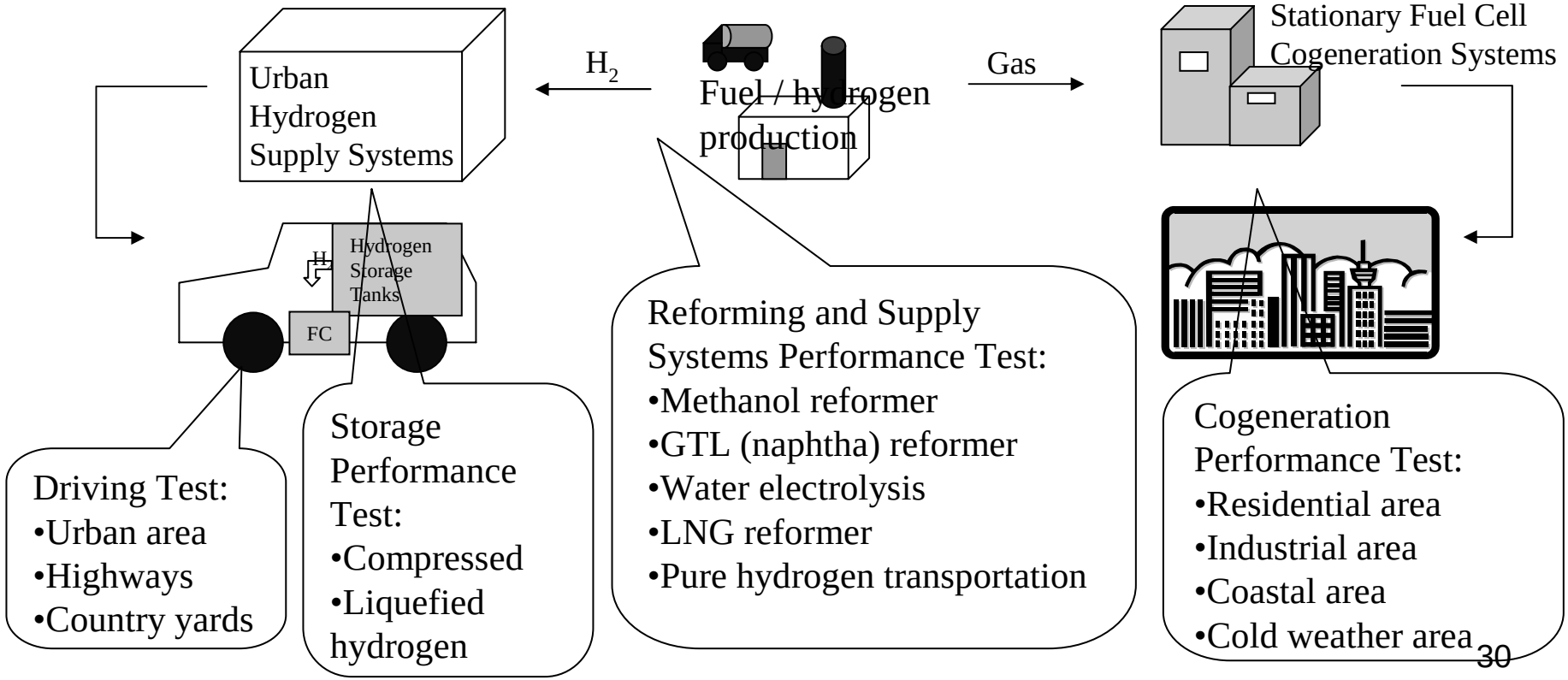
- Objectives:

  Aiming at the establishment of public acceptance vis-à-vis FC and hydrogen systems, gather data and information regarding:
  - Key obstacles against R&D
  - Emissions
  - Energy efficiency (Life cycle assessment: wells to wheel)
  - Necessary fuel quality
  - Public safety

Fuel Cell Demonstration Test Program: Details (2)

Project on FCVs and hydrogen supply stations

Project on stationary fuel cells



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- Fuel cell is gaining much attention due to increasing concern on the environment in these days.
- The recent development of the technology can make significant changes in both the automobile industry and the energy industry in near future.
- One of the main obstacles against widespread use of FCs will be the lack of fuel supply infrastructure including either hydrocarbon- or hydrogen-production and transportation.
- Government's initiatives as well as networking among policy makers, academia, and industries are expected to play an important role in getting rid of such obstacles.
- Currently, they share information and future perspectives.