# Reliable Hydrogen Technologies:
## Challenges in the Kyushu University Hydrogen Project

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**[3]AIST, Research Center for Hydrogen Industrial Use and Storage**

# *Background (Global warming)*

## KYOTO PROTOCOL (Entry into force: Feb. 16, 2005)

***Each country's emissions target must be achieved by the period 2008 - 2012. It will be calculated as an average over the five years. "Demonstrable progress" must be made by 2005. Cuts in the three most important gases – carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$) – will be measured against a base year of 1990. ·····***

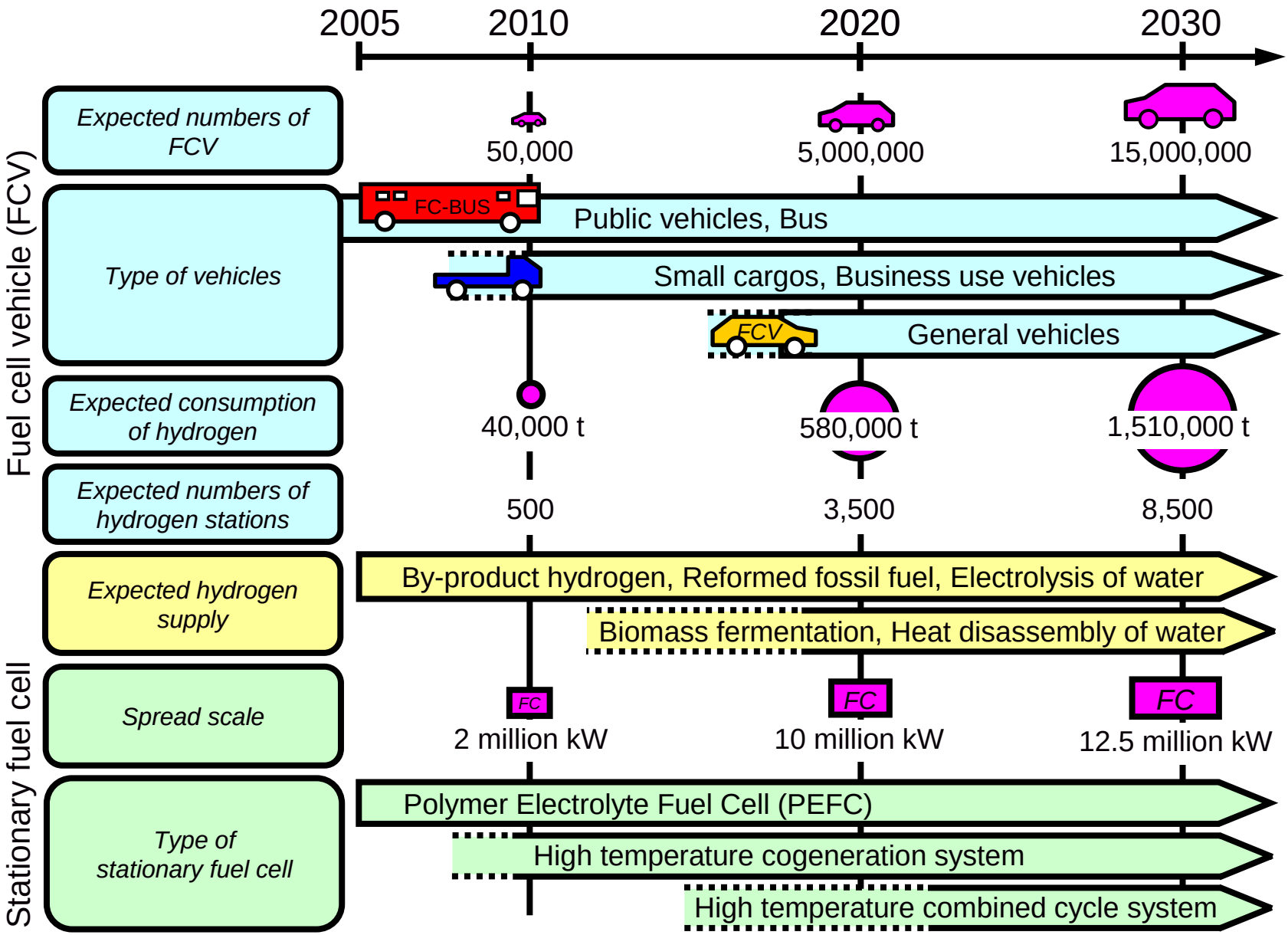
**The 3rd Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (Dec. 1-10, 1997)**

**Reduction target of green house gases**

| Japan | US | EU | Canada | Russia | ····· |
|---|---|---|---|---|---|
| 6% | 7% | 8% | 6% | 0% | |

**Withdrew in 2001**

# *Image of the Hydrogen Society Proposed by Japanese Government for Fuel Cell Commercialization*



# Fuel cell cars developed in Japan
## (December 2, 2002 by Toyota, Honda)



(Homepage of Prime Minister`s Office)

# Issues remained to realize hydrogen energy society

## 1. Hydrogen-related technologies

(1) Hydrogen production

(2) Hydrogen distribution

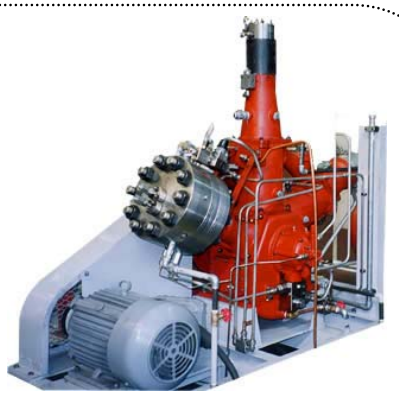
(3) Hydrogen storage

(4) Hydrogen utilization (including fuel cell technologies)

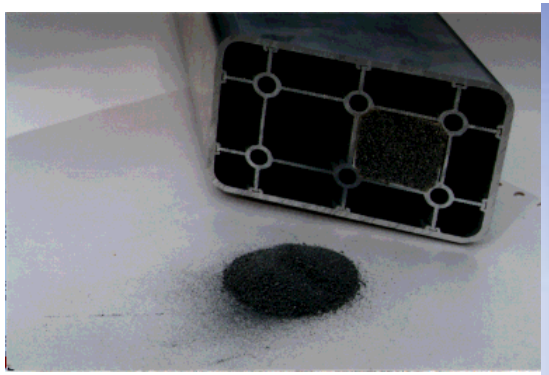
## 2. Hydrogen infrastructure

## 3. Public acceptance

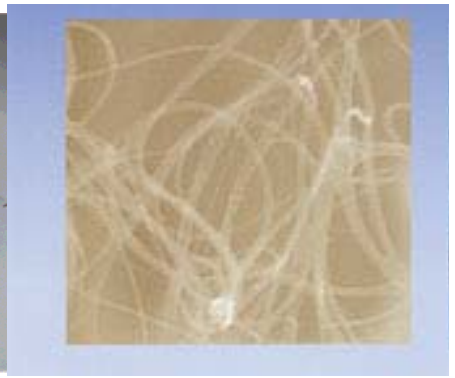
Hydrogen container



Hydrogen compressor



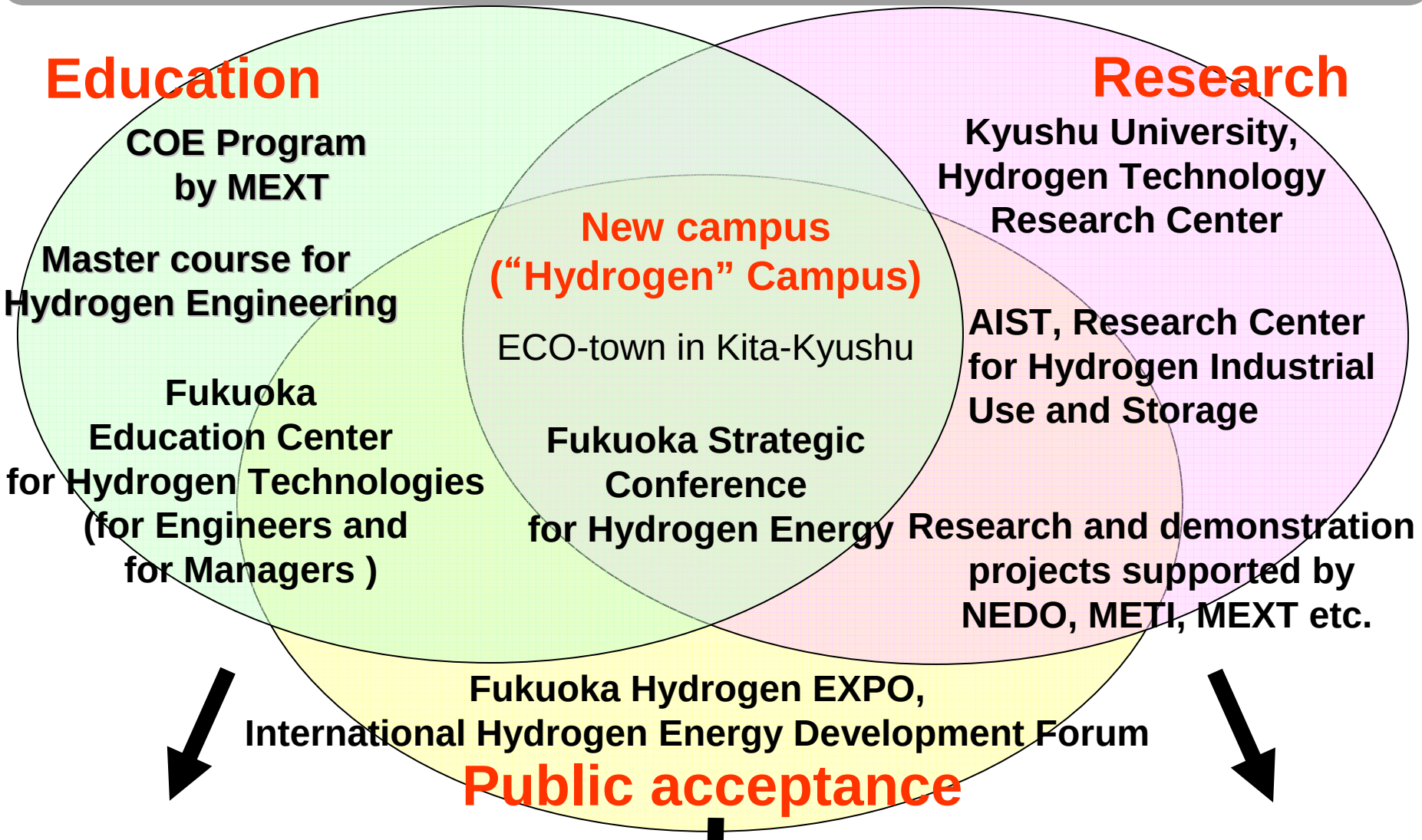
Hydrogen storage



Carbon nanotube

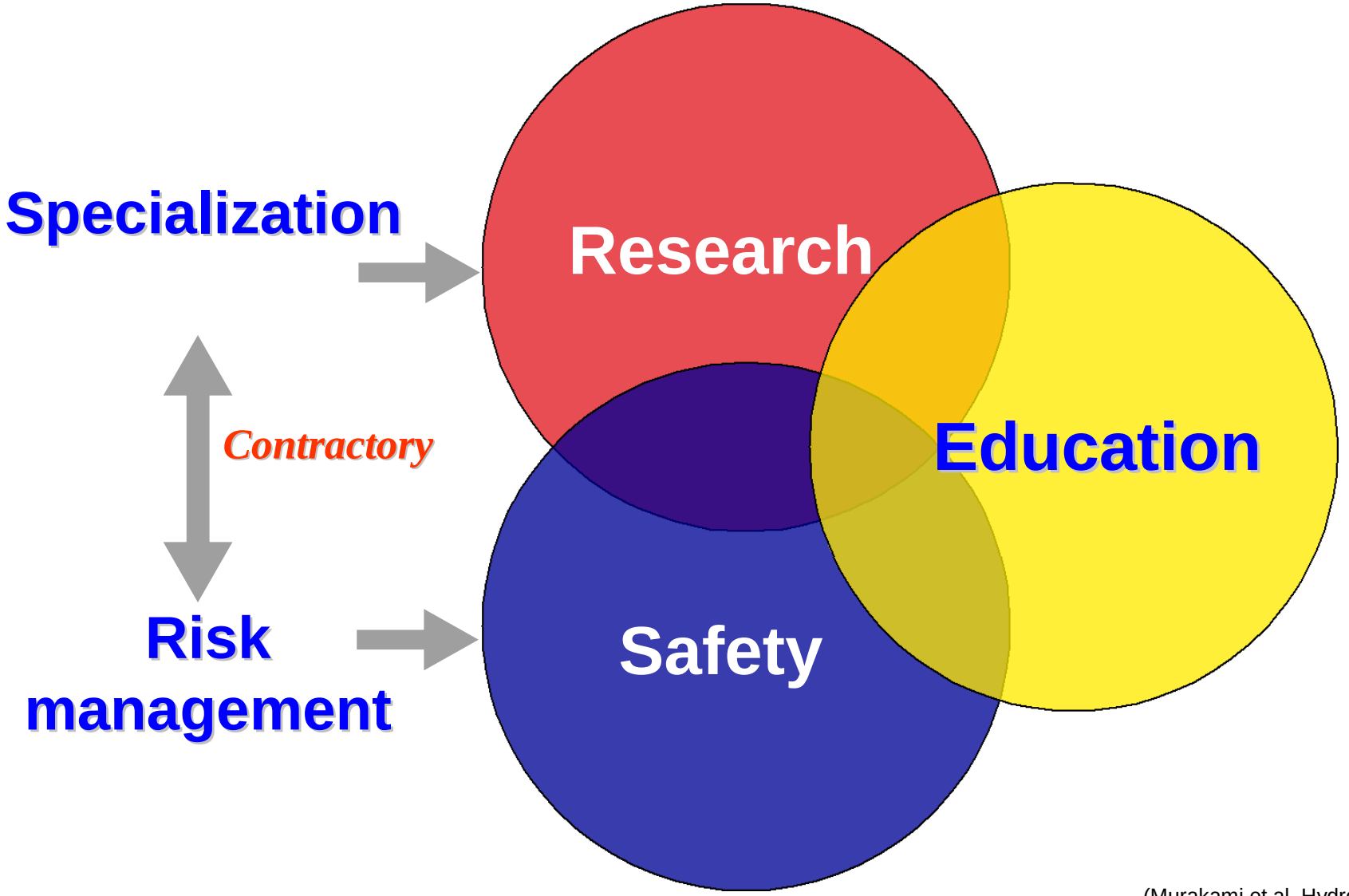
# Fukuoka Hydrogen Project:

**For establishing Center-of-Excellence on hydrogen-related science and technologies**



# Education on Hydrogen-related Technologies

Accidents in large-scale systems ⟷ Specialization of each engineering fields




(Murakami et al. Hydrogen-COE)

# Ph.D course in Hydrogen-COE in Kyushu University

- Ph. D Thesis in each specialized research field
- Internship
- Lectures on integration technologies
- Management of own research project

→ Ph.Ds with broad overview on energy systems

COE Program for Ph.D candidates (students)

| | Lectures / practices | Unit |
|---|---|---|
| **Obligation** | Integration technologies | 2 |
| **Obligation** | Internship in private companies | 2 |
| **Option** | Seminar on integration technologies | 2 |
| **Option** | International internship | 2 |
| **Option** | Specialized lecture on integration technologies | 2 |

# Contributing Core Members of 21-COE Program

## Program Leader

| Name | Faculty | Major |
|---|---|---|
| Prof. Y. Murakami | Vice president | Materials Fatigue |

## Hydrogen Safety

| Name | Faculty | Major |
|---|---|---|
| Prof. A. Sueoka | Engineering | Dynamics of Machinery |
| Prof. A. Furukawa | Engineering | Fluids Engineering |
| Prof. S. Takagi | Engineering | Structural Materials |
| Prof. Y. Kondo | Engineering | Strength of Materials |
| Ass. Prof. M. Inoue | Engineering | Safety |
| Prof. H. Noguchi | Engineering | Strength of Materials |
| Prof. J. Sugimura | Engineering | Tribology |
| Prof. S. Kijimoto | Engineering | Dynamics of Machinery |

## Simulation

| Name | Faculty | Major |
|---|---|---|
| Prof. H. Kanayama | Engineering | Computational Mechanics |
| Prof. M. Yamamoto | Engineering | Robot Engineering |
| Ass. Prof. N. Okada | Engineering | Mathematics |

## Hydrogen Utilization Technology

| Name | Faculty | Major |
|---|---|---|
| Prof. T. Konomi | Engineering | Fuel Cell Systems |
| Prof. H. Mori | Engineering | Thermal Engineering |
| Prof. T. Kitagawa | Engineering | Combustion Engineering |
| Prof. K. Sasaki | Engineering | Fuel Cell Materials |
| Ass. Prof. K. Itoh | Engineering | Thermal Engineering |

## Hydrogen Production & Supply

| Name | Faculty | Major |
|---|---|---|
| Prof. H. Onikura | Engineering | Manufacturing |
| Prof. Y. Ohya | Applied Mechanics | Fluids Engineering |
| Prof. Y. Takata | Engineering | Thermal Engineering |
| Prof. M. Furukawa | Engineering | Fluids Engineering |
| Prof. H. Kitakawa | Science | Inorganic Chemistry |

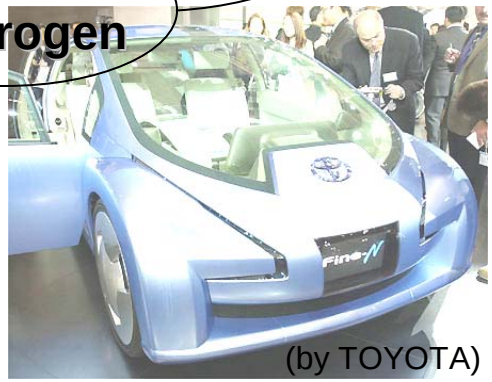
# NEDO project for Reliable Hydrogen Systems (FY2006-2012)

**(Project leader: Prof. Y. Murakami, Sub-leader: Prof. K. Sasaki)**

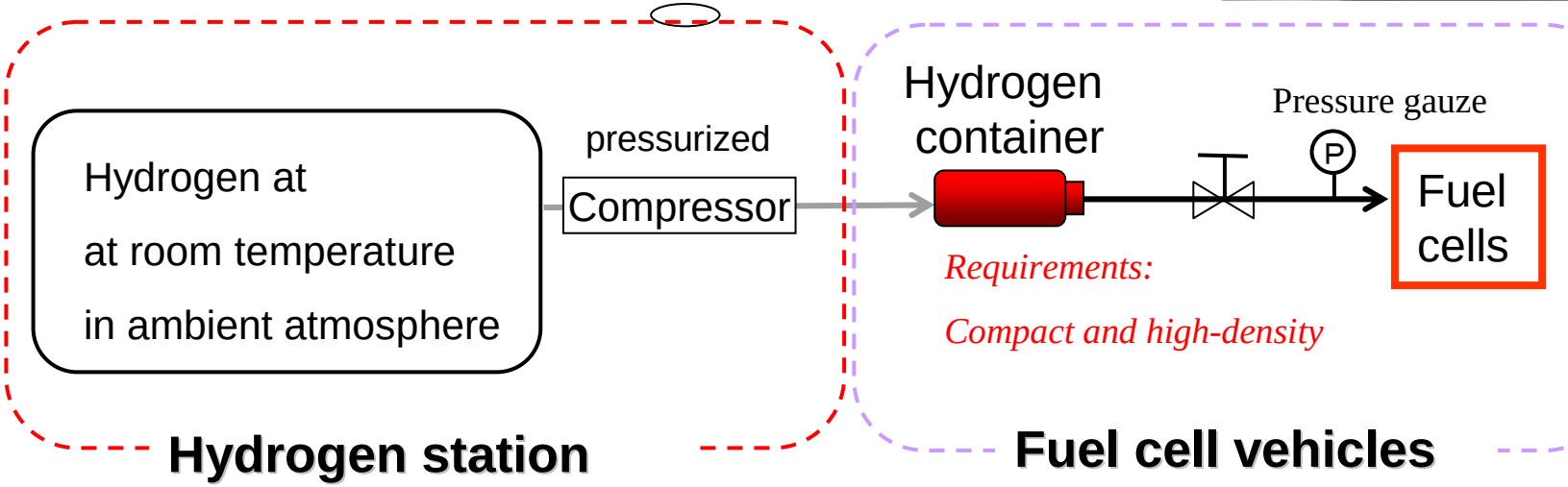
***Many issues are still remained unknown:***

- **Strength and fatigue of mechanical materials in hydrogen systems**
- **Tribology in hydrogen atmosphere**
- **Thermophys. properties of hydrogen**
- **Simulation techniques**

(in ITO-Campus)

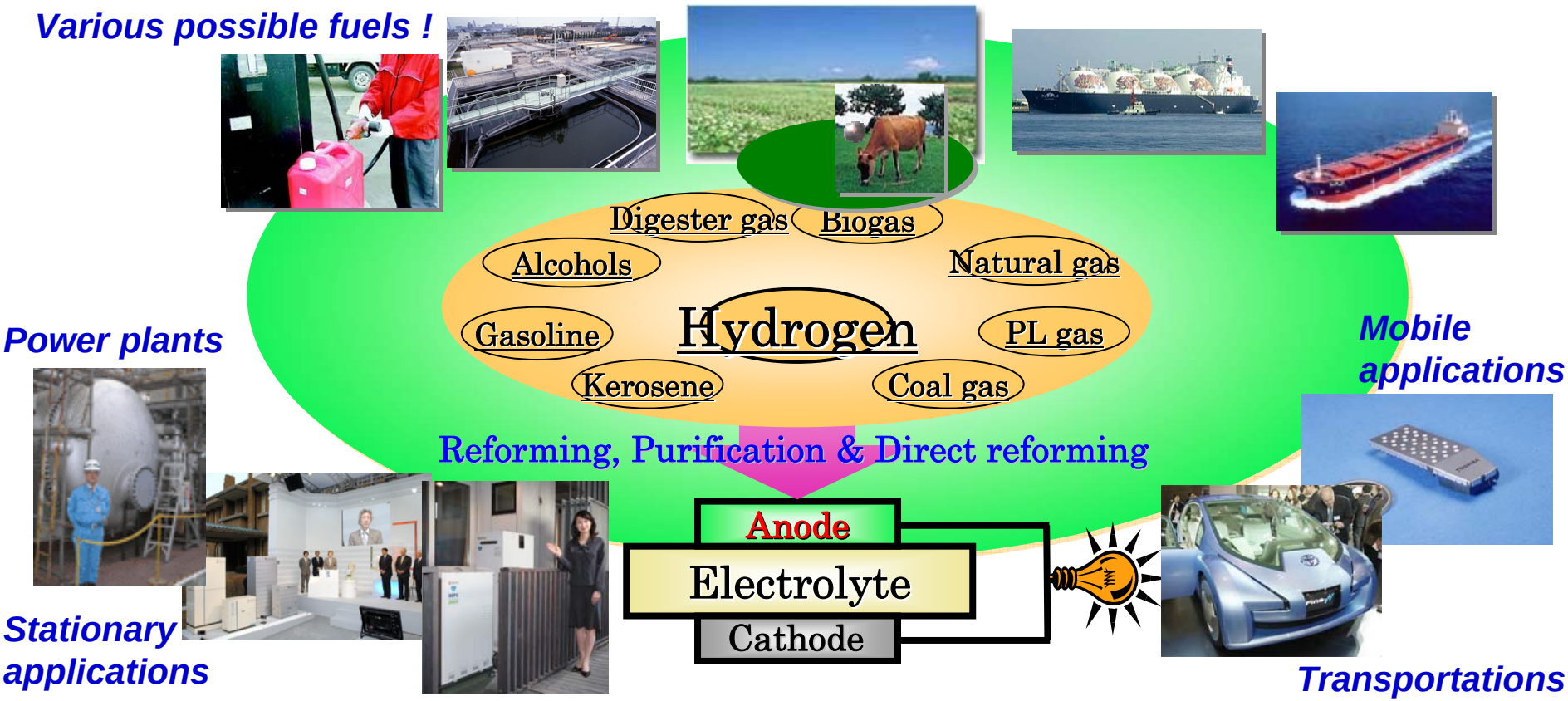


(by TOYOTA)




**Total budget: ca. 100 million$**

# Energy systems based on fuel cell technologies




**Features of SOFCs** (compared to other types of fuel cells)

**Multi-fuel capability**

⇒ Various major & *minor* species will be supplied to SOFCs

**Higher operational temperature**

⇒ Volatile species can be supplied from system components

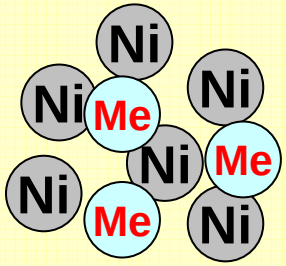
*Chemical degradation must be understood ! (=>NEDO project)*

# Alternative reliable anode materials

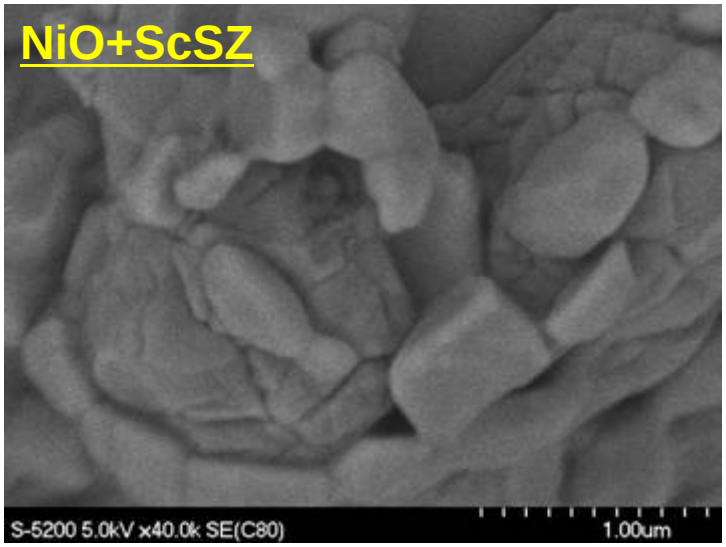
In oxidizing atmosphere

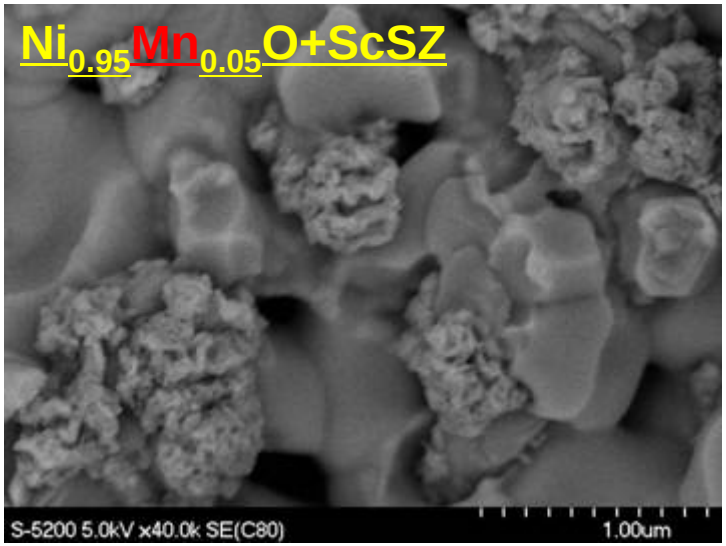
In reducing atmosphere

NiMeOx




*Pinning effect to keep larger electrode reaction area !*

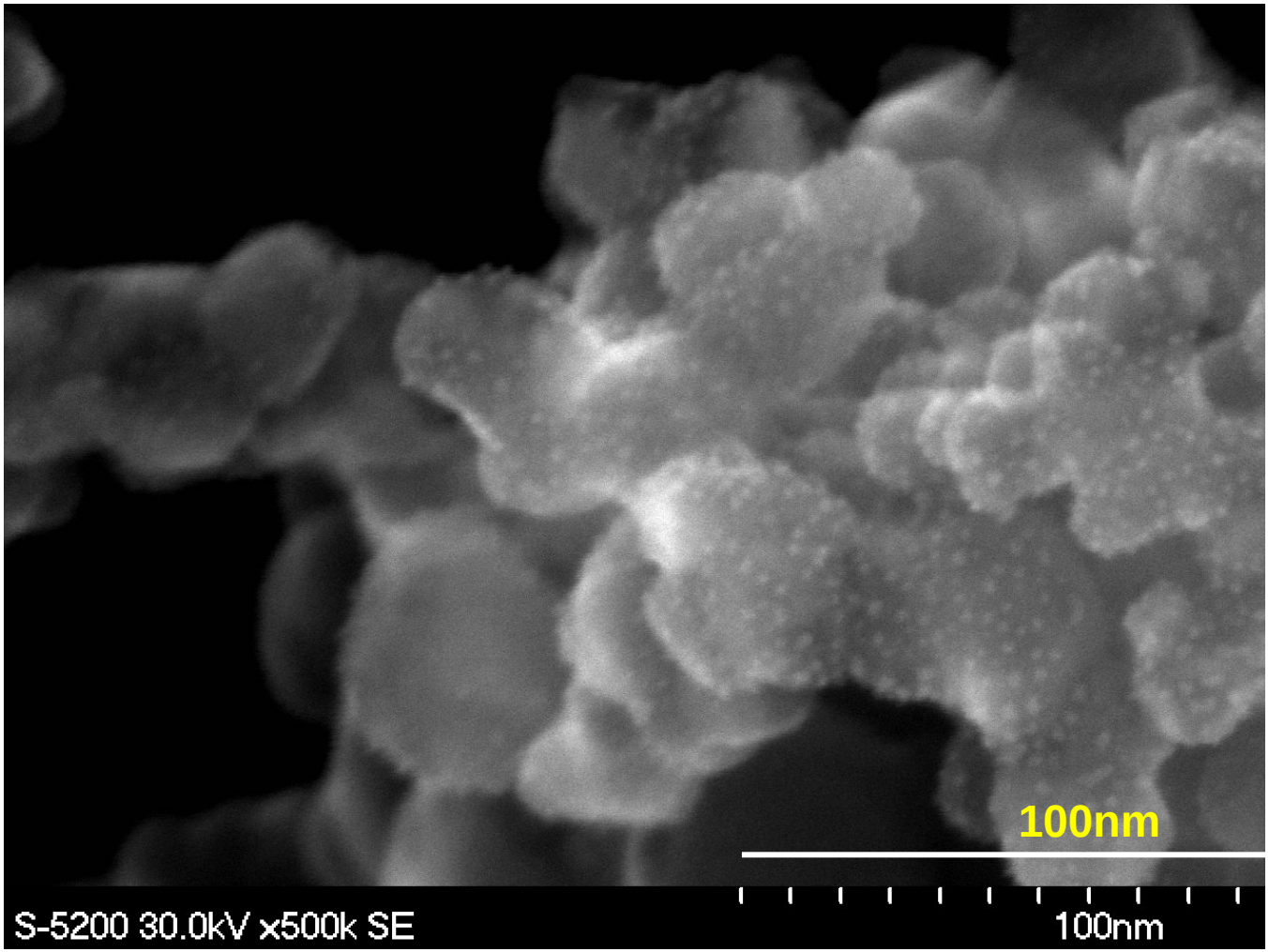



⇒ Larger electrode reaction area

(J. Yamamoto et al.)

# *Carbon-free* Pt electrocatalysts prepared!




**SEM micrograph of $Pt/SnO_2$**

**Pt nanoparticles of ca. 3 nmϕ are supported on $SnO_2$ with longer durability against voltage cycling!**

# Kyushu University Hydrogen Project

**21st Century COE program**
**Integration Technology of Mechanical Systems for Hydrogen Utilization**

NEDO Project

*Researchers are invited from all over the world !*

## Kyushu University
**Hydrogen Technology Research Center**

- Hydrogen energy utilization
- Hydrogen production and supply
- Safety design technology for mechanical system and infrastructure
- Integration technology to optimize total system performance

Including:
fuel cells, electrolysis, hydrogen storage and supply, hydrogen sensing and safety

## AIST (National Institute of Advanced Industrial Science and Technology)
**Research Center for Hydrogen Industrial Use and Storage**

- Strength and fatigue of mechanical materials in hydrogen systems
- Tribology in hydrogen atmosphere
- Thermophys. properties of hydrogen
- Simulation techniques

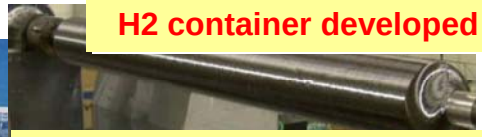
**Center-of-Excellence on Hydrogen-related Technologies**

# Kyushu University "Hydrogen Campus" :

## Towards realizing clean energy society with FUEL CELLS


Hydrogen Technology Research Center

Materials fatigue testing units for hydrogen-related materials



H2 container developed

Stationary PEFC

(for Restaurant)


High-pressure H2 Lab.



SASAKI-LAB
(Fuel cell research laboratory)




High-pressure H2 Lab.

Stationary PEFC

AIST-Research Center for Hydrogen Industrial Use and Storage (HYDROGENIUS)

Hydrogen station

Wind power generator

# Hydrogen Technology Research Center
## in Kyushu University ITO Campus

# Research Center for Hydrogen Industrial Use and Storage (AIST)

# Research Infrastructure

Fuel cell evaluation systems (20 available)

DTA-TG-MS

Spray coating

GC-MS

Automatic GC

## Fuel cell R&D (Sasaki Lab.)

- **Fuel cell materials preparation facilities**
  (High-temperature furnaces, Apparatus for wet-chemical preparation)
- **Fuel cell fabrication facilities**
  (Automated hot-press, Automated spray-coating systems etc.)
- **Fuel cell evaluation facilities**
  (30 evaluation systems available for PEFC/DMFC/SOFC)
- **Electrochemical experimental apparatus**
  (4 impedance analyzers, CV, RDE etc.)
- **Microscopes** (FESEM-STEM-EDX, AFM-STM)
- **Materials analytical instruments**
  (XRD, XPS, DTA-TG-MS etc.)
- **Gas analytical instruments (**GC-MS, automated GC)
- **Materials database**

High-resolution FESEM-STEM-EDX and AFM-STM

# Fuel Cell Demonstration Projects in University Campus

**PEFC demonstration in ITO-Campus**

# Fukuoka Strategic Conference for Hydrogen Energy

**Founded in 3rd August 2004**
**supported by Fukuoka Prefecture**
**(Governor: Mr. ASO)**

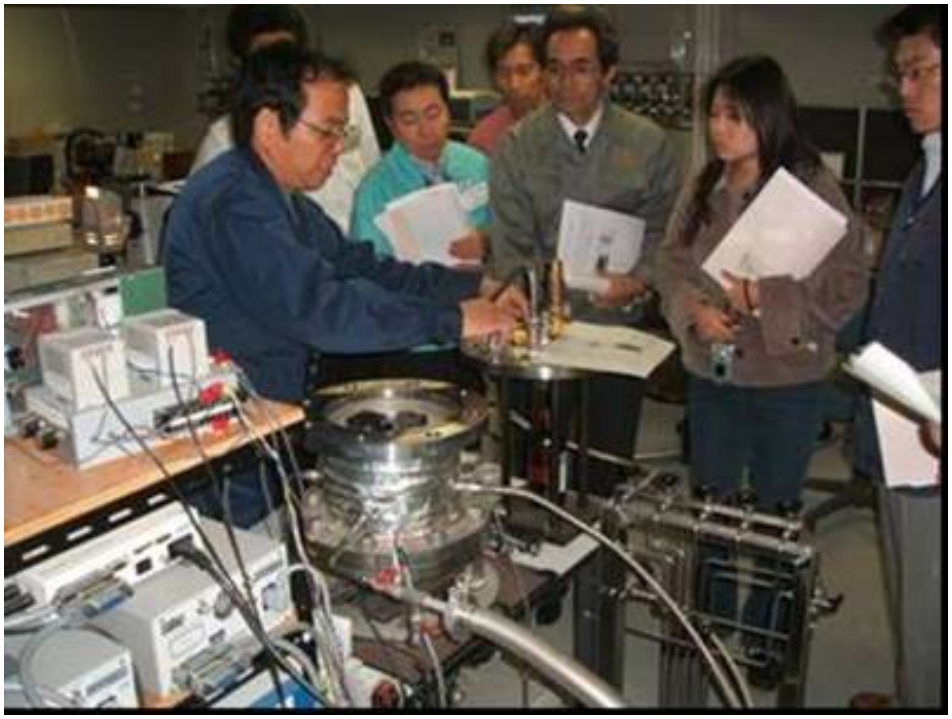
**Aim:**

**Promotion of hydrogen–related technologies and their commercialization and social acceptance**

More than 350 corporate members (private companies), including TOYOTA, Nippon Steel, Kyushu Electric, Saibu Gas, Hitachi, TOTO, Mitsubishi Heavy Industries, Nippon Oil Corp, J-Power, Shimizu Corp.

# Fukuoka Education Center for Hydrogen Technologies

**for Engineers (4-day course) and for Managers (half-day course)**



# Fukuoka EXPO for Fuel Cells and Hydrogen Energy

(Kokura, Kita-Kyushu, Oct. 22-24, 2008)



Homepage： http://www.he-t.jp/

# International Hydrogen Development Energy Forum

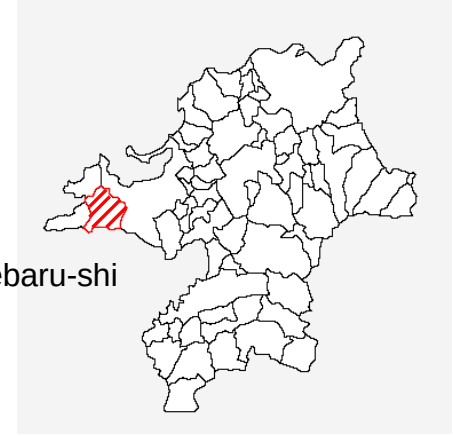
(Fukuoka, to be held in Febr. 4-5, 2009)

# Fukuoka Hydrogen Project:

**For establishing *Model Hydrogen Society***

## “Hydrogen town” in Fukuoka:

## 150 fuel cell cogeneration systems are being installed !


# Fukuoka Hydrogen Project:

**For establishing *Model Hydrogen Society***