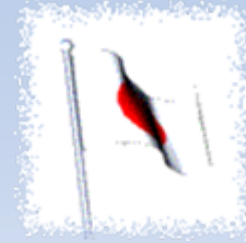


# Table paper 2 (Selected)



## Hydrogen and Fuel Cells save the Earth

July 22, 2008

Cabinet Office, Japan

University of Electro-Communications

Haruhiko ANDO

# “L’Île mystérieuse” (Jules Verne, 1874)



- “One day all the coal will be used up. Without coal, no more progress for modern life.” “What will they burn in the place of coal?”
- “**Water**,” replied Cyrus Smith. “but decomposed into its basic elements. **water** will one day be employed as a fuel, **hydrogen** and oxygen will furnish **an inexhaustible source of heat and light**. Then there will be nothing to fear. As long as this earth is inhabited, it will provide for the needs of its inhabitants. I believe that when the coalmines have been exhausted, they will heat and be heated with **water**. **Water is the coal of the future.**”
- “I would like to see that,” said the sailor.

# Structure of air

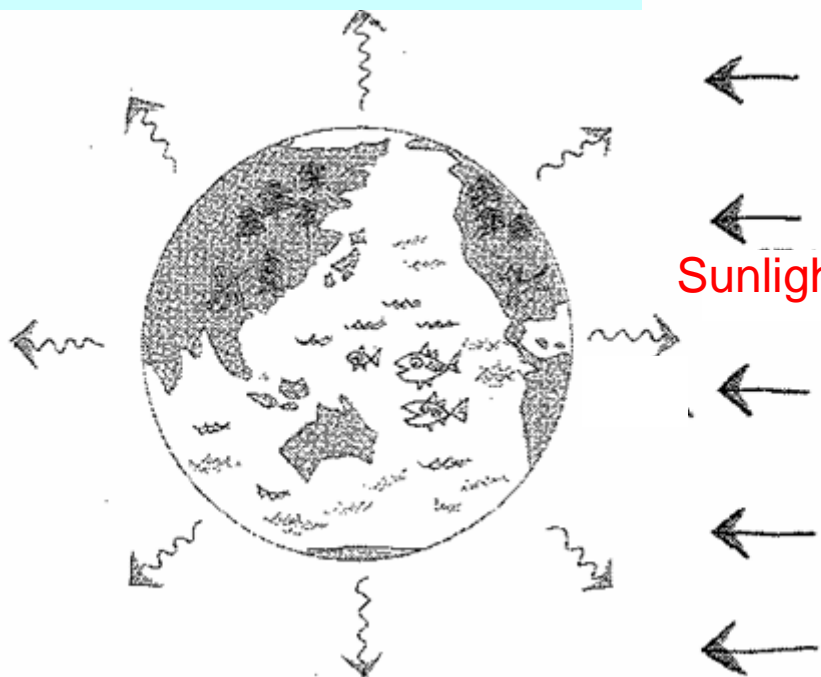
|                    |               |                                      |
|--------------------|---------------|--------------------------------------|
| Thermosphere       | 80-800km      | 2000°C                               |
| Mesosphere         | 50-80km       | 0→-92.5°C                            |
| Stratosphere       | 11-50km       | -70→0°C                              |
| <b>Troposphere</b> | <b>0-11km</b> | <b>15→-70°C</b><br><b>80% of Air</b> |

The radius of Earth = 6,400 km

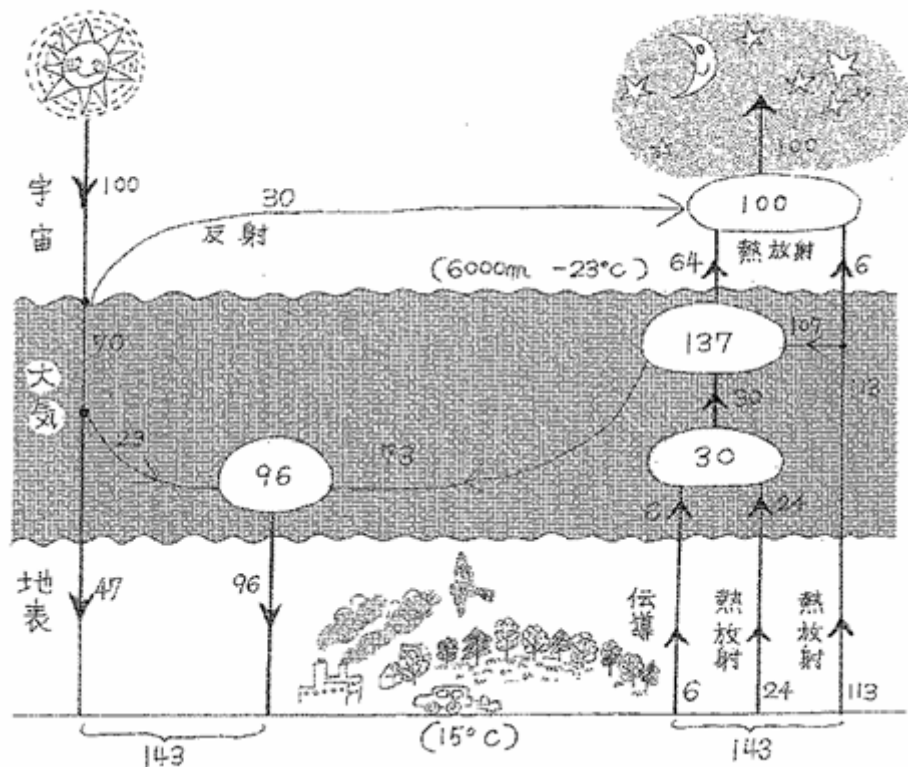
**Fierce Hurricanes, Typhoons occur inside  
Troposphere and surface of sea.**

# Inside “thin film” of the Earth

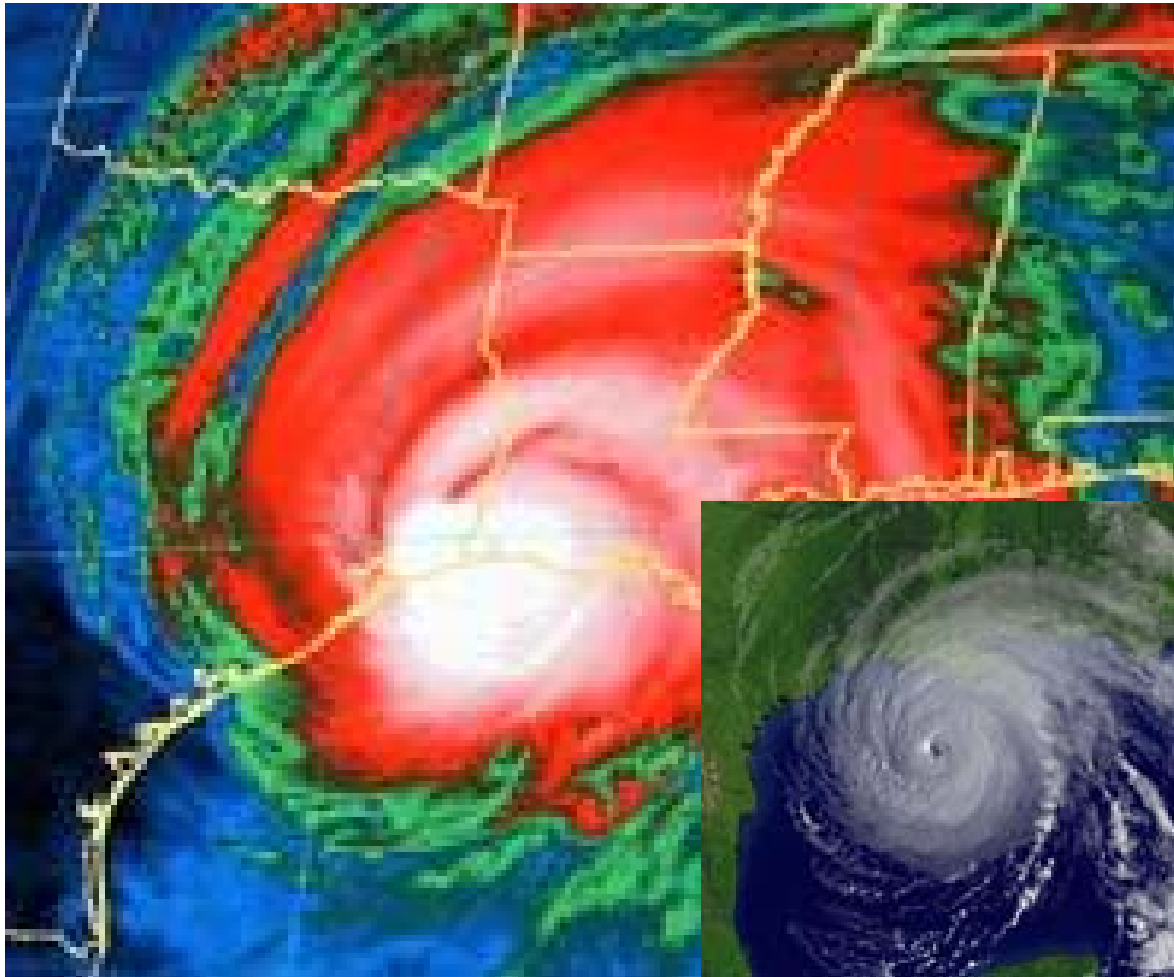
heat absorption and release



Thermal balance of GHG effect



Source: Prof. Tatsunari Hirose

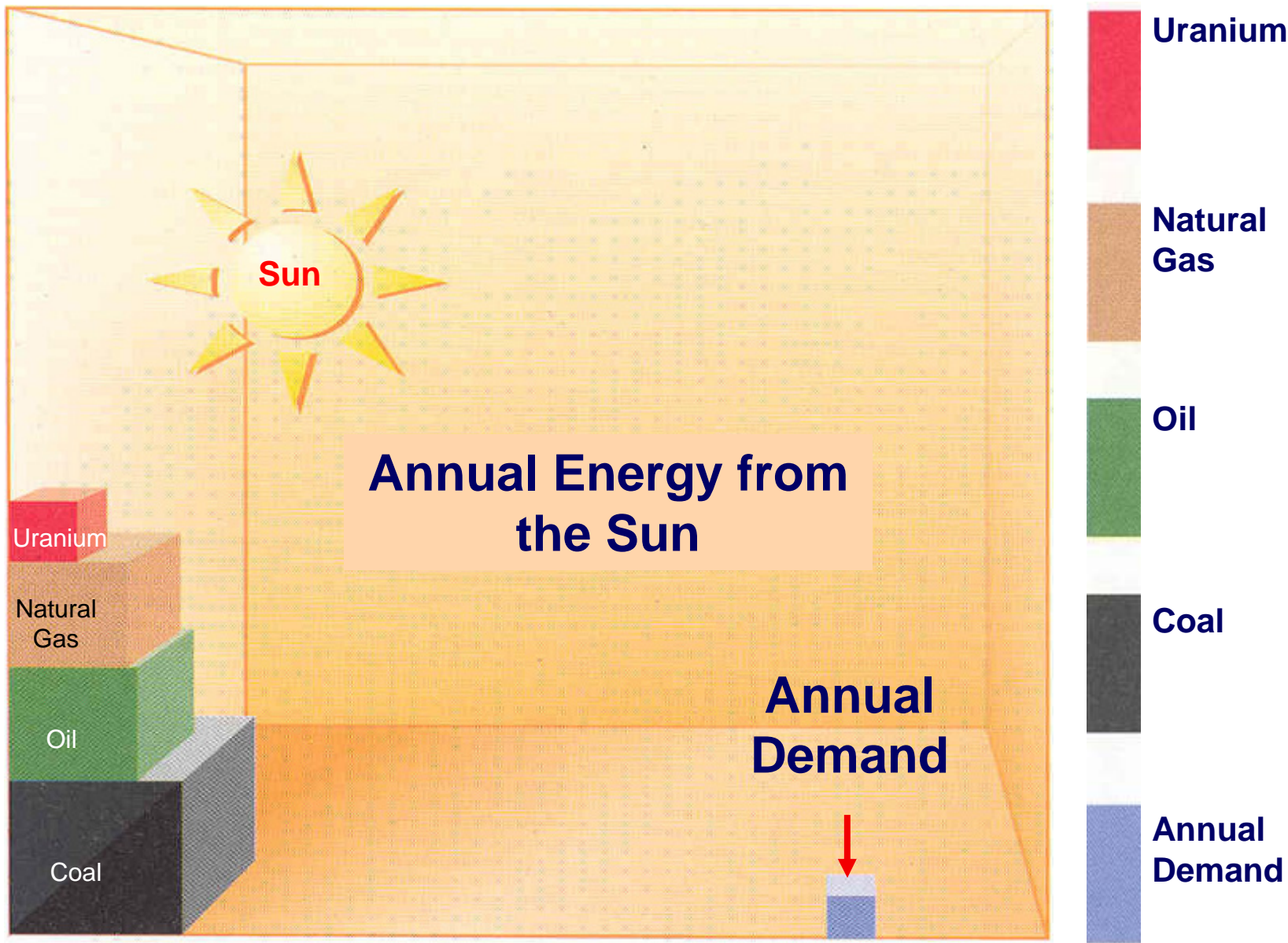


“The **global warming** influence provides a new background level that increases the risk of future enhancements in **hurricane** activity,

Dr. Kevin E. Trenberth is Head of the Climate Analysis Section at the National Center for Atmospheric Research

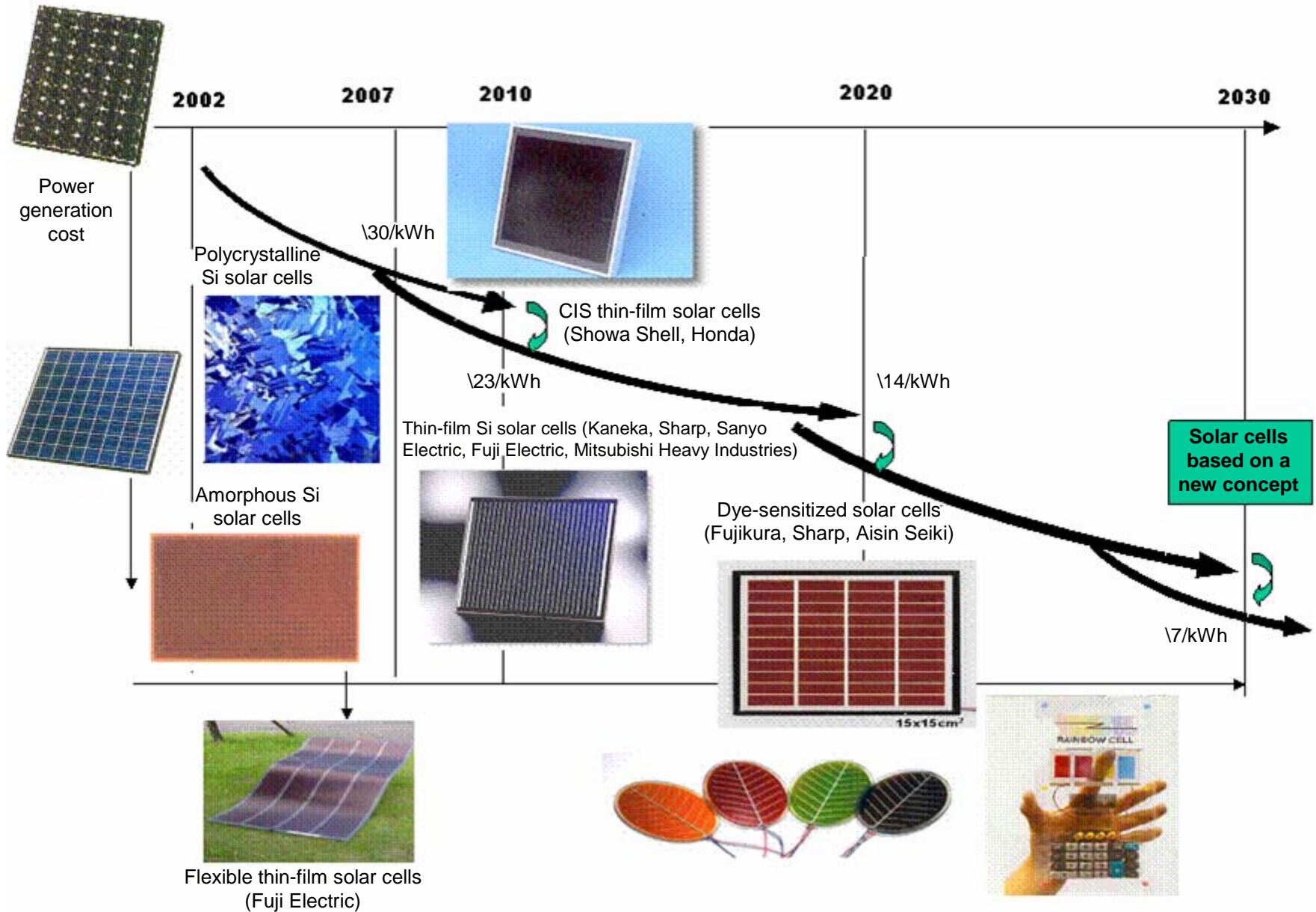
*Hurricane Rita*

**Equivalent Stock of  
Energy Source**

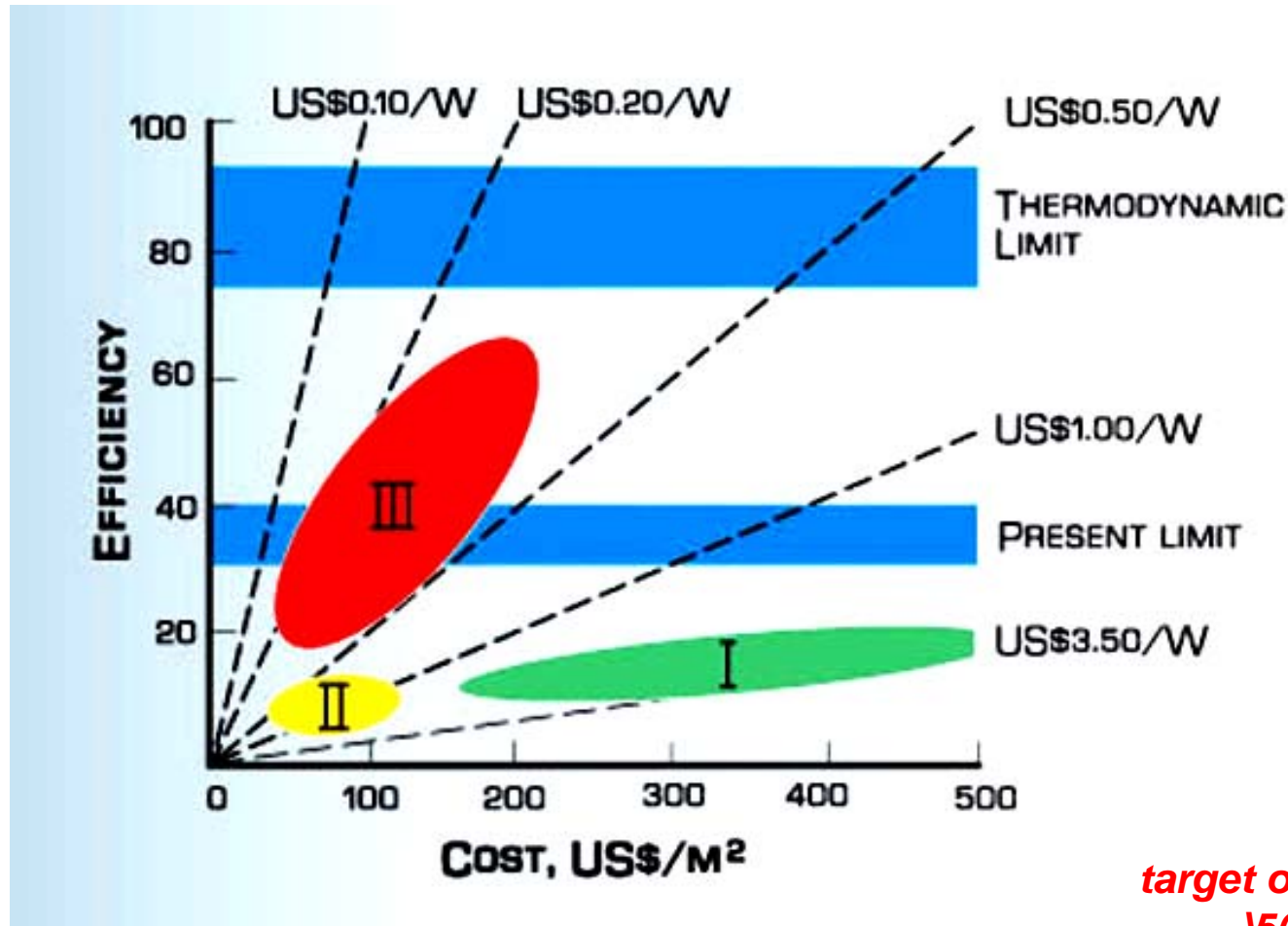


# Scenario for the Development of PV Modules toward 2030

Monocrystalline Si solar cells



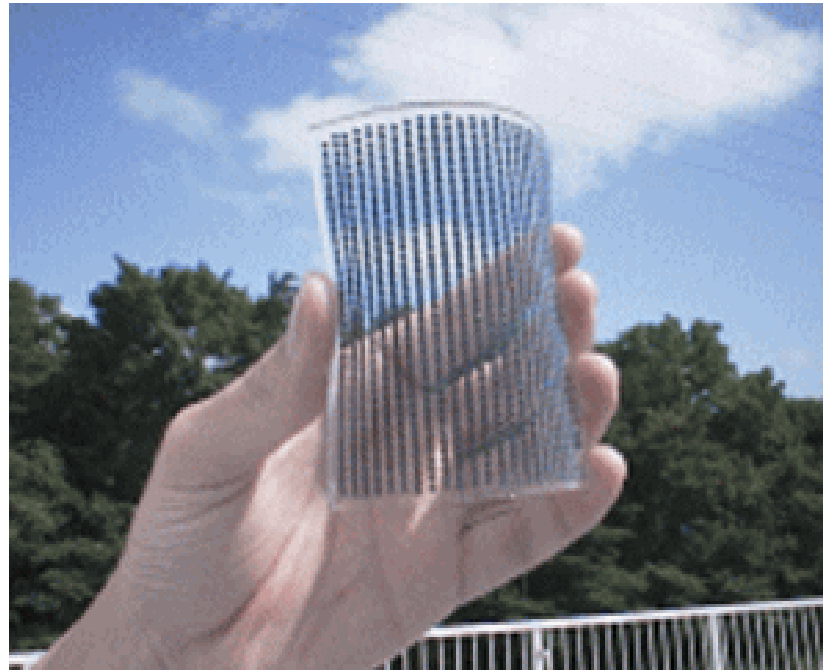
# Third Generation Solar Cell and plan 2020



**target of cost reduction:  
150/W by 2020**

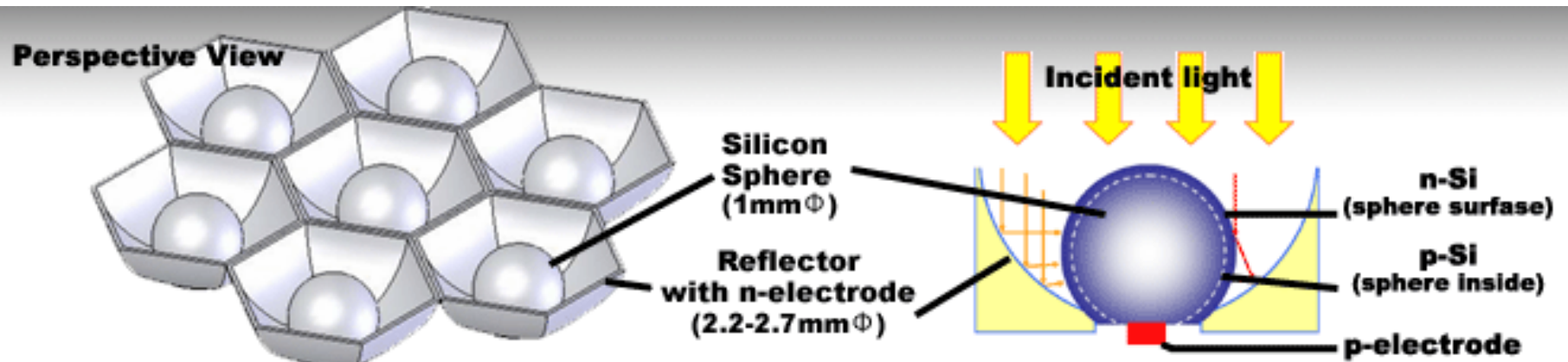


# Silicon-Sphere Solar Module by Japanese small Ventures



Kyosemi

Clean Venture 21





Daibutsu, Big Buddha is named for infinite amount of lightning (अमिताभ, amitaabha).

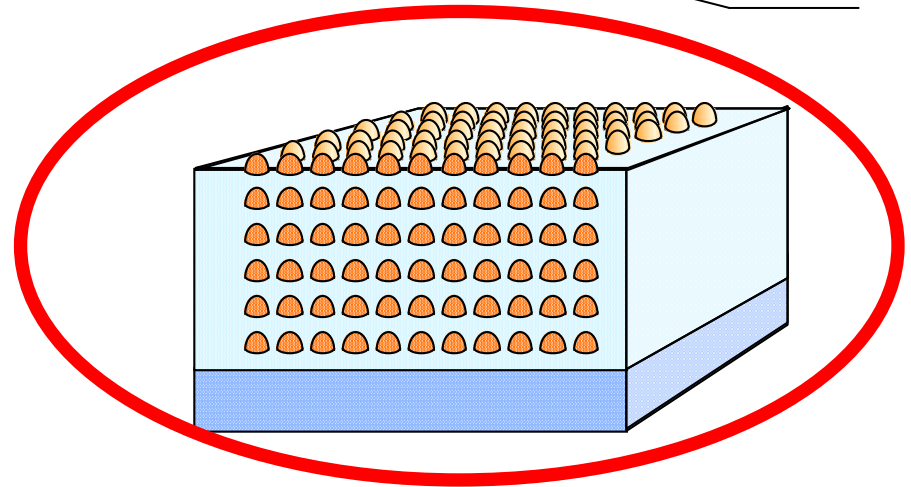
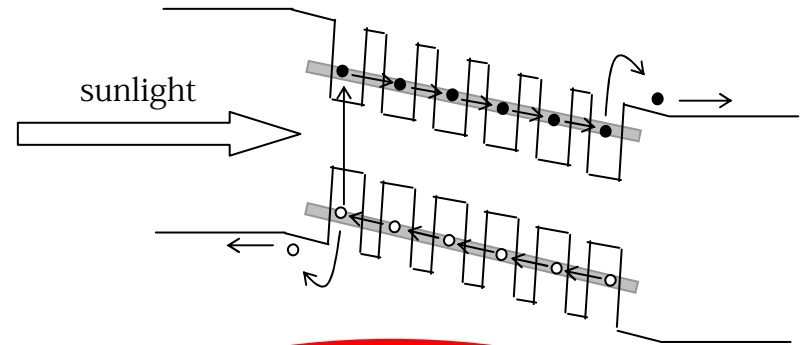
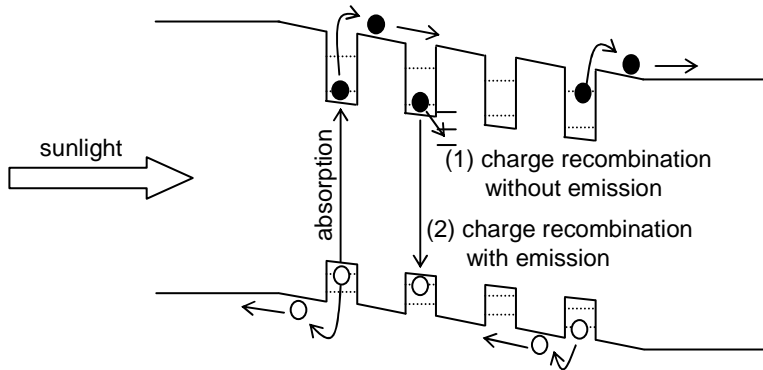
# Promising Quantum-dot Photovoltaic

**Conventional**

**Well Potential**



**Next-Gen Type**



Source: Dr. Yoshitaka Okada

**3D-Quantum dot superlattice**

# The Championships for newer Photovoltaic cells, “Wimbledon” in Japan

- 9 countries, 10 types, 26 different modules severely compete in Hokuto (west of Tokyo)



# Samurai: ancient noble warrior?

*“Innovation Samurai” today is defined here for prepared, decided, devoted, high-minded scientist or engineer who tackles difficult breakthrough targets with bravery, deepest spirits, calm passion and robust personal commitment under empowerment.*



# Personal computer: crazy or not? How about **Personal Generator**?

Gates said on starting Microsoft:

“Microsoft is one of the few companies you can say it just started with a dream. A dream that software would be important. A dream that there would be a computer that was affordable on a personal level. That’s a dream that Paul Allen and I had, which **at the time seemed very crazy.**”

# Next-Generation Vehicle Fuel Initiative

## 1. Biofuel

## 2. Clean diesel

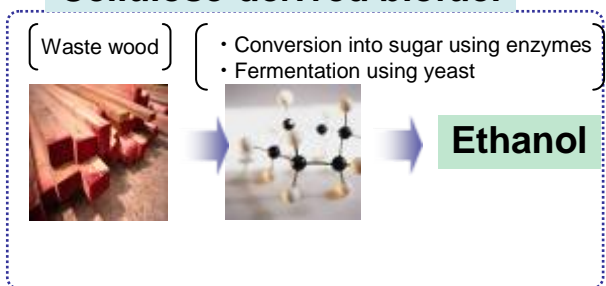
## 3. Next-generation batteries

## 4. Fuel cells/hydrogen Economy

### 1. Biofuel

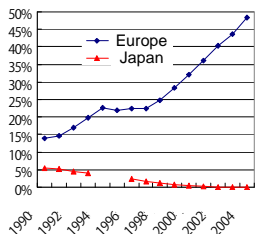
- Bioethanol blended with gasoline, and
- Biodiesel blended with diesel oil

#### Cellulose-derived biofuel

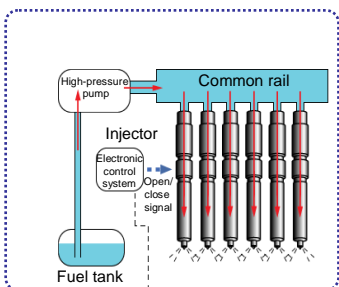


### 2. Clean diesel

#### Share of diesel vehicles

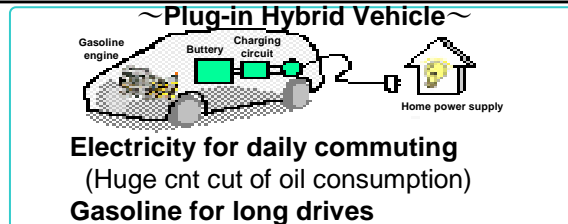


#### Common rail system







### 3. Next-generation batteries

**Next-Generation Vehicle Battery Development Project**  
**Budget (07FY): \$ 50 Million**



Targeted battery performance  
 Targeted battery cost

|  | Improved battery (2010)   | Advanced battery (2015)   |   | Innovative battery (2030)   |
|--|---|---|---|---|
|  | Compact EV  | Compact EV  | PHV   | Standard-sized EV   |
|  |  |  |  |  |
|  | 1   | 1.5   |   | 7   |
|  | 1/2   | 1/7   |   | 1/40  |

R&D of next-gen batteries (improvement in performance)

### 4. Fuel cells/hydrogen Economy

Hydrogen Economy: transition from "carbon cycle" to "water cycle"



Hydrogen supply

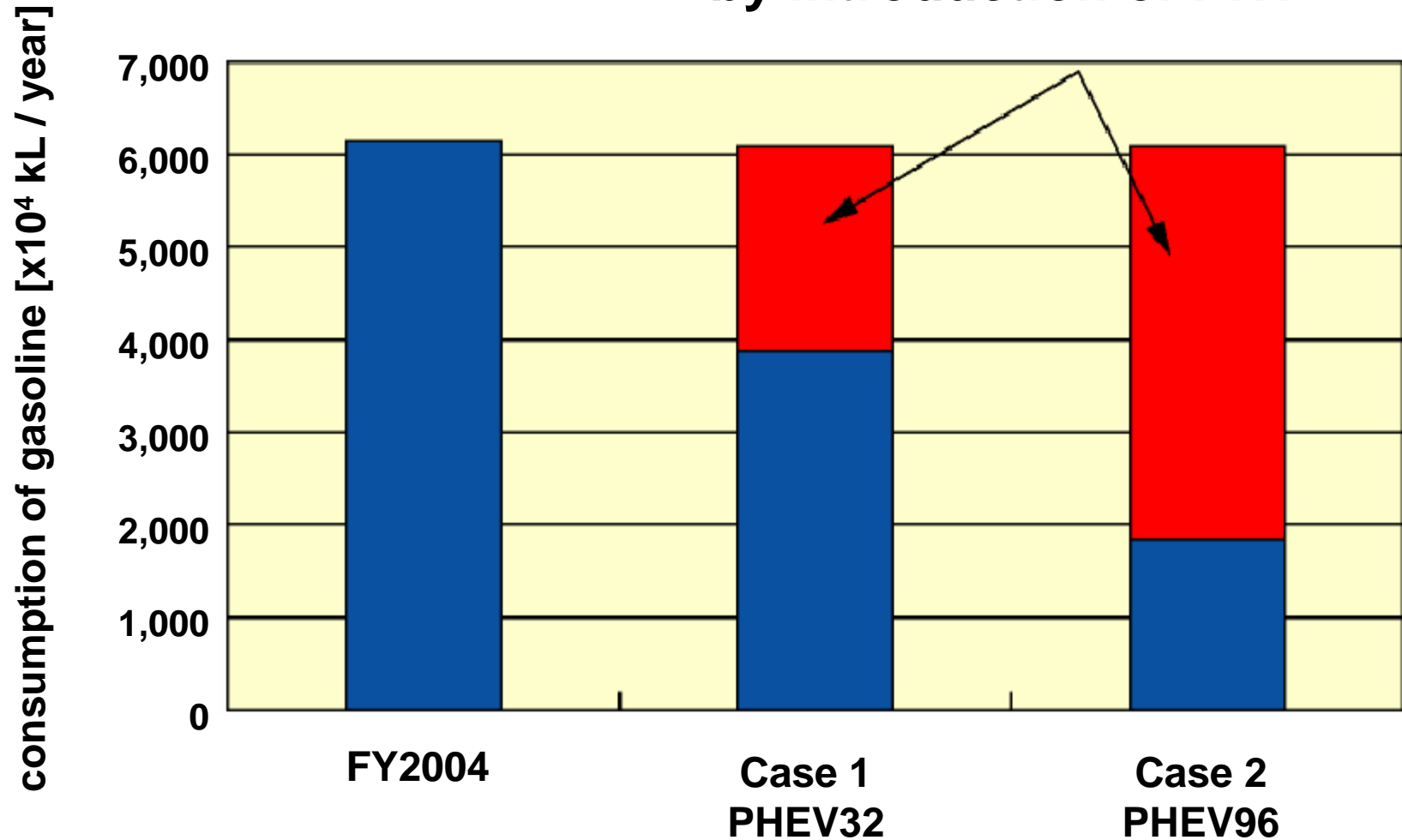


#### Hydrogen vehicles

- Powered by way of the combustion of hydrogen instead of fossil fuel (e.g. gasoline)
- Producing very clean exhaust that contains almost nothing but water



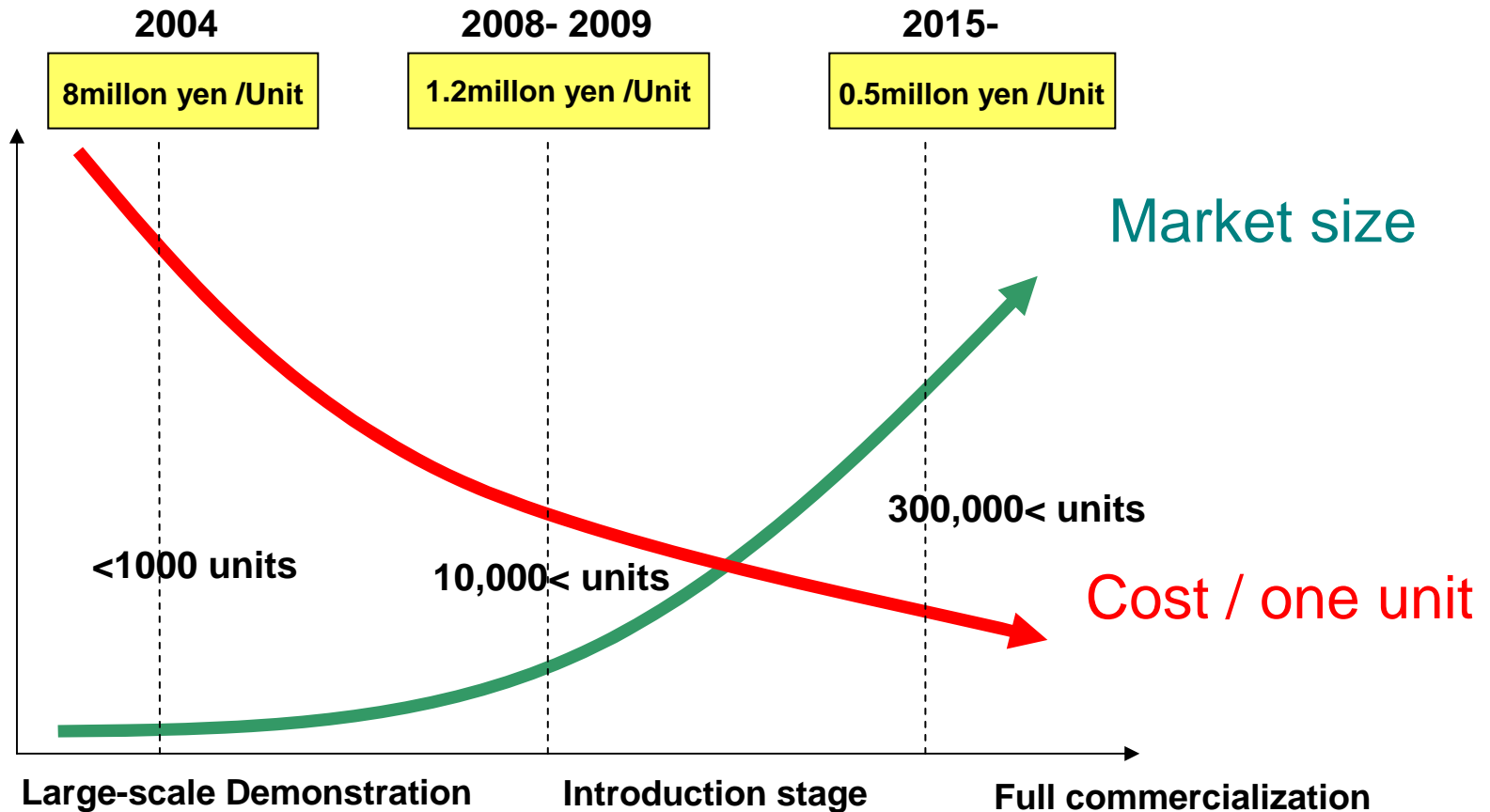
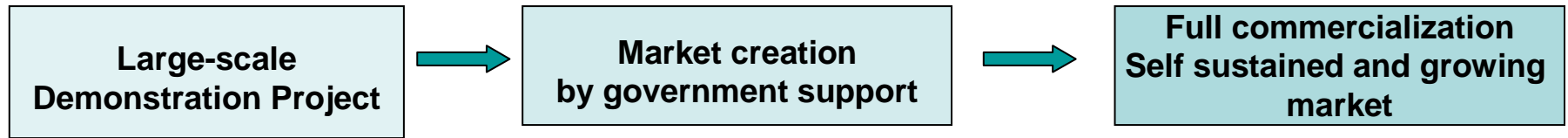
## Reduction in gasoline consumption by introduction of PHV



Source: [http://criepi.denken.or.jp/en/e\\_publication/pdf/den433.pdf](http://criepi.denken.or.jp/en/e_publication/pdf/den433.pdf)



# Scenario of Market Creation for Residential Fuel Cell



Note: \* means annual production rate

# Wanted!!: New Entries in R&D Competition ! for BOPs of Stationary FC Cogeneration System

Specifications of BOPs required for stationary FC system can be seen at the website (<http://meti.go.jp/press/20051227004/20051227/004.html>)

## Solenoid valves

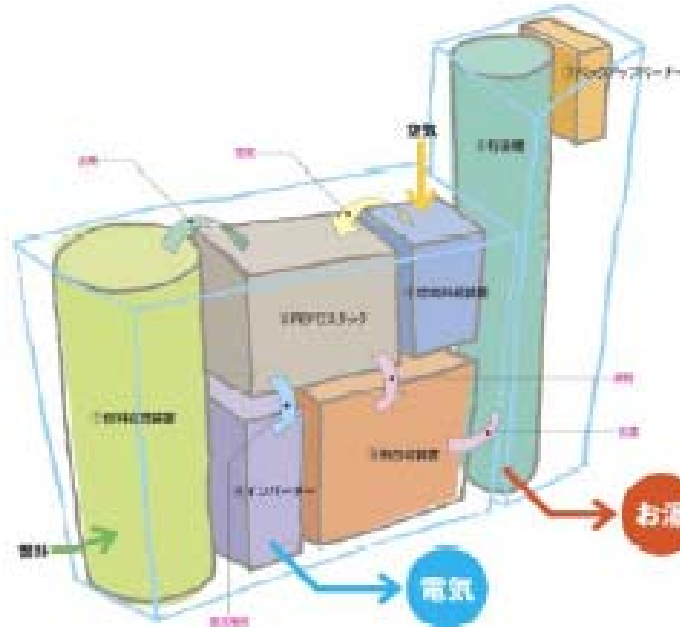


## リリーフ弁 (アイビーエスジャパン)



## Pressure transducers

### 圧力センサー (日本電産コバル電子)



## Precise pumps

### 排熱回転ポンプ (ニクニ)



## Blowers

### バーナ空気ブロワ (日本電産コバル電子)



## Flow meters

### ガス・空気流量計 (山武)



### 水流量計 (愛知時計電機)



### 燃料昇圧ブロワ (イワキ)



# R&D organization for harmonization of BOP of stationary FC cogeneration system

Steering Committee

NEDO

METI

*System makers*

Investigating Committee

**Matsushita**

Fuel compressor,  
blower for selective  
CO oxidation

**Ebara-Ballad**

Liquid/gas flow  
meter, pressure  
transducers

**SANYO**

Water pump

**Toshiba**

Solenoid valves

**Fuji**

Cathode air blower  
Burner air blower

Re-consign

**BOP makers**

Re-consign

Iwaki Co.,Ltd  
Ulvac. Inc.  
Techno Takatsuki Co., Ltd.  
Taisan Ind. Co., Ltd

Yamatake Corporation  
Oval Corporation  
Aichi Tokei Denki Co., Ltd.  
NIDEC Copal Electronics Corp.

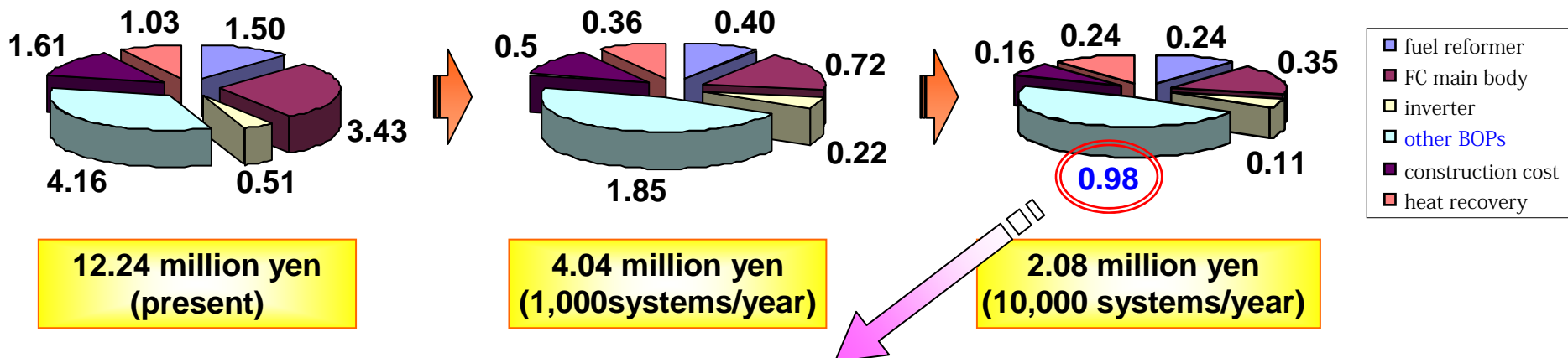
Mikuni Corporation  
Matsushita Electric Works ,Ltd.  
Ogihara Mfg. Co., Ltd.  
Nikuni Co., Ltd.  
Ebara Corporation

IBS Japan Corporation  
SMC Corporation  
Time Giken Corporation  
Saginomiya Seisakusho, Inc.  
Mikuni Corporation

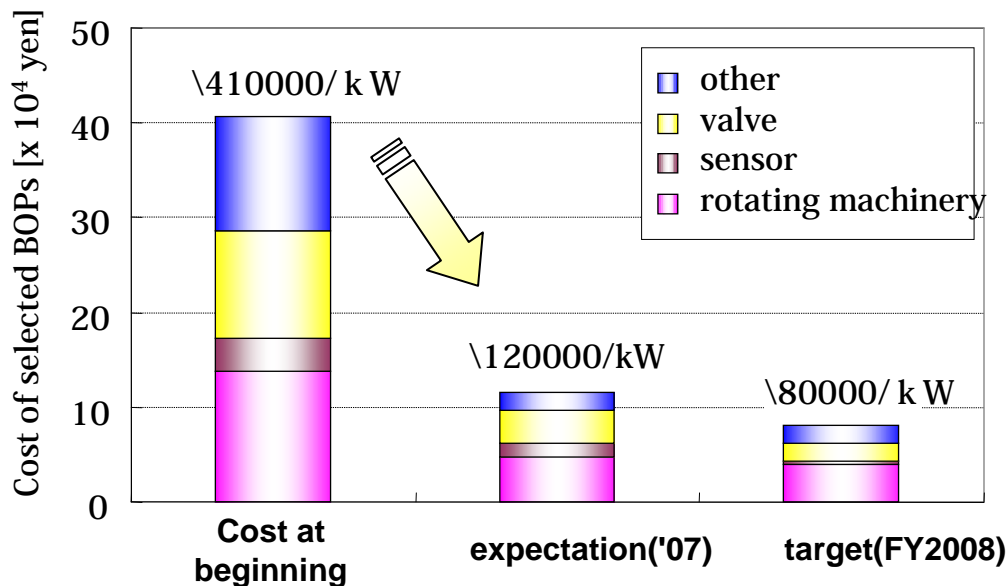
Yasunaga Corp.  
Toshiba Home Tech. Corp.  
Ebara Densan Ltd.  
NIDEC Copal Electronics Corp.

# Strategy for Further Cost Reduction of BOP

Forecast of cost of 1kW PEFC system based on mass production (by major system makers)



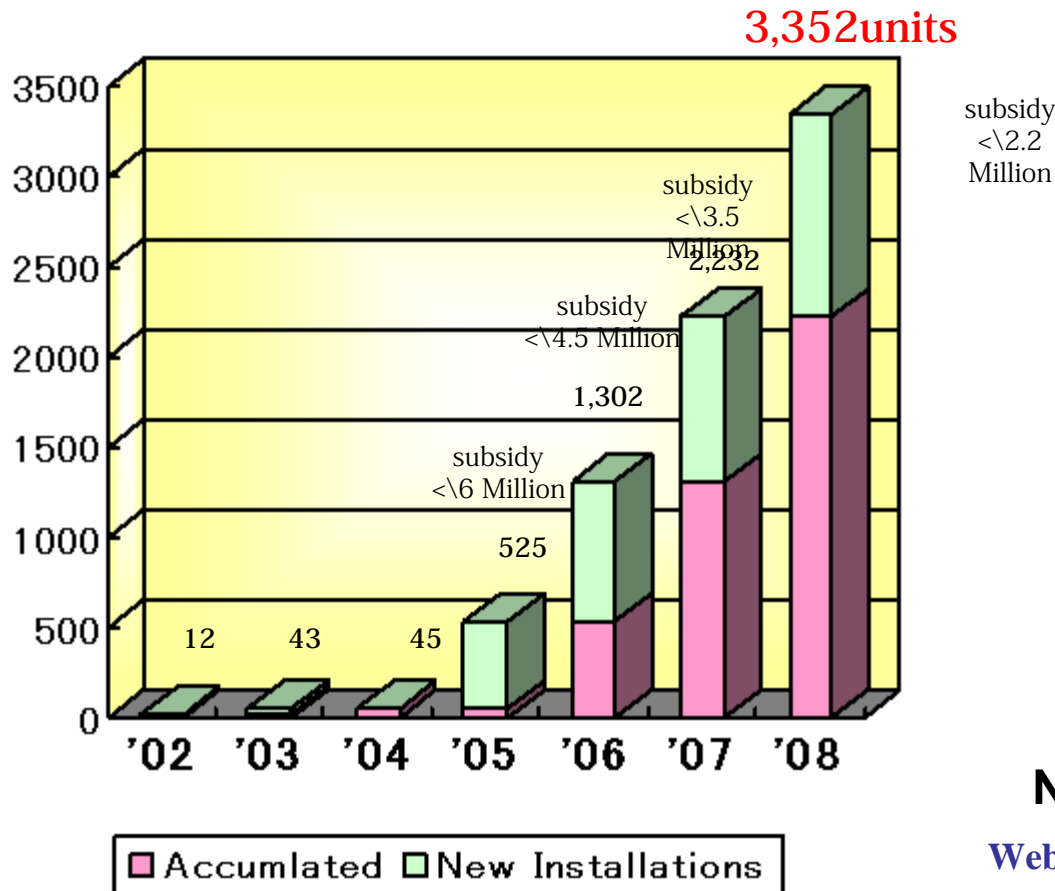
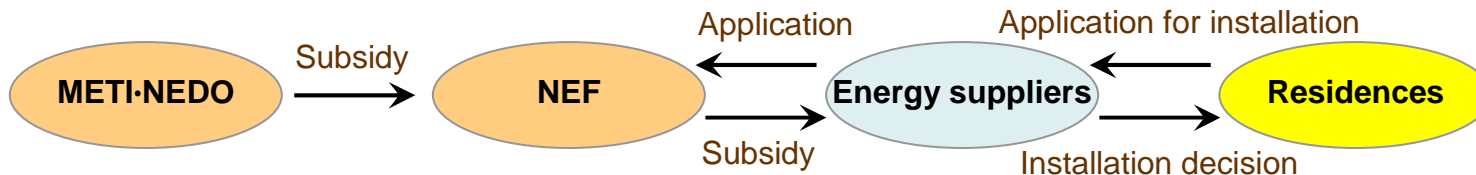
- System manufacturers selected some BOP devices (0.41million yen/kW) which specification can be harmonized among the participating system manufacturers.
- Concentrated R&D for the selected BOPs to satisfy durability, performance and cost.



- As a consequence of the effort in this R&D ('06~'07), drastic cost reduction has been achieved:  
¥ 410,000/kw ⇒ ¥ 120,000/kw
- By concentrated and continuous R&D, improvement of BOPs as well as the further cost reduction will be achieved  
¥ 80,000/kw by FY2008

# Large-Scale Stationary Fuel Cell Demonstration Project

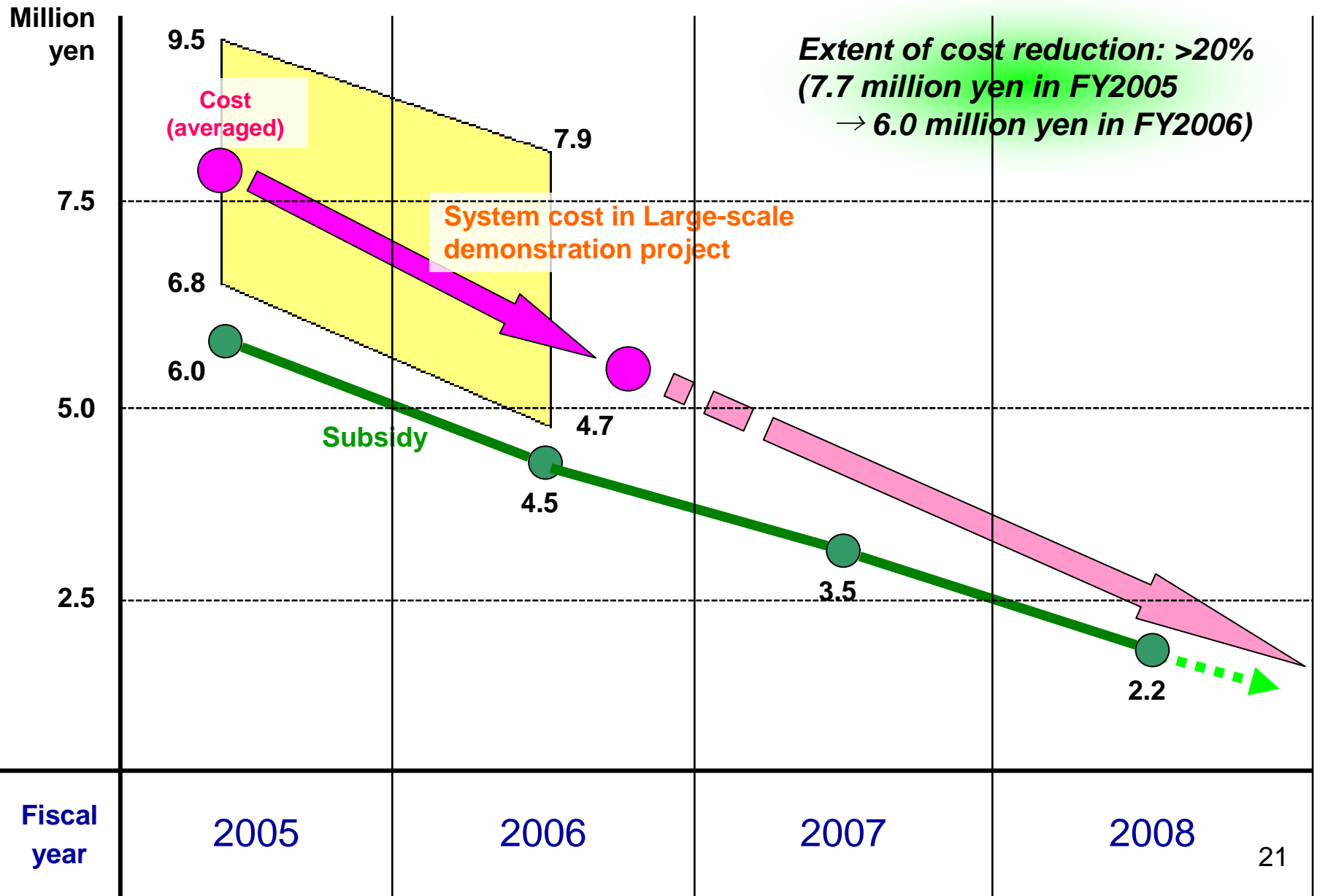
Provide feedback on various demonstration data, for research and development  
 Step up to mass production and inspection of learning curve  
 Price target: 1.2 million yen/system (in 2008)



Number of installation

Web site: <http://happyfc.nef.or.jp>

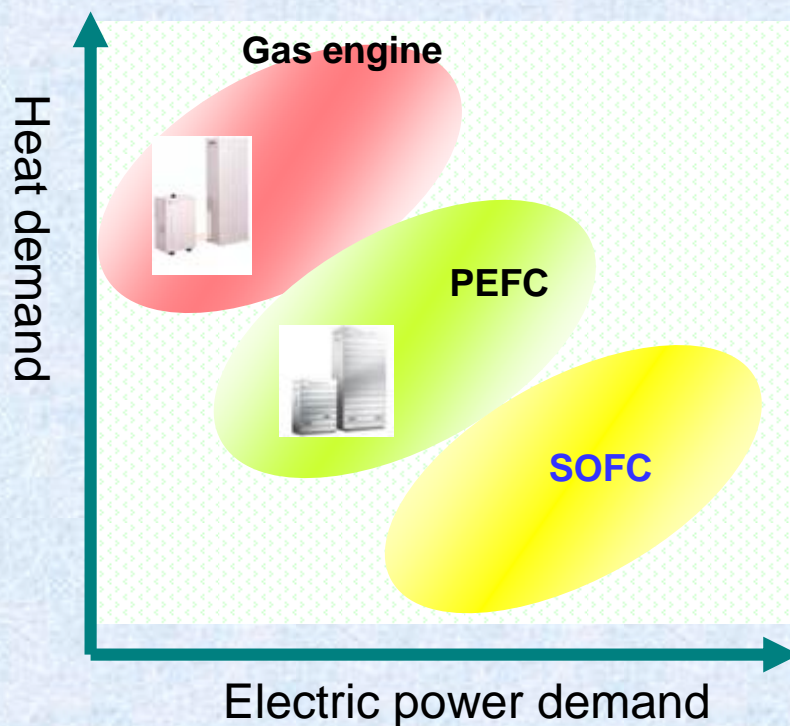
# Trend of Cost of Fuel Cell Co-generation System (1kW-PEFC)



# Solid Oxide Fuel Cell (SOFC) Demonstration Project

Aiming at commercialization of residential SOFC co-generation system, demonstration project is started from FY2007 to accumulate our experience of practical operation of SOFC and extract technical subjects to be undertaken for further development of SOFC.

## Characteristic of co-generation system for household



- Budget: 0.77 billion yen for FY 2007

## Objectives

- clarification of degradation of stack caused by high temperature operation (ca. 90 °C for PEFC, ca. 1000 °C for SOFC)
- Accumulation of experience of practical operation of residential SOFC system

## Characteristic of SOFC

- High efficiency of electric power generation
- No expensive catalysts (Pt etc.) needed
- Mature ceramic technology applicable
- Scale-up

# Ceremony for installation at PM's Residence



**Ebara=Ballard**



**Panasonic**



**PM is turning a key to open  
“Hydrogen Economy”**

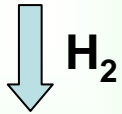




# Demonstration of FCVs and H<sub>2</sub> Station (JHFC-2)

## Identifying Issues and Improving Public Acceptance for Hydrogen Society

### Hydrogen Infrastructure



### FCEV Demonstration Project



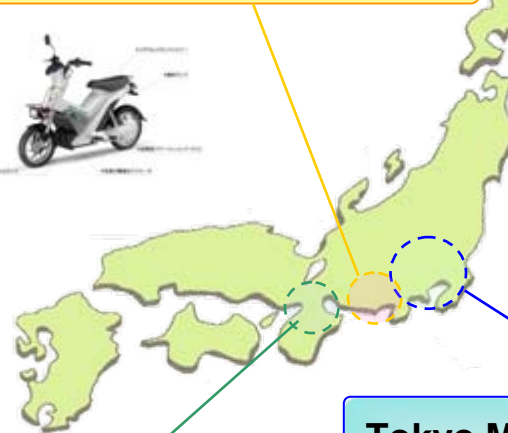
### Kansai Area

- New applications and hydrogen station demonstration (*Wheelchairs, FC motorcycles*)
- Emergency power source applications
- Hydrogen station suitable for cities
- Conventional hydrogen supply (Satellite stations)
- H<sub>2</sub> stations are under construction



### Common

- PR • Educational activities  
Initiate and join events  
JHFC park event
- PR • Long-term strategy  
Proposal for educational curriculums in school and social education

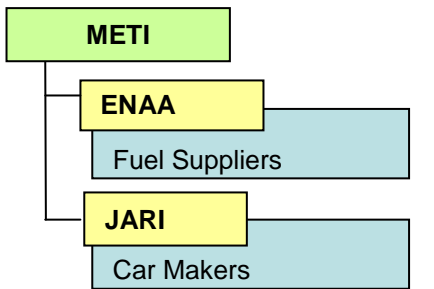


### Chubu Area

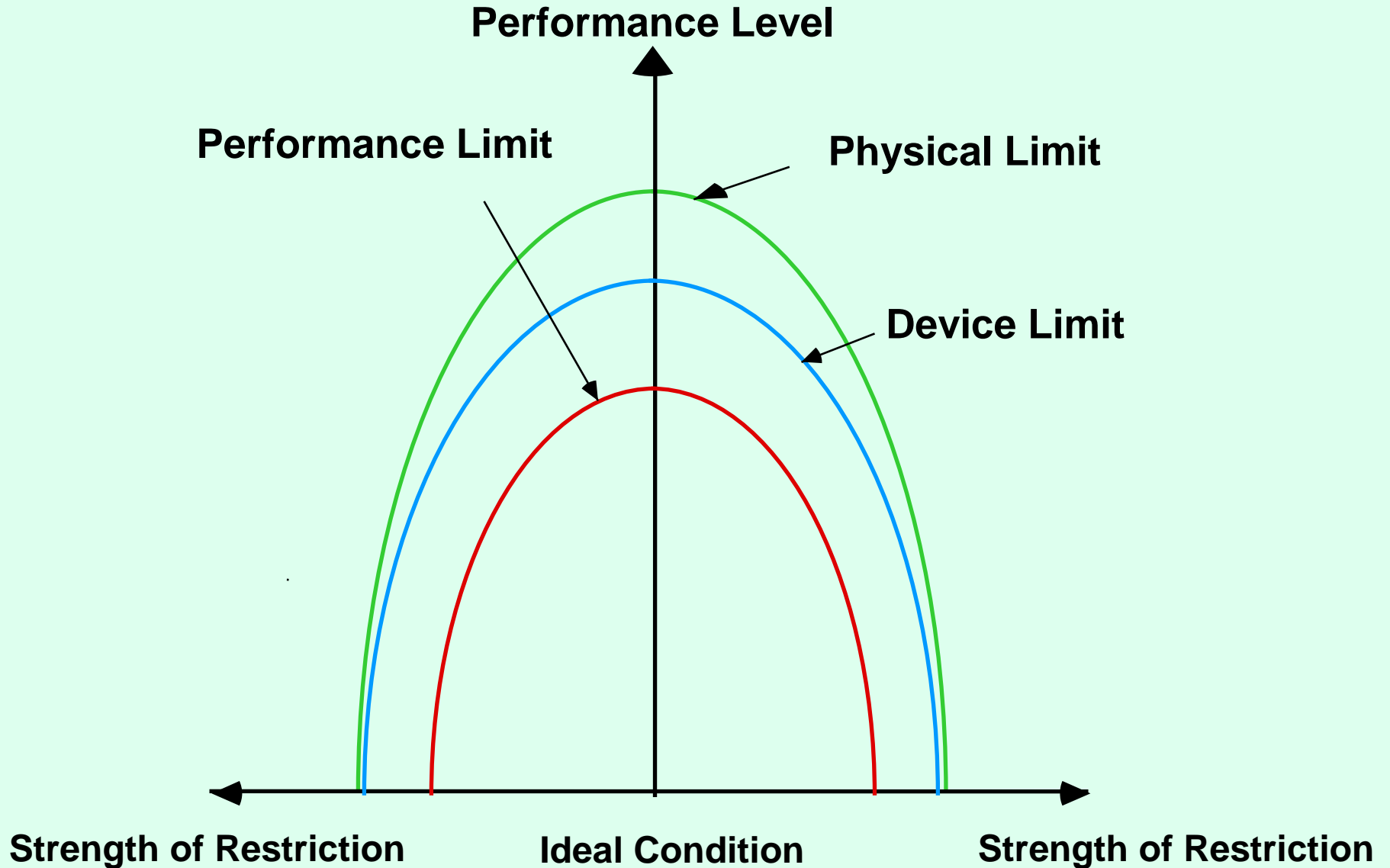
- Fuel cell bus demonstration
- Hydrogen station test
- Natural gas reforming and off-site hybrid hydrogen station
- Two H<sub>2</sub> stations and three FCV

### Tokyo Metropolitan Area

- *Fleet demonstration by third party*
- Verification of safety, reliability and performance improvements for various hydrogen sources and production methods
- Nine H<sub>2</sub> stations and fifty FCVs



# Three layers of Technology



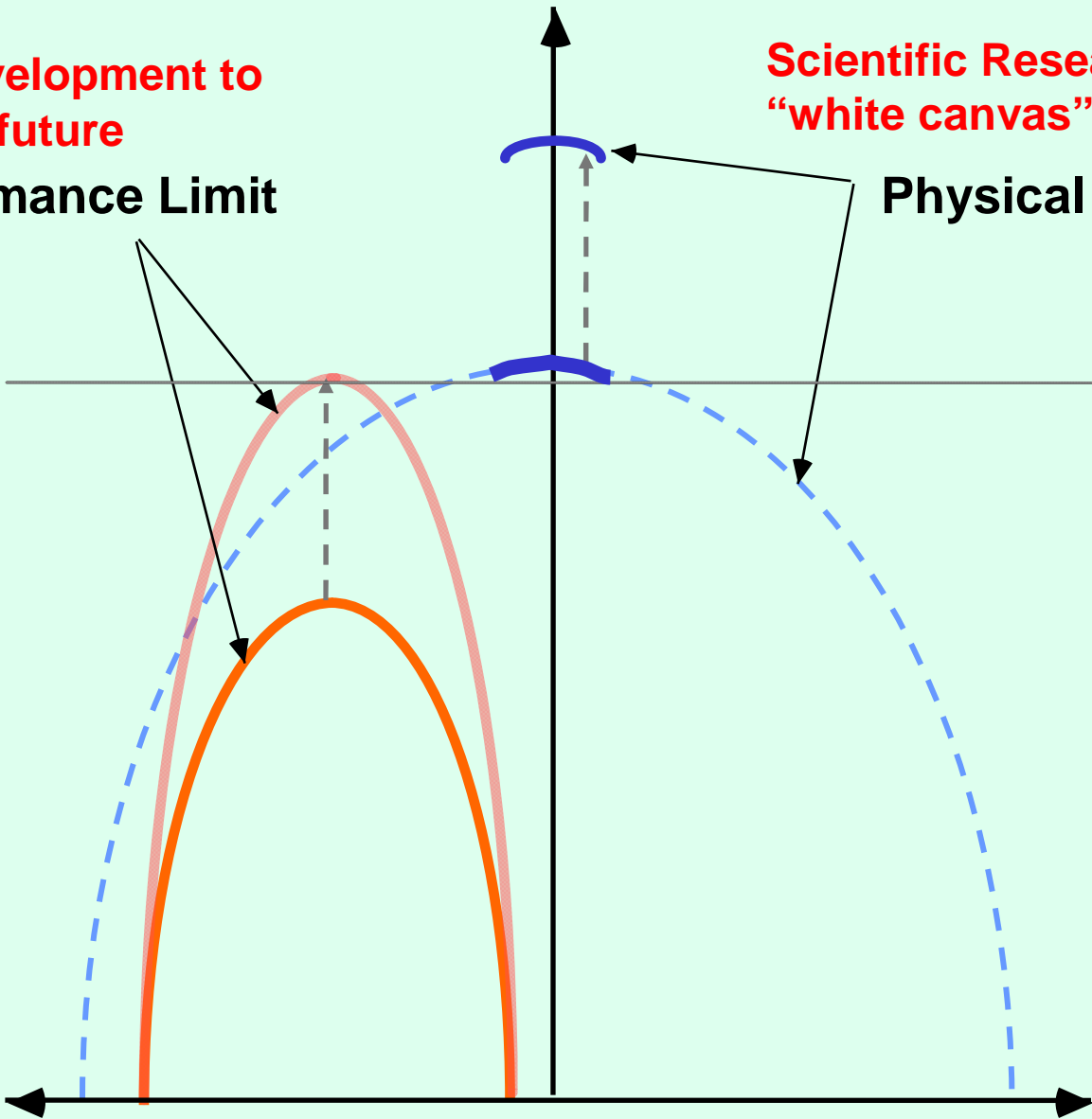
# Performance Level

Industry's Development to "determined" future

Scientific Research toward "white canvas" future

Performance Limit

Physical Limit

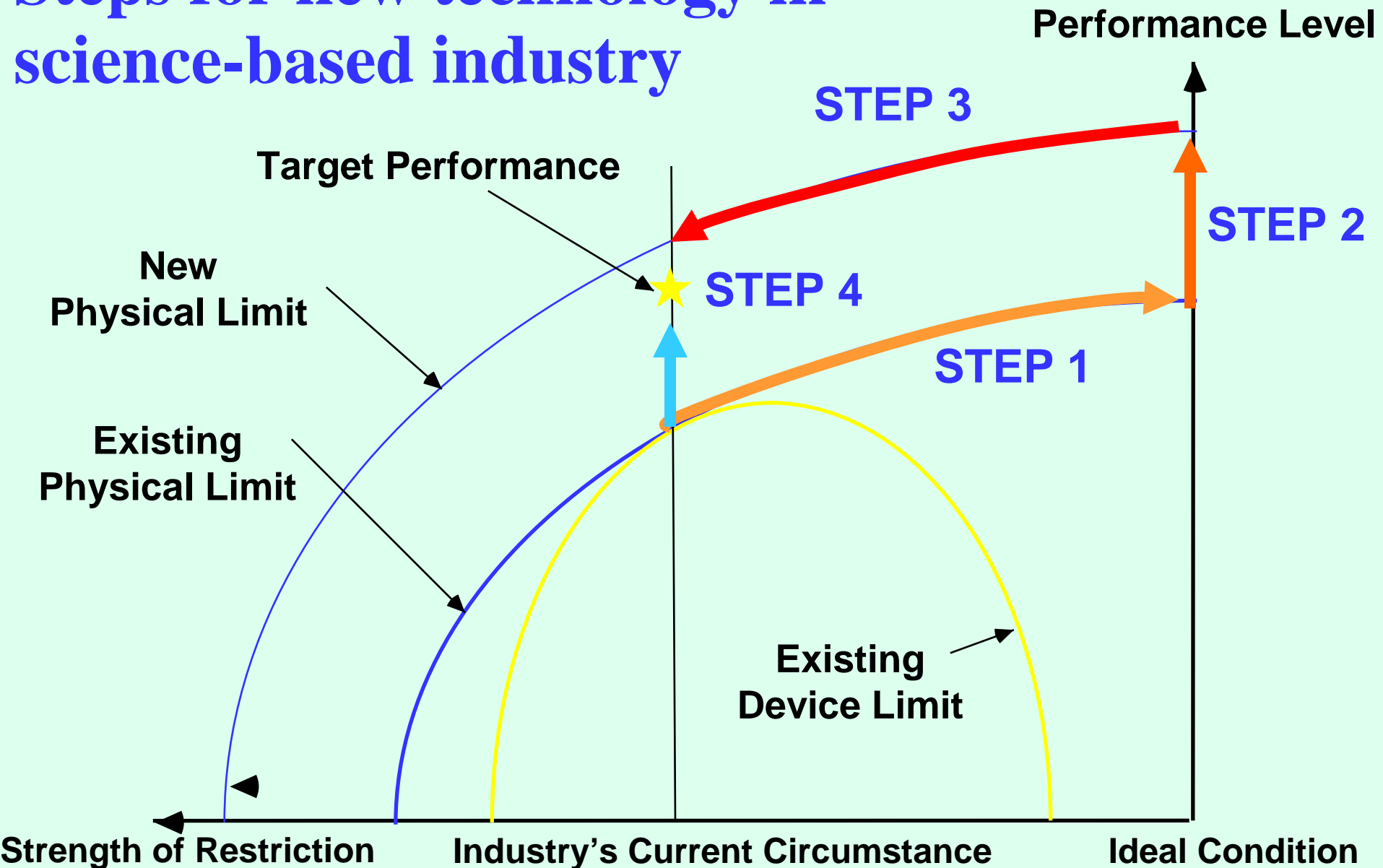


Strength of Restriction

Ideal Condition

Strength of Restriction

# Steps for new technology in science-based industry

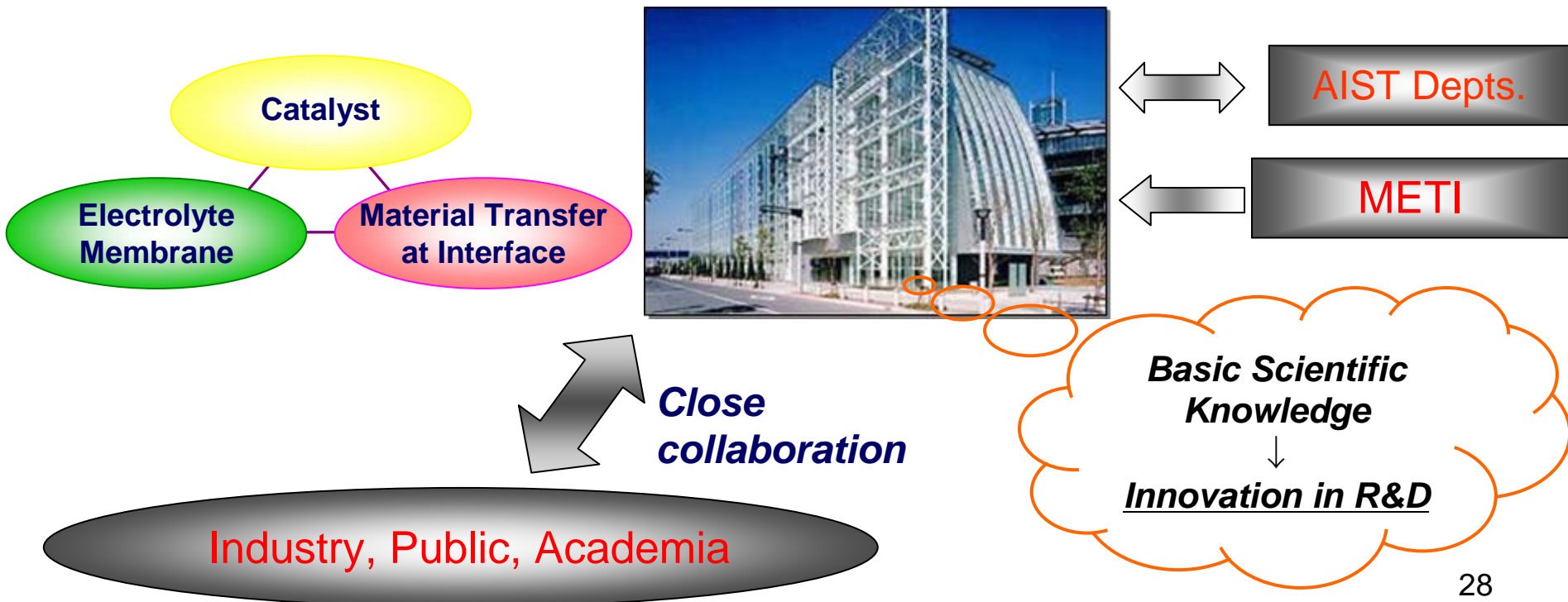


**(Restriction on cost, durability..)**

# A National Lab. for Basic FC R&D

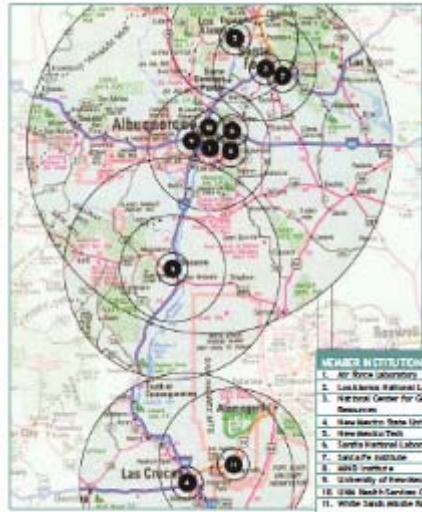
Polymer Electrolyte Fuel Cell Cutting-Edge Research Center ( FC<sup>3</sup> = FC-cubic )

- Established on April 1, 2005
- Director of FC-cubic: Dr. Hiroshi HASEGAWA
- Budget: 1.0 billion yen for FY2007(1.2 billion yen for FY2006)



# Collaboration with First class Labs in NM

## Fusion between top science and Japan's fabrication



### FUEL CELL INITIATIVES IN NEW MEXICO

#### Table of Contents

- Sandia National Laboratories
- Los Alamos National Laboratories
- University of New Mexico
- New Mexico State University
- New Mexico Institute of Mining & Technology
- White Sands Test Facility
- Testing
- New Mexico Business Initiatives
- Suggested Itinerary

| MEMBER INSTITUTIONS               |
|-----------------------------------|
| 1. MIT Space Laboratory           |
| 2. Los Alamos National Laboratory |
| 3. White Sands Test Facility      |
| 4. Sandia National Laboratories   |
| 5. New Mexico State University    |
| 6. New Mexico Tech                |
| 7. Sandia National Laboratories   |
| 8. Sandia National Laboratories   |
| 9. Sandia National Laboratories   |
| 10. Sandia National Laboratories  |
| 11. White Sands Test Facility     |

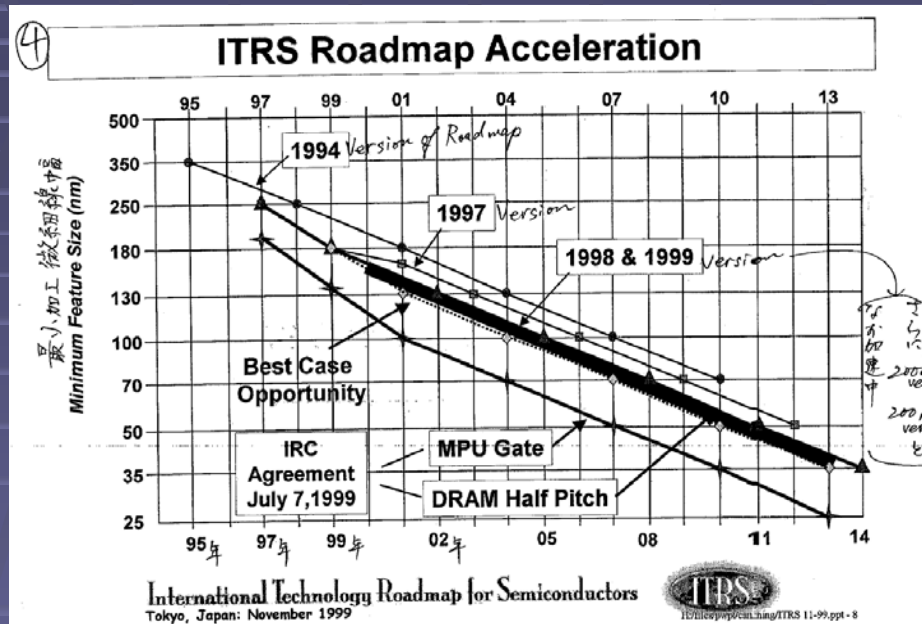


The University of New Mexico



The world's Greatest Science  
Protecting America

# One aspect of ITRS



<http://www.itrs.net/Links/2007ITRS/Home2007.htm>

[http://www.itrs.net/Links/2007ITRS/2007\\_Chapters/2007\\_Lithography.pdf](http://www.itrs.net/Links/2007ITRS/2007_Chapters/2007_Lithography.pdf)

Updated target, time limit and problems are open to everybody alluring investment

# Top mode; Open Innovation

“Open Innovation: Renewing Topline Growth”

Henry Chesbrough

Executive Director, Center for Technology Management  
Haas Business School, UC Berkeley

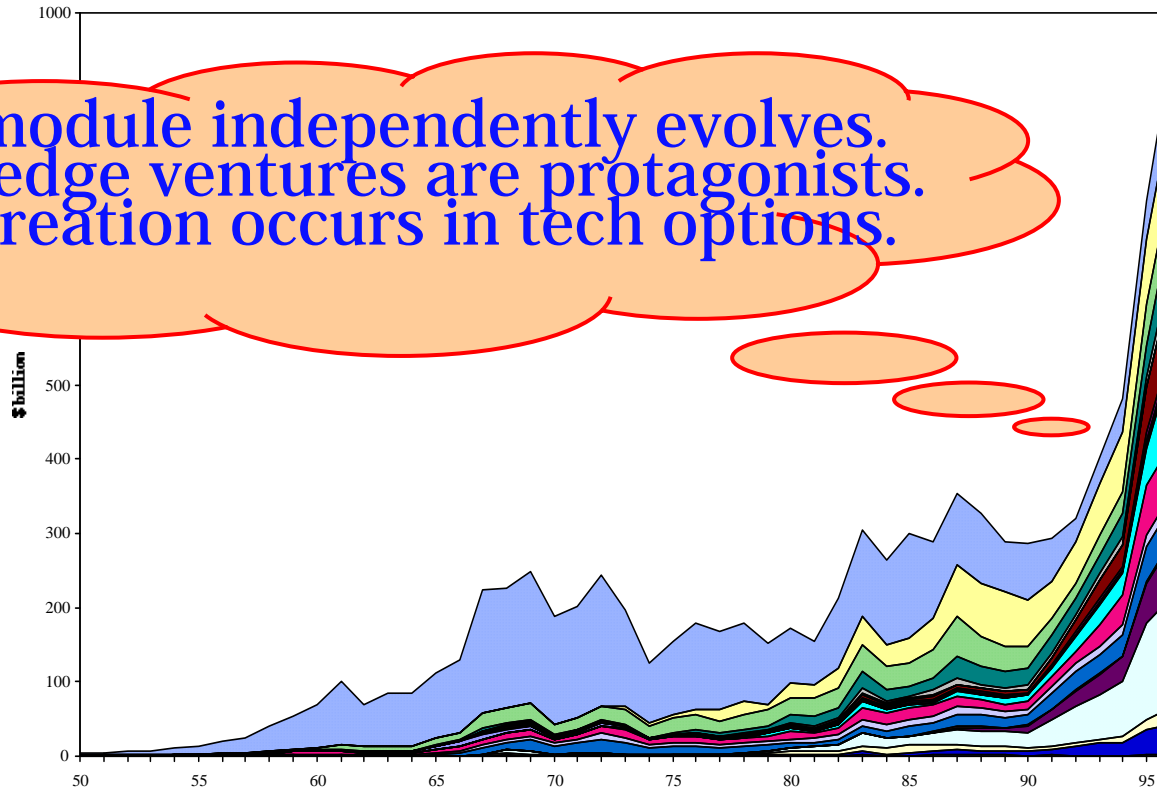
<http://cpd.ogi.edu/MST/capstoneWIN2006/ToplineGrowth.pdf>
















# Value Creation in Modular Industry

## IBM's blue days

Small module independently evolves.  
Cutting-edge ventures are protagonists.  
Value creation occurs in tech options.



# Venture Capital Firms Specializing in Fuel Cell Industry

| Targets   | Outline   |
|---|---|
|     | <p>Polymer electrolyte membrane for high-temperature operation<br/>A spin-off from Hoechst AG</p> |
|     | <p>Fuel cells for emergency power supply<br/>A spin-off from Vodafone</p>                         |
|     | <p>Fuel cells for fork lifts</p>  |
|     | <p>Fuel cells for compact mobiles</p>   |
|     | <p>DMFC (a spin-off from SRI)</p>   |
|   | <p>New-type membrane for DMFC</p>   |
|    | <p>Japanese university venture (Micropump)</p>  |



Shell Hydrogen, Mitsubishi Corp., Johnson Matthey, Danfoss, Solvay 33

# New Funds Investing

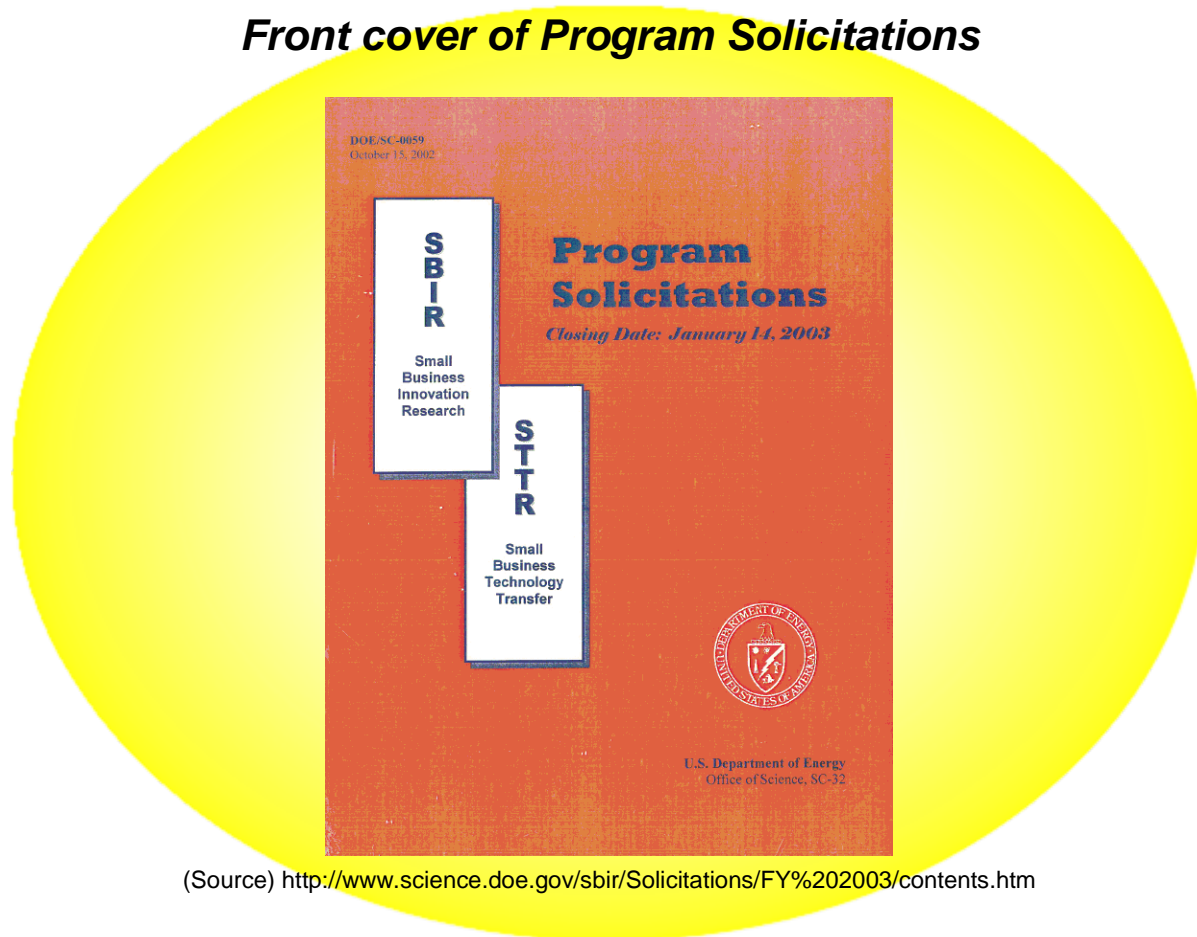
| Recently launched funds         | Geography | Currenc | Size | Tech scope | Lead investor |                  |
|---------------------------------|-----------|---------|------|------------|---------------|------------------|
| Zouk Ventures                   | UK        | Apr-06  | EUR  | 25         | Energy        | N/A              |
| LSP BioVentures (Syngenta fund) | US        | Q1 06   | USD  | 100        | Biofuel       | Syngenta         |
| Dexion Alpha (fund of funds)    | UK        | Q1 06   | GBP  | 130        | New energy    | IPO              |
| Impax Environment Markets       | UK        | Q1 06   | GBP  | 20         | New energy    | New share issues |
| CorStone Capital                | US        | Mar-06  | USD  | 100        | Tech in China | N/A              |
| NW Brown                        | UK        | Q1 06   | GBP  | 25         | SMEs in UK    | UK government    |
| DFJ Element                     | US        | Q1 06   | USD  | 270        | Green tech    | Calpers          |
| Hydro                           | Norway    | Feb-06  | NOK  | 400        | Energy        | Hydro            |
| Kleiner Perkins                 | US        | Q1 06   | USD  | 100        | Green tech    | N/A              |
| <b>Conduit Ventures</b>         | UK        | Q2 06   | EUR  | 100        | H2 & FC       | Shanghai etc     |

# USDOE's SBIR R&D Topics

- In Program Solicitations annually published, the DOE indicates R&D topics eligible for grants by each DOE office.
- For the 2006 version, refer to:

[http://www.science.doe.gov/sbir/solicitations/fy%202006/table\\_of\\_contents\\_sub.htm](http://www.science.doe.gov/sbir/solicitations/fy%202006/table_of_contents_sub.htm)

## Front cover of Program Solicitations



(Source) <http://www.science.doe.gov/sbir/Solicitations/FY%202003/contents.htm>

# New attempt: Strategic Promotion of R&D for Renewable Energy Introduction through Small Business Innovation Research Program

## [What's SBIR and why?]

SBIR is a highly competitive program which encourages small business to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and Japan gains entrepreneurial spirit as it meets its specific research and development needs.

## [Scheme]

Phase 1 (Feasibility study) [up to \$90,000]

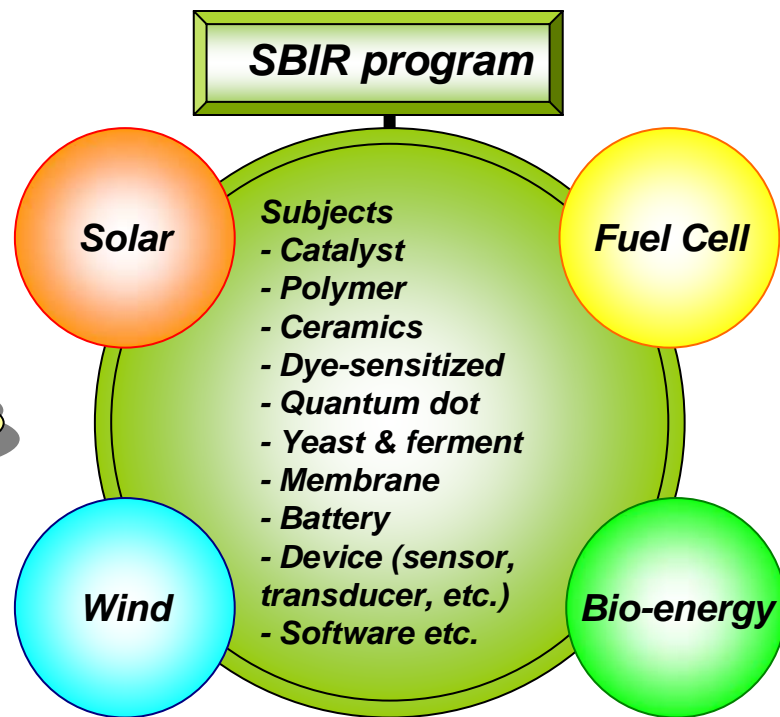
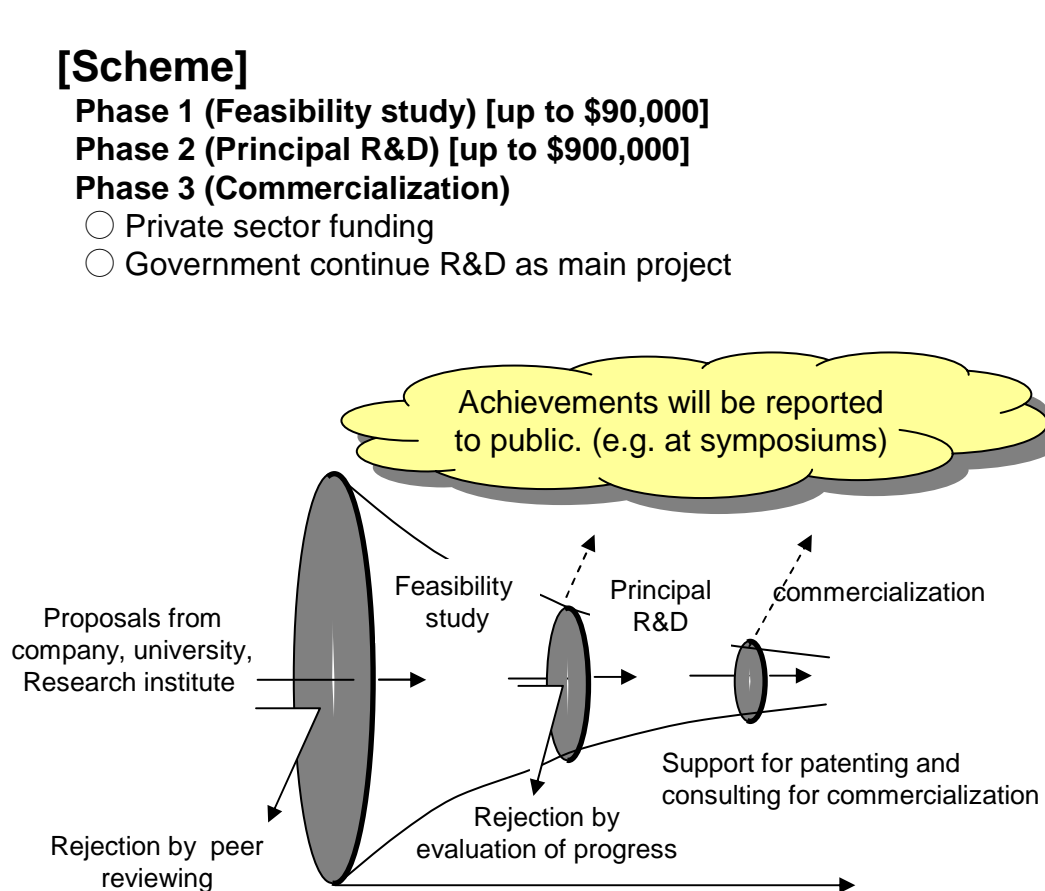
Phase 2 (Principal R&D) [up to \$900,000]

Phase 3 (Commercialization)

- Private sector funding
- Government continue R&D as main project

## [Target and areas]

Small and medium companies, universities, and research group that which have a strong venture-capitalism in the new energy businesses such as solar energy, wind energy, tidal energy, geo-thermal, biomass energy as well as other related technologies for reliable and efficient utilization of new energy such as fuel cell and battery.



These subjects are complementary to main R&D projects for new energy introduction but crucial for innovation and breakthrough for existing status of technology.

# US Top 10 Biopharmaceutical Companies in Sales in 2000 used SBIR in their early stage

| Rank | Company name               | Sales (\$ million) | With/without grants | Established in: | Phase I | Phase II | Title  |
|------|----------------------------|--------------------|---------------------|-----------------|---------|----------|--|
| 1    | Amgen                      |                    |                     | 80              | 86      | 88       | RECOMBINANT DNA-DERIVED PERTUSSIS SUBUNIT VACCINE            |
|      |                            |                    |                     |                 | 89      |          | EXPRESSION   |
| 2    | Genentech                  |                    |                     | 76              | —       |          |  |
| 3    | Serono                     |                    |                     | 06              | —       |          |  |
| 4    | Chiron                     |                    |                     | 81              | 83      | 84       | FEEDBACK CONTROLLED OLIGONUCLEOTIDE SYNTHESIZER PHASE I      |
|      |                            |                    |                     |                 | 85      |          |  |
|      |                            |                    |                     |                 | 85      | 87       | GENETIC ENGINEERING APPROACHES FOR AIDS VACCINES (MICE, RABB |
|      |                            |                    |                     |                 | 85      |          |  |
|      |                            |                    |                     |                 | 86      | 88       | GENETIC ENGINEERING APPROACHES FOR MALARIA VACCINES          |
|      |                            |                    |                     |                 | 90      |          | CYTOMEGALOVIRUS GLYCOPROTEIN B RECOMBINANT ANTIGENS          |
|      |                            |                    |                     |                 | 90      |          | DEVELOPMENT OF A CYTOMEGALOVIRUS SUBUNIT VACCINE             |
| 5    | Biogen                     |                    |                     | 78              | 90      |          | DEVELOPMENT OF A DEFECTIVE HEPATITIS                         |
|      |                            |                    |                     |                 | 86      |          |  |
|      |                            |                    |                     |                 | 86      | 87       | MULLERIAN INHIBITING SUBSTANCE                               |
|      |                            |                    |                     |                 | 87      |          | SOLUBLE MHC MOLECULES TO INDUCE ALLOGRAFT TOLERANCE          |
|      |                            |                    |                     |                 | 87      |          | PRODUCTION OF RECOMBINANT PROTEINS IN MILK                   |
| 6    | Genzyme General            |                    |                     | 81              | 96      | 97       | High Numerical Aperture Scintillating Fibers                 |
|      |                            |                    |                     |                 | 83      |          |  |
|      |                            |                    |                     |                 | 84      |          |  |
|      |                            |                    |                     |                 | 85      |          |  |
|      |                            |                    |                     |                 | 86      |          |  |
|      |                            |                    |                     |                 | 88      | 89       | PURIFICATION OF HIGH MANNOSE OLIGOSACCHARIDES                |
|      |                            |                    |                     |                 | 97      |          | EMBRYONIC STEM CELLS   |
| 7    | Immunex                    |                    |                     | 81              | 86      |          |  |
|      |                            |                    |                     |                 | 86      |          |  |
|      |                            |                    |                     |                 | 88      |          | MOLECULAR CLONING  |
| 8    | MedImmune                  |                    |                     | 88              | —       |          |  |
| 9    | Millennium Pharmaceuticals |                    |                     | 91              | 97      | 98       | NOVEL DRUGS FROM UNCULTURABLE FUNGI                          |
|      |                            |                    |                     |                 | 97      |          | IDENTIFICATION OF FUNGAL DERIVED IMMUNOSUPPRESSANTS          |
|      |                            |                    |                     |                 | 98      |          | GENETIC ENGINEERING OF FUNGAL POLYKETIDES                    |
| 10   | Gilead Sciences            |                    |                     | 87              | 89      |          | RIBOZYME-LIKE ANALOGUES OF OLIGORIBONUCLEOTIDES              |
|      |                            |                    |                     |                 | 92      | 94       | OLIGONUCLEOTIDES BEARING FORMACETAL LINKAGES AGAINST HIV     |
|      |                            |                    |                     |                 | 92      |          | PERMEATION-ENHANCED PRIMER-DISRUPTING ANTIVIRAL AGENTS       |
|      |                            |                    |                     |                 | 92      | 93       | NOVEL INHIBITORS OF THROMBIN                                 |

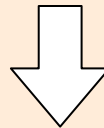
Source:

The ranking in sales was compiled by NRI based on the data available on Contract Pharma and Hoovers Online.

The use of SBIR grants was confirmed on Tech NET, SBA.

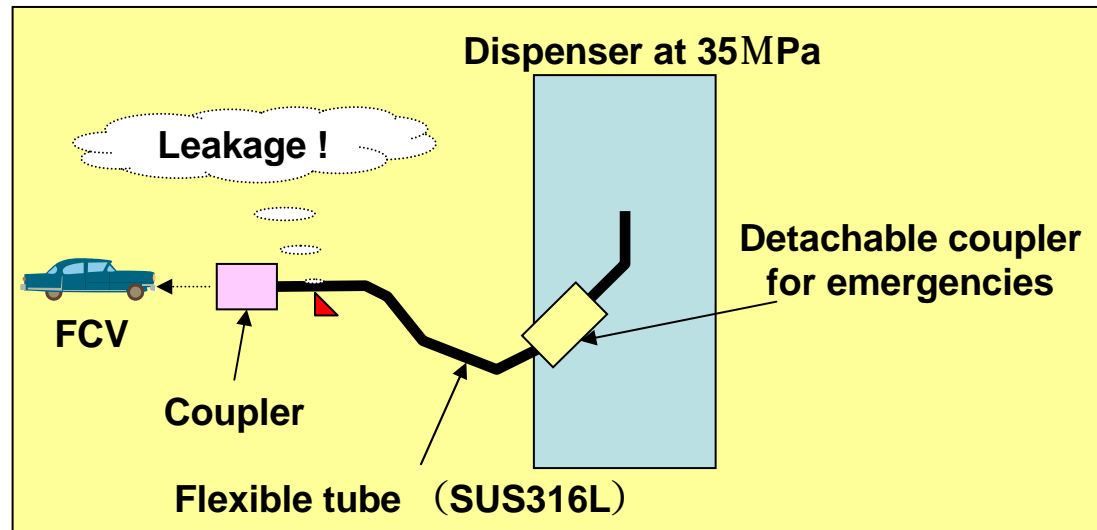
# Trouble in Flexible Tube of H<sub>2</sub> Station during EXPO 2006 in Aichi

**H<sub>2</sub> leakage due to crack in flexible tube of H<sub>2</sub> dispenser  
(the material lasted only 1/10 of its stated lifespan)**



**Leakage attributable to H<sub>2</sub> embrittlement.**

H<sub>2</sub> station at Seto-minami (EXPO 2005)



# A New National Lab. for Hydrogen Material R&D



*In order to realize a hydrogen energy society, a new laboratory **"HYDROGENIUS"** was founded last June, which aims to establish basic technologies to use hydrogen more safely and conveniently.*

- **HYDROGENIUS** was established on June 1, 2006.
- **Budget: 1.67 billion yen for FY2007**

## Organization of HYDROGENIUS



**Director**  
Dr. Murakami, Y.



**Deputy Director**  
Dr. Sasaki, K. (Research)  
Mr. Ogata, T (General Affairs)  
Dr. Yotsumoto, H. (Planning)



### Research teams



Leader  
Dr. Fukuyama

**Hydrogen Dynamics in Metal Research Team**



Leader  
Dr. Matsuoka

**Hydrogen Fatigue and Fracture Team**



Leader  
Dr. Fujii

**Hydrogen Thermophysical Properties Team**



Leader  
Dr. Murakami

**Hydrogen Simulation Team**



Leader  
Dr. Sugimura

**Hydrogen Tribology Team**



# **HYDROGENIUS: Top Scientists from Overseas**



**Prof. R.O. Ritchie**  
University of California,  
USA (2007~)



**Dr. Jean-Marc Olive**  
University of Bordeaux I,  
FRANCE (2006.8.16~)



**Dr. Veronique Doquet**  
Ecole Polytechnique,  
FRANCE (2007~)



**Prof. Dan Eliezer**  
Ben Gurion University of  
The Negev, ISRAEL  
(2006.10.5~10.15)



**Prof. Petros Sofronis**  
University of Illinois at  
Urbana-Champaign, USA  
(2006.6, 2007.1~2)



**Prof. Richard P. Gangloff**  
University of Virginia,  
USA (2007.1~2)



**Dr. Sergiy M. Stepanyuk**  
Paton Electric Welding Institute  
of National Academy of Sciences  
UKRAINE (2007.2.1~)



**Dr. Brian P. Somerday**  
Sandia National Laboratories,  
USA (2007.1~2)

# Advanced Basic Technology for Hydrogen Storage Materials

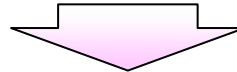
Budget: 0.76 billion yen (FY2007)

Project year: FY2007-FY2011

**Establish compact and highly-efficient hydrogen storage/delivery technology through revolutionary performance improvements of hydrogen storage materials**

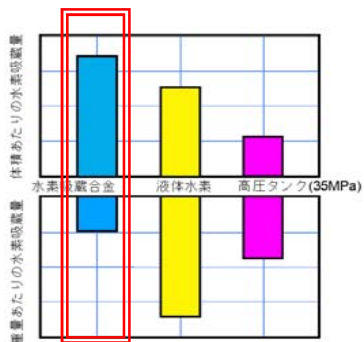
## Background

- Key for Hydrogen Society  
= Establish of compact and high efficient hydrogen storage and delivery technology
- Technology of “hydrogen storage material (metal hydride)” as promising candidate  
**Japan has world-leading technology**
- Key issue is to attain a significant increase of adsorption capacity in hydrogen storage material

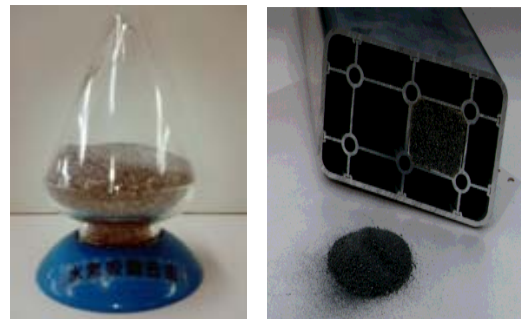


## Project Policy

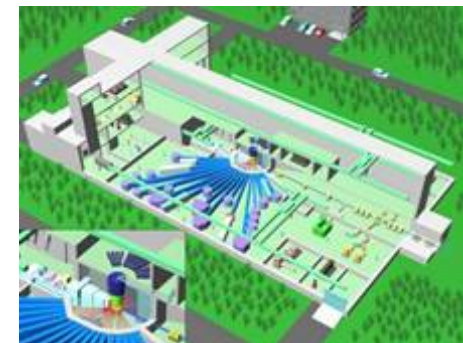
- Intensive R&D through close and flexible network of national laboratories
- Open the rise of new talent or new comers from different fields
- Collaboration with top class laboratories outside of Japan (ex. Los Alamos National Laboratory) in simulation technology  
(High Energy Accelerator such as “J-PARC Project” would be used to analyze the structure of hydrogen storage materials)



[ability of hydrogen storage materials]



[hydrogen storage alloy]



[quantum beam lab. image]

# ***Mr. Nikai, Ex-Minister of METI Visited to LANL (2006.8)***



# Global-Scale Collaboration for the Development of Fuel Cells

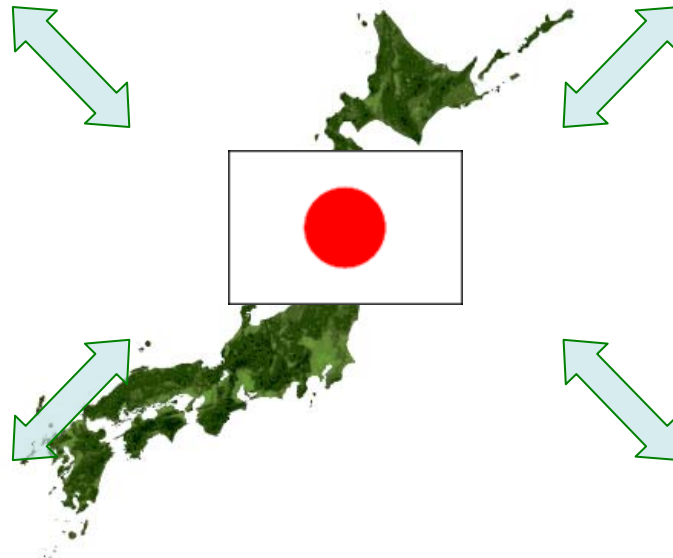
## International Partnership for the Hydrogen Economy (IPHE)

- International cooperative framework for promoting technology development, standardization, and exchange of information concerning hydrogen and fuel cells
- Members: 17 countries/organizations, including Japan



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

- Researchers get together from countries around the world, including the US, France, Ukraine, and Israel



## Polymer Electrolyte Fuel Cell Cutting-Edge Research Center (FC-Cubic)

- Exchange information with the Los Alamos National Laboratory

## High-Performance Fuel Cell Project

- Inviting foreign researchers

## Advanced Research Project for Hydrogen Storage Materials

- Joint research with the Los Alamos National Laboratory
- Hold Japan-China Seminar on Hydrogen Storage Materials

# The World's Largest FC EXPO

February 25 [Wed] - 27 [Fri], 2009

5th Int'l Hydrogen & Fuel Cell Expo

## FC EXPO 2009

第5回 国際水素・燃料電池展

International Exhibition & Conference  
featuring all kinds of technologies,  
equipment and products related  
to the R&D and manufacturing of  
Fuel Cells & Hydrogen

List of FC EXPO 2008 Participants  
(by country/region)

### Europe

- Austria
- Belgium
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Netherlands
- Norway
- Portugal
- Romania
- Russian Federation
- Spain
- Sweden
- Switzerland

### Middle East

- Israel
- Saudi Arabia
- Turkey

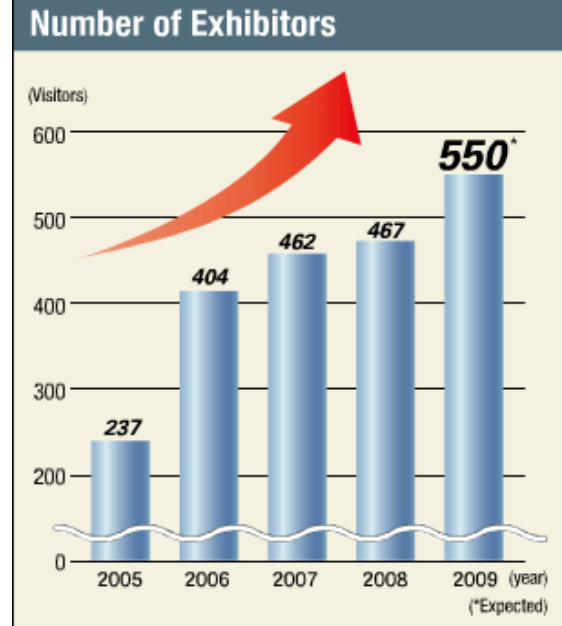
### Oceania

### Asia

- Bangladesh
- Brunei Darussalam
- China
- Hong Kong
- India
- Malaysia
- Philippines
- Singapore
- Sri Lanka
- Taiwan
- Thailand
- Viet Nam

### North/South America

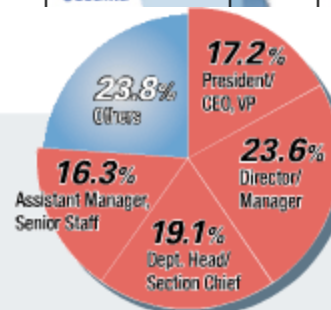
- Canada
- Colombia
- El Salvador
- United States



## Breakdown of FC EXPO 2008 Visitors

**76.2%** of total visitors were decision makers with purchasing authority.

A large number of specialists including CEOs/Presidents, Directors, Managers and Chief Engineers of fuel cell related companies visit FC EXPO every year. Exhibit at FC EXPO 2009 to conduct face-to-face business meetings with key buyers!



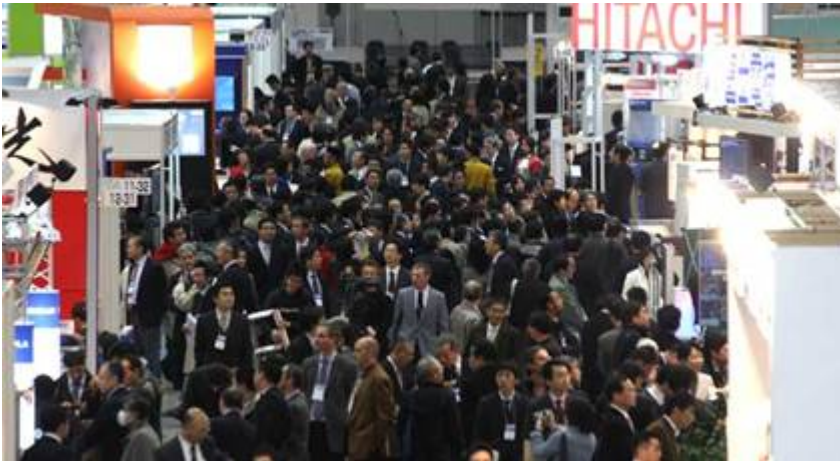
<http://www.fcexpo.jp/>

## Numbers of visitors:

2005 : 20,037  
2006 : 23,039  
2007 : 24,494  
2008 : 24,617

## Numbers of exhibitors:

2005 : 237  
2006 : 404  
2007 : 462  
2008 : 467



**Serious business discussions  
and technical consultations**

**Exhibitions of leading companies from Japan and abroad**



**JHFC Demonstration Project (Fuel Cell Vehicle)**



**FC EXPO Keynote session**

# "Samurais" have just begun battles toward the Hydrogen Economy

## Big challenges to overcome

### Limit of known methods:

Foreseeable innovations as "kaizen," "kanban," etc.

Closed, self-supporting innovation style

Huge amount of R&D costs

### Circumstances:

Rapid innovations in competing technologies like hybrid-cars, heat pump systems

Uncertainty of new infrastructure

### R&D challenges:

Drastic cost reductions

Degradation factors

Hydrogen storage

Durability, etc.

## Self-sustaining innovations in integral architecture

- Collaborative activities in non- & pre-competitive areas
- Alliances with external enterprises
- Robust engineering technology in manufacturing arena



## Scientific breakthroughs and industrial application

- Basic mechanism
- Degradation factors
- Accumulations of scientific knowledge
- Fusing disparate knowledge (Schumpeter's principles)



|   | 2005   | 2010     | 2020   |
|---|--------|----------|--------|
| <b>FCVs</b>                                   |        |          |        |
| Cruise range [km]                             | 300    | 400      | 800    |
| Price compared to ICVs                        | x 20   | x 3-5    | x 1.2  |
| <b>Stationary FC</b>                          |        |          |        |
| Efficiency [HHV, %]                           | 30     | 32       | 37     |
| Durability [hour]                             | 20,000 | 6-70,000 | 90,000 |
| <b>H<sub>2</sub> price [Y/Mm<sup>3</sup>]</b> | 150    | 80       | 40     |



FCV: 5 million



Stationary FC: 10GW



H<sub>2</sub>: 140/Nm<sup>3</sup>

## Expansion from realistic niches

- Tech. marketing
- Mix & match of best modules
- Inversion of modules
- DC applications



## "Destructive" innovation by ventures

- Unprecedented modules
- Unexpected synergies
- Bridge to integrated architecture



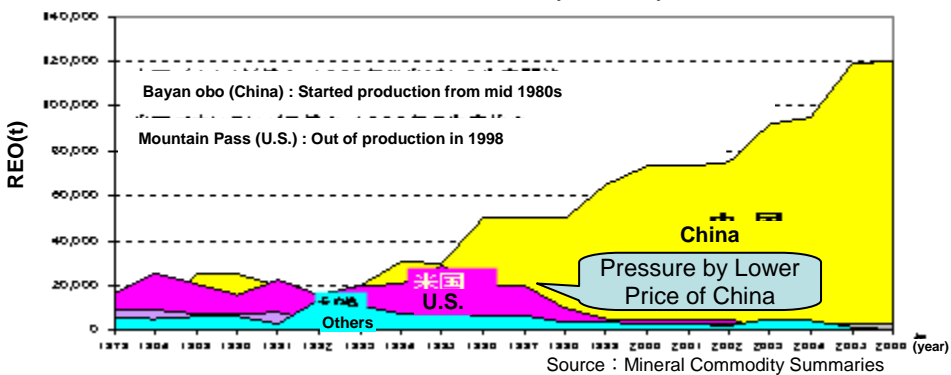
# Outline of the Latest Document of the Industrial Structure Council ① METI

- Resource constraints are internationally becoming severer (Demand growth, drastic rise in prices, conservatism in resource trading)
  - \*The risk is eminent in **“rare metal supply”** which is indispensable with the production process of “High-Tech” commodities such as automobile, digital home appliance and other electronic devices
  - \*Academic reports suggests the possibilities in the shortage of metal source by the year 2050.

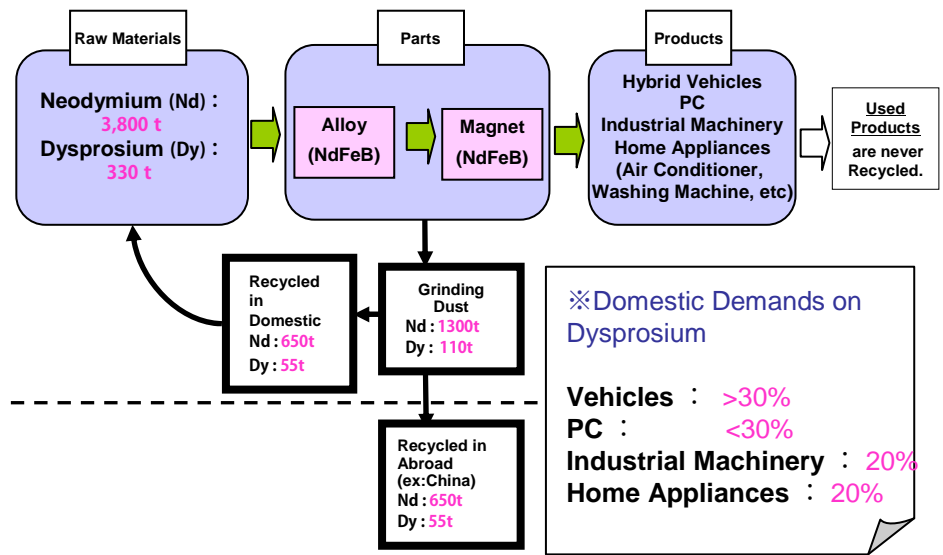
● Escalating Price of Natural Resources (Indium, Neodymium, dysprosium, etc) Compared the figures of 2002's to 2007's, prices are escalating by 4 to 8 times.

|                         |             | Mar/2007 | May/2007 | %    |
|-------------------------|-------------|----------|----------|------|
| Iron Scrap              | US\$/t      | 73.9     | 273.3    | 370% |
| Aluminum                | US\$/ka     | 1.4      | 2.7      | 196% |
| Copper                  | US\$/ka     | 1.6      | 7.4      | 459% |
| Lead                    | US\$/ka     | 0.5      | 2.2      | 441% |
| Indium                  | US\$/ka     | 85.0     | 710.0    | 835% |
| Nickel                  | US\$/ka     | 6.5      | 52.2     | 798% |
| Rare Earth (Neodymium)  | US\$/ka     | 7.3      | 44.0     | 603% |
| Tungsten (Ore)          | US\$/MTU(*) | 35.3     | 165.0    | 467% |
| Rare Earth (Dysprosium) | US\$/ka     | 34.0     | 120.0    | 353% |
| Platinum                | US\$/ka     | 16.517.7 | 41.465.5 | 251% |

● Total Amount of Production of Rare Earth by Country



● Material Flow of Neodymium/Dysprosium



The Industrial Structure Council is...

An official organization that responds to inquiries from the Minister of Economy, Trade and Industry on important topics relating to METI's policy, particularly improving the economic strength of the private sector and promotion of good international economic relations.



Minimization of input by the reduction of production loss and consumption loss

Maximization of the output from natural resources

Ultimate utilization and reduction in the consumption of natural resources

## Achievement of “Most resource-efficient society in the world”

- Promoting the cooperation among whole industrial sectors in product life cycle
- Paradigm shift into “Green” production and social system reducing resources

### “Green Supply-Chain”

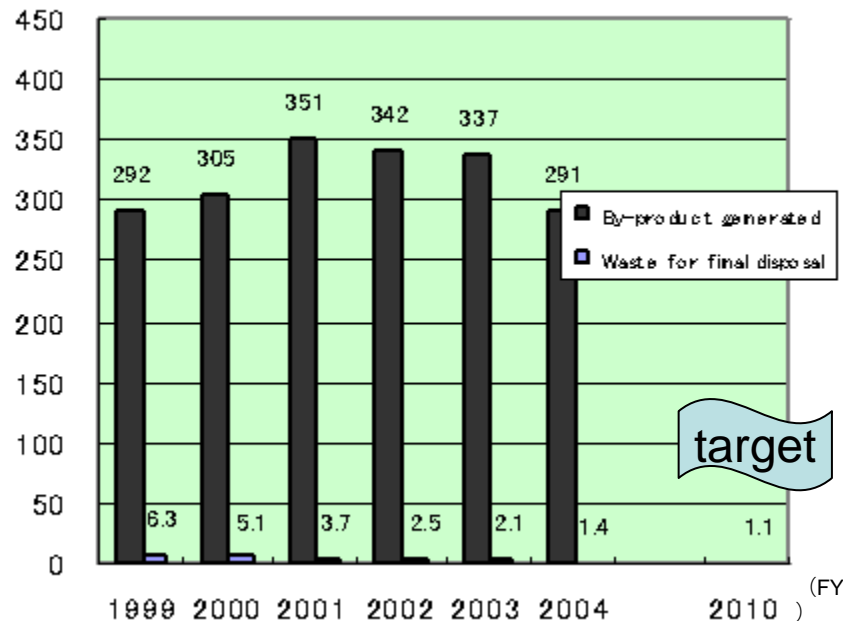
- Integrated approaches with the national policies of stable Rare Metal supply, carbon reduction, and enhancement of industrial competitiveness

# Generation of wastes in Automobile manufacturing / Car parts manufacturing

In the car part manufacturing (which is the middle-stream industry) as well as in the automobile manufacturing, promotion of the 3Rs contributes to the reduction in the amount of final disposal. But generation of wastes are bigger than that of the automobile manufacturing, and going sideways in recent years.

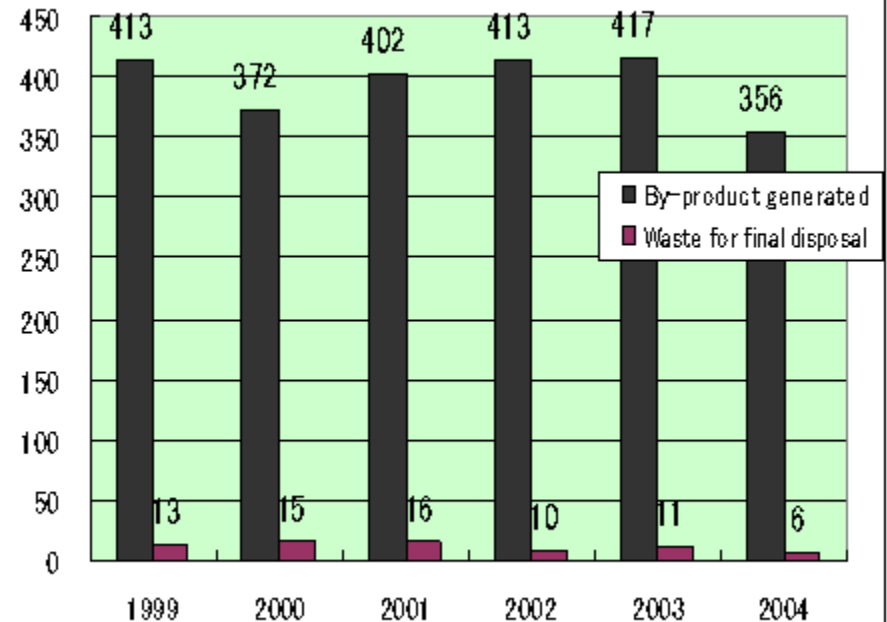
The amount of wastes and their final disposal generated in **automobile manufacturing**

(Unit : 10 thousand ton)



The amount of wastes and their final disposal generated in **Car parts manufacturing**

(Unit : 10 thousand ton)



○ According to estimates of the amount of direct and induced generation of industrial by-products using the input-output table, **the transportation equipment (automobiles, etc.) manufacturers and electrical /electronic (home appliances/PCs, etc.) manufacturers produce a larger amount of induced generation of by-products than direct generation, as well as a large total amount of direct and induced by-products.**

○ It is assumed that **there is much room to further curtail the generation of by-products in the process of production of products with a large supply chains through full optimization in collaboration between upstream/mid-stream firms and downstream firms.**

Amount of direct generation . . .

Amount of by-products generated by downstream firms

Amount of induced generation . . .

Amount of by-products generated in the supply chain of the production of final goods, or in the process of raw materials and parts (upstream/mid-stream)

### ● Amount of direct/induced generation of by-products in different industries (FY2005)

|   | Induced (1)<br>(Unit: ton) | Direct (2)<br>(Unit: ton) | (1) / (2)   |
|---|----------------------------|---------------------------|-------------|
| Precious machinery manufacturers                              | 225,024                    | 48,000                    | 4.69        |
| Other manufacturers   | 344,547                    | 102,000                   | 3.38        |
| <b>General machinery manufacturers (copier, etc.)</b>         | <b>2,831,032</b>           | <b>1,331,000</b>          | <b>2.13</b> |
| <b>Electrical/electronic (home appliances/PCs etc.) (*)</b>   | <b>4,423,768</b>           | <b>2,706,000</b>          | <b>1.63</b> |
| <b>Transportation equipment (automobiles, etc.) (*)</b>       | <b>7,211,252</b>           | <b>5,422,000</b>          | <b>1.33</b> |
| Rubber products manufacturers                                 | 299,757                    | 293,000                   | 1.02        |
| Printing/related businesses                                   | 541,445                    | 536,000                   | 1.01        |
| Textile industry (dye/sorting)                                | 192,994                    | 195,000                   | 0.99        |
| Furniture/accessory manufacturers (metallic furniture/others) | 71,443                     | 102,000                   | 0.70        |
| Chemical industry   | 3,549,650                  | 8,416,000                 | 0.42        |
| Ceramic/clay product manufacturers                            | 321,296                    | 772,000                   | 0.42        |
| Non-steel metal manufacturers                                 | 242,466                    | 757,000                   | 0.32        |
| Plastic product manufacturers                                 | 585,150                    | 1,843,000                 | 0.32        |
| Petroleum & coal product manufacturers                        | 131,785                    | 449,000                   | 0.29        |
| Steel industry  | 853,498                    | 4,198,000                 | 0.20        |
| Pulp/paper/paper product manufacturers                        | 748,714                    | 5,796,000                 | 0.13        |

Source: Estimates based on the survey on industrial waste and by-products with value (FY2005) and the 2005 Input-Output Table (Simple Extended Table/2000 Fixed Price)

# "Greenising" of the Procurement Strategy (Reducing / Cost Down) and Strategy for next-gen. Automobiles

Reduce

Cost Reduction

## Evolution of Japan's favorite Procurement

*Further "Kaizen"*

Next-gen. Strategy

Material-flow Management

### < Possible Case >

- Transforming manufacturer's recent experiences to supplier's
- 3R and CO2 Optimization of materials / process (cutting, forging, casting, sinter, Molding, near-shape etc.)
- **"Greenising" may become key point for further VAVE activities and cost reduction**

### < Linkage to Rare Metal Strategy >

- High performance magnet contained Nd/Dy and alternative materials
- lithium battery electrode contained Li, Co, Mn/Fe related and alternatives
- Reduction/ Substitute (Pt/Rh/Pd/Ru)

### < Fuel Cell >

### < Successful Experiences in other industries >

- Canon: reduce of glass sludge by 80%
- NITTO DENKO: reduce the negative product by 2/3
- Tanabe Pharma: change sludge treatment which contributes to decrease maintenance fee, energy saving, CO2 reduction.
- **These successful MFCA experiences of other industries may contributes to further cost reduction.**

**Cost Reduction / Future Strategy / International Competitiveness**  
**"Greenising"**

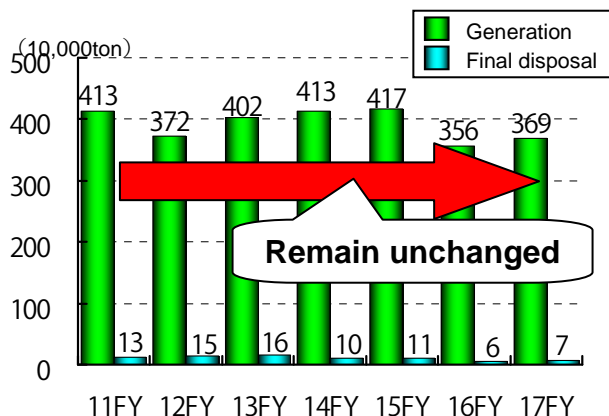
# Strengthen industrial competitiveness by resource-saving design & manufacturing ("New Suriawase version 2.0")

- There are much resource losses in the integral manufacturing industry where Japan has competitiveness. The tough industrial structure is necessary that is not negatively affected by price rises of resources like the rare metals which are indispensable for next-gen. cars (plug-in-hybrids etc.).
- The actions of Japanese companies who seek high qualities promote more generation of resources losses as a result.  
(The reduction of losses is limited by the designs and specs of downstream companies / Process yield becomes unintentionally lower by severe demand of quality)
- Fourfold effect of resource saving / energy saving / CO2 saving / workload reduction (= cost cut) can be realized by downstream companies' considering resource losses in all stages of supply-chain including the upper stage through resource conserving manufacturing.
- Only several pioneering companies have begun to tackle with these resource conserving manufacturing, which does not be generally done by Japanese companies because it may not lead to short-term profit of them.
- By improving related systems, competitiveness of Japanese industry should be increased by "Power of New Integration (Suriawase version 2.0)" again through resource conserving.



- Examination of a legal system to obligate downstream companies to design and procure with consideration of loss reduction in the process of the upstream and mid-stream companies. (For example : cars, home appliances, copying machines)
- "Visualization" of the outputs by the creation of excellent examples.

## ● Resource losses in upstream and mid-stream



## ● Examples of pioneering companies

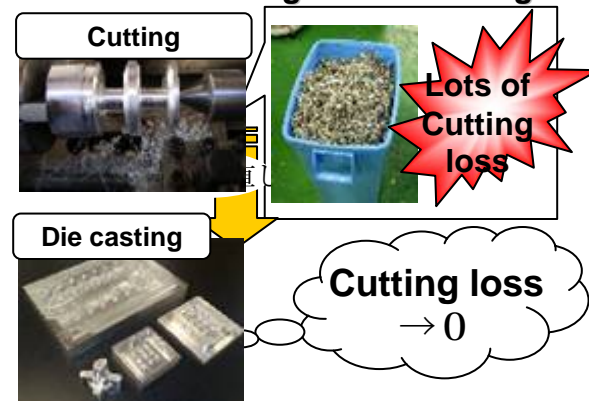
### TOYOTA

- Promoting lightweighting by review of the raw materials and part designs in cooperation with makers of materials and parts. Realizing improvement of the mileage and CO2 saving by the lightweighting.

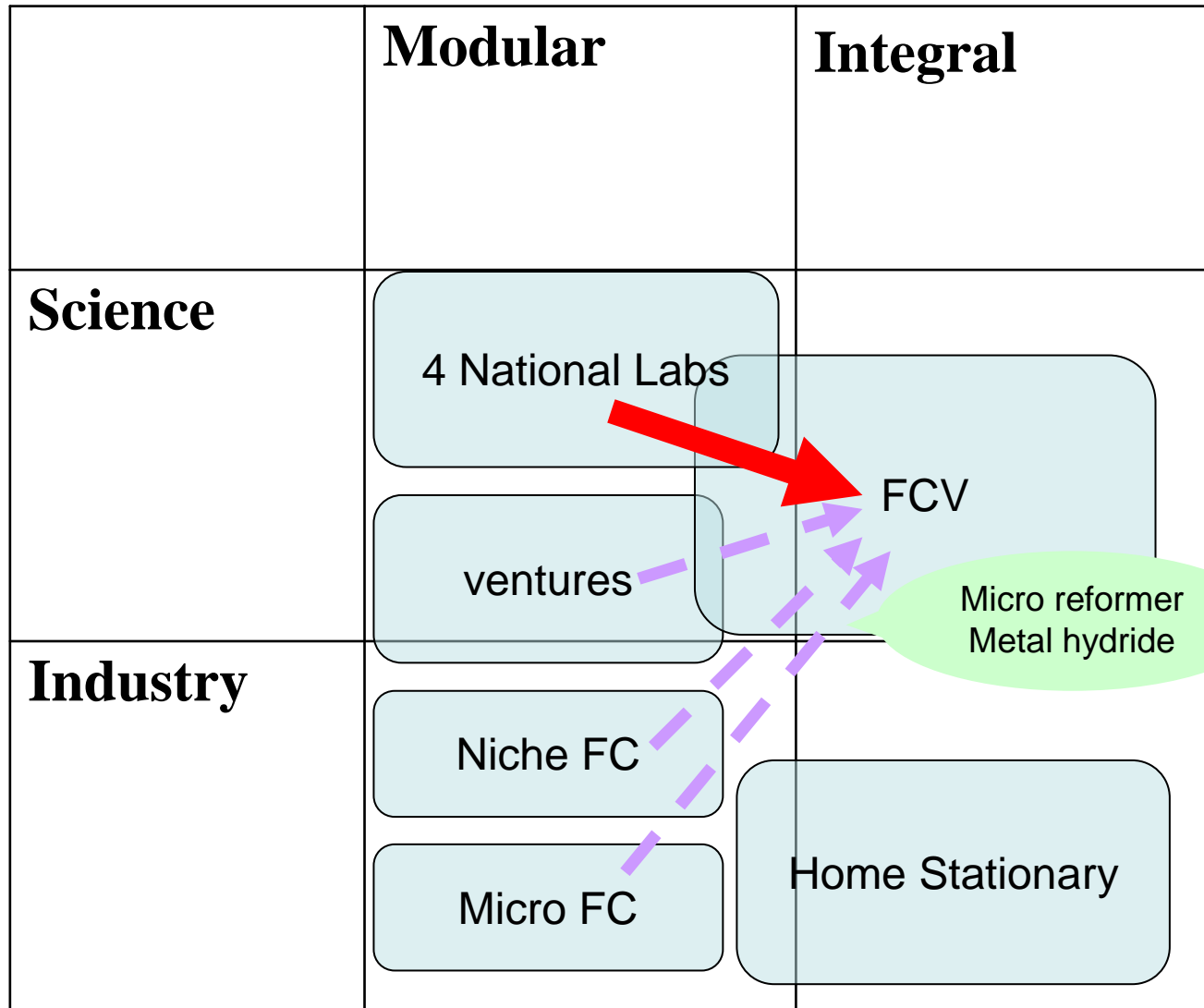
### Ricoh

- Reviewing the product designs which promote environmental load reduction in the part production. (carrying it out in 50 companies, spreading it in about 200 companies in the future).

## ● Examples of reducing losses with resource-conserving manufacturing



# Architecture and Innovation phase



# Options and Progress so far

|             |      |                      |
|-------------|------|----------------------|
| HYDROGENIUS | AAA+ | Superb               |
| Home PEFC   | AAA  | Very Excellent       |
| Home SOFC   | AA+  | Promising            |
| FCV         | AA   | Good; To be improved |
| Hydrostar   | AA   | Just started         |
| HiPerFC     | AA   | Just started         |
| FC-Cubic    | A+   | Last spurt?          |
| Micro FC    | A+   | When Products?       |
| Ventures    | A-   | Waiting new star...  |
| RMFC        | B    | New team?            |
| Niche       | B    | New team?            |

# Innovation management

## Key words

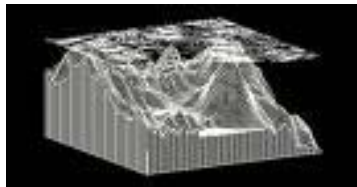
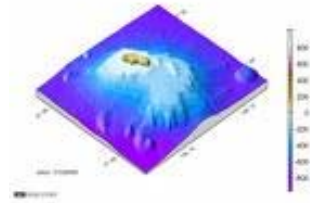
- Passion
- Mission
- Options
- Competition
- Persistency
- Architectural Design
- Open Innovation
- Science-Industry Bridge
- Tangible target
- Samurai Spirit

## Role of Government

- National Focus
- Super neutrality
- Encouragement
- Stubborn support
- Empowerment
- Fair Battle field for competition
- Salon for exchange of information and passion
- Budget allocation (inferior)



# Value Landscape incessantly changes under modular economy



“Der Tag ist Schön auf jenen Höhen.”

“*Design Rules: Power of Modularity*” (C. Baldwin et al., MIT Press, 2000)

# References

- “*Design Rules: Power of Modularity*” (C. Baldwin et al., MIT Press, 2000)**
- “*Mojuru-ka*” (Modularity: the Nature of New Industrial Architecture) (M. Aoki, H. Ando et al., Toyokeizaishinposha, 2002)**
- “*Nihonkeizai Kyosoryoku no koso*” (Japan’s Economy and vision for competitiveness: Modular architectural strategy to challenge in new era of speed) (H. Ando et al., Nihonkeizaishinbunsha, 2002)**
- “*Nenryodenchi Kaihatsu to Mojuru-ka (R&D of Fuel Cells and Modularity)*”, *Akamon Management Review*, AMR 5-9, 2006**
- “*Nenryodenchi Kaihatsu to Architecture (R&D of Fuel Cells and Architecture)*”, *Nenryodenchi Jituyoka heno Chosen (Fuel Cells: Challenge for Commercialization)* (A. Tsutsumi et al., Kogyochosakai, 2007)**