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Science and Technology Foresight on Green Innovation and Future Smart Community in Japan

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Contents

1. Science and Technology Policy and Green Innovation Strategy

Aiming to be an advanced science- and technology-oriented nation

Science and Technology Basic Law
（enacted in 1995）

1st & 2nd Basic Plan（FY 1996-2005）

●**Increase in governmental R&D expenditure**

●**Construction of new R&D system**

- **Doubling of competitive research funds**
- **Promotion of industry–academia–government collaboration**
- **Support plan for 10,000 post-doctoral fellows (including PhD students)**

●**Three basic ideas**

(i) Creation of wisdom
(ii) Vitality from wisdom
(iii) Sophisticated society through wisdom

3rd Basic Plan（FY 2006-2010）

● **S&T Policy Goals**

- Quantum leap in Knowledge Discovery & Creation
- Innovator Japan
- Sustainable Development etc.

- **Our focus for future: stronger emphasis on the role of “Wisdom”**

Nurturing creative S&T personnel

Further reform of S&T systems, leading to higher performance irrespective of Japan’s serious situation due to limited resources

4th Basic Plan（FY 2011-2015）

● **Science, Technology and Innovation**

- **Green Innovation**
  Regeneration from disaster
  For Environment and Energy
- **Life innovation**

●**Basic research and reinforcement to foster S&T personnel**

- **Establish more than 100 research/education centers within the world’s top 50 citations ranking in individual research areas**
- **Major enhancement of graduate school education**

Investment under the Basic Plan
Approx. 25 trillion yen
(Annual investment - over 4% of GDP,
Gov. investment - 1% of GDP)

Green Innovation

- **NEW MARKETS in Green Innovation**
  - ■ **Demand Creation by 2020: ¥50 trillion**
  - ■ **Job Creation by 2020: 1.4 million Jobs**

- **POLICY MEASURES**
  - ■ Rapid increase in renewable energy by introducing feed-in tariff system
  - ■ “Future City” initiative
  - ■ Forest and forestry revitalization plan

Low Carbon Energy Supply - 4th S&T Basic Plan-

- R&D of renewable energy technologies

  solar power, biomass utilization, wind power, small scale hydropower, geothermal power, tidal power, and wave power
- Innovation for distributed energy supply systems

  storage batteries, fuel cells, hydrogen supply systems, superconducting power transmission, smart grids
- Higher efficiency and low-carbon generation in basic energy supply sources

  a zero-emission thermal power generation system where an integrated gasification combined cycle and collection and storage of carbon dioxide are combined, high efficiency thermal power generation, high efficiency petroleum refining, R&D related to nuclear energy

High Efficient and Smart Use of Energy - 4th S&T Basic Plan-

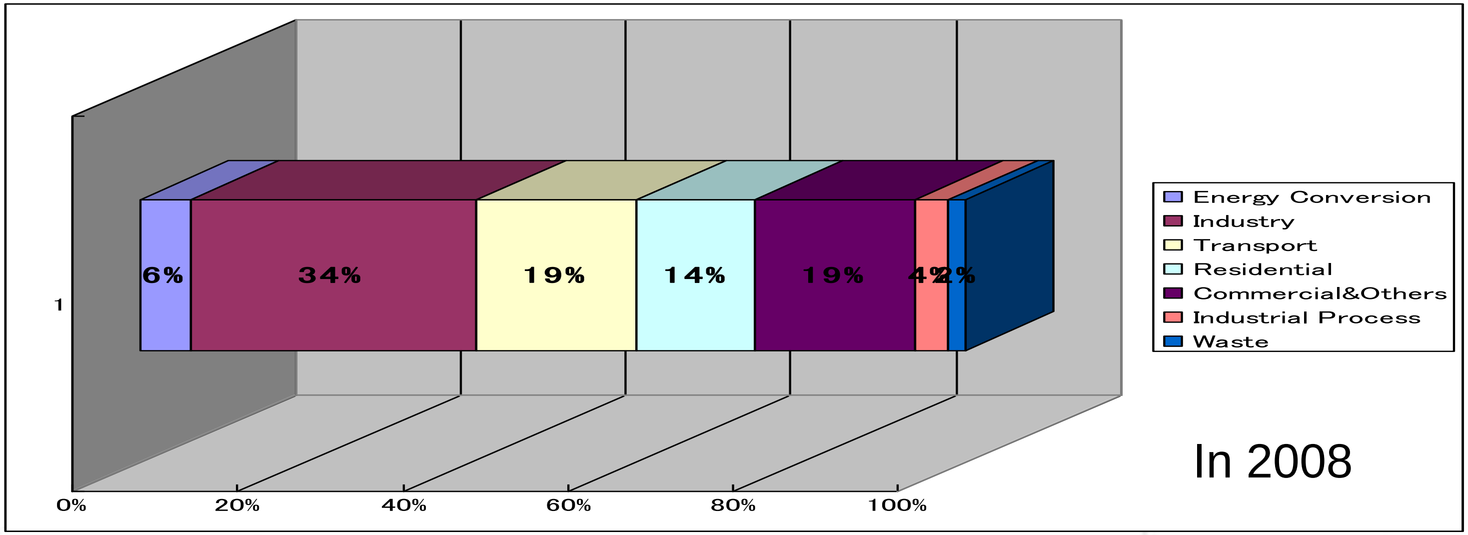
- In manufacturing sectors

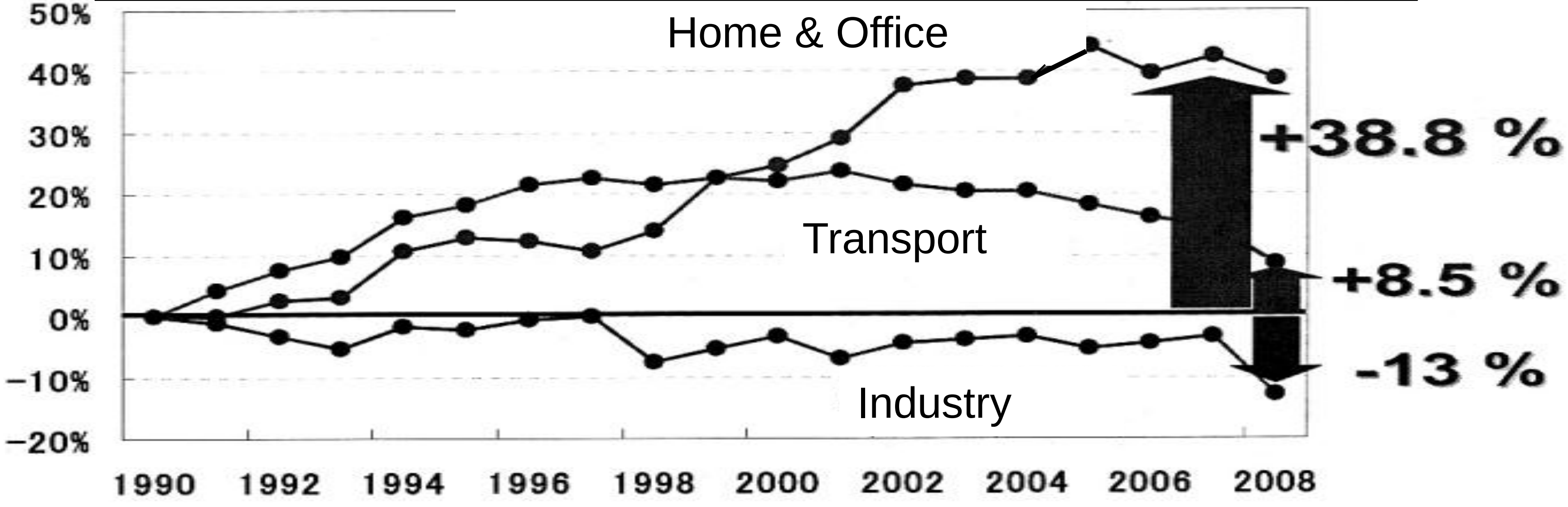
  Innovative manufacturing process in steel production, green sustainable chemistry, bio-refineries, innovative catalyst technology
- In consumer sectors (household and commercial) and transport sectors

  higher grade insulation systems for houses and buildings, stationary fuel cells, more efficient lighting, power semiconductors, next-generation heat pump system, next-generation automobiles
- Information and telecommunication technology

  next-generation IT networks, further energy-savings for IT equipment and system components, optimized control of entire network systems

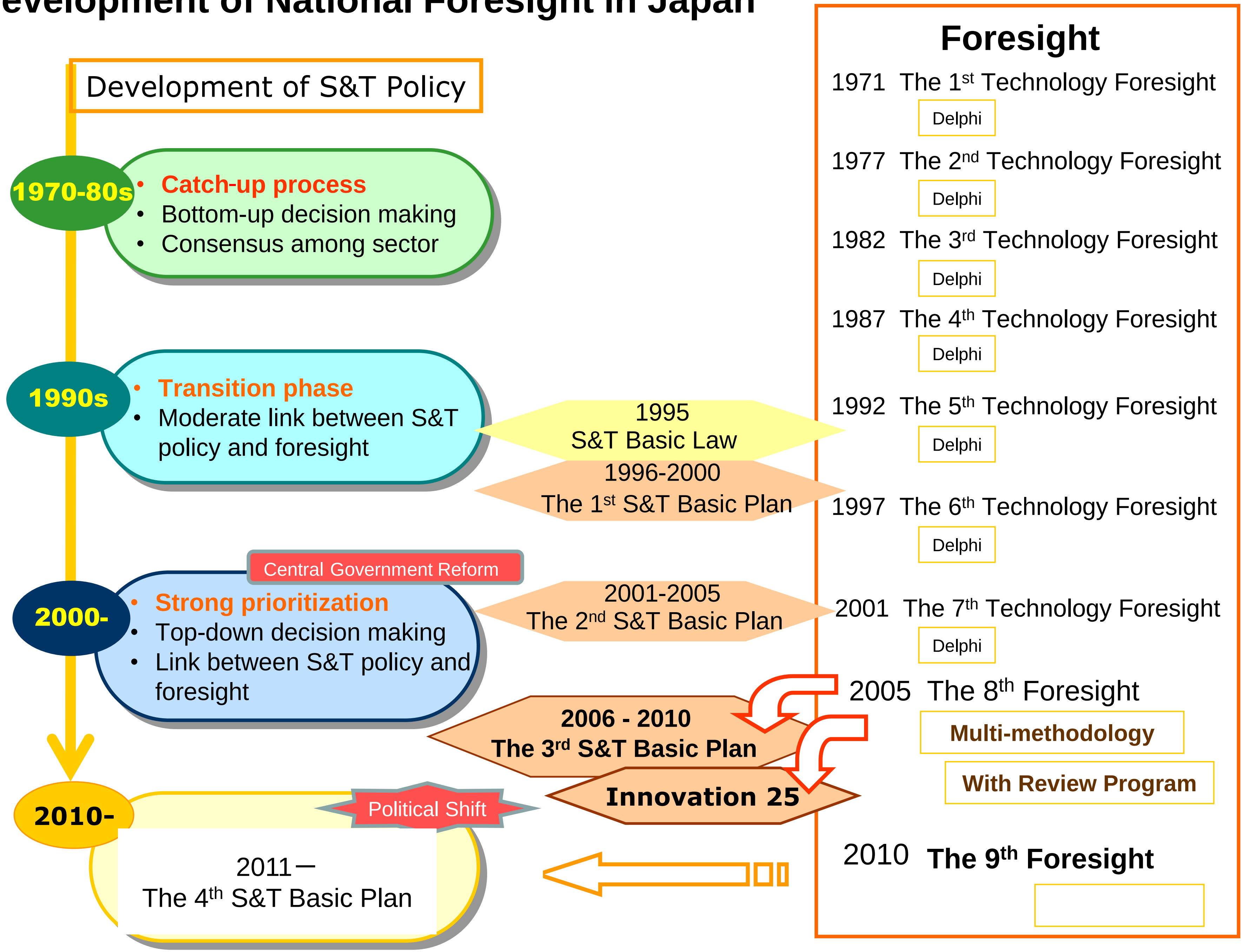
CO_2 Emissions in Japan





2. Science & Technology Foresight on Green Innovation

Development of National Foresight in Japan



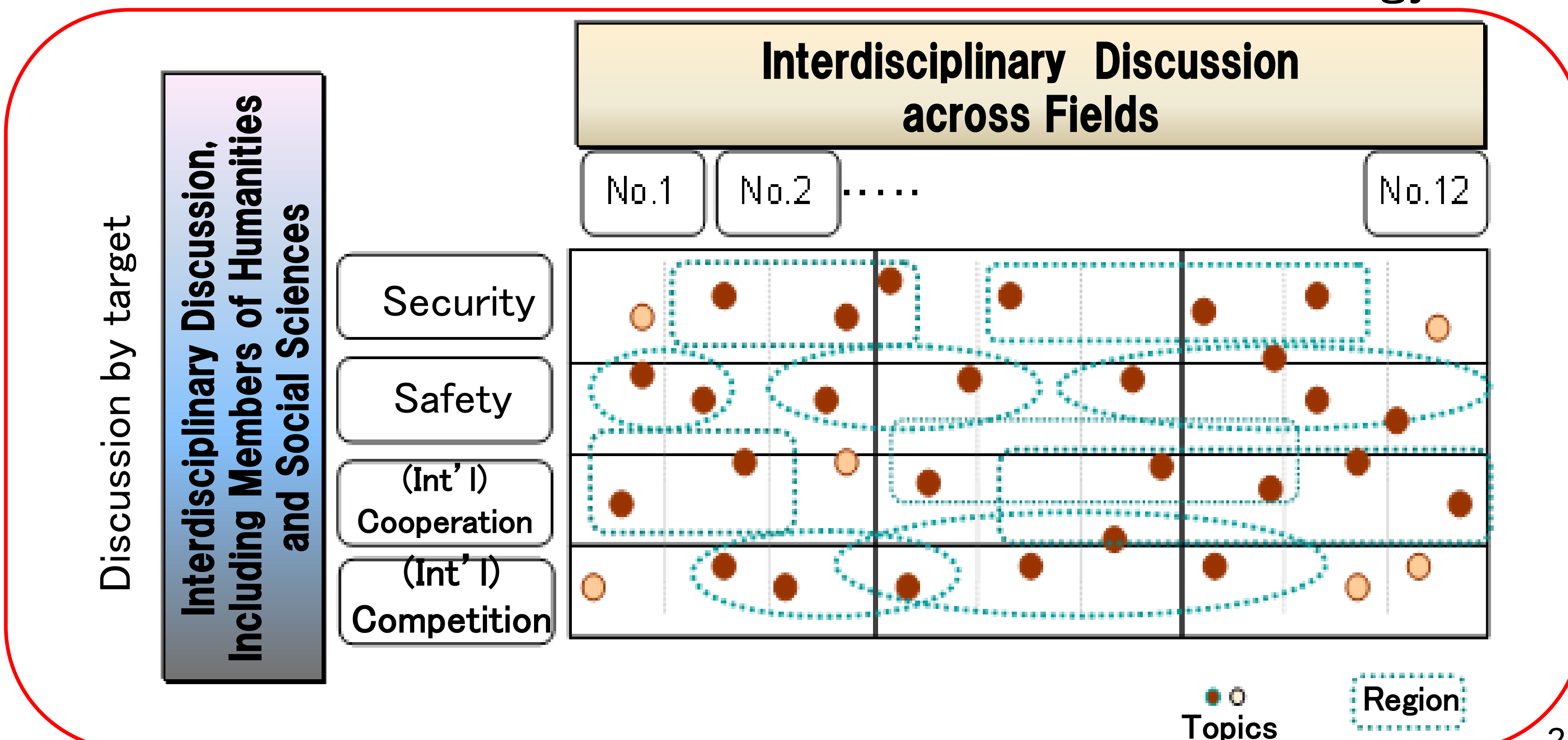
What is Delphi?: "Convergence of Expert Opinions"

- The name "Delphi" is taken from the location of the Temple of Apollo in ancient Greece, where the gods were said to visit the Oracle in order to have their futures told
- Originally developed by RAND corporation in the USA, in the 1950s
- Intuitive (qualitative) and quantitative data gathered: Opinion survey to a large number of experts repeated at least twice
- Encouraged exchange of opinions among experts with respect to convergence
- Useful for long-term foresight, where the opinions of experts are the only available source

Coupling and mixing two types of interdisciplinary subcommittees that extend beyond existing fields

Discussion by 4 Targets + **12 Interdisciplinary Subcommittees**

Cross-Field Discussion of Science and Technology



Delphi Survey - Targets and Technological Themes

Target

- Safety
- (Int'l) Cooperation
- Security
- (Int'l) Competition

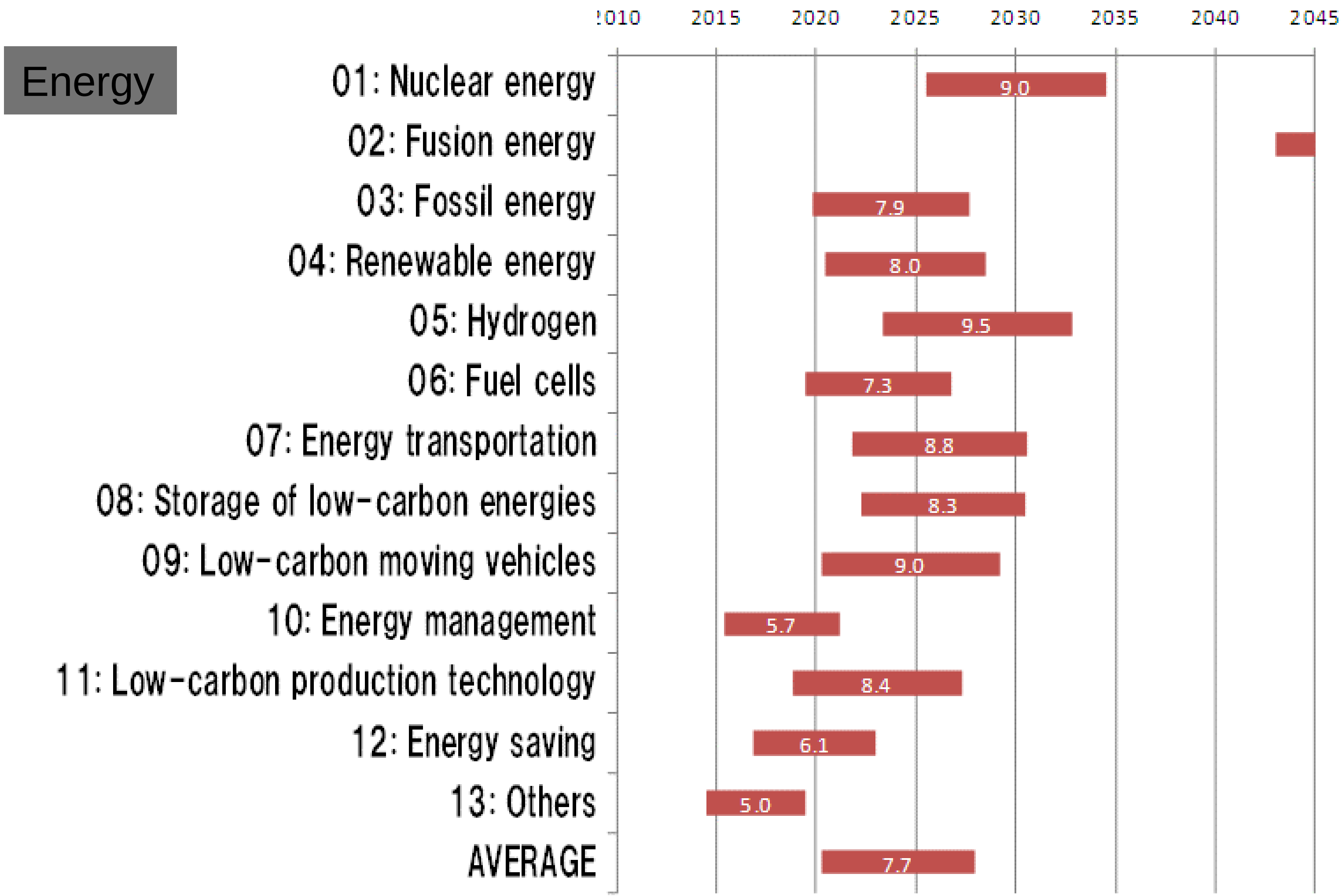
No	Technological theme
1	Fully utilize electronics, communications technology, and nanotechnology in a **ubiquitous society**
2	Expand the scope of discussions on **information processing technology** to the media and contents
3	Link **biotechnology** and nanotechnology, to contribute to human quality of life
4	Make full use of IT to realize people's lives more **healthy**, with highly advanced medical technology
5	Use science and technology to help people understand the dynamism of **space and the earth** and expand the human sphere of activities
6	Make diversified changes in **energy technology**
7	Handle all kinds of necessary **resources**, including **water, food, and minerals**
8	Develop technology to preserve the **environment and build a sustainable recycling society**
9	Develop fundamental technology concerning substances, **materials, nanosystems**, processing and measurement
10	Develop **manufacturing technology** to comprehensively support the development of industry, society, and science and technology in general
11	Place overall subject matters under stricter management, due to advancements in **science and technology**
12	Create **infrastructural technologies** to support infrastructural and industrial bases

Important R&D Items in Energy Field (Top 10)

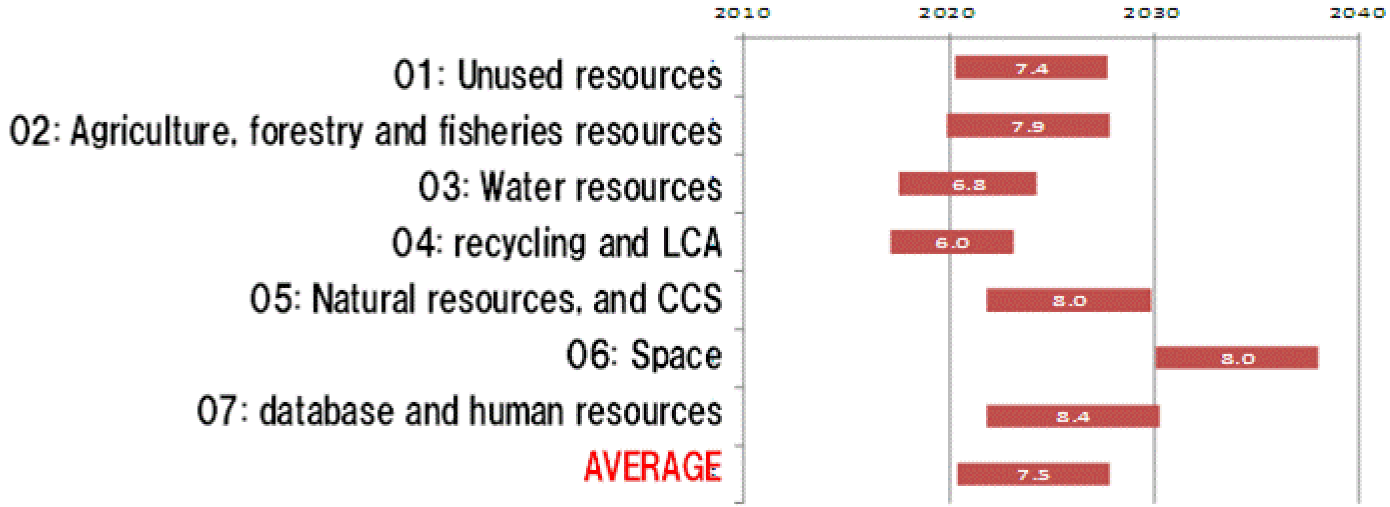
R&D Item	%	Technological Realization	Social Realization
Safe and rational decommissioning technology of commercial LWRs	100	2020	2028
Wide-area thin solar battery with more than 20% efficiency	98.9	2019	2027
Next-generation high-efficiency lighting with more than 150lm/W (LED, organic EL, etc.)	98.6	2018	2023
Fast-breeder reactor cycle technology	97.7	2029	2038
Low-cost secondary battery for automobiles (>100 Wh/kg, >2,000 W/kg, <¥30,000/kwh,)	97.7	2019	2025
Land-disposal technology of high-level radioactive waste	96.9	2022	2034
Super-high-efficiency heat pump for houses (COP > 8 for AC, COP > 6 for boiler)	96.9	2017	2022
Next-generation light water reactor technology (more than 5% LEU fuel, plant life of 80 years)	96.8	2026	2034
New material technology with higher energy conversion efficiency than Si/Ga-As batteries	96.8	2021	2029
Large-scale combined-cycle power generation using high-efficiency gas turbine (>1,700℃)	96.6	2018	2025

Results

Technological Realization Time and Social Realization Time



Resources



Environment

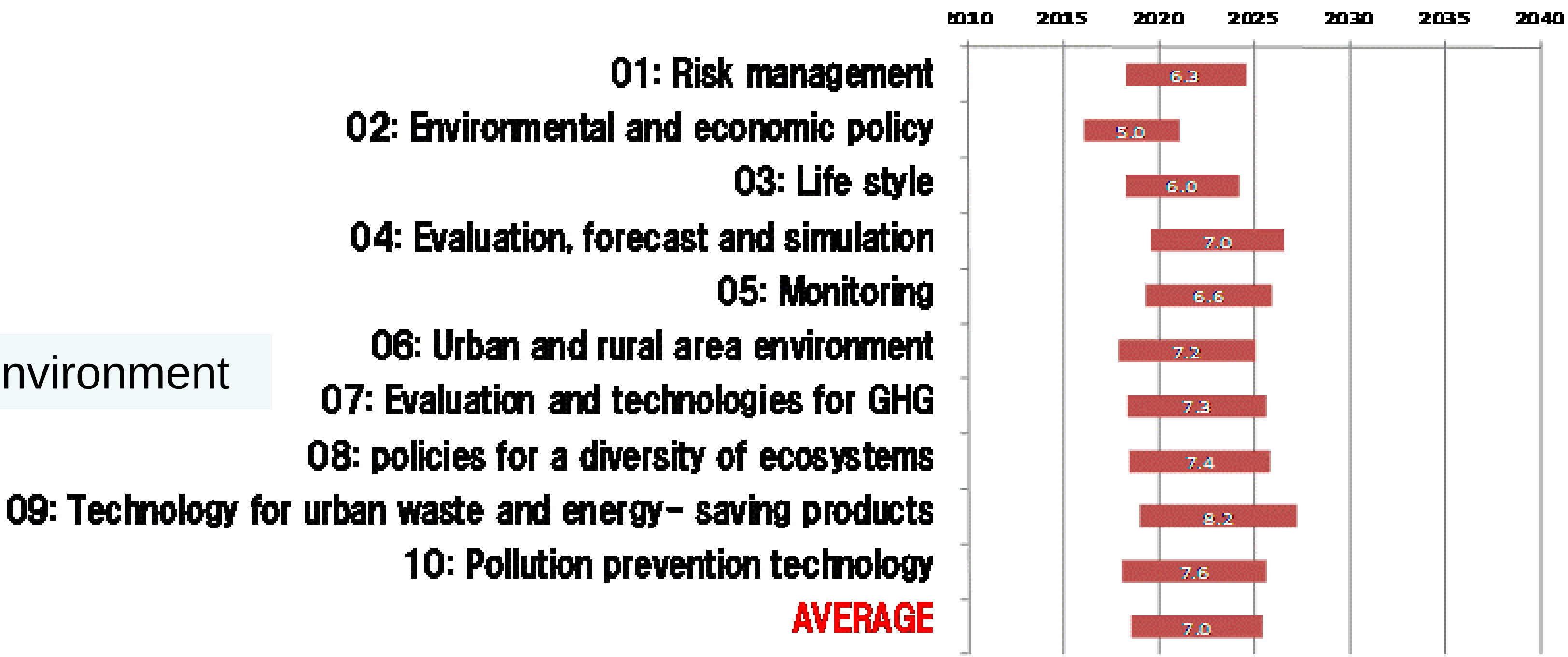


Illustration of Better Life around 2025, Based on the 9th Delphi Survey*

People will use a variety of energy sources selectively, based on their own values; they will actively participate in activities related to environmental protection and the prevention of global warming.

Microgrid technology that optimizes power supply through distribution power network communication, control and management technology, and telecommunications(2020)

Next generation energy transmission and distribution network technology enabling stable, low-cost and low-carbon power supplies, through the optimal management of the entire supply-and-demand balance of large power supplies, by utilizing information and communications technology (ICT).(2025)

A high-quality electricity supply system where natural energy sources are sufficiently utilized .(2026)

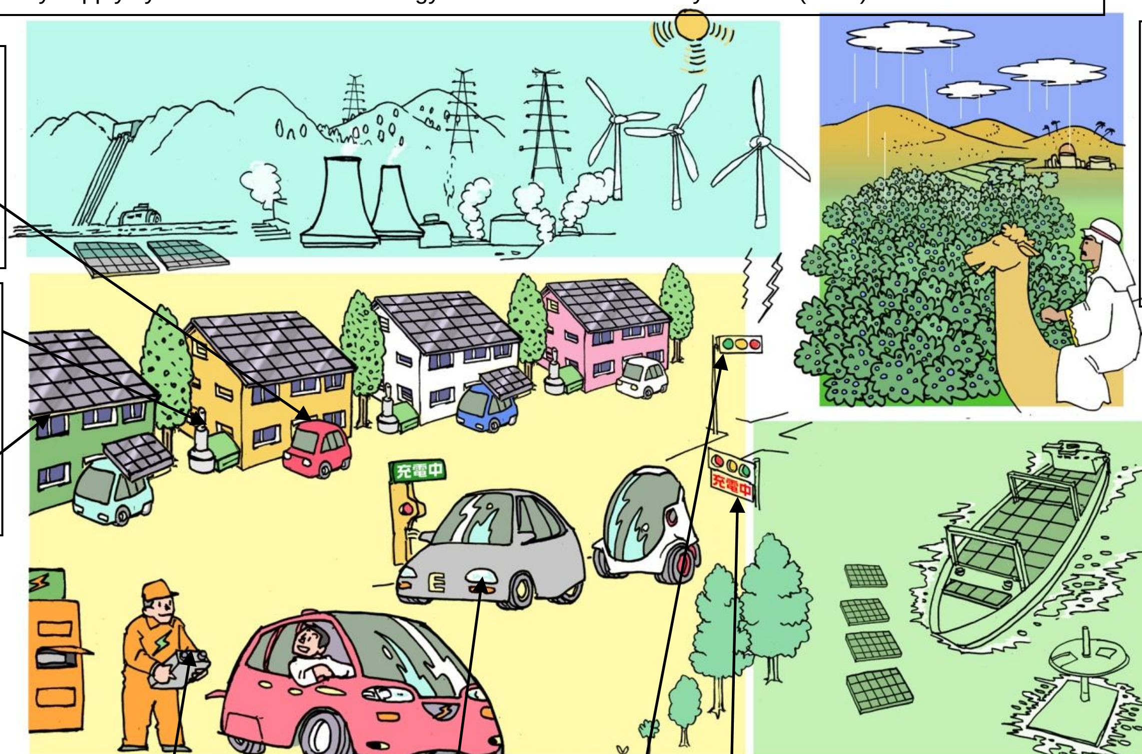
*Figures in parentheses show years when experts predict that technology will be applied in the real world.

A supply-and-demand control system for customers and a distribution system by using batteries for Plug-in Hybrid Electric Vehicles (V2G).(2022)

A micro turbine cogeneration system featuring ultra-lean combustion for high efficiency, enhanced pressure ratio for high power and downsizing, and low-NOx combustors.(2023)

Spread of a residential energy system integrating renewable energies such as solar cells and fuel cells.(2019)

Construction technology for energy-autonomous buildings enabling the use of natural energies, natural ventilation, natural lighting, rainwater, groundwater and other natural resources.(2020)



New technology for vegetation regeneration in deserts.(2029)

Improvement of quality of life for inhabitants of desert and semiarid areas based on the promotion of land use techniques that secure adequate food production.(2030)

A large-scale thin-film solar cell with a conversion efficiency of 20% or higher.(2027)

Power generation technology based on one of the ocean energy resources.(2030)

Low-cost secondary cells for vehicles (2025)

Electric vehicle battery technology with high energy (2025)

Successive contactless charging technology that charges electric vehicles and/or hybrid vehicles when they are parked at public parking lots and/or stopped on roads and at intersections.(2023)

Promotion of vehicles that control the speed and operation of the engine to minimize fuel consumption by detecting the timing of traffic signals, as well as a traffic control system enabling the operation of such vehicles.(2025)

3. Future Energy Policy and Smart Community

Tsunami wave strikes Fukushima Nuclear Power Plant on March 11, 2011

無人飛行機がとらえた福島第一原発のすさまじい破壊ぶり。上から１、２、３、４号機（３月24日、エア・フォート・サービス提供）

Fukushima Daiichi
Nuclear Power Plant (4696 MW)

	No.1 Unit	No.2 Unit	No.3 Unit	No.4 Unit	No.5 Unit	No.6 Unit
Capacity (MW)	460	784	784	784	784	1100
Operations Started from	1971	1974	1976	1978	1978	1979
Status in March 11	Operation	Operation	Operation	Shutdown	Shutdown	Shutdown
AC Power	Lost	Lost	Lost	Lost	Lost	Lost
Emergency power	Lost by tsunami	Lost by tsunami	Lost by tsunami	Lost by tsunami	Lost by tsunami	Safe
Sea water pump&Motor	Broken by tsunami	Broken by tsunami	Broken by tsunami	Broken by tsunami	Broken by tsunami	Broken by tsunami
Injection date of water from line for extinguishing fire	March 12 5:30	March 14 19:54	March 13 9:25	No	No	No
Hydrogen explosion	Hydrogen explosion March 12, 15:36	No	Hydrogen explosion March 14, 11:01	Explosion March 15, 6:00	No	No
Fuel in core	Meltdown	Meltdown	Meltdown	None	Safe	Safe

Reasons why Fukushima nuclear accident occurred

- TEPCO (Tokyo Electric Power Company) and NISA (Nuclear and Industrial Safety Agency) had recognized that the cores of the nuclear reactors could be damaged if a tsunami higher than the ground level of the nuclear plant occurred, but no action was taken because of the interference with the plant operations, inducing concern over plant safety among residents, and weakening their stance in potential lawsuits,
- Guidelines from the Cabinet Office's Nuclear Safety Commission stated that power companies need not consider a situation where all electric power is lost for an extended amount of time because the probability was so small and other measures were in place.
- After the Sept. 11, 2001, terrorist attacks on the United States, the U.S. government required power companies to prepare for the potential loss of all electricity. NISA did not adopt similar requirements.

Electricity Saving in summer 2011 and 2012

- In 2011, a legally mandated 15% cut was put in place from July 1st (until the beginning of September) due to expected power shortages after the March 11, 2011 disaster.

- Instructions for all home users
  - If there is 10% electricity to spare
    - continue normal energy saving.
  - If there is 6% electricity to spare
    - turn off air conditioners.
  - If there is 2% electricity to spare
    - turn off televisions and air conditioners and unplug personal computers.

- In fact, more than 20% saving in electricity was realized by the efforts of factories and home users.

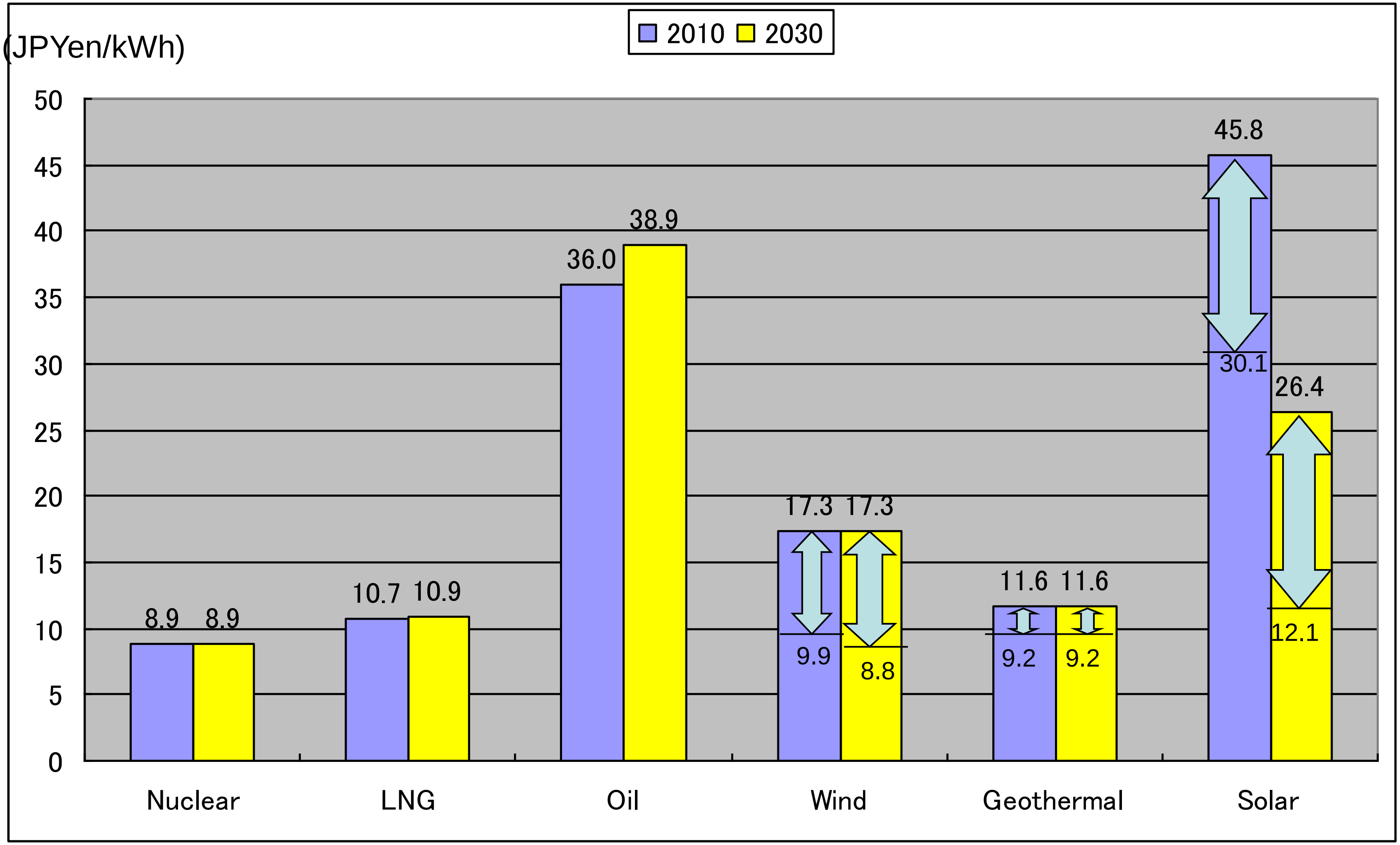
- In 2012, a 3% to 10% cut was put in place in some local areas of Japan in summer.

Lighting in Japan

(NASA)

Quantum of light such as illumination used by one person in Japan is about 40% more than that in Europe.

Estimating the future costs of power generation



Recent Progress on Shale Gas

- It used to be difficult to mine shale gas because it is confined in hard shale.
- In 2005, technology for breaking down the hard, deep-strata bedrock using water pressure was developed and put into practical use.
- As a result, in the United States, production of shale gas has been sharply increasing in Pennsylvania and Texas, to the extent that, by 2009, the United States had overtaken Russia as the world's leading producer of LNG.
- Shale gas is widely distributed in North America, Europe, China and Australia. Combustion of LNG produces significantly less carbon dioxide emissions than burning heavy oil or coal.
- Japan is already the world's largest importer of LNG. Its LNG sources include Malaysia, Australia and Indonesia. And Japan is planning to increase LNG imports from the U.S. After obtaining approval from the U.S. Energy Department, it plans to begin importing the gas as early as 2015.

Fixed purchase cost of renewable energy (July, 2012)

Proposed purchase prices (per kilowatt-hour)

Power sources	Purchase prices	Purchase prices requested by industry
Large-scale solar power	¥42	¥42
Wind power	¥23.1	¥22-¥25
Small wind power	¥57.75	¥50-¥55
Geothermal power	¥27.3 (above 150,000 kilowatts)	¥25.8 (at about 30,000-kilowatt level)
Small or midsize water power	¥25.2-¥35.7	¥24-¥34.06
Biomass	¥13.65-¥40.95	¥14.5-¥39

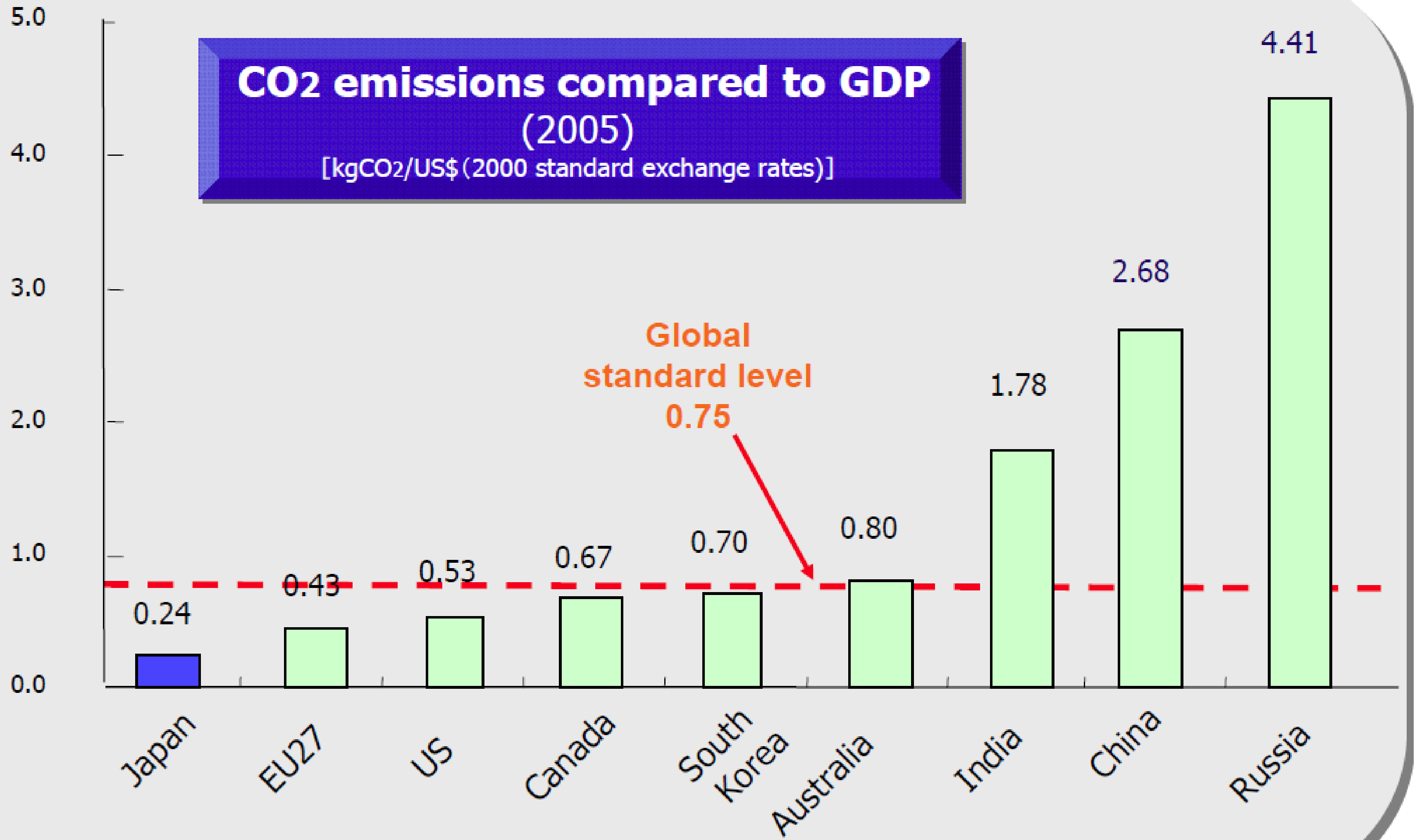
Impact of overseas production

- Overseas production rate of Japanese companies

  23% (in 2000) ⇒ 31.8% (in 2010)
- If the overseas production rate increases by 1%, the number of employees in domestic industries will decrease by 280,000.

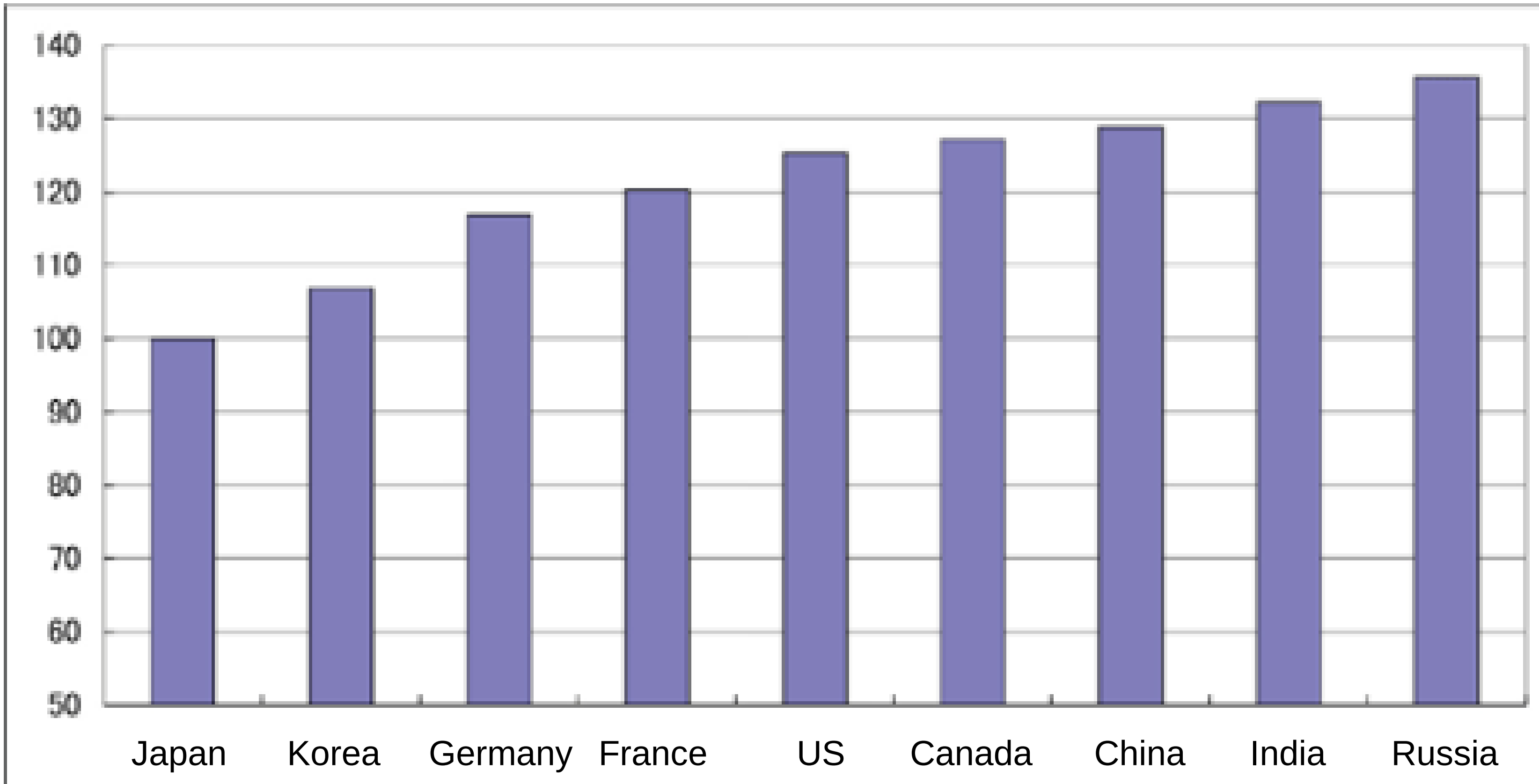
(estimate by Daiichi Life Economic Research Institute)

Expanding Advanced Technologies to Reduce Global Emissions



Source: IEA (2007), "CO_2 emissions from fuel combustion 1971-2005"

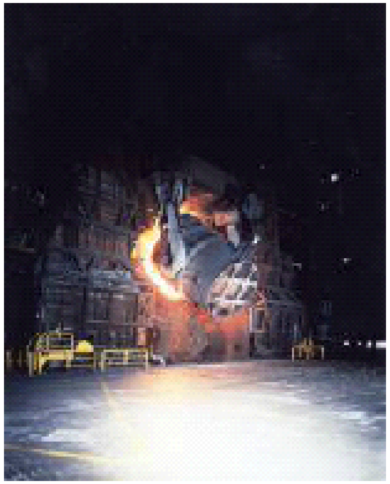
Energy consumption/unit production in steelmaking in 2000 (Japan = 100)



(NISTEP)

Cutting 30% of CO_2 through Innovative Steel Manufacturing Processes

Approximately 6% of total global CO_2 emissions were emitting from the steel sector (2005) * according to IEA calculations



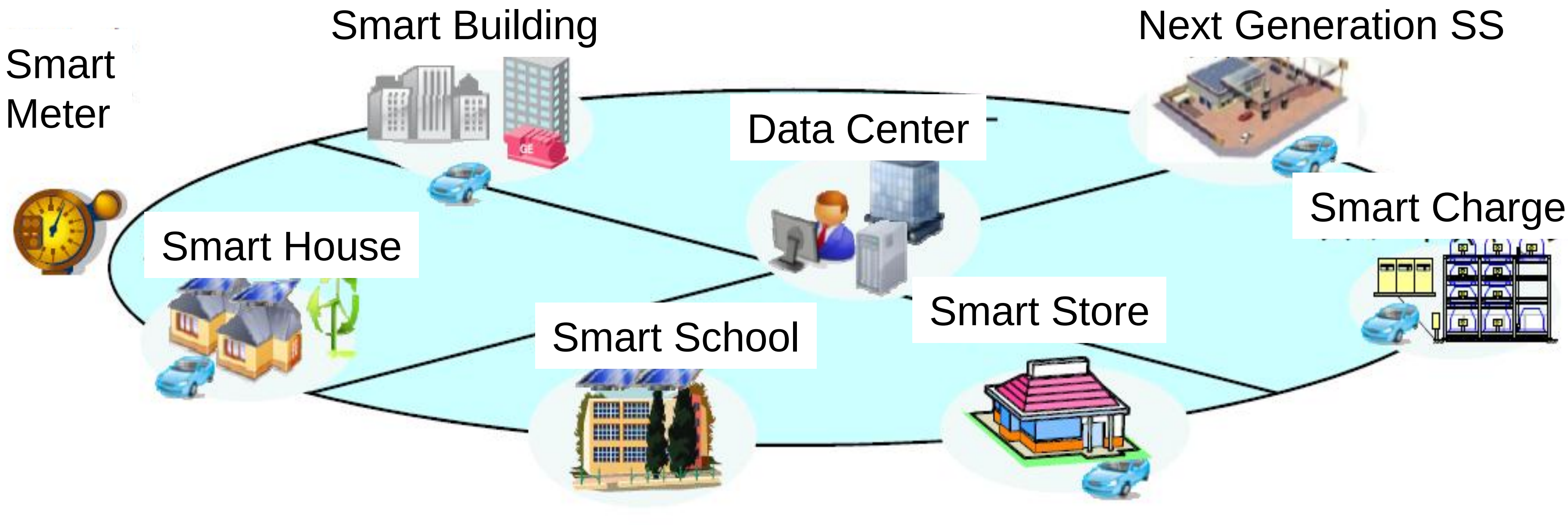
- Development of innovative steel manufacturing technology using hydrogen as a reducing agent, as a partial substitute for coke
- Technology for separation/capture generated from blast furnace

- We can cut CO_2 emissions by approximately 30% through a combination of these two technologies

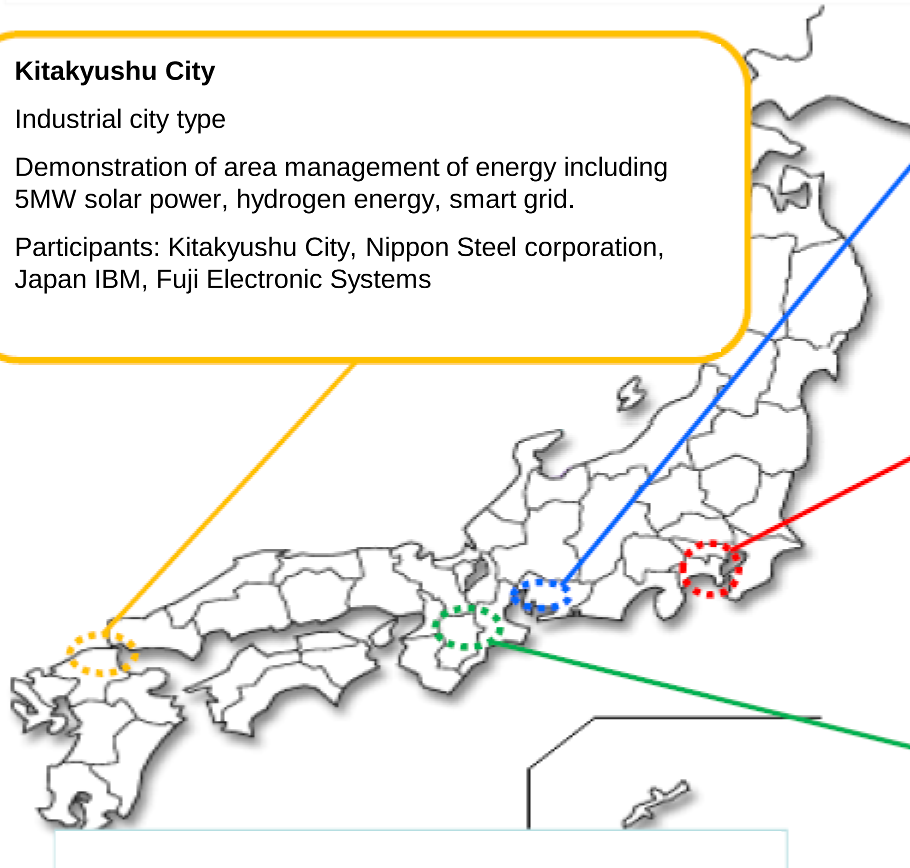
Annual Power Consumption at a standard house (3LDK) in Japan

	Latest model	5 years ago
Lighting	432 kWh	1,646 kWh
Air conditioner (L) x 1	1,255 kWh	1,336 kWh
Air conditioners (S) x 2	1,520 kWh	1,800 kWh
Refrigerator x1	230 kWh	830 kWh
Washing Machine x 1	243 kWh	894 kWh
Personal Computers x 2	12 kWh	44 kWh
Televisions x 2	90 kWh	234 kWh
TOTAL	**3,782 kWh**	**6,784 kWh**

Image of Smart City



Four Smart Community Demonstration Areas in Japan



Kitakyushu City

Industrial city type

Demonstration of area management of energy including 5MW solar power, hydrogen energy, smart grid.

Participants: Kitakyushu City, Nippon Steel corporation, Japan IBM, Fuji Electronic Systems

Toyota City

Local city based on everyday living

Effective use of energy including low-carbon transportation system (3100 next generation vehicles), .

Participants: Toyota City, Toyota, Denso, Chubu Electric Power, Toyota Home, Fujitsu, Sharp, etc.

Yokohama City

Major city, large- scale

27 MW solar power, 4,000 smart houses, 2,000 next generation vehicles

Participants: Yokohama City, Accenture, Toshiba, Nissan Motors, Panasonic, TEPCO, Tokyo Gas, Meidensha

Keihanna Eco City

Academic Research Town based on new technologies

Demonstrations of technologies for visualization of energy and energy control in each home and building

Participants: Kansai Science City, Doshisha Urban City Commission, Kansai Electric Power, Osaka Gas, etc.

Kitakyushu Smart Community Project

1.Outline

A wide range of demonstrations in areas of communication, town construction, transportation, and lifestyle, mainly in order to make people realize about the smart use of electricity

2. Operator

Kitakyushu Smart Community Association

(Kitakyushu City, Shin-nihon Steel, Japan IBM, Fuji Electronics, and other 49 firms)

3. Area

Yahata East area (approximately 120 ha) in Kitakyushu City

4. Period

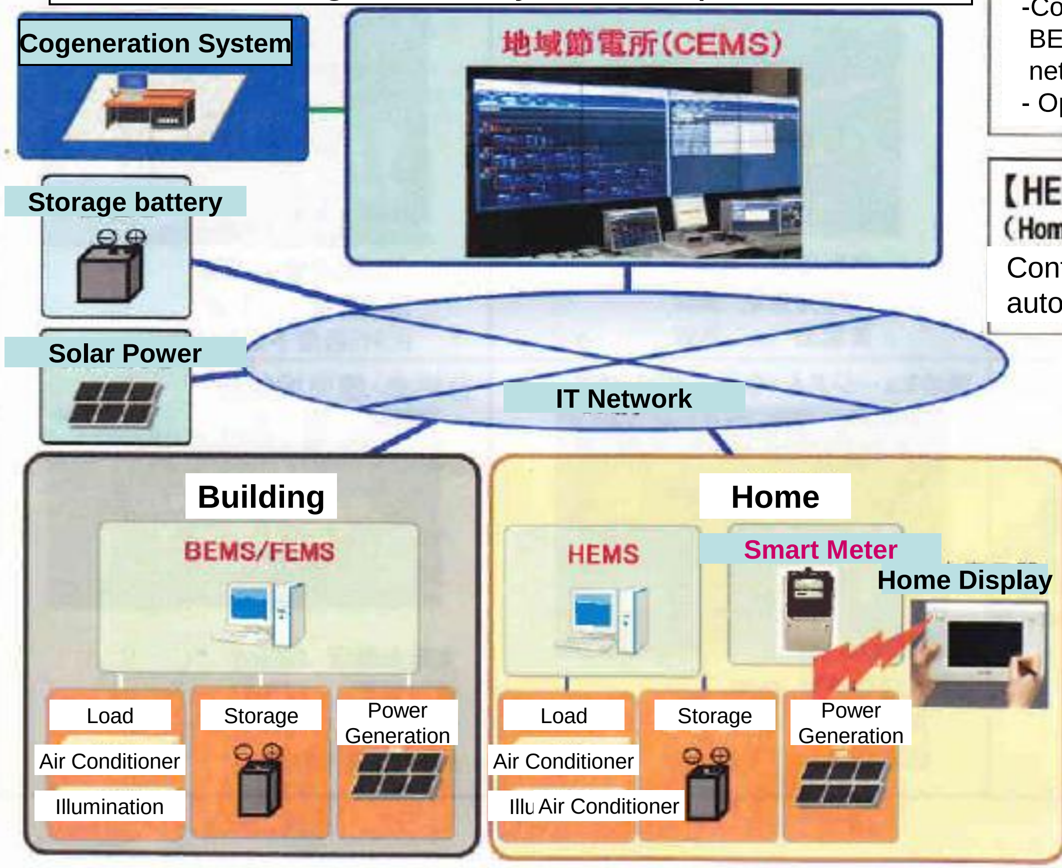
2010–2014 (5 years)

5. Budget

16.3 billion Japanese Yen over 5 years

Kitakyushu Smart Community Project
(Energy Field)

[Smart Meter]
Receiving the notice of electricity cost and sending electricity consumption



[CEMS]
(Cluster Energy Management System)
-Connected with renewable energy, BEMS, HEMS, Electricity Grid, and IT network
- Optimized control of local energy

【HEMS】
(Home Energy Management System)
Controlling energy usage in homes automatically, connected with CEMS

【BEMS】
(Building and Energy Management System)
Controlling energy usage in buildings automatically, connected with CEMS

【FEMS】
(Factory Energy Management System)
Maintaining stable electric supply to factory, connected with CEMS and its own renewable energy

Progress of the Project (Renewable Energy)

(As of February, 2012)

Apartment Building, Dormitory

[Apartment]

Solar Power 170kW
HEMS
Smart Meter

[Dormitory]

Solar Heat System
Geothermal System
BEMS

Hydrogen demonstration house

Fuel Cell 1kW × 7
Solar Power 3kW
Storage Battery 3kW

Tenant office Building (CEMS)

Solar Power 10kW
Wind Power 3kW
BEMS (2012)

Hospital

Solar Heat System
BEMS

Eco-museum, Eco-house

Solar Power 6kW
Wind Power 3kW
Storage Battery 1kW

History Museum

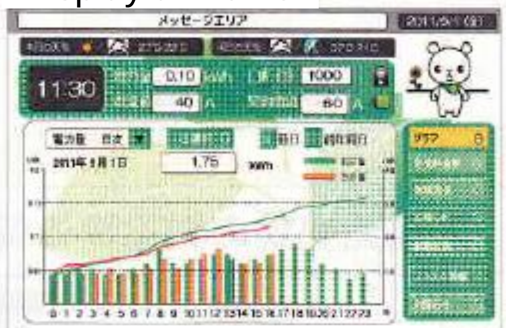
Solar Power 160kW
Fuel Cell 100kW
Storage Battery 120kW
BEMS (2012)

Progress of the Project
(Establishment of HEMS & Smart Meter)

Smart Meter : 230 Households (low voltage), 50 companies (high voltage)
HEMS : 9 Households in one apartment , 14 houses

Smart Meter

Display at Home



(Consumption of Electricity)

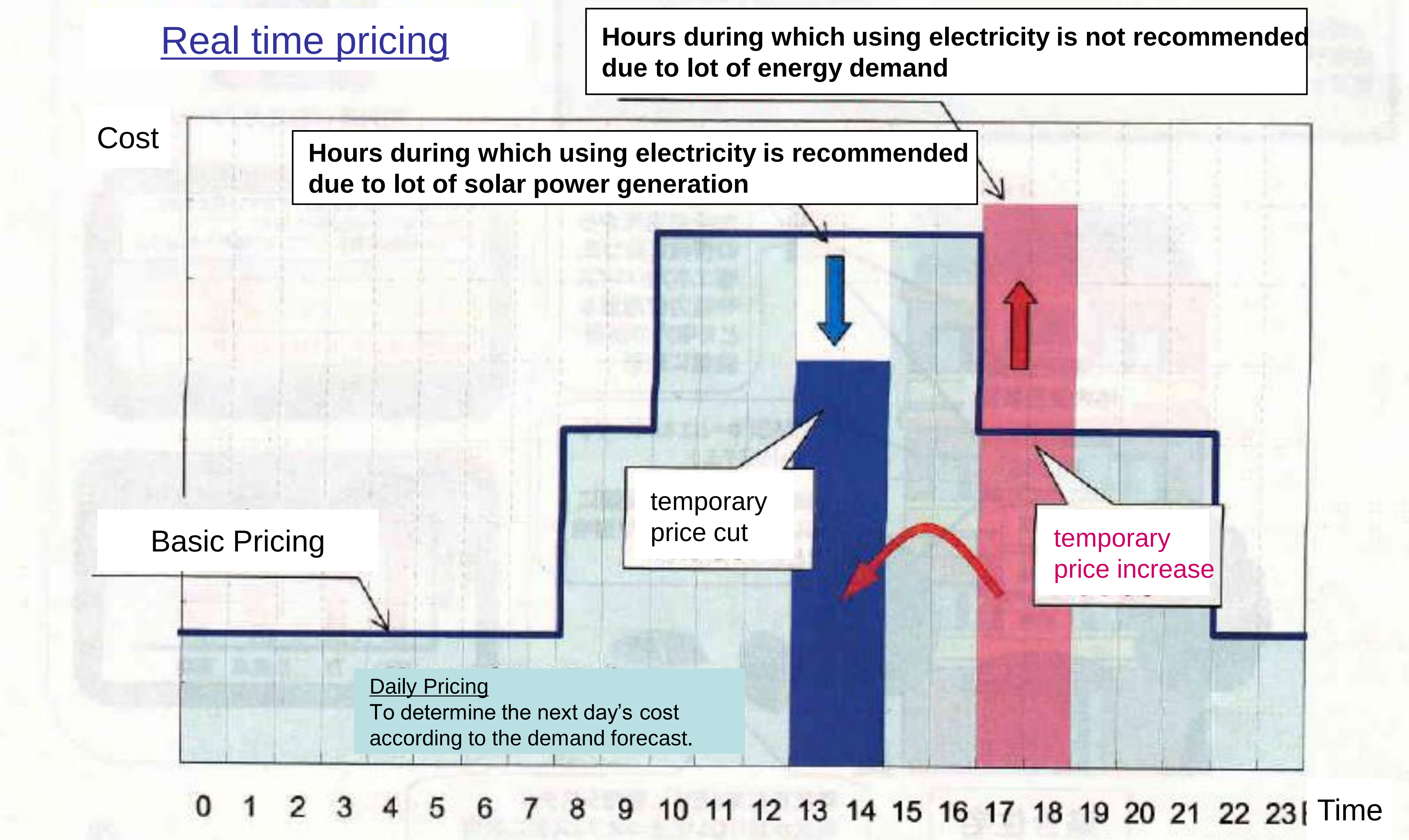
(Message Board)

Hand Display

(Confirming Electricity Cost)

Communication Robot installed in HEMS

Demonstration of Dynamic Pricing



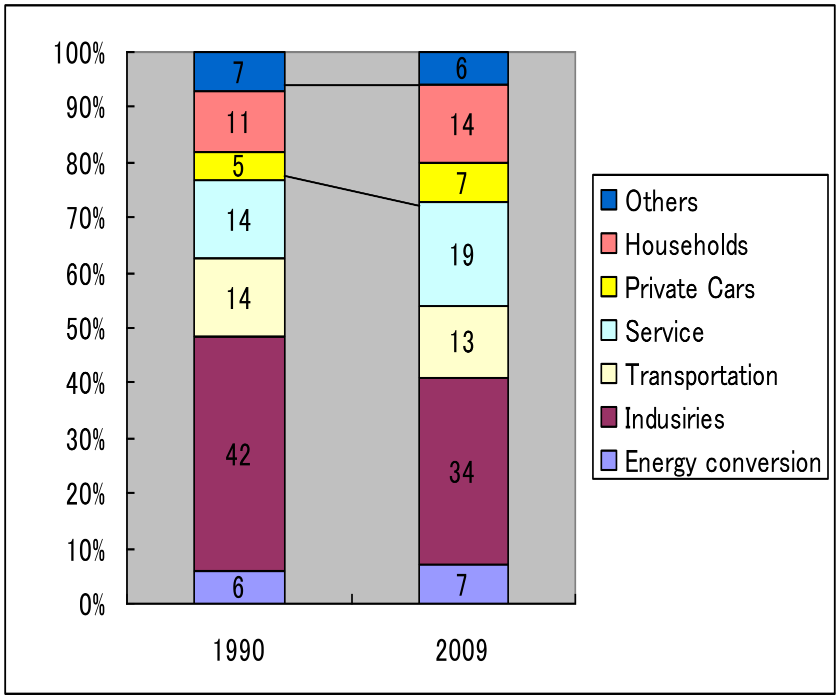
Toyota Smart Community Project

Outline of Demonstration

	At home	Transportation	Destination	City Life
Project	●67 demonstration houses ●Energy control by HEMS ●Power supply from EV/PHV to home (V to H)	●Next generation cars on a massive scale ●Eco- driving ●Traffic control by ITS ●FC bus, TDMS*	●EV charger and storage battery at convenience store ●Utilization of batteries on EV/EHV at the disaster	●Analysis of energy consumption data by EDMS** ●Promotion of contributions to low carbon society
Coordinator	ハイブリッド・シティ とよた, TOYOTA, 中部電力, DI			愛知県, 名古屋大学, 豊田商工会議所
Promoting Companies (27)	DENSO, TOYOTA HOME, TOYOTA, トヨタすまいるライフ株式会社, AISIN, KDDI, 中部電力, TOYOTA, SHARP, YAZAKI, SECOM, TOHO GAS	ハイブリッド・シティ とよた, TOYOTA, TOYOTA, 豊田通商, 三菱商事, MEITETSU, TOHO GAS, KDDI, NEXCO 中日本	TOYOTA, DENSO, 豊田通商, ヤマト運輸, ハイブリッド・シティ とよた, TOYOTA, 三菱商事, TOHO GAS	TOYOTA, ハイブリッド・シティ とよた, DI, TOSHIBA, FUJITSU, KDDI, 中部電力, 三菱商事, TOHO GAS, トヨタすまいるライフ株式会社, hp, TOYOTA HOME, ENERES
Demonstration Area	•67 houses in Takahashi& Higashiyama area	•Whole city	•Commercial/public facilities •Low carbon society model area	•Whole city •Low carbon society model area

*Traffic Data Management System **Energy Data Management System

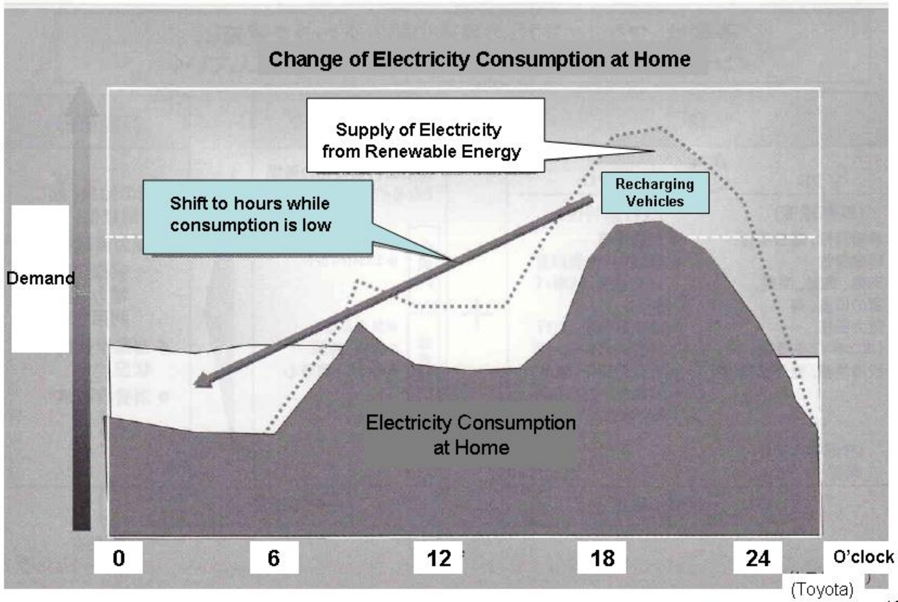
Challenge in reducing CO_2 emission for the household sector, which is important for realization of a low carbon society



Total 1.14 billion ton CO2 1.14 billion ton CO2

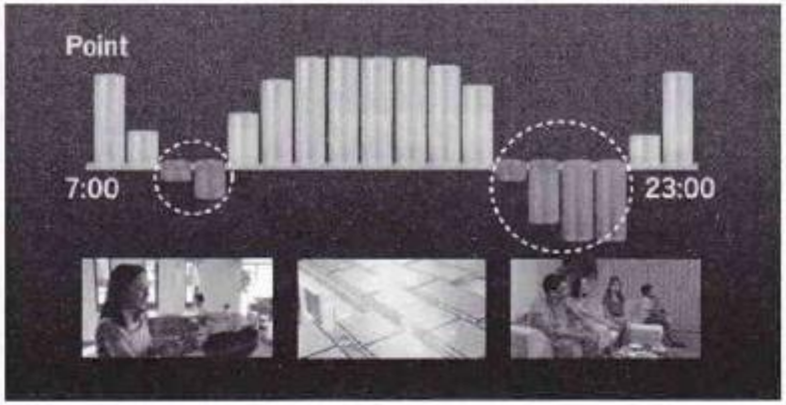
- The CO_2 emissions from households and private cars increased from 27% in 1990 to 43% in 2009.
- The margin for reduction of CO_2 is large, but it is difficult to achieve because small emitters are widely distributed.

Equalization between Electricity Supply and Consumption

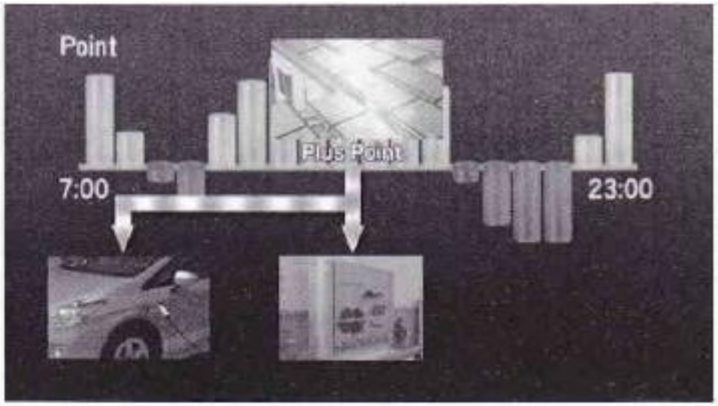


Point Incentive System

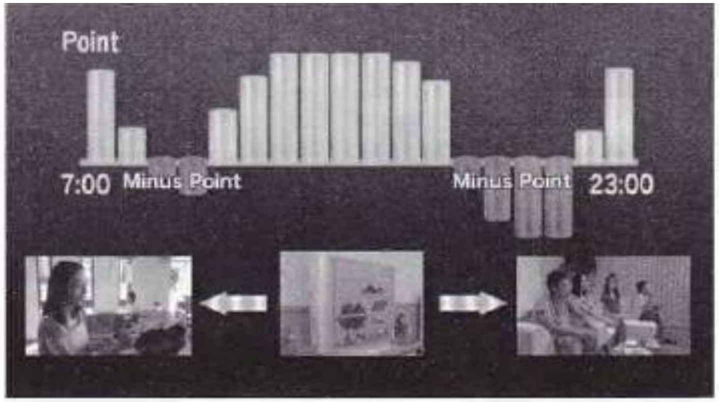
Getting plus points when Energy demand is low	⟺	Getting minus points when Energy demand is high



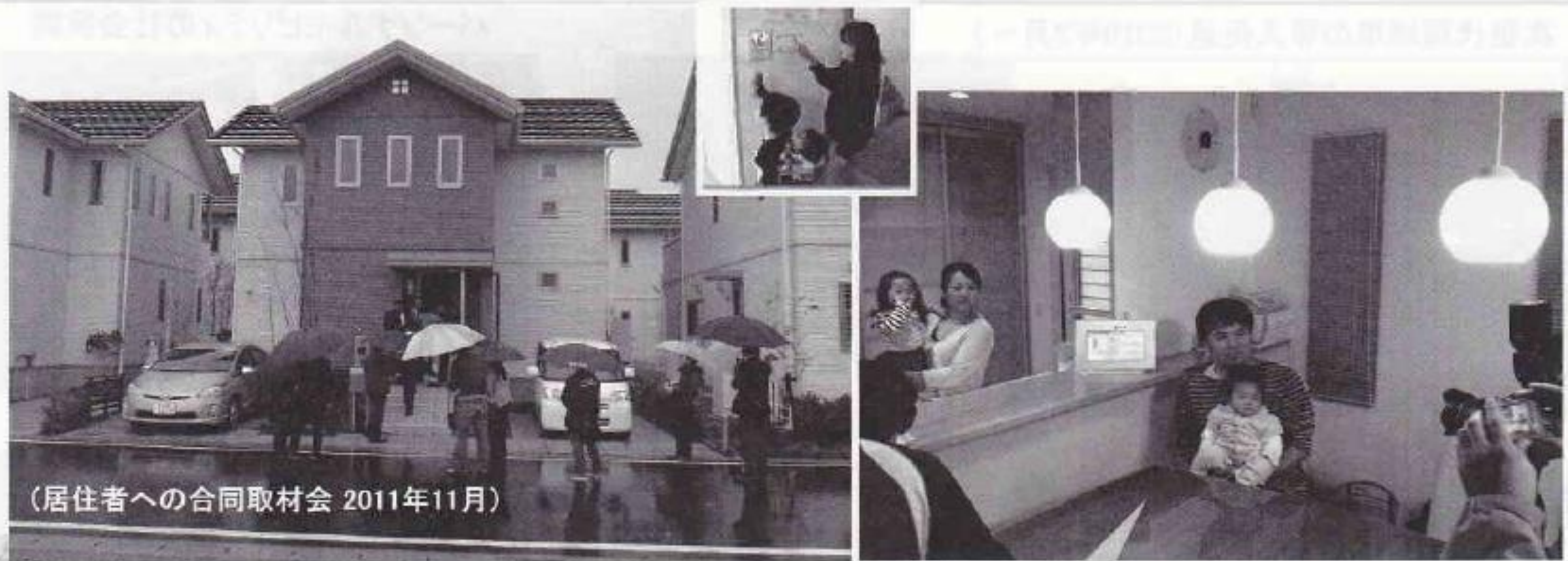
Use/Save electricity when point is plus



Use saved electric power when point is minus



Voices of Residents



“The entire family has started taking measures to save energy.”

“ It was difficult at first, but we have deepened our understanding and interest since starting to use the system.”

“This system is optimizes energy utilization, so we can work on energy saving without effort.”

Chinese Eco-cities

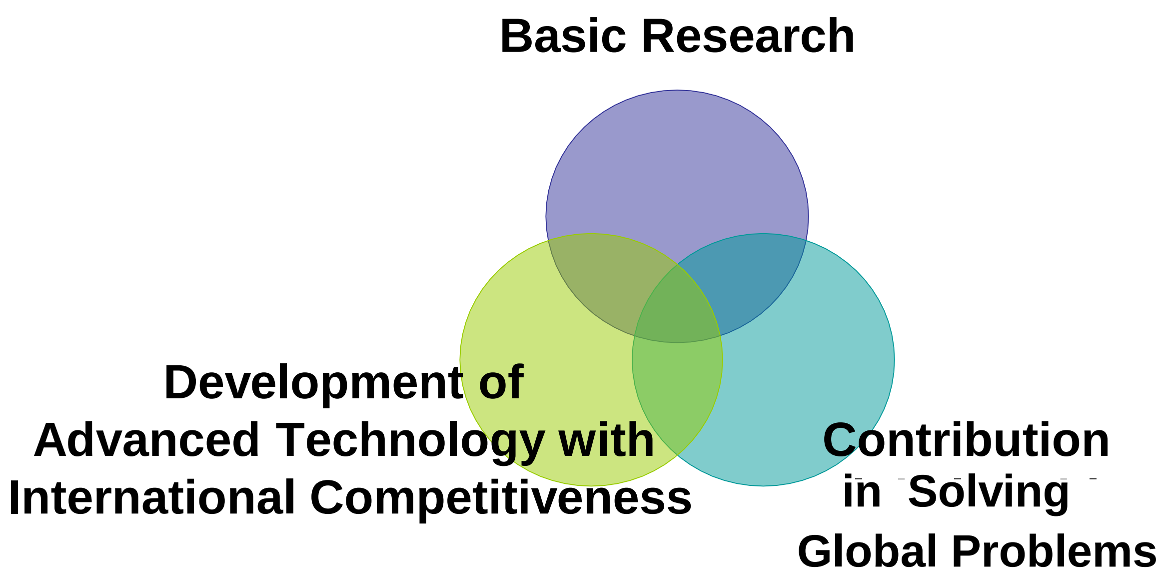
- In China, around 200 low carbon cities are being developed. These cities are known as 生態城 (sheng tai cheng).
- Tianjin(天津), Caofeitian(曹妃甸), Wuxi(無錫), and Shenzhen(深圳) are the most advanced eco-cities.
- These cities have technological goals to help achieve low carbon emissions, such as obtaining 20% of energy from renewable sources in Tianjin.
- The aim of these Chinese eco-cities is to build apartments and attract eco-friendly companies.

Caofeitian Eco-city (future plan)

Apartment houses under construction (Tianjin)

Direction of Japanese S&T for the next decade

☆Focused Areas



☆Societies to be realized

- Low carbon society, new energy system society
- Advanced Medical system
- Advanced system for education and human resource development
- Contribution for global problems such as global warming & infectious diseases
- Maintaining R&D Japanese capability under sluggish economy
- S&T collaboration structure in Asia