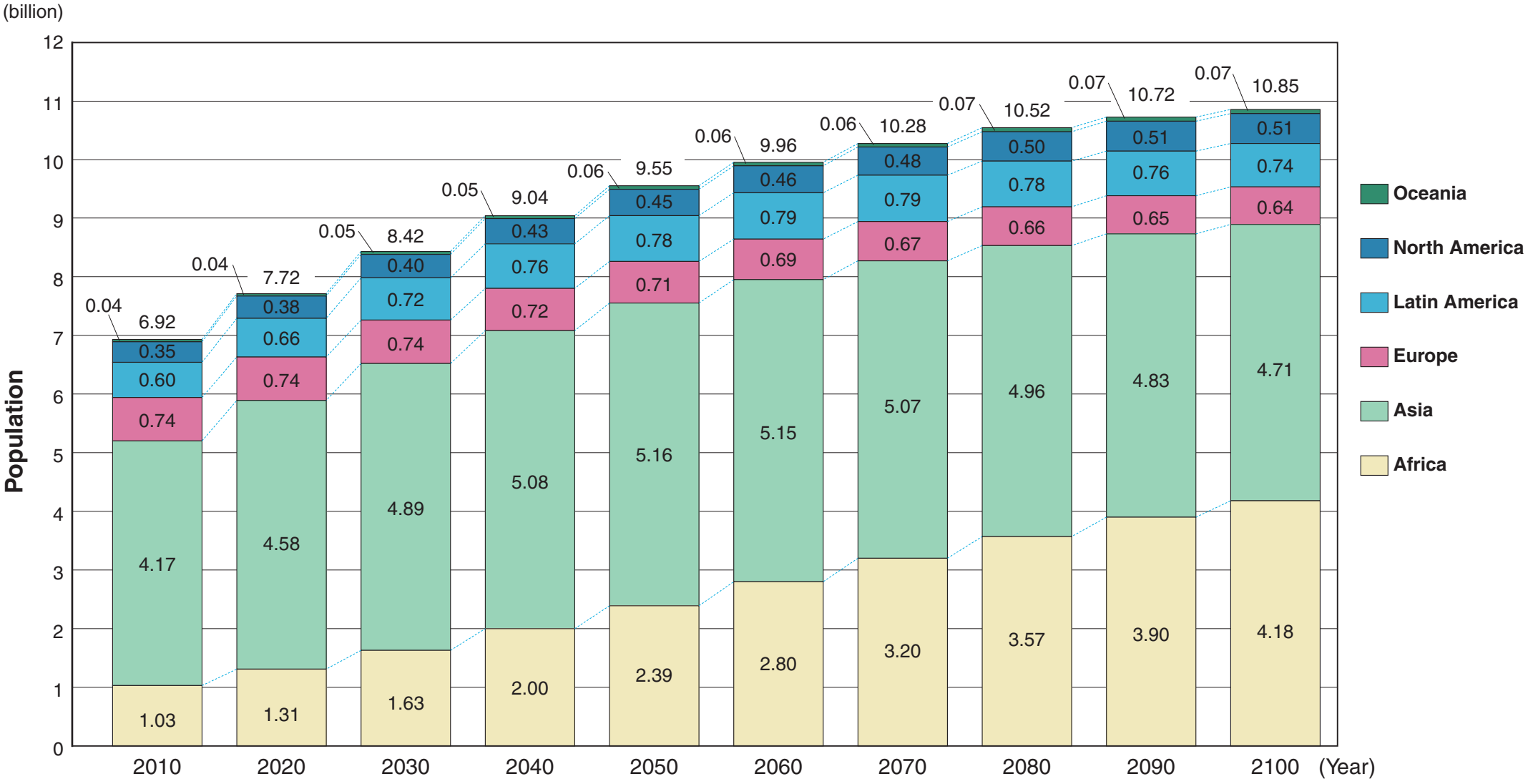
Graphical Flip-chart of Nuclear & Energy Related Topics 2014

CONTENTS

World Population Projections

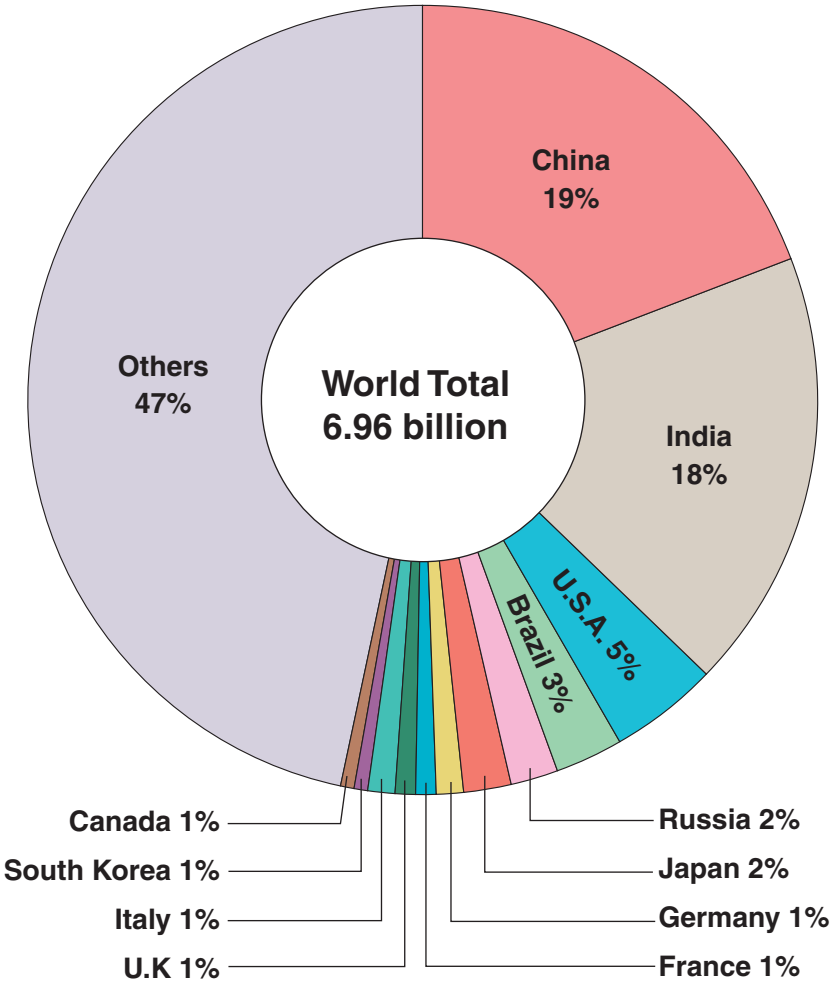


(Note) Figures may not add up to the totals due to rounding.

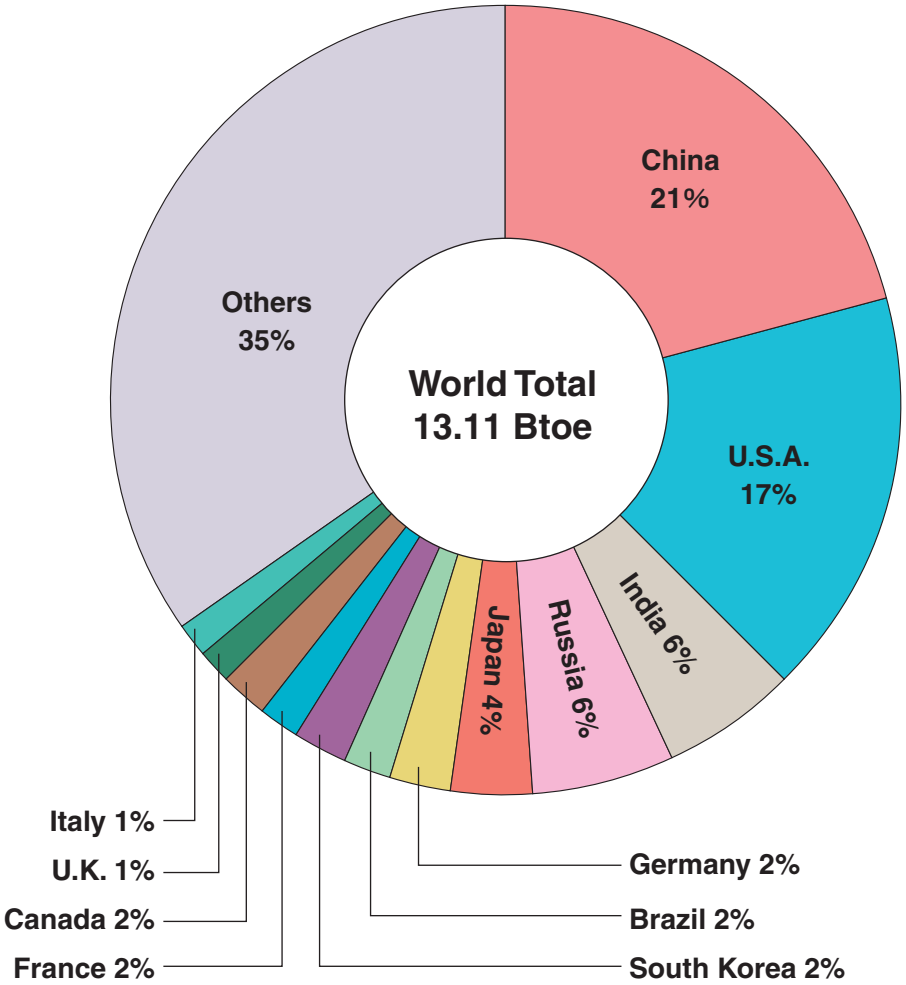
Source: UN "World Population Prospects, the 2012 Revision"

World Population and Energy Consumption

Population by Countries (2011)



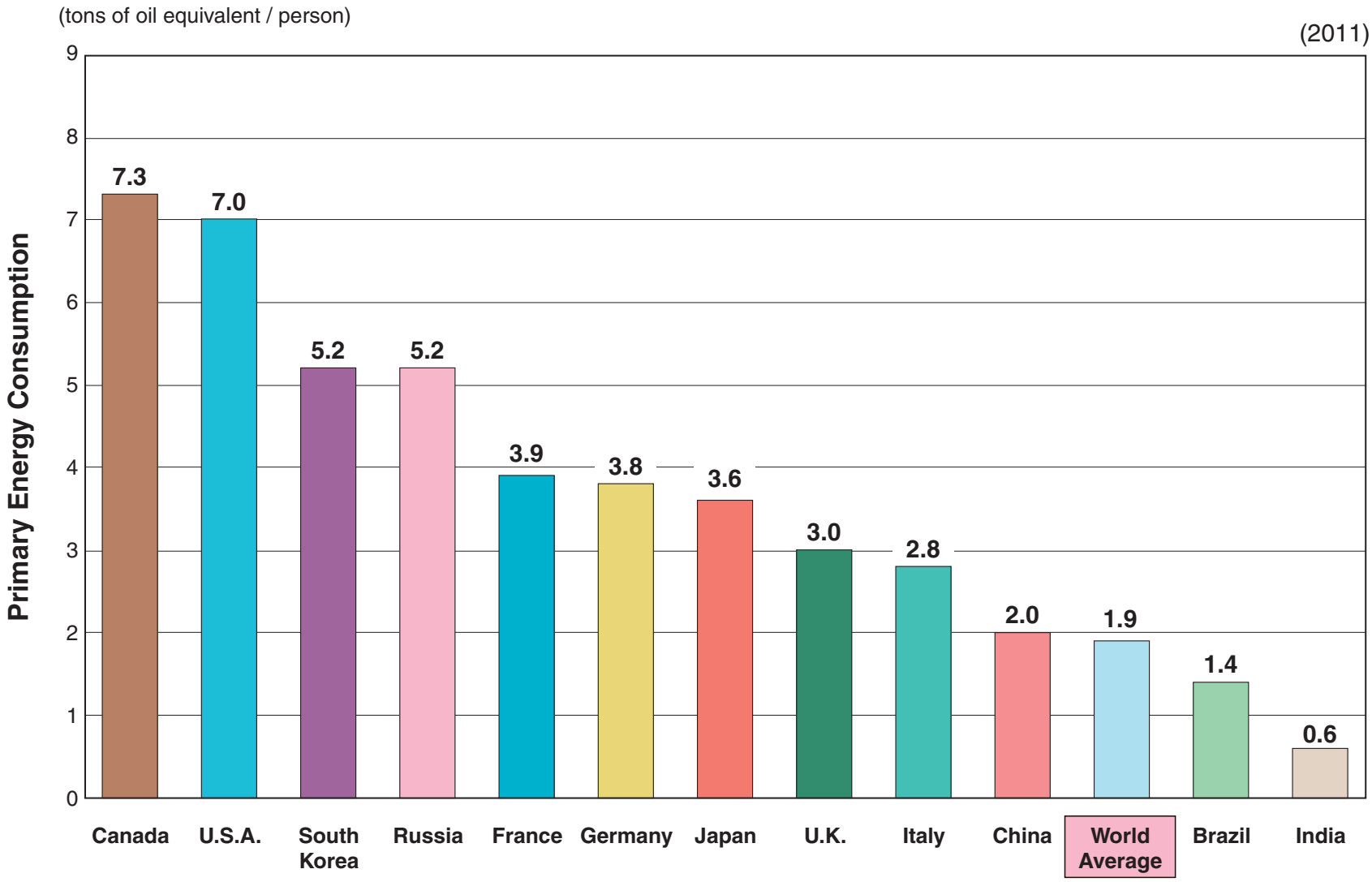
Primary Energy Consumption by Countries (2011)



(Note) Figures may not add up to the totals due to rounding.
Btoe: billion tons of oil equivalent

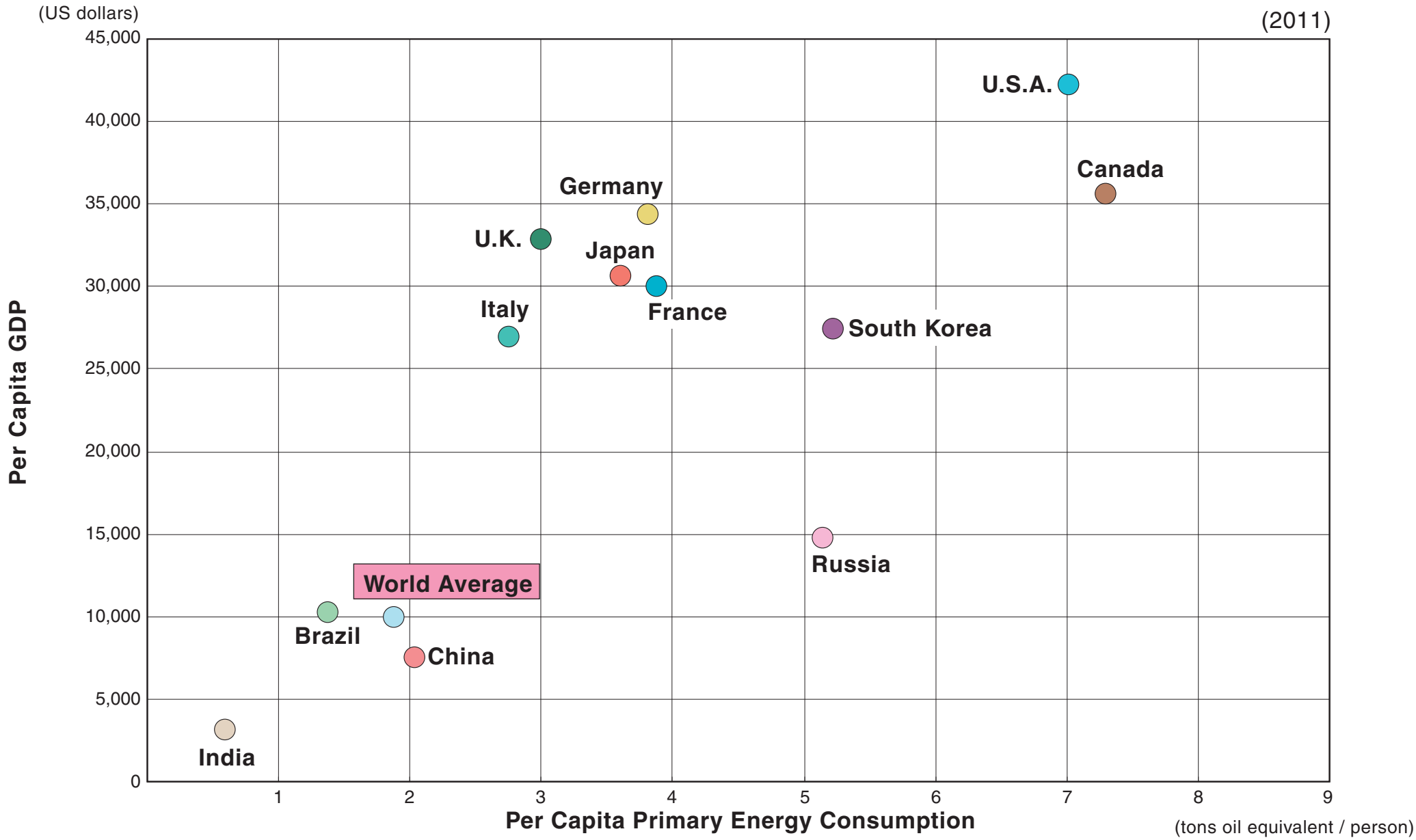
Source: IEA "ENERGY BALANCES OF OECD COUNTRIES (2013 Edition)" / "ENERGY BALANCES OF NON-OECD COUNTRIES (2013 Edition)"

Primary Energy Consumption per Capita



Source: IEA "ENERGY BALANCES OF OECD COUNTRIES (2013 Edition)" / "ENERGY BALANCES OF NON-OECD COUNTRIES (2013 Edition)"

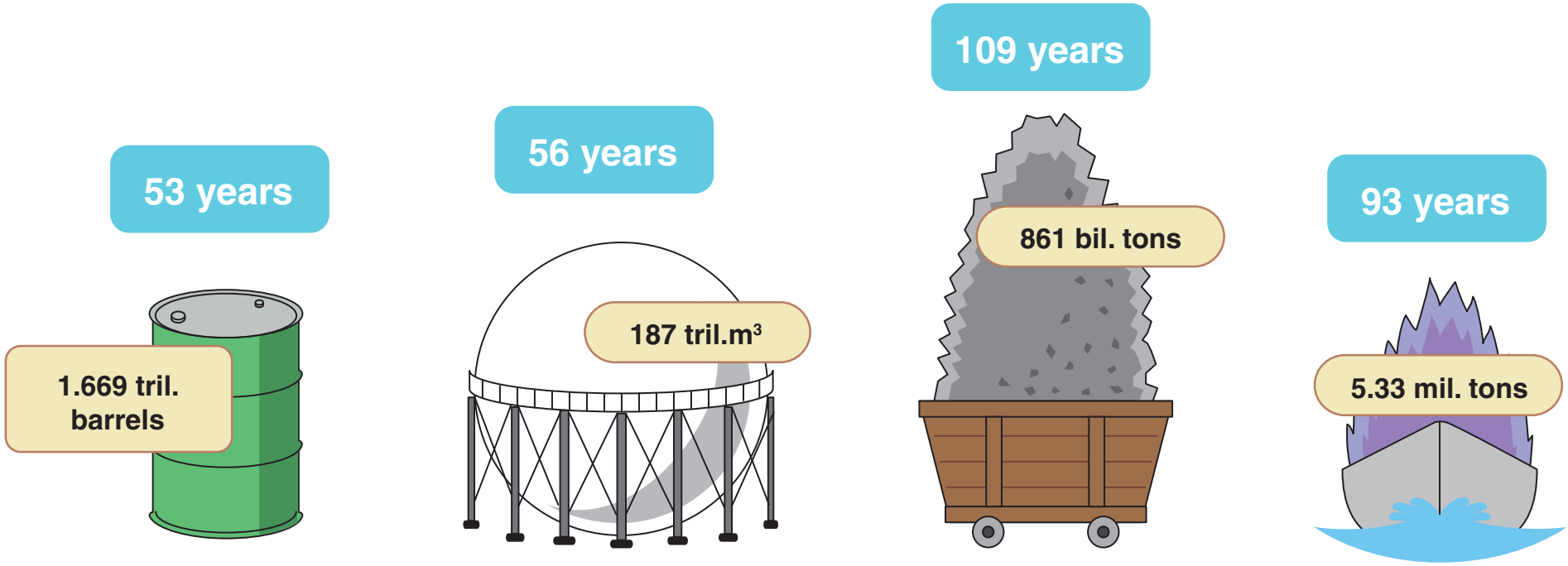
Per Capita GDP and Primary Energy Consumption



(Note) Total domestic production based on purchasing power parity conversion (US dollars, 2005 prices)

Source: IEA "Energy Balances of OECD Countries (2013 Edition)" and "Energy Balances of Non-OECD Countries (2013 Edition)"

Proven Reserves of Energy Resources



Oil※1
(at the end of 2012)

Natural Gas※1
(at the end of 2012)

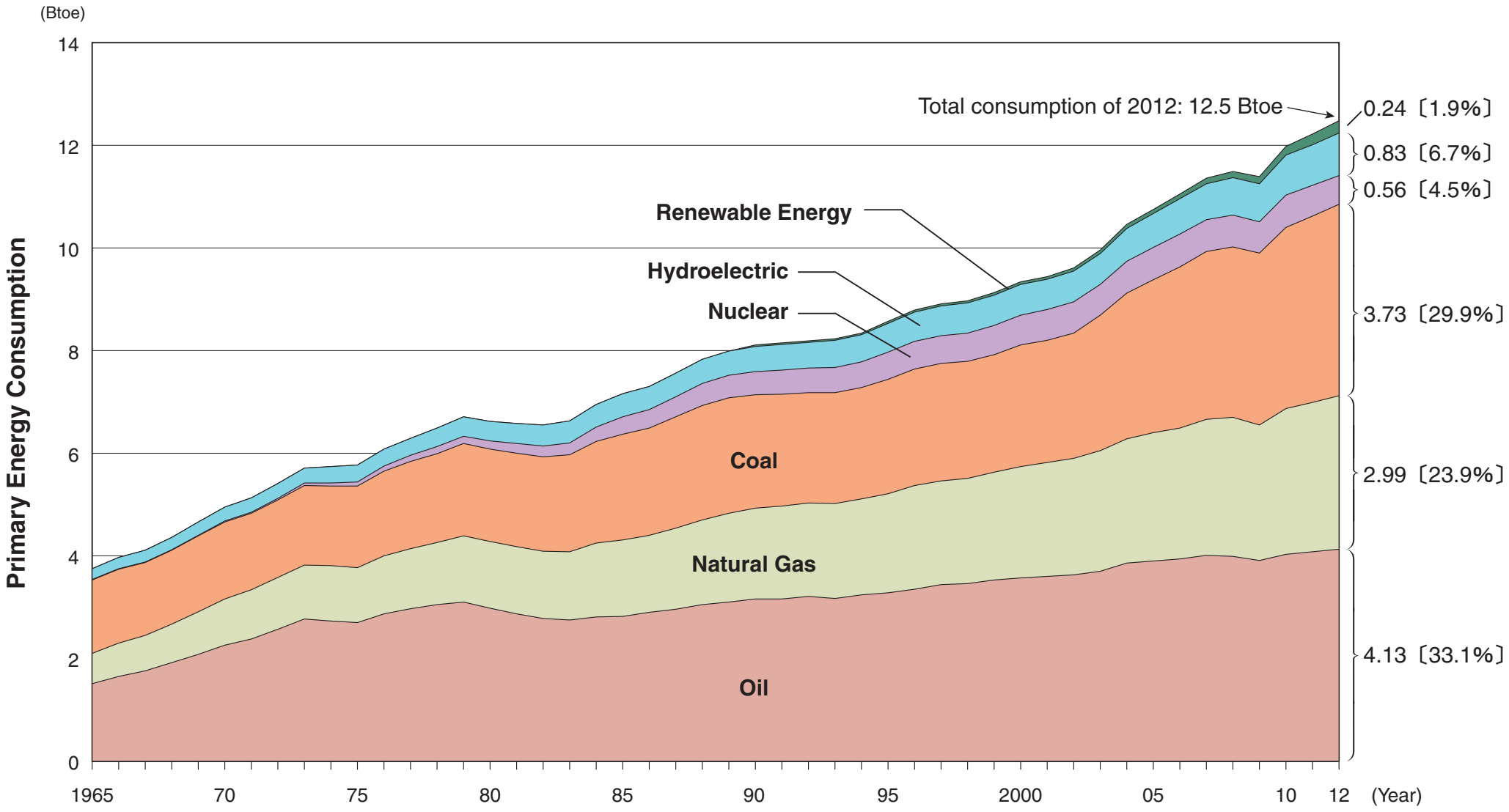
Coal※1
(at the end of 2012)

Uranium※2
(Jan. 2011)

(Note) Reserves-to-production (R/P) ratio=Proven Reserves / Annual Production
RAR (reasonably assured resources) of Uranium is estimeted at a prodaction cost less than USD 130kg/U.

Source: ※1 BP Statistical Review of World Energy 2013 ※2 OECD, IAEA "Uranium 2011"

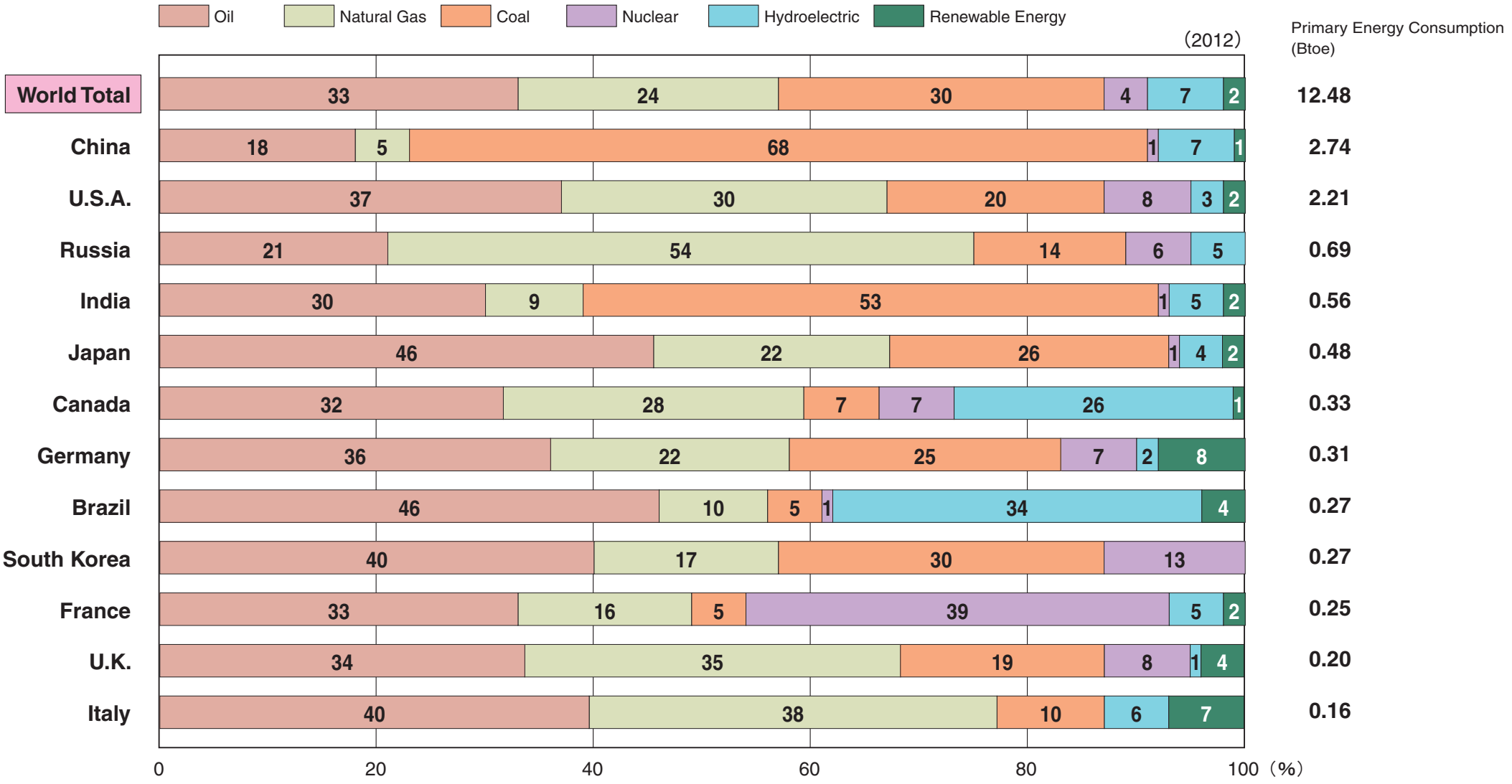
The World's Primary Energy Consumption



(Note) Figures may not add up to the totals due to rounding. The figures in parentheses are share of total.
Btoe: billion tons of oil equivalent

Source: BP Statistical Review of World Energy 2013

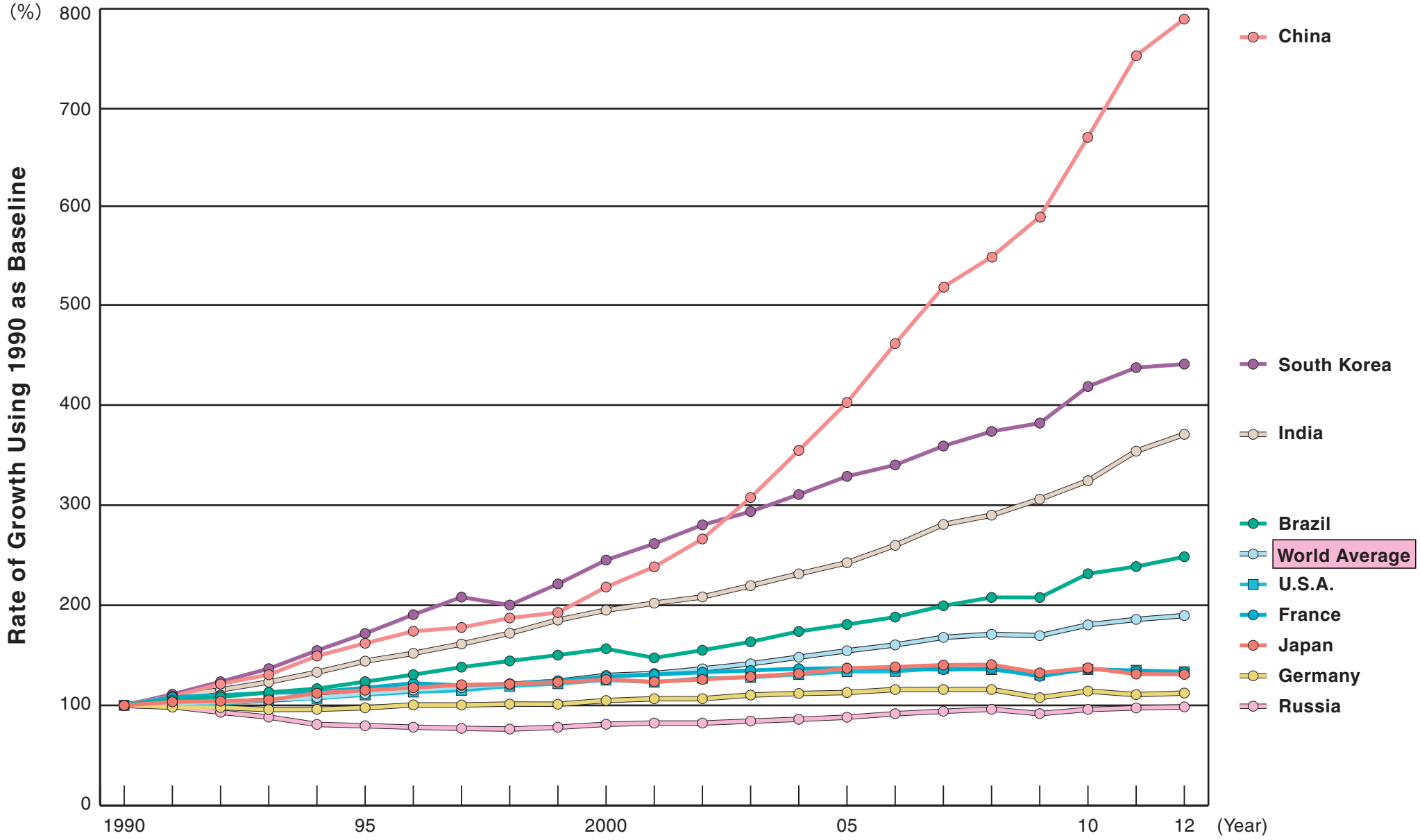
Primary Energy Consumption in Major Countries



(Note) Figures may not add up to the totals due to rounding.
Btoe: billion tons of oil equivalent

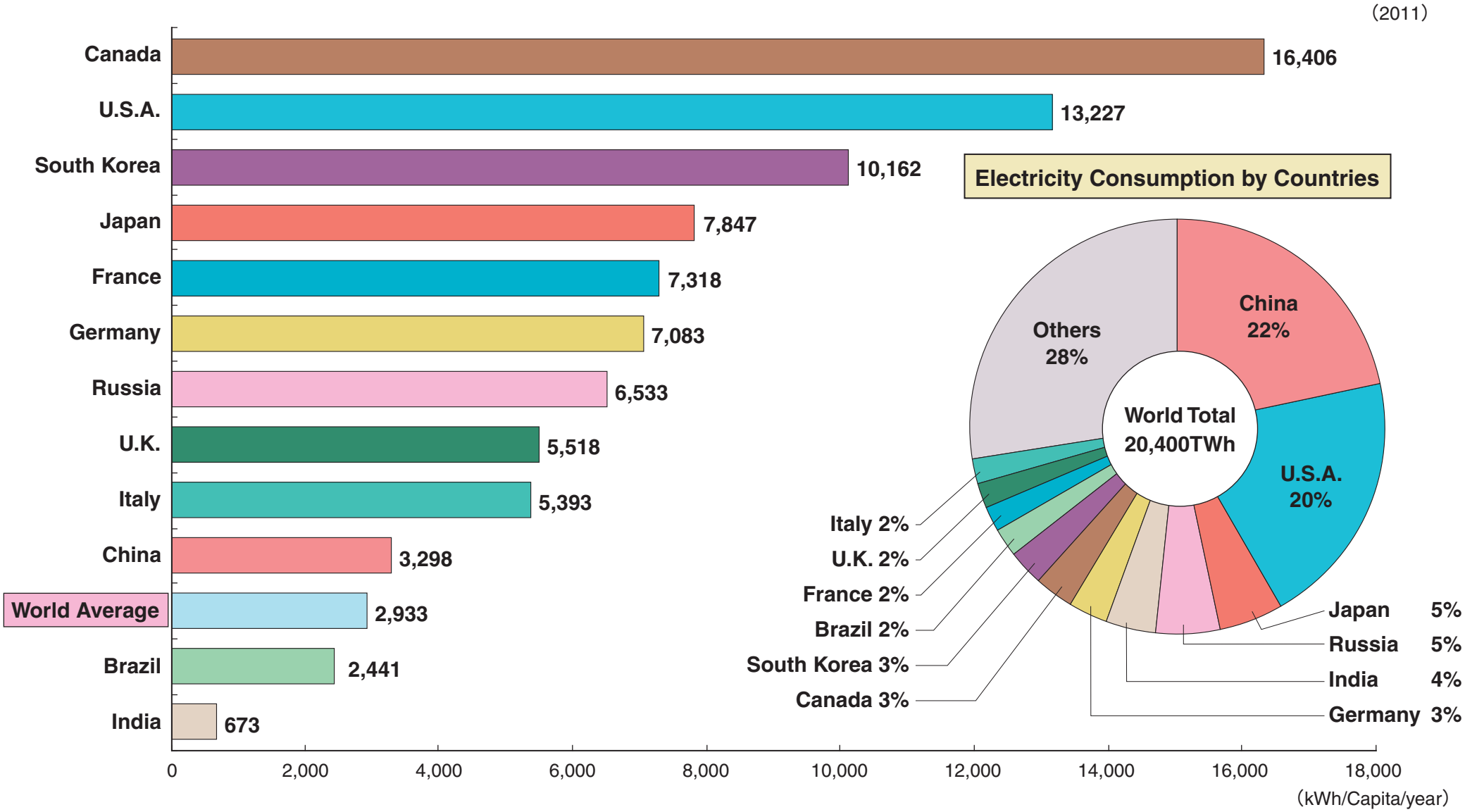
Source: BP Statistical Review of World Energy 2013

Electricity Generated by Major Countries (Rates of Growth)



Source: BP Statistical Review of World Energy 2013

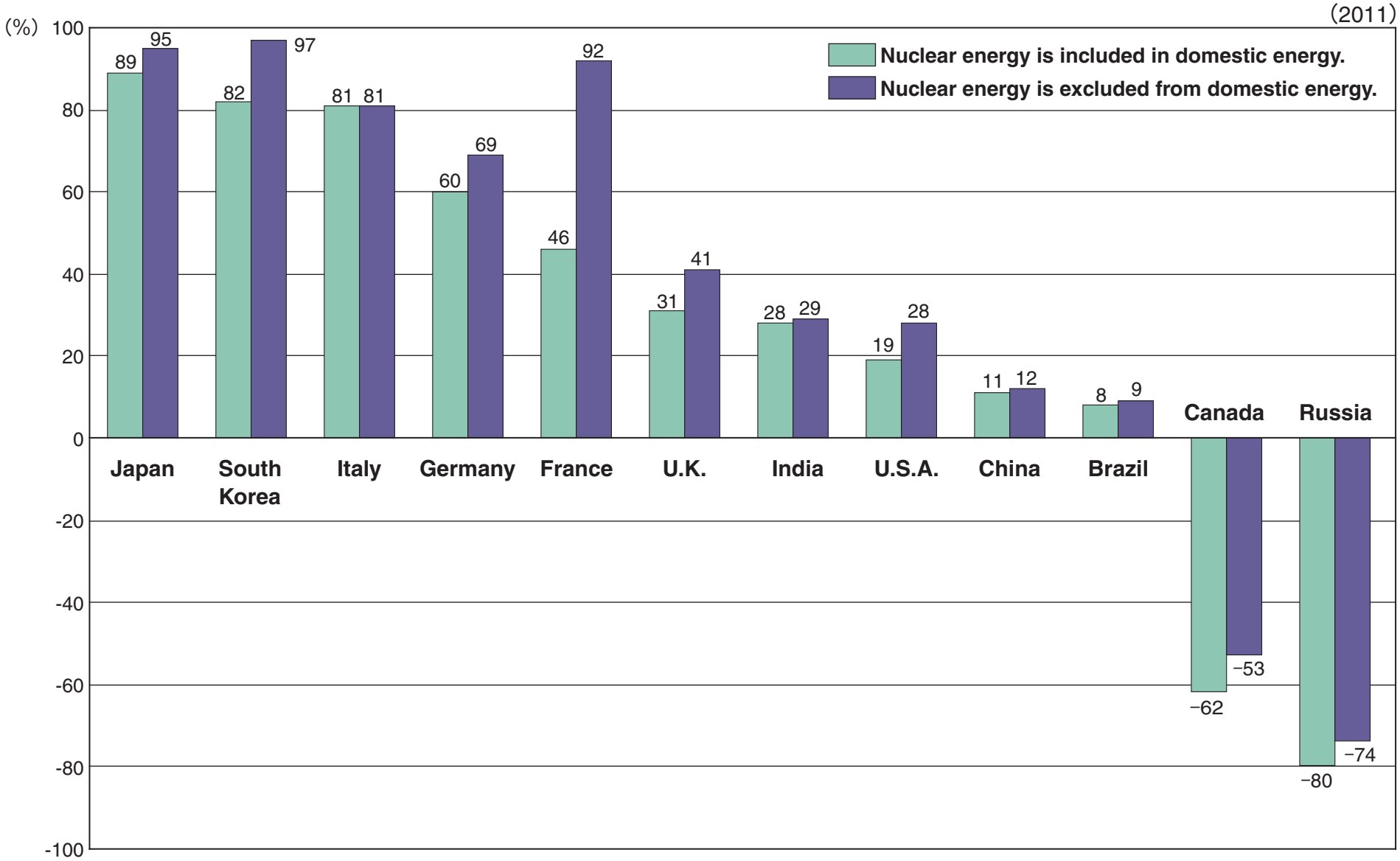
Electricity Consumption per Capita in Major Countries



(Note) Figures may not add up to the totals due to rounding.

Source: IEA "KEY WORLD ENERGY STATISTICS 2013"

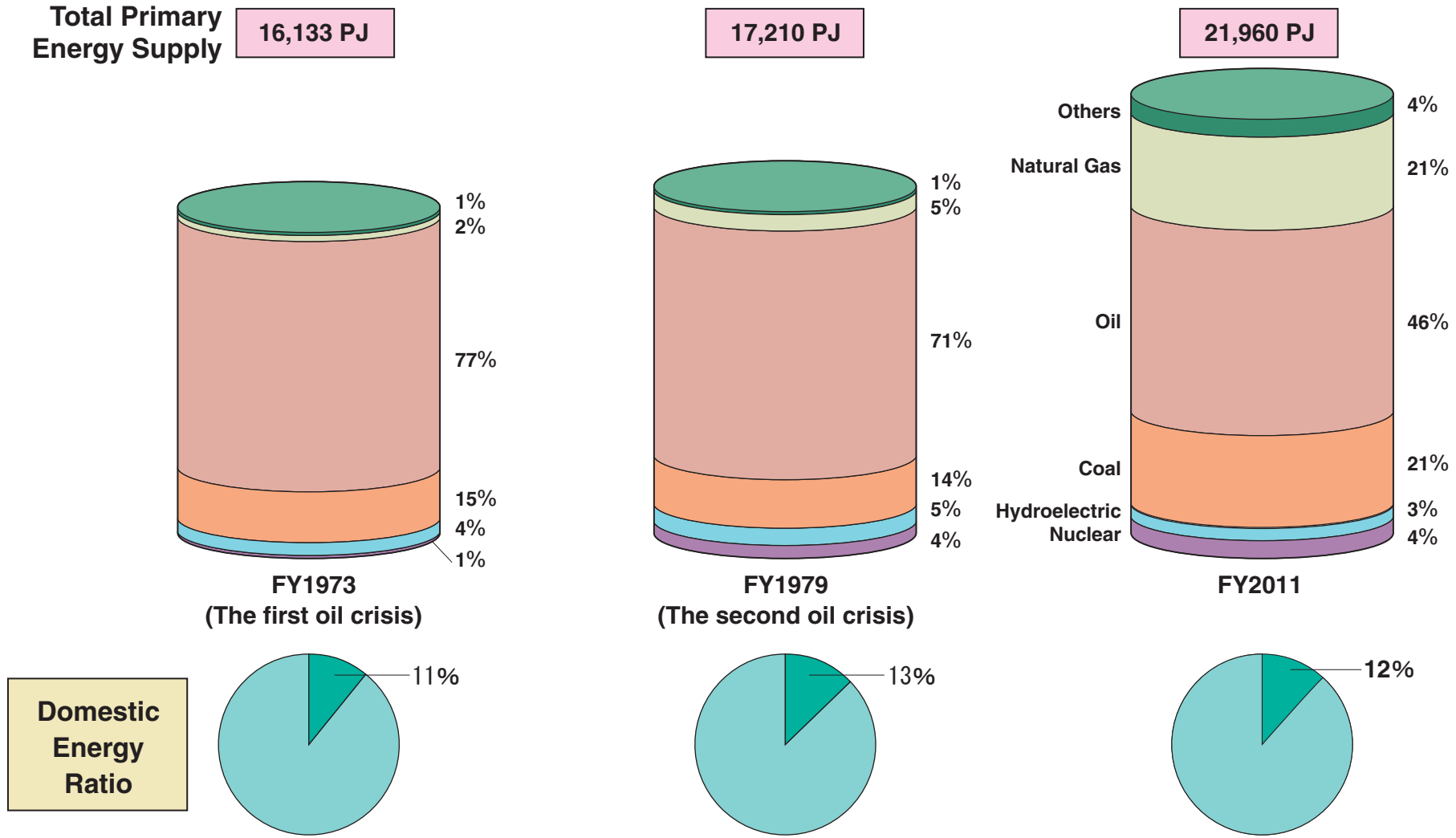
Dependence on Imported Energy Sources in Major Countries



(Note) Canada and Russia are net-exporting countries.

Source: IEA "ENERGY BALANCES OF OECD COUNTRIES (2013 Edition)" / "ENERGY BALANCES OF NON-OECD COUNTRIES (2013 Edition)"

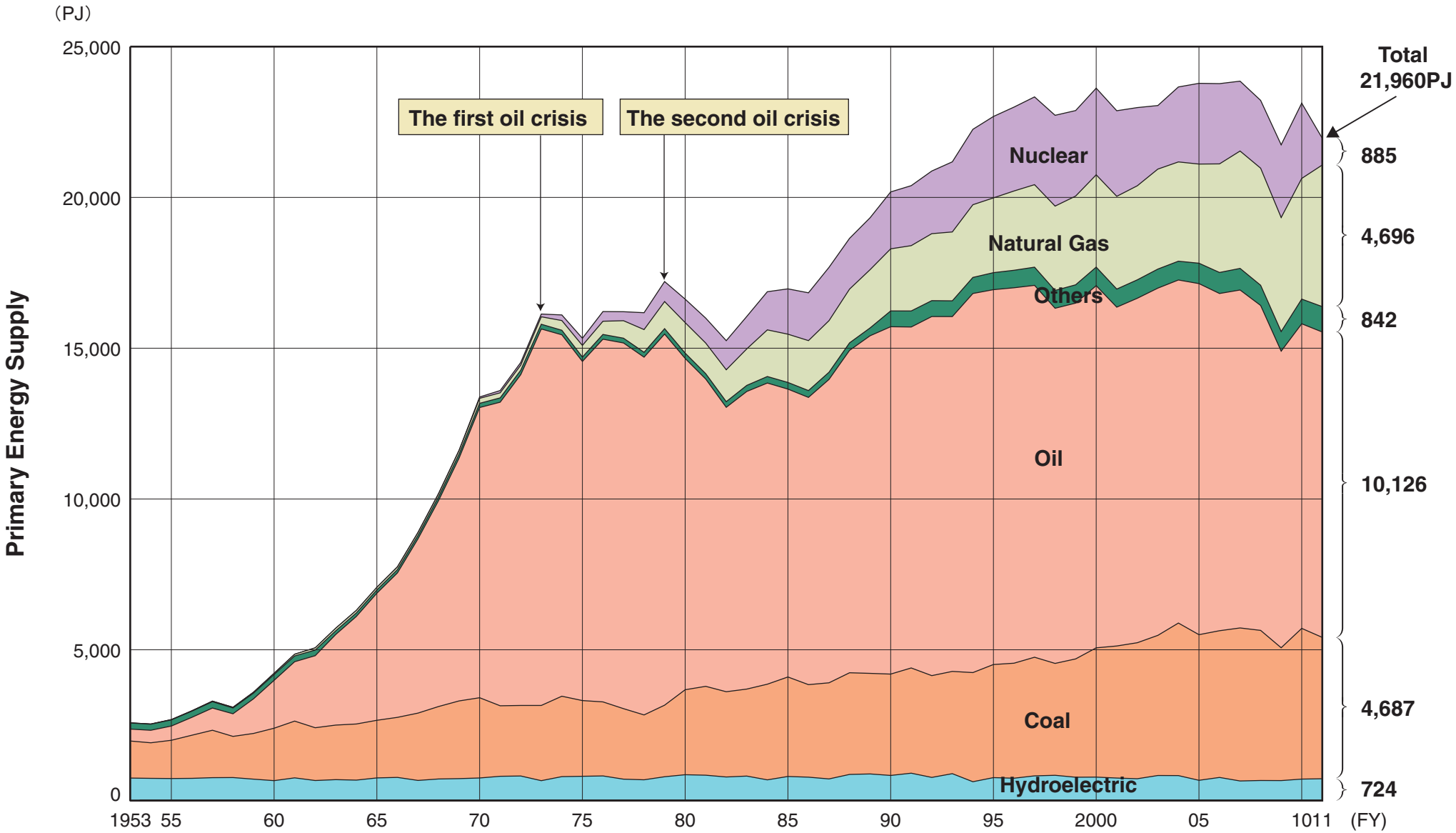
Changes of Japan's Primary Energy Supply Structure



(Note) Figures may not add up to the totals due to rounding.
1PJ (=10^{15}Joules) is equivalent to approx. 25,800 kiloliters of crude oil in calorie.
Nuclear energy is classified into semi-domestic energy due to its characteristic.

Source: Agency for Natural Resources and Energy "FY2011 Energy Supply & Demand Performance" etc.

Historical Trend of Japan's Primary Energy Supply

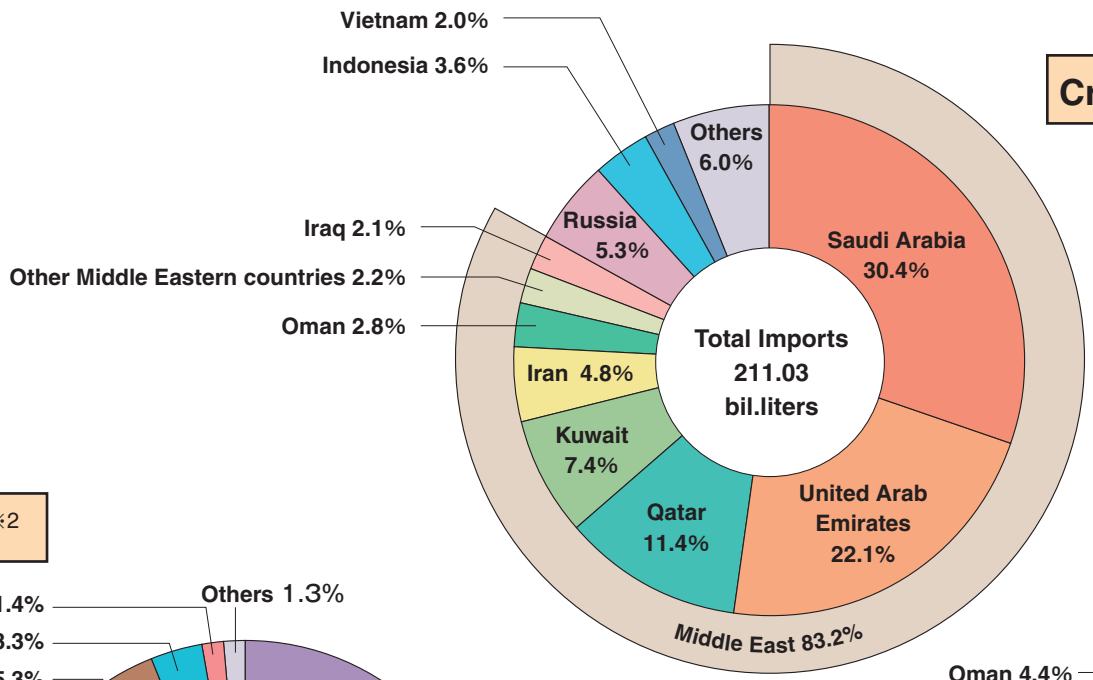


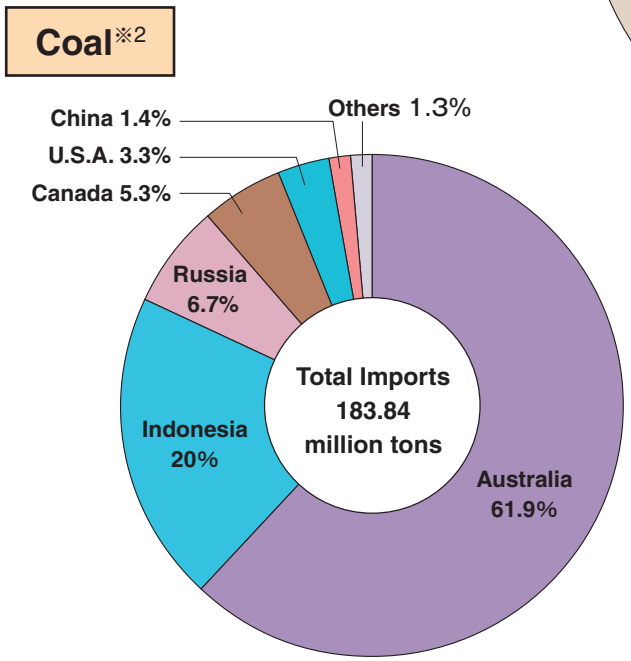
(Note) 1PJ (=10^{15}Joules) is equivalent to approx. 25,800 kiloliters of crude oil in calorie.

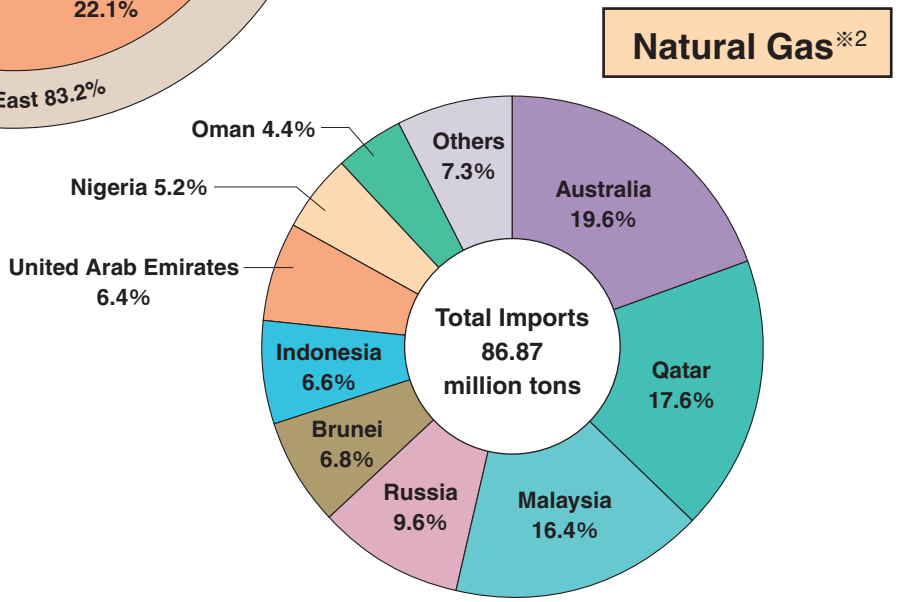
Source: Agency for Natural Resources and Energy "FY2011 Energy Supply & Demand Performance" etc.

Japan's Fossil Fuel Imports by Country of Origin

FY 2012 result



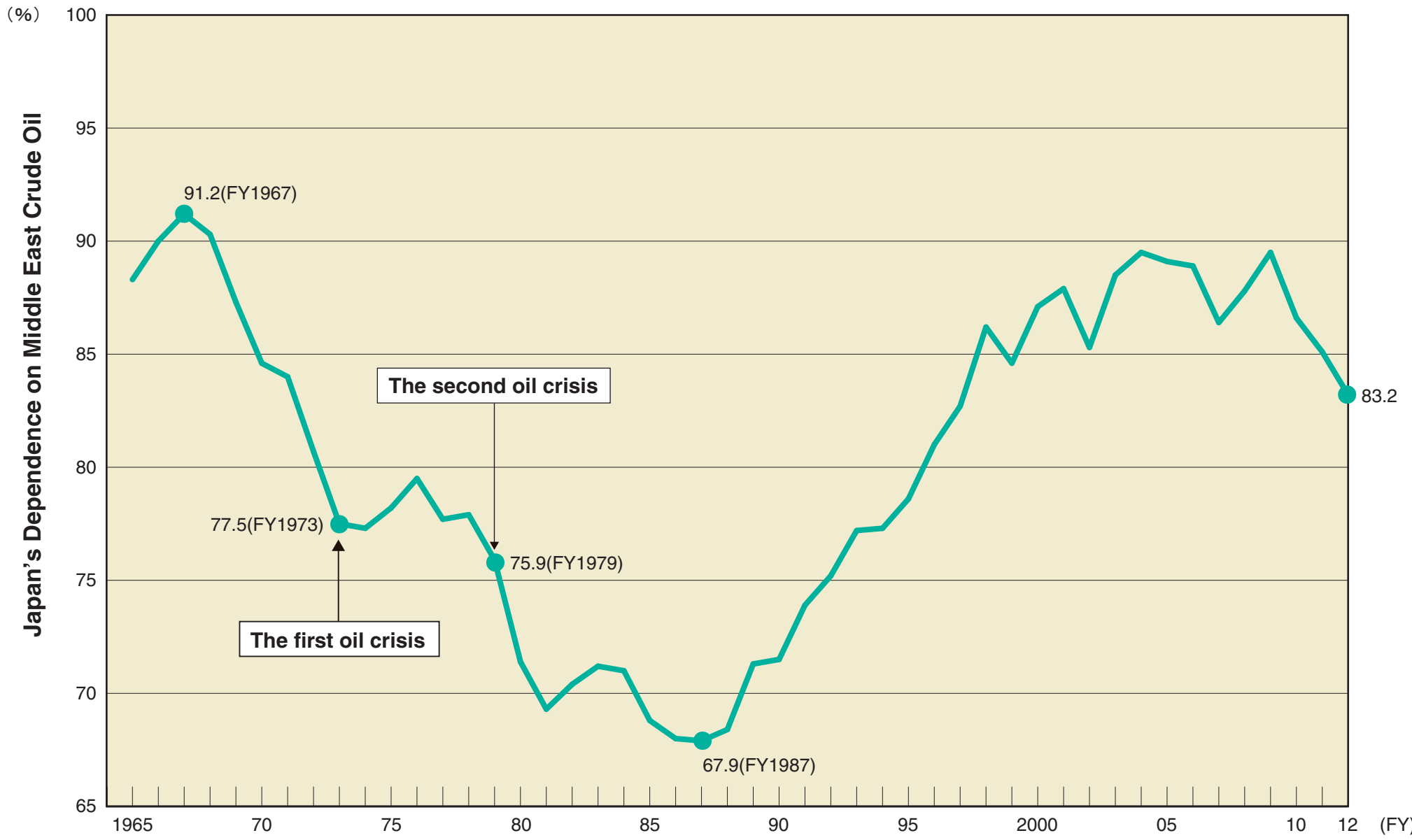




(Note) Figures may not add up to the totals due to rounding.

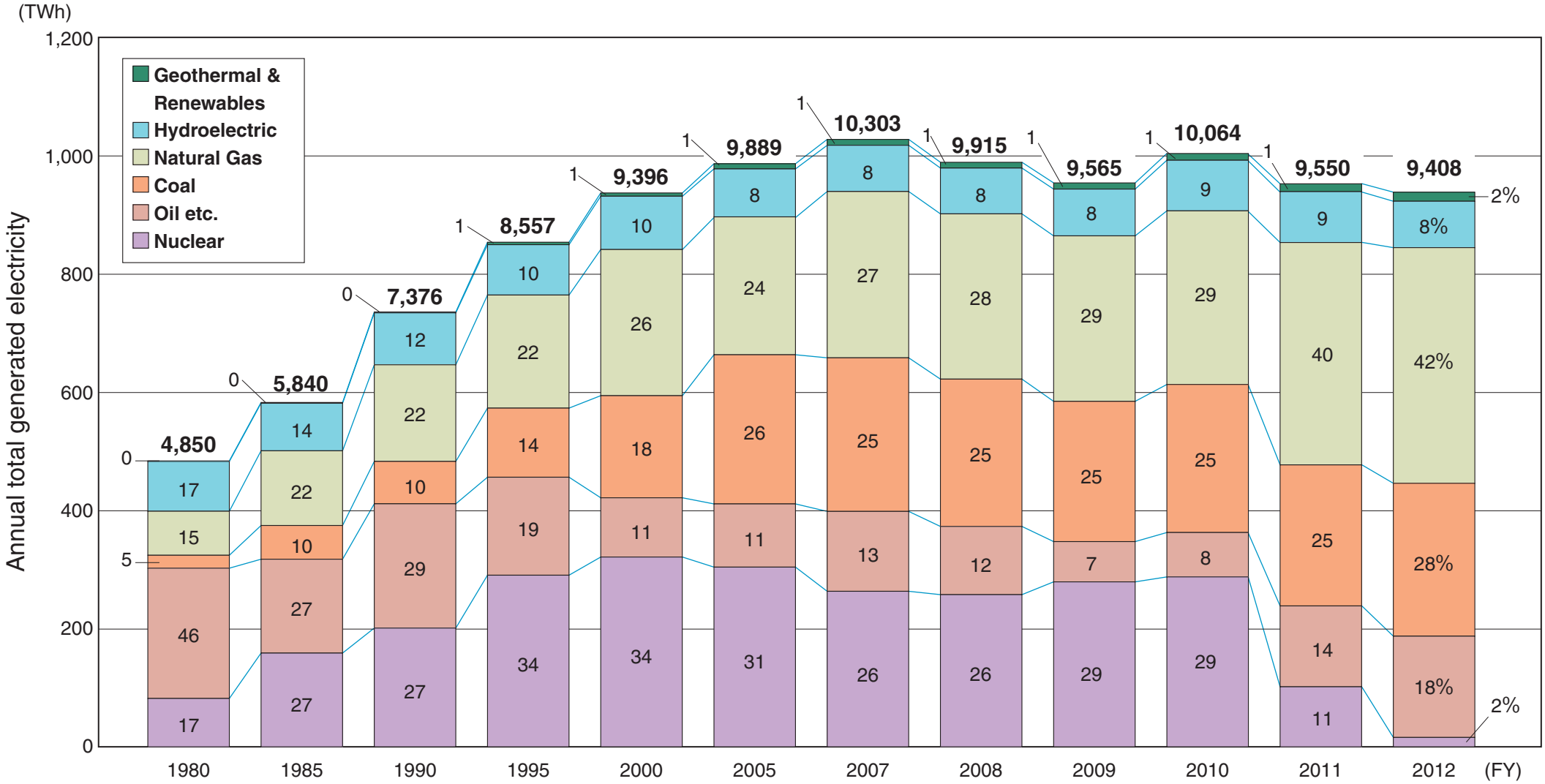
Source: ※1 Petroleum Association of Japan ※2 Trade Statistics of Japan

Japan's Dependence on Middle East Crude Oil of Total Imports



Source: Petroleum Association of Japan

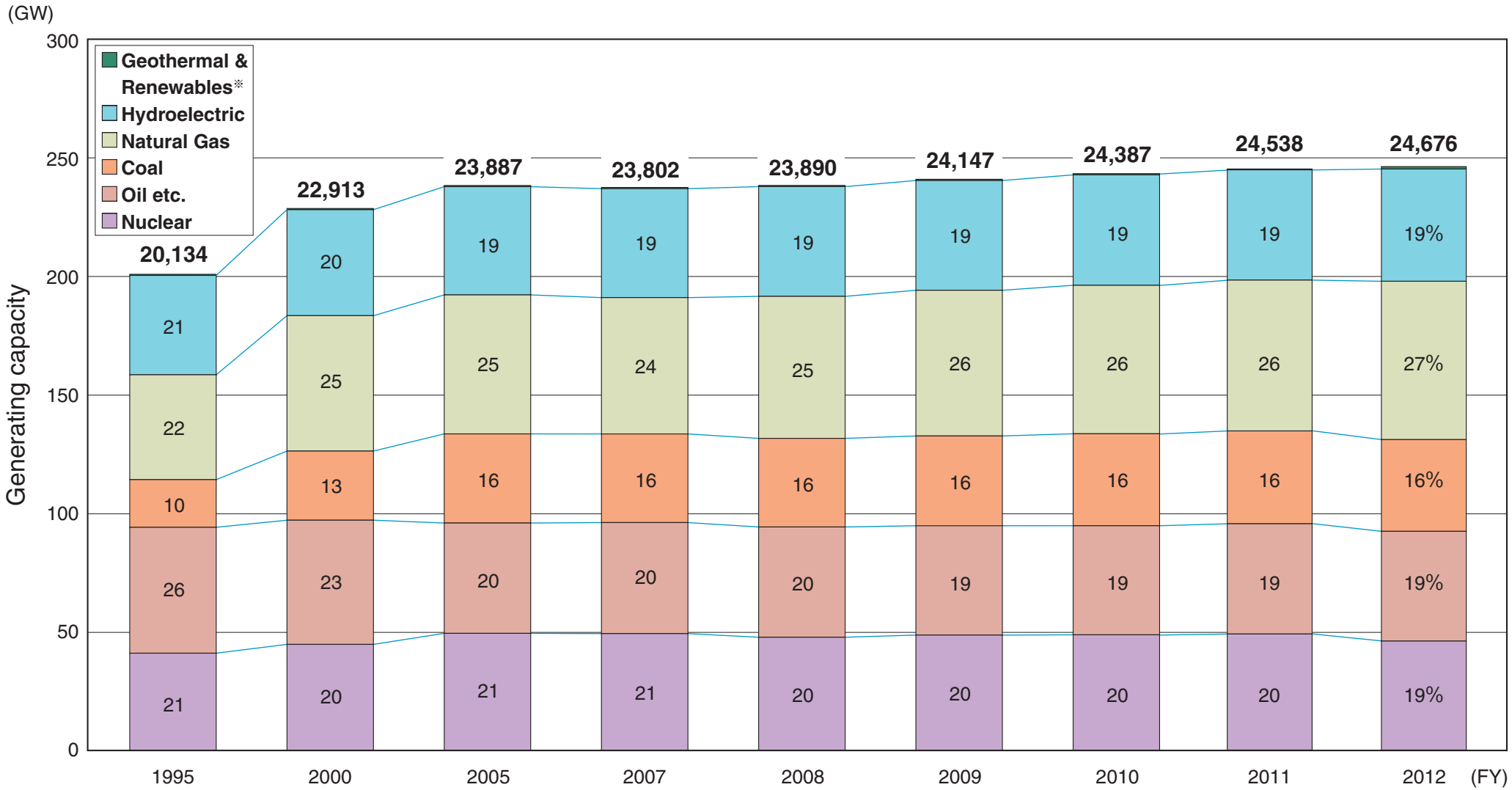
Historical Trend of Power Generation Volume by Source in Japan



(Note) Oil etc. includes LPG and other gases.
Figures may not add up to the totals due to rounding.
Total of 10 electric power companies and power purchased.
Figures within the graph represent the composition ratio.

Source: The Federation of Electric Power Companies

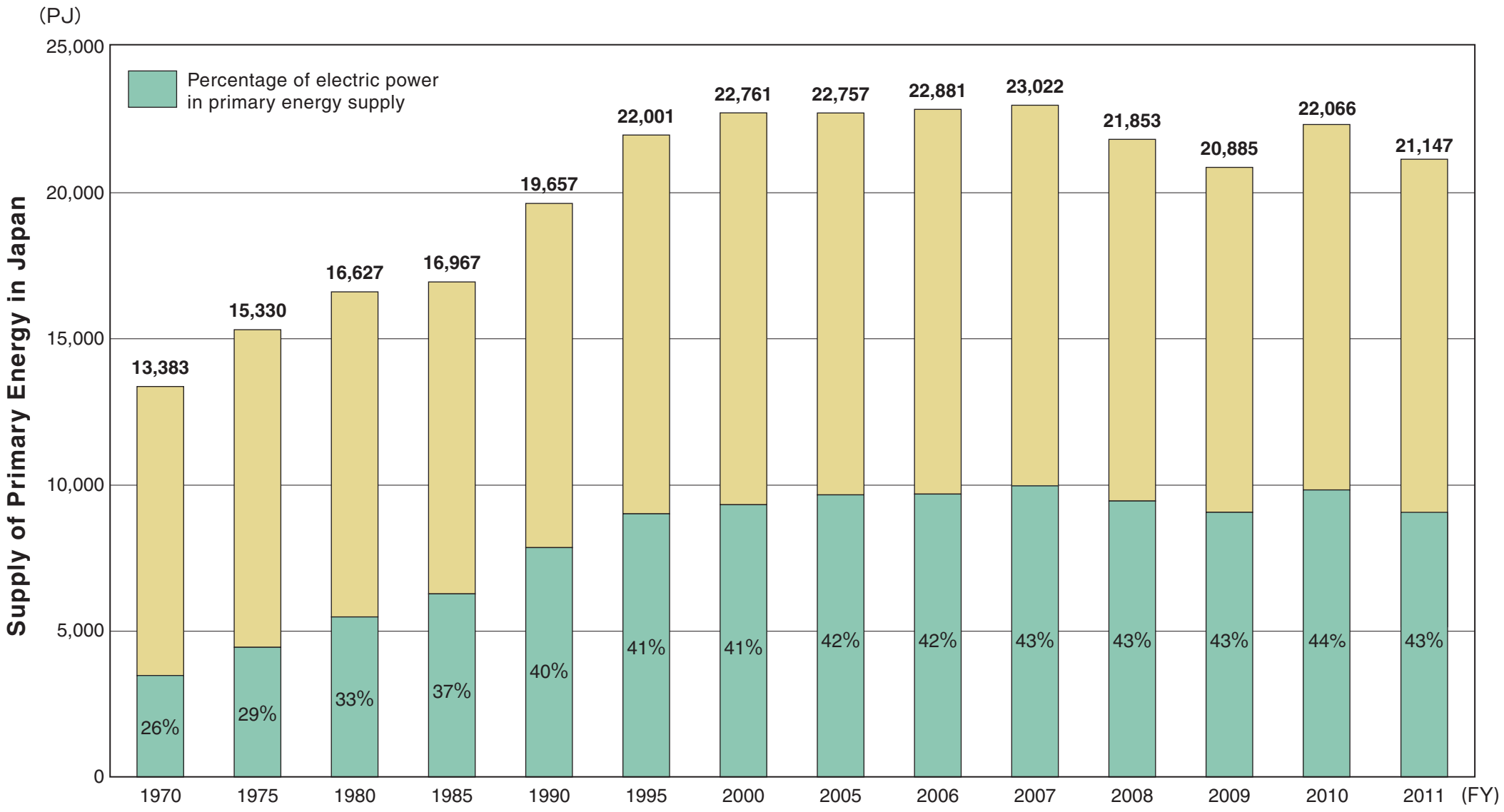
Historical Trend of Generation Capacity by Source in Japan



(Note) Figures may not add up to the totals due to rounding.
※The shares of Geothermal & Renewables are less than 1%.

Source: The Federation of Electric Power Companies

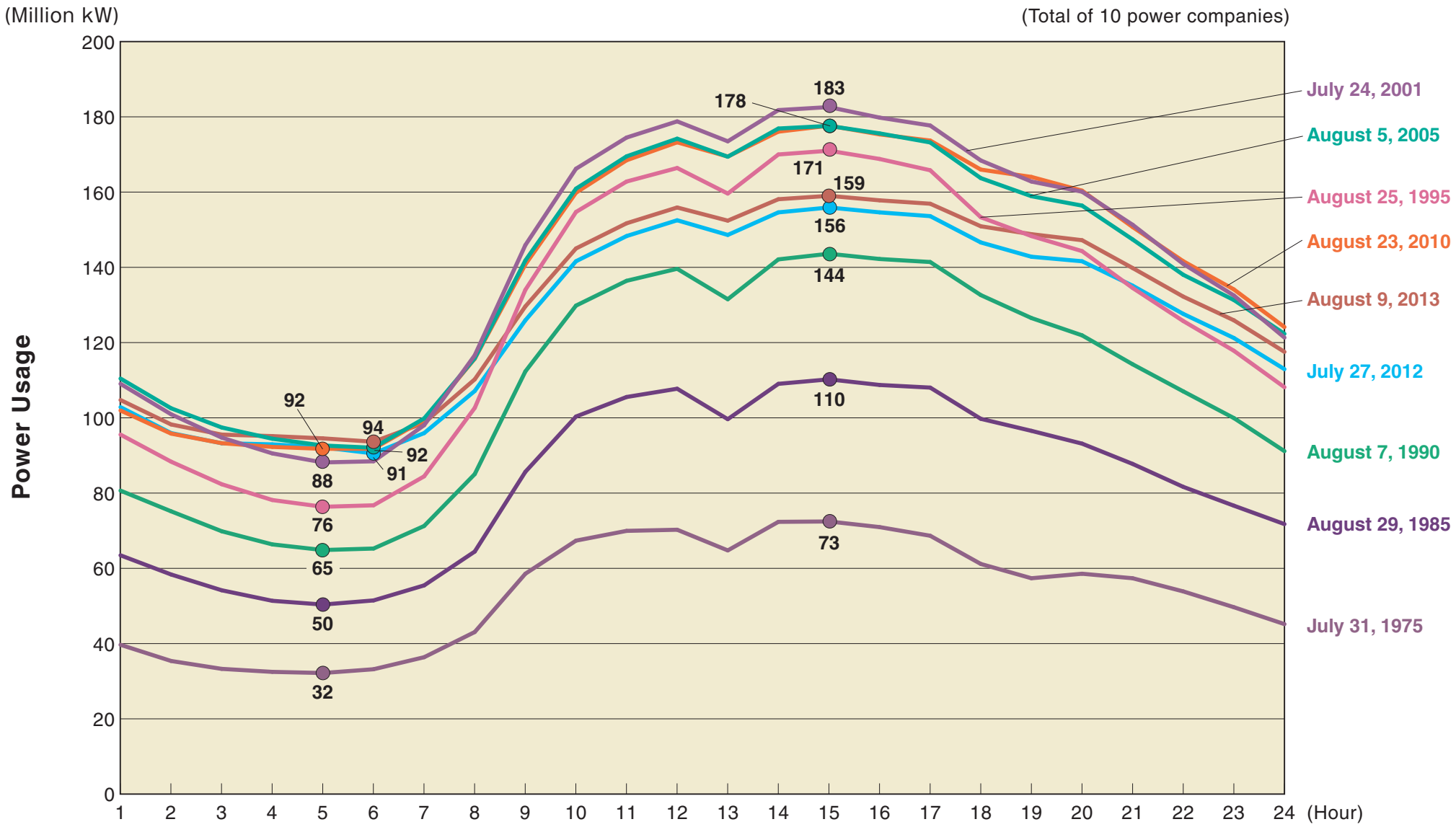
Percentage of Electric Power in Primary Energy (Electrification Ratio)



(Note) 1PJ (=10^{15}Joules) is equivalent to approx. 25,800 kiloliters of crude oil in calorie.

Source: Agency for Natural Resources and Energy "General Energy Statistics"

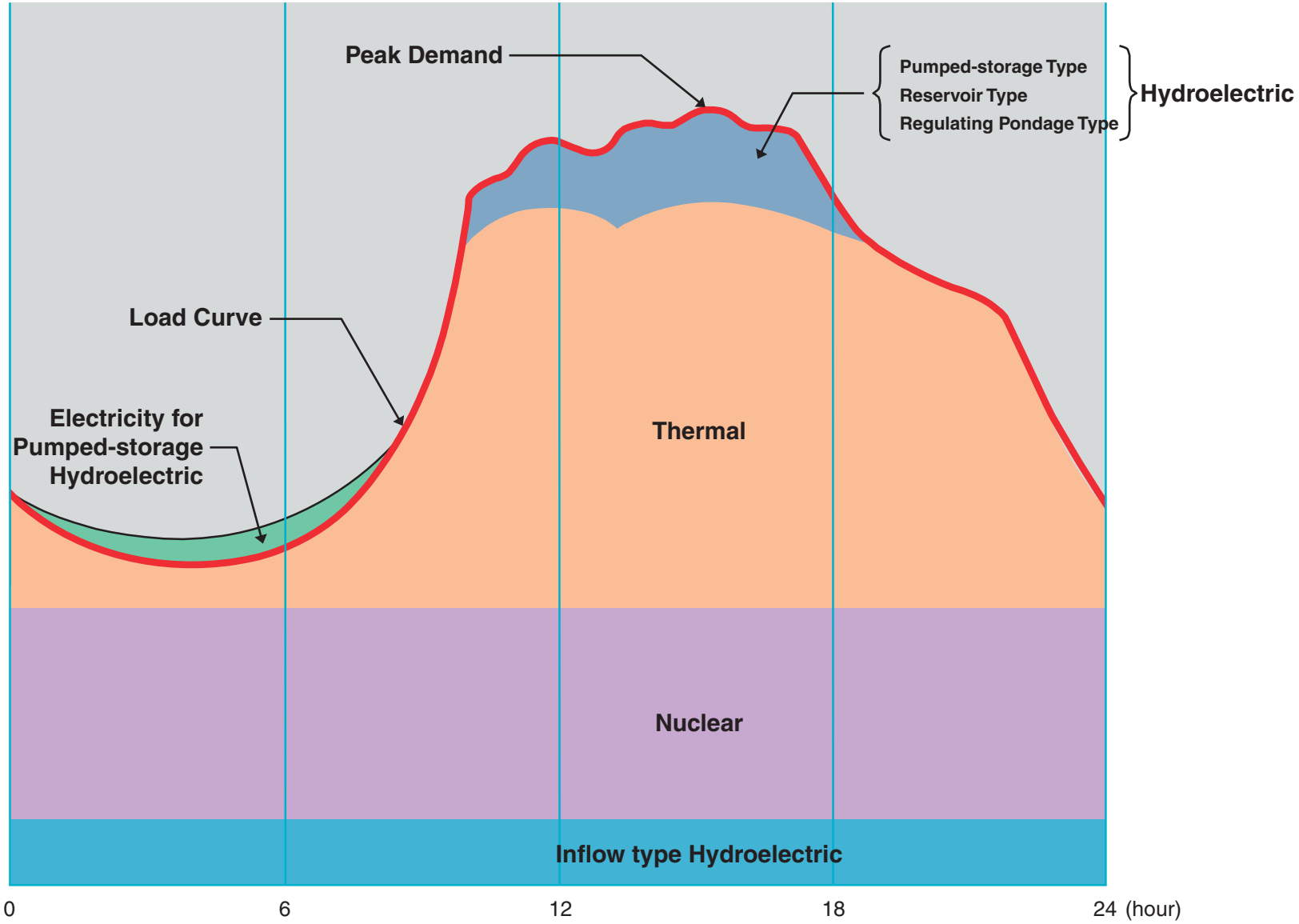
Hourly Power Usage on Peak Power Days



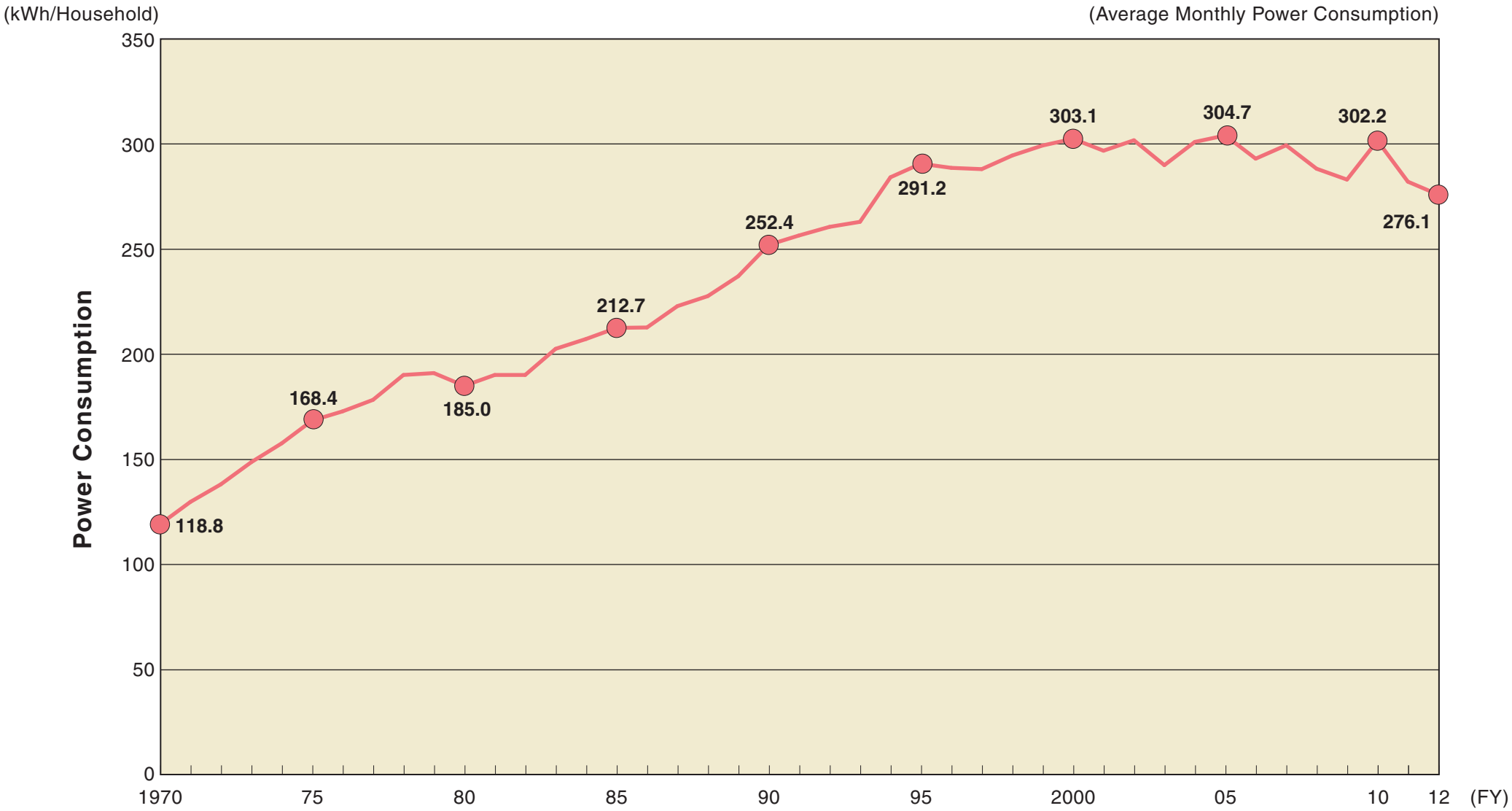
(Note) The value for 1975 uses only 9 power companies.

Source: The Federation of Electric Power Companies

Optimal Combination of Power Sources to Correspond to Demands (Example)



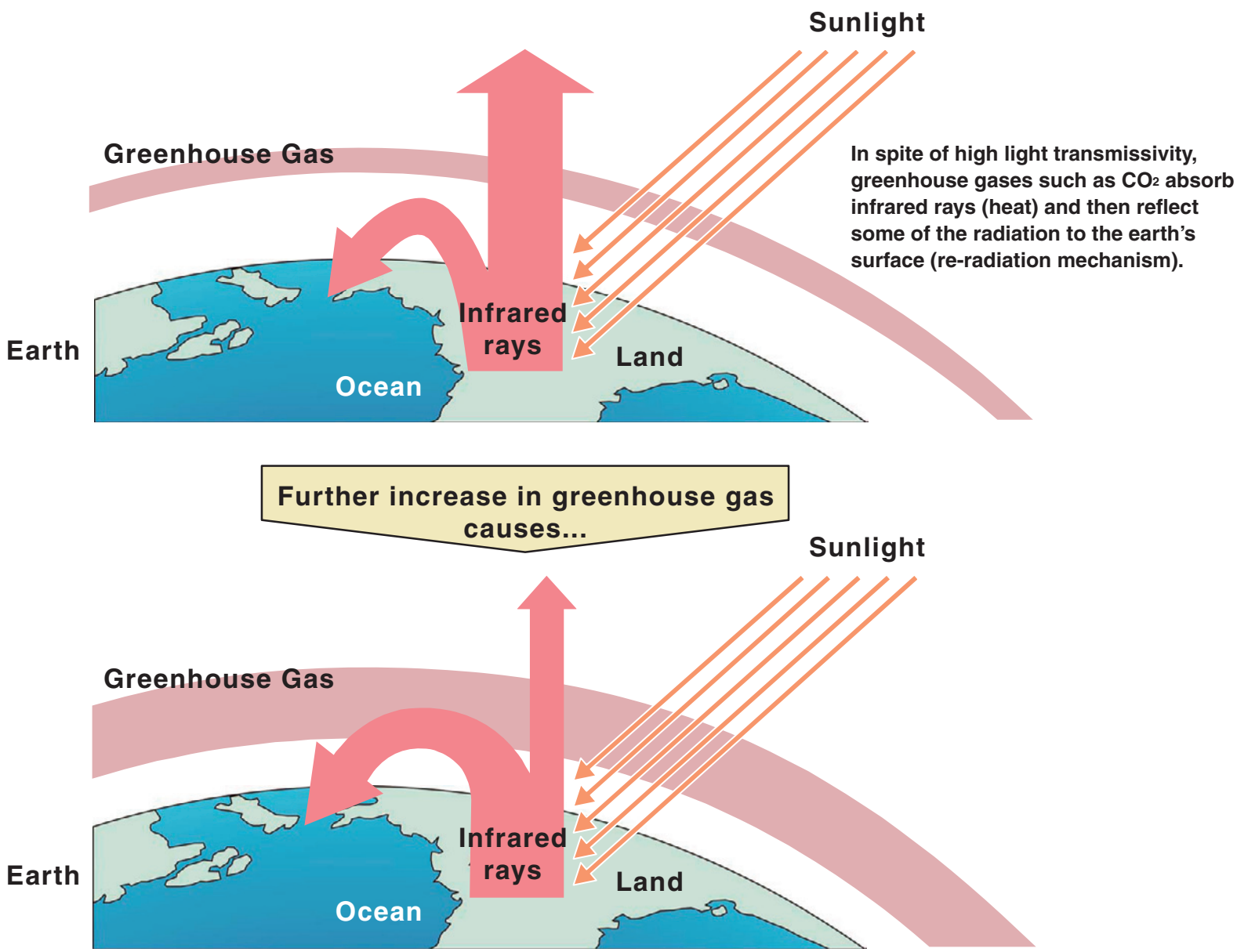
Power Consumption Per Household



(Note) The values are the average for 9 power companies.

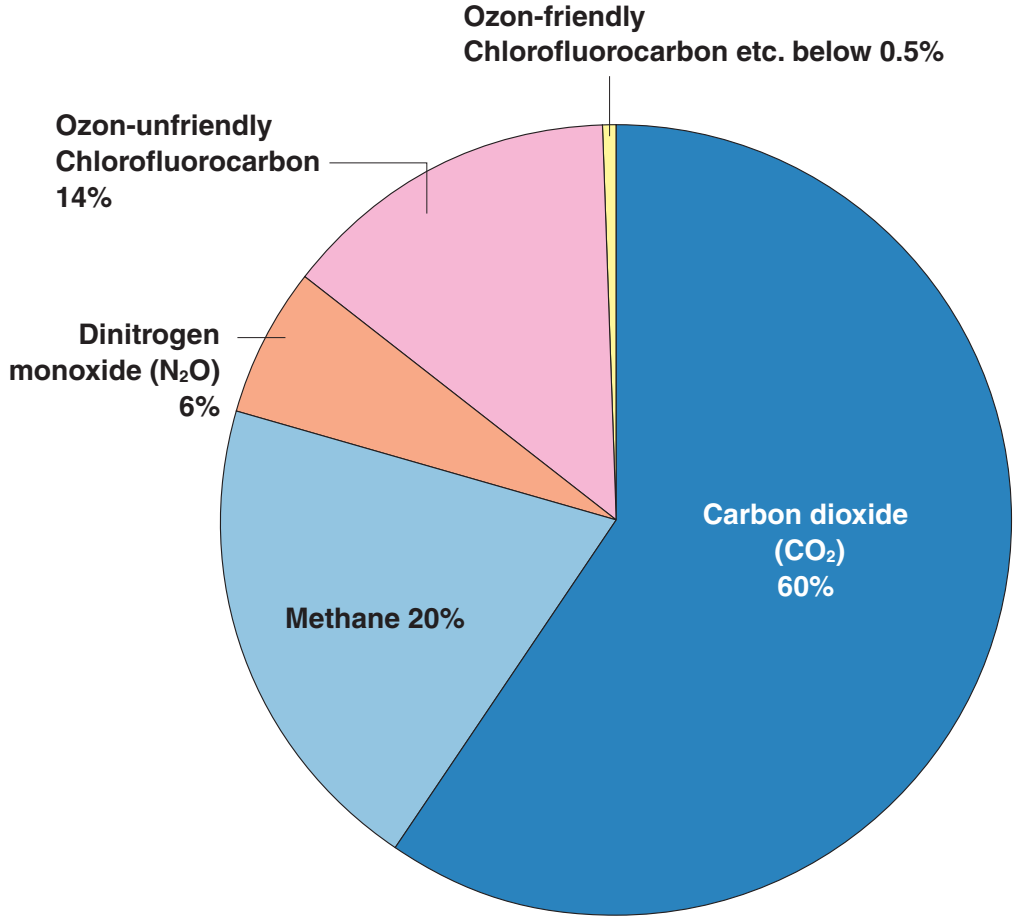
Source: The Federation of Electric Power Companies

Mechanism of Greenhouse Effect

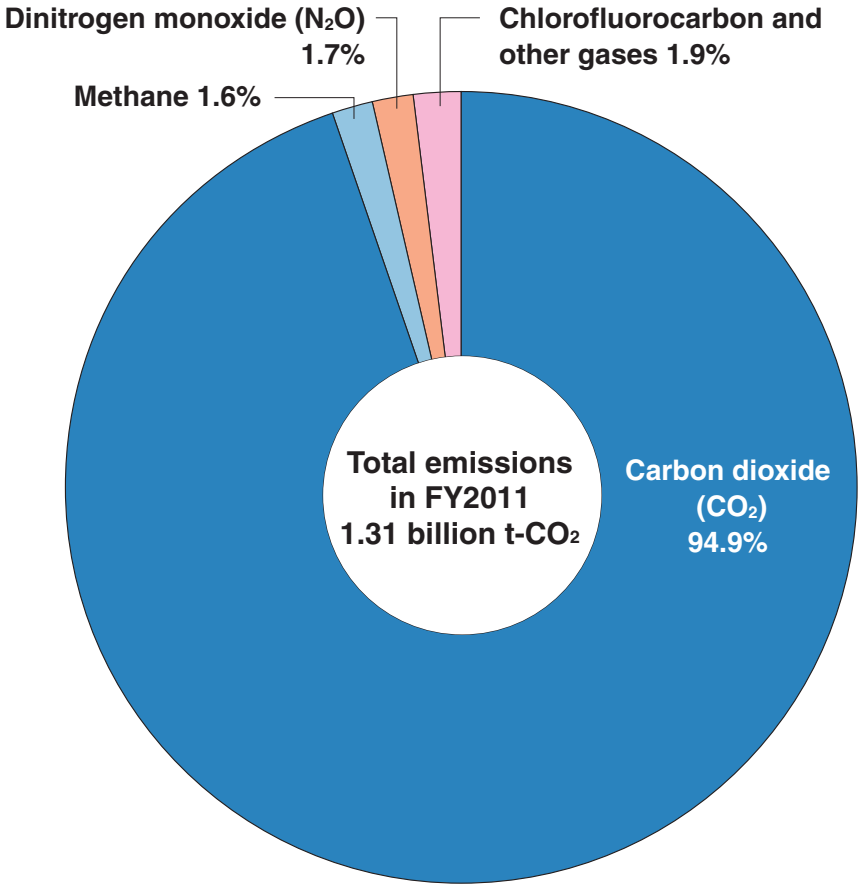


Contribution of Greenhouse Gases to Global Warming

Direct contribution to global warming of GHGs emitted by human activities after the Industrial Revolution



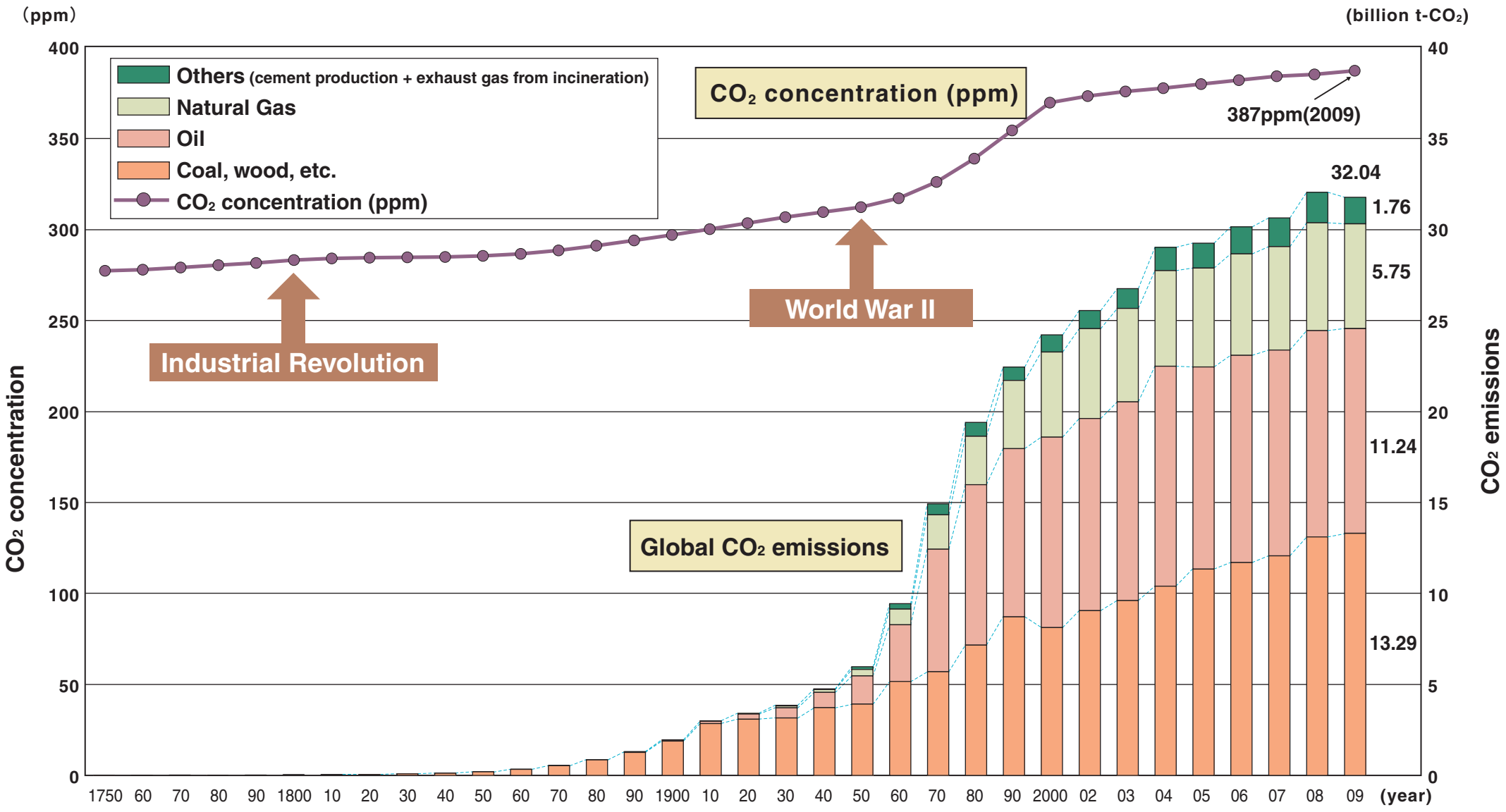
Direct contribution to global warming of GHGs emitted by Japan (for the single year of fiscal 2011)



(Note) Figures may not add up to the totals due to rounding.
GHGs: Greenhouse Gases

Source: Ministry of the Environment "White Paper on the Environment, the Sound Material-Cycle Society and the Biodiversity 2013" etc.

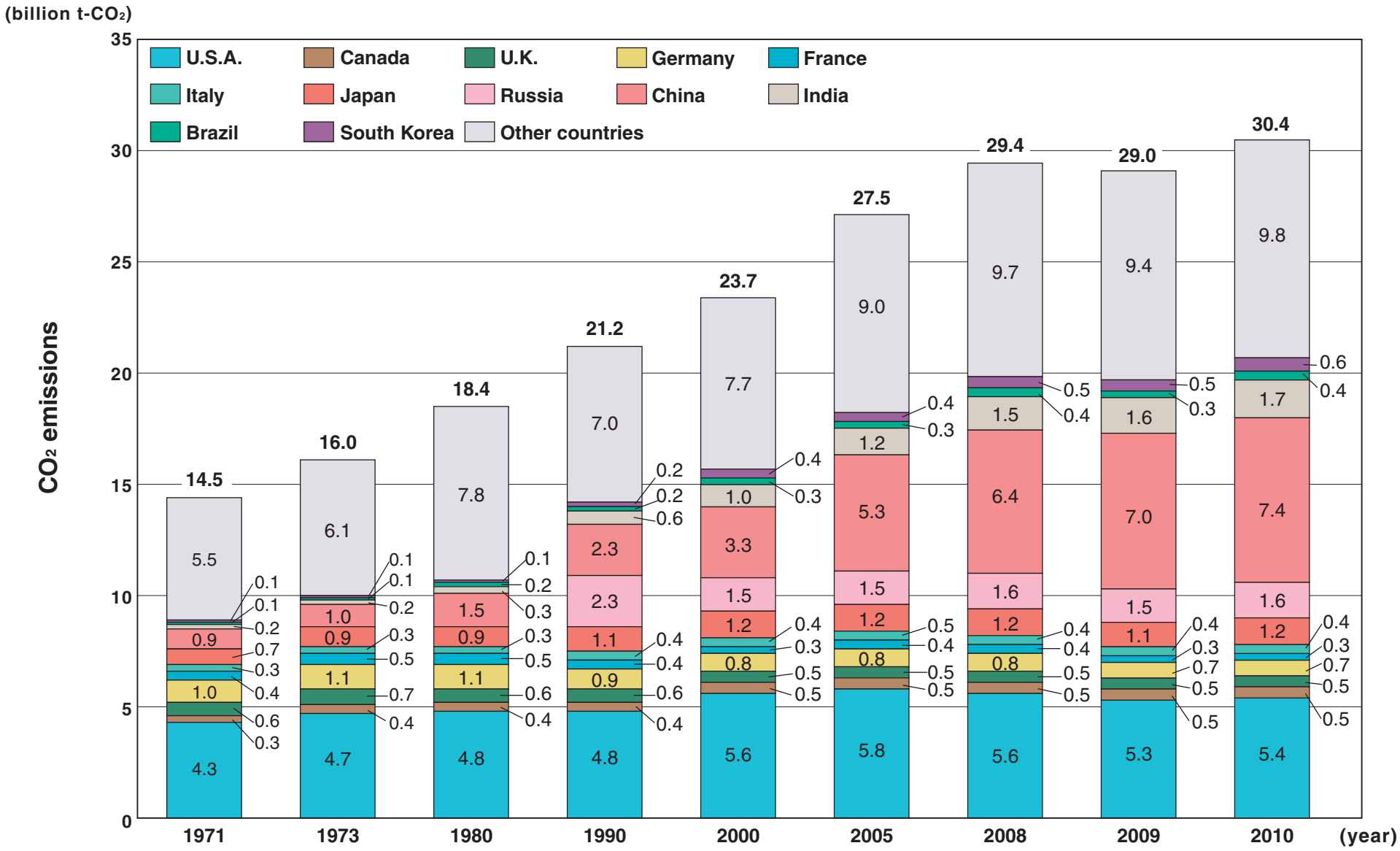
Changes in CO_2 Emissions from Fossil Fuels and Atmospheric CO_2 Concentration in Japan



(Note) Figures may not add up to the totals due to rounding.

Source: CDIAC "Global Fossil-Fuel Carbon Emissions" etc.

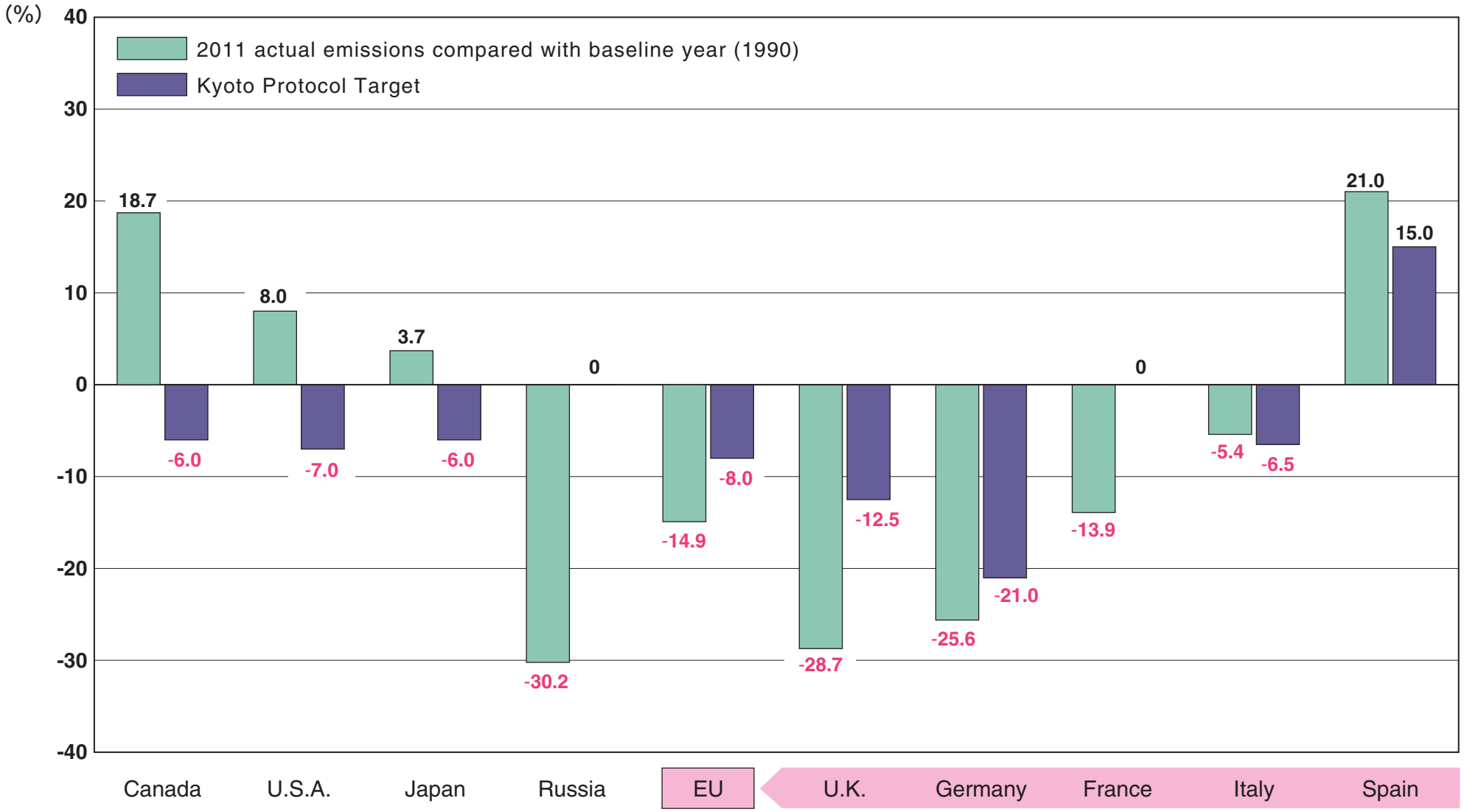
Historical Trends in World's CO_2 Emissions



(Note) Figures may not add up to the totals due to rounding.
Until 1990, Russia's CO_2 emissions are included in "Other countries".

Source: The Institute of Energy Economics, Japan "FY2013 Handbook of Energy & Economic Statistics in Japan"

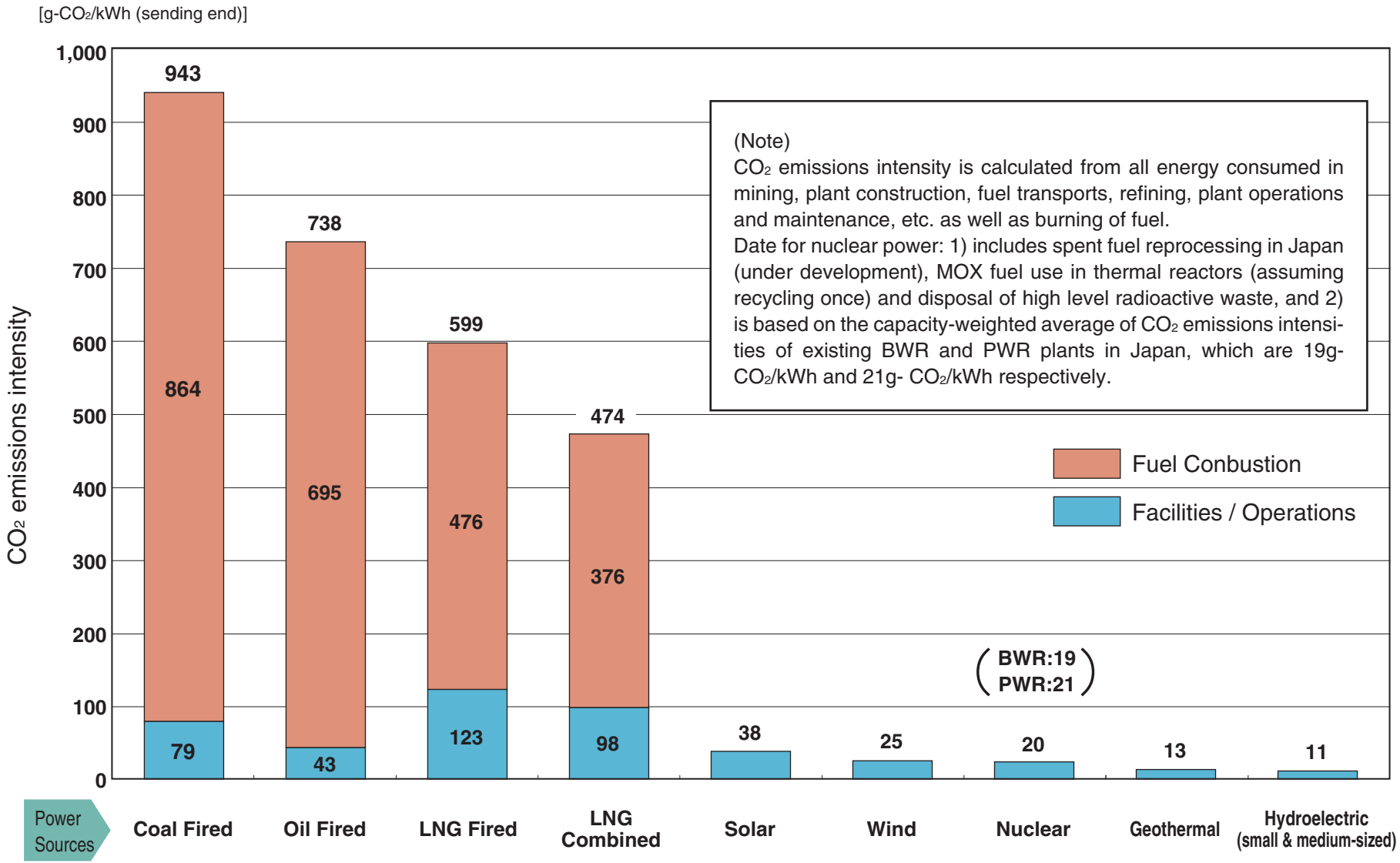
Kyoto Protocol Targets and Current Status of GHG Emissions



(Note) The United States has ratified the kyoto Protocol, and Canada withdrew in December 2012.

Source: Institute for Global Environmental Strategies "The GHGs Emissions Data"

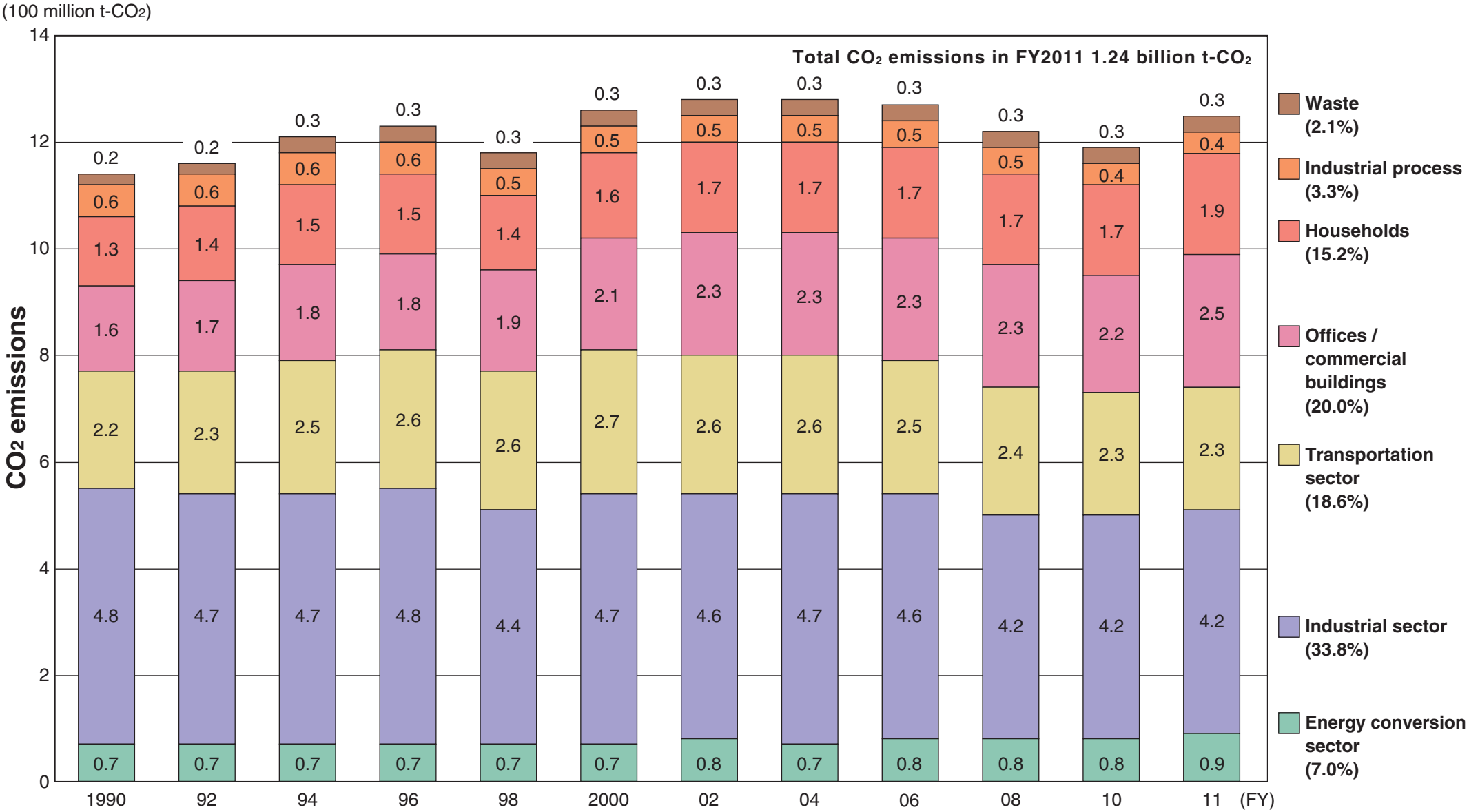
Lifecycle Assessment CO_2 Emissions Intensity for Japan's Erergy Source



(Note)
CO_2 emissions intensity is calculated from all energy consumed in mining, plant construction, fuel transports, refining, plant operations and maintenance, etc. as well as burning of fuel.
Date for nuclear power: 1) includes spent fuel reprocessing in Japan (under development), MOX fuel use in thermal reactors (assuming recycling once) and disposal of high level radioactive waste, and 2) is based on the capacity-weighted average of CO_2 emissions intensities of existing BWR and PWR plants in Japan, which are 19g-CO_2/kWh and 21g- CO_2/kWh respectively.

Source: Central Research Institute of Electric Power Industry "Evaluation of Life Cycle CO_2 Emissions of Power Genevations technologies (July 2010)"

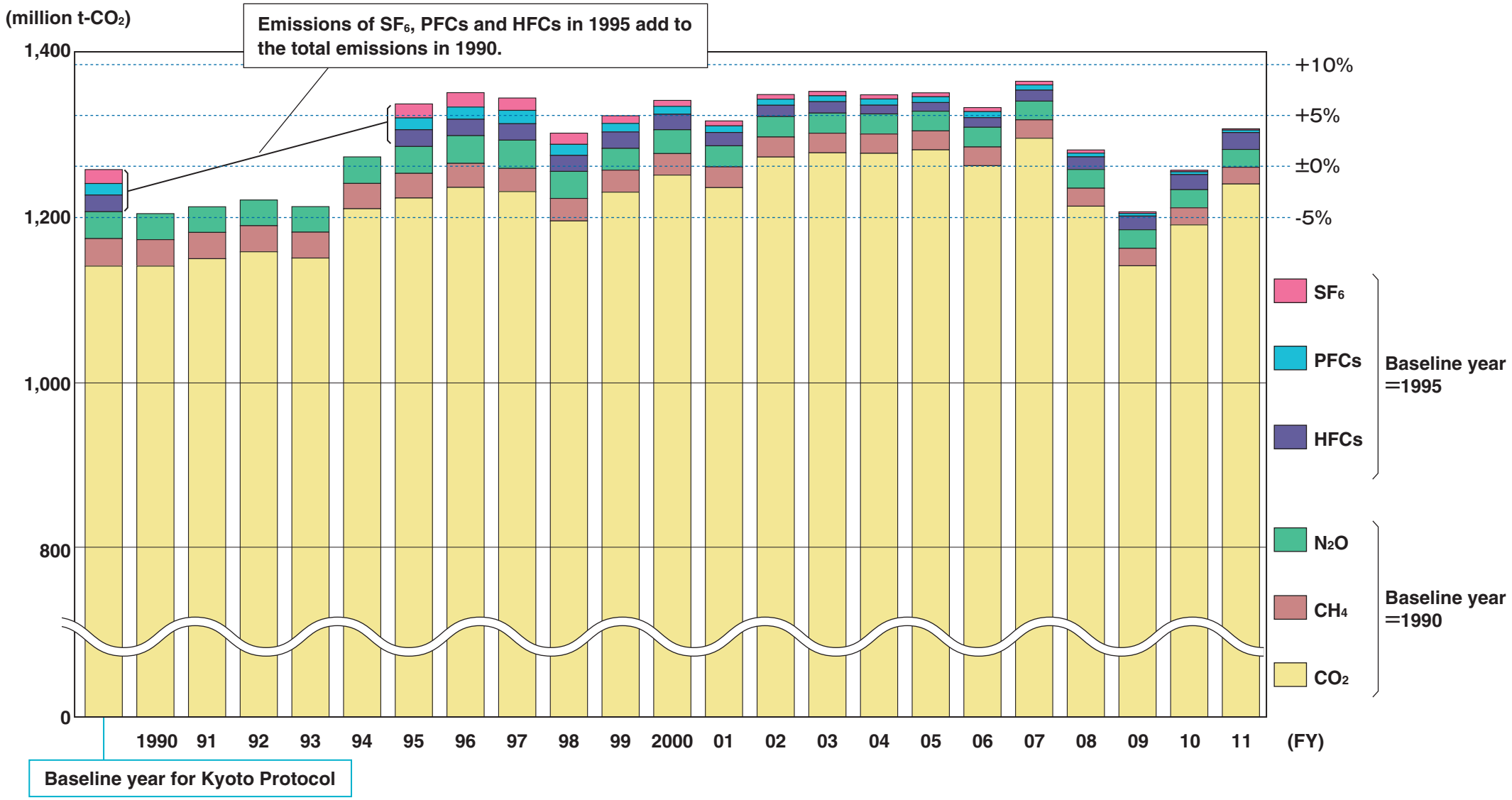
Japan's Changes in CO_2 Emissions by Sector



(Note) The numerical values show the indirect emissions (CO_2 emissions associated with power generation or heat generation are allocated to individual end demand sectors according to the electricity and heat consumption.)

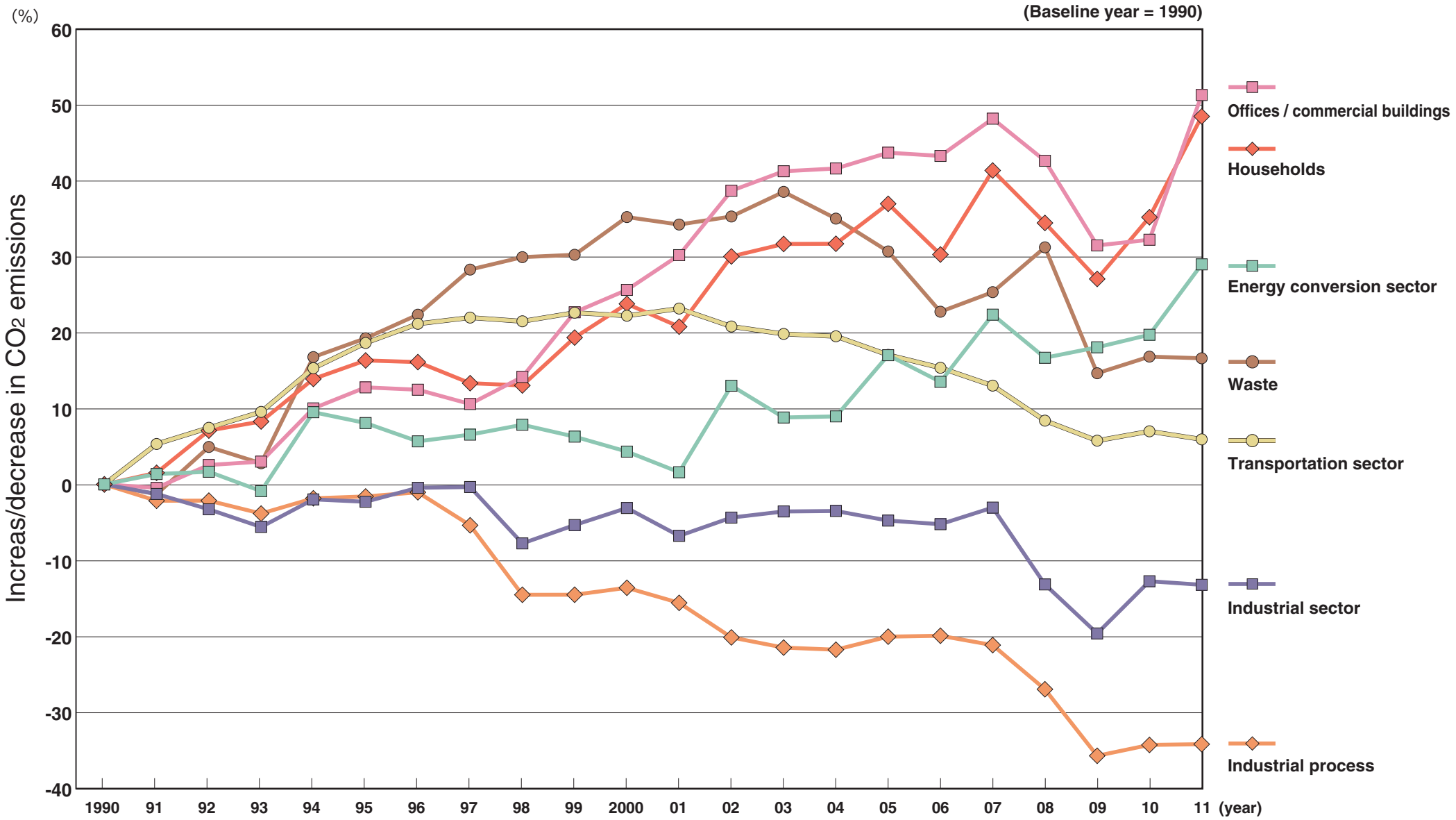
Source: National Institute for Environmental Studies "Greenhouse gas emission (fixed annual) in FY2011"

Changes in GHGs Emissions in Japan



Source: Greenhouse gas Inventory office of Japan

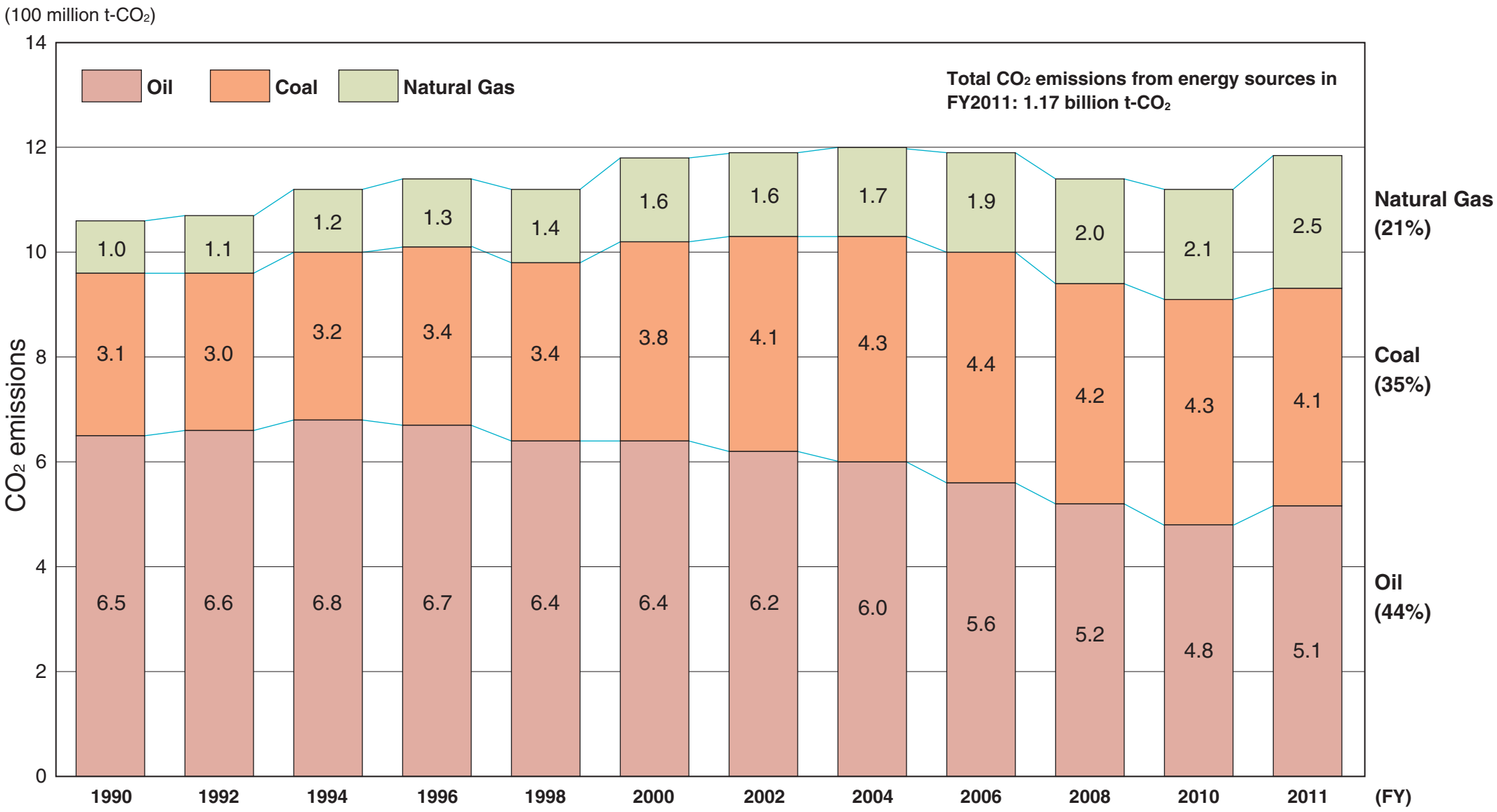
Increase/Decrease in CO_2 Emissions by Sector in Japan



(Note) The numerical values show the increase and dearease of the indirect emissions (CO_2 emissions associated with power generation or heat generation are allocated to individual end demand sectors according to the electricity and heat consumption.)

Source: National Institute for Environmental Studies "Greenhouse gas emission (fixed annual) in FY2011"

Changes in CO_2 Emissions by Energy Source



(Note) Figures may not add up to the totals due to rounding.

Source: Greenhouse Gas Inventory Office of Japan "National GHGs Inventory Report of JAPAN"

Measures by Japan's Electric Power Industry to Reduce CO_2 Emissions

Efforts in domestic business activities

Expanding the use of non-fossil energy sources

- **Using nuclear power with safety as a major premise**
- **Using renewable energies**
  - Using hydropower, geothermal, solar and wind power,and biomass
  - Studies for dealing with the output fluctuation of renewable energies and for expanding their introduction

Improving the efficiency of power facilities

- **Improving the efficiency of thermal power**
  - In developing thermal power, adopting the highest level of technology suitable for the size of the plant
  - Appropriately maintaining and controlling the thermal efficiency of existing plants

Strengthen ing the collaboration between the supply and demand sides including customers

Energy conservation

- **Promoting high-efficiency electrical devices to enhance the efficient use of electricity**
  - Heat pumps(EcoCute, etc.), TES air-conditioning systems
- **PR activities and providing information on energy-saving and CO_2 reduction**
  - Environmental housekeeping books, exhibitions on energy appliances, seminars on energy saving
- **Introducing smart meters for the efficient use of electricity**

Efforts by electric utility industry as users

- **Efforts in office-use energy conservation and the use of company-owned vehicles**
  - Reduction of amount of power consumption
  - Introduction of electric vehicles and fuel-efficient vehicles

Promoting international contributions

International efforts

- **Assisting developing countries to reduce carbon through international partnership(GSEP) activities**
  - Transfer and granting of Japanese electricity technology through coal thermal facility diagnosis and CO_2 emissions reduction activities
- **Reducing carbon in all parts of society through international efforts**
  - Developing and introducing advanced and feasible technology through international efforts such as the "International Electricity Partnership"

Developing innovative technologies

Research and development

Supply-side

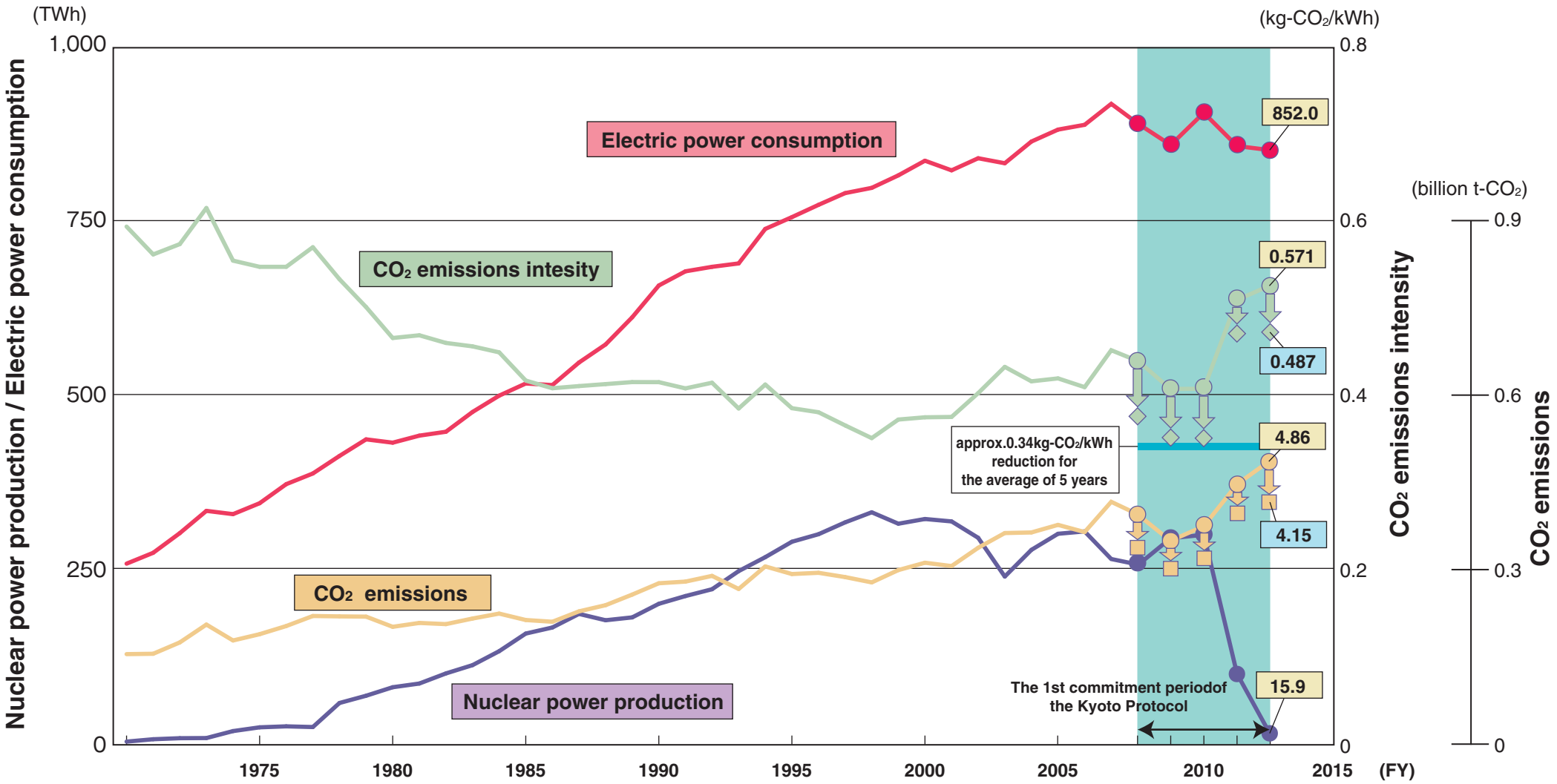
- **Clean coal technology, CCS, next-generation power transmission and distribution technology**

Customer-side

- **Ultra-high efficiency heat pump, EV-related technologies**

Source: The Federation of Electric Power Companies "Environmental Action Plan by the Japanese Electric Utility Industry (September, 2013)"

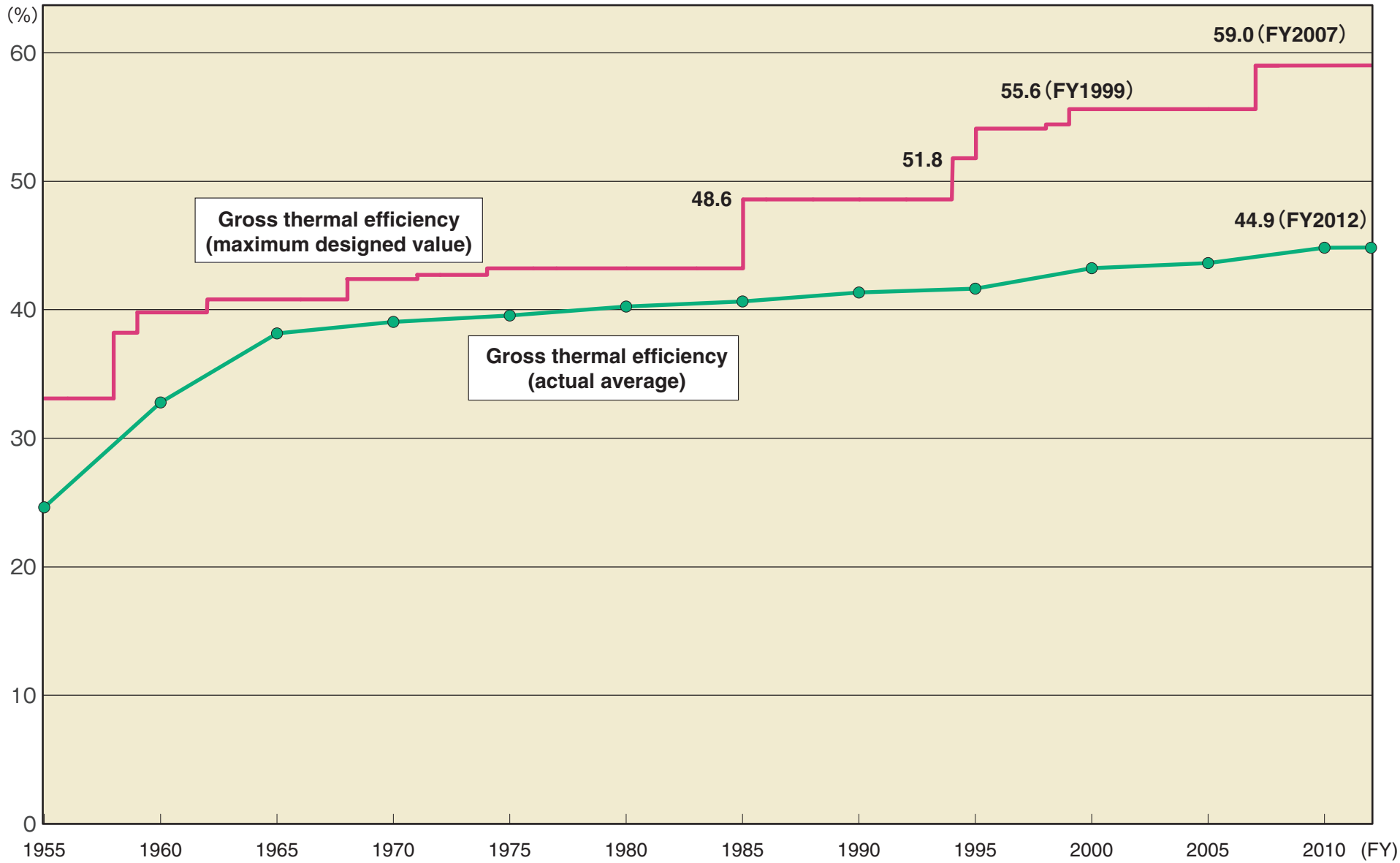
Historical Trends in CO_2 Emissions from Electricity Production in Japan



(Note) The marker (◇,□) indicates user-end CO_2 emissions intensity after the Kyoto Mechanism credit was reflected and CO_2 emissions after adjustment. The electric utility industry targets approximately 20% reduction (approx. 0.34kg-CO_2/kWh reduction) for the average of 5 years between fiscal 2008 and fiscal 2012, compared to 1990.

Source: The Federation of Electric Power Companies "Environmental Action Plan by the Japanese Electric Utility Industry (September, 2013)"

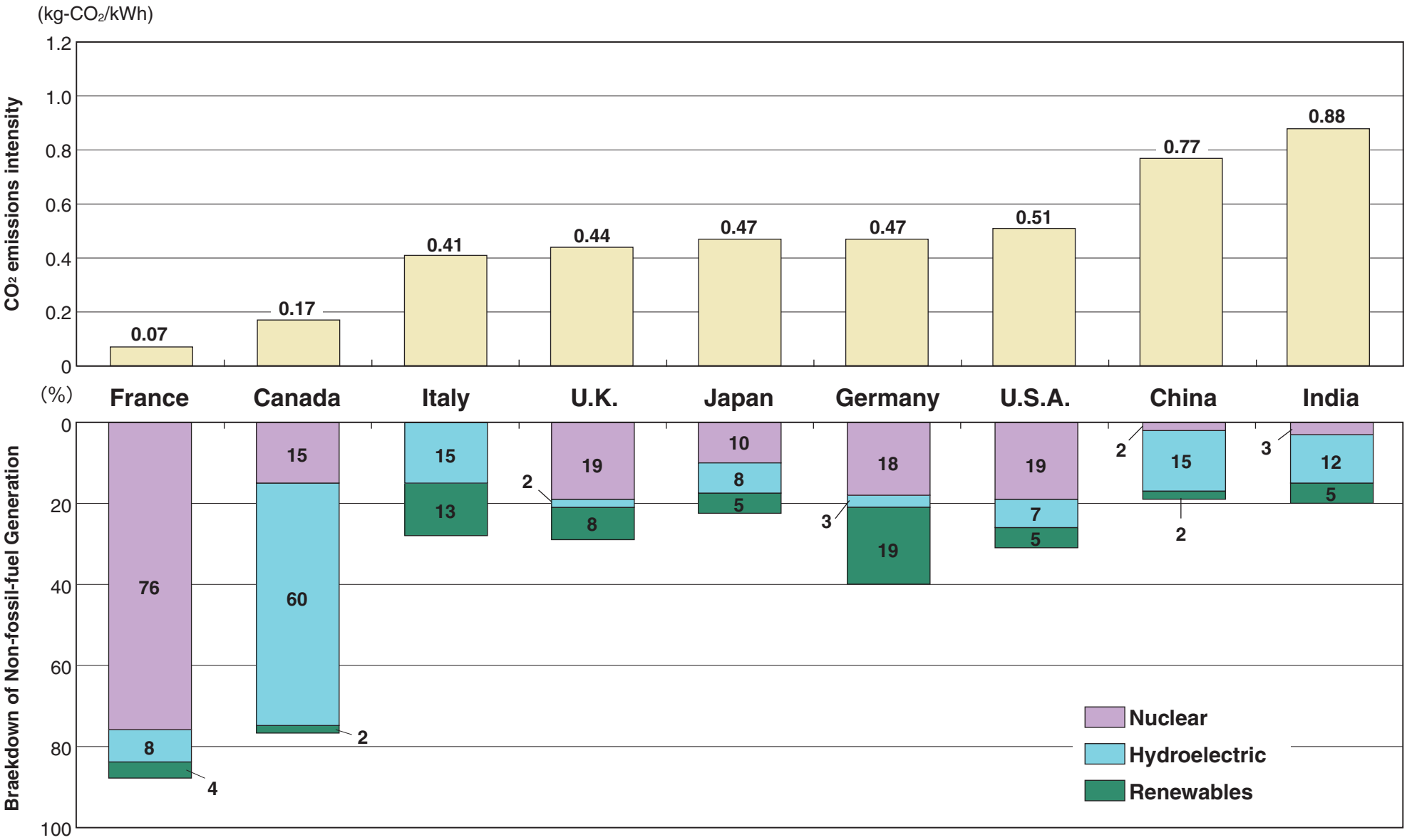
Thermal Efficiency and T&D Loss Factor in Japan



(Note) Lower Heating Value : Estimated from higher heating value standard based on the conversion factor of the comprehensive energy statistics (FY2010).

Source: Agency for Natural Resources and Energy "Japan Electric Utilities Handbook" etc.

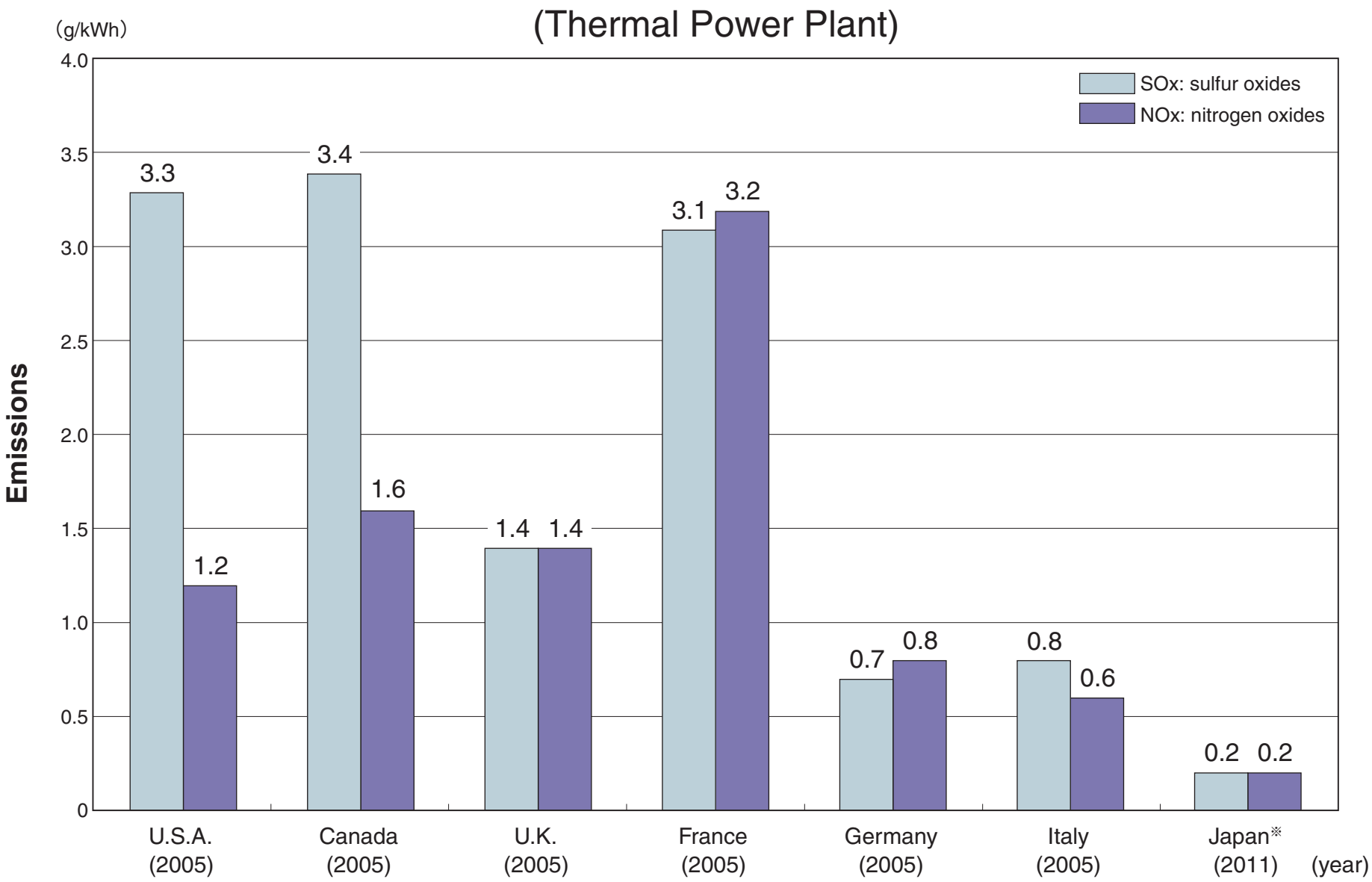
Comparison of CO_2 Emissions Intensity by Country



(Note) Fiscal 2010 figures. The figures contains Combined Heat and Power (CHP) plants. The figures of Japan contains non-utility generation facilities.

Source: IEA "ENERGY BALANCES OF OECD COUNTRIES (2013 Edition)" / "ENERGY BALANCES OF NON-OECD COUNTRIES (2013 Edition)"

SOx and NOx Emissions per Unit of Electricity Generated in Major Countries

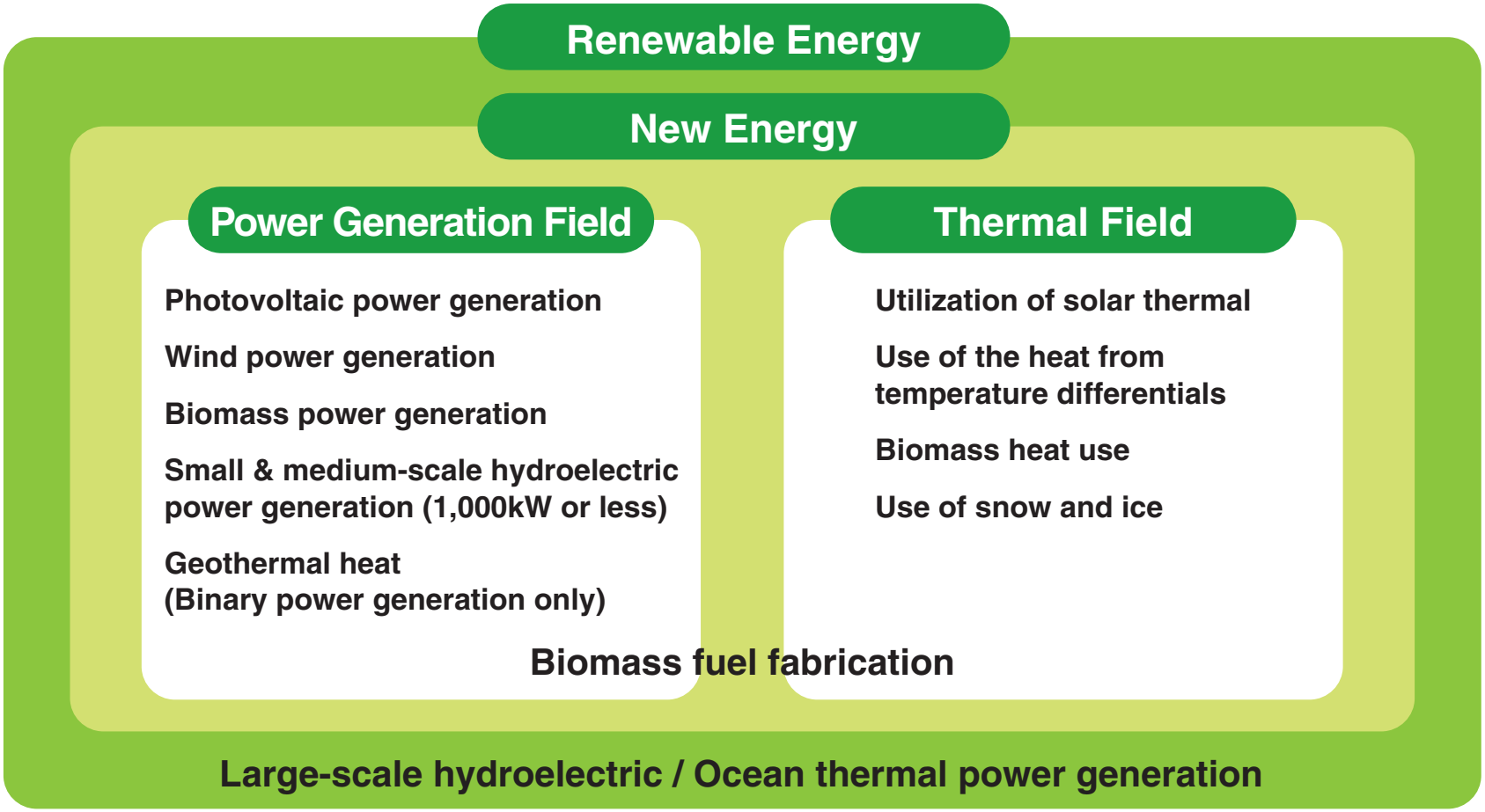


※10 electric power companies and Electric Power Development Co. Ltd.

Source: "OECD Environmental Data compendium (2006/7)" / "ENERGY BALANCES OF OECD COUNTRIES (2008 Edition)"/ The Federation of Electric Power Companies

What is New Energy?

"New Energy" is defined under Japanese law* as "something that although it has reached the stage of being capable of implementation on a technical level, has not been deployed fully due to economic restraints, and has specific requirements in order to introduce it as an energy to replace oil," and 10 types have been specified, such as solar and wind power generation, bio-mass, etc.Most of the new energies result in purely domestic energy products, and the promoting the development of such technologies offers enormous value to resource-poor Japan.



*Act on Special Measures for the Promotion of New Energy Use, abbreviated as New Energy Act

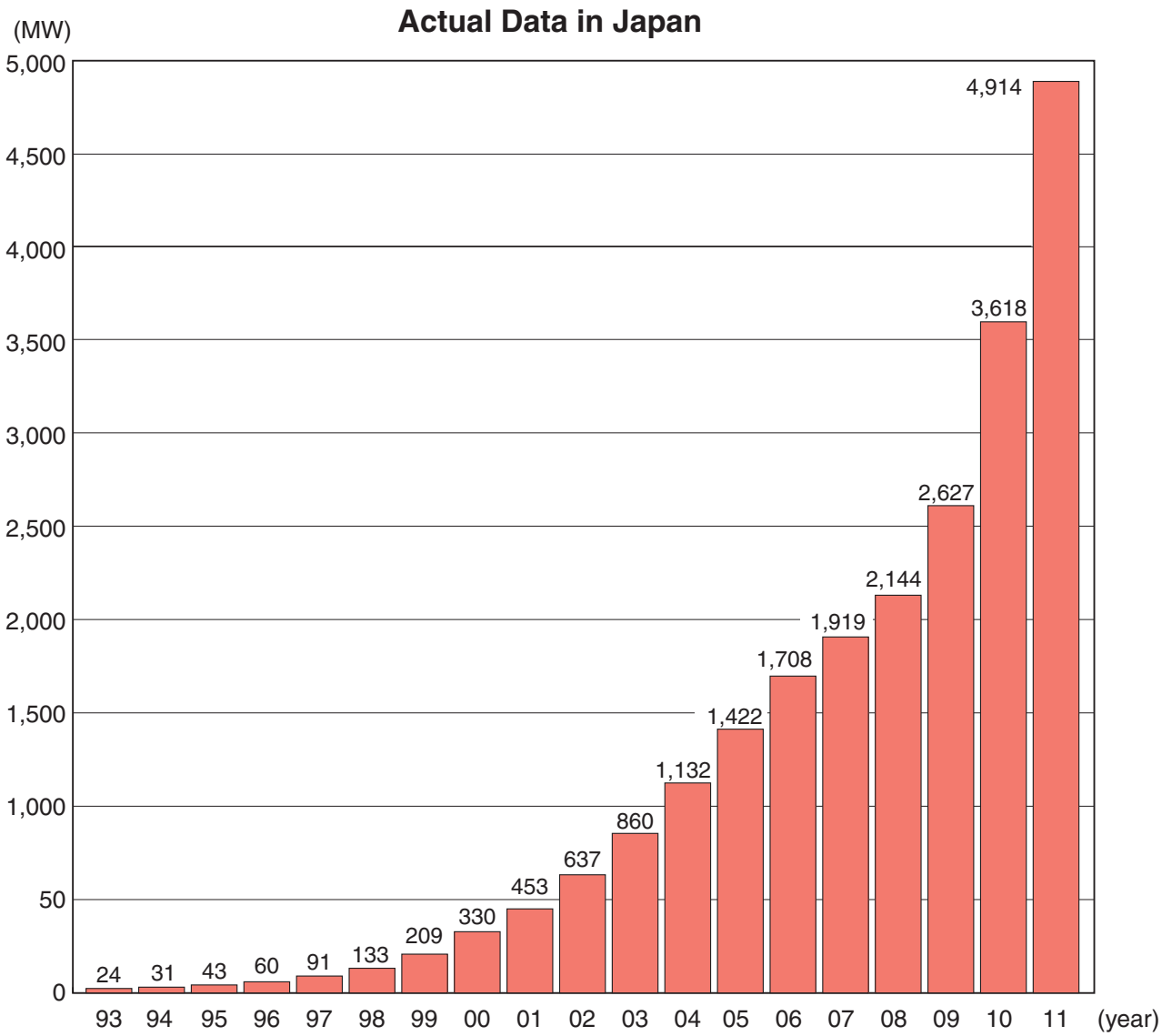
Source: Agency for Natural Resources and Energy

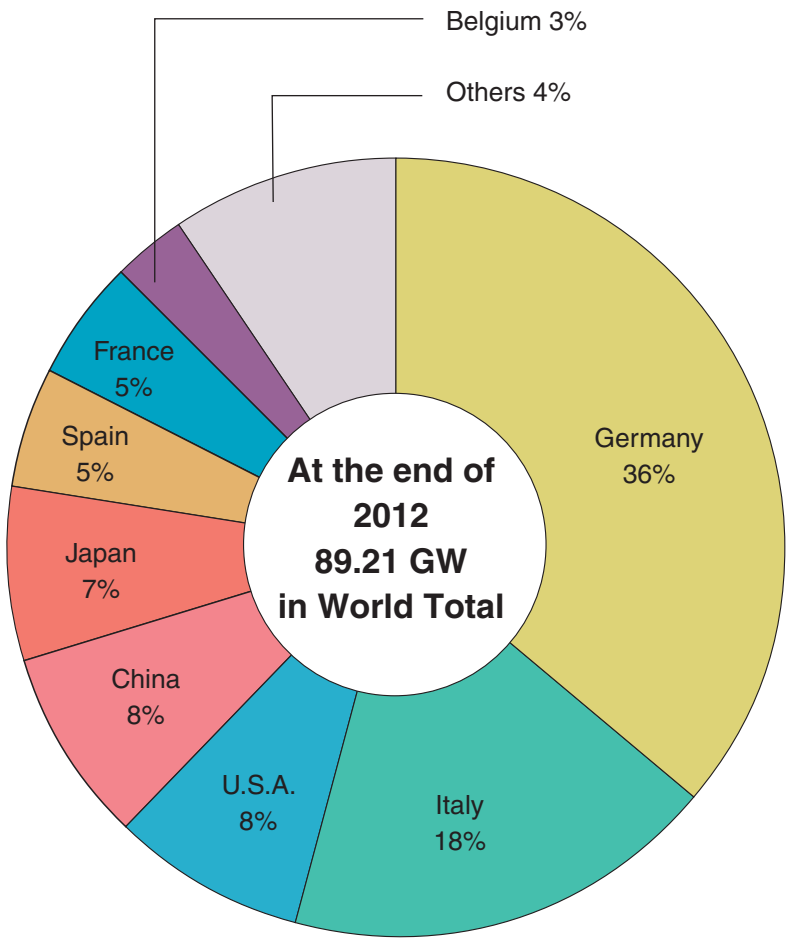
Evaluation & Problems of New Energy

	Photovoltaic Power	Wind Power	Waste Power(Biomass Power)
Merits	○No fear of exhaustion ○Emit no CO_2 or other gases in the process of power generation ○Due to neighboring the demand area, there is no transmission loss ○Generate at daytime when the demand rises	○No fear of exhaustion ○Emit no CO_2 or other gases in the process of power generation	○No additional CO_2 emission by power generation ○Continuously supplied stable power source among new energies
Demerits	○Due to low energy density ※1, it needs much larger area than thermal and nuclear power generation for the same amount of power generation ○Unstable due to no generation at night and low power output in rainy or cloudy days ○High costs on facilities	○Due to low energy density, it needs much larger area than thermal and nuclear power generation for the same amount of power generation ○Unstable due to occasional and seasonal volatility in wind directions and speed ○Makes noises when windmills rotate ○Locations where the wind situation is good are unevenly distributed ○High costs on facilities	○Low generation efficiency ○Needs further environmental loads reduction measures such as dioxin emission control measures and ash reduction
Necessary Site Area ※2	to substitute for a 1,000MW-class nuclear power plant		
	approx. 58 km^2, almost as same as the area inside the Yamanote Line (Tokyo Loop Line)	approx. 214 km^2, approx. 3.4 times larger than the area inside the Yamanote Line	
Load Factor	12%	20%	

※1 Energy density is the figure which shows the amount of generation in area.
※2 Figures from the Study Group on Low Carbon Power Supply System (July 2008)

Solar Power Generation Capacity in Japan and the World

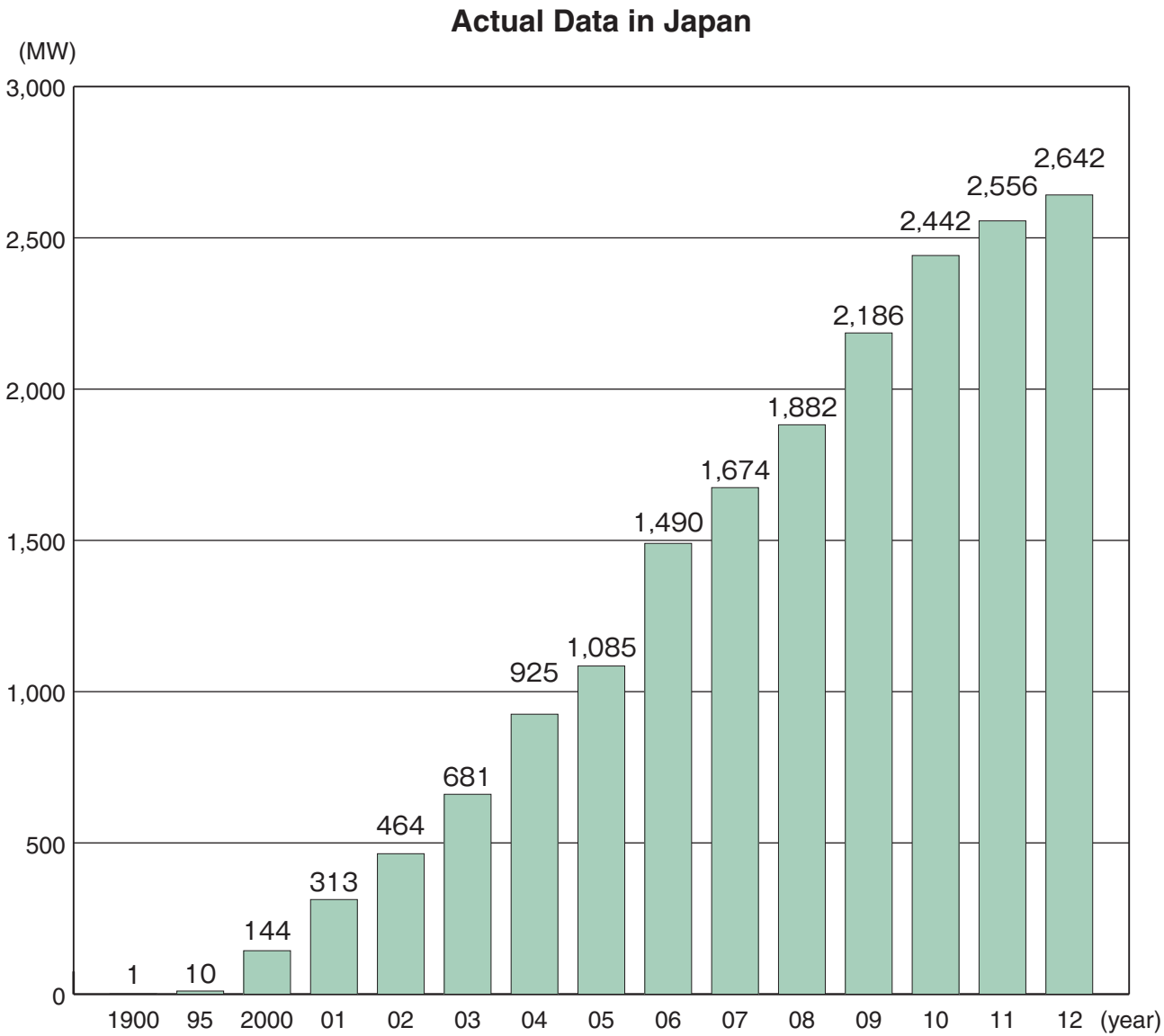


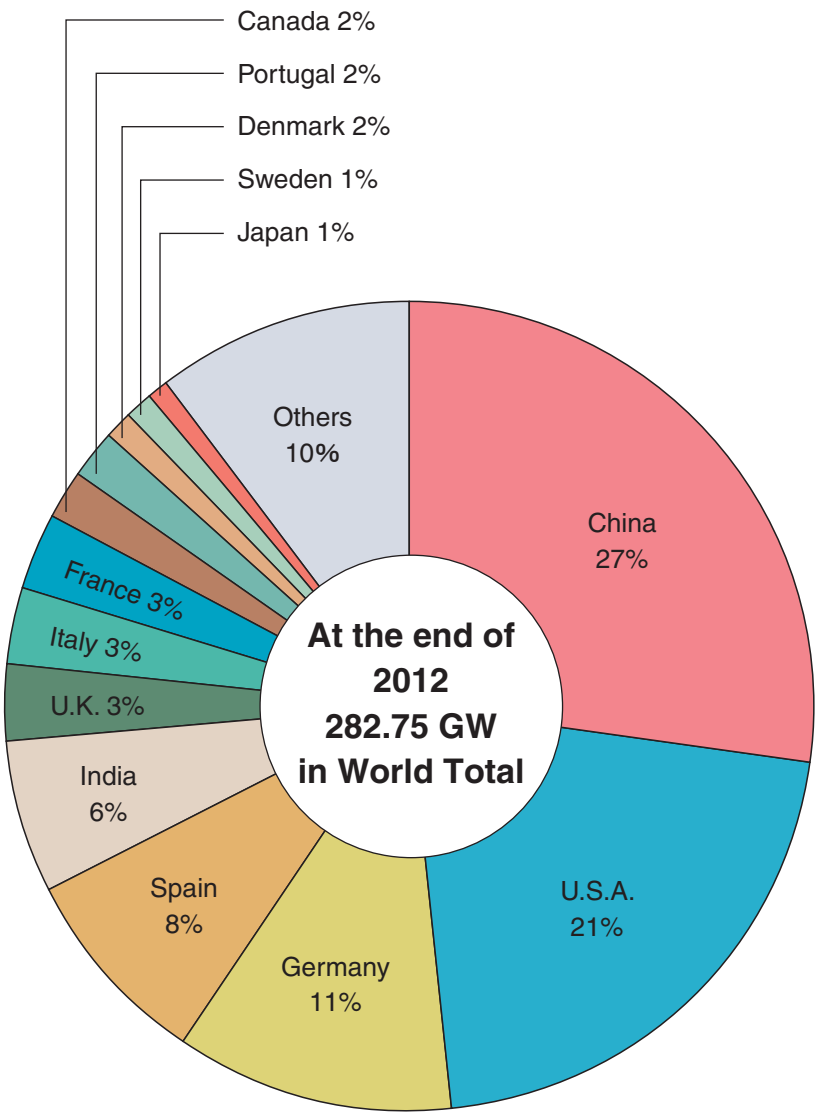


(Note) Figures may not add up to the totals due to rounding.

Source: IEA "TRENDS 2013 IN PHOTOVOLTAIC APPLICATIONS"/Agency for Natural Resources and Energy

Wind Power Generation Capacity in Japan and the World



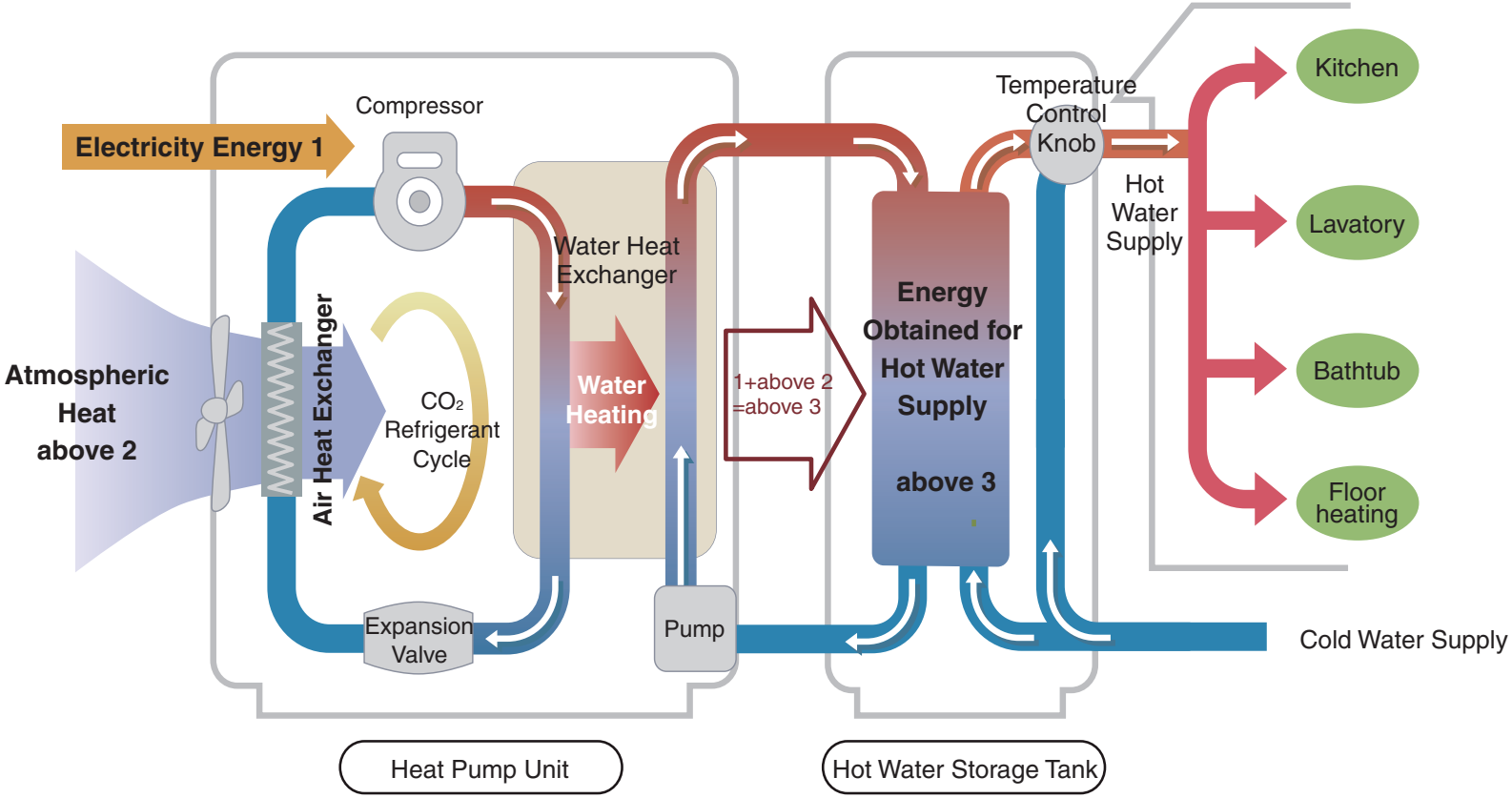


(Note) Figures may not add up to the totals due to rounding.

Sources: WWEA "World Wind Energy Report 2012"/ NEDO

Mechanism of Heat Pump System Utilizing CO_2 Refrigerant

EcoCute

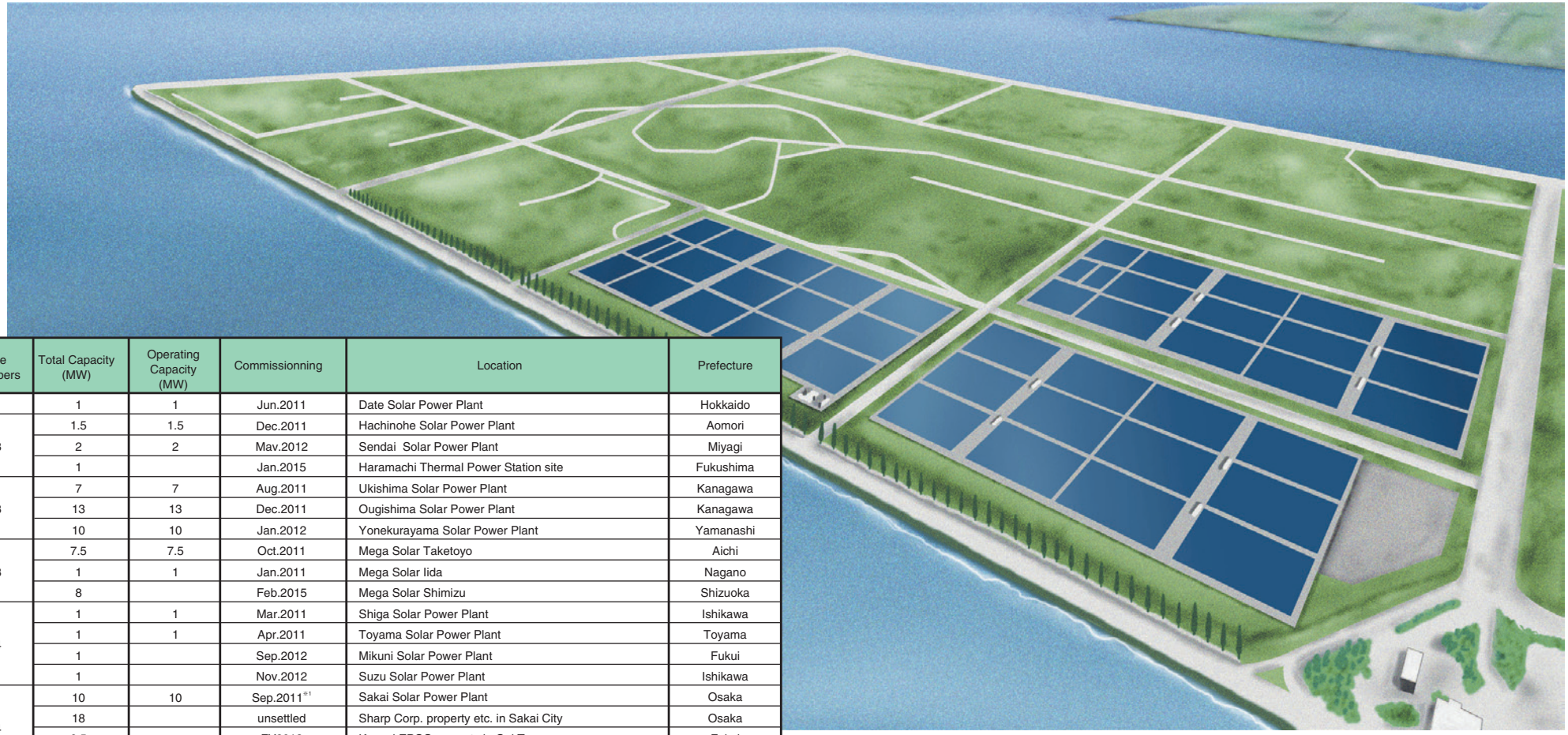


1 **Electricity Energy** + above 2 **Atomospheric Heat** = above 3 **Energy Obtained for Hot Water Supply**

Source: The Federation of Electric Power Companies "Environmental Action Plan by the Japanese Electric Utility Industry" etc.

Mega Solar Power Generation Plant Projects in Japan

(as of August, 2012)



Company (EPCO)	Site Numbers	Total Capacity (MW)	Operating Capacity (MW)	Commissionning	Location	Prefecture
Hokkaido	1	1	1	Jun.2011	Date Solar Power Plant	Hokkaido
Tohoku	3	1.5	1.5	Dec.2011	Hachinohe Solar Power Plant	Aomori
		2	2	Mav.2012	Sendai Solar Power Plant	Miyagi
		1		Jan.2015	Haramachi Thermal Power Station site	Fukushima
Tokyo	3	7	7	Aug.2011	Ukishima Solar Power Plant	Kanagawa
		13	13	Dec.2011	Ougishima Solar Power Plant	Kanagawa
		10	10	Jan.2012	Yonekurayama Solar Power Plant	Yamanashi
Chubu	3	7.5	7.5	Oct.2011	Mega Solar Taketoyo	Aichi
		1	1	Jan.2011	Mega Solar Iida	Nagano
		8		Feb.2015	Mega Solar Shimizu	Shizuoka
Hokuriku	4	1	1	Mar.2011	Shiga Solar Power Plant	Ishikawa
		1	1	Apr.2011	Toyama Solar Power Plant	Toyama
		1		Sep.2012	Mikuni Solar Power Plant	Fukui
		1		Nov.2012	Suzu Solar Power Plant	Ishikawa
Kansai	4	10	10	Sep.2011※1	Sakai Solar Power Plant	Osaka
		18		unsettled	Sharp Corp. property etc. in Sakai City	Osaka
		0.5		FY2013	Kansai EPCO property in Ooi Town	Fukui
		0.5		FY2014	Kansai EPCO property in Takahama Town	Fukui
Chugoku	2	3	3	Dec.2011	Fukuyama Solar Power Plant	Hiroshima
		3		Dec.2014	Ube Solar Power Plant	Yamaguchi
Shikoku	1	4.3※2	2	Dec.2010	Matsuyama Solar Power Plant	Ehime
Kyushu	2	3	3	Nov.2010	Omuta Mega Solar Power Plant	Fuokuoka
		13※3		FY2012･2013	Kyushu EPCO property in Omuta City	Nagasaki
Okinawa	2	4	4	Oct.2010	Miyako Island Mega Solar Demonstration Research Facility	Okinawa
		1	1	Mar.2012	Abe Mega Solar Demonstration Research Facility	Okinawa
Total	25	116.3	68			

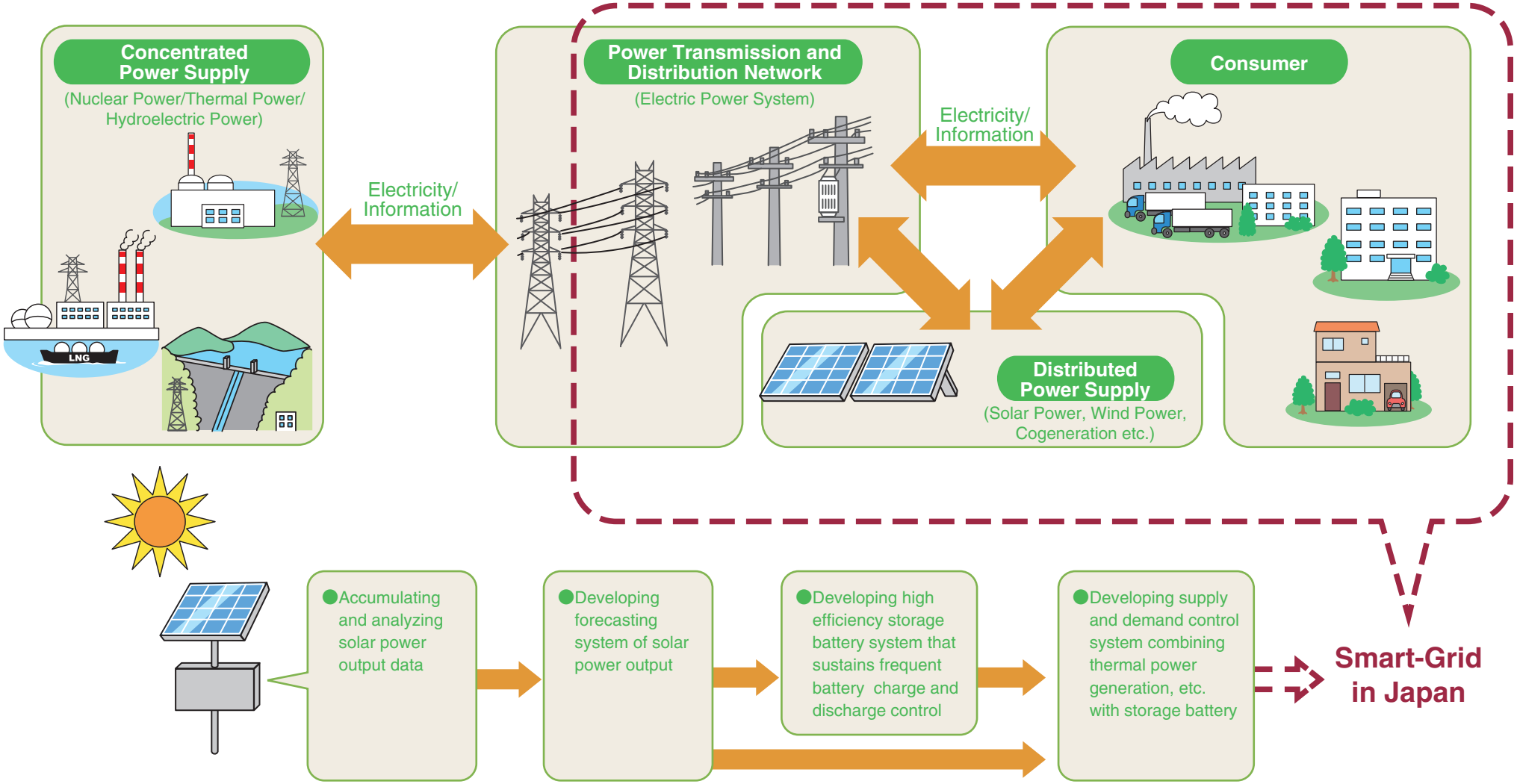
※1 Start of partial operation in October 2010.

※2 Full operation (4.3MW total) will be scheduled by FY2020.

※3 Operation (3MW) will be scheduled by FY2012. and Operation (10MW) will be scheduled by FY2013.

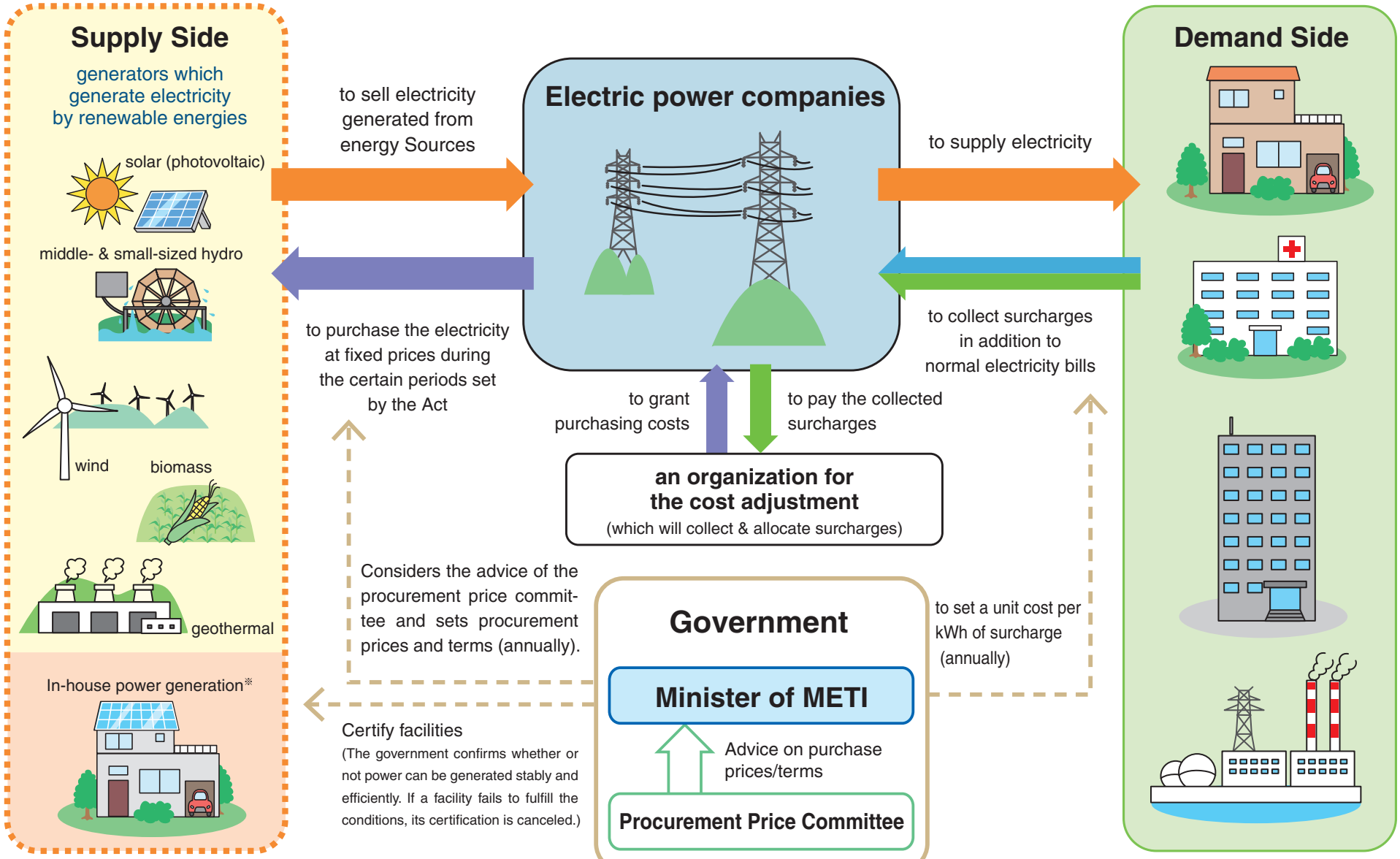
Source: The Federation of Electric Power Companies

Basic Concept of Smart-Grid in Japan



Source: The Federation of Electric Power Companies "Environmental Action Plan by the Japanese Electric Utility Industry"

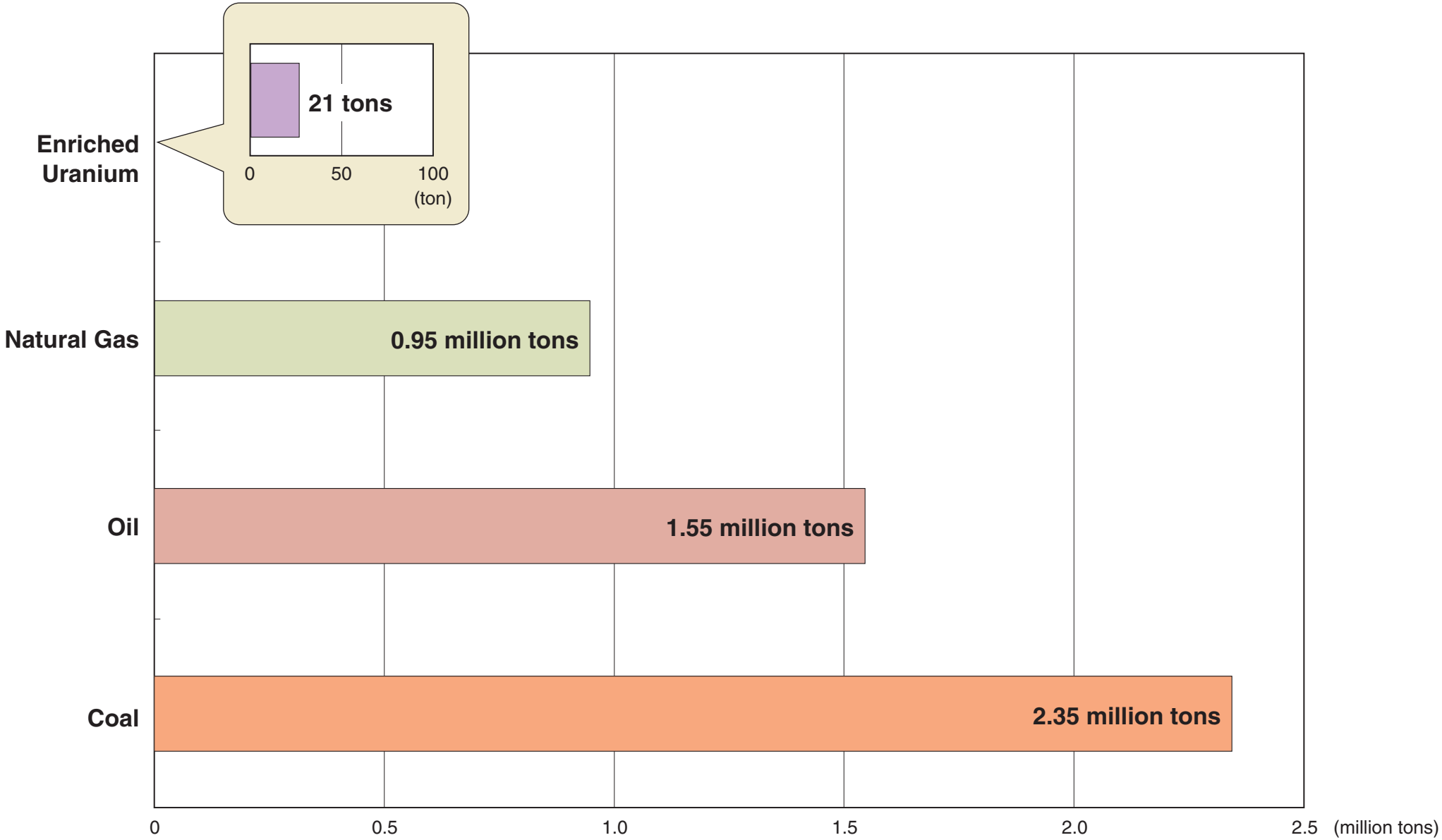
Outline of Feed-in Tariff Scheme for Renewable Energies



※The sunlight below 10 kW is surplus acquisition.

Source: Agency for Natural Resources and Energy etc.

Comparison of Various Fuels Required to Operate a 1GW Power Plant per Year

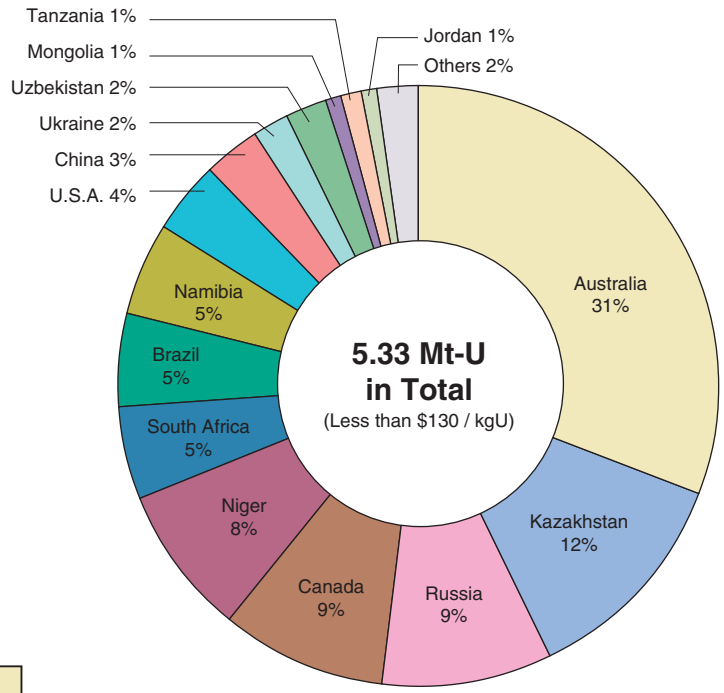


Source: Agency for Natural Resources and Energy "NUCLEAR ENERGY 2010"

Proven Reserves and Japan's Procurement of Uranium

Proven Reserves of Uranium

(as of Jan. 2011)



Japan's Procurement of Uranium

(as of Mar. 2012)

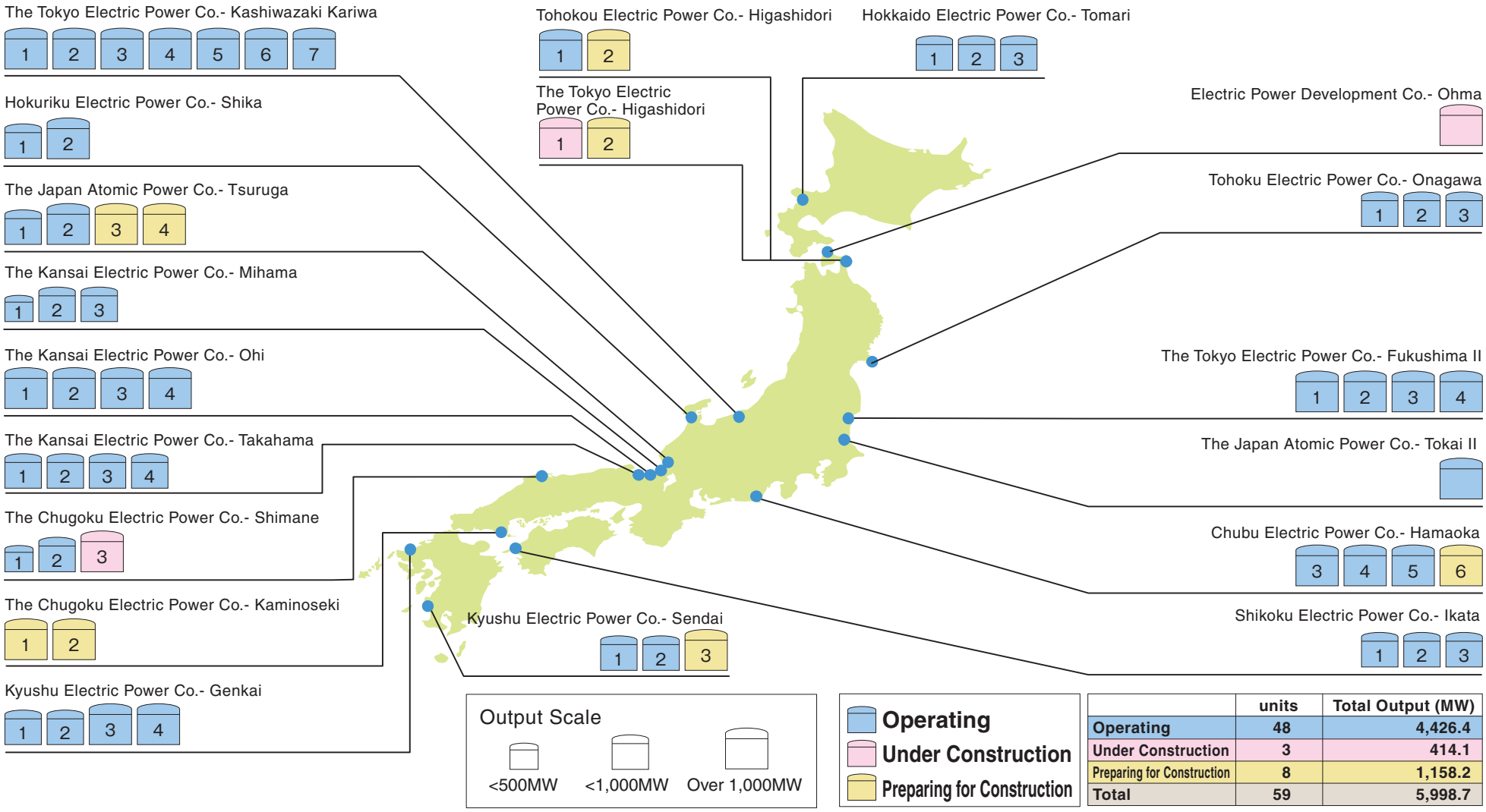
Contract type of Import	Supply countries	Contract quantity (in U_3O_8 short ton)
Long and short term contracts, and purchase of products	Canada, U.K., South Africa, Australia, France, U.S.A. and others	Approx. 379,800
Development and import scheme	Niger, Canada, Kazakhstan and others	Approx. 82,100
Total		Approx. 461,900

(Note) Figures may not add up to the totals due to rounding. t-U: tons of uranium
1 short ton = approx. 0.907 metric ton

Source: Japan Oil,Gas and Metal National Corporation "Uranium 2011 resources, production, demand"/The Denki Shimbun "Nuclear Pocket Book FY2013"

Nuclear Power Plants in Japan

(Commercial Plants, as the end of 2013)

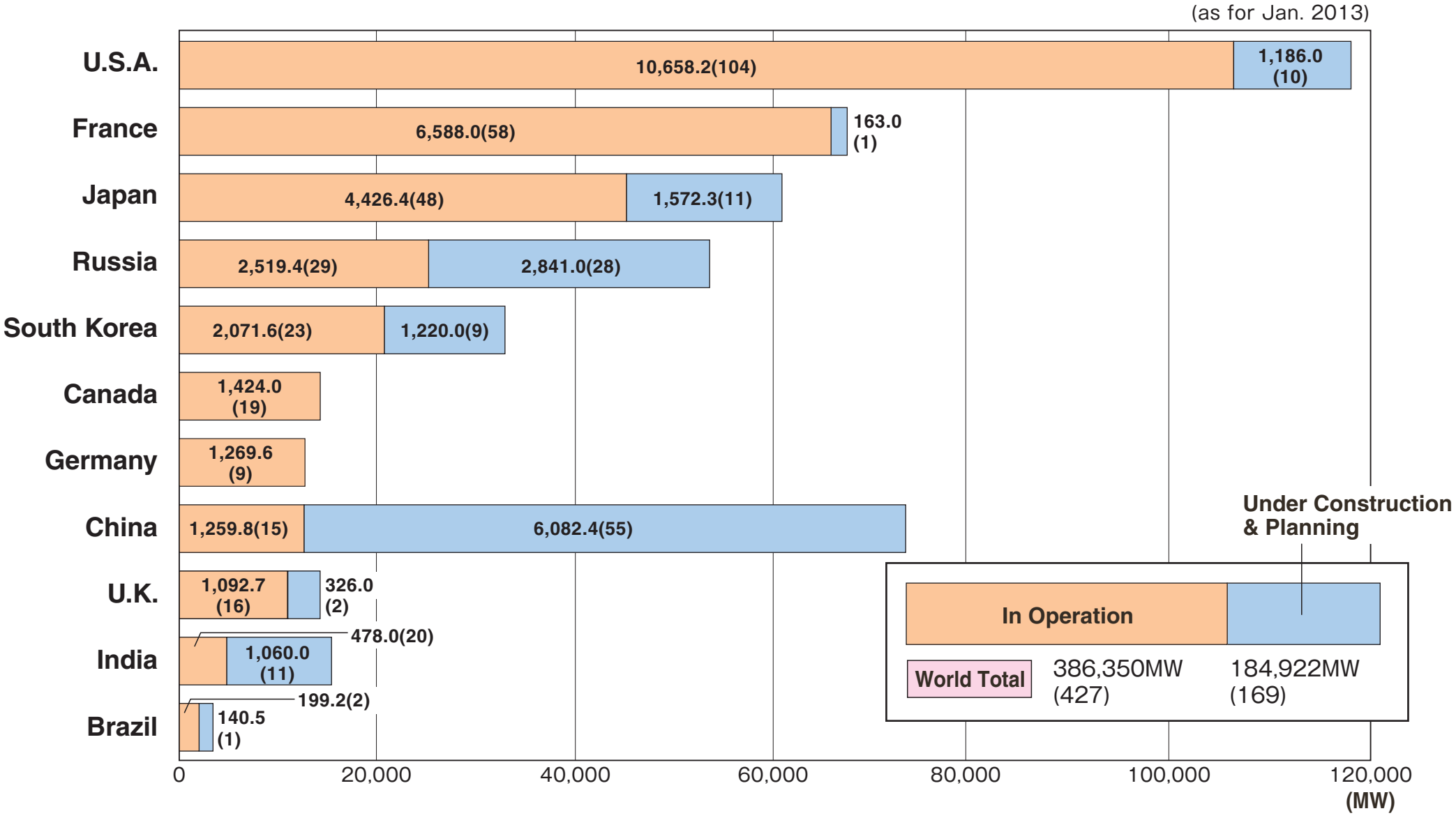


	units	Total Output (MW)
Operating	48	4,426.4
Under Construction	3	414.1
Preparing for Construction	8	1,158.2
Total	59	5,998.7

The Tokyo Electric Power Company abolished the unit 1-4 of Fukushima Daiichi Nuclear Power Station on April 19, 2012 and the unit 5&6 of Fukushima Daiichi Nuclear Power Station on January 31, 2014.
Chubu Electric Power Company abolished the unit 1 and 2 of Hamaoka Nuclear Power Station on January 30, 2009 and is currently decommissioning them.
The Japan Atomic Power Company abolished Tokai Power Station on March 31, 1998 and is currently decommissioning it.

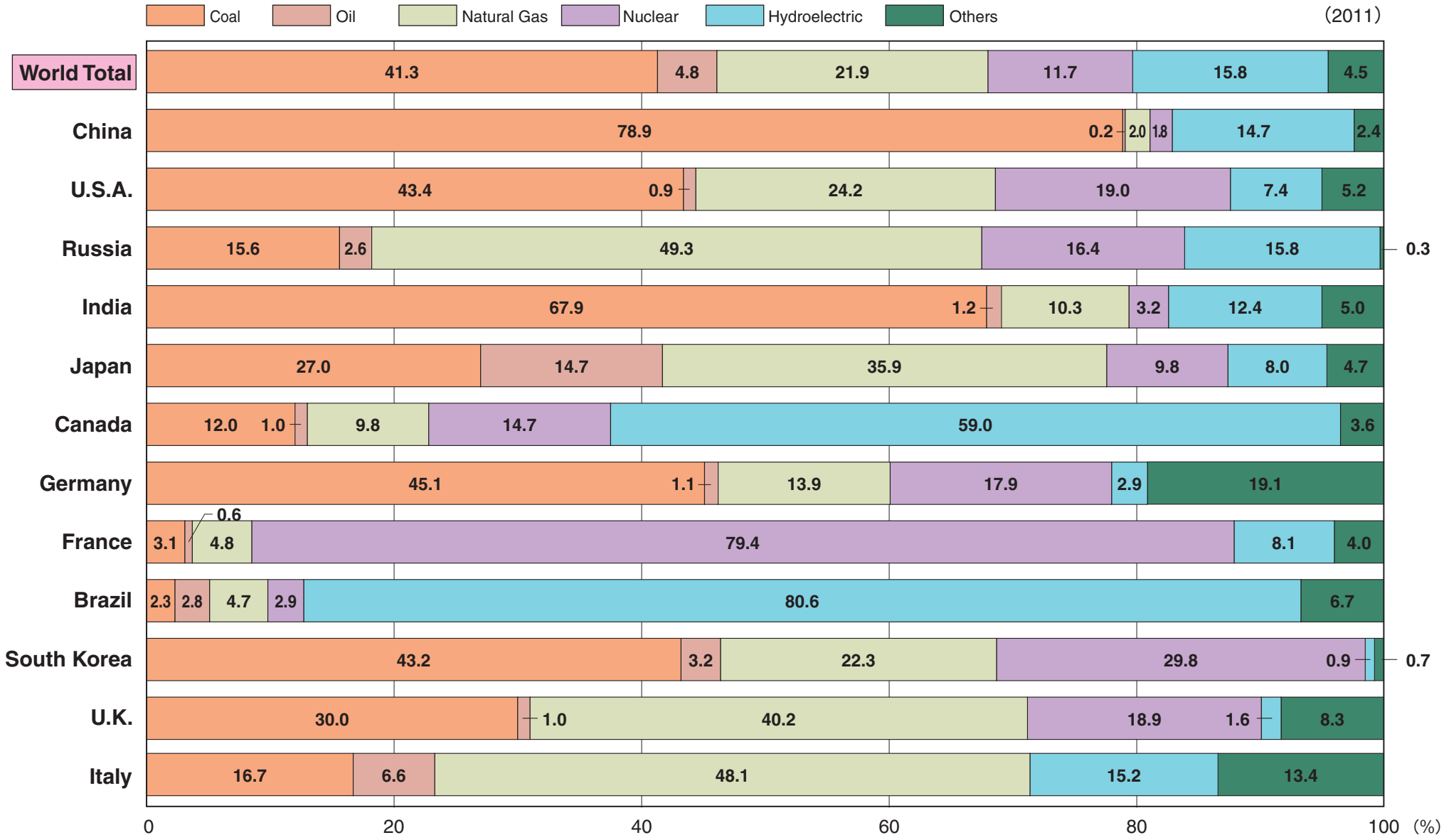
Source: JapanNuclear Energy Safety Organization "Operational Status of Nuclear Facilities in Japan (2013)" ete.

Generating Capacity of Nuclear Power Plants in Major Countries



Source: Japan Atomic Industrial Forum, Inc. "World Nuclear Power Plants 2013", Japan Nuclear Energy Safety Organization "Operational status of Nuclear Facilities in Japan (2013)"

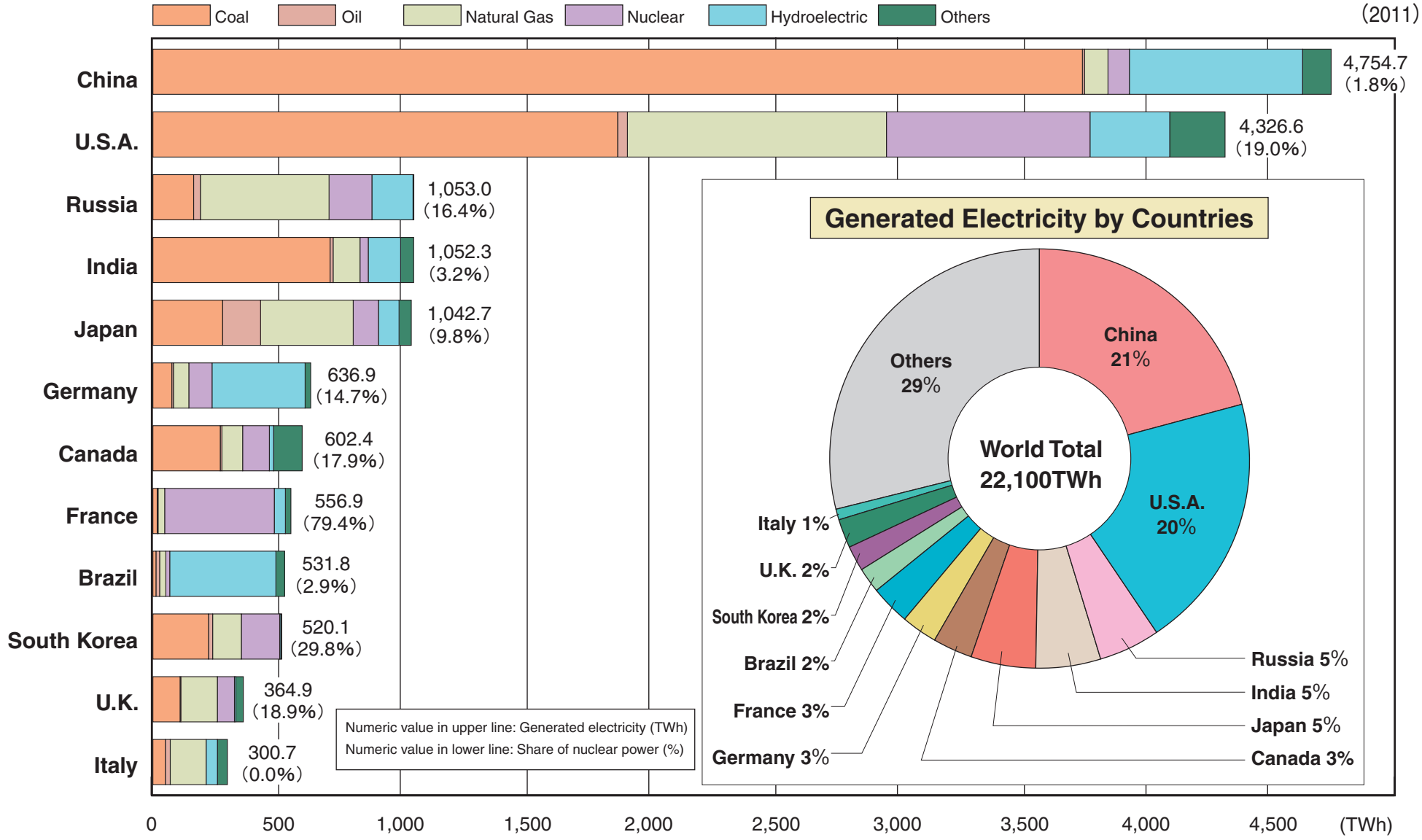
Power Generation Composition by Source in Major Countries



(Note) Figures may not add up to the totals due to rounding.

Source:IEA "ENERGY BALANCES OF OECD COUNTRIES (2013 Edition)"/ "ENERGY BALANCES OF NON-OECD COUNTRIES (2013 Edition)"

Electricity Generated and Share of Nuclear Power in Major Countries



(Note) Figures may not add up to the totals due to rounding.

Source:IEA "ENERGY BALANCES OF OECD COUNTRIES (2013 Edition)"/ "ENERGY BALANCES OF NON-OECD COUNTRIES (2013 Edition)"

New Regulatory Requirements for Nuclear Power Plants

〈 Previous Regulatory Requirements 〉

Design basis to prevent severe accidents
(Confirm that a single failure would not lead to core damage)

- Consideration of natural phenomena
- Fire Protection
- Reliability of power supply
- Function of other SSCs*
- Seismic/tsunami resistance

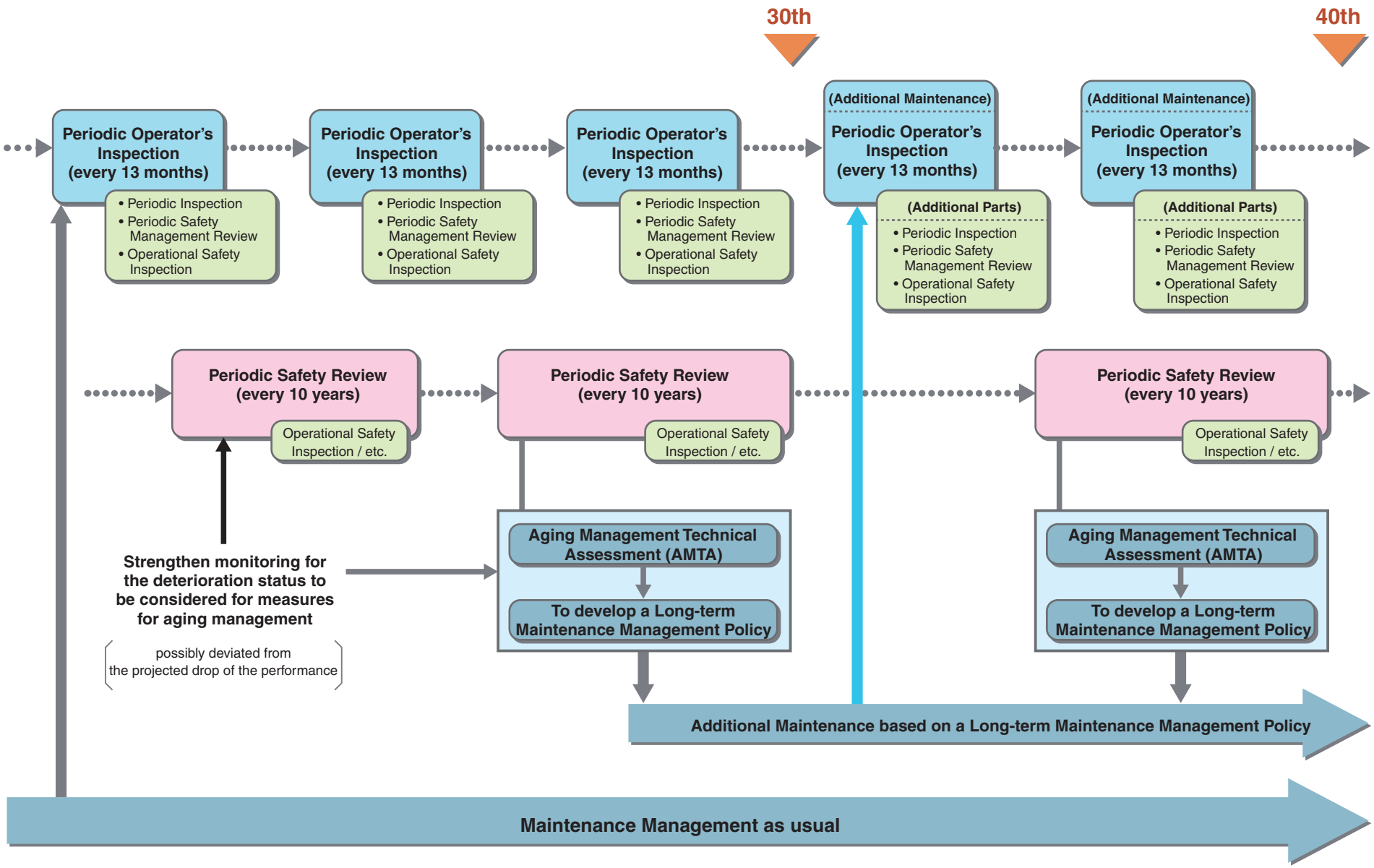
〈 New Regulatory Requirements 〉

- Response to international aircraft crashes — Newly introduced (measures against terrorism)
- Measures to suppress radioactive materials dispersion
- Measures to prevent containment vessel failure
- Measures to prevent core damage (Postulate multiple failures) — Newly introduced (measures against severe accidents)
- Consideration of internal flooding (newly intoroducted)
- Consideration of natural phenomena in addition to earthequakes and tsunamis-volcanic eruptions, tornadoes and forest fires
- Fire Protection
- Reliability of power supply
- Function of other SSCs — Reinforced or newly introdused
- Seismic/tsunami resistance — Reinforced

*SSC: Structure, Systems and Components

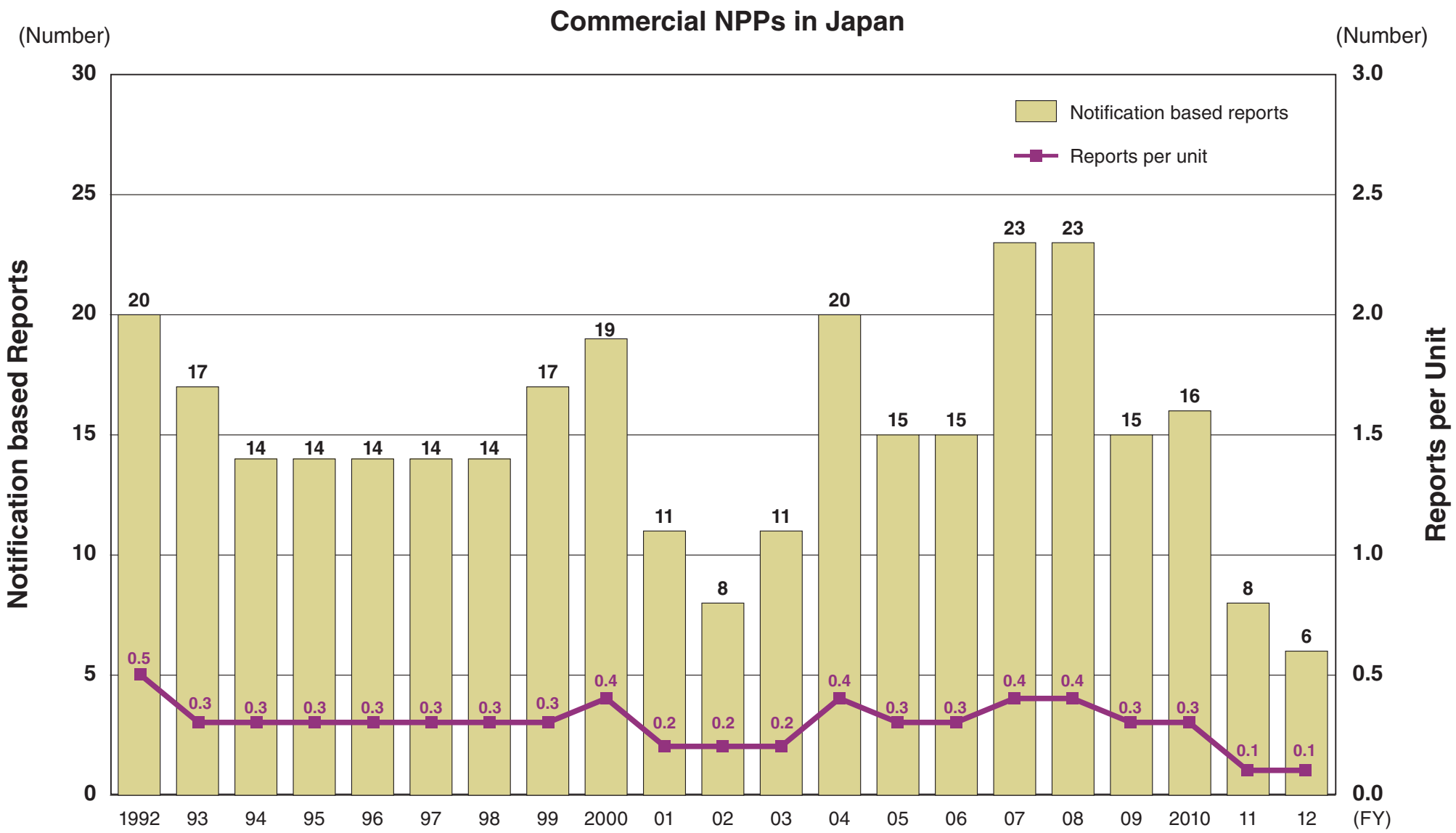
Source: Nuclear Regulation Authority

Periodic Safety Review of Nuclear Power Plant and Measures for Aging Management



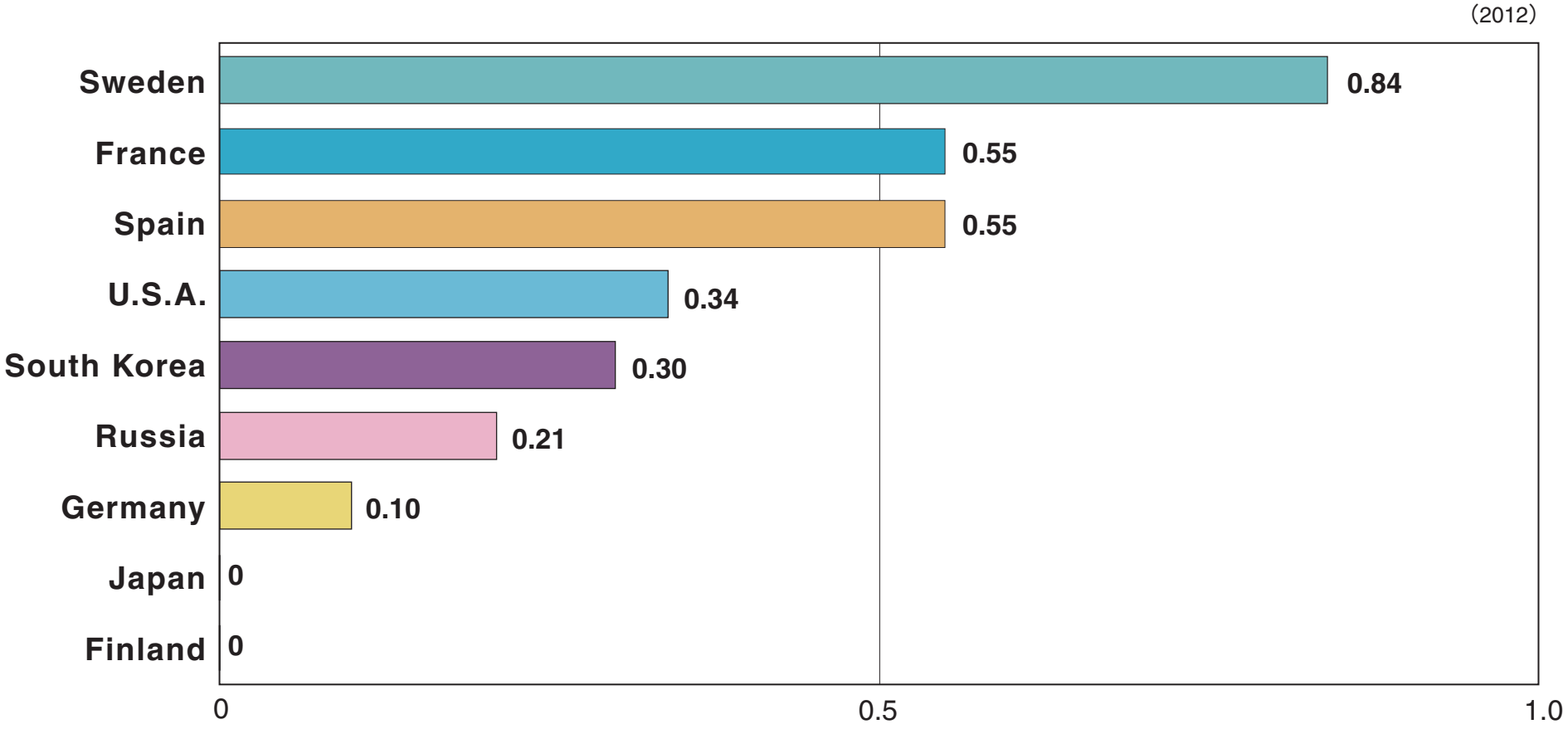
Source: White paper on Nuclear Energy 2009

Historical Trends in Reported Incidents and Failures at NPPs in Japan



Source: Japan Nuclear Energy Safety Organization "Operational Status of Nuclear Facilities in Japan (2013)" etc.

Unplanned Automatic Scrams per 7,000 Hours Critical in Major Countries

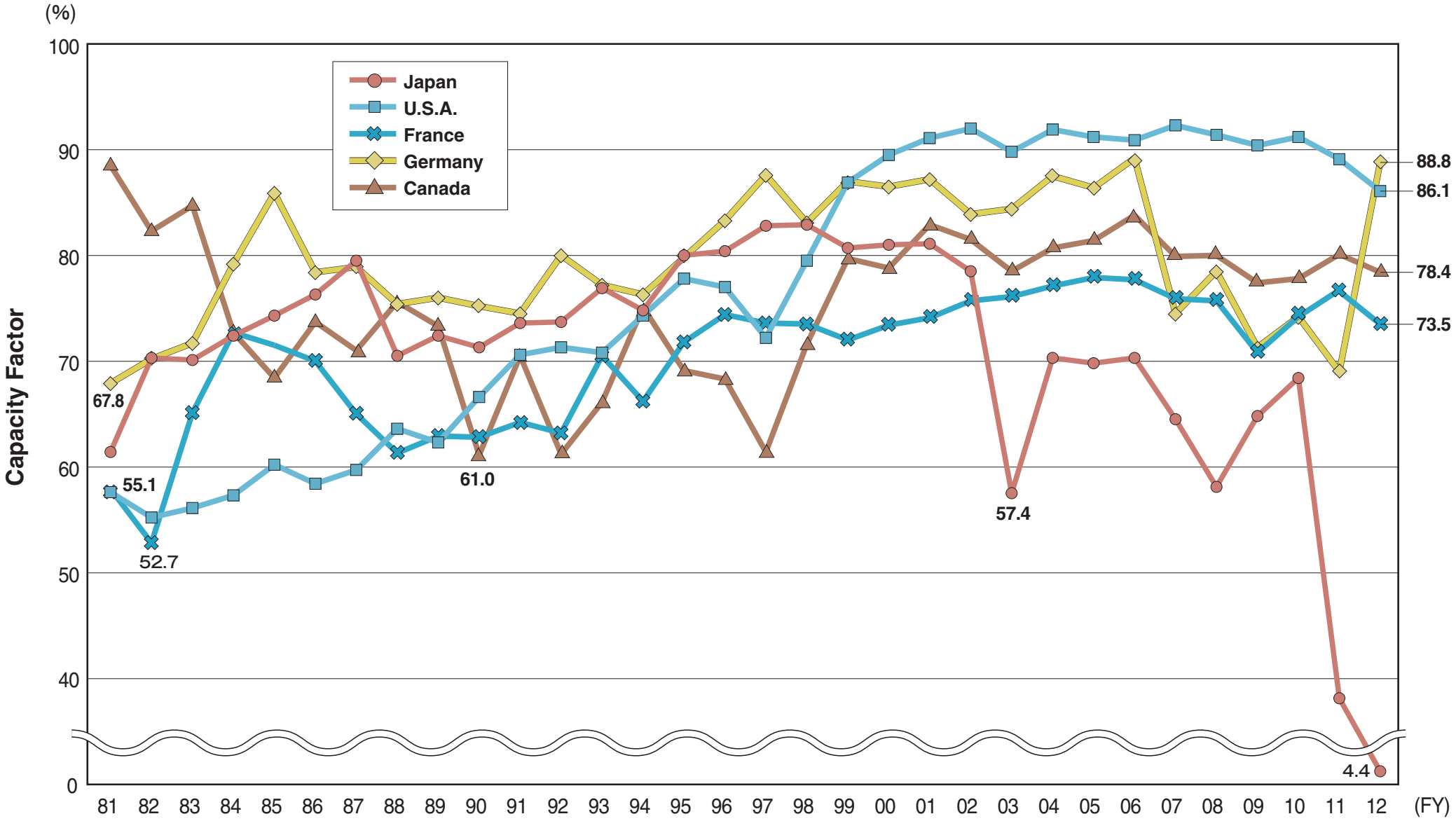


$$\left(= \frac{\text{The unplanned automatic scrams per 7,000 hours critical (UA7)}}{\text{total unplanned scrams while critical in the previous 4 qtrs} \times \text{7,000 hrs}} \Big/ \text{total number of hours critical in the previous 4 qtrs} \right)$$

(Note) Automatic Scram: Emergency shutdown of the reactor

Source: IAEA PRIS

Historical Trends in Capacity Factors of NPPs in Major Countries



Source: Japan Nuclear Energy Safety Organization "Operational Status of Nuclear Facilities in Japan (2013)"

Causes of the Accident at Chernobyl Nuclear Power Plant

Lack of Safety Culture

Design Defects

- No Containment Vessel
- Designed to easily turn off safety equipment
- Positive void coefficient; during low power operation, the more voids (froths) in cooling water, the more output, etc.

Operator's Regulation Violation

- Withdrew control rods more than regulated
- Operated with Emergency Core Cooling System (ECCS) turned off
- Conducted a special test at lower power than planned

(Continuous operation was prohibited due to instability at low power range (less than 20% of total output), etc.)

Operational Mismanagement

- Managed by a non-reactor-specialist
- A special test was conducted without due processes or approval throughout the power plant
- Inadequate examinations on safety measures, etc.

Enhancement of the Nuclear Emergency Preparedness System

As a precaution against emergencies, a new Nuclear Emergency Preparedness Commission (NEPC) will be permanently established under the Cabinet to promote nuclear emergency preparedness measures throughout the government from normal times.

Ordinary times

Newly and permanently established under the Cabinet.

Nuclear Emergency Preparedness Commission

Chairperson : Prime Minister

Vice-Chairman : Chief Cabinet Secretary, Minister of the Environment, NRA Chairman

Commissioners : Minister of State, Deputy Chief Cabinet Secretary for Crisis Management, Vice Ministers, Parliamentary Secretaries,etc.

Secretary General : Minister of the Environment

(Role)

- Promoting policy enforcement,etc. based on the Nuclear Emergency Response Guidelines※1
- Promoting the long-term comprehensive policy enforcement in the case of nuclear accident occurrence

Relevant Ministries and Agencies

[National Police Agency, MEXT, MHLW, MLIT, Japan Coast Guard, Ministry of the Enviroment, Ministry of Defense, etc.]

Emergency

Nuclear Emergency Response Headquaters

(Provisional installation under the Cabinet Office at the time of Declaration of the State of Nuclear Emergency)

Director-general : Prime Minister

Deputy direcror-generals : Chief Cabinet Secretary, Minister of the Environment, NRA Chairman

Members : Minister of State, Deputy Chief Cabinet Secretary for Crisis Management, Vice Ministers, Parliamentary Secretaries,etc.

(Role)

- General coordination of nuclear emergency response measures and post accident measures.

Relevant Ministries and Agencies

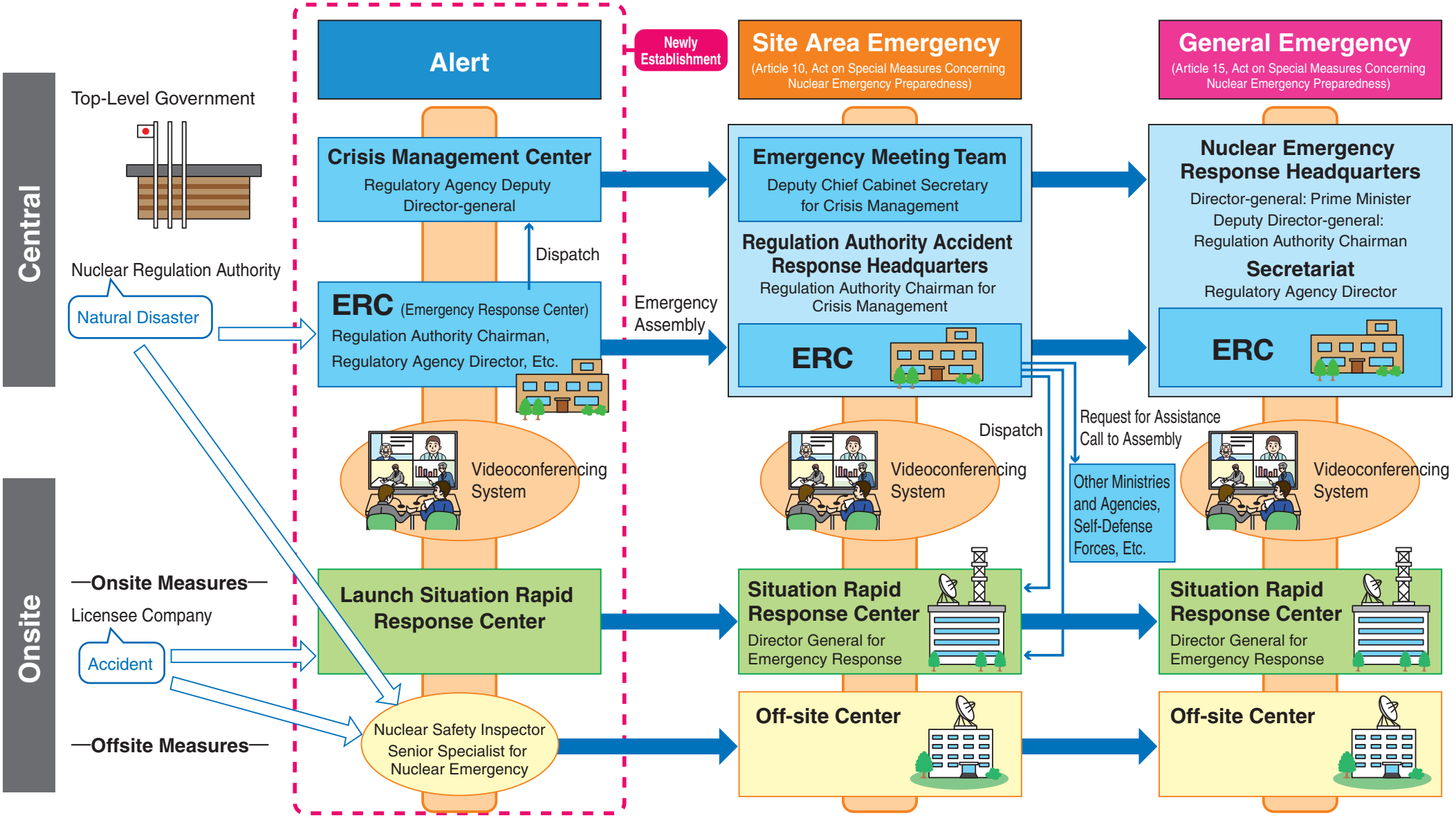
[National Police Agency, MEXT, MHLW, MLIT, Japan Coast Guard, Ministry of the Enviroment, Ministry of Defense, etc.]

※ These are guidelines prepared by the Nuclear Regulation Authority for nuclear operators and local governments, etc. to ensure smooth implementation of nuclear emergency preparedness measures, emergency response measures, and measures for restoration from nuclear emergency.

Source: Nuclear Regulatory Authority

Clarification of Nuclear Emergency Categories (3 Stages)

Operational Chart—From Alert to General Emergency



Expansion of Nuclear Emergency Response Action Zone

Approx. 5 km Radius

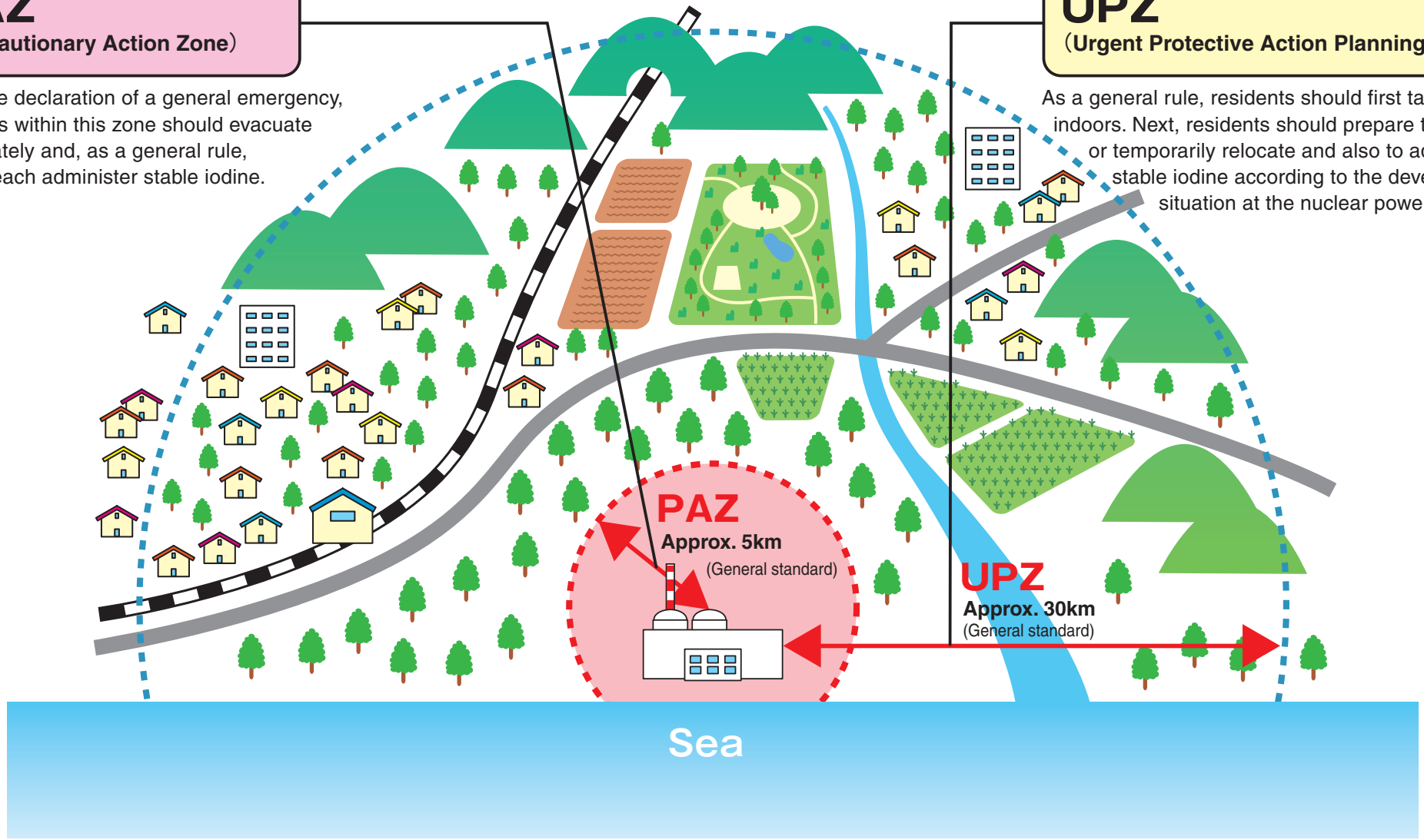
PAZ
(Precautionary Action Zone)

Upon the declaration of a general emergency, residents within this zone should evacuate immediately and, as a general rule, should each administer stable iodine.

Approx. 30 km Radius

UPZ
(Urgent Protective Action Planning Zone)

As a general rule, residents should first take shelter indoors. Next, residents should prepare to evacuate or temporarily relocate and also to administer stable iodine according to the developing situation at the nuclear power plant.



Radiation Protection for Residents

Extent of Emergency	PAZ (–5 km)	UPZ (5–30 km)	30– km
According to the situation at the facility, the nuclear power plant operator reports the emergency category to both the national government and local authorities.	● Local authorities will prepare and implement necessary evacuations in response to instructions or orders from the national government. ● Either the national government or local authorities may issue instructions to residents to prepare and administer stable iodine.		
EAL1 (Alert) Newly Established (Ex.) Occurrence of large tsunamis, earthquakes with seismic intensity of 6 or higher, etc.	● Preparations for evacuation of persons requiring special assistance (those who are ill or injured, the elderly, physically challenged persons, infants, expectant and nursing mothers, etc.)		● Assistance with preparations for the evacuation of persons requiring special protection.
EAL2 (Site Area Emergency) (Ex.) Station Blackout over 30 minutes beyond, etc.	● Evacuation of persons requiring special assistance. ● Preparations for general evacuation. ● Preparations for administration of stable iodine.	● Preparations for indoor sheltering.	● Reception of persons requiring special assistance.
EAL3 (General Emergency) (Ex.) Station Blackout over 1 hour over, etc. **No Emission of Radioactive Materials**	● Administration of stable iodine. **Evacuation of residents to outside the PAZ following the instructions of the national government.**	● Indoor sheltering. ● Preparations for administration of stable iodine. ● Preparations for evacuation, etc. **Start of emergency monitoring by national government, local authorities and nuclear power plant operator.**	● Reception of evacuees. ● Assistance with evacuation, etc. ● Preparations for administration of stable iodine. **Start of emergency monitoring by national government and local authorities.**
Emission of Radioactive Materials Outside of the Facility		**Based on the results of emergency monitoring, the national government will implement necessary protective measures, such as evacuations, on the basis of air dose rates or other appropriate standards.**	

OIL※1 — Air dose rate of 500 microsieverts per hour. → **Evacuation**

OIL2 — Air dose rate of 20 microsieverts per hour. → **Temporary Relocation**; **Restrictions on the intake of local produce, etc.**

OIL6, etc. — Radioactive iodine in drinking water. 300 becquerels/kg, etc. → **Screening of food and drink, restrictions on intake.**

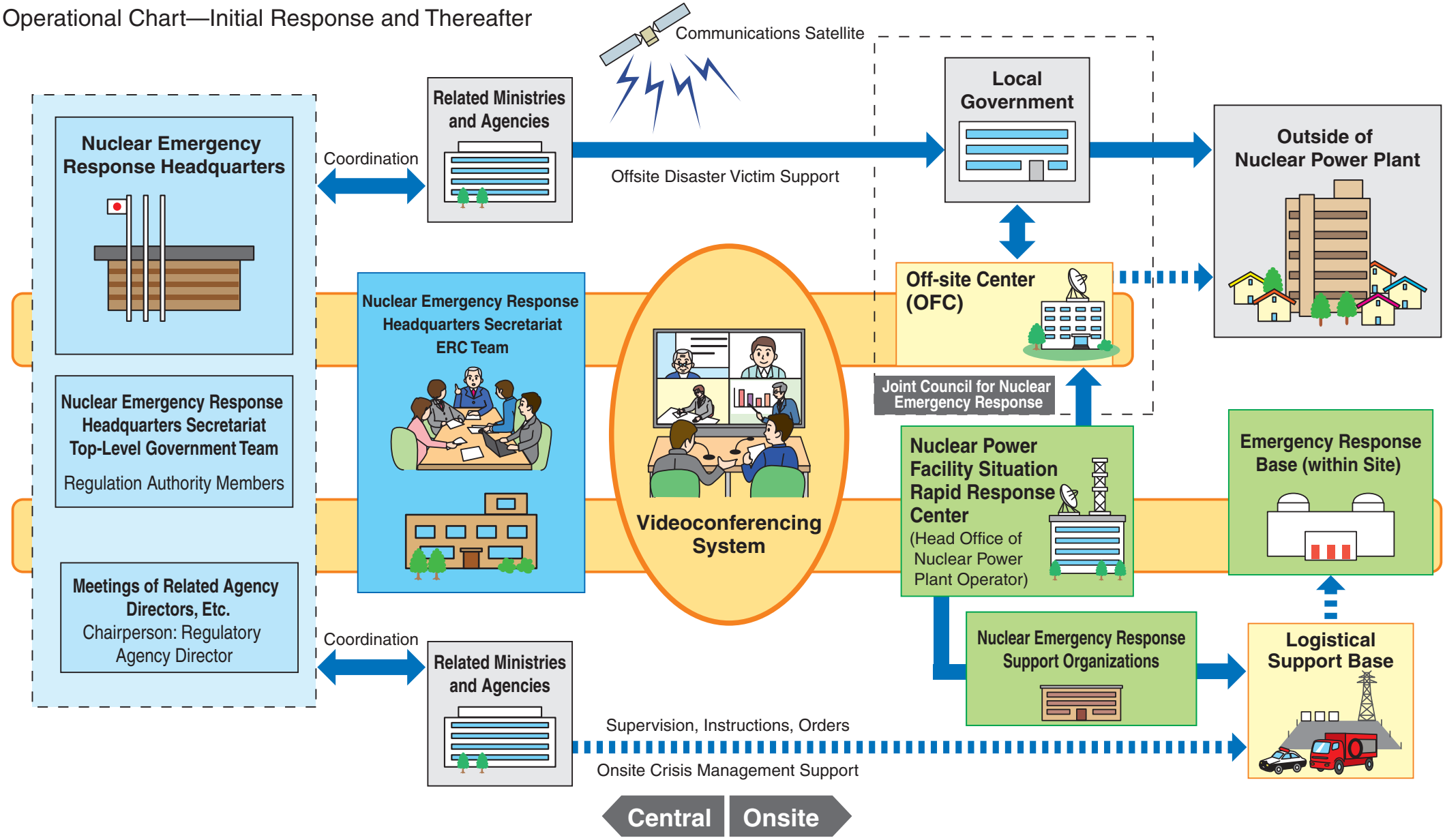
→ **Contamination Examination** → **OIL4** — Body surface beta radiation exposure of 40,000 cpm. (Dropping to 13,000 cpm after 1 month.) → **Body Surface Decontamination**

※OIL: Standard for determining the necessity and extent of measures to be implemented for the protection of residents when radioactive materials have been emitted, based on the results of monitoring, etc.

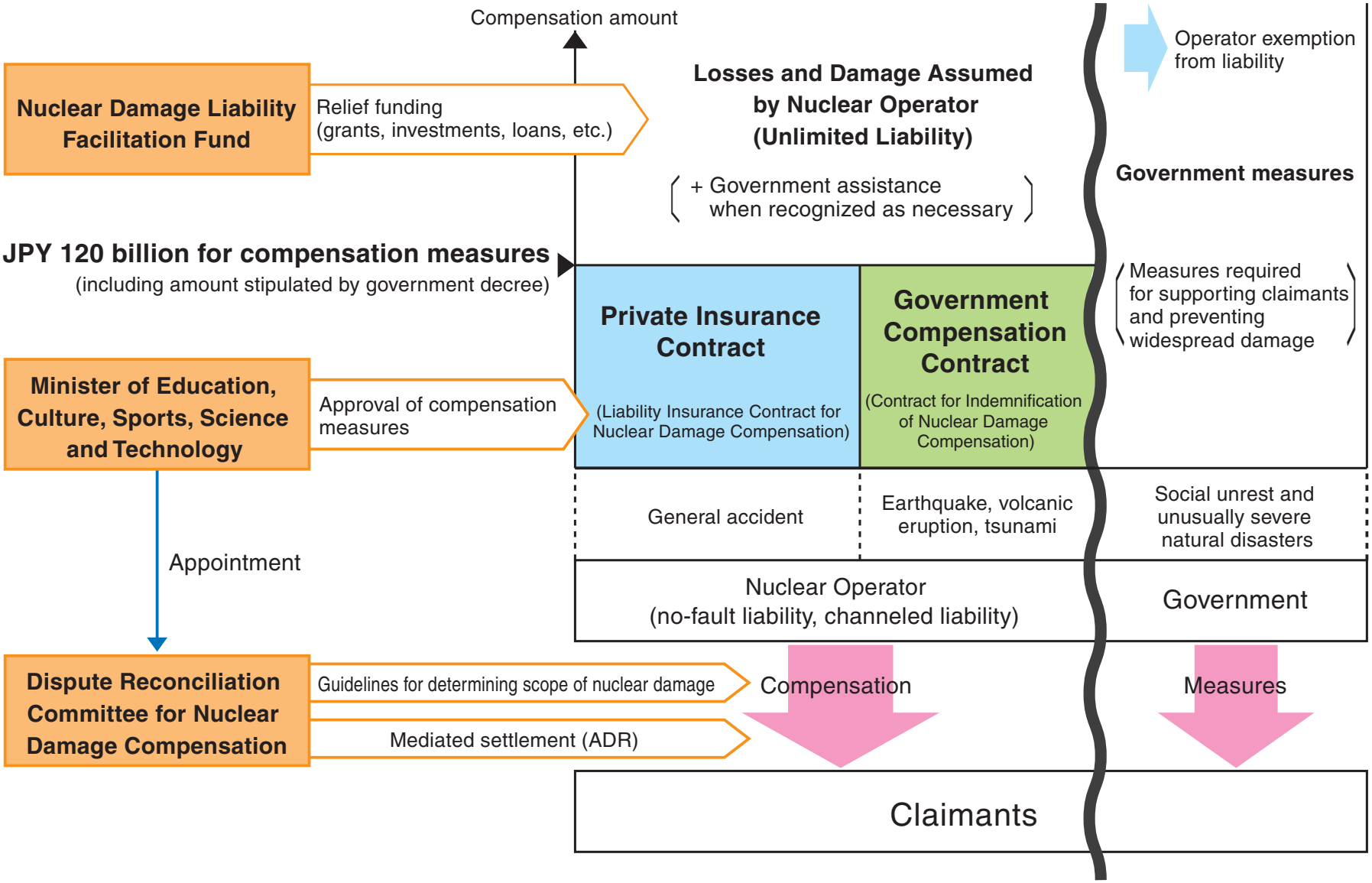
Source: Nuclear Regulation Authority, Federation of Electric Power Companies

Reinforcement of Network between Government and Nuclear Power Plant Operators

Operational Chart—Initial Response and Thereafter



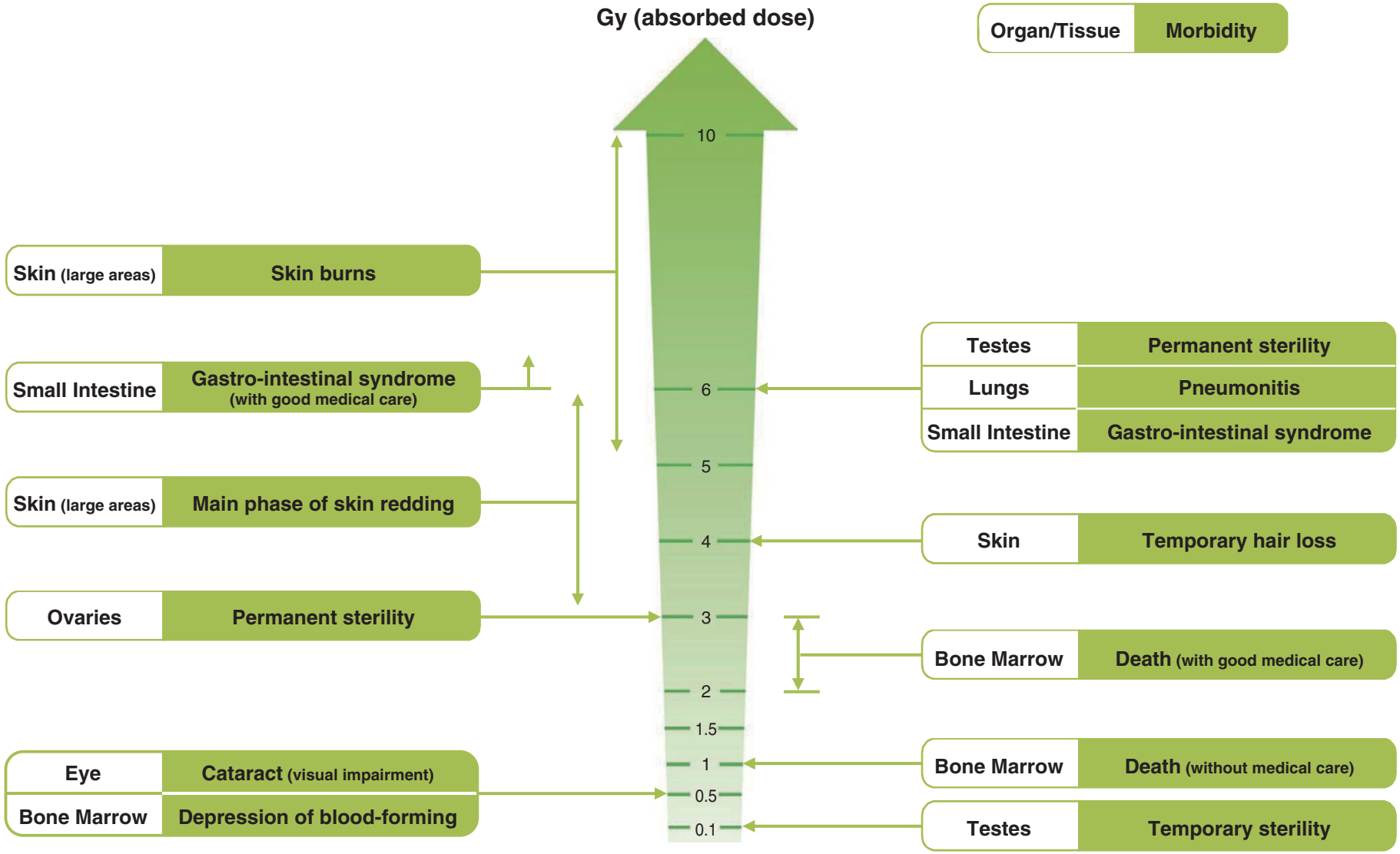
Nuclear Damage Compensation System



Source: Ministry of Education, Culture, Sports, Science and Technology

Acute Radiation Effects

Projected threshold※ estimates of the acute absorbed does for 1% incidence of morbidity and mortality.



※Threshold:the maximum level of radiation considered to be acceptable or safe

Source: ICRP "Publication 103,118"

Relative Cancer Risk Estimation for Radiation Exposure and Lifestyle Factors

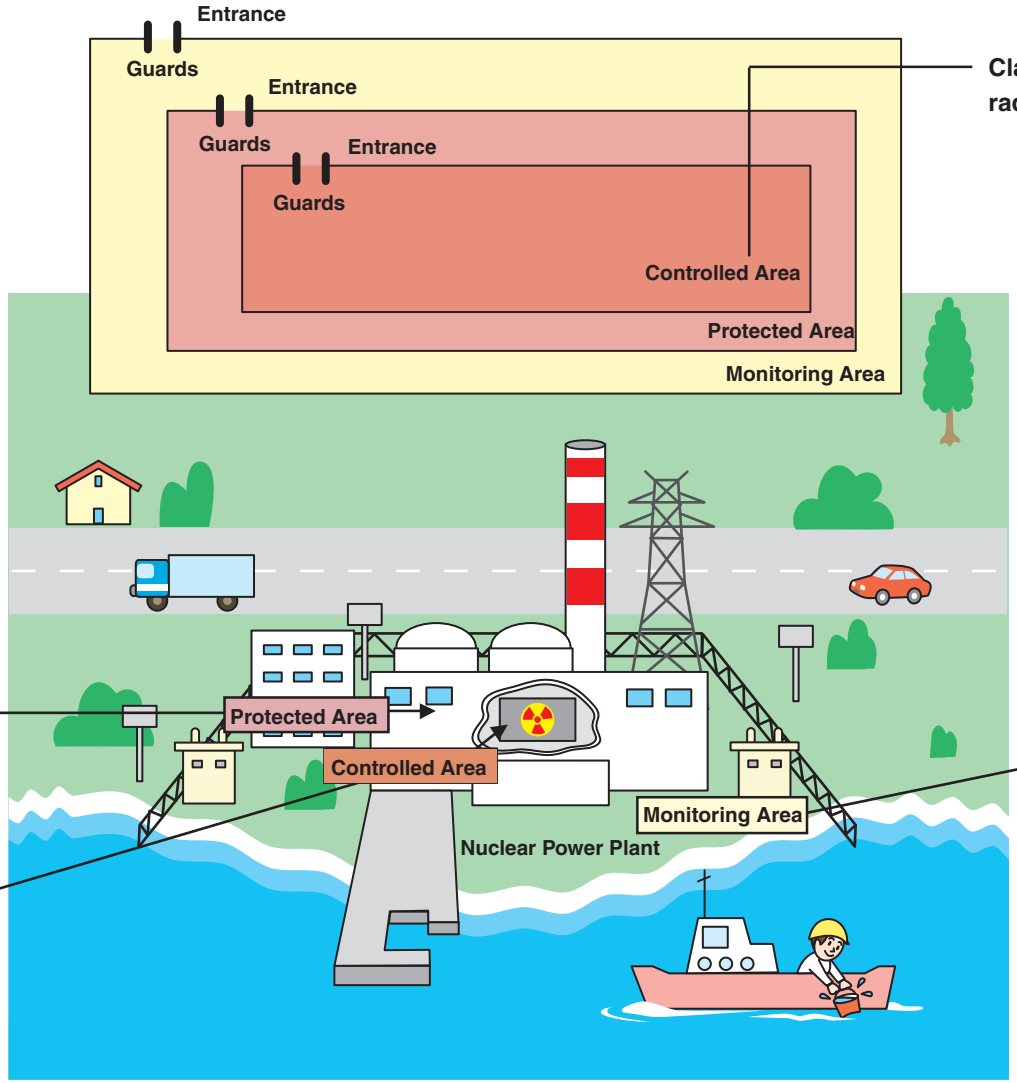
(Targeted for Japanese between the ages of 40 and 69)

Factors	Cancer Risk Estimates
Radiation exposure (1,000 - 2,000 mSv)	x1.80
Smoking	x1.60
Drinking (above 0.54 litter/day)	
Underweight	x1.29
Obesity	x1.22
Radiation exposure (200 - 500 mSv)	x1.19
Inactivity (too little physical activity)	x1.15 - 1.19
Too much salt intake	x1.11 - 1.15
Radiation exposure (100 - 200 mSv)	x1.08
Lack of vegetable intake	x1.06

(Note) Risk estimates for radiation exposure are based on the analysis of instantaneous dose effects in the case of A-bomb at Hiroshima and Nagasaki (solid cancer incidence only) and not based on the observations on prolonged dose effects.

Source: National Cancer Center

Controls in a Nuclear Power Plant by Area



Classified in detail according to the extent of radiation or contamination

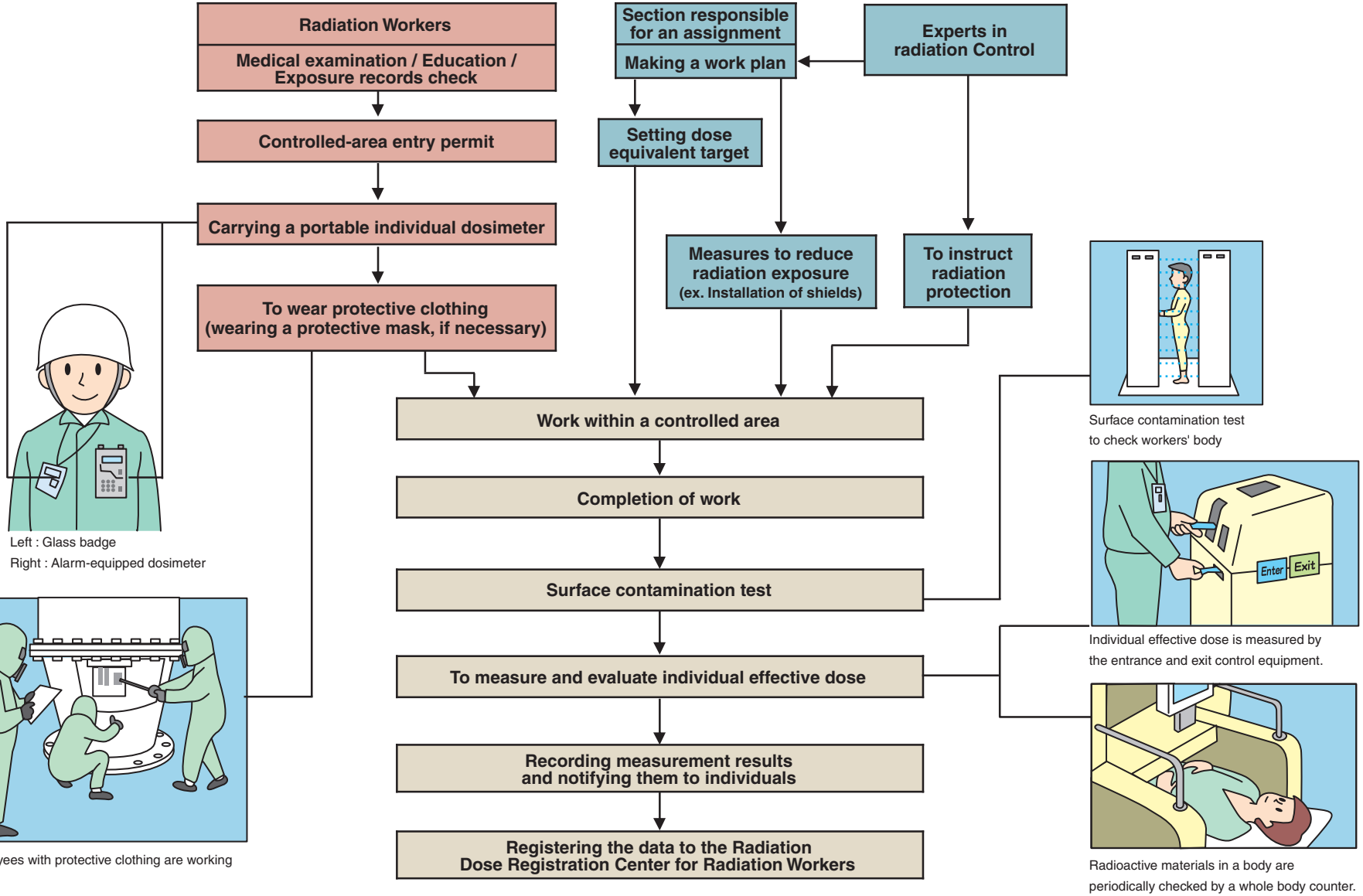
Control is especially needed to preserve a nuclear power plant (except a controlled area).

Within the area, unnecessary entry of the general public is restricted to prevent them from being exposed to more dose emitted from nuclear facilities than regulated by laws.

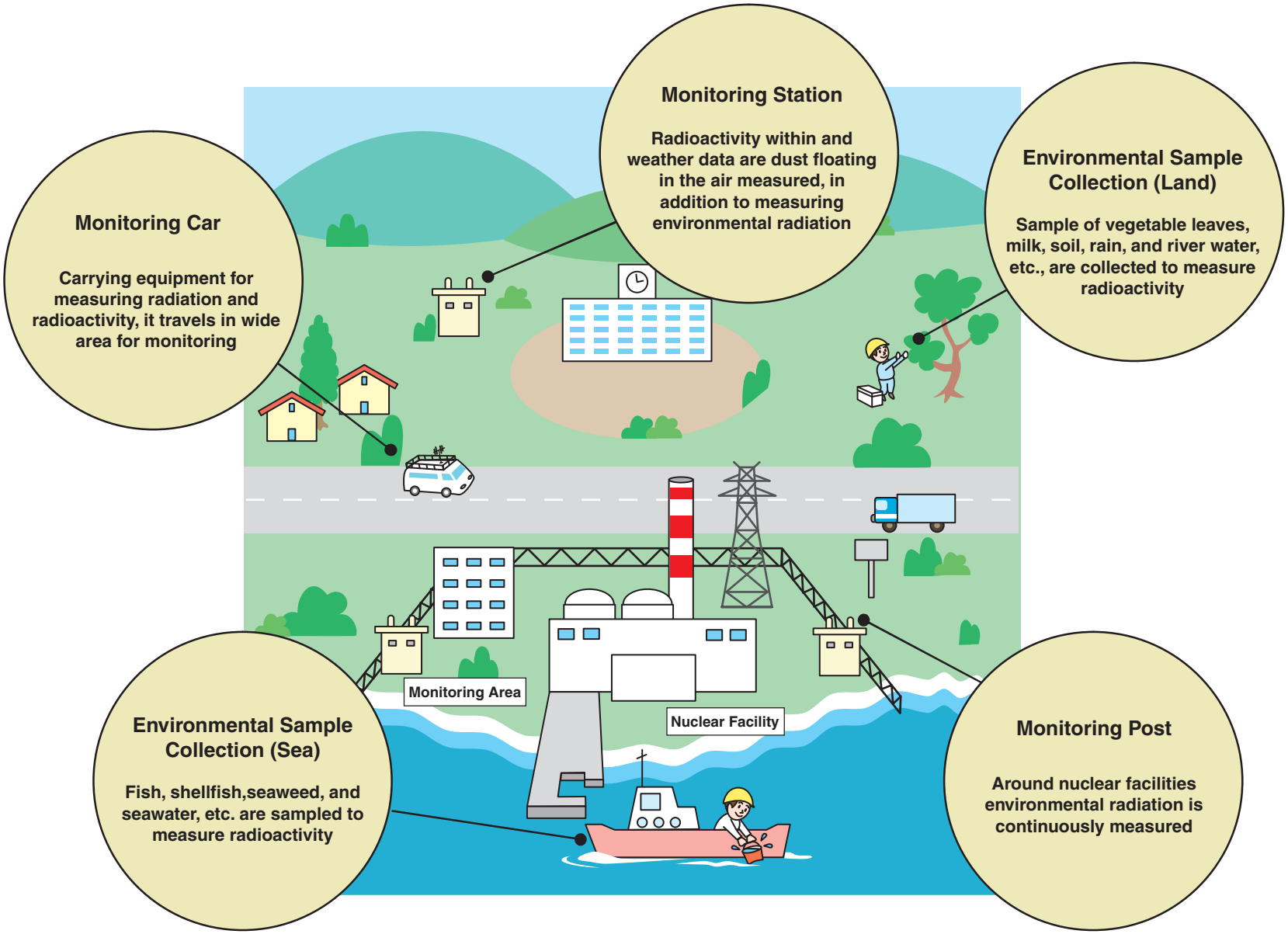
Entry is restricted to prevent a damage by radiation and radioactive materials.

Radiation Exposure Control for Radiation Workers

Radiation Control Flow

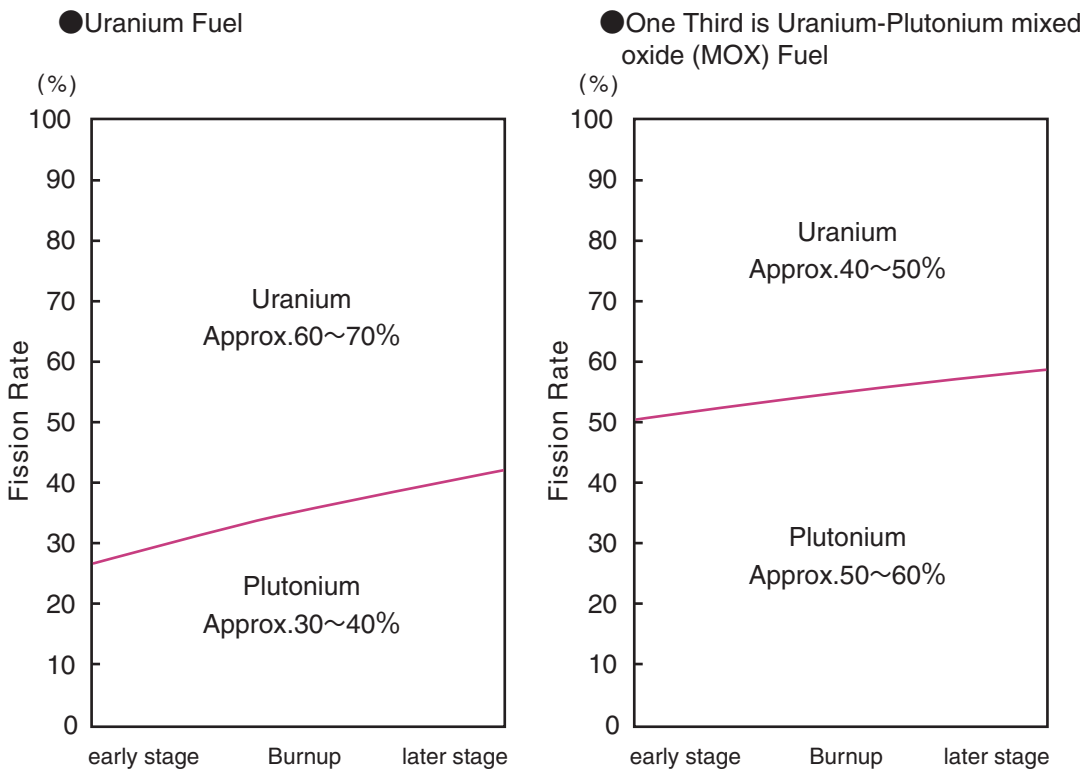


Environmental Radiation Monitoring around Nuclear Facilities

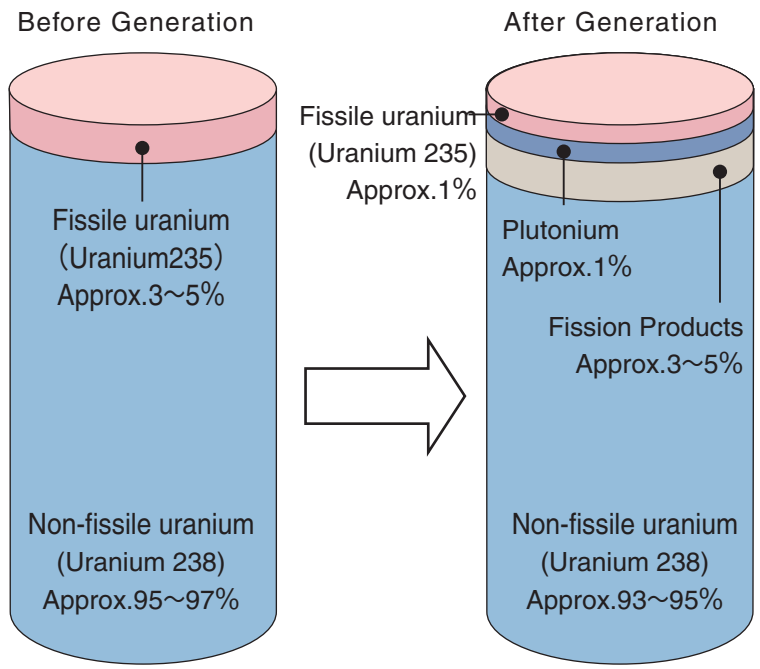


Nuclear Fission inside Light Water Reactors

① **Fission Rate of Uranium and Plutonium in Reactor Core (BWR equilibrium core)**

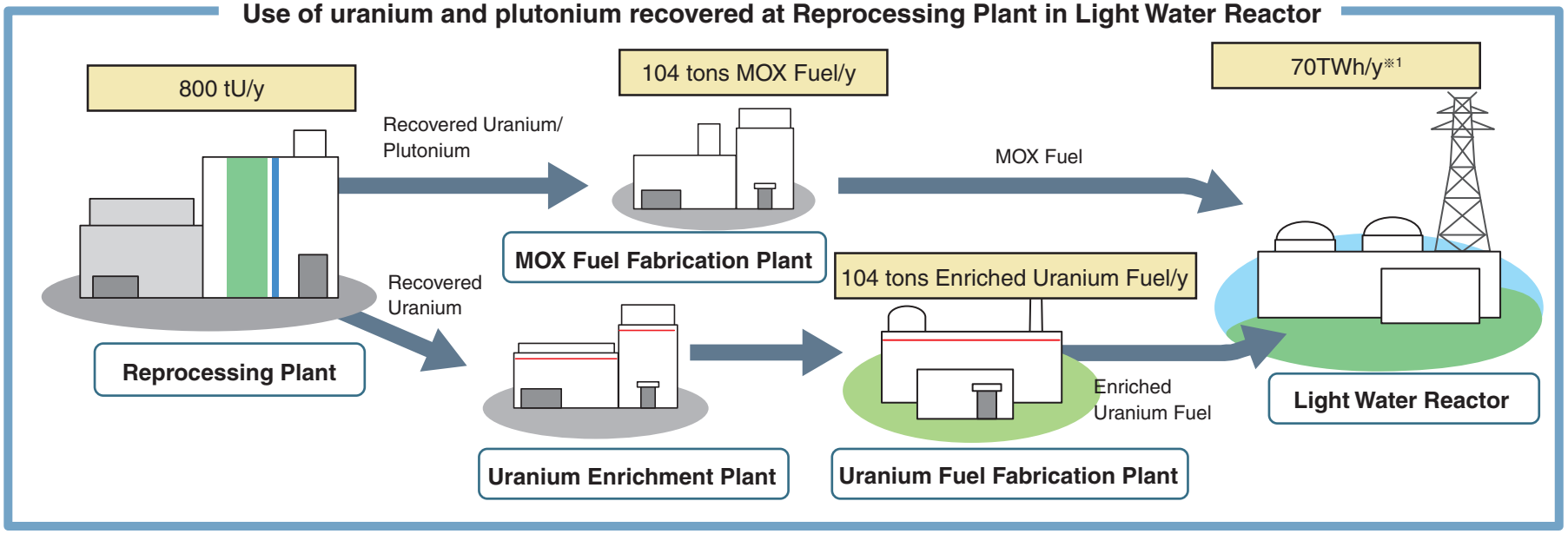


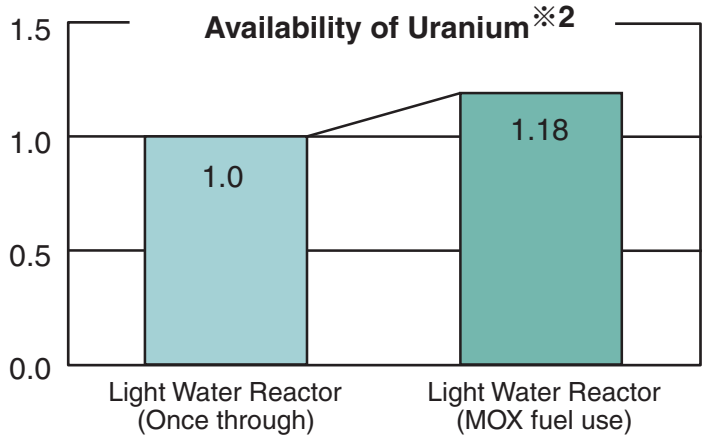
② **(Ex.) Composition change of uranium fuel through generation**



Source: Agency for Natural Resources and Energy

Utilization of Uranium Resources

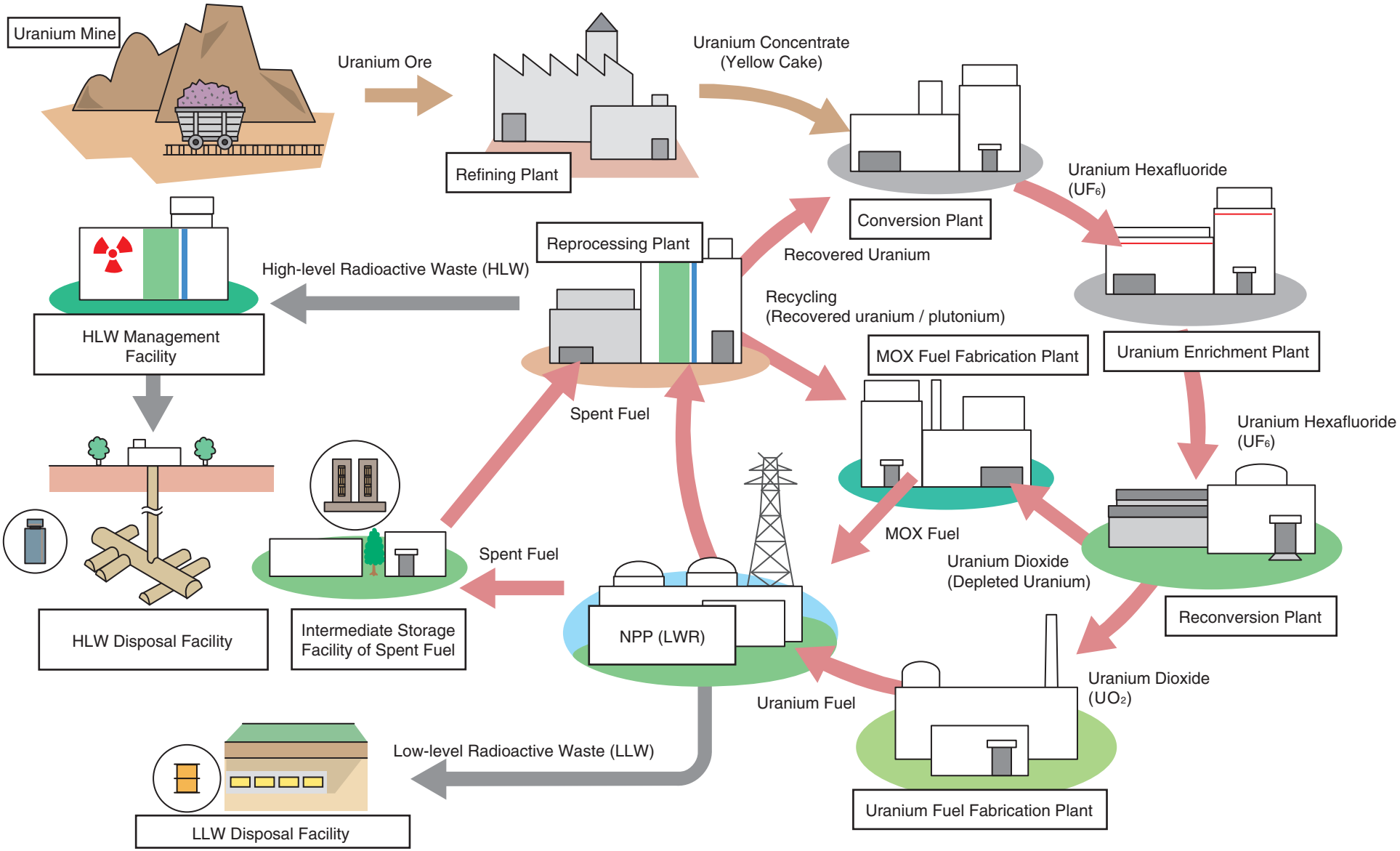




※1 70TWh is equivalent to annual output of ten 1GW capacity nuclear reactors. (1)
※2 Usage of plutonium can utilize the use of uranium by about 30 times when Fast Breeder Reactor came into practical use. (2)

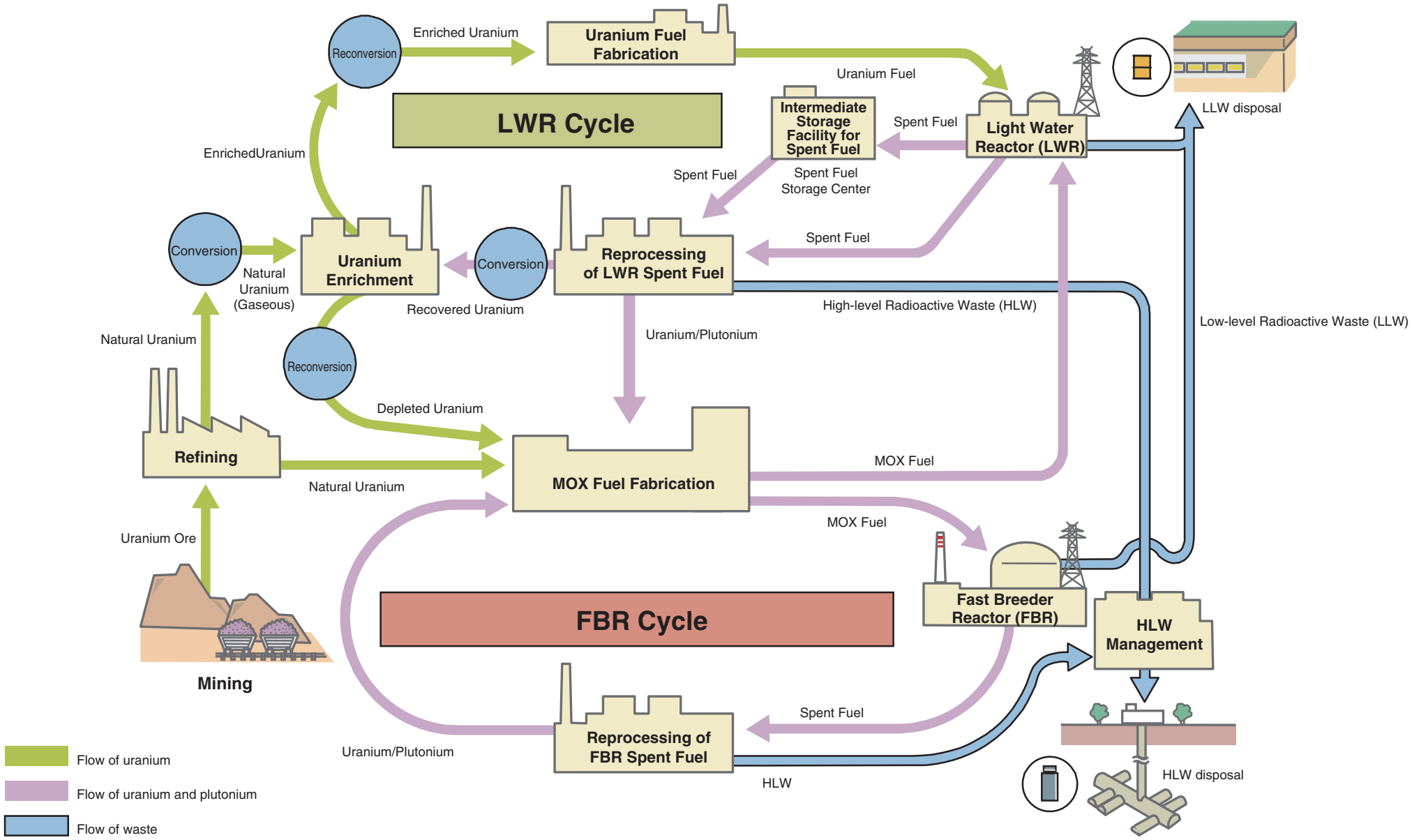
Source: (1) Atomic Energy Commission of Japan (2004) (2) OECD, IEA "URANIUM2003"

Nuclear Fuel Cycle



(Note) MOX Fuel: Uranium-Plutonium mixed oxide fuel

Nuclear Fuel Cycle (Including FBR)



Outline of JNFL's Nuclear Fuel Cycle Facilities

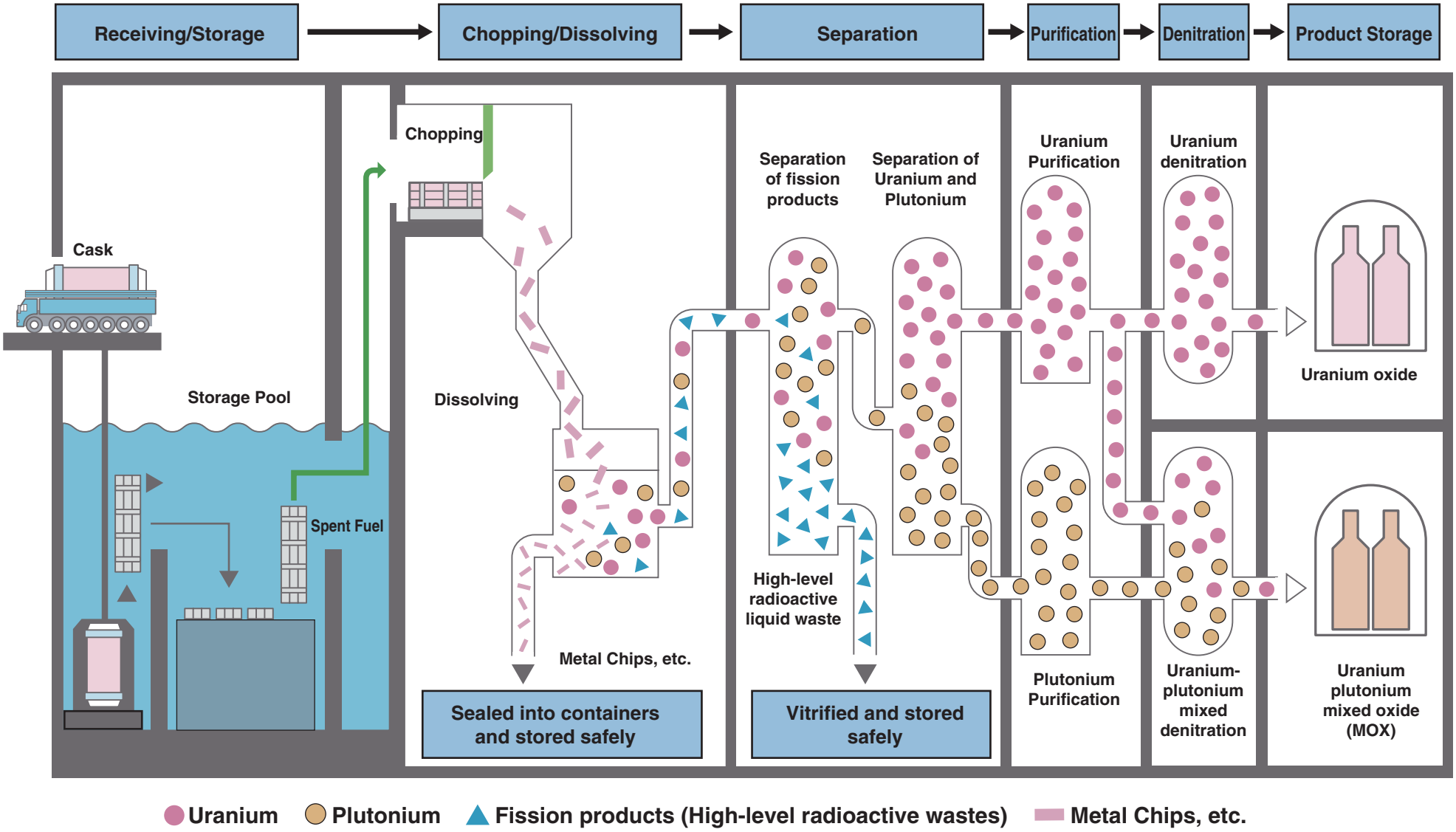
(as of December, 2013)

	Reprocessing Plant	Vetrified Waste Storage Center	MOX Fuel Fabrication Plant	Uranium Enrichment Plant	Low-level Radioactive Waste Disposal Center
Location	Iyasakatai, Rokkasho-mura, Aomori Prefecture			Ohishitai, Rokkasho-mura, Aomori Prefecture	
Capacity	Maximum capacity: 800 t-U/y Storage capacity for spent fuel: 3,000 t-U	Storage capacity for wastes returned from oversea plants: 2,880 canistiers of vitrified waste	Maximum capacity: 130 t-HM/y※1 MOX fuel assemblies for domestic light water reactors (BWR and PWR)	Design capacity of 1,500 t-SWU※2/year	Planned to be expanded to 600,000 m^3 (equivalent to 3 million 200 liter drums)
Current Status	Under Construction	Cumulative number of stored canisters:1,442	Under Construction	In operation	Number one disposal facility: 147,507 drums Number two disposal facility: 113,112 drums
Schedule	Start of construction:1993 Commissioning :2014 (planned)	Start of construction: 1992 Commissioning: 1995	Start of construction:2010 Commissioning:2017 (planned)	Start of construction: 1988 Commissioning: 1992	Start of construction: 1990 Commissioning: 1992

※1 HM indicates the weight of plutonium and uranium metallic content in MOX.
※2 SWU : Separating work units when the natural uranium is separated from enriched uranium.
※3 Construction expense regarding 200,000m^3 low-level radioactive waste (equivalent to 1 million of 200 liter drums).

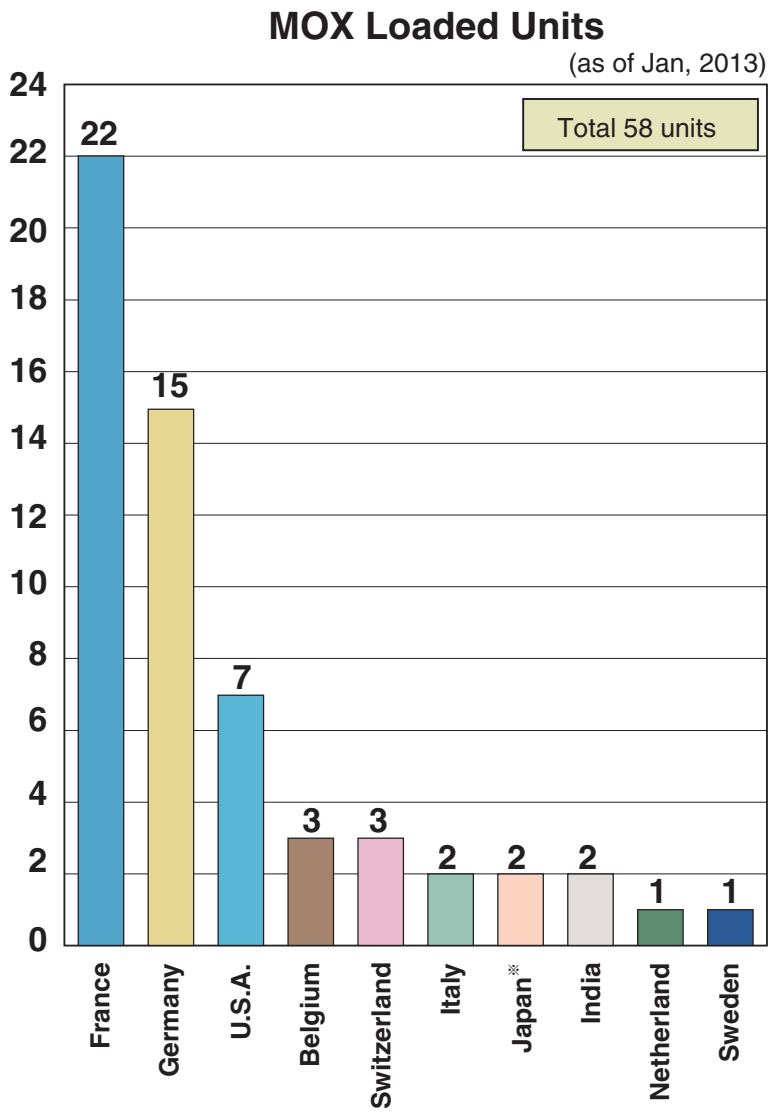
Source: Japan Nuclear Fuel Ltd., etc.

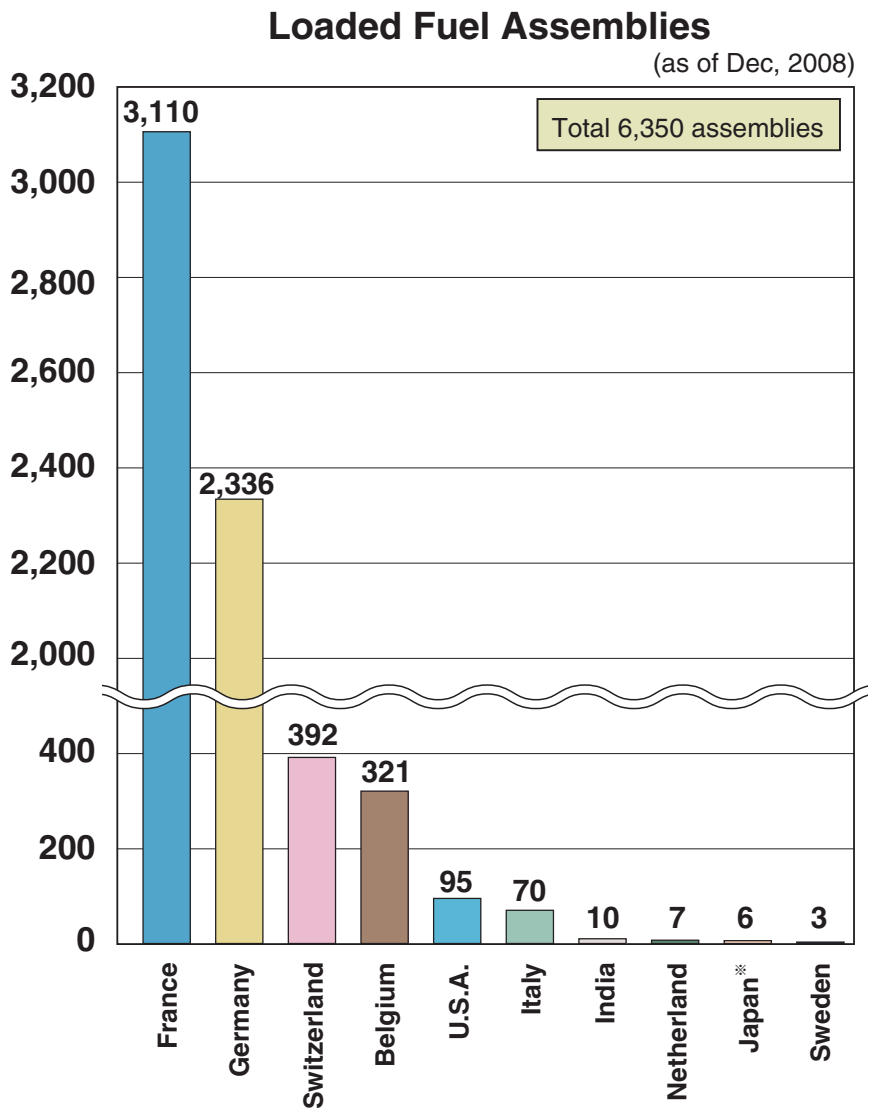
Flow of Reprocessing



Source: Japan Nuclear Fuel Ltd.

MOX Fuel Use in LWRs in the World

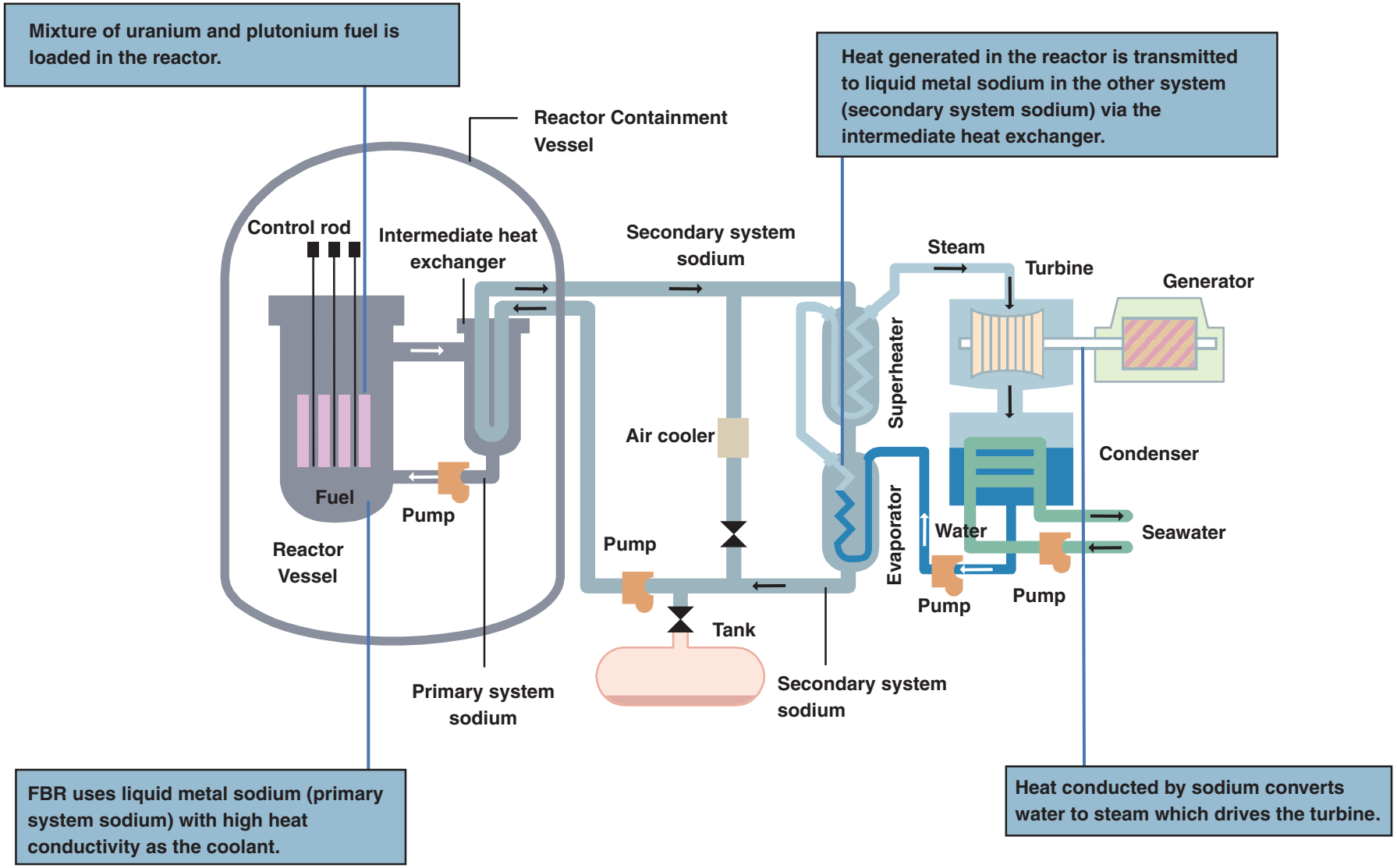




(Note) Fugen, an advanced thermal reactor (ATR), loaded 772 MOX fuel assemblies in Japan. (Fugen was closed down in March 2003)
The end of December 2012, MOX fuels were loaded in 22 plants in France, 8 plants in Germany, 3 plants in Switzerland, 1 plant in Belgium.
※ Further total 88 MOX fuel assemblies have been loaded into 4 reactors on and after December 2009.

Source: Agency for Natural Resources and Energy "NUCLEAR ENERGY 2010" etc.

Mechanism of Fast Breeder Reactor (FBR)



Source: Ministry of Education, Culture, Sports, Science and Technology

Spent Fuel Interim Storage Facility

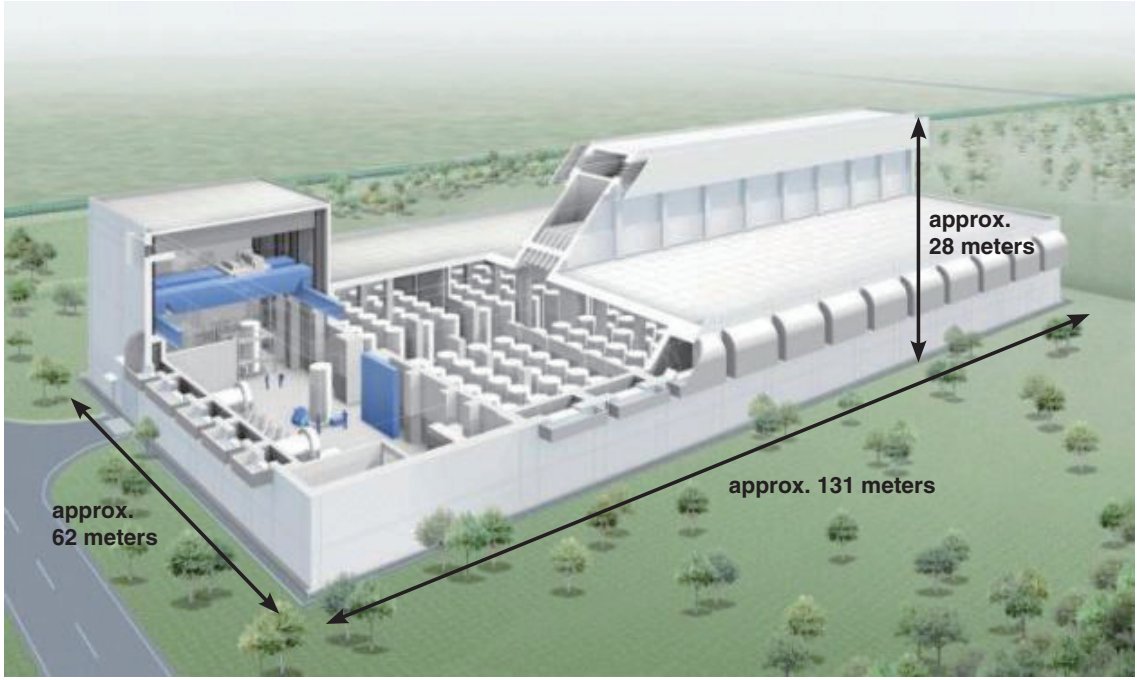
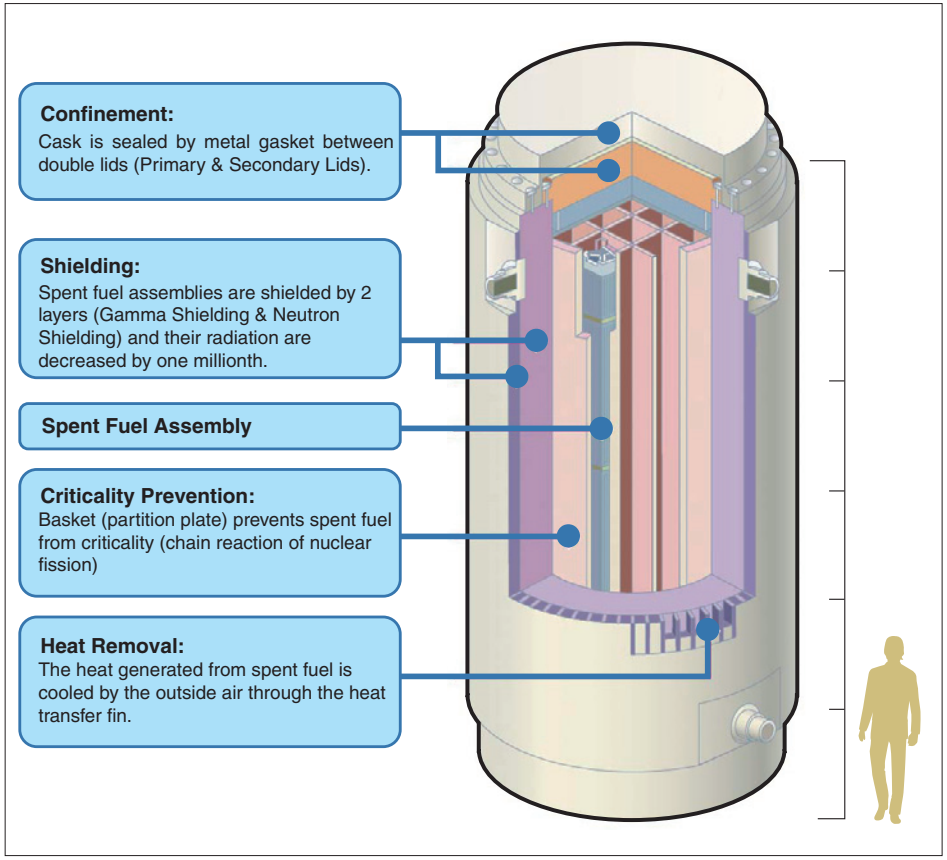


Image for the Recyclable Fuel Storage Center which is under construction in Mutsu City, Aomori Prefecture
(storage capacity: 3,000tU)

Cask for Transport & Storage



Source: Recyclable-Fuel Storage Company “Outline of construction work for the storage building” etc,

Safety Regulation Flow of Nuclear Fuel Transport

Design Stage

Approval of designs of materials to be transported

Authorities:
- Land transport included : Nuclear Regulation Authority or Ministry of Land, Infrastructure, Transport and Tourism
- Marine transport only : Ministry of Land, Infrastructure, Transport and Tourismt

Manufacturing Stage

Approval of containers

Authorities:
- Land transport included : Nuclear Regulation Authority or Ministry of Land, Infrastructure, Transport and Tourism
- Marine transport only : Ministry of Land, Infrastructure, Transport and Tourism

Before Transportation Stage

Inspection of materials to be transported

Authorities:
- Land transport included : Nuclear Regulation Authority or Ministry of Land, Infrastructure, Transport and Tourism
- Marine transport only : Ministry of Land, Infrastructure, Transport and Tourism

Inspection of transport methods

Authorities:
Ministry of Land, Infrastructure, Transport and Tourism

Notification of transport

Authorities:
- Land transport : Public Safety Commission
- Marine transport : Regional Coast Guard Headquarters of the Japan Coast Guard

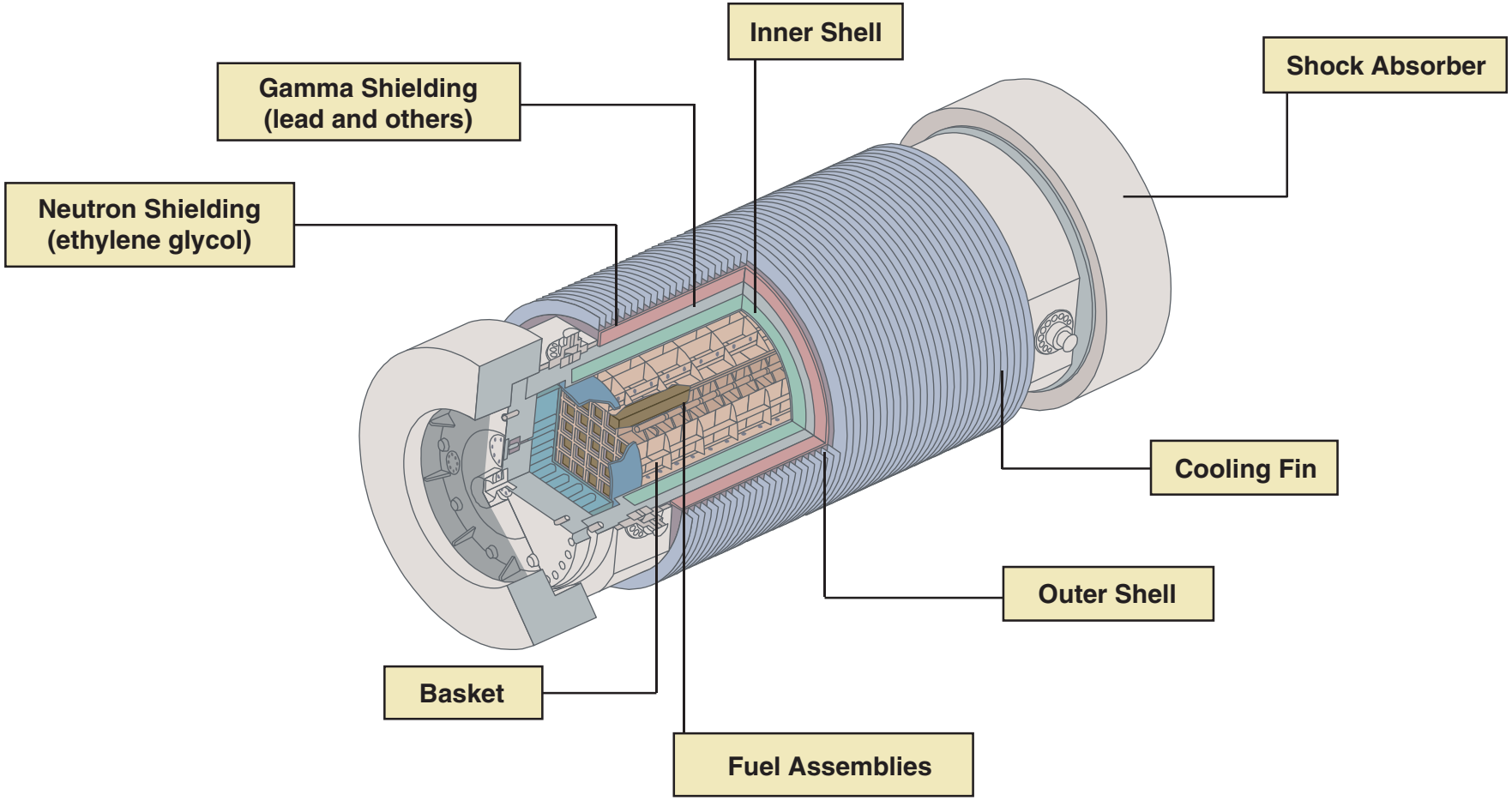
Confirmation on agreement of nuclear materials physical protection

Authorities:
Nuclear Regulation Authority

Transportation

In case of land transport, a truck is accompanied with escort cars to lead or guard.

Transport Casks for Spent Fuel



(Note) Figure shown is NFT-38B(Dry Cask) used for domestic transport.

Source: Nuclear Fuel Transport Co., etc.

Transport Vessels for Spent Fuel

(1) Securing safe navigation

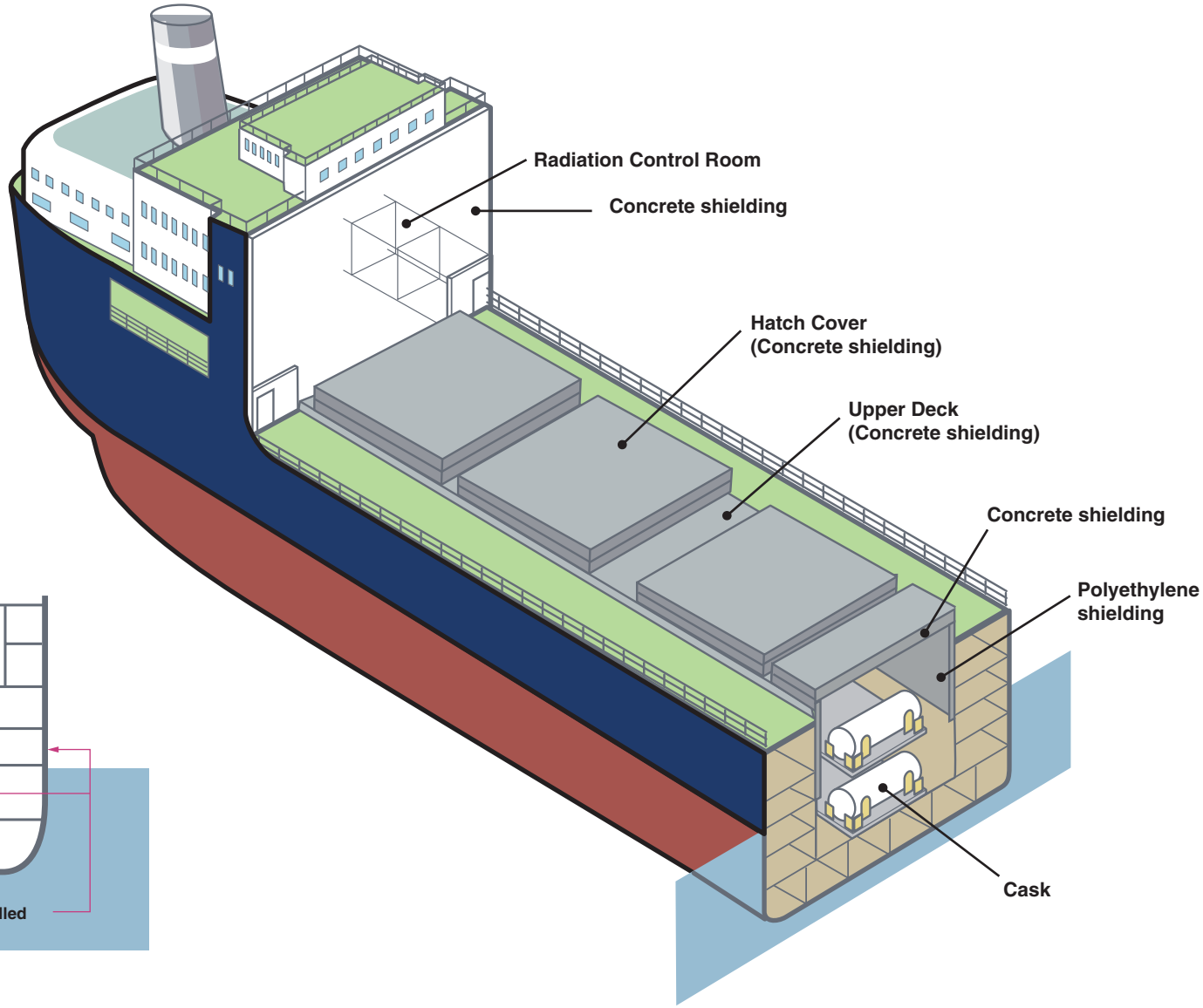
- Collision prevention radar, etc.

(2) Safe structure

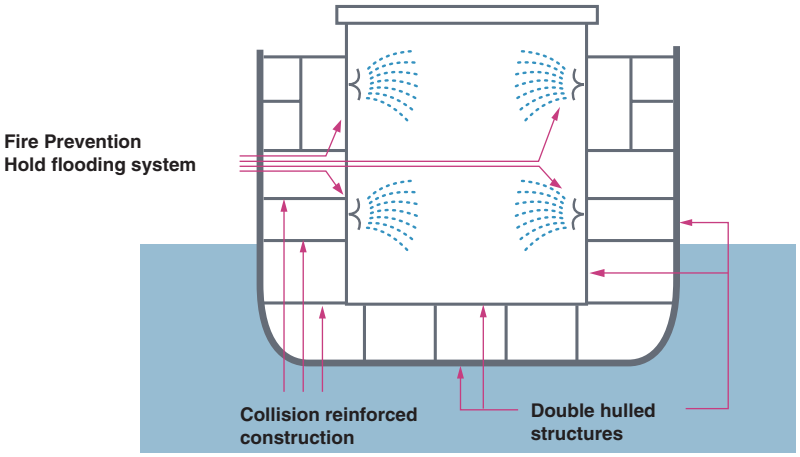
- Double hulled structures
- Enhanced buoyancy

(3) Fire preventions

- Hold flooding system, etc.



Cross Section

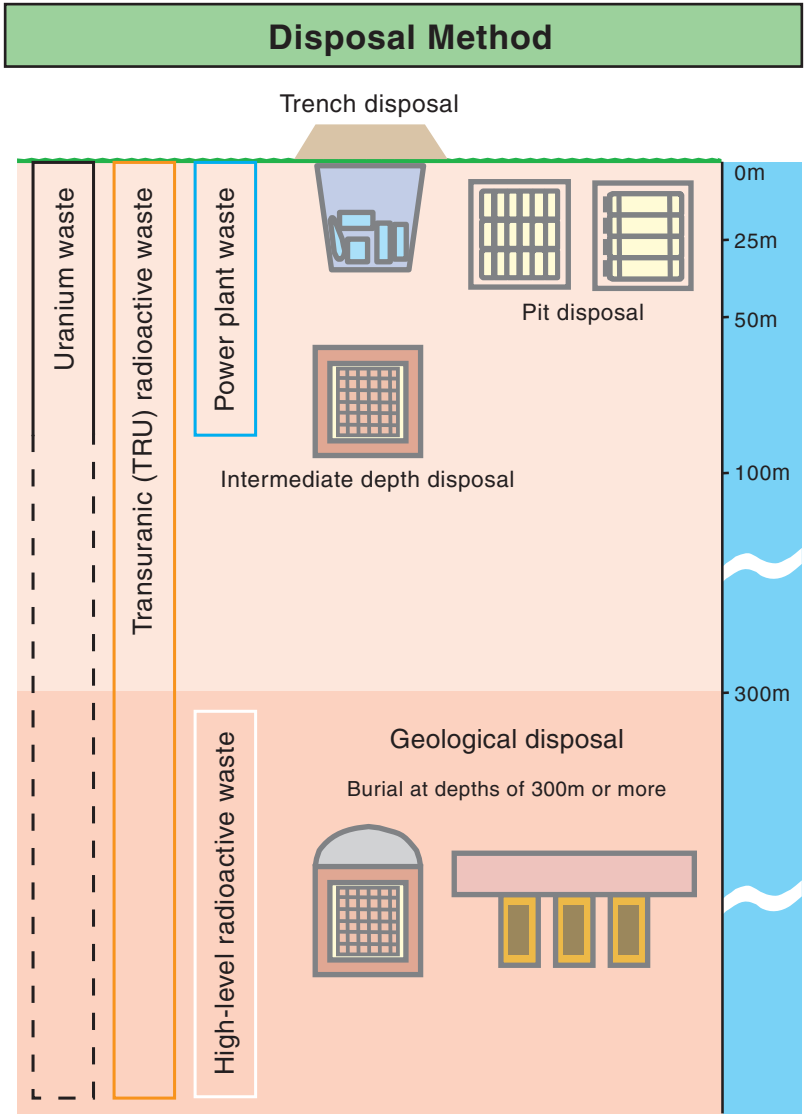


Source: Nuclear Fuel Transport Co.

Radioactive Waste Types and Disposal

The depths and barriers are selected based on the radioactivity level, and the disposal of radioactive waste is divided into shallow ground disposal, intermediate depth disposal, and geological disposal.

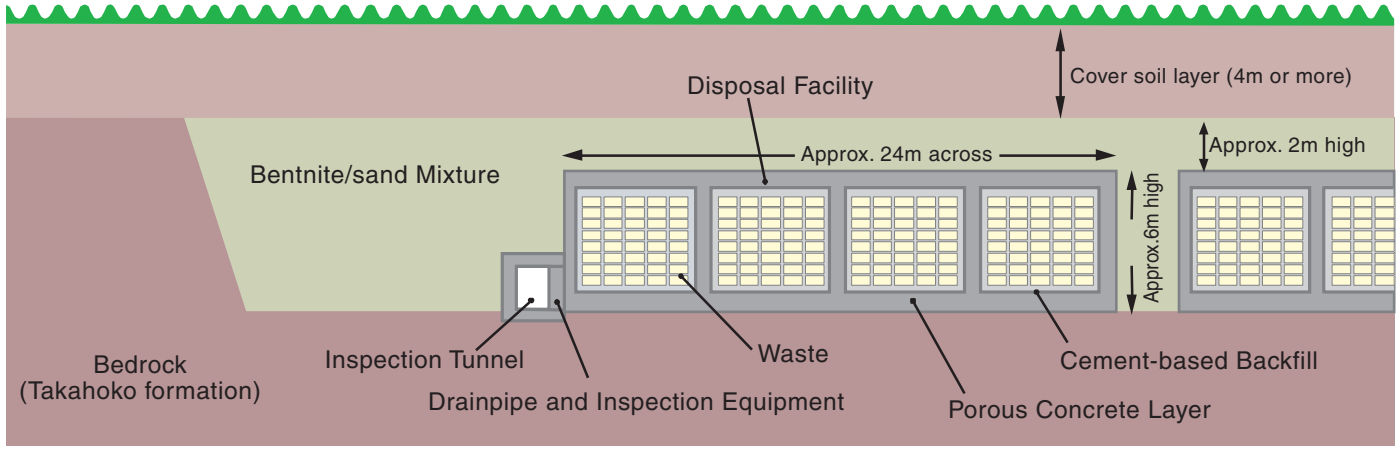
Source	Waste Types		
Nuclear power plant	Low-level radioactive waste	Power plant waste	Waste having an extremely low radioactive level
			Waste having a relatively low radioactive level
			Waste having a relatively high radioactive level
Uranium enrichment and fuel processing plant		Uranium waste	
MOX Fuel Fabrication Plant		Transuranic (TRU) radioactive waste	
Reprocessing plant			
	High-level radioactive waste		



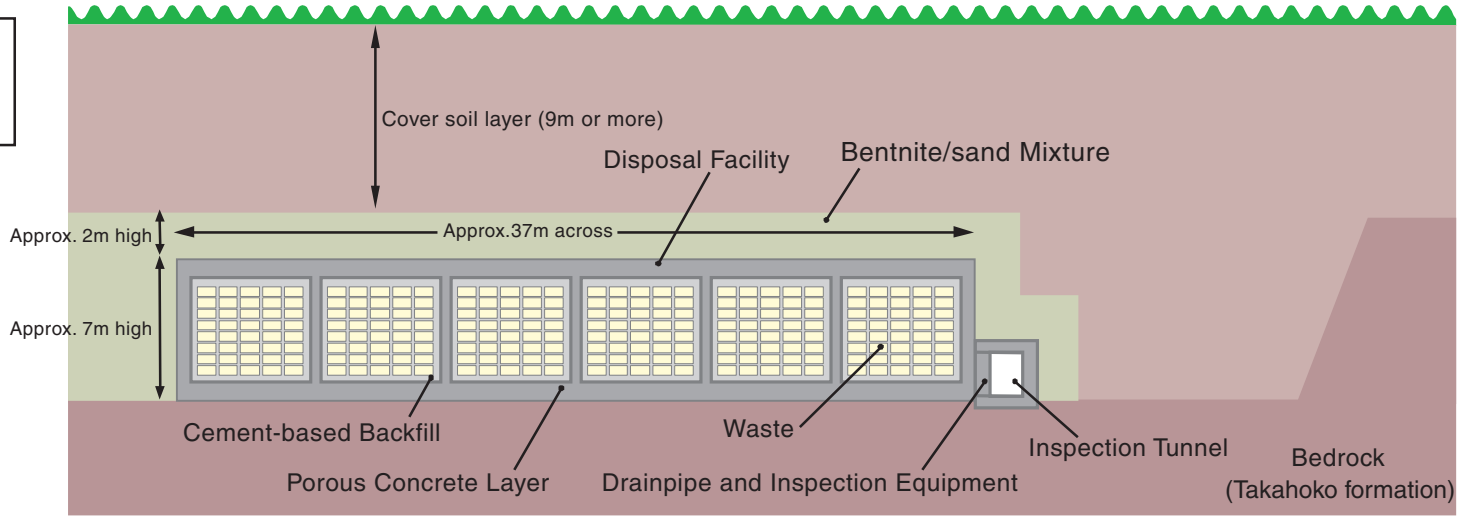
Source: Agency for Natural Resources and Energy

Structure of Low-level Radioactive Waste Disposal Facility

Structure of No.1 Disposal Facility

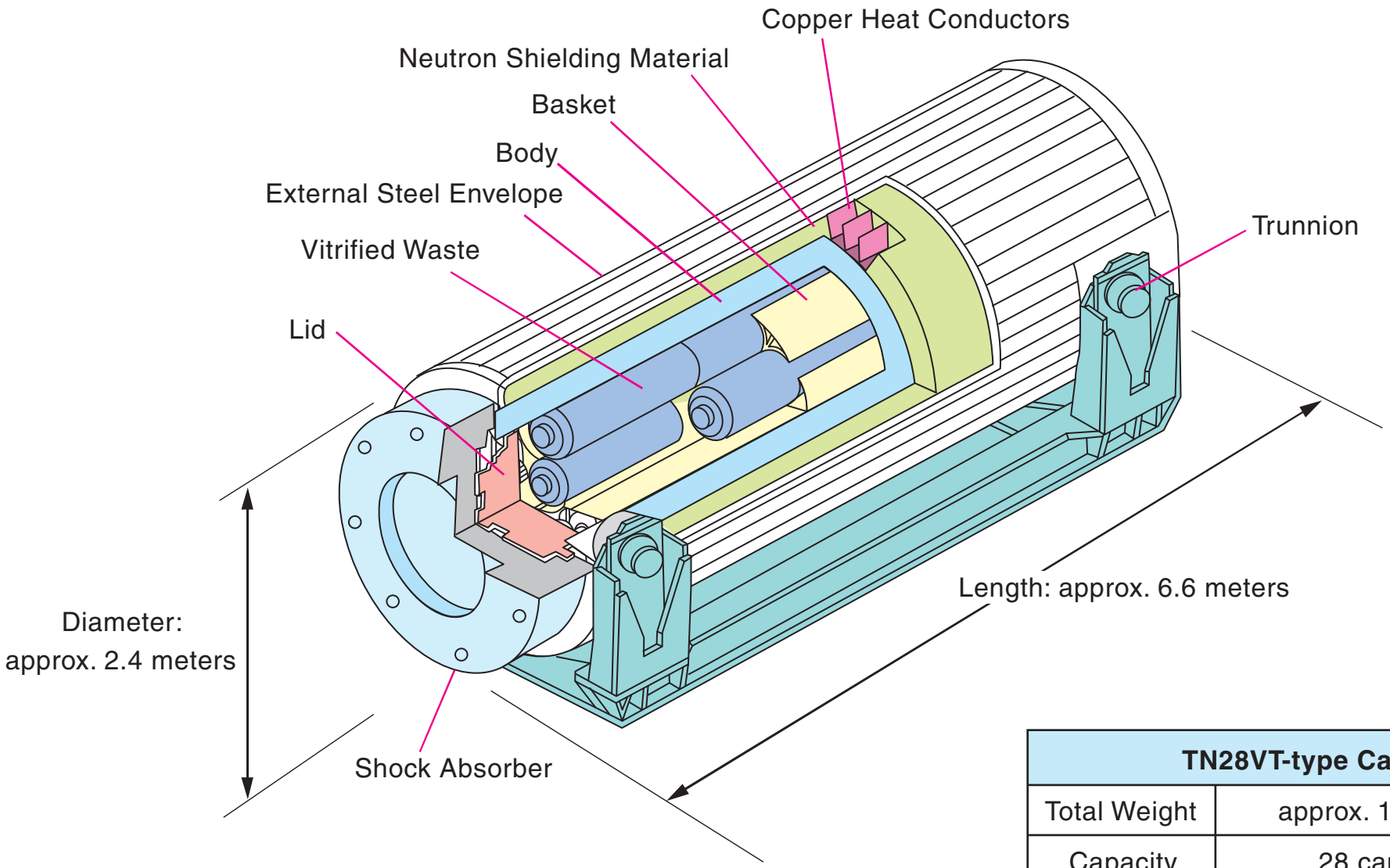


Structure of No.2 Disposal Facility



Source: Japan Nuclear Fuel Ltd.

Transport Casks for High-level Radioactive Waste (Vitrified Waste) Shipment container



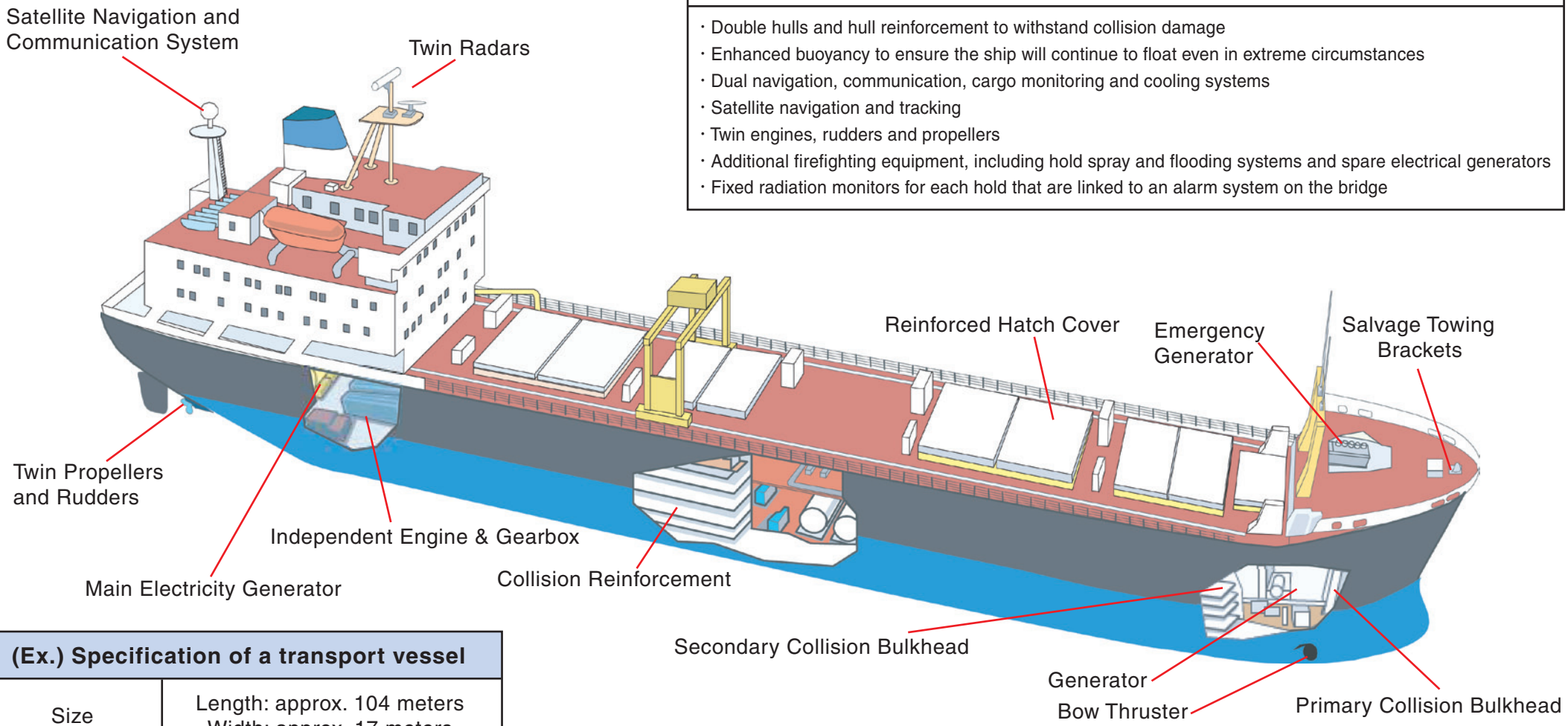
TN28VT-type Cask	
Total Weight	approx. 113.5 tons
Capacity	28 canisters

Source: Nuclear Fuel Transport Co.

Transport Vessels for High-level Radioactive Waste (Vitrified Waste)

Safety features of Transport Vessels for HLW (vitrified waste)

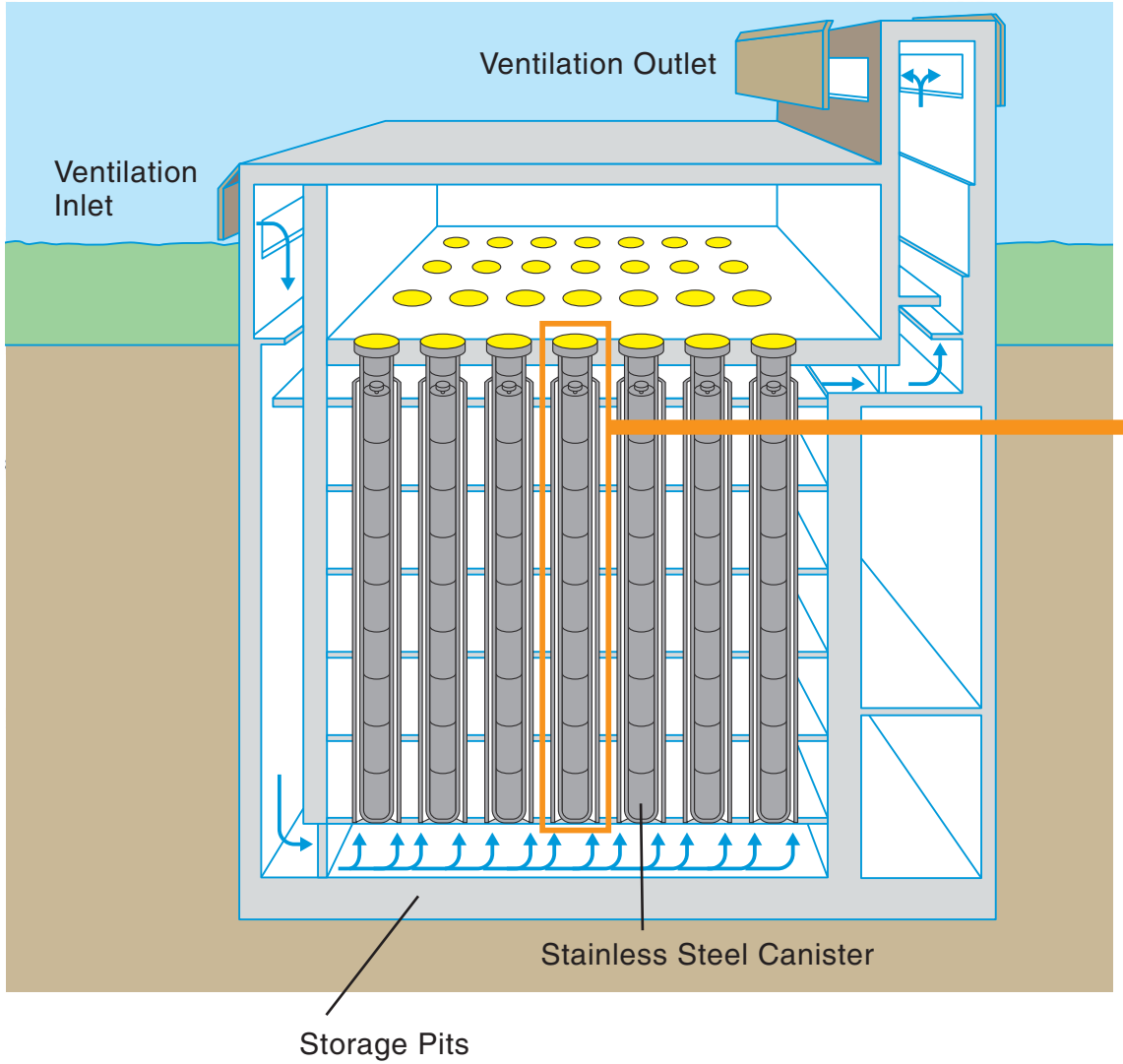
- Double hulls and hull reinforcement to withstand collision damage
- Enhanced buoyancy to ensure the ship will continue to float even in extreme circumstances
- Dual navigation, communication, cargo monitoring and cooling systems
- Satellite navigation and tracking
- Twin engines, rudders and propellers
- Additional firefighting equipment, including hold spray and flooding systems and spare electrical generators
- Fixed radiation monitors for each hold that are linked to an alarm system on the bridge



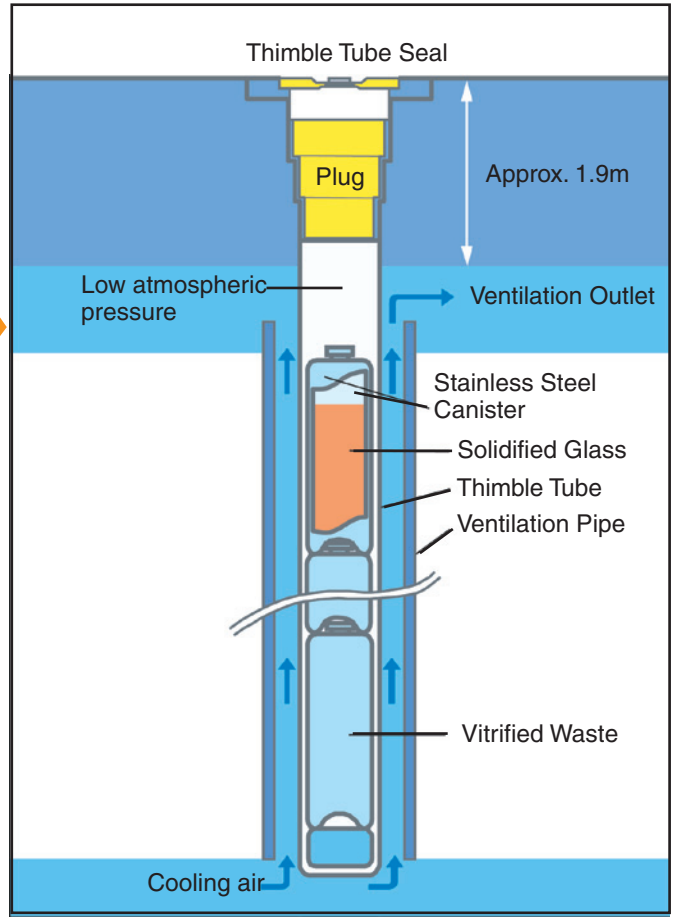
(Ex.) Specification of a transport vessel	
Size	Length: approx. 104 meters Width: approx. 17 meters
Gross Tonnage	approx. 5,000 tons
Deadweight	approx. 3,500 tons

Source: The Federation of Electric Power Companies

Temporary Storage for High-level Radioactive Waste (Vitrified Waste)



Enlarged image of storage pits

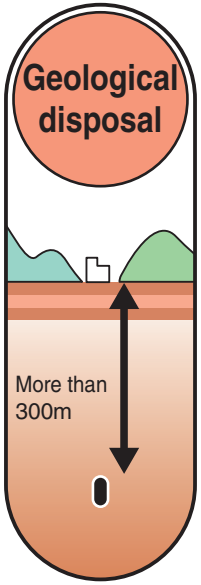


Source: Making it in reference a brochure by Japan Nuclear Fuel Ltd.

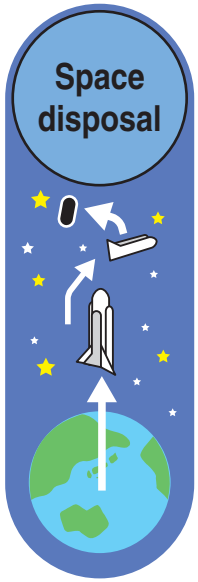
Examination of Methods for Disposing of High-Level Radioactive Waste

Given the difficulties of people managing wastes into perpetuity and not burdening future generations with monitoring them, we examined methods that would allow safe disposal without the need for human management.

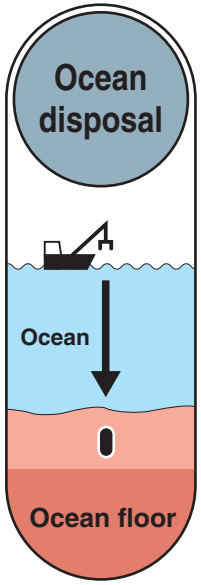
- **Disposal in geological formations, highly feasible, given the numerous examples of underground resources already being maintained for a long time.**
- **With disposal in space, Problems exist in reliability of launching technologies.**
- **Disposal at bottom of ocean, banned under the London Convention, which regulates dumping at sea.**
- **Disposal in polar ice, banned under the Antarctic Treaty.Further, features of the ice sheet are not fully known.**



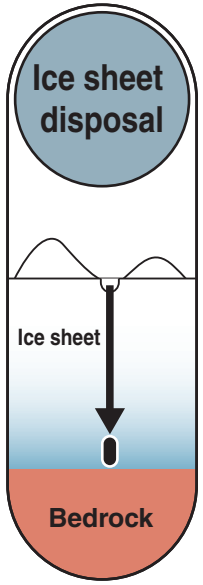
●Use the properties inherent to geological formation to lock up materials



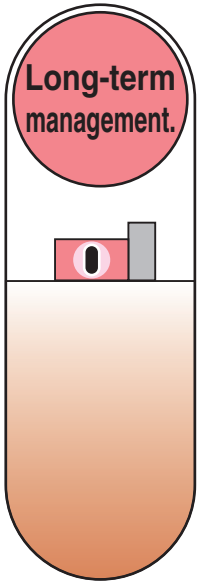
●Problems with reliability of launch technologies



●Banned by London Convention regulating ocean dumping



●Banned by Antarctic Treaty
●Features of ice sheet not fully known



●Human management. in perpetuity difficult
●Burdens future generations with monitoring

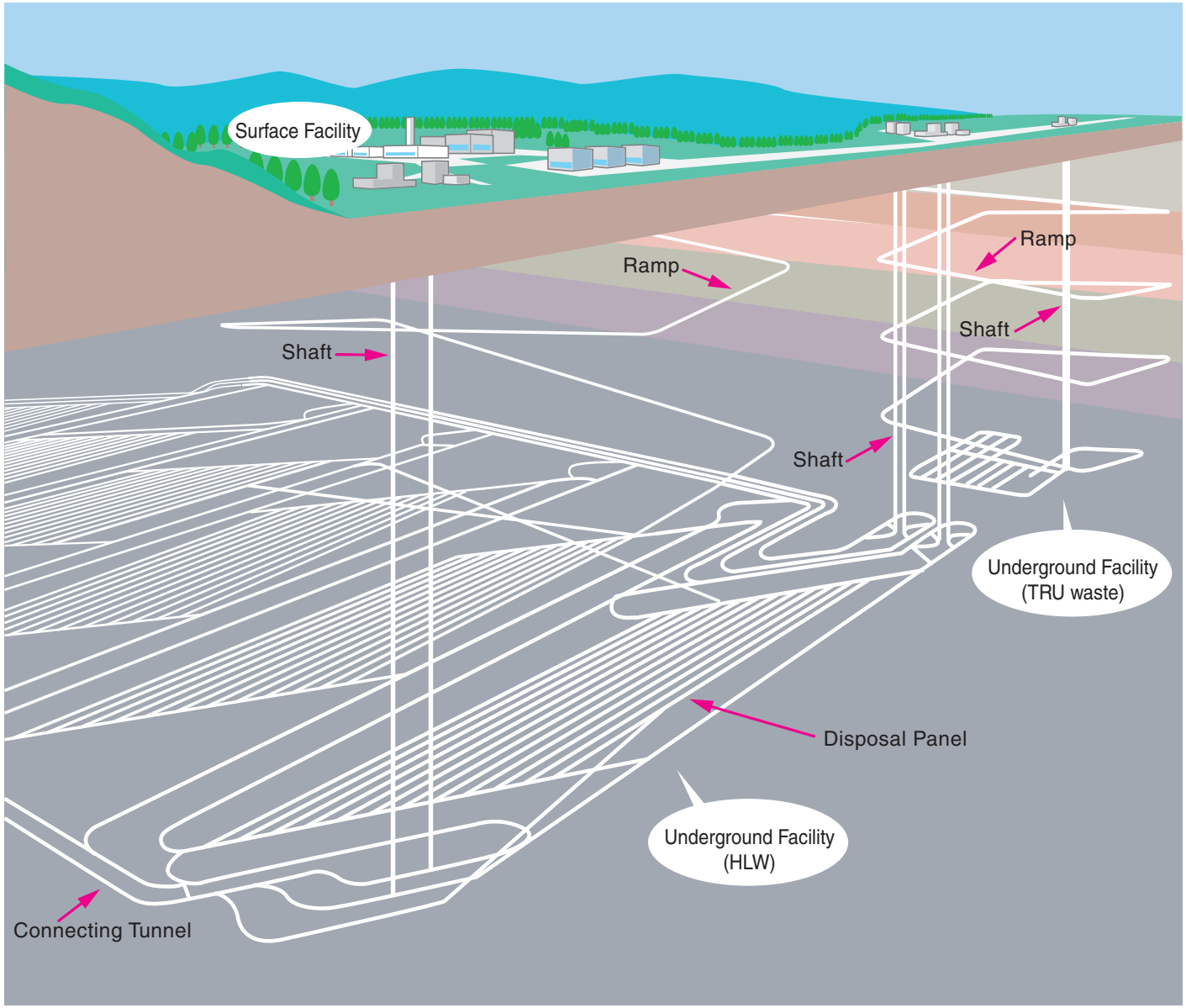
Source: Nuclear Waste Management Organization of Japan (NUMO)

Geological Disposal of High-level Radioactive Waste

Example of layout in case of co-location with TRU waste disposal facility

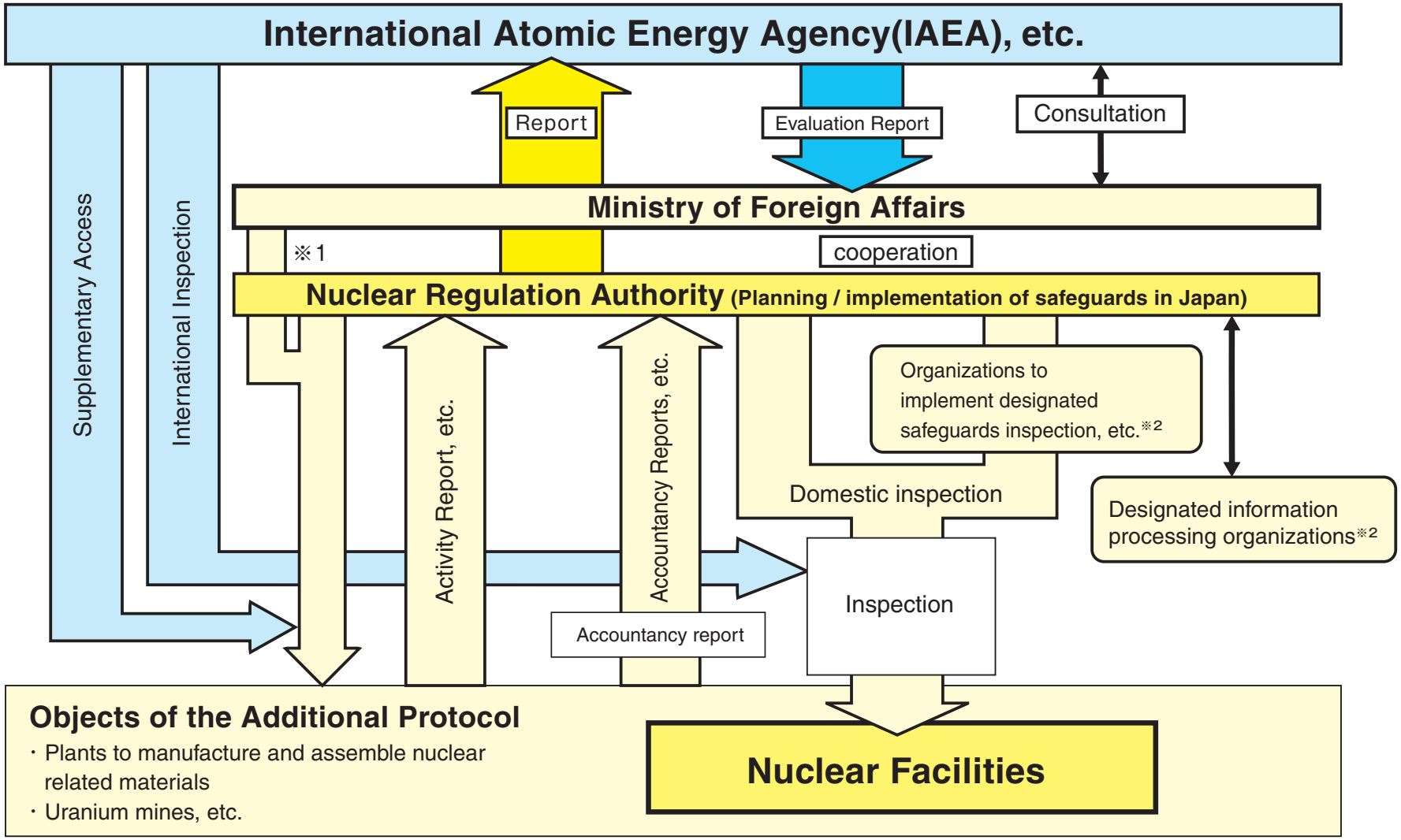
Example of specifications
(crystalline basement, depth of 1,000m)

Surface Facility	Ground area: 1 ~ 2km^2
Underground Facility for HLW	Disposal area: Approx. 3km x 2km
Underground Facility for TRU waste	Disposal area: Approx. 0.5km x 0.3km



Source: Nuclear Waste Management Organization of Japan

Safeguards System in Japan



※1 Except supplemental access, such as arises during a normal inspection
※2 Nuclear materials control center specified based on the Nuclear Reactor Regulation Law (public property) as a designated organization for implementing safeguards and inspections or as a designated information processing organization.

Source: Nuclear Regulation Authority

Electric Power Development based on the Three Laws

①Law on Tax for Promotion of Electric Power Development

Tax rate
Until Sep.2003 JPY 0.445/kWh
Oct.2003 - Mar.2005 JPY 0.425/kWh
Apr.2005 - Mar.2007 JPY 0.40/kWh
Apr.2007 From JPY 0.375/kWh

①,② and ③are called "Electric Power Development based on the Three Laws".

(Consumers)
↓
Electric Power Companies

The initial budget for FY2013※

↓
(Tax for Promotion of Electric Power Development)
JPY 330 billion
↓
General account
JPY 275 billion
↓

②Law on Special Accounts

Surplus from previous fiscal year, etc. — JPY 37.1 billion →

Fund for developing surrounding areas — JPY 6.6 billion →

Independent administrative corporation contribution — JPY 1.9 billion →

Special Accounts for Energy Measures
Accounts for Promotion of Power Development
JPY 322.1 billion

Budget by Ministries
Cabinet Office JPY 11 billion
Ministry of Education, Culture, Sports, Science and Technology JPY 113.8 billion
Ministry of Economy, Trade and Industry JPY 152.9 billion
Ministry of Environment JPY 44.3 billion

Measures for Electric Power Plant Location Accounts
- ○Development of power supply region
  - ・Development of infrastructure
  - ・Industrial development
- ○Emergency preparedness measures for power source region
- ○Promotion of public understanding of long-life fixed generation facilities
- ○Enhancement and strengthening of activities for harmonious coexistence in power supply regions
- ○Enhancement and strengthening of measures for nuclear emergency preparedness, environmental conservation and safety
- ○Measures for enhancement of public understanding of nuclear power generation

Electric Power Generation Diversification Accounts
- ○Promotion of development of power generating facilities etc.
- ○Measures for smoother power supply
- ○Nuclear safety measures
- ○Promotion of research and development concerning the nuclear fuel cycle
- ○Promotion of advanced nuclear science and technology
- ○Securing the safety, and others

Nuclear safety regulation measure
- ○Ensuring the safety of nuclear power facilities, etc.
- ○Disaster prevention measures around nuclear acilities
- ○Health management for victims of nuclear accidents

③Law on the Development of Areas Adjacent to Power Generating Facilities

Grant for to support power supply region

Financial support to smoothen construction and operation of power generation facilities

Grants for location electric power plants

Subsidy for supporting industrial development in power supply regions

Subsidy for development of power supply regions

and others

※ "Special Accounts for Promotion of Electric Power Development Acceleration Measures" and "Special Accounts for Petroleum and Sophisticated Structure of Energy Supply and Demand" were merged into "Special Accounts for Energy Measures" in FY2007. In that, "Accounts for Promotion of Electric power Development" succeed to the operation of "Special Account for Promotion of Electric Power Development Acceleration Measures".

※ Since FY2007, the revenue from "Promotion of Power-resources Development Tax" has transferred to the annual revenue of general account. Necessary amount has been transferred from the general account to "Special Accounts for Energy Measures" each year.

※ In addition, approximately 5 trillion yen is decided as atomic energy compensation for damages support calculation

Source: The Denki Shimbun "Nuclear Pocket Book FY2013"

Outline of the Tohoku-Pacific Ocean Earthquake

Date of Occurrence:

14:46 on Friday, March 11, 2011

Epicenter:

Offshore Sanriku

Latitude, Longitude and Depth of Hypocenter:

38°06.2' N, 142°51.6' E, 24km

Magnitude:

9.0 (Moment magnitude scale)

Seismic Intencity (Japanese seismic scale)

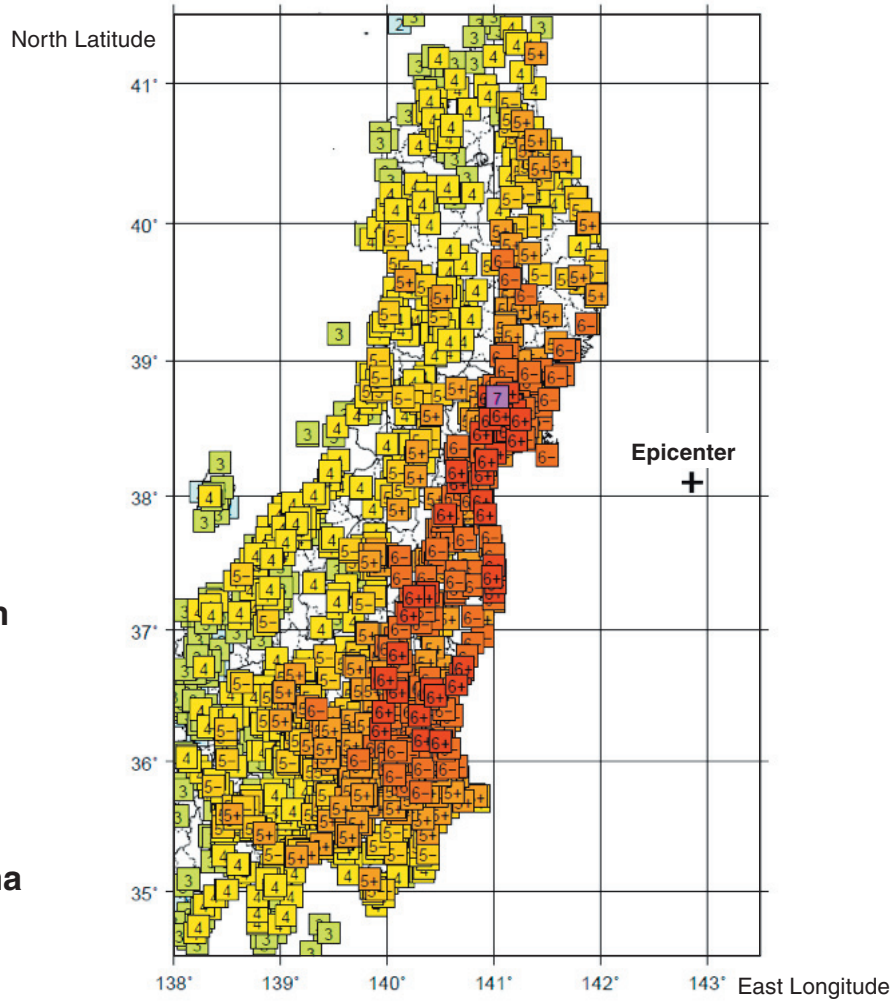
7: Kurihara City of Miyagi Pref.

Upper 6: Naraha Town, Tomioka Town, Okuma Town and Futaba Town of Fukushima Pref.

Lower 6: Ishinomaki City and Onagawa Town of Miyagi Pref. and Tokai Village of Ibaraki Pref.

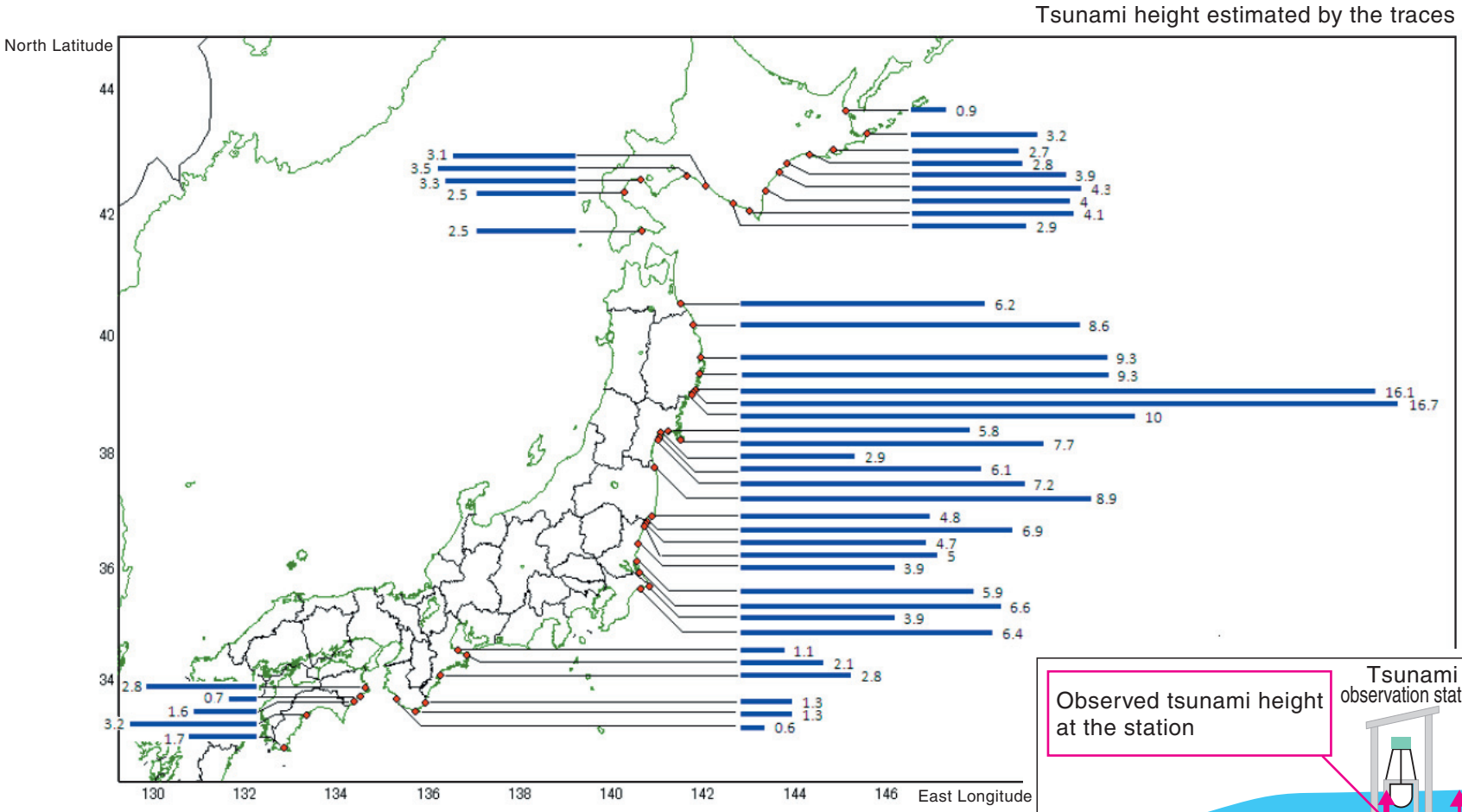
Lower 5: Kariwa Village of Niigata Pref.

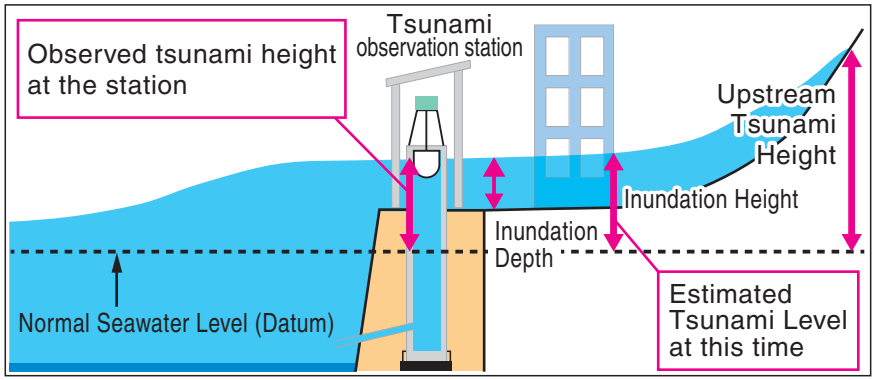
4: Rokkasho Village, Higashidori Village, Mutsu City and Ohma Town of Aomori Pref. and Kashiwazaki City of Niigata Pref.



Source: Japan Meteorological Agency "Prompt Disaster Repots of Earthquake & Tsunami, the Tohoku-Pacific Ocean Earthquake, 2011"

Height of Tsunami triggered by the Tohoku-Pacific Ocean Earthquake

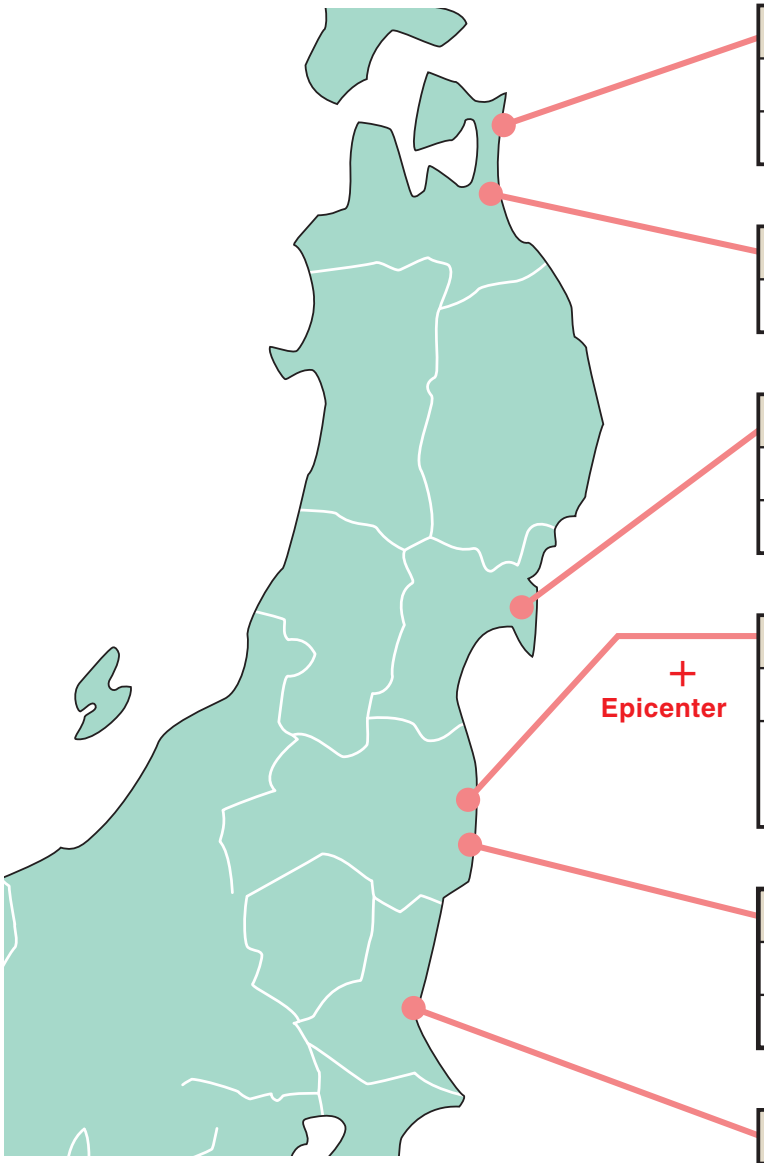




Source: Japan Meteorological Agency "Prompt Disaster Repots of Earthquake & Tsunami, the Tohoku-Pacific Ocean Earthquake, 2011"

Current Status of NPSs Affected by the Tohoku-Pacific Ocean Earthquake

(as of December 2013)



Tohoku Electric Power's Higashidori NPP
Unit 1
Outage status for periodic inspection at the time the earthquake occurred

JNFL reprocessing plant
No significant event

Tohoku Electric Power's Onagawa NPPs		
Unit 1	Unit 2	Unit 3
Shutdown automatically due to the earthquake		

Tokyo Electric Power's Fukushima Daiichi NPPs					
Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Shutdown automatically due to the earthquake and shifted to cold shutdown status※			Outage status for periodic inspection at the time the earthquake occurred		

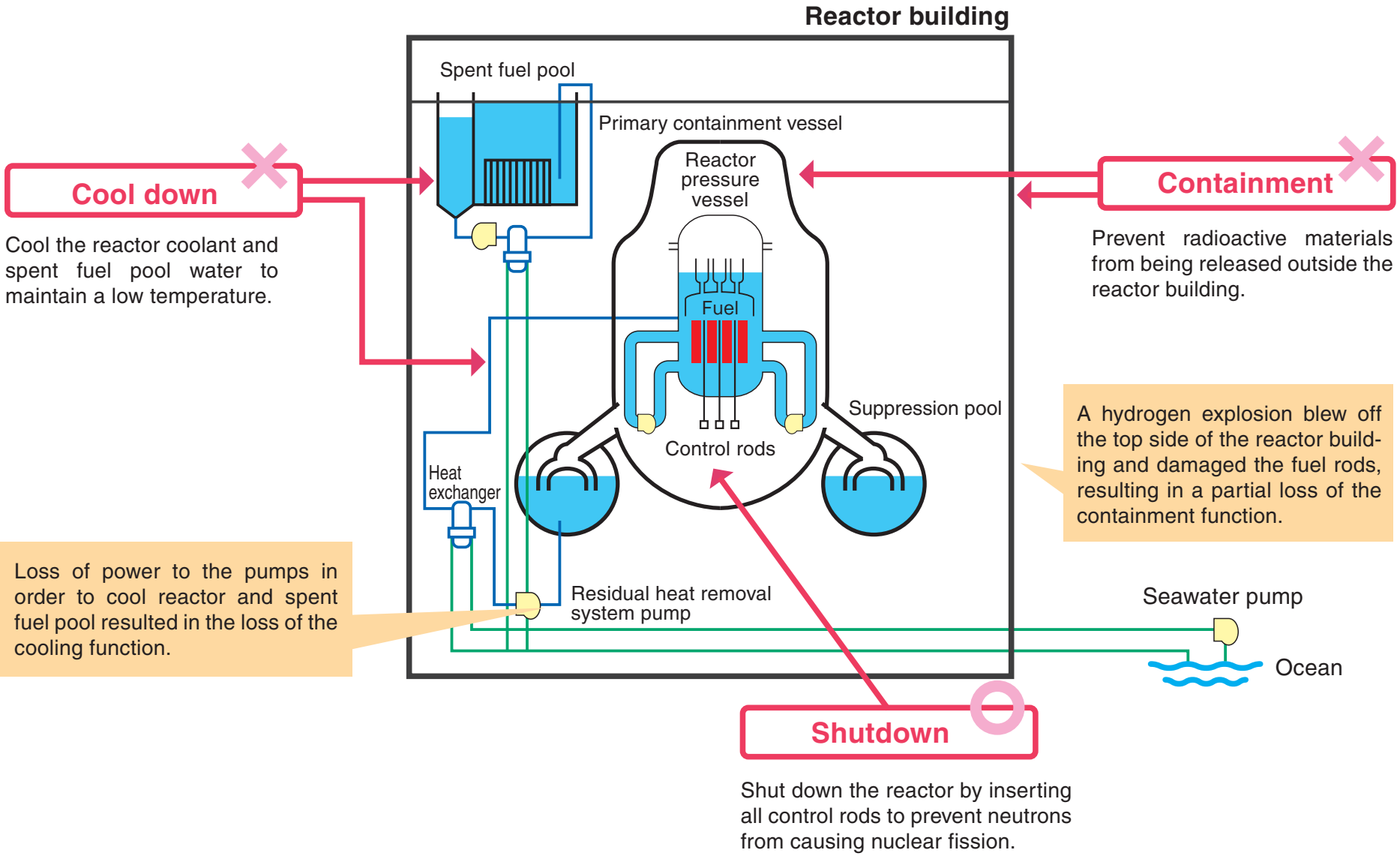
Tokyo Electric Power's Fukushima Daini NPPs			
Unit 1	Unit 2	Unit 3	Unit 4
Shutdown automatically due to the earthquake			

JAPC's Tokai II NPP
Shutdown automatically due to the earthquake

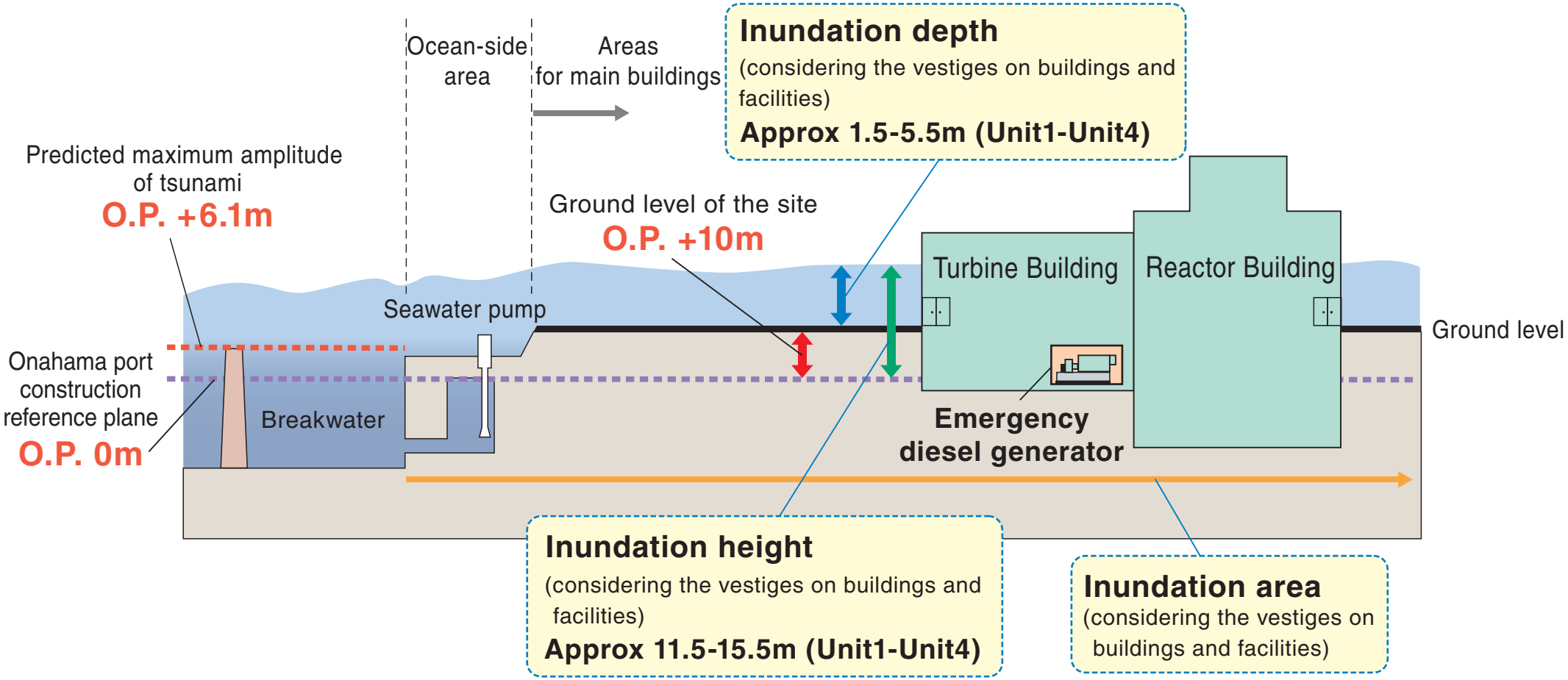
※Definition of cold shutdown state

- Temperature at the bottom of the pressure vessel is at/below 100°C
- The release of radioactive material from the containment vessel is under control and the dosage of radiation to the public from additional releases is greatly suppressed (the target at the time of evaluation for the dosage of radiation at the boundary of the site from additional releases from the container vessel is 1 mSv/year)
- In order to maintain the two conditions above, must be able to ensure the medium-term safety of the circulating injection cooling system.

Outline of the Accident at the Fukushima Daiichi Nuclear Power Station



Scale of Tsunami and Inundation at the Fukushima Daiichi Nuclear Power Station



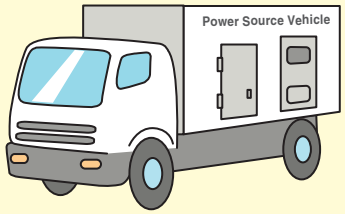
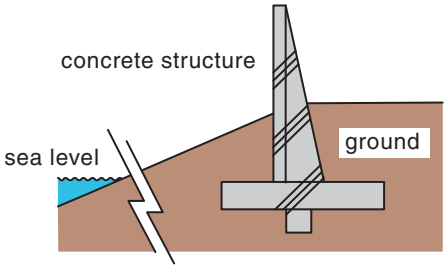
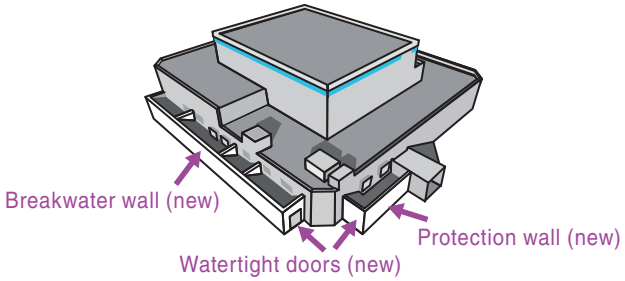
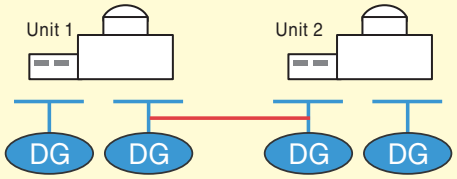
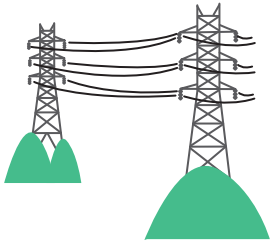
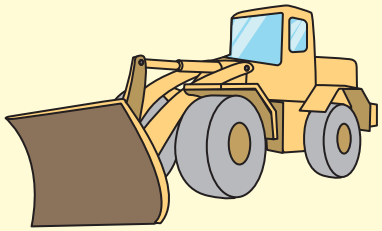
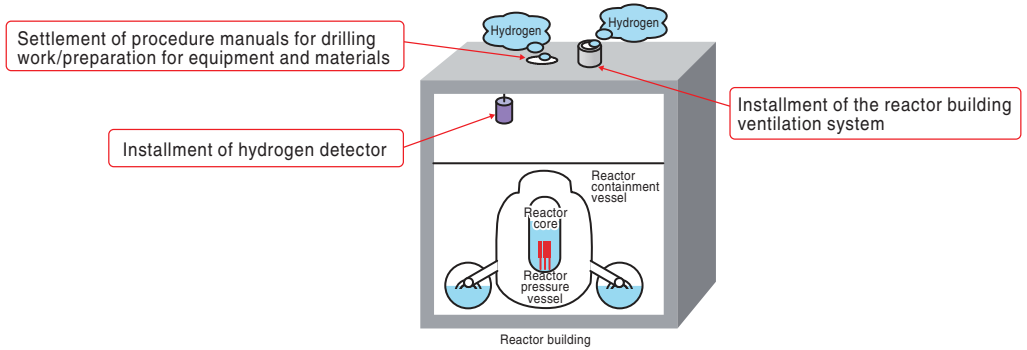
Source: Nuclear and Industrial Safety Agency

Outline of Safety Assurance Measures implemented after the Fukushima Daiichi Accident

	Short Term Measures (completed)	Mid & Long Term Measures (to be implemented in a few years)	
Emergency Safety Measures	○ Review of emergency response manuals, etc. ○ Additional deployment of emergency power source vehicles ○ Additional deployment of fire engines ○ Additional deployment of fire hoses ○ Conduct of emergency response drills	○ Installation of coastal levee ○ Strengthening watertightness of the buildings ○ Preparing the spare equipments (seawater pump, etc.) ○ Installation of large-sized air cooled generators	Prevention of the occurrence
Measures for enhancing Power Supplies	○ Interconnection of emergency diesel generators between units	○ Connection between all units and grids ○ Inspection of transmission line towers and measures against earthquake and tsunami ○ Seismic measures for switch yards, etc.	
Severe Accident Measures	○ Securing work environment at the main control room ○ Securing hydrogen discharge measures ○ Securing communication tools ○ Preparing high-dose-resistant protective clothing ○ Deployment of wheel loaders	○ Transfer of equipments (PBX, etc.) on high ground ○ Installation of the static hydrogen combiner, etc. (PWR) ○ Installation of ventilation and hydrogen detectors (BWR)	Response of the occurrence

Source: Atomic Energy Commission's New Nuclear Policy-planning Council

Examples of Safety Assurance Measures implemented after the Fukushima Daiichi Accident

	Short Term Measures (completed)	Mid & Long Term Measures (to be implemented in a few years)	
Emergency Safety Measures	Additional deployment of emergency power source vehicles  	Installation of coastal levee  	Installation of protection walls 
Measures for enhancing Power Supplies	Interconnection of emergency diesel generators between units  	Inspection of transmission line towers and measures against earthquake and tsunami 	
Severe Accident Measures	Deployment of wheel loaders 	Installation of the reactor building ventilation and hydrogen detectors (BWR)  	

Source: Atomic Energy Commission's New Nuclear Policy-planning Council

Chart No.	Title	Summary of Contents
1-1-2	World Population Projections	World population in the year 2010 was 6.92 billion. It is forecast that the world's population will reach 10.85 billion by 2100, which is 1.6 times more than that of 2010, due primarily to the increase in developing countries.
1-1-3	World Population and Energy Consumption	Although the population in China and India represented around 40% of the total world population in 2011, annual per capita primary energy consumption in both countries was below the global average. Japan with only 2% of the world's population consumed as much as 4% of the total primary energy used. Annual per capita energy consumption was equivalent to that in European countries.
1-1-4	Primary Energy Consumption per Capita	
1-1-5	Per Capita GDP and Primary Energy Consumption	As the per capita GDP increases, the primary energy consumption tends to increase. And so, as the economies grow in developing countries with extremely high rates of population growth, this is expected to lead to increased primary energy consumption over the coming years.
1-1-6	Proven Reserves of Energy Resources	Because of the limited energy resources and future increases in energy consumption, the securing of energy resources remains a great challenge. For this reason, it is important to always strive to conserve resources and energy.
1-1-7	The World's Primary Energy Consumption	Although world energy consumption is increasing as years go by, the growth in oil consumption has been moderated by positive use of alternative energy (nuclear energy and other forms) in advanced countries.
1-1-8	Primary Energy Consumption in Major Countries	The composition of primary energy consumption in major countries differs, depending on the situation in each country. Japan is one of the countries with a high dependence on crude oil. Another notable feature is that the composition of energy supplied from nuclear power is high (about 40%) in France.
1-1-9	Electricity Generated by Major Countries (Rates of Growth)	Because of the convenience of electric power, the power generation capacities of countries tend to increase year by year. Whereas the rate of increase is low in Japan, North and South America, and Europe, it is on the rise in China, South Korea, and India.
1-1-10	Electricity Consumption per Capita in Major Countries	Per capita electricity consumption in Canada and the U.S.A. is high. Moreover, China & the U.S.A. consume approximately 40% of the world's total electricity.
1-1-11	Dependence on Imported Energy Sources in Major Countries	Compared to other major countries, Japan's energy supply structure is vulnerable because Japan imports approximately 90% of its energy resources (95% when nuclear energy is not included in domestic energy).
1-2-2	Changes of Japan's Primary Energy Supply Structure	Since the oil crisis in the 1970s, Japan has attempted to reduce its dependence on oil. However, oil still accounts for about 50% of the total primary energy supply.
1-2-3	Historical Trend of Japan's Primary Energy Supply	Japan's primary energy supply has been almost constant in recent years and heavily depended on oil even after the oil crises in the 1970s.
1-2-4	Japan's Fossil Fuel Imports by Country of Origin	Japan imports around 83% of its crude oil from Middle Eastern countries and imports coal mainly from Australia and liquefied natural gas (LNG) from Southeast Asian nations.

Chart No.	Title	Summary of Contents
1-2-5	Japan's Dependence on Middle East Crude Oil of Total Imports	Japan's dependence on Middle Eastern crude oil had decreased to 67.9% in the late 1980s. However, since then it has increased and is now at the same level as prior to the oil crises in the 1970s.
1-2-7	Historical Trend of Power Generation Volume by Source in Japan	The amount of electricity generated had been increasing over the years, but has been flat since the Great East Japan Earthquake. Consequent to the stoppage of nuclear power plants, the proportion of power generated with natural gas (LNG), oil, etc., is increasing.
1-2-8	Historical Trend of Generation Capacity by Source in Japan	In Japan's generation capacity today, the share of oil fired plants, which was a major generation facility around 1995, has been gradually decreasing and the share of non-oil fired (gas-fired and others) has been increasing.
1-2-9	Percentage of Electric Power in Primary Energy (Electrification Ratio)	The need for convenient and easy-to-use electrical energy is increasing year by year, and the percentage of electric power in primary energy is currently 40% or more.
1-2-10	Hourly Power Usage on Peak Power Days	There is a wide gap between how power is used during the day and at night, and this gap tends to widen each year as power usage increases.
1-2-11	Optimal Combination of Power Sources to Correspond to Demands (Example)	Because Japan imports most of its energy resources, it is crucial not to depend on any particular energy source, but to seek an optimal combination of power sources in order to make the best use of the characteristics of each power source. Electric power companies currently use nuclear power for their base-load, because it excels in stability of generation cost and fuel supply. Thermal and pumped storage hydroelectricity adjust the total supply to meet demand fluctuations.
1-2-13	Power Consumption Per Household	Although power consumption per household was on the upswing with the proliferation of electric home appliances, since the Great East Japan Earthquake the monthly amount of energy consumed has decreased.
2-1-1	Mechanism of Greenhouse Effect	Greenhouse gases such as CO_2 absorb infrared rays (heat) radiated from the ground and return part of the heat to the ground, while easily transmitting sunlight with short wavelengths. Accordingly, as CO_2 concentrations increase, infrared rays which cannot be released to outer space increase the ground temperature.
2-1-2	Contribution of Greenhouse Gases to Global Warming	Global warming is thought to be caused by increases in greenhouse gases generated from burning fossil fuels. In particular, increased CO_2 emissions have the highest contribution.
2-1-3	Changes in CO_2 Emissions from Fossil Fuels and Atmospheric CO_2 Concentration in Japan	Atmospheric CO_2 concentration has risen dramatically since the Industrial Revolution due to the burning of large volumes of fossil fuels.
2-1-4	Historical Trends in World's CO_2 Emissions	Worldwide CO_2 emissions in 2010 were 2 times higher than they were 39 years before in 1971. This increase of CO_2 emissions is mainly due to the rapid growth of emissions in Asia (especially in China and India). CO_2 emissions in Japan increased slightly in 2010 over the base year of the Kyoto Protocol (1990).
2-1-8	Kyoto Protocol Targets and Current Status of GHG Emissions	To reduce the greenhouse gas emissions of industrialized countries by at least 5% from the baseline year of 1990 by the year 2008 to 2012, the Kyoto Protocol sets specific reduction targets for each country during this period.

Chart No.	Title	Summary of Contents
2-1-9	Lifecycle Assessment CO_2 Emissions Intensity for Japan's Energy Source	Nuclear power emits significantly less CO_2 per kWh than coal, oil or LNG-fired plants, and about the same as renewable energies such as solar and wind power.
2-1-11	Japan's Changes in CO_2 Emissions by Sector	The industrial and transportation sectors accounted for about 52% of Japan's CO_2 emissions in FY2011. The emissions from households and offices/commercial buildings (business sector) have increased from the 1990 level.
2-1-12	Changes in GHGs Emissions in Japan	Total emissions in FY2011 increased approximately 4% over the baseline year of the Kyoto Protocol.
2-1-13	Increase/Decrease in CO_2 Emissions by Sector in Japan	CO_2 emissions from industrial processes (cement manufacturing, etc.) and the industrial sector have fallen below the 1990 level through continuous efforts to reduce emissions. Although CO_2 emissions since 2008 decreased for a time due to the decrease in energy demand following the economic recession, it is on the rise again due to demand from households, businesses and other sectors.
2-1-14	Changes in CO_2 Emissions by Energy Source	Although CO_2 emissions from oil resources have decreased over 1990, they still accounted for about 44% of total emissions from energy sector in FY2011 in Japan.
2-1-15	Measures by Japan's Electric Power Industry to Reduce CO_2 Emissions	Japan is working to cut the emission of CO_2 via initiatives such as Supply-side Efforts, Strengthening Cooperation among Drivers, including Demand-side, Promotion of International Contributions and Development of Innovative Technologies.
2-1-16	Historical Trends in CO_2 Emissions from Electricity Production in Japan	The introduction of nuclear power has contributed to a decrease in the percentage of CO_2 emissions. The user-end CO_2 emissions intensity (after the Kyoto credit was applied) for FY2012 was 0.487 kg-CO_2/kWh, which was an increase of 0.137 kg-CO_2/kWh from FY2010. This is attributed to the increase in thermal power generation due to the long-term shutdown of nuclear power plants in the wake of the Tohoku-Pacific Ocean Earthquake and tsunami.
2-1-17	Thermal Efficiency Factor in Japan	In Japan, introduction of combined-cycle power generation and other efforts have improved thermal effi ciency in order to reduce CO_2 emissions from thermal power plants.
2-1-18	Comparison of CO_2 Emissions Intensity by Country	Those countries that utilize more hydroelectric and nuclear power emit less CO_2 from generation. This trend is especially significant in France where the composition of nuclear is high (about 80%).
2-2-2	SOx and NOx Emissions per Unit of lectricity Generated in Major Countries	Compared to other countries, thorough combustion control at thermal power plants has made Japan's SOx and NOx emissions per unit of electricity generated extremely low.
3-1-1	What is New Energy?	Renewable energy such as solar, wind, biomass, geothermal, and hydraulic is an energy derived from natural process and is supplied inexhaustibly. "New Energy" is defined as a part of renewable energy which needs support for the dissemination.
3-1-2	Evaluation & Problems of New Energy	Although new and renewable energy sources are inexhaustible as well as environmentally friendly, they have several drawbacks such as low energy density, instability of supply and uneconomical performances in comparison to conventional energy sources.
3-1-4	Solar Power Generation Capacity in Japan and the World	More photovoltaic power has been introduced in Japan every year and Japan's share accounts nearly 7% of the world's total capacity.

Chart No.	Title	Summary of Contents
3-1-5	Wind Power Generation Capacity in Japan and the World	More wind power has been introduced in Japan every year.
3-1-7	Mechanism of Heat Pump System Utilizing CO_2 Refrigerant	Heat pump is a system for gathering heat from the air utilizing the Boyle-Charle's law (the volume of gas is directly proportional to the absolute temperature and inversely proportional to the pressure). If heat pump systems are spread through air conditioning and hot water supplying in Commercial and Residential sector, and drying processes and air conditioning in Industrial sector, it would allow CO_2 emissions to be suppressed by max. 130 million t- CO_2 per year. This is equivalent to approx. 10% of Japan's total CO_2 emissions.
3-1-9	Mega Solar Power Generation Plant Projects in Japan	Mega solar is a large-scale solar power plants which the electric power companies and others has been promoting. In comparison with the in-house photovoltaic generation system (its capacity is around 2-4kW) being equipped with rooftops, mega solar has a capacity of 1,000-20,000kW.
3-1-10	Basic Concept of Smart-Grid in Japan	Smart-Grid in Japan is a next-generation electric power transmission and distribution technology. With the high dissemination goals for photovoltaic generation by government aiming for the realization of a low carbon society, the electric utility industry is advancing government-subsidized research on evaluation of the effect of the large-scale expansion of photovoltaic generation on the power system and measures to stabilize the power system using battery storage system.
3-1-11	Outline of Feed-in Tariff Scheme for Renewable Energies	The "Act on Purchase of Renewable Energy Sourced Electricity by Electric Utilities" was approved at the Diet and will come into force on July 1, 2012, for the purpose of enhancement of renewable energy utilization which can contribute to stable energy supply, mitigation of global warming and development in environment related industries as a driving power for the nation's economic growth. The Act obliges electric power companies to purchase the electricity generated from renewable energy sources (solar PV, wind power, hydraulic power, geothermal and biomass) based on a fixed-period contract with fixed price. The costs for purchasing such electricity will be collected from customers in form of a surcharge in proportion to electricity consumption together with ordinary electricity rates.
4-1-1	Comparison of Various Fuels Required to Operate a 1GW Power Plant per Year	Nuclear power can generate a large amount of energy from a small amount of uranium fuel. It is also superior in terms of transportation and storage.
4-1-2	Proven Reserves and Japan's Procurement of Uranium	Uranium is superior in stability of supply because it is supplied mainly by politically stable countries.
4-1-3	Nuclear Power Plants in Japan	As of the end of FY2013, 48 commercial nuclear power reactors were in operation in Japan, with a total generation capacity of 44,264MW.
4-2-1	Generating Capacity of Nuclear Power Plants in Major Countries	As of January 1, 2013, there were 427 nuclear power plants in operation around the world, and this number of nuclear power plants reaches 596 when those under construction and being planned are also included. Japan is third in the world in nuclear power generation facilities (electric output), behind the United States and France.
4-2-2	Power Generation Composition by Source in Major Countries	Major countries have a different mix of power sources, depending on the abundance and type of domestic energy resources. Since Japan has limited resources and is far from energy independence, it has tried to diversify its power sources to improve its energy security and spread risk.

Chart No.	Title	Summary of Contents
4-2-3	Electricity Generated and Share of Nuclear Power in Major Countries	China produces the most electricity in the world with a heavy bias toward coal generation, while the number 2, America, is a major nuclear power country with 104 plants in operation.
5-2-9	New Regulatory Requirements for Nuclear Power Plants	The new regulations are based on "defense in depth," which aims to prevent the loss of all safety functions all at once from a common cause. In conjunction with enhancing the design standards, such as the ability to withstand earthquakes and tsunamis, the reliability of power supplies and performance of cooling equipment, they require countermeasures for terrorism and severe accidents that can cope with incidents that exceed the assumptions of such designs. The regulatory requirements prescribe performance based, and specific measures that fulfill those requirements are to be selected by the licensee according to the characteristics of each nuclear power plant.
5-2-11	Periodic Safety Review of Nuclear Power Plant and Measures for Aging Management	Before 30 years after commissioning the nuclear power plant, the utility implements the technical review for plant life management and establishes 10-year maintenance plan. After national government approves the plan, the utility draws up the additional maintenance program based on the maintenance plan. The technical review and long term maintenance plan is revised every 10 years with introducing the up-to-date technical information.
5-3-1	Historical Trends in Reported Incidents and Failures at NPPs in Japan	The number of reported incidents and failures of nuclear power plants in Japan has been decreasing since 1981. Due to the revision of the Law on the Regulation of Nuclear Source Material, Nuclear Fuels Material and Reactors in October 2003, quantification and clarification of reporting standard of incidents and failures have been reinforced and notification standards now comply with statutory standards.
5-3-3	Unplanned Automatic Scrams per 7,000 Hours Critical in Major Countries	Until the Fukushima Daiichi Nuclear Power Station accident in 2011, the rate of unplanned automatic shutdowns of nuclear power plants in Japan had remained at a low level of 0.1 or less, indicating a good operating performance. Currently, at the end of fiscal 2012, all nuclear power plants are shut down.
5-3-4	Historical Trends in Capacity Factors of NPPs in Major Countries	Japanese nuclear power plants have maintained a favorable record of operation (high rate of facility use), regardless of the having regular inspections about once per year. Since the accident at the Fukushima Daiichi Nuclear Power Station, all nuclear power plants in Japan are currently stopped, as of the end of fiscal 2012.
5-4-3	Causes of the Accident at Chernobyl Nuclear Power Plant	The Chernobyl accident occurred due to various reasons, such as design defects, operators' violating regulations, and operational mismanagement. The lack of a safety culture is thought to be the basis of these problems. Safety culture is the philosophy that all individuals and organizations involved in the nuclear industry or studies should give top priority to safety.
5-8-1	Enhancement of the Nuclear Emergency Preparedness System	To prepare for emergencies, Nuclear Emergency preparedness Council was newly established permanently within the Cabinet for implementing nuclear disaster prevention measures across the entire government in ordinary times.

Chart No.	Title	Summary of Contents
5-8-4	Clarification of Nuclear Emergency Categories (3 Stages)	In the early stages of an emergency, it is necessary to gather information in order to grasp the situation, as well as to judge the preparations and measure to take, such as evacuation to prevent radiation exposure, and having dosages of stable iodine. To this purpose, emergencies are divided into three categories, "Site Area Emergency", "General Emergency" and a new one, "Alert," each of which organizes the roles of operators and national and local governments. The newly established "Alert" facilitates the collection of information at an early stage, before a situation becomes an emergency.
5-8-5	Expansion of Nuclear Emergency Response Action Zone	Under previous disaster prevention guidelines, prevention measures indicated the criteria of a priority area with a radius of 8 to 10 km around nuclear power plants, but that range was reviewed based on the accident at the Fukushima Daiichi Nuclear Power Station and international standards.
5-8-6	Radiation Protection for Residents	When local governments decide on their local disaster management plans, it is important for them to establish areas such as PAZ's (precautionary action planning zone) or UPZ's (urgent protective action planning zone) as one aim, based on the circumstances of the areas, such as their topography, and natural and social circumstances, as well as the characteristics of the nuclear power plant.
5-8-7	Reinforcement of Network between Government and Nuclear Power Plant Operators	A satellite-based communication systems has been developed, with facilities such as a video conferencing system, to provide smooth and reliable contact among national and local government and operators, so they can share information even in an emergency situation.
5-8-9	Nuclear Damage Compensation System	In principle, nuclear operators are liable for all damages caused by accidents in nuclear power plants. The operators are legally bound to have insurance to compensate for any damages suffered. If compensation needs exceed insurance cover, the government will extend aid, pursuant to a Diet resolution.
6-3-4	Acute Radiation Effects	When a person is exposed to a large amount of radiation at one time, the effects vary in proportion with the quantity of radiation received.
6-3-12	Relative Cancer Risk Estimation for Radiation Exposure and Lifestyle Factors	According to the follow-up survey on health effects among people exposed to radiation at Hiroshima and Nagasaki, and the research results on cancer risks for lifestyle factors, it is found that the cancer risk estimates for 100 mSv of radiation exposure (100 times stronger than dose limit for general public) increases only 1.08 times. It is almost equivalent to a case of lack of vegetable intake.
6-4-2	Controls in a Nuclear Power Plant by Area	The site of a nuclear power plant is legally classified into three distinct areas: a controlled area, a protected area and a monitoring area.
6-4-3	Radiation Exposure Control for Radiation Workers	Radiation exposure is rigorously controlled in accordance with the predefined procedures for radiation workers in controlled areas.
6-4-6	Environmental Radiation Monitoring around Nuclear Facilities	Nuclear operators monitor environmental radiation around their facility and radioactivity in environmental samples in order to confirm that there is no harmful effect on the surrounding environment.
7-1-3	Nuclear Fission inside Light Water Reactors	In light water reactors, not only uranium 235 but also uranium 238 undergoes fission. Plutonium 239 is produced as a result of uranium 238 absorbing neutrons. About 30-40% of power output is generated by plutonium in light water reactors and plutonium recovered from spent fuel can be reused as fuel.

Chart No.	Title	Summary of Contents
7-1-4	Utilization of Uranium Resources	Uranium and plutonium obtained by reprocessing are classified as quasi-domestic energy resources. Japan, which has a scarcity of energy resources, needs to reprocess spent fuel to ensure effective use of uranium resources. When JNFL's Rokkasho reprocessing plant goes into full-scale operation and the recovered uranium and plutonium are used in light water reactors, it will correspond to 70TWh of electricity annually.
7-2-1	Nuclear Fuel Cycle	Spent fuel from nuclear power plants contains unburned uranium and plutonium that are produced during power generation. Both resources are recovered and used as fuel again.
7-2-2	Nuclear Fuel Cycle (Including FBR)	A fast breeder reactor is a nuclear reactor that can use plutonium directly as a fuel. While such a reactor is being developed for practical use, the use of plutonium (MOX) in light water reactors is planned to ensure effective utilization of uranium resources.
7-2-5	Outline of JNFL's Nuclear Fuel Cycle Facilities	Four different types of facilities are under construction or in operation at Rokkasho: reprocessing; high-level radioactive waste storage; uranium enrichment; and low-level radioactive waste underground disposal. The reprocessing plant will commission in 2014 and a MOX fuel fabrication plant is scheduled to start its operation in 2017.
7-4-1	Flow of Reprocessing	The purpose of reprocessing is to recover residual unburned uranium and newly produced plutonium that are left in spent fuel.
7-5-6	MOX Fuel Use in LWRs in the World	European countries such as France, Germany, Belgium and Switzerland have loaded nearly 6,350 MOX fuel assemblies into LWRs over the last 40 years. The U.S.A. recommenced MOX fuel usage in 2005. In Japan, an advanced thermal reactor, Fugen (closed down in March 2003), had safely consumed a total of 772 MOX fuel assemblies apart from light water reactors.
7-6-1	Mechanism of Fast Breeder Reactor (FBR)	A fast breeder reactor is a nuclear reactor that can use plutonium directly as a fuel. It uses sodium as a coolant and generates steam by transferring the heat from the sodium heated in the nuclear reactor to water.
7-7-3	Spent Fuel Interim Storage Facility	The spent fuel rods from the nuclear power plant are inserted in sturdy steel casks and safely stored until reprocessing in the interim storage facility. Interim storage of the spent fuel rods enables adjustment of the time schedule until they are reprocessed and is one effective way of providing flexibility in the operation of the entire nuclear fuel cycle.
7-8-1	Safety Regulation Flow of Nuclear Fuel Transport	Nuclear fuel is packed in transport containers that have been inspected by the government. The containers are shipped after being checked several times.
7-8-5	Transport Casks for Spent Fuel	Spent fuel is transported in exclusive-use casks. The casks possess the ability to shield radiation and prevent radioactive materials from escaping in cases of collision or fire.
7-8-6	Transport Vessels for Spent Fuel	Vessels used exclusively to transport spent fuel are equipped with ample safety measures including double-hulls and double-bottomed construction to prevent foundering, even in case of collision or stranding.

Chart No.	Title	Summary of Contents
8-1-5	Radioactive Waste Types and Disposal	Generally, low-level radioactive waste is planned to be disposed by burying underground, and high-level radioactive waste is to be vitrified and stored for 30 to 50 years, and then it is disposed of underground at depths of 300 meters or more (geological disposal).
8-2-1	Structure of Low-level Radioactive Waste Disposal Facility	Metal drums containing LLW are emplaced in the facility with various barriers and under strict control.
8-3-2	Transport Casks for High-level Radioactive Waste (Vitrified Waste) Shipment container	High-level radioactive waste is transported in exclusive-use casks. The casks can shield radiation and are designed and built in accordance with national standards to ensure reliability in cases of severe accidents such as fire, collision or sinking.
8-3-3	Transport Vessels for High-level Radioactive Waste (Vitrified Waste)	Vessels used to transport high-level radioactive waste (vitrified waste) have the following features: (1) a doublehulled structure; (2) wide-ranging fire fighting equipment; and (3) radar installation.
8-3-4	Temporary Storage for High-level Radioactive Waste (Vitrified Waste)	HLW (vitrified waste) storage pits have many thimble tubes. Each thimble tube can store 9 vitrified wastes. Indirect natural air cooling system is employed, and cooling air ventilate outside of the thimble tubes not to contact the vitrified waste directory.
8-3-6	Examination of Methods for Disposing of High-Level Radioactive Waste	Bearing in mind the difficulties of people managing wastes into perpetuity and not burdening future generations with monitoring them, we are examining methods that allow the disposal of high-level radioactive wastes safely without the need for human management.
8-3-8	Geological Disposal of High-level Radioactive Waste	HLW will be disposed of in a stable geological formation at a depth of more than 300 meters. All disposal tunnels will be backfilled at the end and sealed up completely.
9-2-2	Safeguards System in Japan	Under the Treaty on the Non-proliferation of Nuclear Weapons (NPT), all nuclear facilities in Japan receive inspections by the International Atomic Energy Agency (IAEA) as well as the Japanese government to ensure that nuclear energy is only used for peaceful purposes.
9-3-1	Electric Power Development based on the Three Laws	The three laws consist of 1) the Law on Tax for Promotion of Electric Power Development, 2) the Law on Special Accounts, and 3) the Law on the Development of Areas adjacent to Power Generating Facilities. These laws were enacted to develop public facilities and other facilities in order to boost local industries and provide infrastructure for the convenience of local communities where nuclear, thermal and hydro power generation facilities stand.
10-1-1	Outline of the Tohoku-Pacific Ocean Earthquake	14:46 on March 11, 2011, the “Tohoku-Pacific Ocean Earthquake” (the Great East Japan Earthquake) with magnitude 9.0 in Richter scale struck the eastern part of Japan. The epicenter was offshore Sanriku (around 130 km east-southeast of the Ojika Peninsula) and the depth of hypocenter was approx. 24 km.
10-1-2	Height of Tsunami triggered by the Tohoku-Pacific Ocean Earthquake	As the Tohoku-Pacific Ocean Earthquake, a series of tsunami was observed widely at the Pacific coast (mainly from Tohoku region to the northern part of Kanto region). According to the Japan Meteorological Agency’s field survey on tsunami, over-10-meters-high tsunami struck the coast of Iwate prefecture and fewmeter-high traces of tsunami strike was found everywhere at wide range of Pacific coast (from Hokkaido to Shikoku).

Chart No.	Title	Summary of Contents
10-2-1	Current Status of NPSs Affected by the Tohoku-Pacific Ocean Earthquake	When the Great East Japan Earthquake struck, all the reactors operating at the time at Tohoku Electric Power's Onagawa Nuclear Power Station, Tokyo Electric Power's Fukushima Daini Nuclear Power Station and Japan Atomic Power's Tokai No.2 Power Station shut down automatically and their cooling systems functioned properly. Consequently, all these reactors went into cold shutdown in a few days. On the other hand, although Tokyo Electric Power's Fukushima Daiichi Nuclear Power Station shut down automatically, the reactors and the spent fuel pools cooling functions failed due to the loss of all AC power because of the tsunami. This led to hydrogen explosions and release of radioactive materials into the atmosphere.
10-2-2	Outline of the Accident at the Fukushima Daiichi Nuclear Power Station	When the earthquake struck at the Fukushima Daiichi Nuclear Power Station, of the six units at the plant, the nuclear reactors for units 1, 2, and 3, which were operating at the time, automatically shut down. Although the earthquake caused all the external power supplies to fail, the emergency diesel generators started up automatically to provide the necessary power supplies. However, when the massive tsunami struck, many electrical power boards were flooded and damaged by sea water, and except for unit 6, the emergency diesel generators stopped, and all AC power was lost. As a result, the cooling functions of the nuclear reactors and spent fuel pool for units 1 to 3 remained stopped for a considerable period of time. This caused damage to the cladding of the nuclear reactor fuel rods, and hydrogen was generated due to the chemical reaction with water vapor. Then, an explosion thought to be due to the hydrogen that leaked from the primary containment vessel occurred in units 1 and 3, damaging the upper section of the nuclear reactor buildings, and causing the release of radioactive materials into the environment.
10-2-3	Scale of Tsunami and Inundation at the Fukushima Daiichi Nuclear Power Station	The Fukushima Daiichi Nuclear Power Station used seafloor topography data and other information to estimate the height of a potential tsunami of 6.1 meters, but the tsunami that followed the Great East Japan Earthquake greatly surpassed that estimate and reached a height of some 14 to 15 meters. The massive tsunami overran the main building site (units 1 to 4 are 10 meters high and units 5 and 6 are 13 meters above sea level), flooding the entire area and penetrating the main buildings. As a result, all power was lost in units 1 to 4 of the Fukushima Daiichi Nuclear Power Station.
10-3-1	Outline of Safety Assurance Measures implemented after the Fukushima Daiichi Accident	Taking on the lessons from the accident at the Fukushima Daiichi Nuclear Power Station, where all power failed due to the earthquake and the tsunami, the electric power companies in Japan have undertaken safety measures at their nuclear power plants, with a focus on measures against tsunamis. The companies have taken measures (such as enhancing internal communication procedures and preparing clothing to protect against high doses of radiation), to enable work to progress steadily even in the face of a severe accident, including deploying additional emergency power source vehicles and fire engines, as emergency safety measures to prevent fuel damage no matter what by ensuring the continuous cooling of the reactor and spent fuel pools. They are also proceeding with medium and long-term measures, such as additional installation of uninterruptible emergency power supplies on high ground, building seawalls and deploying watertight construction, as well as temporary large capacity seawater pumps.
10-3-2	Examples of Safety Assurance Measures implemented after the Fukushima Daiichi Accident	After the earthquake the electric power companies promptly took emergency safety measures including deploying additional emergency power source vehicles and wheel loaders, etc. The companies are also taking medium- to long-term measures which include constructing coastal levees and tide walls in order to increase safety margin of the nuclear power stations.

The Federation of
Electric Power Companies of Japan

Keidanren-kaikan,
1-3-2, Otemachi, Chiyoda-ku, Tokyo
100-8118, Japan
http://www.fepc.or.jp/english/index.html