Future Perspective of Nuclear Utilization as Electric Utilities Industry

April 11, 2017

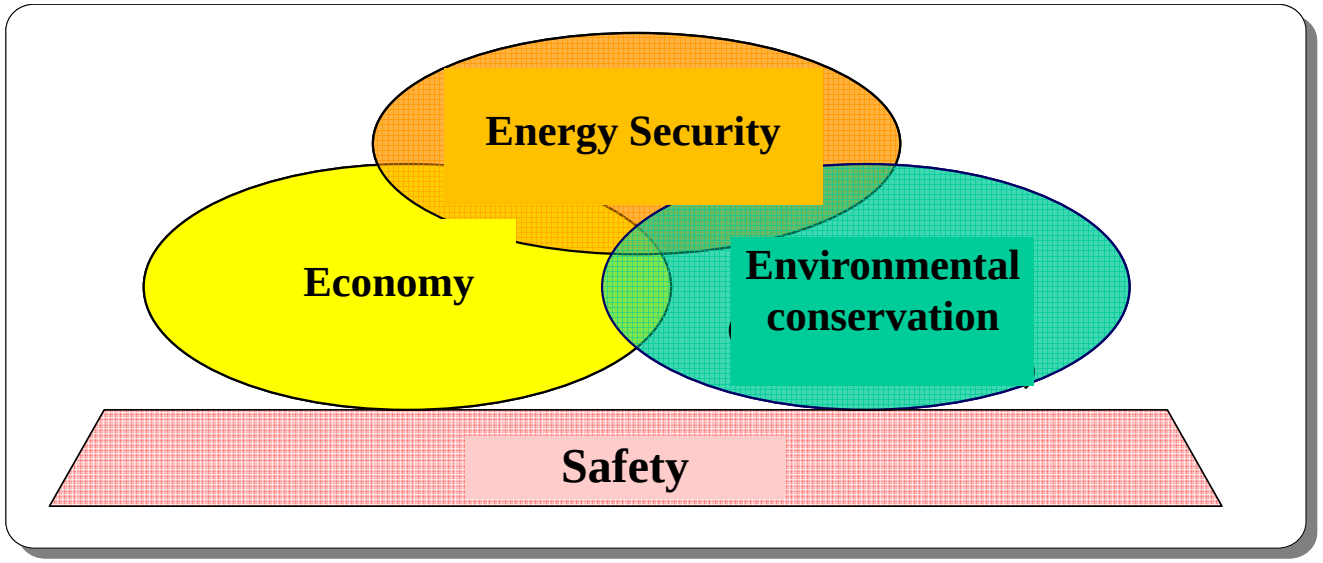
The Federation of Electric Power Companies of Japan

Contents

1. Restructuring of energy mix

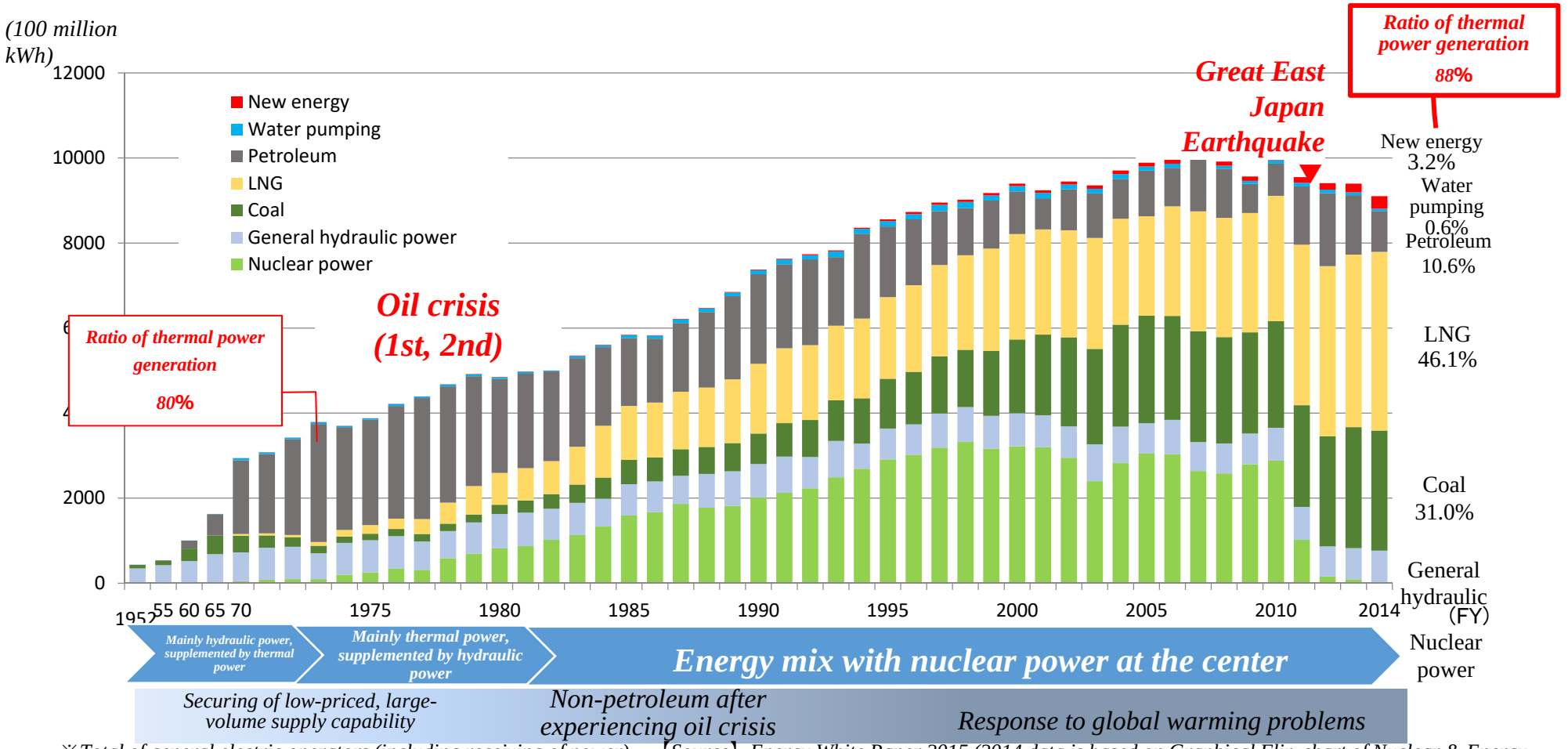
Nuclear power is essential for structuring of 3E

- In Japan which is a country poor in resources, it is necessary to combine various energy sources from the perspective of “S+3E”.
- Thus far, Japan has realized balanced energy mix without depending on specific energy sources.
- Among energy sources, nuclear power shows excellent qualities for all of 3E, and it is an important power source that cannot be left out from energy mix.
- After the Great East Japan Earthquake, shutdown of nuclear power is prolonged and excess dependency on thermal power continues, but it is necessary to secure various options including nuclear power and restructure balanced energy mix.



【Energy security】 Transition of composition ratio of generated energy in Japan

- Reflecting the oil crisis, composition of power sources has diversified to improve vulnerable energy security.
- Due to shutdown of nuclear power stations after the Great East Japan Earthquake, ratio of thermal power generation exceeded 88% in FY2014, which is higher than the ratio at the time of the oil crisis (FY1973: 80%).

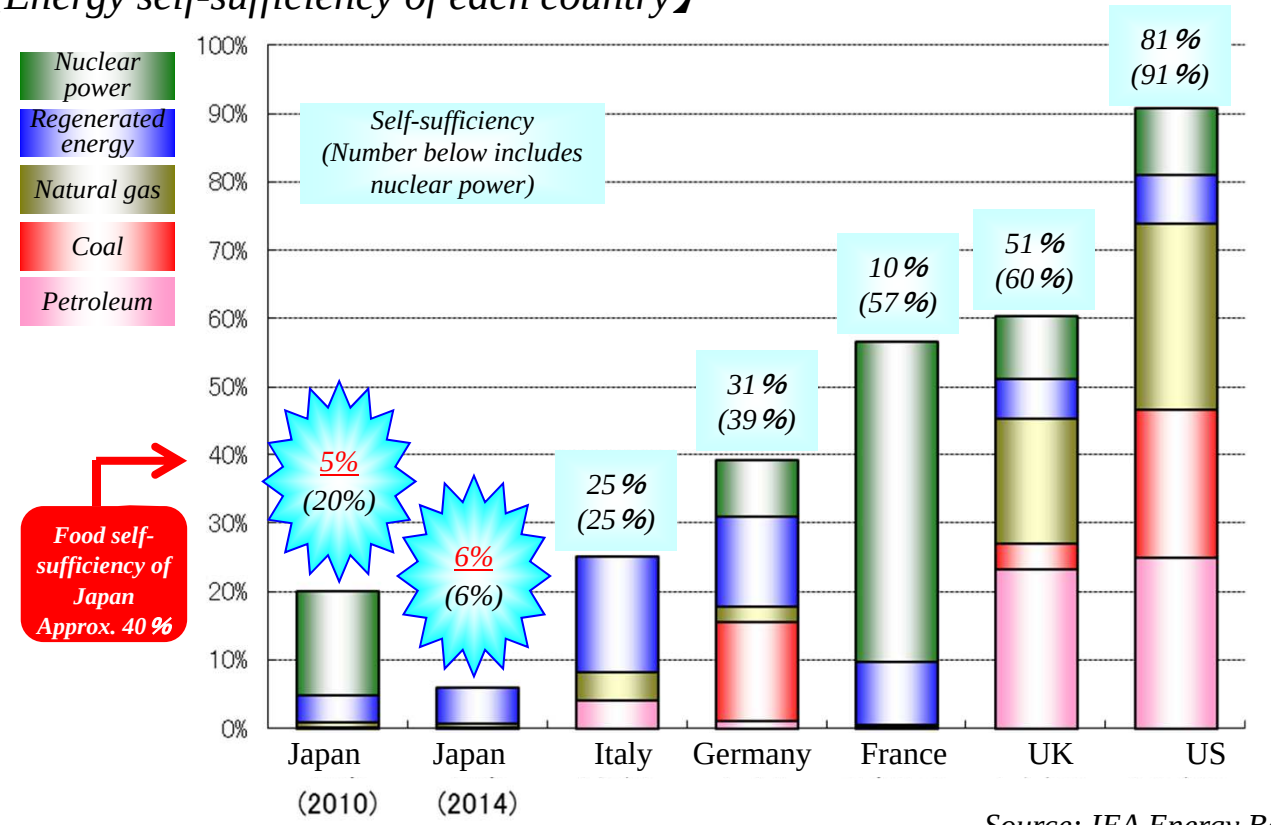


※Total of general electric operators (including receiving of power)　【Source】 Energy White Paper 2015 (2014 data is based on Graphical Flip-chart of Nuclear & Energy Related Topics 2016)

【Energy security】Ratio of energy self-sufficiency of each country

- Energy self-sufficiency of Japan is only 6%, which indicates extremely vulnerable structure in terms of energy security.
- Nuclear power has high stockpiling effect, and even if energy supply from overseas is cut off, power generation will not be stopped immediately and time to implement measures is secured.

【Energy self-sufficiency of each country】



・The total may not add up due to rounding.
・Figures are actual results of 2014.

Source: IEA Energy Balances 2016 Edition

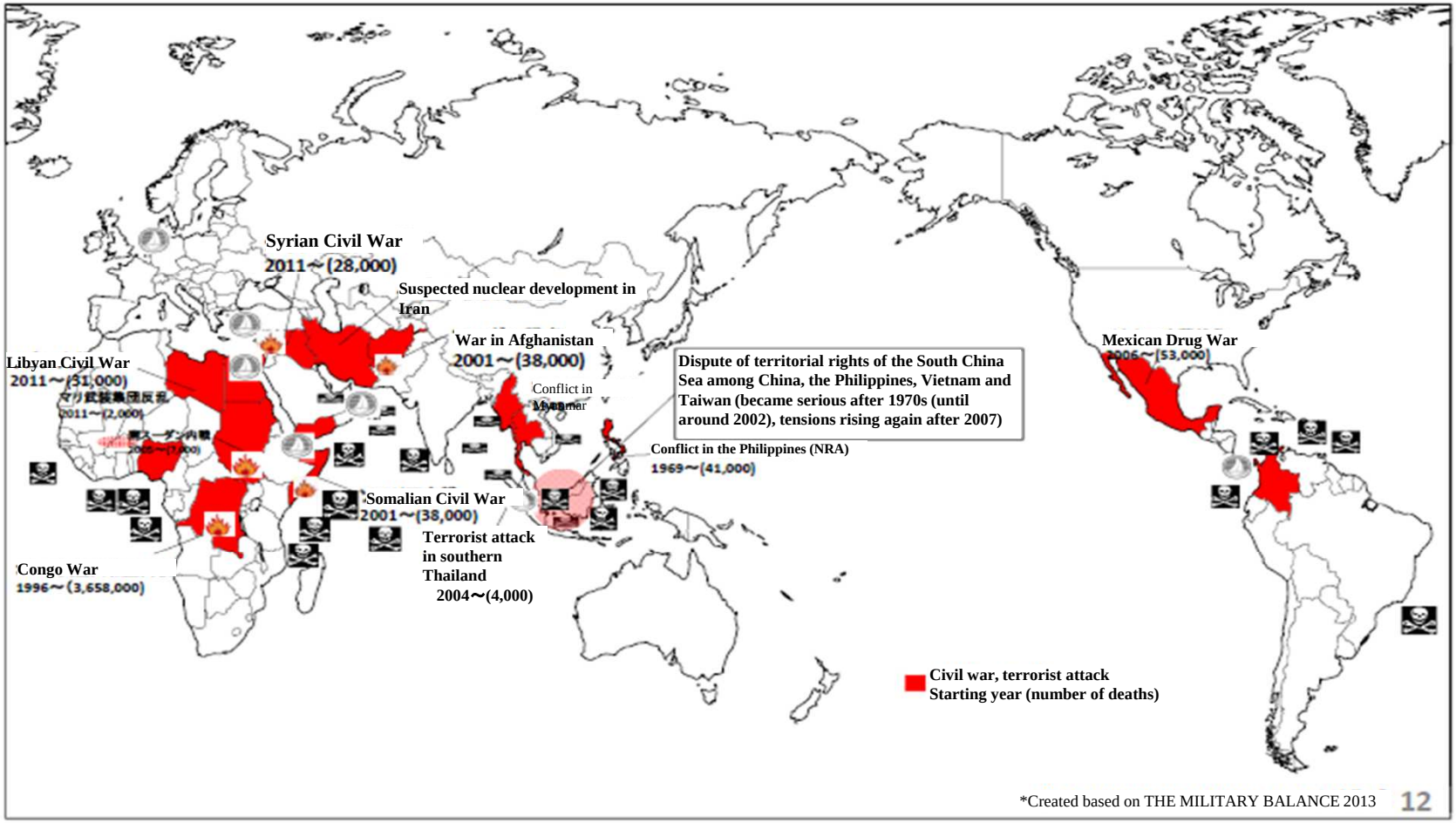
【Stockpiling effect of nuclear power】

LNG	Approx. 14 days
Petroleum	Approx. 170 days (statutory stockpiling)
Coal	Approx. 30 days
Nuclear power	Approx. 2.7 years

Source: Long-term Energy Supply and Demand Subcommittee

【Energy security】Geopolitical risks concerning procurement of resources

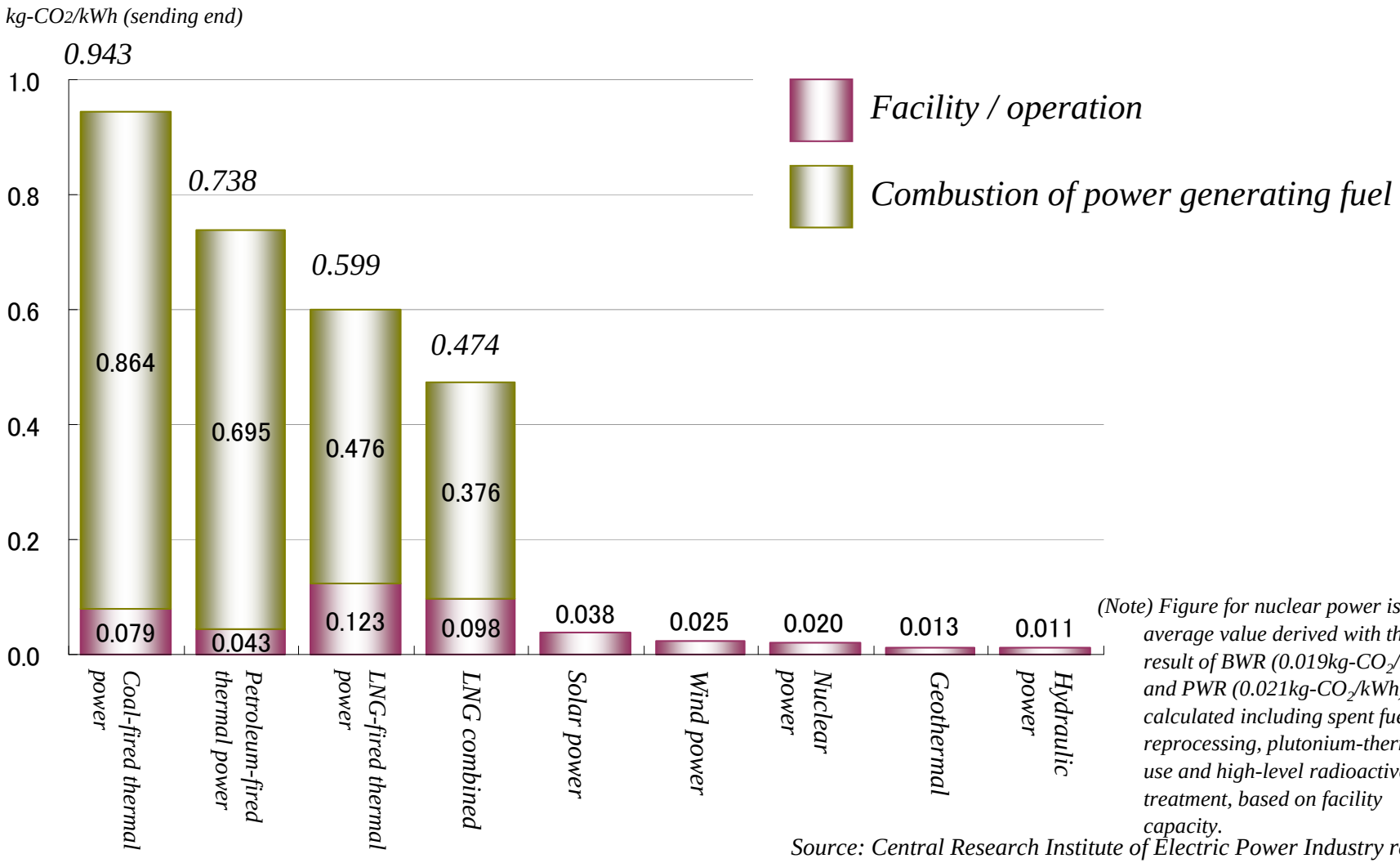
- After the Great East Japan Earthquake, shutdown of nuclear power is prolonged and thermal power generation including LNG has drastically increased.
- More than 80% of crude oil and approximately 30% of LNG depend on the Middle East (Especially, dependency of LNG on the Middle East drastically increased from the approximately 20% before the Great East Japan Earthquake). If there is some kind of crisis or blockade in the Strait of Hormuz, there is risk of procurement becoming difficult.



【Environmental conservation】Comparison of lifecycle CO_2 by power source

- As nuclear power does not generate CO_2 when generating power, it is an extremely effective global warming measure.

【Comparison of lifecycle CO_2 by power source】



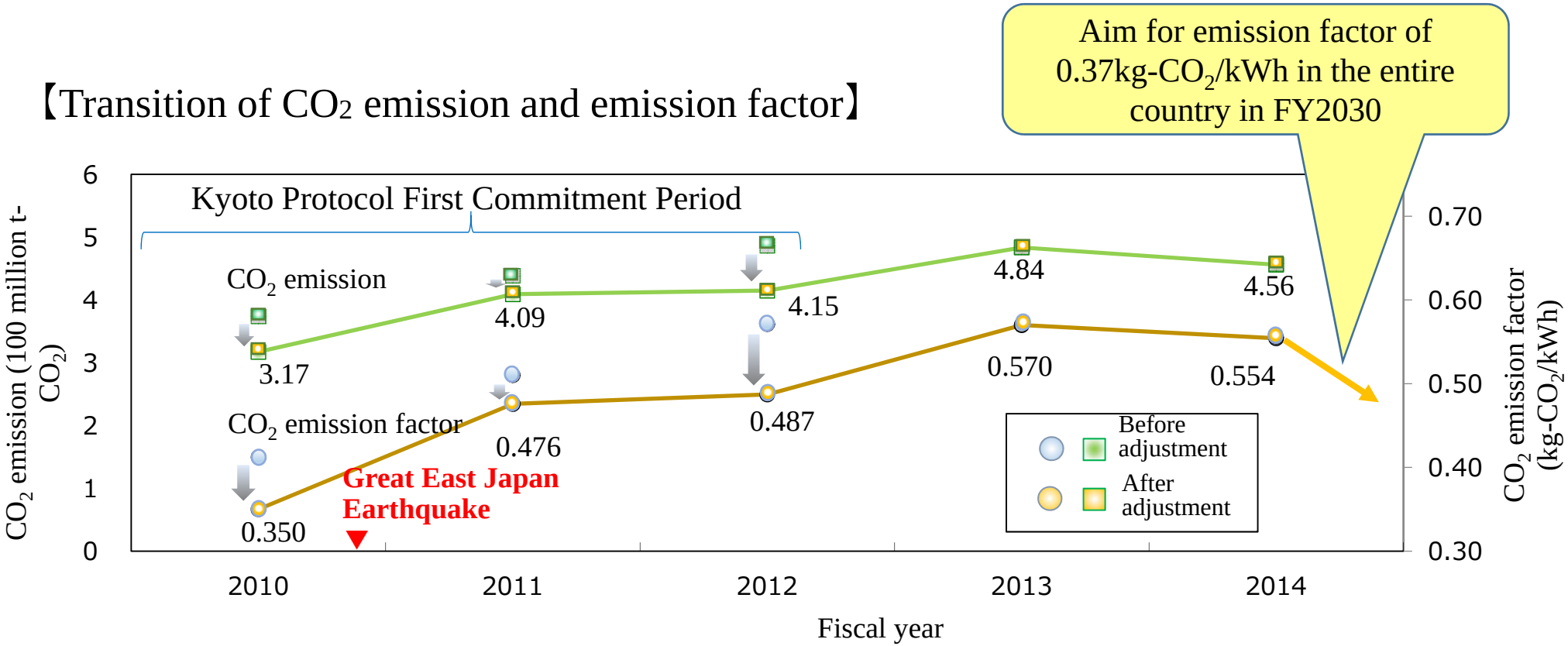
(Note) Figure for nuclear power is the average value derived with the result of BWR (0.019kg-CO_2/kWh) and PWR (0.021kg-CO_2/kWh) calculated including spent fuel reprocessing, plutonium-thermal use and high-level radioactive waste treatment, based on facility capacity.

Source: Central Research Institute of Electric Power Industry report

【Environmental conservation】CO_2 emission of electric utility industry

- Due to shutdown of nuclear power, consumption of fossil fuel drastically increased and CO_2 emission increased by more than 100 million tons.

【Transition of CO_2 emission and emission factor】

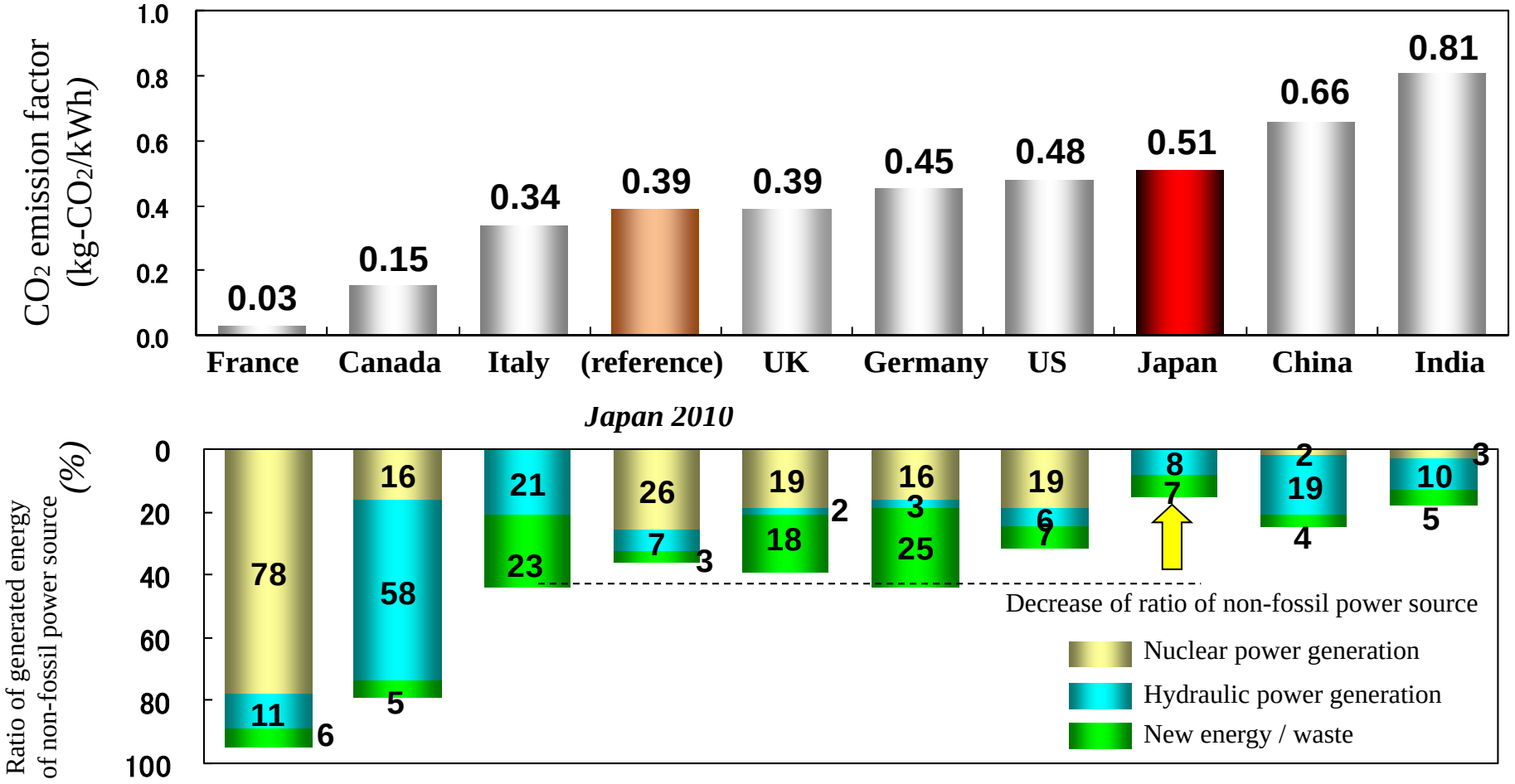


Source: Environmental Action Plan by the Japanese Electric Utility Industry 2015

* Values are adjusted due to Kyoto mechanism credit, system of purchasing surplus electricity from solar power generation and fixed price purchase system of renewable energy, based on the calculation method stipulated in “Calculation and disclosure of actual emission factor and adjusted emission factor of each electric operator”. Values during the Kyoto Protocol First Commitment Period (FY2008-2012) reflect credit of approximately 270 million t-CO_2 total in 5 years due to the method stipulated in the Act on Promotion of Global Warming Countermeasures.

【Environmental conservation】Rise of CO_2 discharge rate

- Due to decrease of ratio of non-fossil power source, CO_2 discharge rate of electricity in Japan is largely behind other countries.



*Value of 2014
*Source: IEA Energy Balances 2016Edition
*Home-use power generation facilities included for Japan
*Includes CHP plants (cogeneration)

【Environmental conservation】Greenhouse gas reduction target
(Draft commitment of each country in the Paris Agreement)

➢ With energy mix in mind, Japan proposed 26% reduction compared to FY2013 as a feasible FY2030 reduction target.

	Compared to 1990	Compared to 2005	Compared to 2013
Japan	▲18.0% (2030)	▲25.4% (2030)	▲26.0% (2030)
US	▲14～16% (2025)	▲26～28% (2025)	▲18～21% (2025)
EU	▲40% (2030)	▲35% (2030)	▲24% (2030)

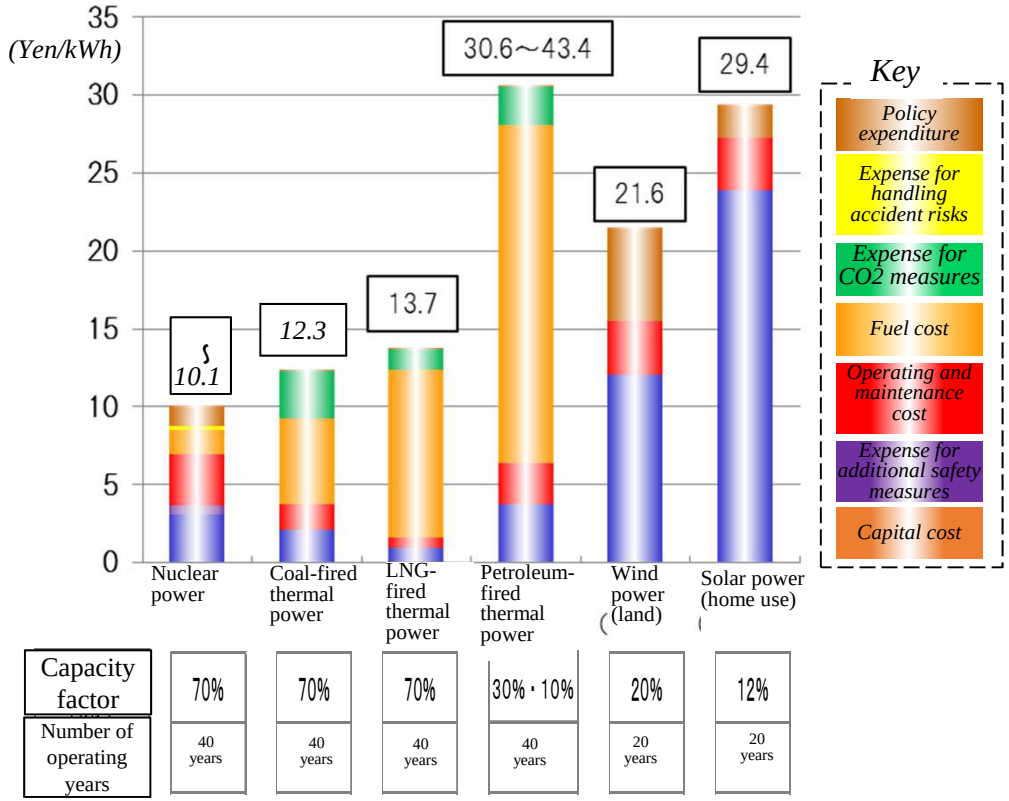
**The US submitted a figure comparing with 2005 and EU submitted a figure comparing with 1990 to the UN as the reduction target.*

【Efforts made toward reduction of CO_2】
○Use of nuclear power generation with securing of safety as the major premise
○Use of renewable energy
○High efficiency of thermal power generation facilities
○Provision of energy-saving and CO_2 reduction services which contribute to low-carbon society

【Economy】Power generation cost per 1kWh of each power source

- Power generation cost of nuclear power compares favorably with other power generation methods. Since percentage of fuel cost to power generation cost is small with nuclear power, it is unlikely to be affected by change of fuel price.
- Energy density of uranium fuel is high, and once fuel is put into the reactor, power can be generated for 1 year without replacement.

【Power generation cost per 1kWh of each power source】

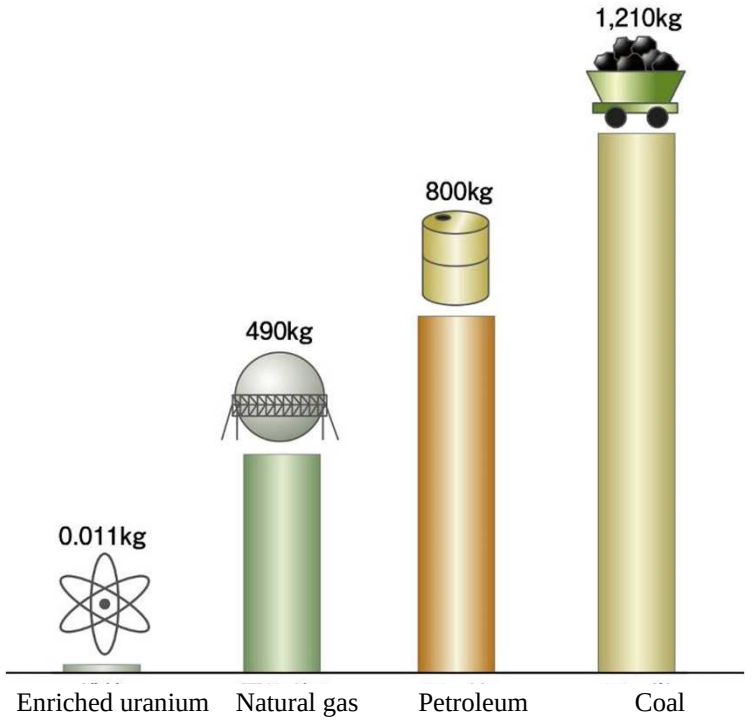


【Points on calculating cost】

・Expense for additional safety measures, expense for CO2 measures, expense for handling accident risks of nuclear power and social expense such as policy expenditure are added.

・Expense for handling accident risks is ¥0.3/kWh at least. As damage increase by ¥1 trillion, cost increased by ¥0.04. ¥10.1/kWh is the lower limit.

【Fuel necessary for generating 1 year of electricity for general households】



(Note) 1 month of electricity usage of general households is calculated as 300kWh based on data of Agency for Natural Resources and Energy "Nuclear Power 2010".

【Economy】Economic impact due to operation shutdown of nuclear power stations

➢ In Japan which is a country poor in resources, increase of cost due to increase of combustion for thermal power generation makes national wealth flow out due to increase of import of fossil fuel.

【Impact of fuel cost on all of Japan】

In FY2016 (estimated), compared to before the Great East Japan Earthquake (average of FY2008-2010)

Increase of cost of ***approx. 1.3 trillion yen per year***

In total

Increase of cost of ***15.5 trillion yen***

≒

In FY2016 (estimated), per 1 Japanese person

Increase of burden of ***approx. 10,000 yen per year***

In total

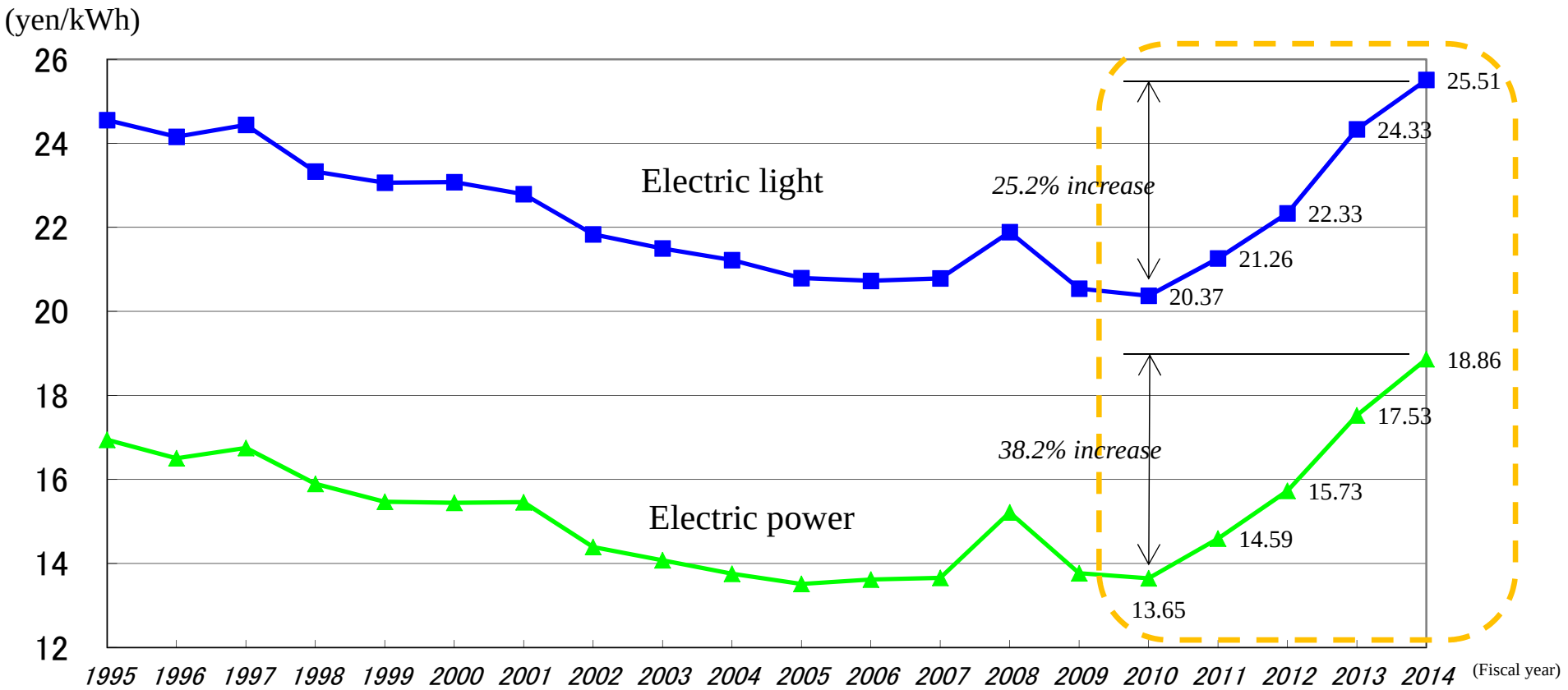
Increase of burden of ***approx. 120,000 yen per year***

9 electric power companies	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016
Total cost	¥14.6 trillion	¥16.9 trillion	¥18.1 trillion	¥19.0 trillion	¥19.3 trillion	¥16.4 trillion	¥16.2 trillion
Fuel cost	¥3.6 trillion	¥5.9 trillion	¥7.0 trillion	¥7.7 trillion	¥7.2 trillion	¥4.4 trillion	¥4.2 trillion
Increase of fuel cost	–	**+¥2.3 trillion**	**+¥3.1 trillion**	**+¥3.6 trillion**	**+¥3.4 trillion**	**+¥1.8 trillion**	**+¥1.3 trillion**
Percentage of increase of fuel cost to total cost	–	13.6%	17.1%	18.9%	17.6%	10.9%	8.0%

(Source): Electricity Supply-Demand Verification Subcommittee report (October 2016)

【Economy】Rise of electricity rate due to change of composition of power source

- Due to increase of dependency on fossil fuel and transition to yen depreciation, average unit price of general households (electric light charge) increased by approximately 25% and average unit price of industrial use such as factories and offices (electric power charge) increased by approximately 40%, compared to before the Great East Japan Earthquake.



(Note) Electric light charge is average unit price of electricity rate of mainly general households, and electric power charge includes demand for electricity deregulation at each time point and is average unit price of electricity rate of mainly factories and offices. Average unit price is derived by respectively dividing income of electric light charge and income of electric power charge by sold amount of power of electric lamp and electric power (kWh).

(Source) Created based on the Federation of Electric Power Companies of Japan "Record of electricity demand" and "Electric power industry handbook"

Indirect impact of long-term shutdown of nuclear power stations after the Great East Japan Earthquake

- Distrust of local supporters, stagnation of activities for gaining understanding

- Depletion of human resources
  Human resources, especially young people, are continuing to distance themselves from nuclear power at nuclear operators, manufacturers and contractors, as students interested in nuclear power decrease if they do not see future vision of nuclear power.
  Lack of operation and maintenance experience due to long-term shutdown.

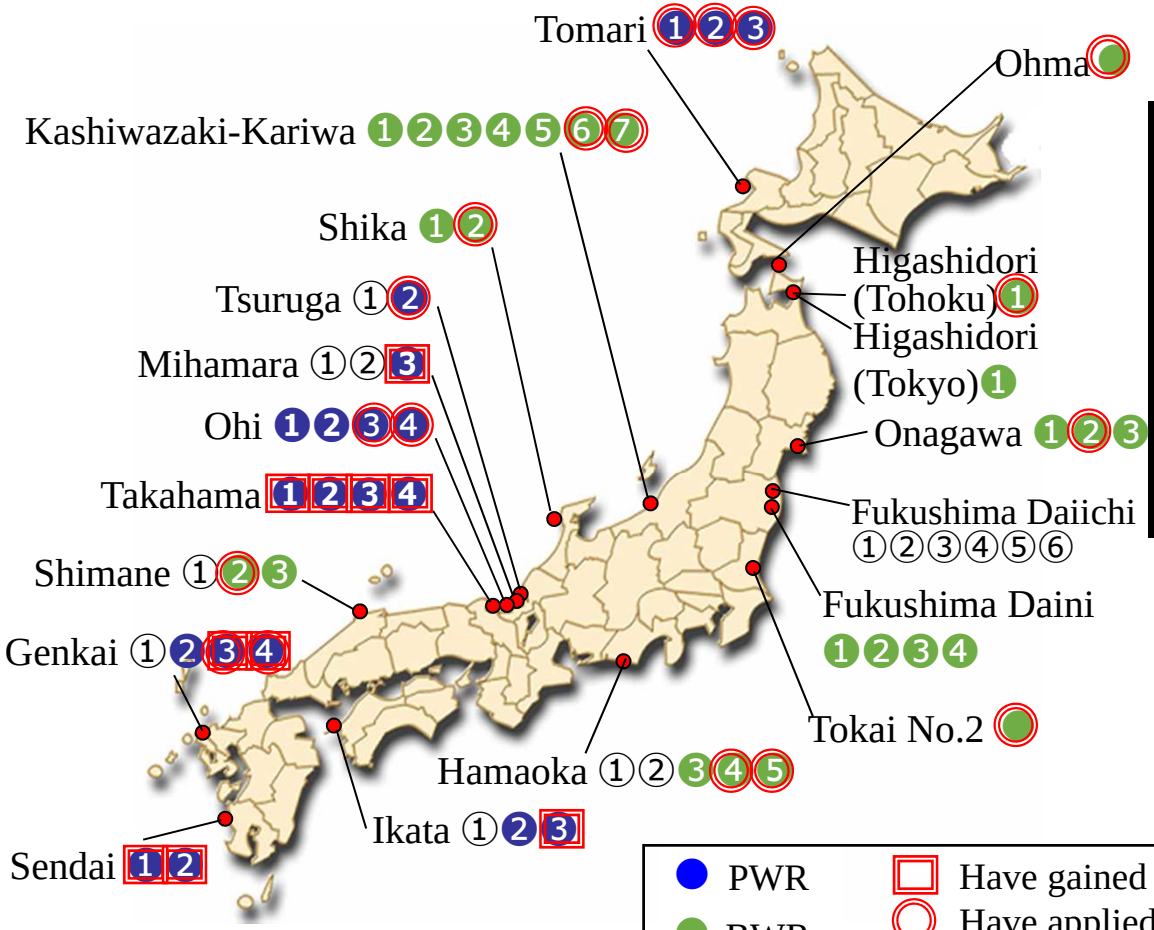
- Decreasing business for manufacturers involved in nuclear power (e.g. nuclear fuel manufacture)
  Due to decrease of construction work volume and fuel processing volume due to long-term shutdown of nuclear power stations, construction companies and fuel fabrication manufacturers are experiencing a difficult management situation.

- Low position of Japan in the nuclear industry in the world
  Countries that had domestic nuclear plant manufacturers currently maintain a certain scale of nuclear power generation

2. Towards restart of nuclear power stations

Status of review towards restart ①

- 26 units (PWR: 16 units, BWR: 10 units) have applied for review of conformity to New Regulatory Requirements
- 10 units (PWR) of the 26 units have acquired permission and approval

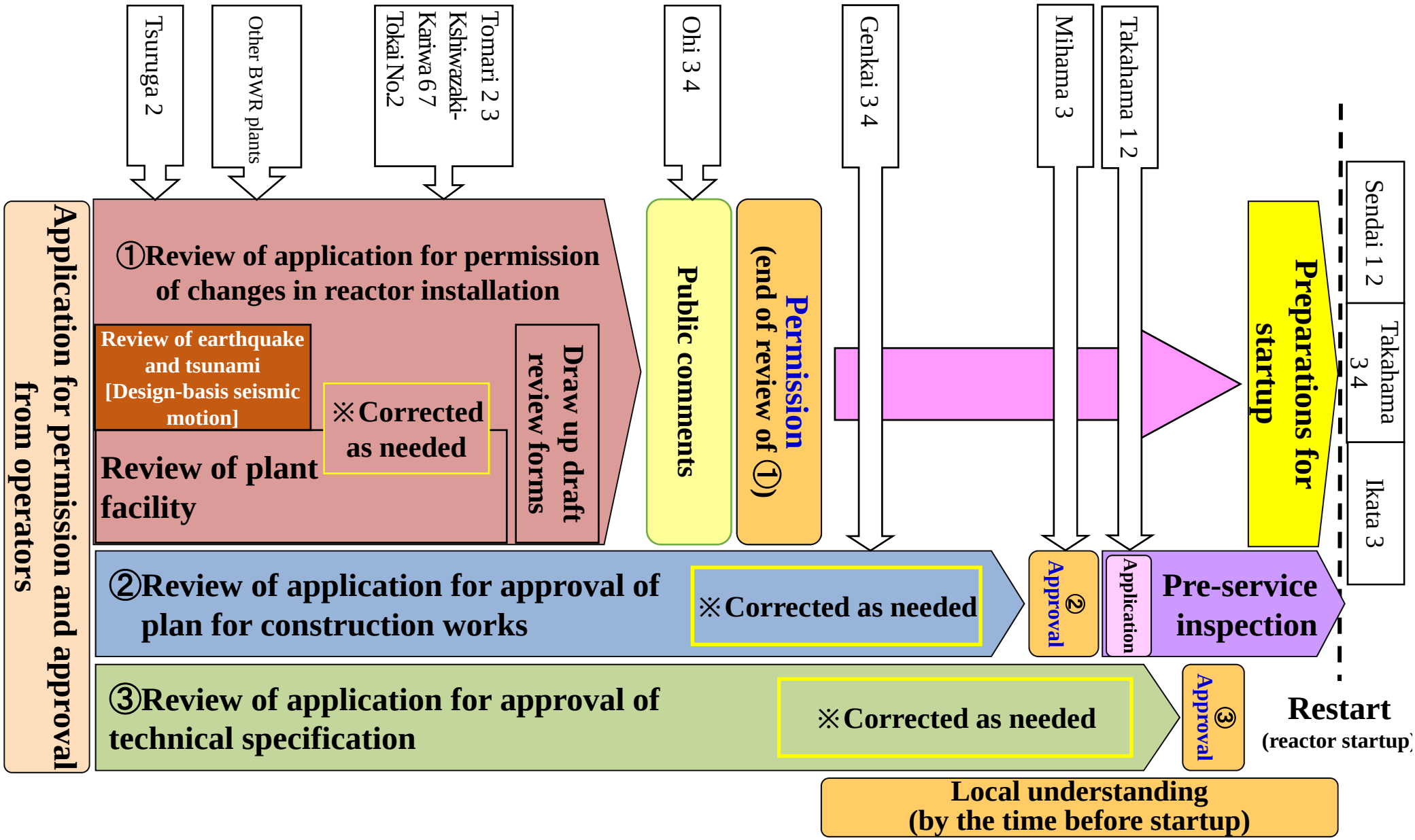


Status of permission and approval concerning New Regulatory Requirements	PWR(●)	BWR(●)	Total
Have gained permission(□)	10 units	0 units	10 units
Have applied for review(◎)	6 units	10 units	16 units
Have not applied for review	4 units	15 units	19 units
Total	20 units	25 units	45 units

Plants under construction (3 units) are included in the above

Status of decommissioning	PWR	BWR	Total
To be decommissioned (○)	4 units	10 units	14 units

Status of review towards restart②



Status of review concerning approval of extension of operation period (operation exceeding 40 years)

- KEPCO Takahama Units 1 and 2 and Mihama Unit 3 have gained approval of extension of operation period
- Succeeding plants shall be appropriately handled.

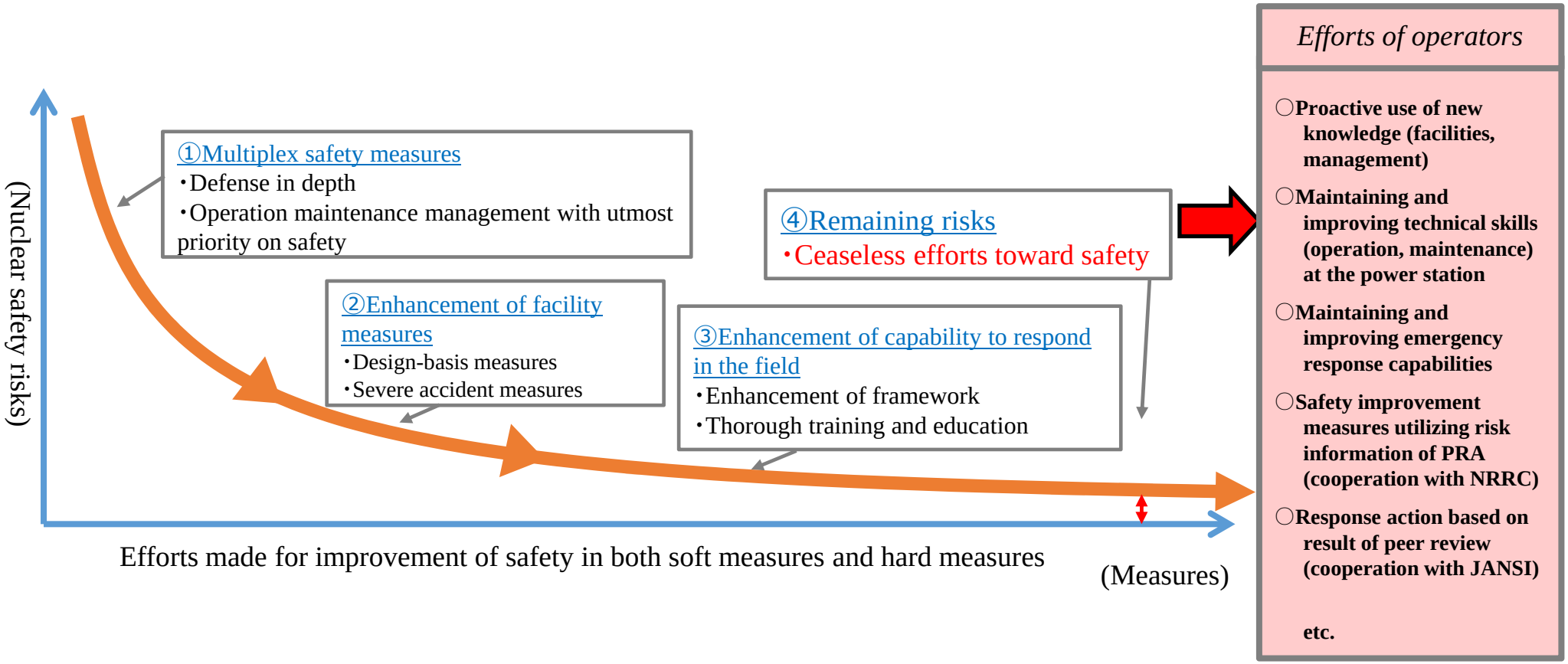
○Plants that gained approval of extension of operation period

Plants	Date of application for review of conformity to New Regulatory Requirements	Date of application for approval of extension of operation period	Permission for changes in reactor installation	Approval of plan for construction works	Approval of extension of operation period	Deadline
Takahama Unit 1	2015/3/17	2015/4/30	2016/4/20	2016/6/10	2016/6/20	2016/7/7
Tkahama Unit 2	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above
Mihama Unit 3	Same as above	2015/11/26	2016/10/5	2016/10/26	201611/16	2016/11/30

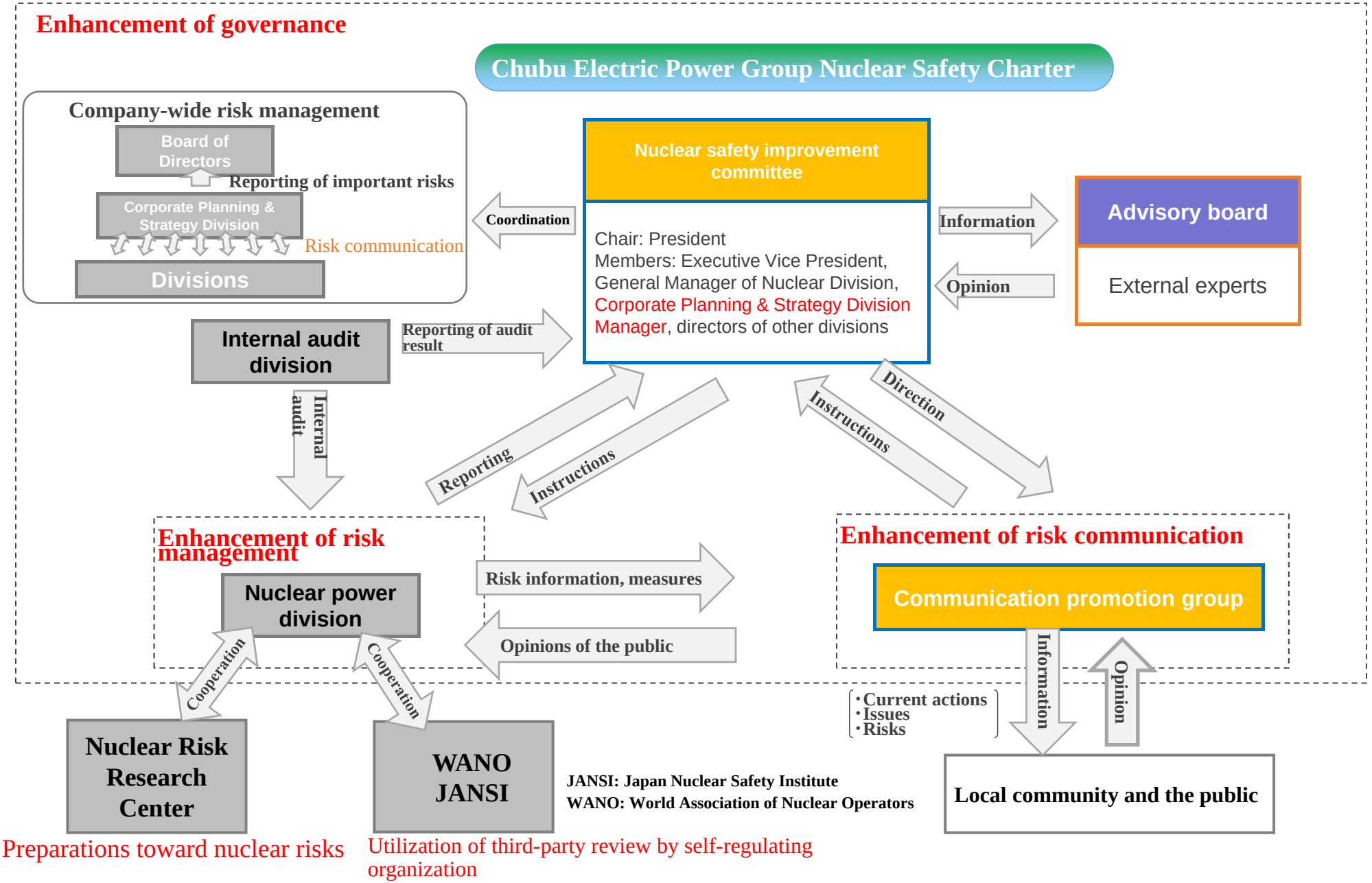
3. Efforts made for improvement of safety

Efforts made for improvement of safety toward reduction of risks

- Implement safety improvement measures and disaster prevention measures, and minimize risks concerning nuclear power generation
- Ceaseless efforts for constantly reducing risks are necessary and are the mission of operators.



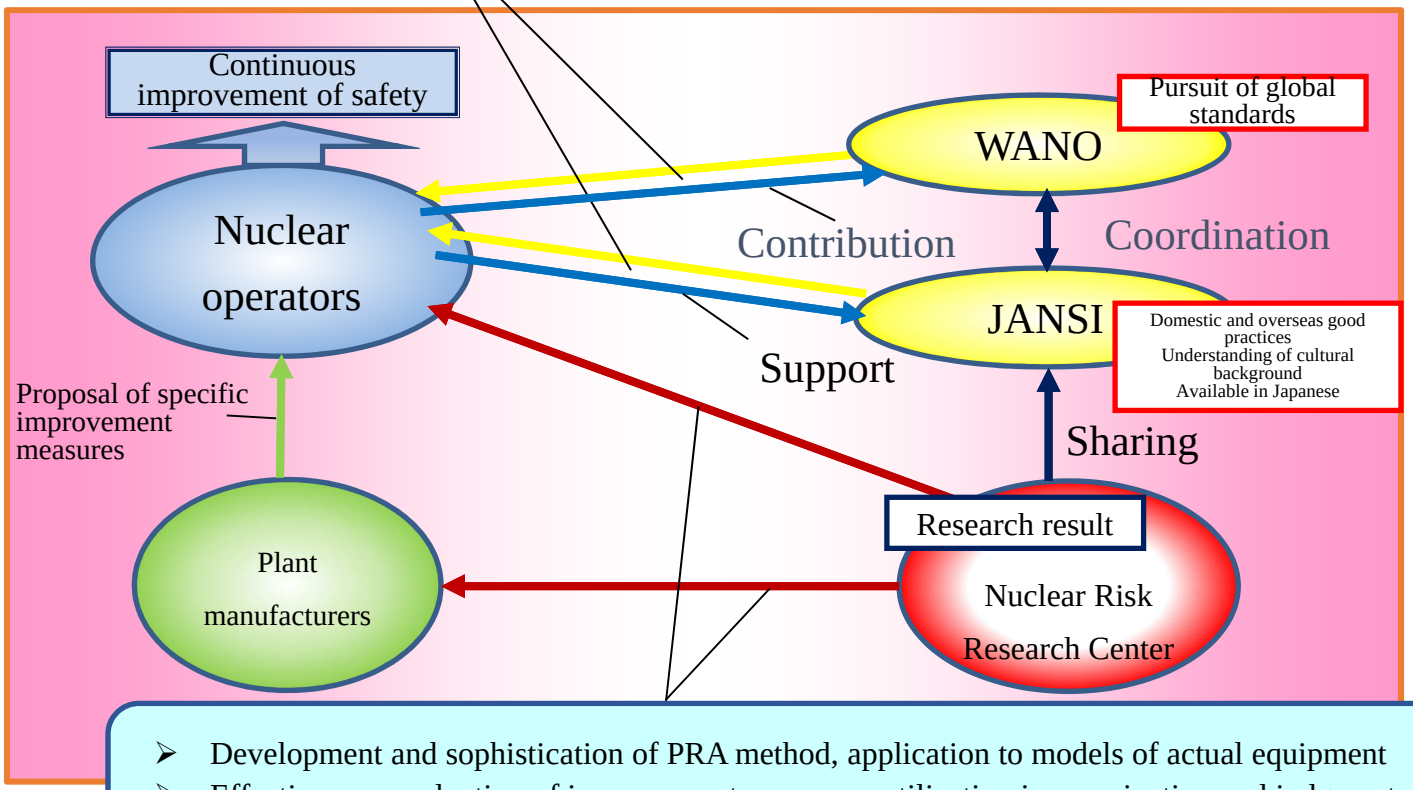
Enhancement of governance of nuclear risks by top management (efforts of Chubu Electric Power)



Coordination with self-regulating organizations

- Self-regulating organizations lead world's top-level safety activities by going to power stations with other operators as a third party and extracting strengths and weak points of the power station through on-site observation and interviews of station workers.

Coordination with self-regulating organizations (WANO, JANSI)



- Development and sophistication of PRA method, application to models of actual equipment
- Effectiveness evaluation of improvement measures, utilization in examination and judgment of safety measures
- Utilization in ROP

Enhancement of “places of communication” - Overview of communication activities

➢ In addition to “dialogue through visits” and “station caravan” which respond to concerns, questions and interest concerning nuclear power, “opinion-exchange meetings” are held with local governments and women’s organizations for local residents living near the nuclear power station.

Opinion-exchange meetings

In order to continuously hold opinion-exchange meetings for various groups of people, opinion-exchange meetings are planned and held with local governments and women’s organizations near the power station and Chubu Electric Power also participates in opinion-exchange meetings organized by governmental administration.

- ***Participation and holding of opinion-exchange meetings***

Omaezaki City・・・Organized by the city. Held 2 times in the past, 1 meeting being planned for H2.
Held with the residents’ association. Held in 1 of 8 districts in the city.
Makinohara City・・・Organized by the city. Held 4 times this autumn.
Held with the residents’ association. Being planned for 10 districts in the city.
Kakegawa City・・・・・・ Held with the residents’ association. Being planned for 32 districts in the city.
Kikukawa City・・・・・ Held with the residents’ association. Held in 7 of 11 districts in the city.

(record as of end of November)

- ***“Talk meeting” for women***

Opinion-exchange meetings are held from the approach of providing information concerning energy with programs that women have high interest in (aromatherapy, yoga). Held 7 times this fiscal year.

(record as of end of November)

Opinion-exchange meeting (Omaezaki City)

Talk meeting

Dialogue through visits

People living in Omaezaki City and 3 neighboring cities are visited for face-to-face dialogue.

Households to be visited: Approx. 82,000 households (1 round in approx. 1 year. Current in second round.)

Station caravan

Booths are set at shopping centers and customer facilities in Omaezaki City and 3 neighboring cities for face-to-face dialogue.

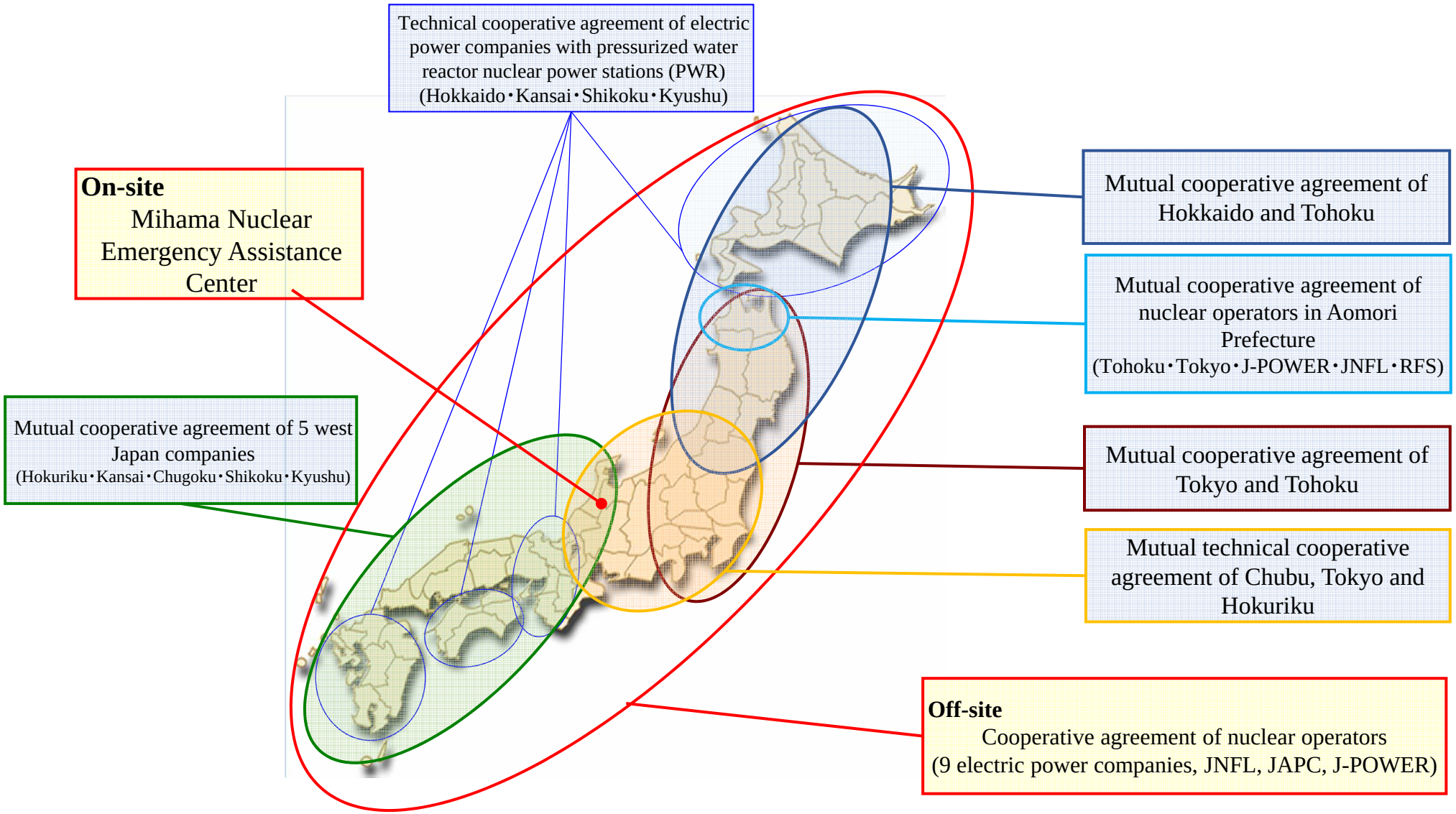
Record of FY2016 (as of end of November): Held for 15 days at 14 locations

Station tour

The power stations’ efforts for improvement of safety are directly observed. Emphasis is also put on communication such as setting a place for communication with workers actually working at the power station.

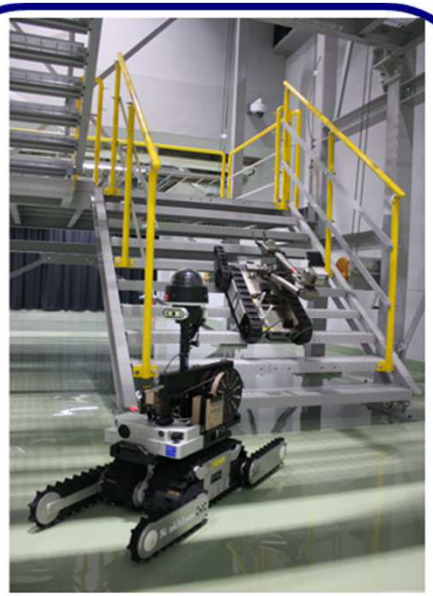
Number of visitors: Approx. 32,000 people per year (average from FY2012 to FY2015)

Conclusion of cooperative agreement with other operators



Mihama Nuclear Emergency Assistance Center (commencement of operation on December 17, 2016)

Heliport(air transportation of equipment and materials)



Robot training (image)

Full view of Mihama Nuclear Emergency Assistance Center (Mihama Town, Fukui Prefecture)

Owned equipment and materials

Wireless helicopter
(collection of information from high area)

Small and large wireless heavy machine
(removal of debris indoors and outdoors)

Robot-controlled vehicle

Further enhancement of nuclear disaster measures (efforts of operators (example))

- When a nuclear disaster occurs, since residents living in the PAZ area (within 5km radius from the nuclear power station of the disaster) are evacuated first, provide necessary transportation (bus, vehicle for disabled persons, helicopter, ferry) for evacuation of people who need support, as much as possible.
- After completing evacuation of residents in PAZ, provide transportation provided for evacuation of PAZ to evacuation of residents living in the UPZ area (within 5-30km radius from the nuclear power station of the disaster).

【Bus】

・Provide 10 buses of the worker pickup buses of the nuclear power station.

・Dispatch drivers from the operator.

【Vehicle for disabled persons】

・Provide a total of 25 vehicles for disabled persons (wheelchair type, stretcher type).
(Lease 21 vehicles to the local government. Provide 4 vehicles to head office of the operator.)

・Provide drivers and assistants from the operator.

【Helicopter / ferry】

・When evacuation route on land is blocked,
provide one helicopter and ferry each.

4. Promotion of nuclear fuel cycle

Benefits and efforts of nuclear fuel cycle

<Benefits>

○Enhance energy security

Enhance energy security by effectively using resources

○Reduce high-level radioactive waste

Contribute to reduction of waste volume and lowering of hazard level, through reprocessing

○Do not own excess plutonium

Use generated plutonium as fuel

<Efforts>

○Construction of JNFL cycle facility

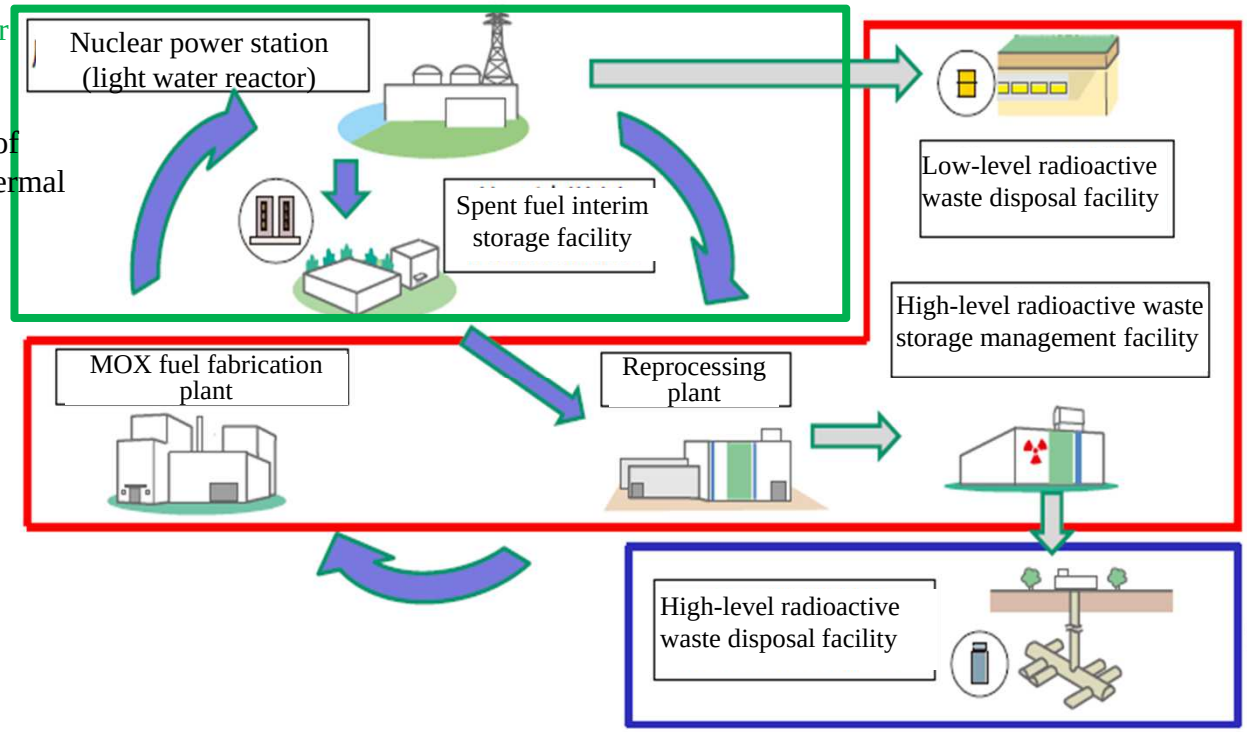
Establishment of Japan Nuclear Fuel Limited through joint investment

○Promotion of disposal of high-level waste

Establishment of NUMO, promoted by electric power companies

○Promotion of plutonium-thermal

Introduction of plutonium-thermal at the power station



Construction and operation of nuclear fuel cycle facility

- For 30 years, construction of nuclear fuel cycle facilities has been promoted with understanding and cooperation of the people of Rokkasho Village and Aomori Prefecture.
- It will continue to be steadily promoted with understanding and cooperation of the local people.

Uranium enrichment plant

1988: Start of construction
1992: Start of operation

Present
Operating in scale of 75tSWU/year

Low-level radioactive waste disposal center

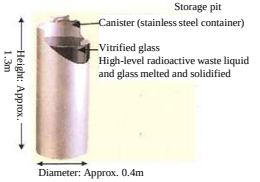
1990: Start of construction
1992: Start of operation

Present
No. 1 Disposal Facility : 149,000 drums
No.2 Disposal Facility : 147,000 drums
(end of February 2017)

High-level radioactive waste storage management center

1992: Start of construction
1995: Start of operation

Present
Accepted number of canisters: 1830 canisters
(end of February 2017)



Spent fuel receiving and storage facility

1988: Start of construction
1992: Start of operation

Present
Received amount in total : 3,393tU
Curate storage amount : 2,968tU
(end of January 2017)

Reprocessing plant

1993: Start of construction
2018: Scheduled for completion

Maximum processing capacity 800tU/year

MOX fuel fabrication plant

2010: Start of construction
2019: Scheduled for completion

Maximum processing capacity 130t-HM/year

Status of Rokkasho Reprocessing Plant

● Overview of Rokkasho Reprocessing Plant

- From March 2006, tests using actual spent fuel (active test) began.
- **Test of main process** that extracts plutonium and uranium from spent fuel **was smoothly completed**.
- It took time for the test of the facility that vitrifies high-level waste liquid, but **all tests conducted by operators were completed in May 2013**.
- Application for checking conformity to New Regulatory Requirements was submitted to the Nuclear Regulation Authority in January 2014, and it is being reviewed.
- Construction work for conformity to New Regulatory Requirements is being advanced aiming for completion in the first half of 2018.

＜Performance＞

- General progress rate of construction work　99.7%
- **425tU of spent fuel** has been reprocessed (BWR fuel 219t, PWR fuel 206t)
- Recovered products
  - Uranium product powder　364 tU
  - MOX product powder　6.7 tHM※
  - **Vitrified glass　346 canisters**

※　Heavy metal. Metal weight of uranium and plutonium

Efforts of promotion of high-level radioactive waste disposal business

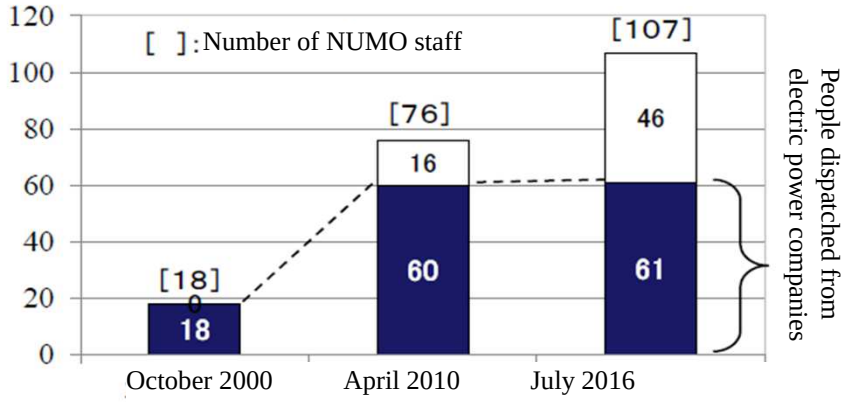
定訳不明です。
「最終処分連絡協議会」

○Development of framework: "Final disposal liaison committee" (members: president of each electric power company) is established within FEPC

○Establishment and support of NUMO

- In October 2000, NUMO was established, promoted by the 9 electric power companies and JAPC.
- Since the establishment of NUMO, support of human resources is provided from electric power companies

Transition of number of NUMO staff and number of people dispatched from electric power companies



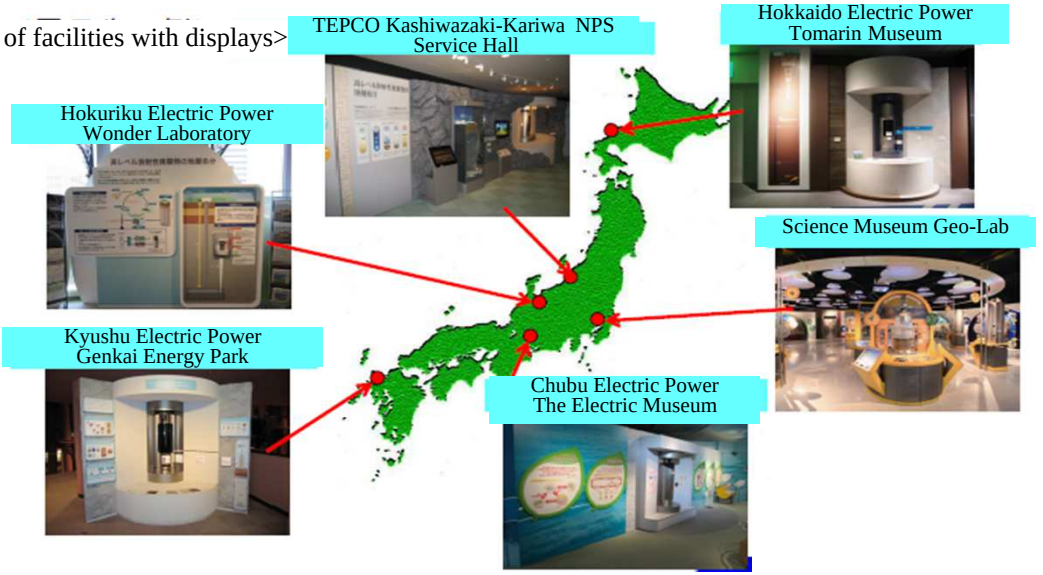
➢ Activities for gaining understanding: Support to the national government and NUMO symposiums, communication activities, and activities for gaining understanding using PR tools and displays at PR facilities are in place

○Creation of pamphlet

"Nuclear Consensus"

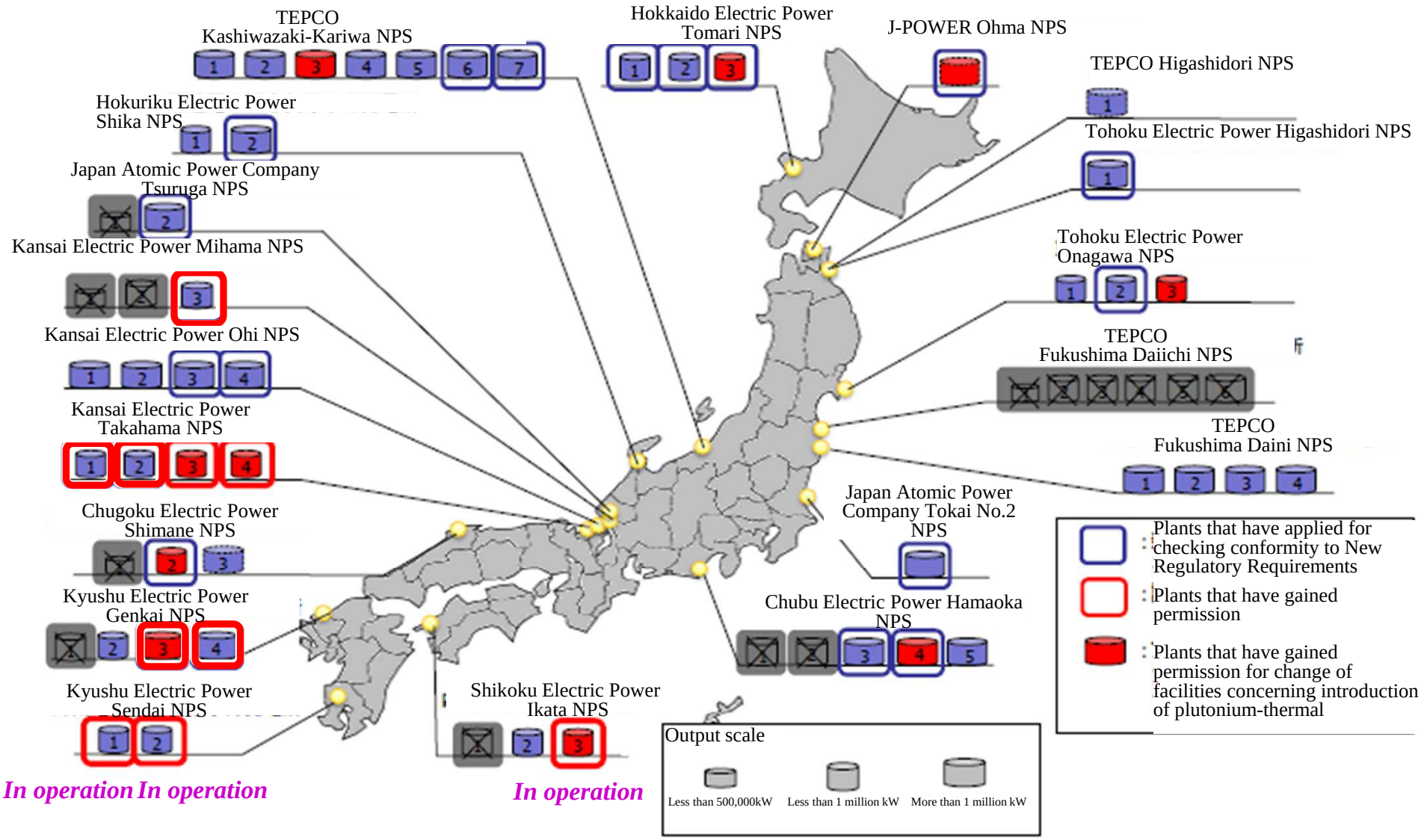
"Radioactive Waste Q&A"

<Example of facilities with displays>



Status of plutonium-thermal plan of each company

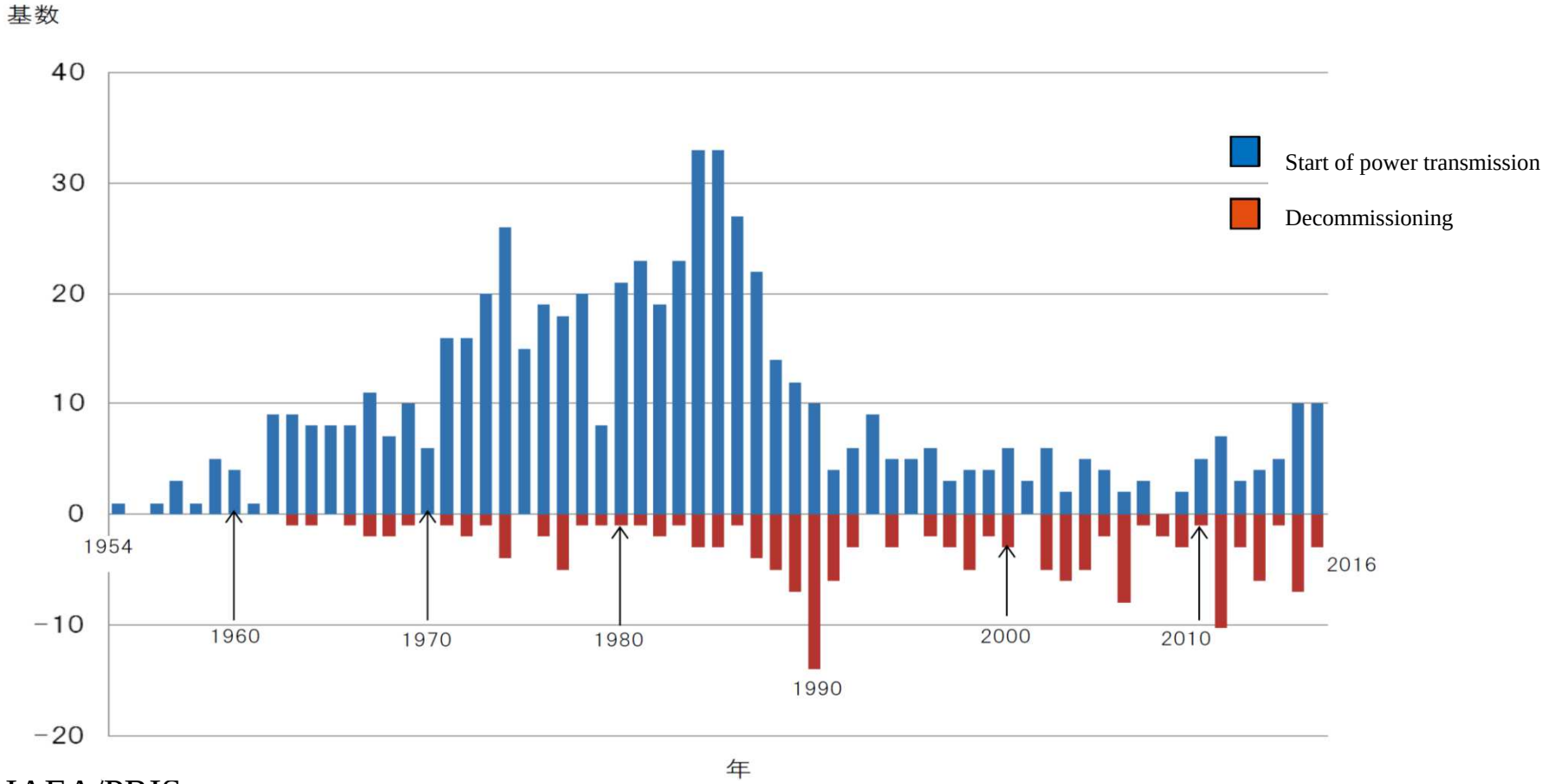
➢ Under the principle of "not owning plutonium with no usage purpose", electric operators aim for introduction of plutonium-thermal at 16-18 reactors for sure use of plutonium.



5. Global trend of nuclear power stations

Transition of start of power transmission and decommissioning of commercial reactors in the world

- Nuclear power generation increased in the world from the 1970s and reached its peak in the 1980s. It has been around the same level since the 1990s.
- Decommissioning of the first nuclear power stations began in the 1990s.
- Decommissioning of power stations that were constructed in the 1970s will increase.



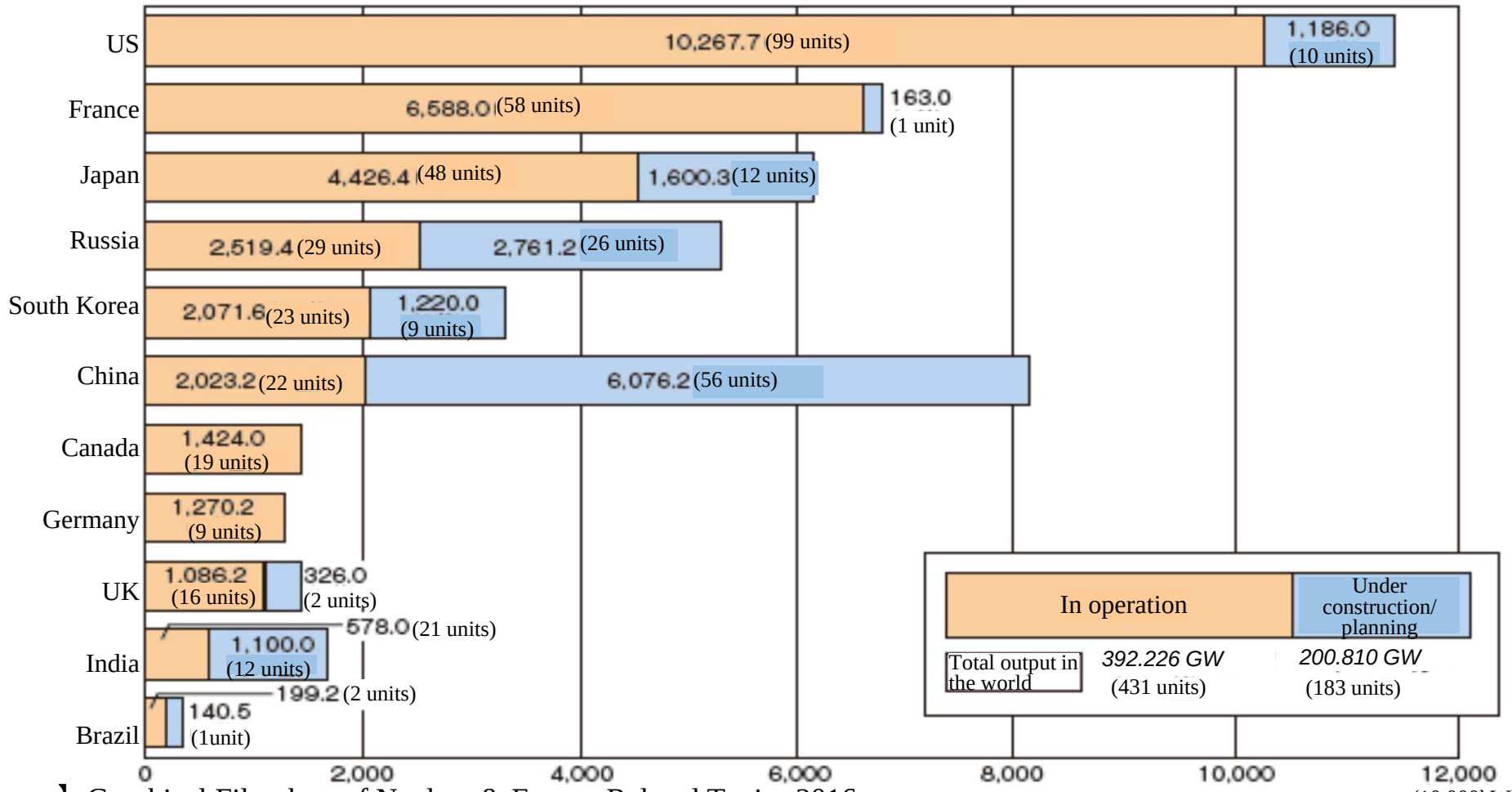
【Source】IAEA/PRIS

Nuclear power development in the world

- There are plans to increase nuclear power stations in China, Russia, India, South Korea and the US. Plan for new construction is especially large in China.
- In Japan, 12 units are under construction/planning※

※Under construction: Ohma, TEPCO Higashidori 1, Shimane 3
Under preparation: Tohoku Higashidori 2, TEPCO Higashidori 2, Namie-Odaka, Hamaoka 6, Tsuruga 3&4, Kaminoseki 1&2, Sendai 3

(as of January 1, 2015)



【Source】Graphical Filp-chart of Nuclear & Energy Related Topics 2016

6. Future outlook

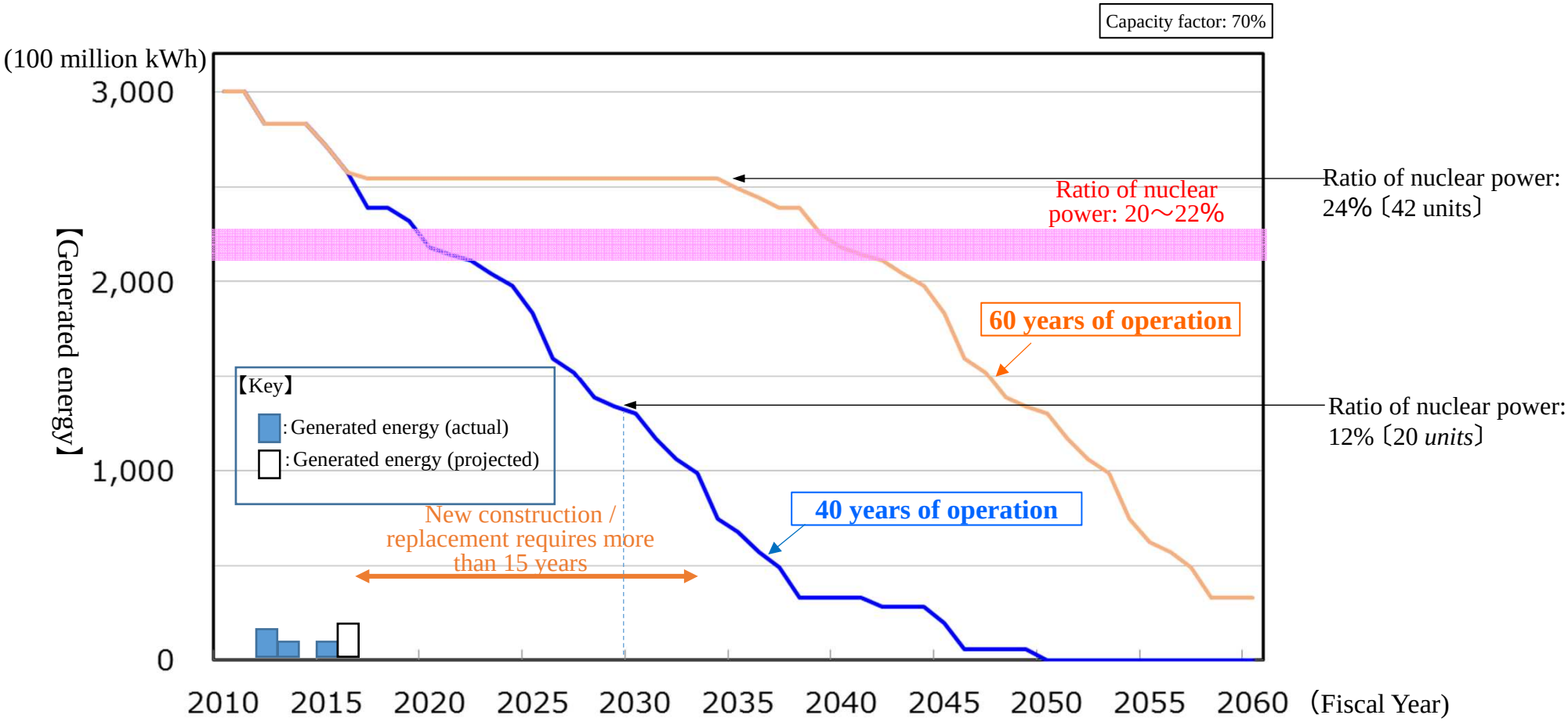
Value of nuclear power generation

- After the Great East Japan Earthquake, shutdown of nuclear power is prolonged, and approximately 90% of generated energy depend on thermal power due to increase of thermal power generation.
  - Concern in energy security ⇒ Extreme embrittlement of energy security of Japan
  - Regarding environmental problems, measures for achieving greenhouse gas reduction target (Paris Agreement) are necessary
  - Regarding economy, electricity rate rises due to increase of dependency on fossil fuel and transition to yen depreciation

○ In Japan which is a country poor in resources, it is necessary to combine various energy sources from the perspective of “S+3E”.

○ **Nuclear power** which shows excellent qualities for all of 3E is an important power source that cannot be left out from energy mix.

Outlook of power generated by nuclear power



Faced issues

(1) Restart (2) Improvement of availability (3) Operation exceeding 40 years
(4) New construction / replacement

Regarding operation exceeding 40 years

From the perspective of effective use of existing power stations, power stations that have been determined to continue operation will be operated for more than 40 years. In regard to issues of review of operation exceeding 40 years, technical issues will continue to be discussed with the regulatory authority.

(Timing of submitting application)

- Timing of submitting application is limited to “within 1 year and 3 months to 1 year before expiration of the operation period”. Since there is not much time until the limit of 40 years of operation, if the application period is revised to within 5 years before expiration, for example, construction for countermeasures can be systematically planned before expiration of the operation period, which contributes to safe and sure implementation of countermeasures.

(Definition of operation period)

- In order to appropriately conduct backfit, it is necessary to take procedures for permission and approval and conduct construction work for countermeasures. Plants are shut down for an appropriate period, but since it is considered that there are no technical problems concerning degradation of facilities important for safety during the shutdown period, shutdown period concerning review and construction work for appropriately conducting backfit is excluded from the operation period.

Toward long-term use of nuclear power

- In order to continue using nuclear power generation as an important power source, untiring improvement of safety is the major premise.

- In addition, first, efforts will made for restart and operation exceeding 40 years of existing power stations, nuclear power generation will be maintained in a certain scale, and human resources, technical capabilities and supply chain will be secured.

- Furthermore, since it is necessary to start efforts for new construction and replacement from the bottom in the future, systems with improved safety, economy and social acceptability should be developed by the industry as a whole by reflecting new technical knowledge in existing reactor design and researching and developing 4th generation nuclear system*.

*Characteristics aimed by 4th generation nuclear power system

- Sustainability (efficient use of fuel, minimization and management of waste)
- Safety/reliability (safe and reliable operation, frequency of core damage is extremely low and scale of core damage is small, emergency response outside the site is unnecessary)
- Economy (lifecycle cost superior to other energy sources)
- Nuclear proliferation resistance and physical protection (difficult to be stolen since attraction to military use is small, resistance to terrorism is high)