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IFRI

“Quick Glance at ENERGY, CHIMATE CHANGE and INNOVATION in Japan”

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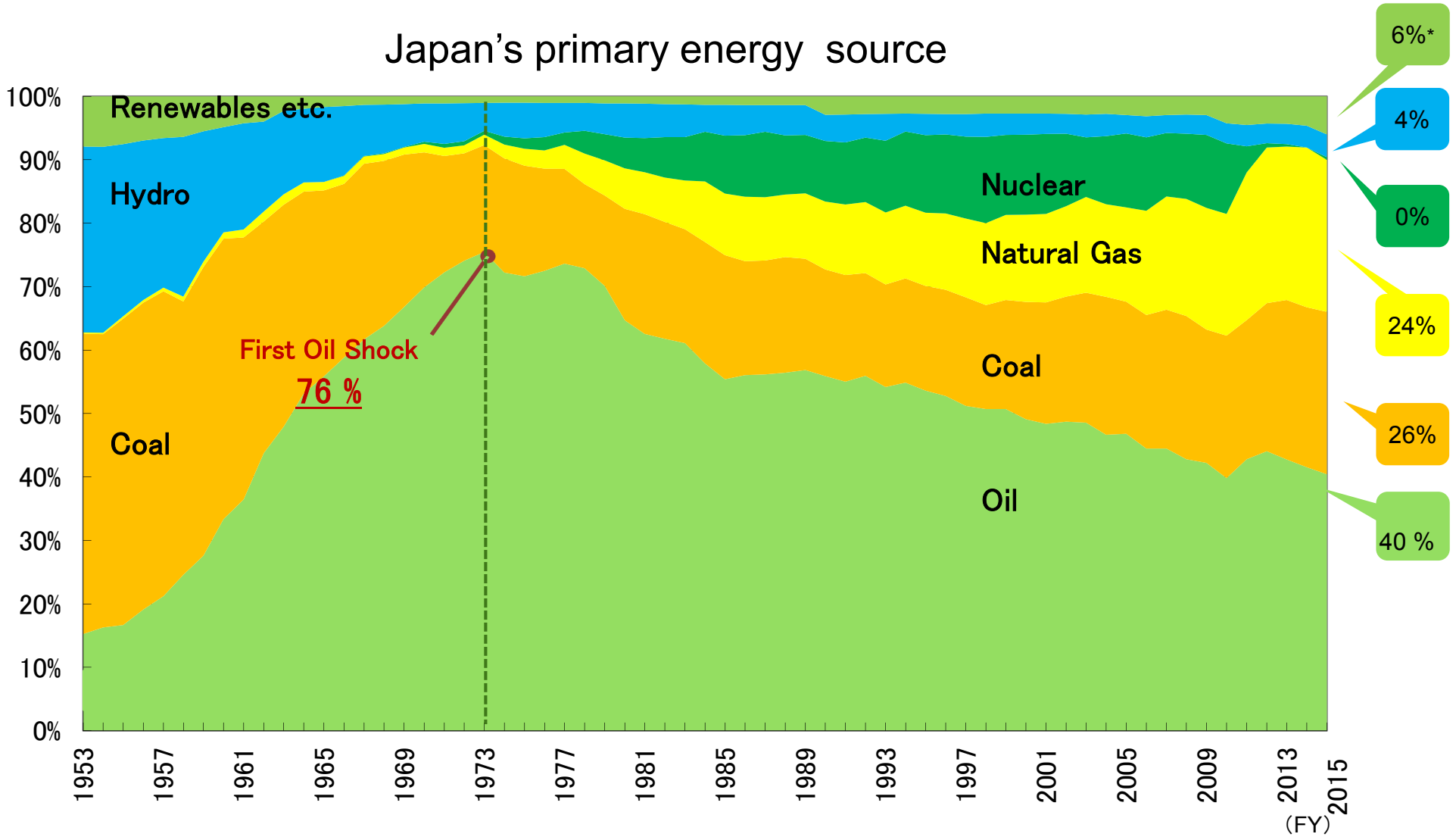
1. Current 3E Situation in Japan

Japan's energy supply structure



* "Renewables etc." consists of solar power (1.5%), wind power (0.2%), geothermal heat (0.1%), and biomass (1.9%), effective recovery use of wasted energy(2.2%).

Source: Prepared based on "Comprehensive Energy Statistics 2016" issued by the Agency for Natural Resources and Energy.

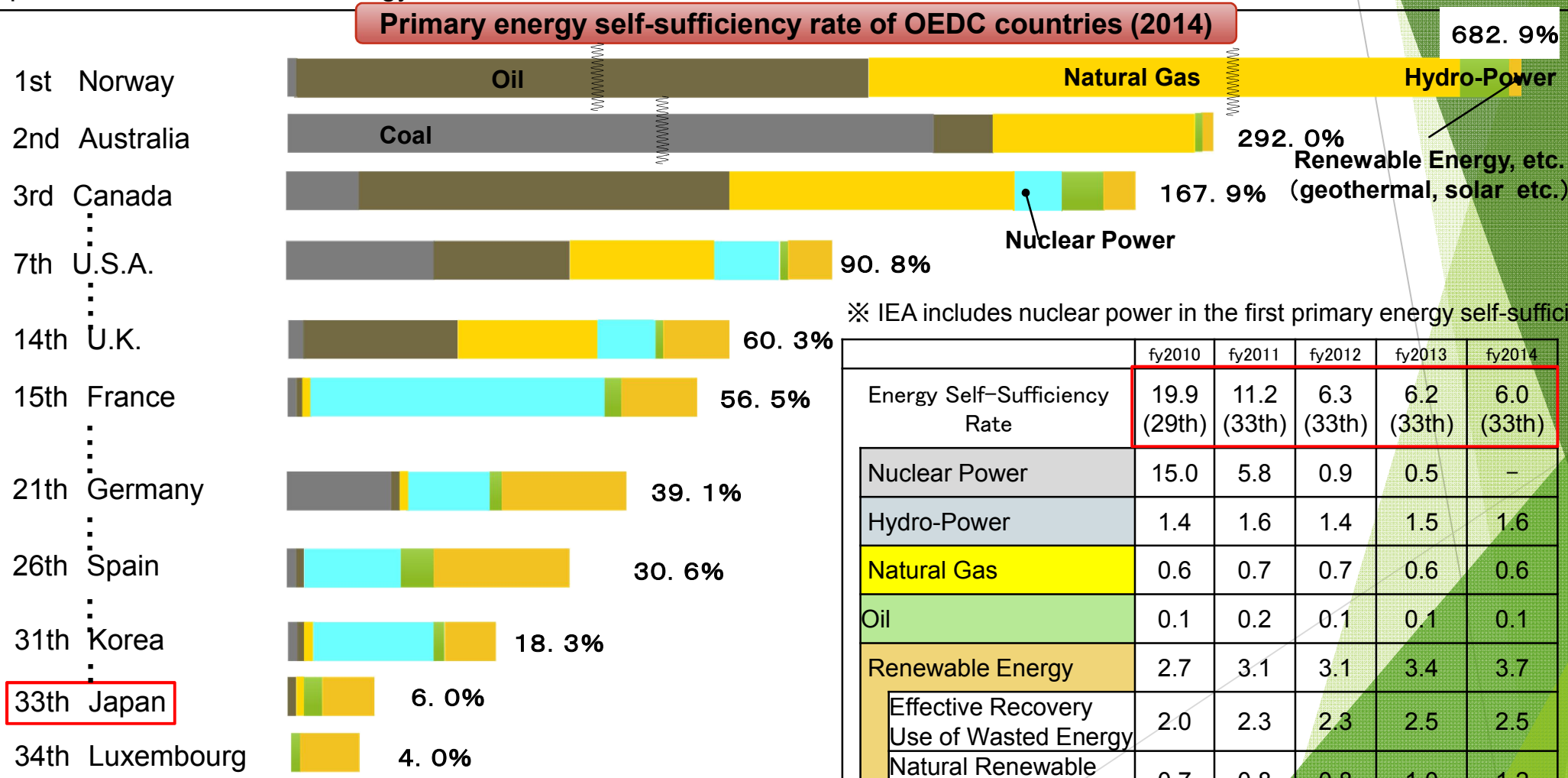
Energy security : Self-sufficiency

○Significantly lower than before the earthquake (19.9% in 2010). Second lowest in 34 OECD countries.

○Aim to improve to about 25%, higher than before the earthquake

*IEA regards nuclear power as domestic energy and includes it in primary energy self-sufficiency. The Strategic Energy Plan of Japan regards nuclear power as semi-domestic energy.

Primary energy self-sufficiency rate of OEDC countries (2014)



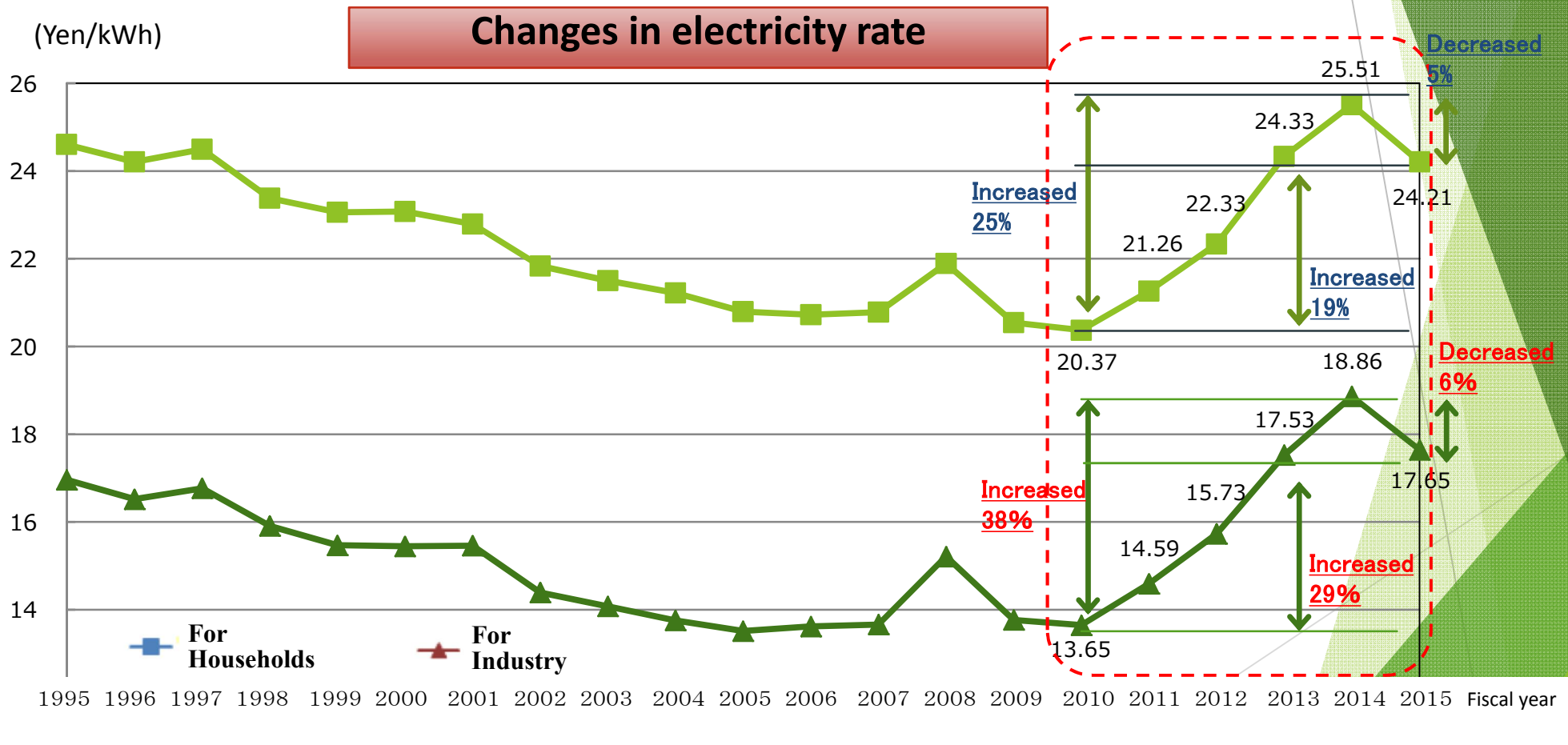
【Source】 IEA “Energy Balance of OECD Countries 2016”

※ IEA includes nuclear power in the first primary energy self-sufficiency rate.

	fy2010	fy2011	fy2012	fy2013	fy2014
Energy Self-Sufficiency Rate	19.9 (29th)	11.2 (33th)	6.3 (33th)	6.2 (33th)	6.0 (33th)
Nuclear Power	15.0	5.8	0.9	0.5	–
Hydro-Power	1.4	1.6	1.4	1.5	1.6
Natural Gas	0.6	0.7	0.7	0.6	0.6
Oil	0.1	0.2	0.1	0.1	0.1
Renewable Energy	2.7	3.1	3.1	3.4	3.7
Effective Recovery Use of Wasted Energy	2.0	2.3	2.3	2.5	2.5
Natural Renewable Energy	0.7	0.8	0.8	1.0	1.2

Economics : Electricity rate

◆Since the Great East Japan Earthquake followed by the nuclear accident, the average electricity rate rose by around 20% for households and around 30% for industry mainly because of increasing fuel costs.



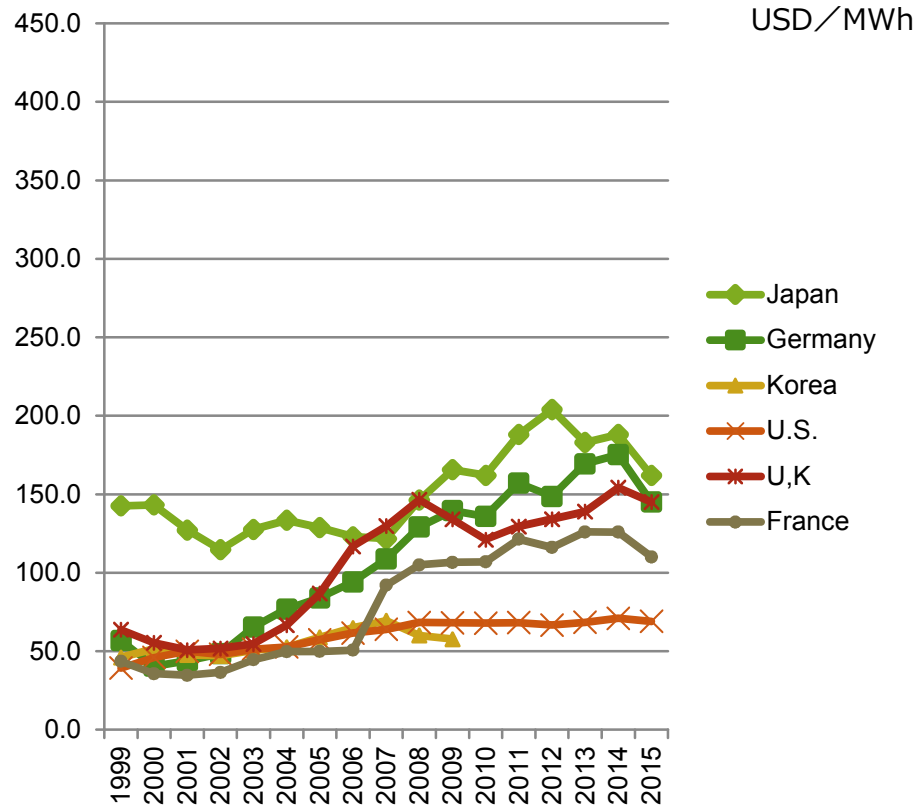
[Source] Created based on the "Electricity Demand Report" (Federation of Electric Power Companies in Japan) and the materials concerning the power companies' final settlement reports, etc.

Comparison : Electricity rate

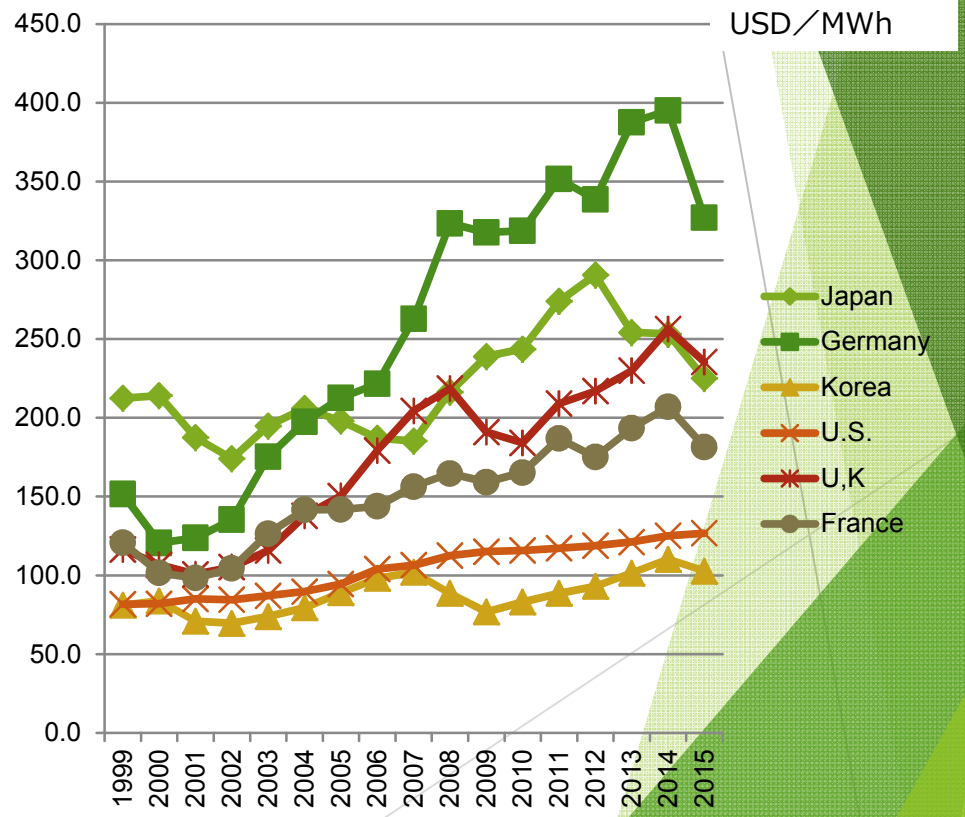
- After the Great East Japan Earthquake, the electricity rate continues to increase due to the rate revisions owing to the increased cost of fossil fuel as a result of suspended NPPs, the rising cost of fuel and renewable power energy promotion surcharge.

（※0.29JPY/kwh（2012） → 0.4JPY/kwh（2013） → 0.75JPY/kwh（2014） → 1.58JPY/kwh（2015））

Electricity rate for industry



Electricity rate for household



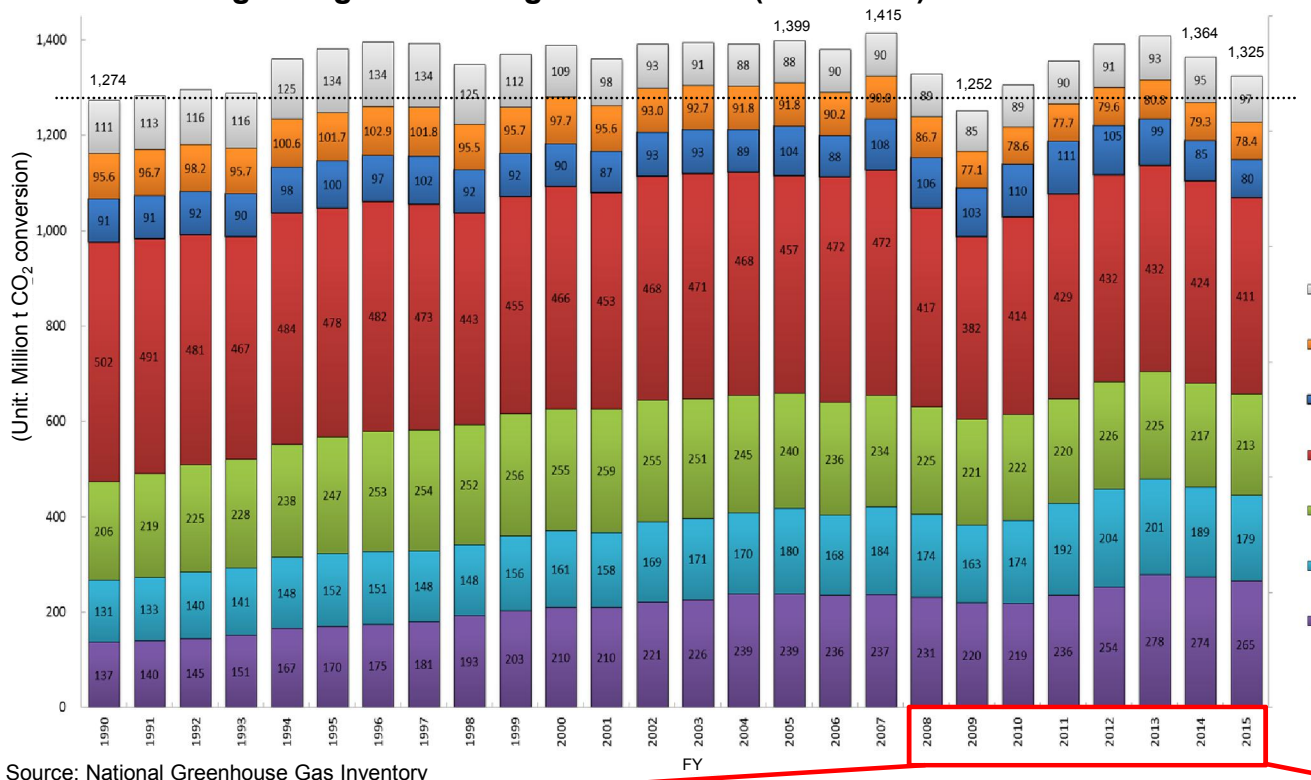
※Electricity rate for industry of Korea use the 2009 data for 2010 and 2014, and Electricity rate for industry of U.K. and Germany use the 2013 data for 2014.
Electricity rate for household of Germany use the 2013 data for 2014.

Source：IEA Energy Prices and Taxes（using the exchange rate of OECD）

Environment : Domestic greenhouse gas emissions

- The toal volume of greenhouse gas emissions from Japan in FY 2015 was 1.325 billion tonnes, which is a decrease for the second year in a row, starting with the previous year.
- A factor that caused a drop in emissions compared to the previous year was a decrease in CO_2 emissions from power (470 million t → 440 million t*) due to decreased power consumption (e.g. energy-saving devices, cold summer, warm winters) and improved emission intensity from electricity (e.g. greater adoption of renewable energy, resumed operation of nuclear power), for example, that resulted in a decrease in energy-derived CO_2 emissions. *Source: Actual CO_2 emissions, Electric Power Council for a Low Carbon Society
- However, the total volume of emissions increased compared to 1990 (after drastic improvement in energy efficiency following the oil crisis; 1990: 1.274 billion t → 2015: 1.325 billion t). Among sectors, emissions are decreasing in the industrial sector and increasing in the residential, business, and transportation sectors.

Changes in greenhouse gas emissions (1990-2015)

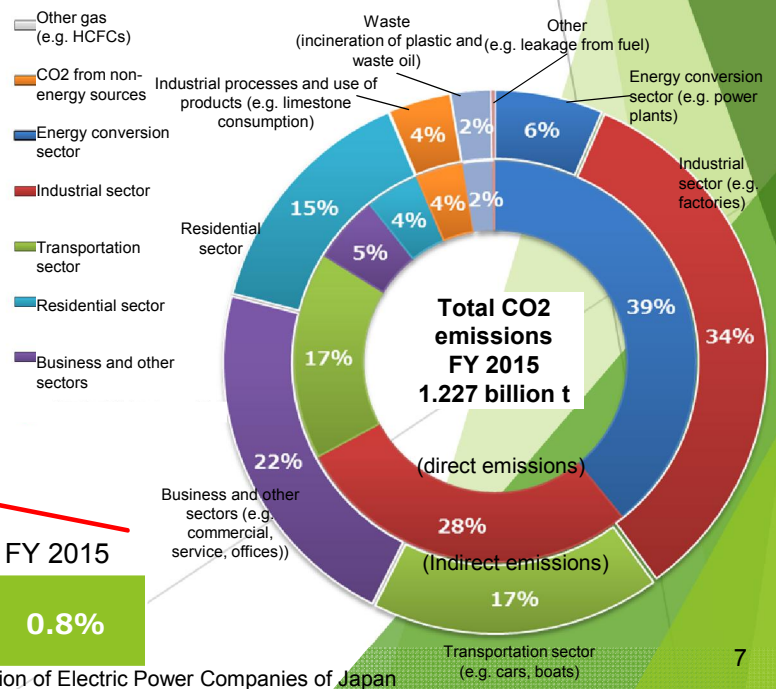


Source: National Greenhouse Gas Inventory Report of Japan

Changes in CO_2 emissions by sector

	1990	2015
Industrial	502 million t →	411 million t (-18.1%)
Transport	206 million t →	213 million t (+3.4%)
Other business	137 million t →	265 million t (+93.4%)
Residential	131 million t →	179 million t (+36.6%)

Breakdown of CO_2 emissions by sector (preliminary figures for FY 2015)



	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
Ratio of nuclear power for electric power	26.0%	29.2%	28.6%	10.7%	1.7%	1.0%	0.0%	0.8%

*Total power from ten former general electrical power suppliers Source: Electrical output composition ratio by power source, Federation of Electric Power Companies of Japan

Japan's contribution to the global warming (Cabinet decision, July 17, 2015)

(Unit: million t-CO_2)

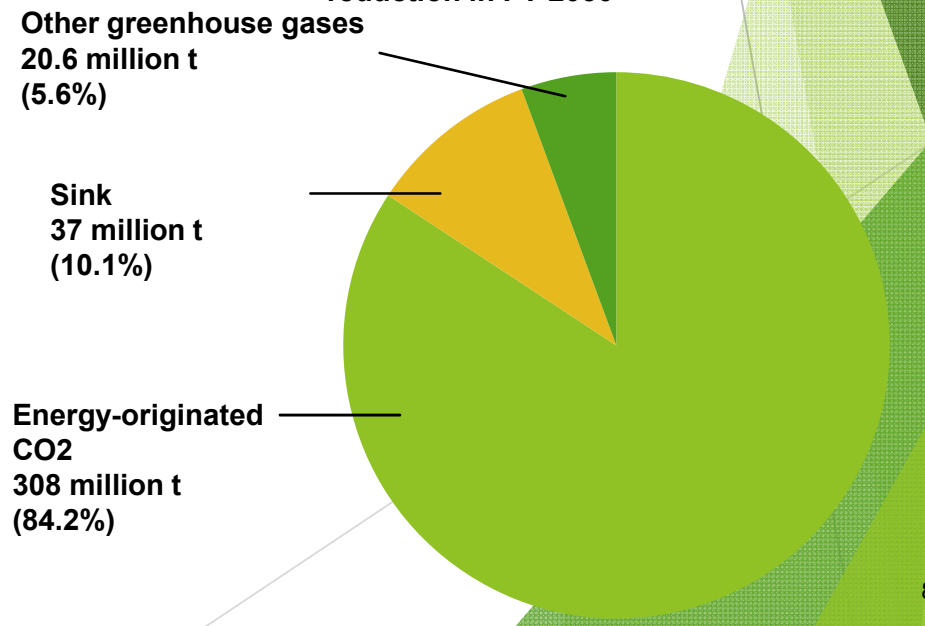
	FY 2030 greenhouse effect Gas reduction target (compared to FY 2013)	FY 2030 greenhouse effect Gas reduction volume (compared to FY 2013)	Greenhouse gas emissions	
			FY 2030	FY 2013
Greenhouse gas reduction volume	**26.0%**	**366**	**1,042**	**1,408**
Energy-originated CO_2	25.0%	308	927	1,235
Other greenhouse gases (*1)	11.9%	20.6	152.4	173.0
Sink measures (*2)	—	37	—	—

*1 CO_2 from non-energy sources, methane, dinitrogen monoxide, four HCFCs
*2 Aim to secure an absorption volume of about 37 million t-CO_2 by FY 2030 (equivalent to 2.6% reduction of the total emissions in FY 2013)

Energy-derived CO2 (breakdown by sector)

	Rough indication of emissions in each sector in FY 2030 (reduction compared to FY 2013)	FY 2013
Energy-originated CO_2	927 (25.0%)	1,235
Industrial sector	401 (6.6%)	429
Other business sectors	168 (39.7%)	279
Residential sector	122 (39.4%)	201
Transportation sector	163 (27.4%)	225
Energy conversion sector	73 (27.5%)	101

Breakdown of the 366 million ton of greenhouse gas emissions reduction in FY 2030



Reduction of greenhouse gas emissions

○ Energy-Originated CO2 will account for 21.9% in FY 2030, compared to total greenhouse gas emission reduction in FY 2013.

○ Our nationally determined contributions towards post-2020 GHG emission reduction is at the level of a reduction of 26.0% in FY 2030 compared to FY 2013 (25.4% reduction compared to FY 2005).

[Intended Nationally Determined Contributions submitted by major countries]

	Compared with 1990	Compared with 2005	Compared with 2013
Japan	-18.0% (2030)	-25.4% (2030)	-26.0% (2030)
U.S.	-14 to 16% (2025)	-26 to 28% (2025)	-18 to 21% (2025)
EU	-40% (2030)	-35% (2030)	-24% (2030)
China	-60% to -65% of carbon dioxide emissions per unit of GDP by 2030 compared to 2005 achieve the peaking of carbon dioxide emissions around 2030		
South Korea	+81% (2030)	-4% (2030)	-22% (2030)

◆ The U.S. submitted emission reduction target compared to 2005 while the EU submitted its target compared to 1990.
◆ South Korea submitted an emission reduction target of -37% in 2030 compared to the business-as-usual (BAU) scenario.

2. Long-term Energy Supply and Demand Outlook

Long-term Energy Supply and Demand Outlook

- In light of the **Strategic Energy Plan***,
- Assuming the policy goals to be achieved regarding **safety, energy security, economic efficiency, and environment (3E+S),** which are the basic perspectives for the energy policy,
- It gives a **forecast and also a vision of a desired future energy supply-demand structure to be realized** by executing the policies based on the basic direction of the energy policy.

* **Strategic Energy Plan**: For comprehensive policies on the energy demand and supply, the Minister of Economy, Trade and Industry develops this plan based on "the Basic Act on Energy Policy" (promulgated and put in force in 2002) and opinions from the directors of related agencies and Advisory Committee for Natural Resources and Energy. The plan is officially approved by the cabinet. The current plan was approved in April, 2014.

Basic principle of Long-term Energy Supply and Demand Outlook

- Through the process to simultaneously achieve specific policy targets related to **safety, energy security, economic efficiency, and environment**, which are basic viewpoints of the energy policy,
- Draw an outlook based on the basic guideline of the policies given in the Strategic Energy Plan, such as **reducing dependence on nuclear power generation as much as possible by promoting thorough energy efficiency and conservation, introduction of renewable energy, and introduction of efficient thermal power plants**
- **The current outlook was published in July 2015 and is under review.**

<Policy target for 3E+S>

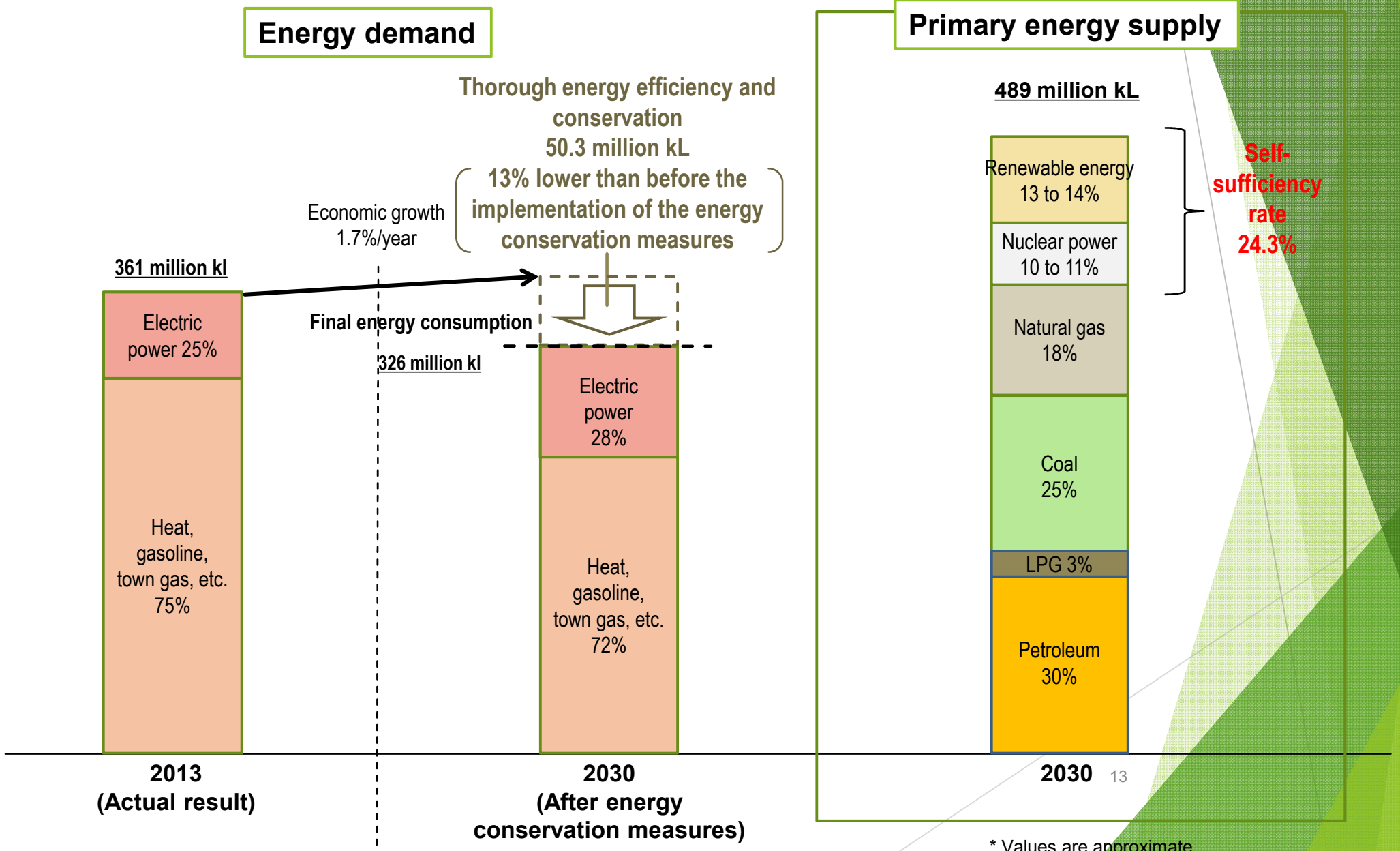
Safety — **Safety is the top priority.**

Energy security — **Self-sufficiency: About 25%, higher than before the earthquake (about 20%)**

Economic efficiency — **Electricity cost: To lower from the current level**
(9.7 trillion yen in FY2013 to 9.5 trillion yen in FY2030)

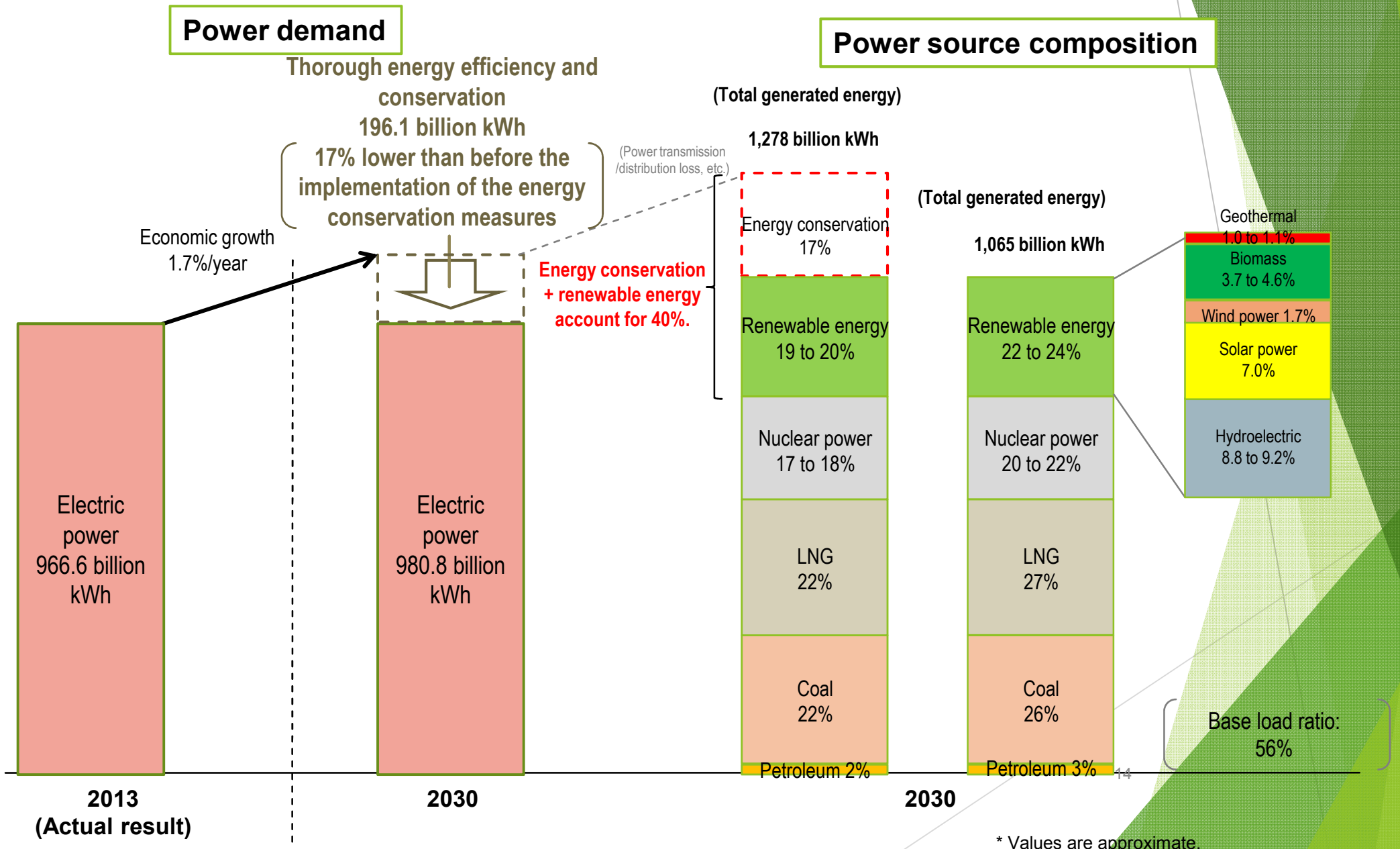
Environment — **Greenhouse gas emission reduction target: comparable to the targets of Europe and the US**

Energy demand and primary energy supply



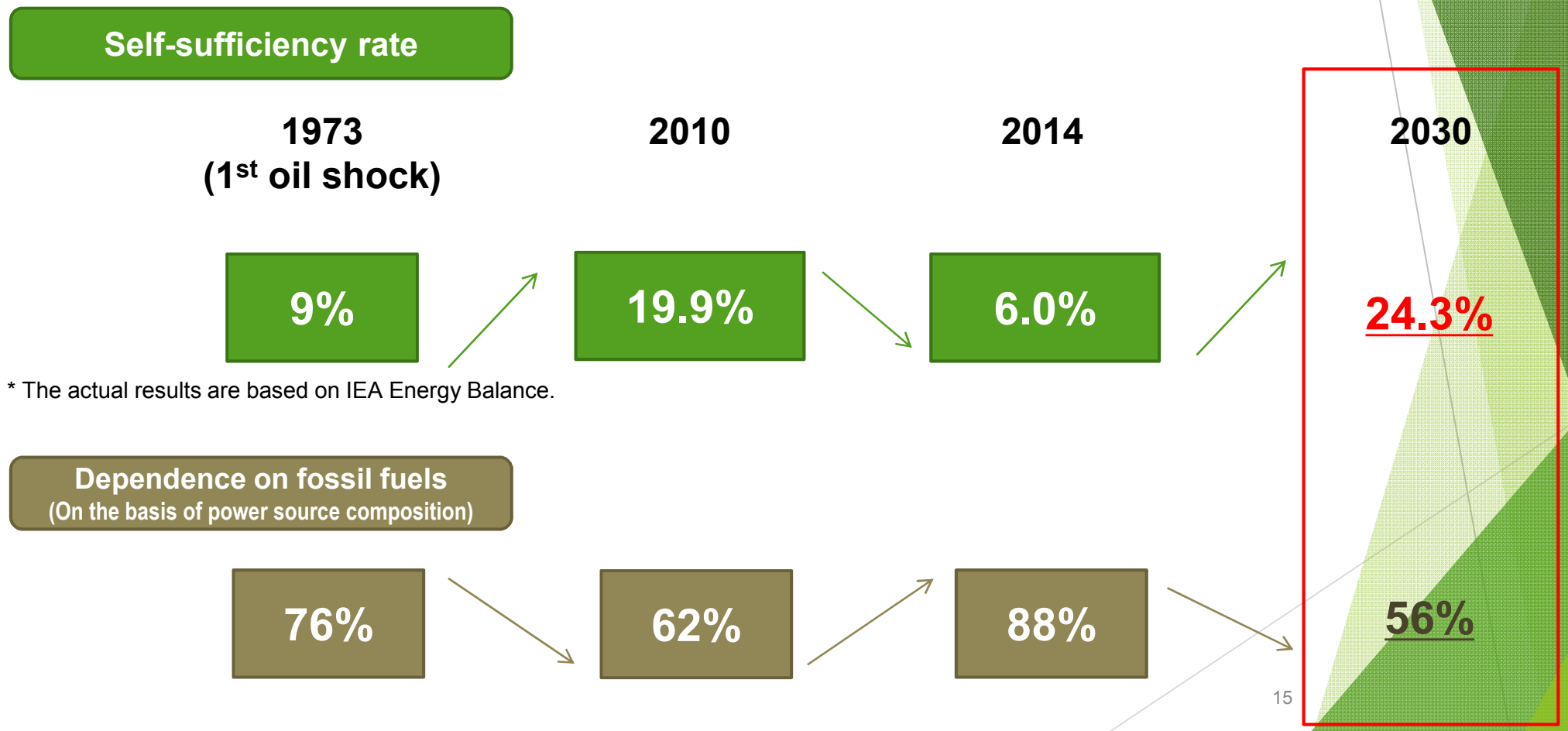
* Values are approximate.

Power demand and power source composition



Self-sufficiency and dependence on fossil fuels

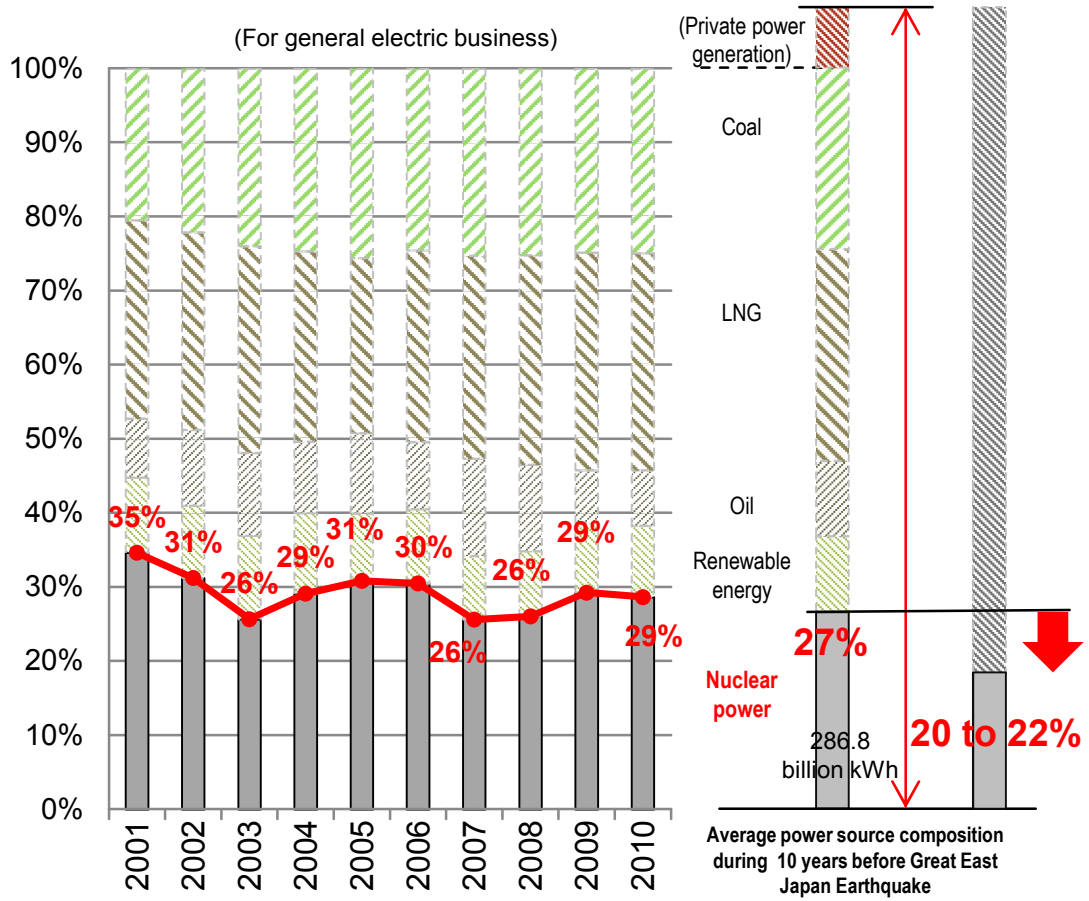
- The self-sufficiency rate will be improved from approx. 6.0% to 24.3%.
- The dependence on fossil fuels (on the basis of power source composition) will be also reduced from approx. 88% in 2013 to 56%.



Decrease of dependence on nuclear power

○ Strategic Energy Plan states that the **dependence on nuclear power will be decreased as much as possible by introducing energy efficiency and conservation and renewable energy, and enhancing efficiency of the thermal power plants**.

Transition of dependence on nuclear power generation



1. Inhibition of electric power demand by energy efficiency and conservation

Reduce a electric power demand in 2030 by 17%, compared with before taking the measures. (Equivalent to reduction of about 213 billion kWh in terms of generated energy)

2. Substitute for nuclear power by expansion of renewable energy

Expand geothermal, hydroelectric and biomass powers which can be operated stably despite weather conditions.
(Approx. 38.2 to 53.1 billion kWh) * Including a smoothing effect of wind power.

3. Reduction of nuclear power by improving the efficiency of thermal power

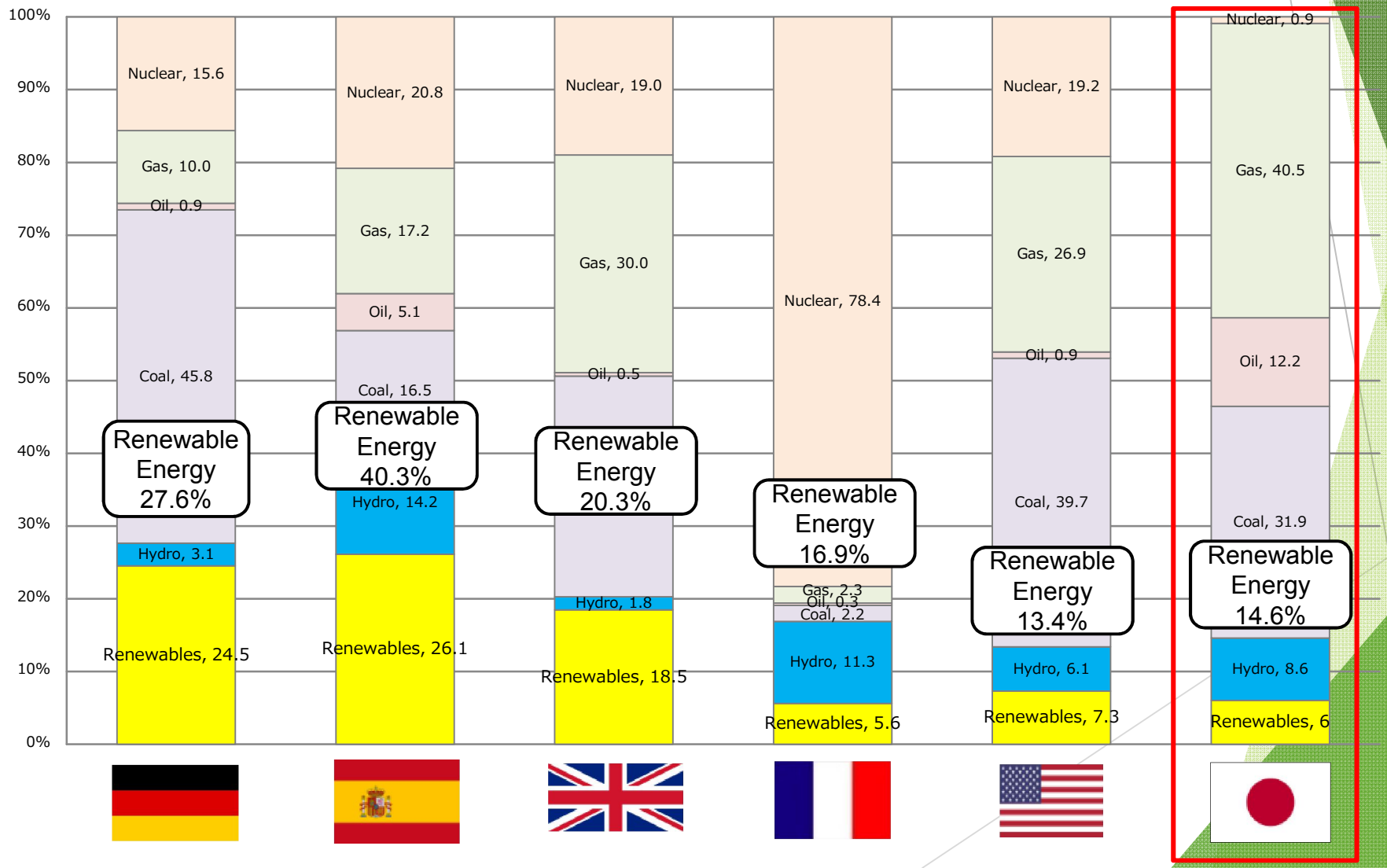
Power generation efficiency of coal-fired thermal power is improved by 6.7% as a whole.
(Approx. 16.9 billion kWh)

Average power source composition of nuclear power during 10 years before Great East Japan Earthquake was 286.8 billion kWh (27%), and the composition is expected to be decreased to 231.7-216.8 billion kWh(20-22%) in 2030.

3. Renewable Energy and Nuclear

Ratio of electricity generated by renewables

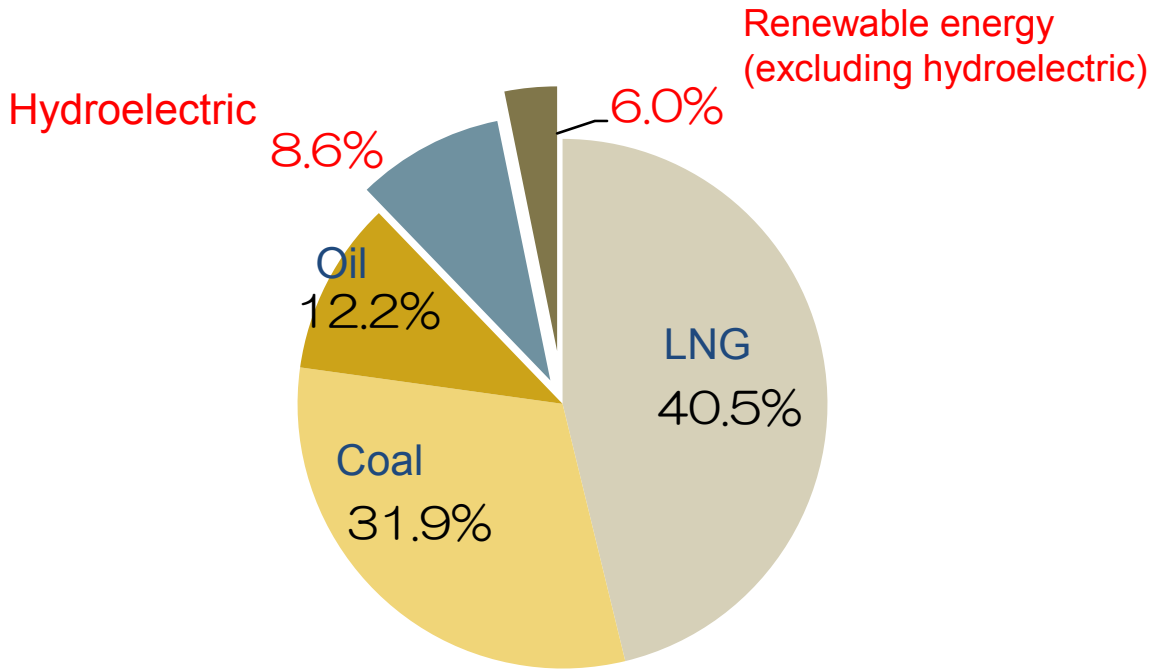
- Ratio of electricity generated by renewable energy in Japan was 14.6 % in 2015 and it was 6.0% if hydro is excluded.



Current state of renewables

- Renewables account for approximately 14.6% of power generation in 2015.
- More specifically, hydroelectric power generated by large-scale dams, etc., accounted for 8.6%, with solar PV, wind, geothermal and biomass power accounting for 6.0%.

Composition of power generation by energy source in Japan (FY 2015)



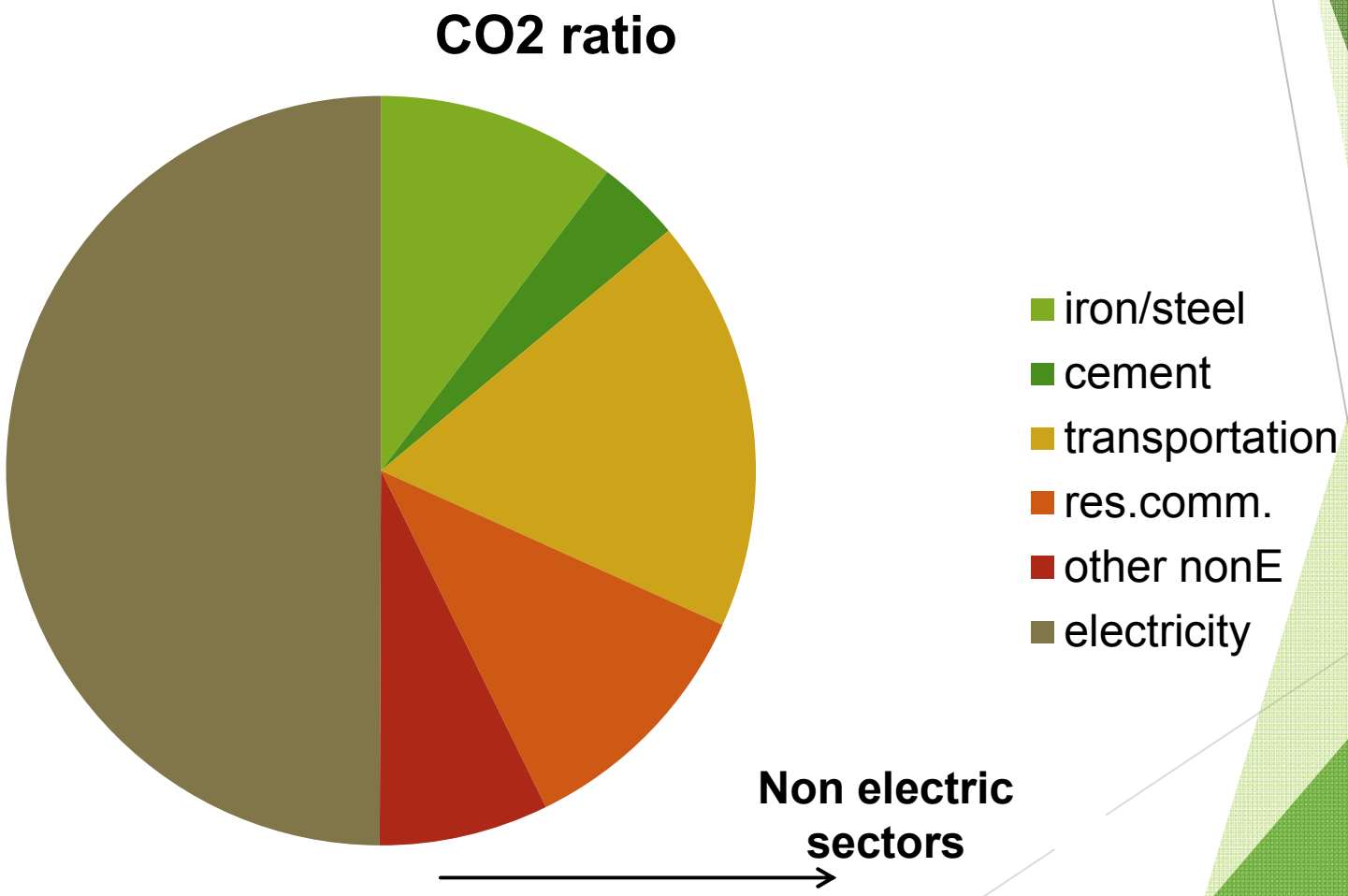
Tariffs (JPY/kWh)

	FY2012	FY2013	FY2014	FY2015	Fy2016	FY2017	FY2018	FY2019
Solar PV (10kW or more)	40	36	32	29 27	24	**21** ※3	TBD	TBD
Solar PV (Less than 10kW)	42	38	37	33 35 ※2	31 33 ※2	**28** 30 ※2	**26** 28 ※2	**24** 26 ※2
Wind	22 (20kW or more)					**22** **21**	**20**	**19**
	55 (less than 20kW)					55	TBD	TBD
				36 (Offshore)		36		
Geothermal	26 (15000kW or more)					26 (15000kW or more)		
	40 (less than 15000kW)					40 (less than 15000kW)		
Hydraulic Power	24 (1000kW or more but less than 30000kW)					24 **20 (5000kW or more but less than 30000kW)** **27 (1000kW or more but less than 5000kW)**		
	29 (200kW or more but less than 1000kW)					29		
	34 (less than 200kW)					34		
Biomass	39 (Biogas)					39		
	32 (Wood fired power plant (Timber from forest thinning))			40 (less than 2000kW) 32 (2000kW or more) ((Wood fired power plant (Timber from forest thinning))		40 (less than 2000kW) 32 (2000kW or more)		
	24 (Wood fired power plant (Other wood materials))					24 **21 (20000kW or more)** 24 (less than 20000kW)		
	13 (Wood fired power plant (Recycled wood))					13		
	17 (Wastes (excluding woody wastes))					17		

※2 With real-time power control system

※3 Auction (2 MW or more), starting from Oct. 2017

CO2 share of Japan（2013)



Nuclear power plant in Japan

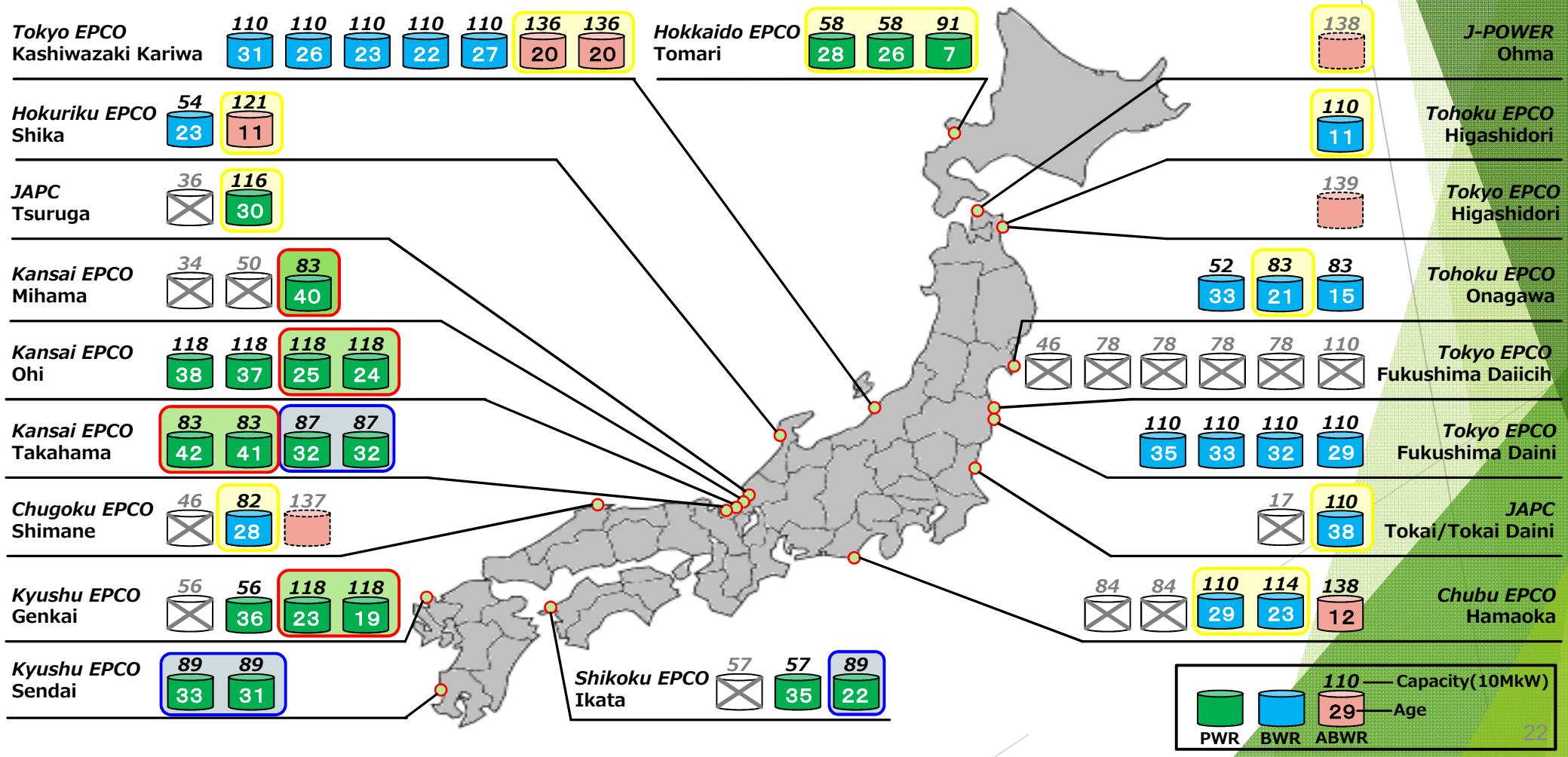
In operation — **5** reactors

Passed NRA review for the Permission for Changes in Reactor Installation — **7** reactors

Under NRA review — **14** reactors

already decided to **decommission** — **15** reactors

As of 11th, July, 2017



4. Climate Change

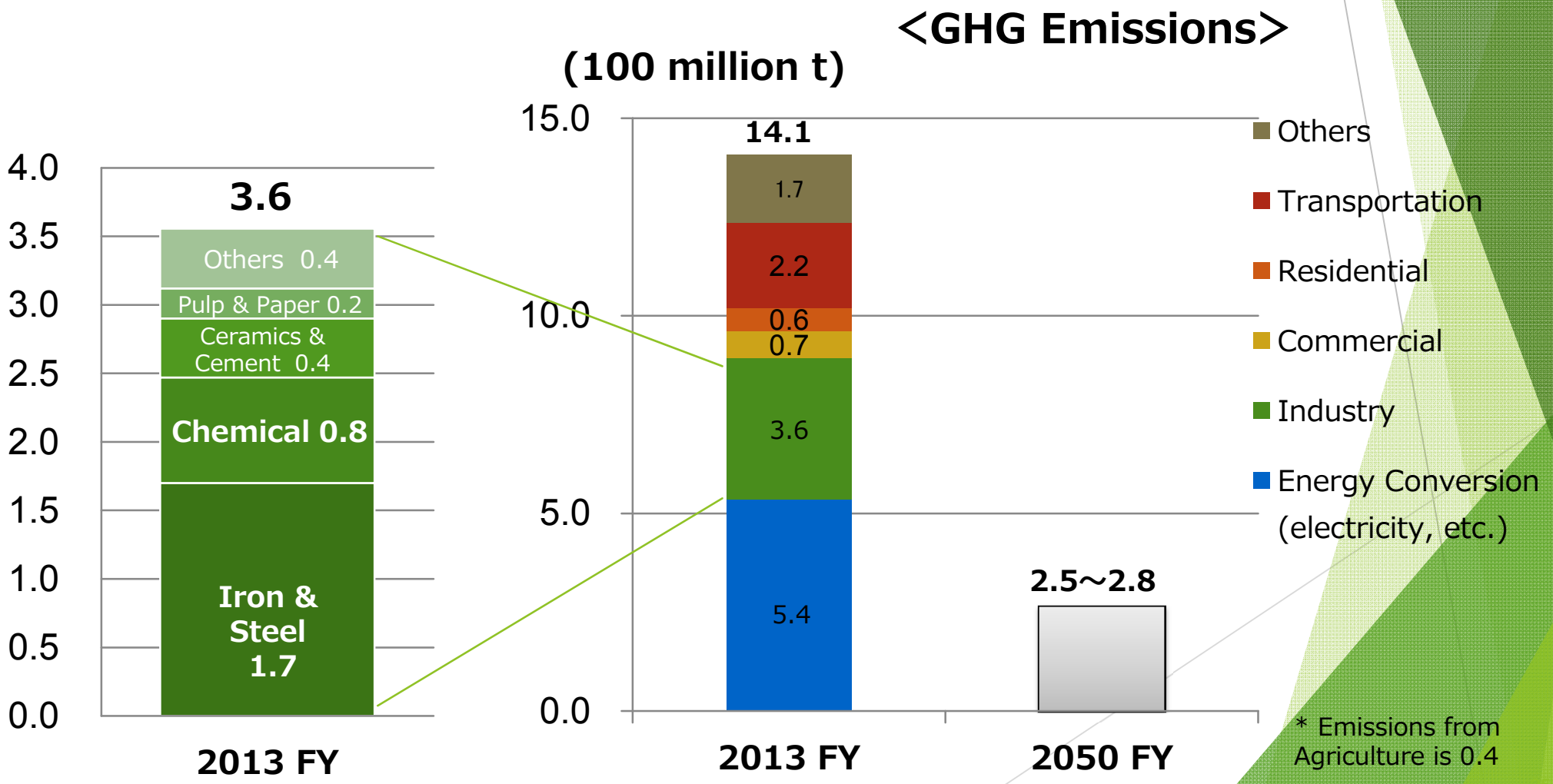
Cabinet decision on the plan for global warming

- “On May 13, 2016, the Plan for Global Warming Countermeasures was decided by the cabinet. The plan defines a path to achieve a mid-term target of 26.0% greenhouse gas emission reduction by FY2030 compared to FY2013, clarifying policies and measures to be implemented, and also sets a long-term goal to pursue 80% reduction by FY2050. This plan is a foundation to progress the global warming countermeasures.”

- Based on the Paris Agreement, under a fair and international framework applicable to all major parties, Japan aims to reduce its greenhouse gas emissions by 80% by 2050. Therefore, Japan pursues solution through innovation such as development and deployment of innovative technologies

Implications of ▲80%

- Assuming domestic measures with existing technologies, ▲80% reduction implies a total replacement of social infrastructure and massive structure change to industry.



5. Challenges and Issues for Discussion

Recent developments in Japan

➢Normalization

▶The Government formulated **Strategic Energy Plan** (April 2014) followed by Long-**term Energy Demand and Supply Outlook** (July 2015) that foresees the future energy mix towards 2030.

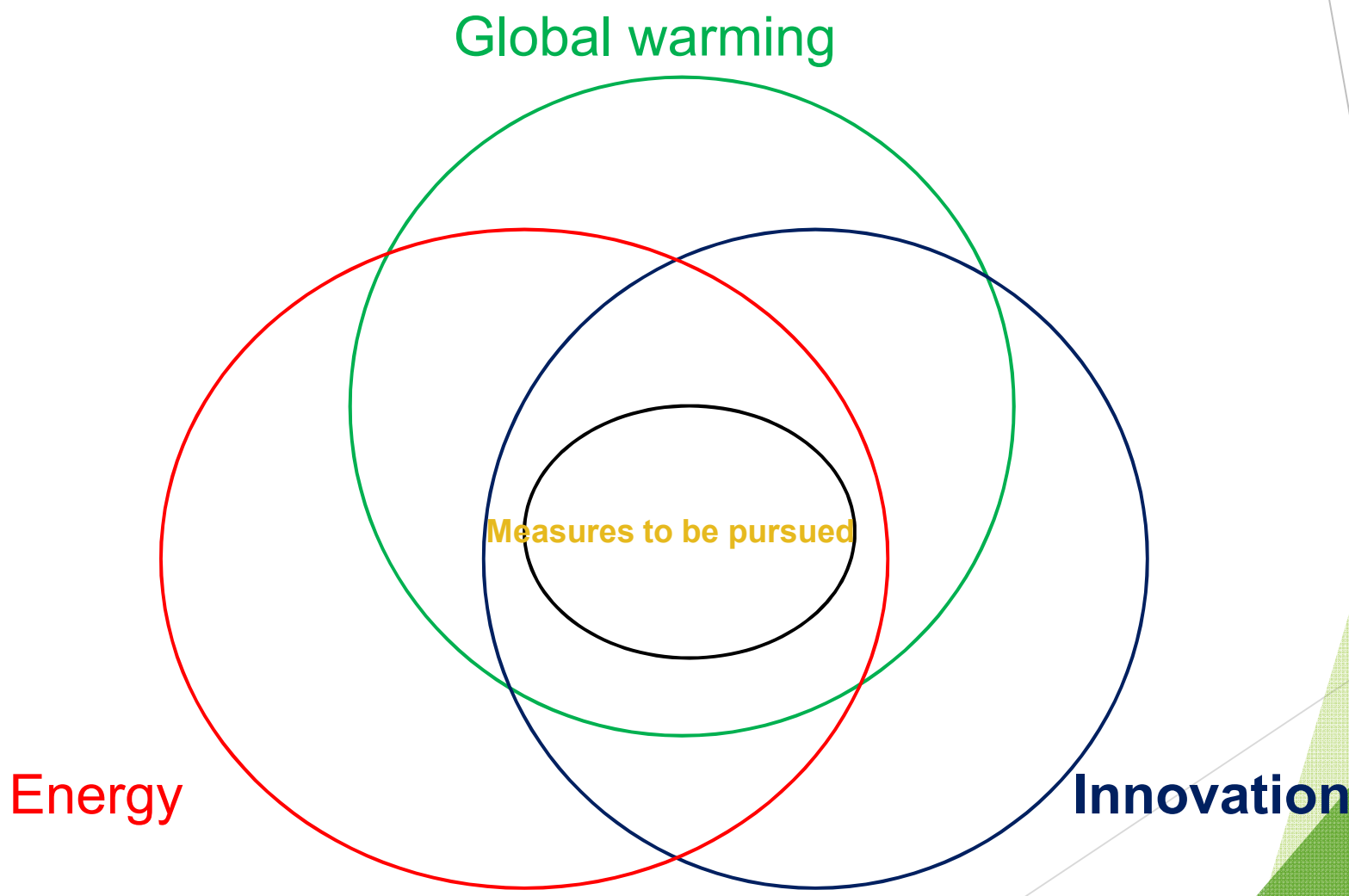
▶**Plan for Global Warming Countermeasures** (May 2016) was also approved by the Cabinet, which illustrates that sets a long-term goal to pursue 80% reduction by FY2050

➢Major challenges

- ▶ Nuclear particularly restart of the plants
- ▶ Innovation

Structured problem – Ideal and reality in Japan –

Solving energy and global warming issues through innovation



Current situation in Japan

Each sector faces with issues and new challenges emerge:

➢**Energy**

- Revision of **Strategic Energy Plan** and **Long-term Energy Demand and Supply Outlook**
- Nuclear restart and finding an appropriate position for nuclear in the future energy mix are challenging

➢**Global Warming**

- MOE and METI independently have studied the future path towards 2050 and published their drafts. The major discrepancies between them are observed in terms the uncertainties for the future and the way to mitigate the risk and cost of possible measures.

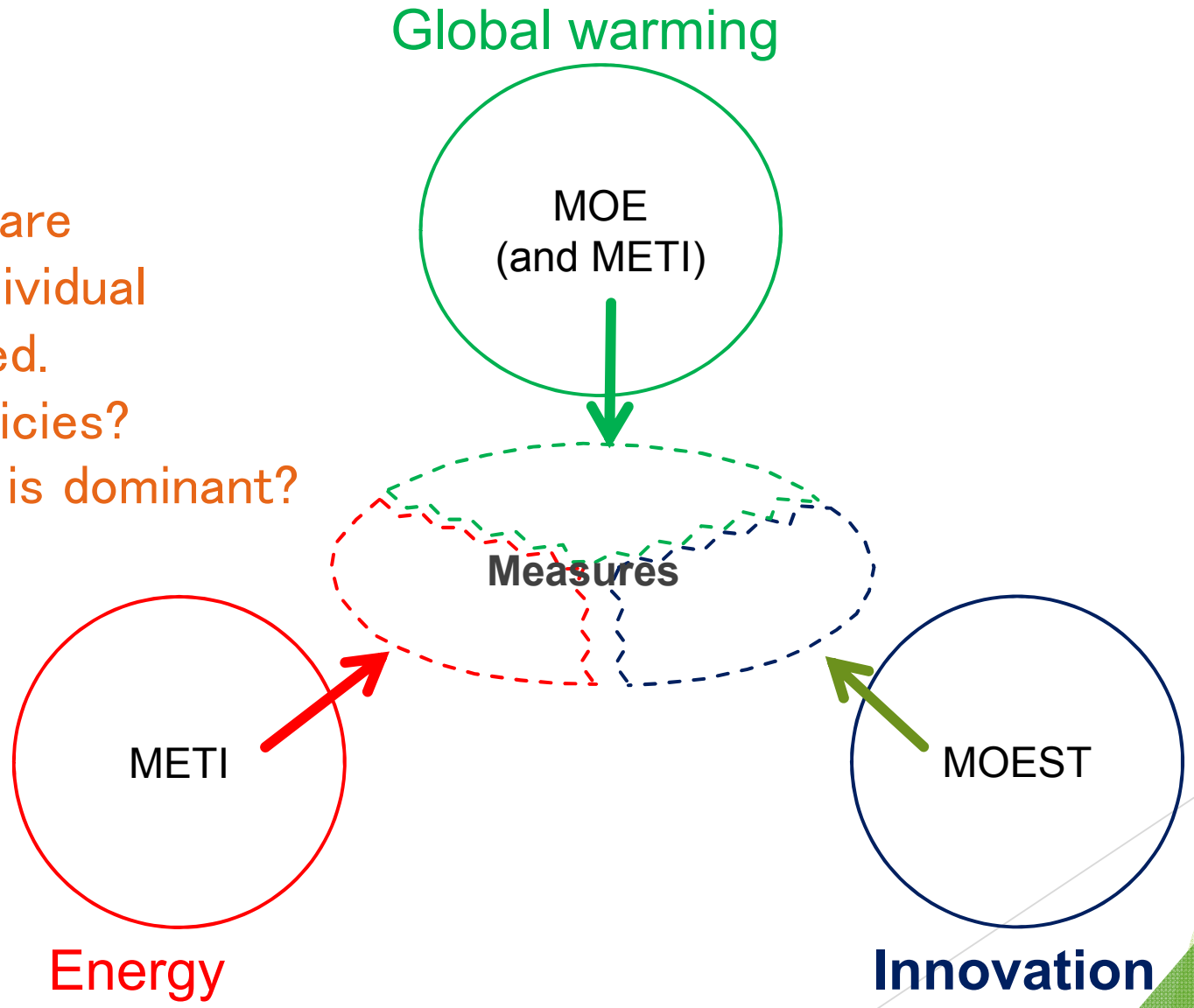
➢**Innovation**

- **Comprehensive and consistent strategy for innovation in energy and global warming?**

Reality in Japan?

Different ministries are responsible then individual policies are combined.

- No integrated policies?
- Centrifugal force is dominant?



Awareness of the issue

- **Discrepancy** between ideal and reality
  - Unique to Japan? Silo is universal phenomenon? However, the grass is greener on the other side.
  - Need to cope with uncertainty that is accompanied by GHG emission reduction
  - long-term and consistent countermeasures including appropriate risk management are necessary
- **Innovation**
  - Japan: need to facilitate innovation in the field of energy and global warming where the population and domestic market decreases, to identify the policy environment and measures, etc.
  - Some tech areas are promising in terms of innovation development such as AI and ICT, however, how the policy could contribute to further promotion of innovation and to use the fruit of the innovation in the field of energy and global warmimg
- International cooperation
  - Conditions and environment necessary for successful productive achievements

Some thoughts and observations

○Political leadership and national strategy

⇒Increased necessity for replacement investment for the energy related infrastructure in Japan would be a good opportunity for innovation development ?

○Basis for innovation

Basic research in the business and industry as well as universities and research institutes has had difficulties

More competition and project management skill are necessary

○Decision making process

Transparency and information sharing

Evidence based decision making