

Japan amidst Changes in the Domestic & International Energy Environment

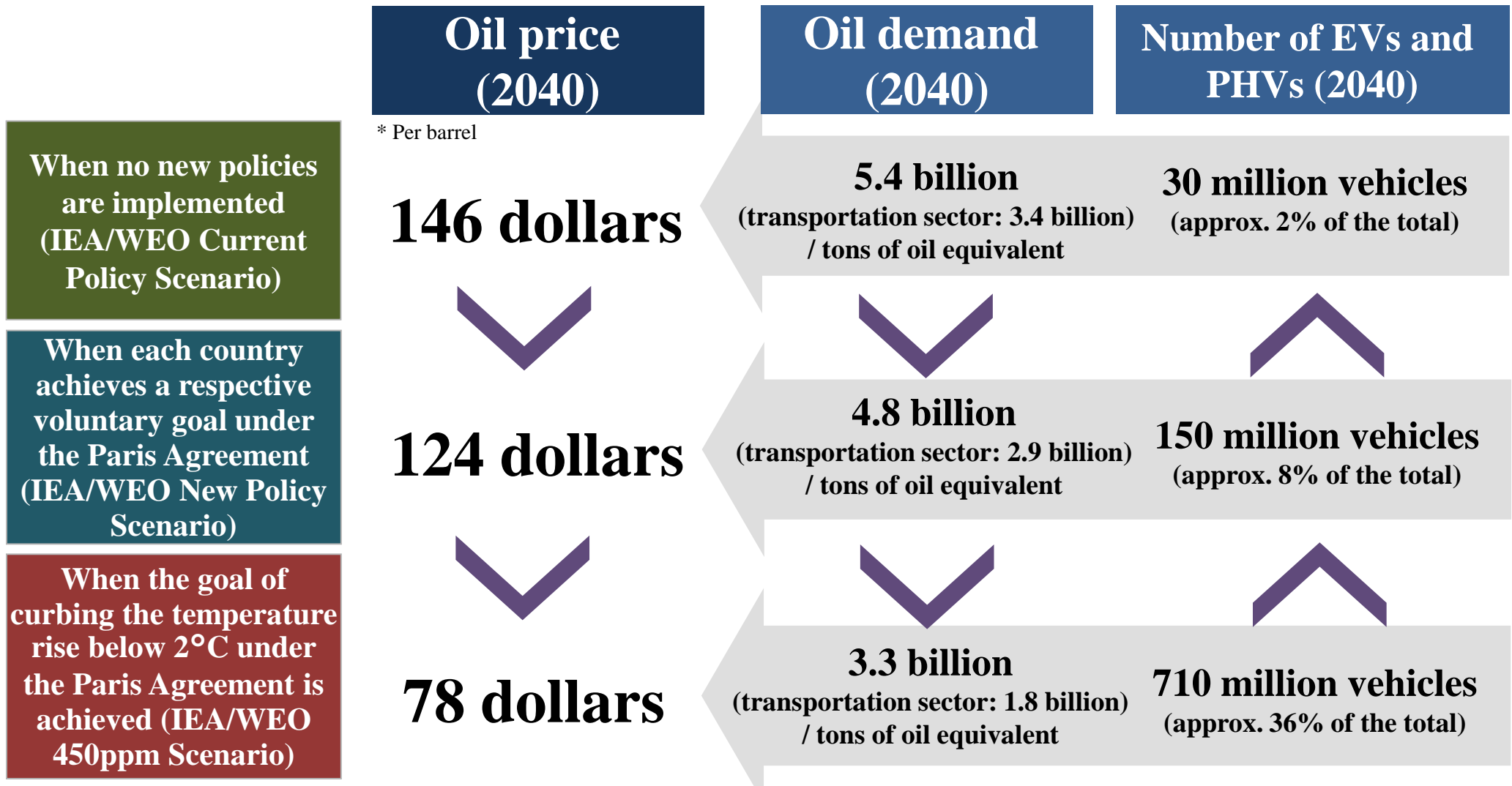
August 30, 2017

Agency for Natural Resources and Energy

[Change 1] Oil price declined from 100 dollars to 50 dollars per barrel.






A shift from nuclear power and coal to gas is anticipated if the United States establishes its presence as a resource-producing country (emergence of a resource producer from an area other than the Middle East) and prices of oil and natural gas remain relatively low. However, some forecast the possibility of an oil price increase to 100 dollars per barrel beyond 2030.

[Change 1-1] Oil price declined from 100 dollars to 50 dollars per barrel. A price increase is anticipated, the significance of which will be largely determined by the future dissemination of EVs.



- A proper forecast of oil price trends is the basis for energy selection.
- Oil prices are significantly affected by the future dissemination of EVs, in addition to the growth of emerging countries and the sustainability of the Shale Revolution. The key to a proper forecast lies in these considerations.

[Change 1-2] There is the possibility of the decoupling of oil prices and gas prices or the possibility of a shift to gas.

		Oil	LNG	Coal
Prices	At present (2016)	41 dollars	7.0 dollars	72 dollars
	IEA assumption (2040)	124 dollars	12.4 dollars	80 dollars
		 Tripled	 Almost doubled	
Amount	At present (2016)	4.4 billion tons	3.0 billion tons	3.8 billion tons
	IEA assumption (2040)	4.8 billion tons	4.3 billion tons	4.1 billion tons
		 Up by 10%	 Up by more than 40%	 Up by 10%

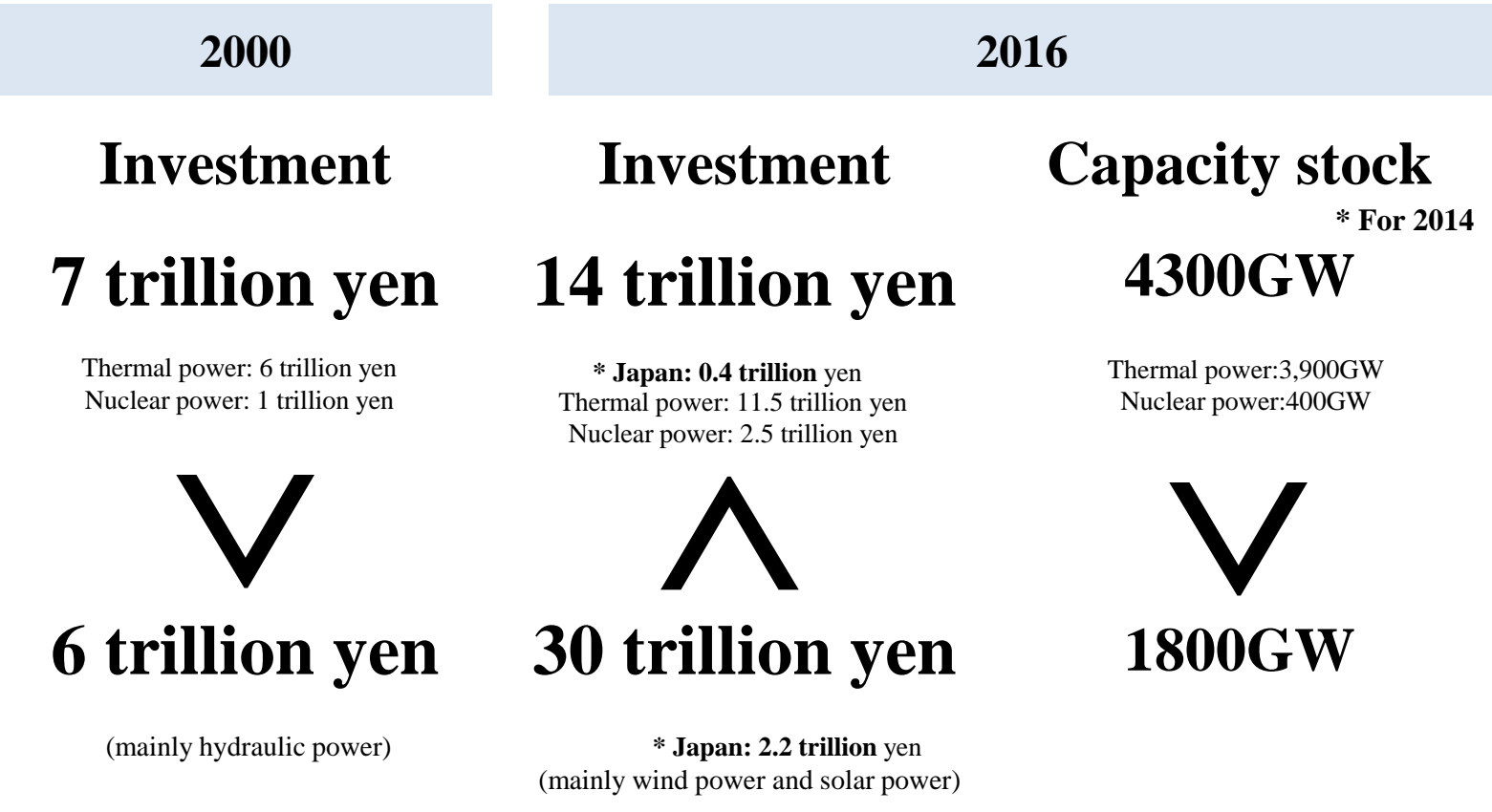
Source: IEA WEO-2016, etc. * Price units: Oil - barrels; LNG - Mbtu; Coal - tons / Amount unit: tons of oil equivalent

* Prices = Import prices in Japan / Amount = Rounded-off world demand for primary energy

[Change 2] The price of renewable energy decreased from 40 yen/kWh to 10 yen/kWh outside Japan.

On the one hand, renewable energy is said to be a major power source after being independent from FIT. On the other hand, the shortage of transmission and operating reserves could lead to new public burden. Moreover, Japan still faces relatively higher generation costs compared to other countries.

[Change 2-1] Renewable energy is the major target of electricity investment



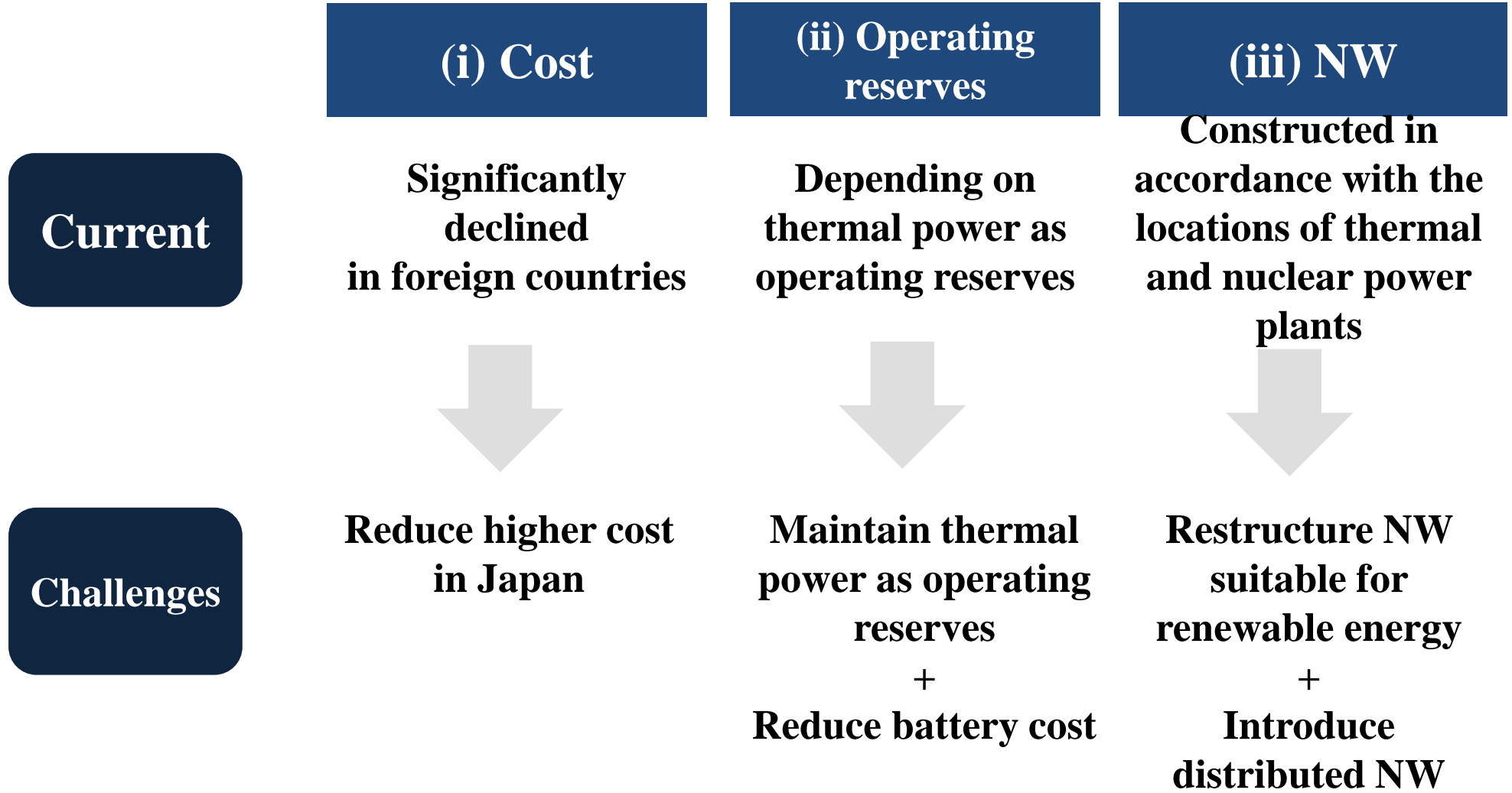
- Due to FIT systems, investment in renewable energy has now exceeded that in thermal and nuclear power plants.
- However, it is necessary to sustain investment in renewable energy in order to be a major power source in terms of installed capacity.
- What is needed for independence from FIT?

* Rough calculation based on 1 \$ = 100 yen; On a worldwide basis

(Source) Prepared by the Agency for Natural Resources and Energy based on the IEA's "World Energy Investment 2017"

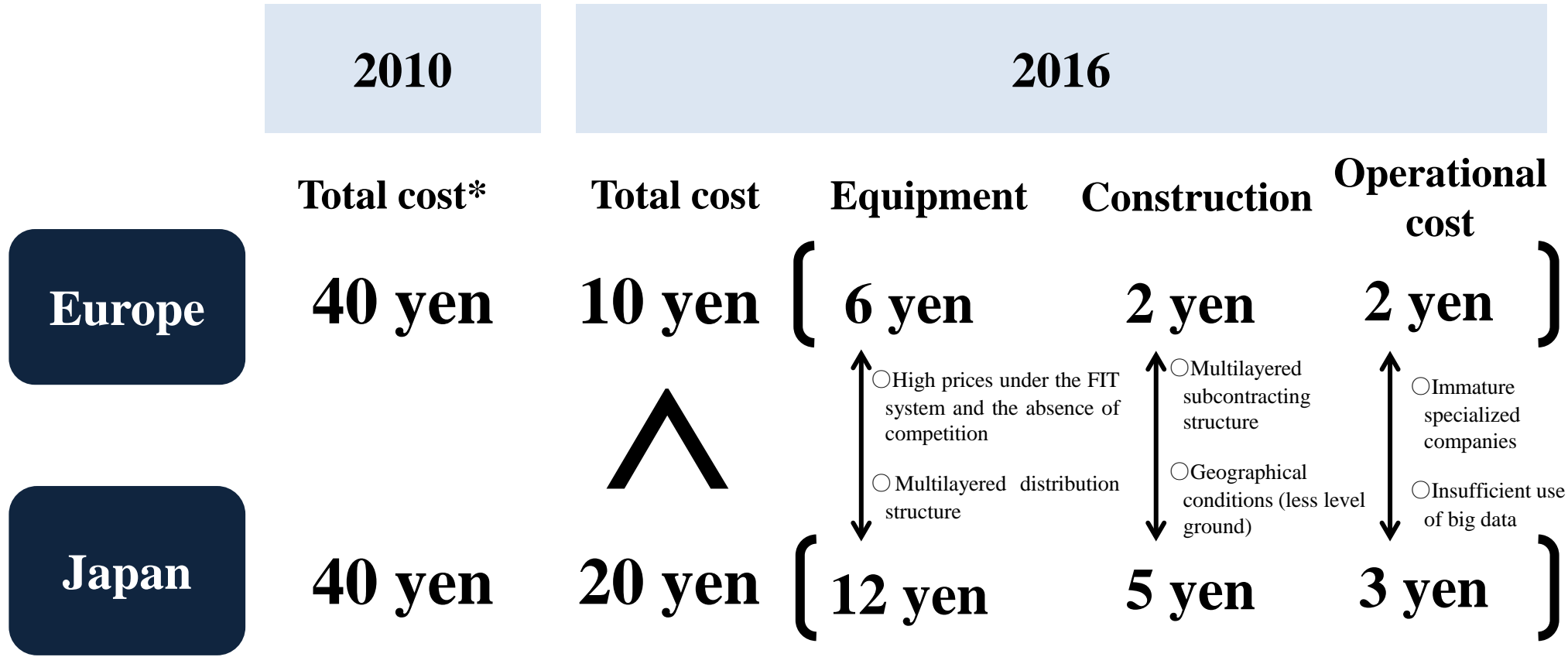
[Change 2-2] Three challenges to be addressed for renewable energy to be a major power source

Referred example “Clean energy’s dirty secret - Wind and solar power disrupting electricity systems”
Economist, Feb 25th 2017



[Change 2-3] Challenge 1: Early correction of the Japanese high-cost structure of renewable energy

Changes in solar power generation costs in Europe and Japan [yen/kWh]



○European countries and China are ahead of Japan in this field. How should Japan's renewable energy industry strengthen its competitiveness?

* The total cost for Europe and Japan for 2010 is the world average solar power generation cost.

(Source) Estimated by the Agency for Natural Resources and Energy based on the Bloomberg New Energy Finance data and other data

[Change 2-4] Challenge 2: Holding thermal power as operating reserves + Fundamental reduction in battery cost

Unit: yen/kWh

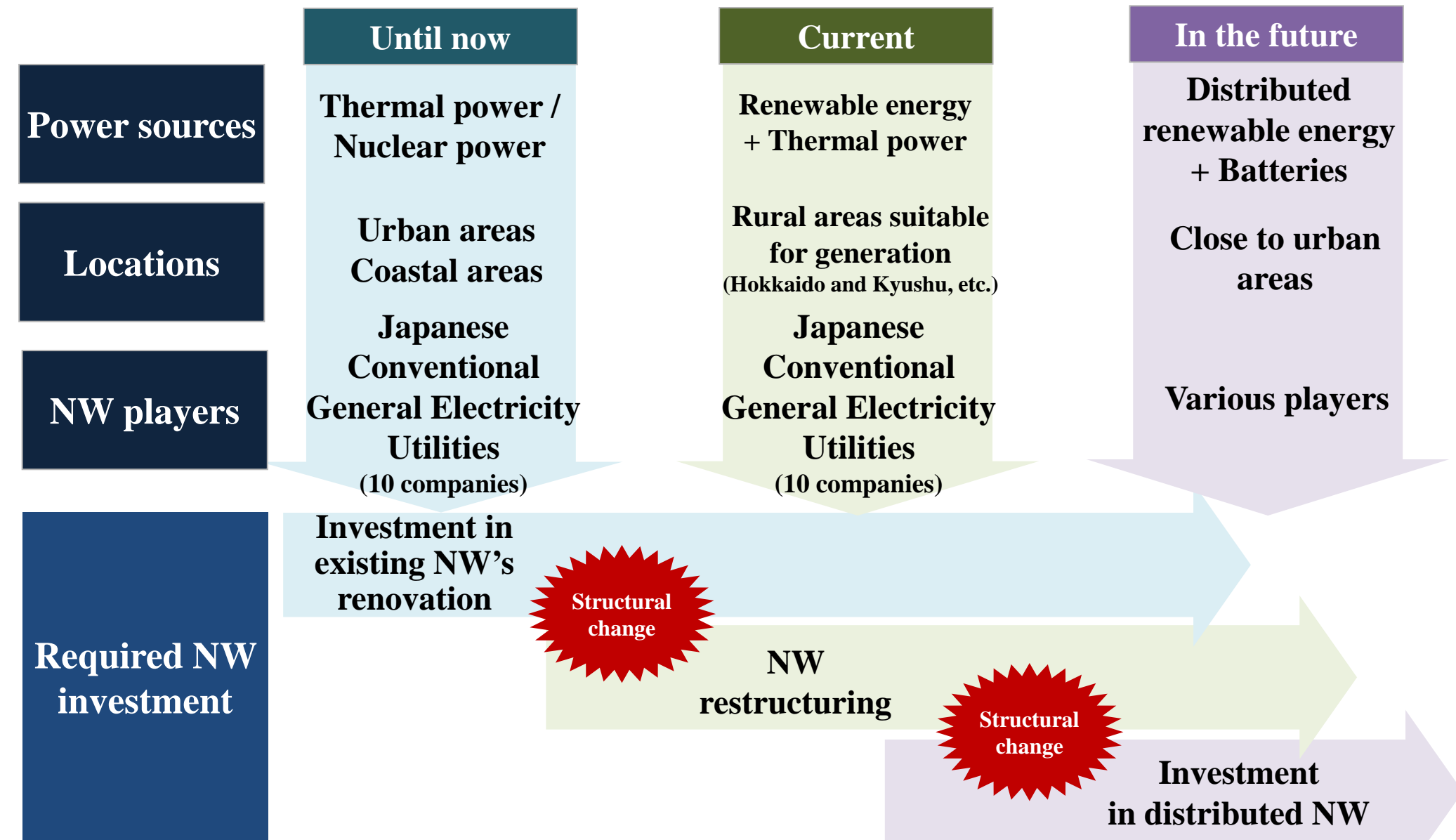
	Current	In the future	Current cost	Parity (household)	Parity (industry)
Power generation	Renewable energy	Renewable energy	150 yen 20 yen	25 yen 7 yen <small>(target for 2030)</small>	15 yen 7 yen <small>(target for 2030)</small>
Adjustment	+ Thermal power	+ Battery	130 yen	> 18 yen	> 8 yen
	CO ₂ emissions	No CO ₂ emissions	Battery cost: 40,000 yen/kWh <small>LIB sales price (hearing by the ANRE)</small> <small>The NAS battery system as a whole costs around 40,000 yen/kWh. (2012 "Storage Battery Strategy" (METI))</small>	Battery cost: approx. 400 yen/kWh 1%	Battery cost: approx. 40 yen/kWh 0.1%

○How can battery innovation be accelerated? What are the necessary conditions for Japan to lead the world in this field?

* Based on the premise of receiving no backup, it is assumed that a battery needs a capacity capable of meeting demand for three full days. The above parities may not be achieved when taking into consideration personnel and material costs (the above battery costs show the cost for a battery pack, and the cost for the entire system is assumed to be five to 10 times larger). Adjustment cost includes control and grid costs.
It should be noted that the term "parity" here has a different meaning from the definition of such terms as "grid parity," which means that the cost for distributed renewable energy that also uses backup thermal power through the grid equates with the cost for grid-connected power.

(Source) Estimated by the Agency for Natural Resources and Energy

[Change 2-5] Challenge 3: Structural reform of electricity NW in accordance with the development of renewable energy



○ How should the restructuring of large-scale NW and investment in distributed NW be simultaneously promoted?

[Change 3] Competition in the development of EVs has intensified in the automobile industry.

There is the possibility for 100% use of renewable energy for automobiles thanks to commercialization of high-performance batteries. However, batteries are still relatively expensive.

[Change 3] EV development race in the automobile industry has intensified.

The development of EVs will exert influence on the energy supply-demand structure.

(1) Influence on demand		IEA/WEO Current Policy Scenario	IEA/WEO New Policy Scenario	IEA/WEO 450ppm Scenario
Estimated oil demand in 2040 (Assumed dissemination of EVs and PHVs)		5.4 billion tons (30 million vehicles)	4.8 billion tons (150 million vehicles)	3.3 billion tons (710 million vehicles)
(2) Influence on supply		At present	Parity level	
EV	Mileage (Battery capacity)	280km (30kWh)	Approx. 700km (56kWh)	
	Vehicle cost (Battery cost)	3 million yen (40 thousand yen/kWh)	NEDO Goal for 2030 1.8 million yen (Approx. 5 thousand yen/kWh)	
Electric power	Renewable energy + Battery (Battery cost)	150 yen (40 thousand yen/kWh)	15 to 25 yen (Approx. 40 to 400 yen/kWh)	No goal is set at present.
(3) Policies				
Policy means	[China] Impose an obligation to sell a certain number of EVs and PHVs from 2018	[Japan] Aim to increase the percentage of new EVs and PHVs sold to between 20% and 30% of the total by 2030	[UK and France] Intend to prohibit the sale of gasoline vehicles and diesel vehicles by 2040	

- The dissemination of EVs may change the energy demand structure and supply structure.
- What policy measures will foreign governments take in this field?
- What strategies do the automobile industry and major auto makers have for the long term?

[Change 4] While some countries have declared policies to abandon nuclear power, many others continue to utilize it as an important source of energy.

After the accident at the Fukushima Daiichi Nuclear Power Station, some countries (Germany, Switzerland, Taiwan and ROK) changed their policies and shifted toward abandoning nuclear power in response to public worry and the varied risks pertaining to starting a nuclear power program, including those related to initial facility construction and operations.

At the same time, there are many countries that choose and support nuclear power as a means for preventing global warming and reducing dependency on fossil fuels. Under such circumstances, maintenance of personnel and technology for ensuring safety and non-proliferation has become a common issue for these countries.

[Change 4-1] After the nuclear accident in Fukushima, four countries changed their policies and shifted toward abandoning nuclear power.

Use nuclear power in the future

- U.S. [99]
 - France [58]
 - China [37]
 - Russia [35]
 - India [22]
 - Canada [19]
 - Ukraine [15]
 - U.K. [15]
 - Sweden [8]
 - Czech Republic [6]
 - Pakistan [5]
 - Finland [4]
 - Hungary [4]
 - Argentina [3]
 - South Africa [2]
 - Brazil [2]
 - Bulgaria [2]
 - Mexico [2]
 - Netherlands [1]
- Figures in [] show the number of units in operation.

- Turkey
- Belarus
- Chile
- Egypt
- Indonesia
- Israel
- Jordan
- Kazakhstan
- Malaysia
- Poland
- Saudi Arabia
- Thailand
- Bangladesh
- UAE

• There are also many countries that have not clarified their stance.

Now using unclear power

- ROK [24] (Policy announced in 2017; Decommissioning scheduled in 2079)
 - Germany [8] (Legislation in 2011; Decommissioning to be completed in 2022)
 - Belgium [7] (Legislation in 2003; Decommissioning to be completed in 2025)
 - Taiwan [6] (Legislation in 2017; Decommissioning to be completed in 2025)
 - Swiss [5] (Legislation in 2017; -)
- Figures in [] show the number of units in operation. * (Year when decision of abandonment was made; Scheduled year of phasing out) Switzerland has not limited the operation period.

Not using unclear power at present

- Italy (Cabinet decision in 1988; Decommissioning completed in 1990)
- Austria (Legislation in 1978)
- Australia (Legislation in 1998)

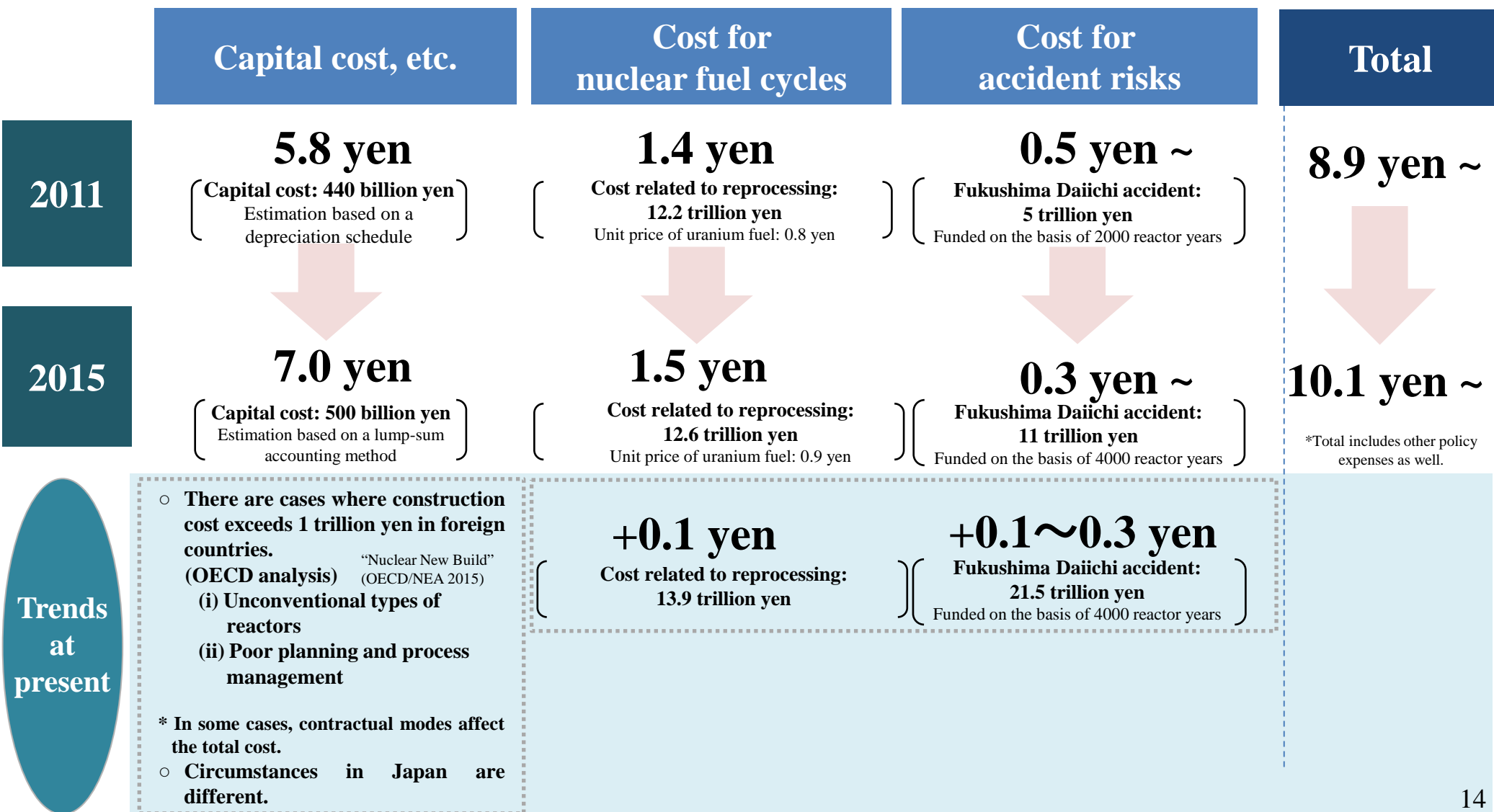
Abandon nuclear power in the future

Source: Prepared by the Agency for Natural Resources and Energy, extracting countries based on the website of the World Nuclear Association (August 1, 2017)

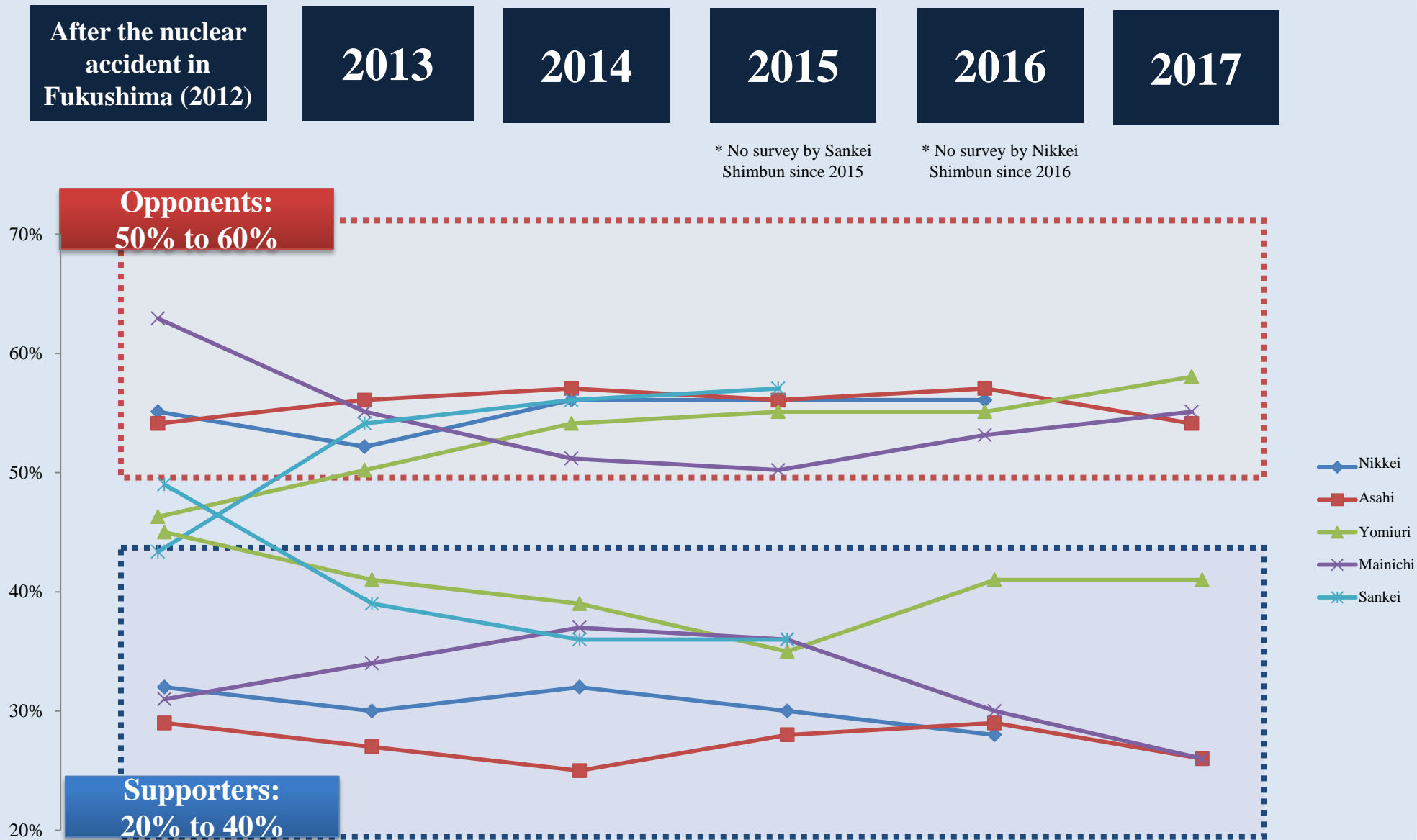
[Change 4-2] Cost for nuclear power generation

○ Increasing expenses for dealing with the aftermath of the nuclear accident in Fukushima and the need to strengthen safety measures are factors that increase overall cost, but such cost increase is shared among multiple nuclear reactors over a long term and exerts only limited influence on the unit cost.

○ OECD attributes the cost increase in overseas nuclear power plants to factors concerning risks for initial units.



[Change 4-3] Regarding resumption of operations of nuclear power plants, opponents outnumber supporters two to one. In Japan, the restoration of public trust is the biggest challenge.



○ How do public opinions concerning nuclear power differ by country?

[Change 4-4] However, many countries select nuclear power as a means for reducing carbon emissions or for other reasons

Use nuclear power in the future

- **U.S.** [99]
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 - **Argentina** [3]
 - **South Africa** [2]
 - **Brazil** [2]
 - **Bulgaria** [2]
 - **Mexico** [2]
 - **Netherlands** [1]
- Figures in [] show the number of units in operation.

- **Turkey**
- **Belarus**
- **Chile**
- **Egypt**
- **Indonesia**
- **Israel**
- **Jordan**
- **Kazakhstan**
- **Malaysia**
- **Poland**
- **Saudi Arabia**
- **Thailand**
- **Bangladesh**
- **UAE**

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Now using unclear power

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Not using unclear power at present

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Abandon nuclear power in the future

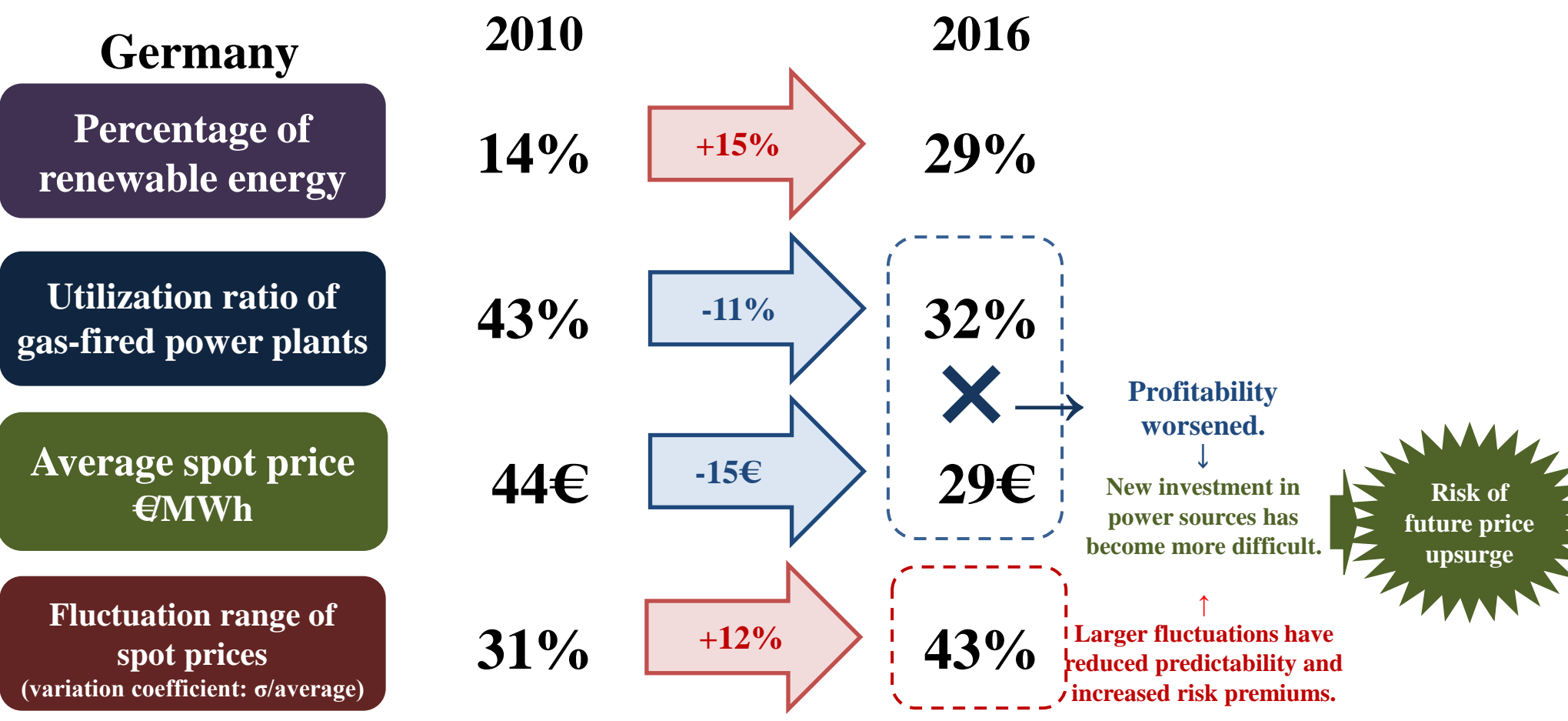
Source: Prepared by the Agency for Natural Resources and Energy, extracting countries based on the website of the World Nuclear Association (August 1, 2017)

○How do respective countries position nuclear power in their energy policy? What future strategies do they have for nuclear power?

[Change 5] The investment environment is facing new challenges caused by the full liberalization of the electricity market and the expanding supply of renewable energy.

The expanding supply of renewable energy with no marginal cost leads to declines in wholesale prices of electricity, which makes it difficult to decide long-term and large-scale investment. The electricity market liberalization and expanding supply of renewable energy pose new challenges.

[Change 5] Dissemination of renewable energy with no marginal cost has decreased the capacity utilization of thermal power plants, which leads to declining profitability of large-scale power sources. Fluctuations in spot prices have reduced predictability in investment.






















* The WTI price for 2010 and 2016 was \$79/bbl and \$43/bbl, respectively.

○ Under circumstances where expanding supply of renewable energy and electricity market liberalization cause large fluctuations in electricity prices, what measures should be taken to ensure sustainable development of and investment in power sources that require longer gestation periods?

[Change 6] Withdrawal of the United States from the Paris Agreement has not changed the global outlook.

The United States declared its commitment to leading the countermeasures against climate change with technology more advanced than China or Europe. The international race will intensify regarding low-carbon initiatives consisting of (i) renewable energy, (ii) nuclear power, (iii) CCS, (iv) economic measures, and (v) overseas contribution. Japan is also taking economic measures amounting to 3 trillion yen per year in the forms of FIT and global warming countermeasure taxes. How to design the economic measures is a new challenge.

[Change 6-1] Withdrawal of the United States from the Paris Agreement has not changed the global trend of abandoning CO₂. International race will intensify regarding low-carbon initiatives consisting of renewable energy, nuclear power, CCS, overseas contribution, and economic measures.

	Renewable energy	Nuclear power	Thermal power	CCS	Overseas contribution	Economic measures
Germany - 80 % to - 95% (from the 1990 level)	 2050: 80%	2022: 0	In principle, provide no support for construction of new coal-fired plants		 Framework for assisting developing countries	
France -75% (from the 1990 level)	Blank for 2050 2030: 40%	Blank for 2050 2025: 50%	Avoid investment in construction of new thermal power plants		 Reduce CO ₂ emissions on a worldwide basis	
Canada -80% (from the 2005 level)	 2050: 50% to 80%	 2050: 5% to 50%	2050: 0% to 20%	 2050: 0% to 5%	 Consider making overseas contribution	
U.S. - 80% or more (from the 2005 level)	 2050: 55% to 65%	 2050: 17% to 26%	2050: 10% to 33% <small>* Scheduled regulations on thermal power were withdrawn due to the change of administration.</small>	 2050: 0% to 25%	 Technical cooperation	
China - 36% or more (from the 2010 level)	 2050: 30% to 60%	 2050: 5% to 20%	2050: 30% to 45%	—	—	—

○What CO₂ strategies do major countries have: especially the United States, Europe, China and India?

Source: Respective countries' long-term strategies and policy goals (German and French long-term strategies on energy mix are not clearly stated in their policies but are stipulated in laws and regulations. The above figures for Canada and the United States are the results of the analysis of multiple models in their long-term strategies. The figures for China are rounded-off estimates by the Chinese Academy of Sciences and Chinese Federation of Electric Power Companies.)

[Reference 6-2] After the Great East Japan Earthquake, Japan has also strengthened economic measures and is striving to better utilize the market function, shifting its economic measures to those centered on renewable energy.

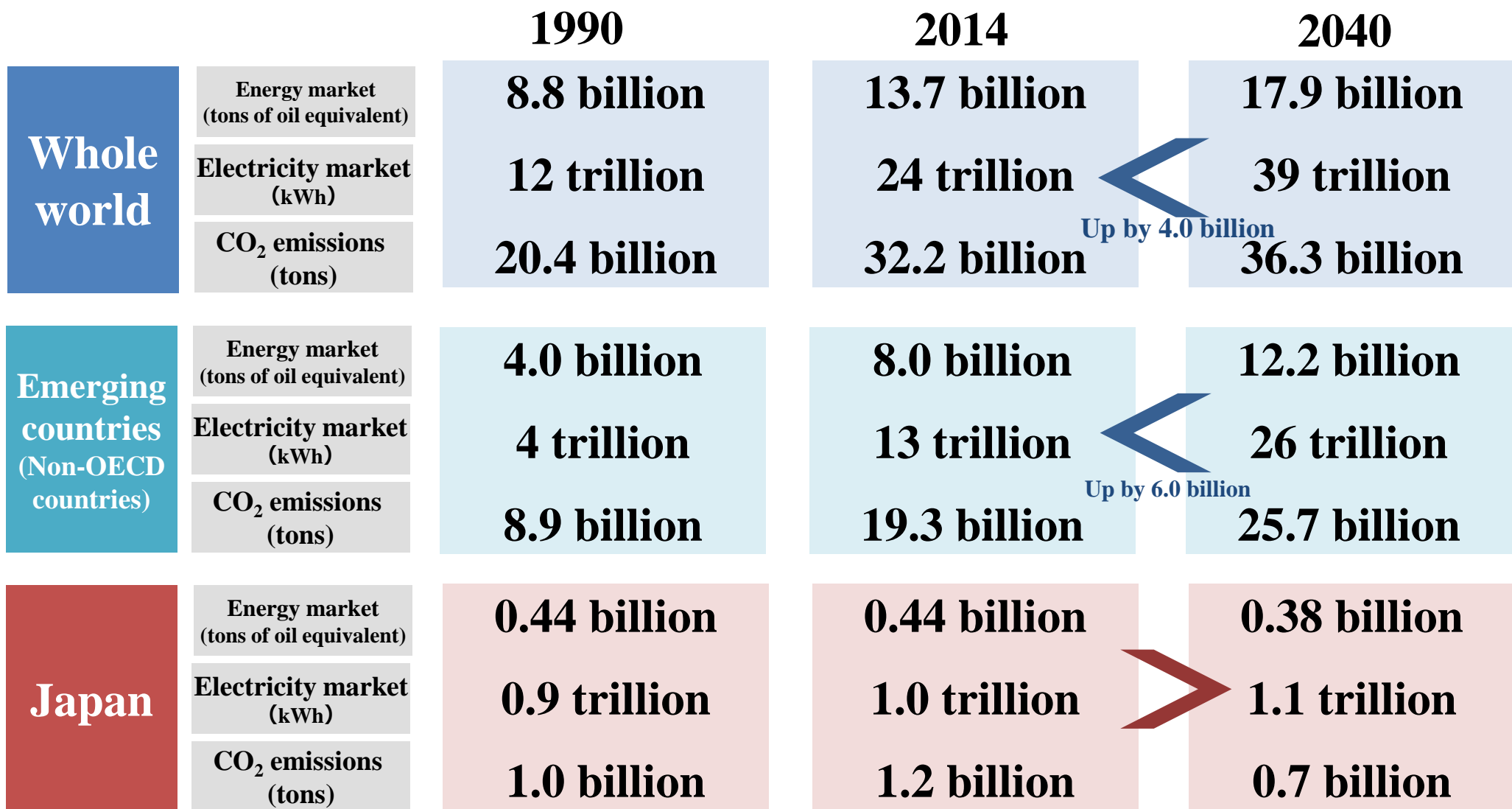
	2010	2016	Energy mix in 2030	
Economic measures	Power sources development promotion tax	0.3 trillion yen	0.3 trillion yen	Around 0.3 trillion yen
	Oil and coal tax	0.5 trillion yen	0.4 trillion yen	Around 0.3 trillion yen
	Global warming countermeasures tax	– Introduced in 2012	0.3 trillion yen	Around 0.2 trillion yen
	FIT charges	– Introduced in 2012	1.8 trillion yen	Around 3 trillion yen
	Total	0.8 trillion yen	2.8 trillion yen	Around 4 trillion yen

Market function	<input type="checkbox"/> Obligation requiring achievement of certain goals for non-fossil fuel → Percentage of zero-emission power sources in FY2030: 44% (Energy Supply Structure Sophistication Act)	X	<input type="checkbox"/> Creation of the non-fossil value trading market → Trading of non-fossil value among companies
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[Change 7] The expanding world energy and electricity markets

Japan's electricity market has matured (approx. 1 trillion kWh). In the meantime, the size of the world electricity market will expand from 20 trillion kWh at present to 30 trillion kWh in 2030. Therefore, Japanese companies' energy investment in emerging markets is important to solving challenges relating to climate change.

[Change 7] The expanding world energy and electricity markets led by emerging countries



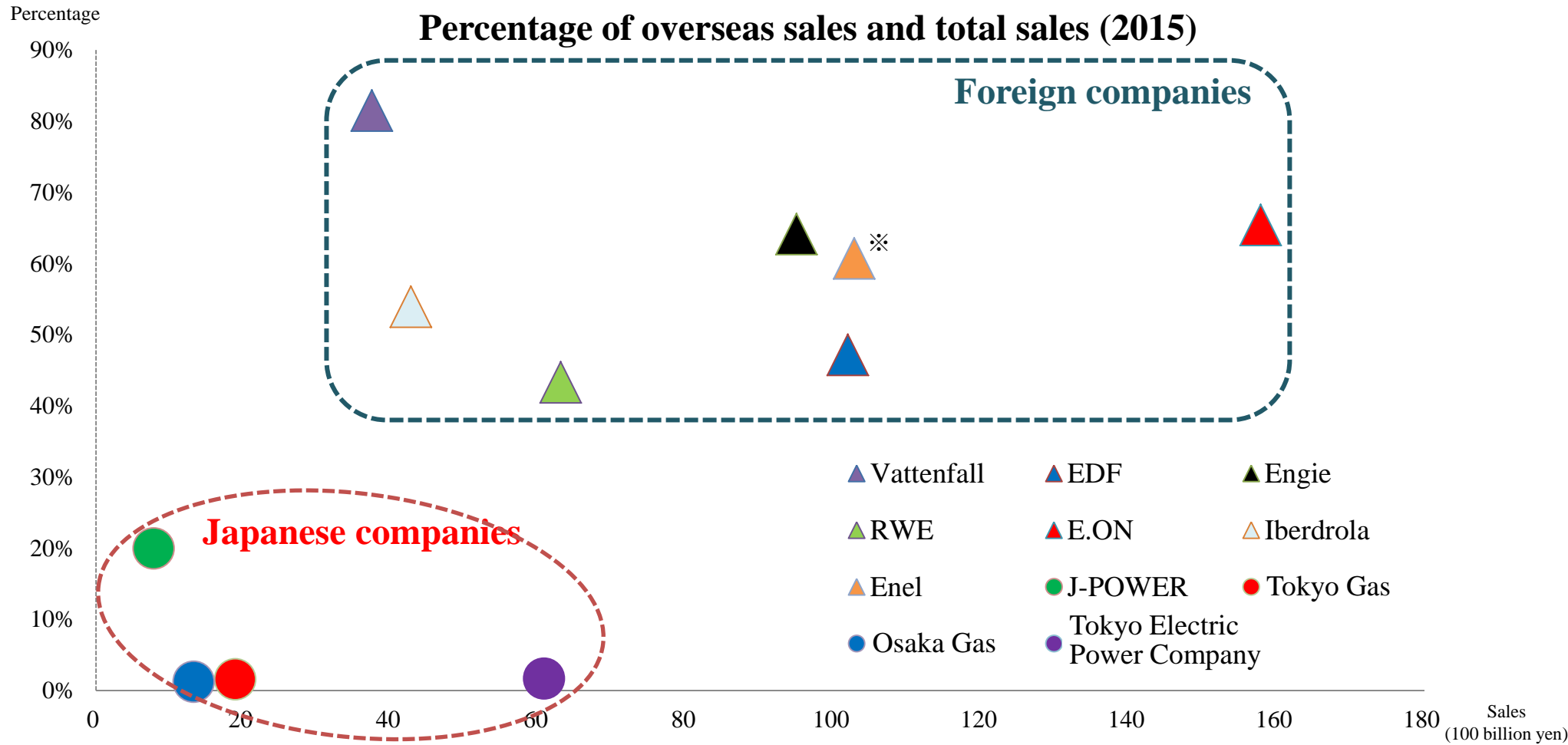
○ The key is the reduction of CO₂ emissions in emerging countries. What is the potential contribution of Japanese industry in emerging markets?

[Change 8] Chinese government-run companies are increasing their presence and M&As of energy companies are becoming active in Europe and the United States.

Both have started cross-border investment. On the other hand, Japanese electricity and gas companies lag far behind in overseas business expansion.

[Change 8] Increased presence of Chinese government-run companies and progress of M&As in Europe and the United States: Expansion of the size of foreign companies

Electricity and gas companies



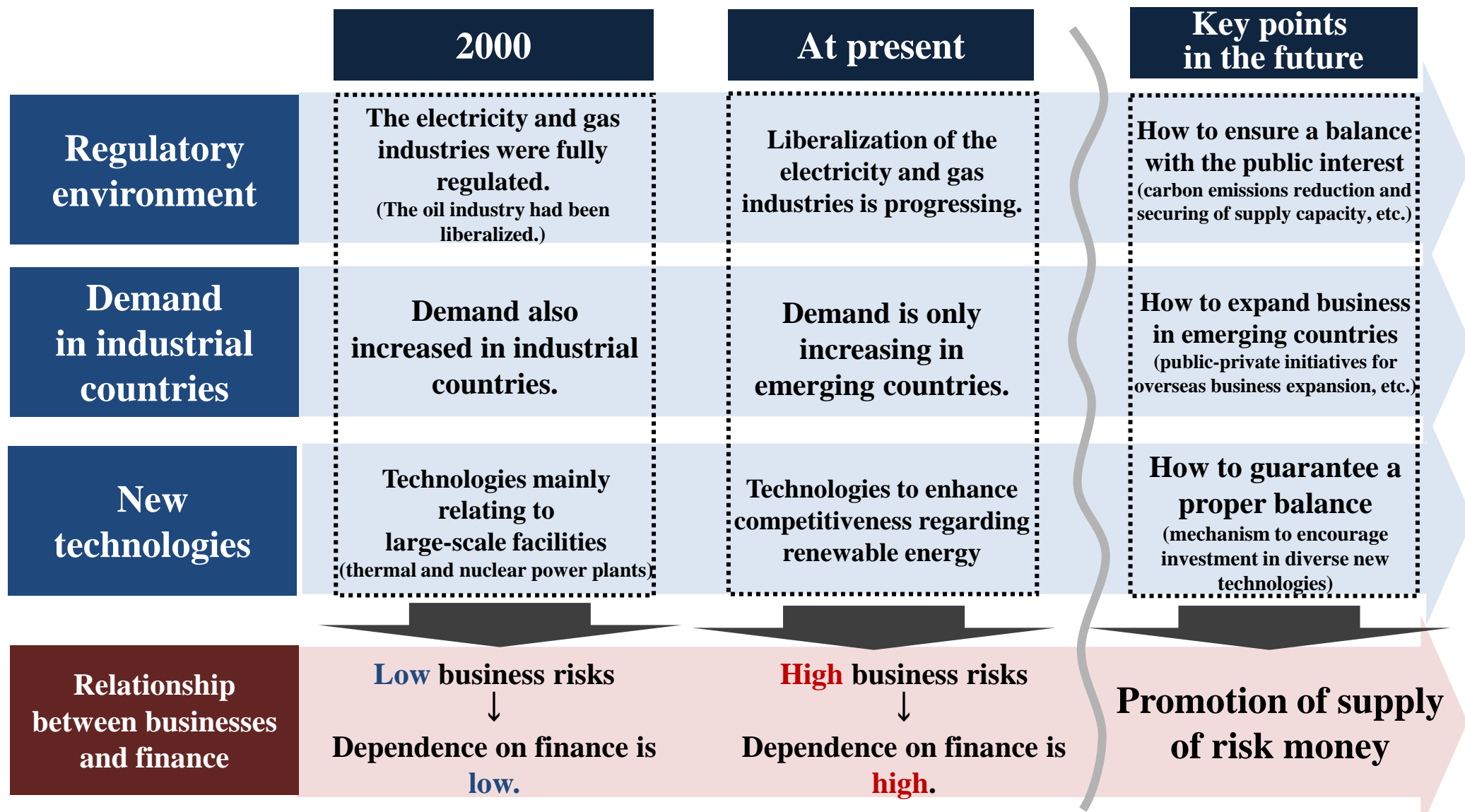
* Percentages of overseas sales are calculated based on the breakdown of the data of Sales and Service.

- What management models do Chinese and Western electricity and gas companies have?
- How should Japanese companies respond to achieve overseas business expansion?

[Change 9] Increasing presence of financial players

The financial sector has a significant impact on global energy selection. While China is strengthening its power, relevant organizations in Japan and the United States have come to take concrete cooperative actions. The designing of an energy finance system is a new challenge.

[Change 9] Increasing presence of financial players









○ Under what strategies should risk money be supplied in the energy field under market liberalization?

[Change 10] Intensifying geopolitical tensions observed worldwide

Major countries, such as the United States, Russia, China, India and Saudi Arabia, are developing national energy strategies and striving to expand their areas of economic influence, respectively. Japan also needs to establish its position.

[Change 10] Current status of Japan amid intensifying geopolitical tensions observed worldwide

	Self-sufficiency rate (2000)		Self-sufficiency rate (2015)	Major domestic resources	International infrastructure (systems and pipelines)
U.S.	73%		93%	Natural gas Coal/Oil	Linked to Canada and Mexico
France	52%		56%	Nuclear power	Linked across Europe
Germany	40%		39%	Coal	Linked across Europe
China	98%		85%	Coal	Linked to the Central Asia and Russia, etc.
India	80%		66%	Coal	Linked to neighboring countries
Japan	20%		7%	None	None

* 2014 for China and India

○ The Japanese energy structure has changed to be more vulnerable to geopolitical influences after the Great East Japan Earthquake.

○ How will geopolitical risks change? What strategies should Japan have?

Points at issue

[Change 1] Oil price declined from 100 dollars to 50 dollars per barrel.

- A proper forecast of oil price trends is the basis for energy selection.
- Oil prices are significantly affected by the future dissemination of EVs, in addition to the growth of emerging countries and the sustainability of the Shale Revolution. The key to a proper forecast lies in these considerations.

[Change 2] Prices of renewable energy decreased from 40 yen/kWh to 10 yen/kWh outside Japan.

- Due to FIT systems, investment in renewable energy has now exceeded that in thermal and nuclear power plants.
- However, it is necessary to sustain investment in renewable energy in order to be a major power source in terms of installed capacity.
- What is needed for independence from FIT?
- European countries and China are ahead of Japan in this field. How should Japanese renewable energy industries strengthen its competitiveness?
- How could battery innovation be accelerated? What are the conditions for Japan to lead the world in this field?
- How should the restructuring of large-scale NW and investment in distributed NW be simultaneously promoted?

[Change 3] EV development race in the automobile industry has intensified.

- The dissemination of EVs may change the energy demand structure and supply structure.
- What policy measure will foreign governments take in this field?
- What strategies do the automobile industry and major auto makers have for the long term?

[Change 4] While some countries have declared policies to abandon nuclear power, many countries are still utilizing nuclear power.

- How do public opinions concerning nuclear power differ by country?
- How do respective countries position nuclear power in their energy policy? What future strategies do they have for nuclear power?

[Change 5] The investment environment has come to face new challenges created by full liberalization of the electricity market and expanding use of renewable energy.

- Under circumstances where expanding use of renewable energy and liberalization of the electricity market cause large fluctuations in electricity prices, what measures should be taken to ensure sustainable development of and investment in power sources that require long gestation periods?

[Change 6] Withdrawal of the United States from the Paris Agreement has not changed the global outlook.

- What CO₂ strategies do major countries have: especially the United States, Europe, China and India?
- How should these economic measures be developed toward the future world in 2050?

[Change 7] The expanding world energy and electricity markets

- The key is the reduction of CO₂ emissions in emerging countries. What is the potential of Japanese industries in emerging markets?

[Change 8] Chinese government-run companies are increasing their presence and M&As of energy companies are becoming active in Europe and the United States.

- What management models do Chinese and Western electricity and gas companies have?
- How should Japanese companies respond to achieve overseas business expansion?

[Change 9] Increasing presence of financial players

- Under what strategies should risk money be supplied in the energy field under market liberalization?

[Change 10] Intensifying geopolitical tensions observed worldwide

- The Japanese energy structure has changed to be more vulnerable to geopolitical influences after the Great East Japan Earthquake. How will geopolitical risks change? What strategies should Japan have?

Schedule for the Energy Situation Roundtable

From the next meeting onward, the Roundtable will examine and ascertain global trends.

September 29 [Trends in geopolitical risks]

➡ Lectures by world intellectuals in the field of geopolitical risks and security

(Guest speakers)

- Prof. Paul Stevens (Royal Institute of International Affairs, UK)
- Mr. Adam Sieminski (Center for Strategic and International Studies, US)

October [Trends concerning global warming]

➡ Lectures by world intellectuals with different standpoints concerning energy selection

From November onward

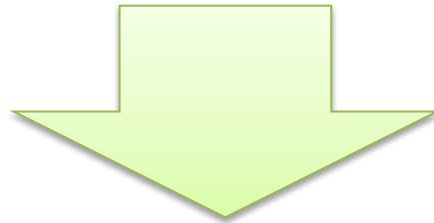
[Management strategies of major players]

➡ Learning from world electricity industries, oil major companies, renewable energy industries and automobile industries

[Energy environment strategies of major countries]

➡ Learning from major countries, such as European countries, the United States, China and India, which are facing different circumstances

- **Achieving a proper energy mix by 2030 and reducing greenhouse gas emissions by 80% by 2050 are the major policy goals of the Japanese government.**
- **Ascertain future global scenarios concerning energy toward 2050**
 - Trends in world situations and development, geopolitical risks, and countermeasures against global warming
 - Future technological reform, changes in industrial structure, and trends in the financial sector
 - Environmental strategies and energy strategies of major countries



- **Envisage comprehensive strategies for the country, system and industry so that Japan can lead the whole world in technological innovation, personnel development, efficient investment, and overseas contribution.**