METI
Ministry of Economy, Trade and Industry

Recent Trends in Energy and the Progress of Policies toward Energy Transition and Decarbonization

July 1, 2019

Agency for Natural Resources and Energy

1. Recent trends in energy

(1) Movements toward energy transition and decarbonization

(2) Recent trends in energy security and geopolitics

2. Study of policies toward energy transition

(1) Progress in liberalization of electricity market

(2) Activities toward decarbonized energy system

- Electricity network policy
- Use of renewable energy as main power source
- Activities toward winning back social trust in nuclear power

(3) Energy conservation (fuel efficiency standards and thermal power generation)

(4) Promotion of innovation (hydrogen and CCS)

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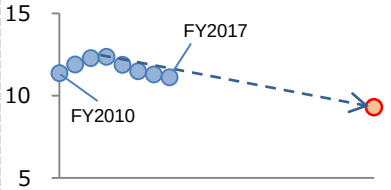
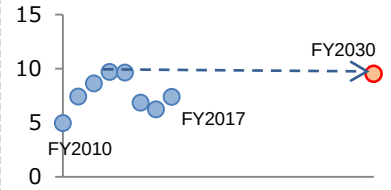
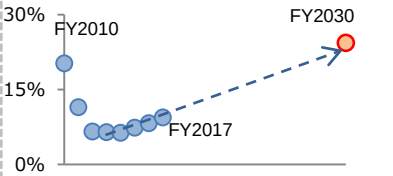
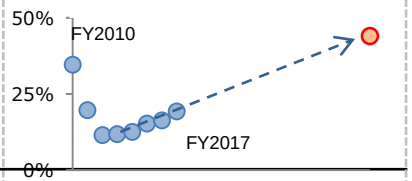
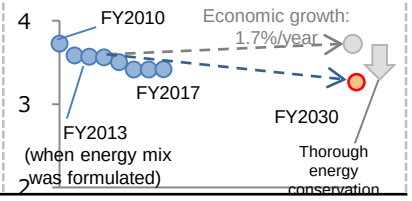
Energy policies and measures to cope with climate change

2014	Apr.	**4th Strategic Energy Plan**	First strategic plan after the Great East Japan Earthquake
2015	Jul.	Energy mix formulated	2030 CO_2: -25% from FY2013 Renewables: 22 - 24% in power generation, nuclear: 22 - 20%
		Intended Nationally Determined Contributions (INDC) formulated	2030 GHG: -26% from FY2013
	Dec.	Paris Agreement adopted	
2016	May	**The Plan for Global Warming Countermeasures formulated**	2050 Working on 80% reduction of GHG emissions as a long-term goal, while balancing global warming countermeasures and economic growth
	Nov.	Paris Agreement comes into effect.	2050 To achieve balance between emissions of greenhouse gas from anthropogenic emission sources and gas removed by absorption sources in the second half of this century Efforts to keep a rise in the average temperature of the whole world to within 2°C above the pre-industrial level and limit it to 1.5°C will be continued.
2017	Apr.	Report of the Long-term Climate Change Policy Platform	2050 Reducing GHG emissions by 80% is difficult with existing technology. International contribution, global value chain, innovation
	Dec.	Basic Hydrogen Strategy	2030 Action plan toward 2050 Development of international supply chains and development of domestic technology for producing hydrogen derived from renewable energy 2050 Vision toward realization of hydrogen society Realization of CO_2-free hydrogen
2018	Apr.	Holding a round-table meeting for discussing energy situation proposed	2050 Possibilities and uncertainties – Ambitious, multi-track scenario Pursuit for every choice
	Jul.	**5th Strategic Energy Plan formulated**	2030 Accurate materialization of energy mix 2050 Challenging energy transition and decarbonization
2019	Apr.	The Recommendation from the Meeting on a Long-Term Strategy under the Paris Agreement as Growth Strategy	2050 Boldly taking measures towards the reduction of GHG emissions by 80% Realizing “a virtuous cycle of environment and growth” Aiming to accomplish a “decarbonized society” ambitiously as early as possible in the second half of this century
	Jun.	**The Long-term Strategy formulated**	

***Black bold:** Measures approved by the Japanese cabinet

Progress in Energy Mix for FY2030
– Japan is making steady progress but halfway through the target energy mix –

	Before the Great East Japan Earthquake (FY2010)	After the Great East Japan Earthquake (FY2013)	Current (FY2016)	Current (FY2017)	Energy mix (FY2030)	Progress
Effort indices (3Es)						
(1) Emissions of energy-related CO_2 (Total GHG emissions)	1.14 Gt (GHG:1.31 Gt)	1.24 Gt (GHG:1.41 Gt)	1.13 Gt (GHG: 1.31 Gt)	1.11 Gt (GHG:1.29 Gt)	0.93 Gt (GHG:1.04 Gt)	
			Use of freon and residential sector increase but decreases in industry and energy transformation sectors.			
(2) Power cost (Fuel cost & FIT purchase cost)	5.0 trillion yen Fuel cost: 5.0 (Oil price: $83/bbl) FIT purchase: 0	9.7 trillion yen Fuel cost: 9.2 (Oil price: $110/bbl) Quantum factor: +1.6 Price factor: +2.7 FIT purchase: 0.5	6.2 trillion yen Fuel cost: 4.2 (Oil price: $48/bbl) Quantum factor: -1.0 Price factor: -4.1 FIT purchase: 2.0	7.4 trillion yen Fuel cost: 5.0 (Oil price: $54/bbl) Quantum factor: -1.4 Price factor: -2.9 FIT purchase: 2.4	9.2 to 9.5 trillion yen Fuel cost: 5.3 (Oil price: $128/bbl) FIT purchase: 3.7 to 4.0	
(3) Energy self-sufficiency ratio (Overall primary energy)	20%	7%	8%	10%	24%	
Achievement indices						
(4) Ratio of zero-emission power sources	35% Renewables: 9% Nuclear: 25%	12% Renewables: 11% Nuclear: 1%	16% Renewables: 15% Nuclear: 2%	19% Renewables: 16% Nuclear: 3%	44% Renewables: 22 to 24% Nuclear: 22 to 20%	
(5) Energy conservation (Final energy consumption in crude oil equivalent)	**380 billion L** Industry/ commercial: 2.4 Residential: 0.6 Transport: 0.9	**360 billion L** Industry/ commercial: 2.3 Residential: 0.5 Transport: 0.8	**340 billion L** Industry/ commercial: 2.1 Residential: 0.5 Transport: 0.8	**350 billion L** Industry/ commercial: 2.2 Residential: 0.5 Transport: 0.8	**330 billion L** Industry/ commercial: 2.3 Residential: 0.4 Transport: 0.6	

*The total may not add up due to rounding.
*Power cost in FY2030 includes 0.1 trillion yen for stabilizing power grids.

Source: Prepared by ANRE based on the data in the General Energy Statistics (FY2017 final), etc.

Strategies of major countries

	Reduction target	Flexibility	Main strategy, posture: Zero emission rate	Main strategy, posture: Energy conservation /electrification	Main strategy, posture: Overseas
Japan	2050: **−80%** Final goal: **Decarbonized society**	**Long-term vision as "ideal model" (pursuit for all choices and flexible review)** This strategy sets forth a long-term vision as an "ideal future model" in each area. In order to achieve such business-led disruptive innovation, it is necessary to explore all possible options and review them in a flexible manner.	Increase in zero-emission rate Renewables + nuclear **Carbon recycle** **Realization of hydrogen society**	**Promotion of energy efficiency and electrification**	**Contribution through introduction of environmental technology and products to global markets**
U.S.	**−80% or more**	**Ambitious vision towards reduction target (not intended as current policy proposals)** providing **an ambitious vision** to reduce net GHG emissions by 80 percent or more below 2005 levels by 2050.	**Increase in zero-emission rate** **Variable renewables + Nuclear**	**Large-scale electrification (from 20% to 45 to 60%)**	**Contribution through expanding market for US products**
Canada	**−80%**	**Information supply for discussion (no blue print for policy)** not a blue print for action. Rather, the report is meant to **inform the conversation** about how Canada can achieve a low-carbon economy.	**Securing the electricity** **Hydro and variable renewables + Nuclear** * Zero emission rate already at approx. 80%	**Large-scale electrification (from 20% to 40 to 70%)**	**Looking to contribute internationally (0 to 15%)**
France	**−75%**	**Possible path for achieving objectives (not an action plan)** the scenario is not an action plan: it rather **presents a possible path** for achieving our objectives.	**Securing the electricity** Renewables + Nuclear * Zero emission rate already at more than 90%	**Large-scale energy conservation (half from 1990)**	**Contribution through international development support by French businesses**
U.K.	**−80% or more**	**Helps players identify steps to take in the next few years (long-term predictions are difficult) by exploring potential pathways** exploring the plausible potential pathways to 2050 **helps us to identify low-regrets steps we can take in the next few** years common to many versions of he future	**Increase in zero-emission rate** Variable renewables + Nuclear	**Promote energy conservation/ electrification**	**Lead the world through environmental investment**
Germany	**−80% to −95%**	**Point to the direction towards reducing emissions (not a search for a masterplan)** * Conduct regular reviews not a rigid instrument; it points to **the direction** needed to achieve a greenhouse gas-neutral economy.	**Increase** **Variable renewables**	**Large-scale energy conservation (half of 1990 levels)**	**Maintaining and bolstering investment in developing countries**

Outlines of Japan's Long-term Strategy under the Paris Agreement (Cabinet decision, June 11, 2019)

Provisional Translation

Chapter 1: Basic Concepts

- **Proclaiming a "decarbonized society" as the ultimate goal and aiming to accomplish it ambitiously as early as possible in the second half of this century**, while boldly taking measures towards the reduction of GHGs emissions by 80% by 2050
  * an unconventional vision of an "ideal future model" * contributing to the achievement of the long-term goals of the Paris Agreement, including efforts to limit the temperature increase to 1.5℃
- **Realizing "a virtuous cycle of environment and growth"** towards the vision with business-led disruptive innovation, Swift implementation of actions from now, contributing to the world, **Action Towards a bright Society with Hope for the Future**

[Factors: Achievement of SDGs; "Co-innovation", Society 5.0; the "Circulating and Ecological Economy"; and leading country in solving problems]

Chapter 2: The Vision of Each Sector and the Direction of Measures

Section 1: Measures for Emissions Reductions

1.Energy: For energy transition/decarbonization, pursuing every option

- Utilizing renewable energy as the major power source
- Reducing CO_2 emissions from the thermal power in line with the long-term goals of the Paris Agreement
- Promoting CCS&CCU/Carbon Recycling
- Realizing a "Hydrogen Society"/battery/nuclear/energy efficiency

2.Industry: Decarbonized manufacturing

- Use of CO_2-free hydrogen
(e g. a challenge towards "zero-carbon steel")
- Feedstock change (e.g. CCU including artificial photosynthesis and biomass utilization)
- Achieving drastic energy efficiency, and complete transition from fluorocarbons in mid-long term

3.Transport: the challenge of "Well-to-Wheel Zero Emission"

- Achieving the highest level of environmental performance of Japanese vehicles supplied worldwide by 2050
- Road/transport systems using big data and IoT

4.Community and Living: Achieving carbon neutral, resilient and comfortable communities and living by 2050/ creating a "Circulating and Ecological Economy"

- Capable communities and corporations to achieve carbon neutrality even before 2050
- Shift to carbon neutral living (encouraging technology development and dissemination to achieve net Zero Energy Buildings, equivalency in stock average of housing and office buildings/ shift of lifestyles)
- Carbon-neutral community building (urban city building, farming/forestry/fishing villages building, and development of distributed energy systems)

Section 2: Measures for Carbon Sinks

Chapter 3: Cross-sectoral Measures for Achieving a Virtuous Cycle of Environment and Growth

Section 1: Promotion of Innovation

- Promoting innovation for practical application and wide usage of cross-sectoral decarbonization technology leading to drastic reduction of GHG, achieving cost that allows commercialization for social application

(1) Progressive Environment Innovation Strategy

- Setting clear goals such as costs, maximizing investment of public and private resources, discovering and creating technological seeds in and outside Japan, setting issues from demands, strengthening support that leads to commercialization
- Challenging R&D, and enhancing alliances among R&D institutes with facilita ion of international joint R&D activities
[Research and Development 20 for clean energy technologies (RD20)]
- Target setting and visualizing challenges for the practical use
  - Realizing hydrogen cost equivalent to existing energy: e.g. lowering manufacturing cost of CO_2-free hydrogen to 1/10
  - CCU/carbon recycled products to be provided with costs equivalent to existing products, nuclear power (such as Reactor, Fusion)

(2) Innovation in Economic and Social Systems/lifestyle

Section 2: Promotion of Green Finance

- Appropriately "visualizing" corporate efforts in innovation etc. and mobilizing finance for innovation by financial ins itutions

(1) Mobilizing green finance through TCFD※ disclosures and dialogues ※Task Force on Climate-related Financial Disclosures

- Industry: improving TCFD Guidance & Scenario Analysis Guide / Financial sector: Formulating a guidance on green investment
- Facilitating dialogue between industry and financial sector (TCFD Consortium)
- Promoting discussion and share the above initiatives with the world (TCFD Summit)

(2) Promoting initiatives to expand ESG finance

- Initia ives for ESG finance (Support to the issuance of green bonds, encouraging local ESG finance), development of ESG Dialogue Platform, enhancing ESG finance literacy, ESG Finance High-Level Panel

Section 3: Business-led Promotion of International Application and International Cooperation

- Promoting competitive technology and products with high environmental performance/ promoting co-innovation benefi ing participants from both countries

(1) Promotion of international application of decarbonization technology together with policy/institutional development and international rule-making

- Promotion of international application of decarbonization technologies and reductions of GHG emissions through development of business environment by improving business environment including working for institutional development in partner countries leading international rule-making cooperating in building policy and institutional framework in partner countries and by international rule-making (e.g. establishing public and private-sector initiatives in ASEAN, and developing appropriate international frameworks for utilizing market-based mechanisms)

(2) Strengthening Development and Investment of infrastructure that contributes to CO_2 emission reductions

- Development and investment of energy and city/transport infrastructure that contributes to CO_2 emission reductions in line with the long-term goals of the Paris Agreement (e.g. renewable energy such as offshore wind power and geothermal power, hydrogen, CCS&CCU/carbon recycling, smart cities)

(3) Creating platforms for global scale decarbonized society building

- Supporting partner countries in the formulation of NDCs and mitiga ion measures, enhancing transparency in the overall supply chains

Chapter 4: Other Measures

- Human Resource Development
- Just transition
- Government-led initiatives
- Integrating climate change adaptation with development of a resilient society
- Carbon Pricing (Expert/technical level discussions)

Chapter 5: Review and Implementation of the Long-term Strategy

- **Review:** Re-examining policies and measures flexibly about every 6 years with reference to situa ions, and improving the Long-term strategy if necessary
- **Implementation:** Analyzing relevant factors responding to future changes in the situations / collaborating and having dialogues with stakeholders including he youth

Significance and purpose of G20 ministerial meeting on energy transitions and global environment for sustainable growth

- Focus on the importance of **virtuous cycle of environment and growth** and **energy transitions**.
- Communiqué and Action Plan were issued at the ministerial meeting on June 15 and 16.

Result of G20 ministerial meeting in Karuizawa

(1) Documents produced

Communiqué	Basic policy for international information sharing and cooperation.
Karuizawa Innovation Action Plan	The concrete actions to realize the contents of the Communiqué. Activities of each nation are summarized and attached. International organizations will provide follow-up.

(2) Matters agreed to:

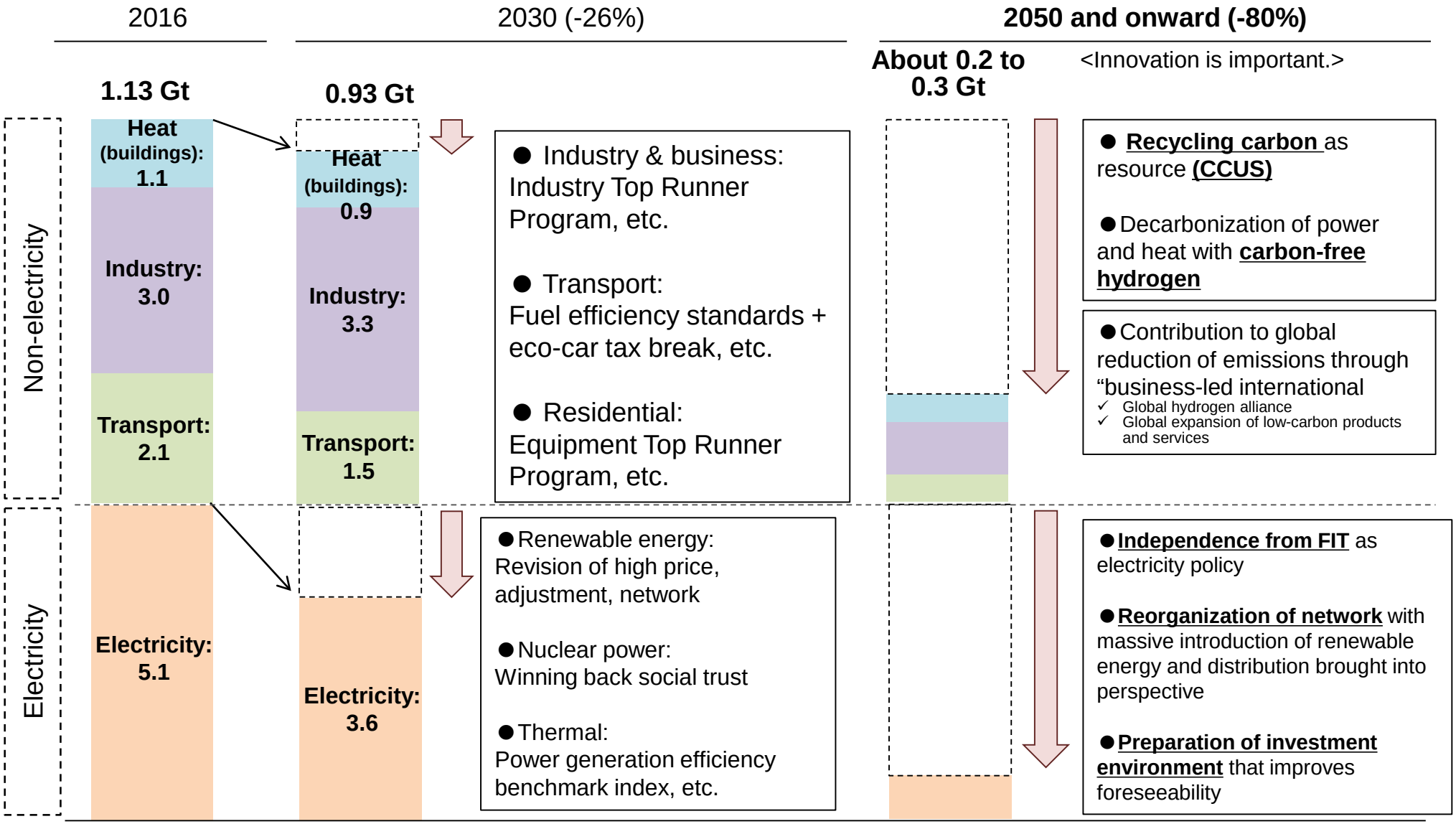
✓ Sharing of policy concept toward energy and environment fields
- Importance of **virtuous cycle of environment and growth** based on domestic long-term growth strategies discussion
- Realization of **energy transitions**. Importance of **energy security** (referring to "recent developments highlighting concern" (in mind the attack in the Strait of Hormuz))

✓ Specific cooperation of G20 members
- Collecting wisdom from around the world including the annual conference of **RD20 (Research and Development 20)**, **mobilizing finance**, and improving **business environments** to encourage innovation
- Strengthening **international cooperation on innovation such as hydrogen, CCUS,** and **nuclear**. Japan proposes "**Carbon Recycling**".
- Analysis of global energy efficiency benchmark (including **Well-to-Wheel**)
- **Promotion of investment in low-carbon power sources** and **system integration of renewable energy**
- **Cooperation in decommissioning and final disposal of radioactive waste regarding nuclear, cleaner fossil fuel technologies, transparency and flexibility of the international market for natural gas including LNG, and improvement of energy access**

*Result of environment part: **Implementation Framework for Actions on Marine Plastic Litter** and **Action Agenda on Adaptation and Resilient Infrastructure**

Action toward 2030 and 2050

Substantial reduction of CO_2 emissions through innovation and international cooperation is indispensable for energy transition and decarbonization.



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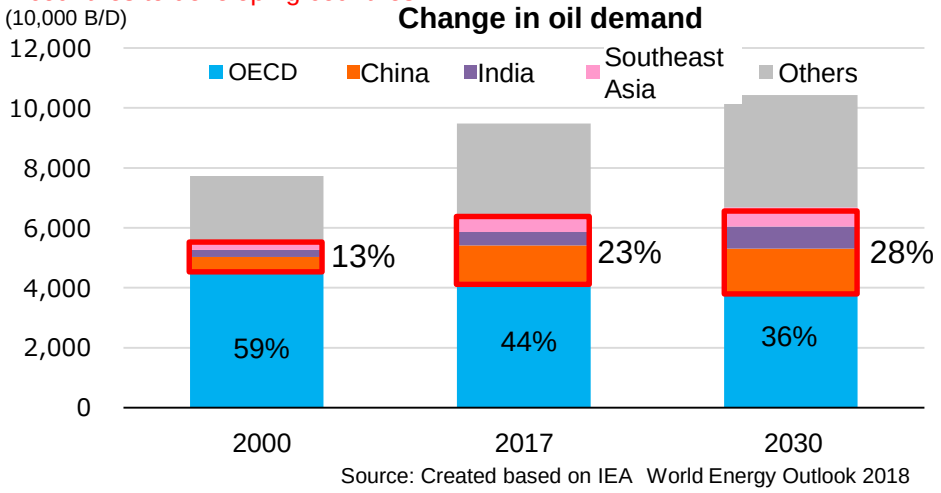
Five changes in recent trends in energy security and geopolitics (1)

First change: Change in supply and demand structure

(1) Demand: Expansion of presence of developing countries and progress in shift to low carbon

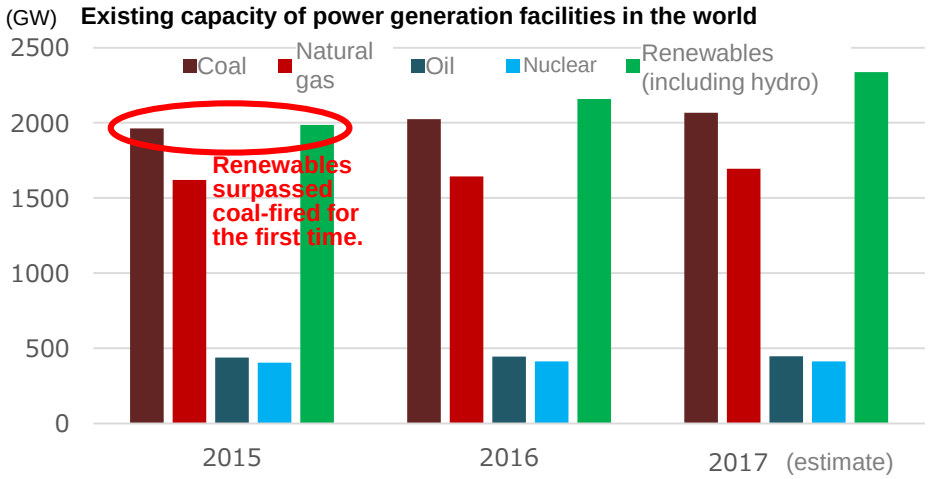
(2) Supply: Diversification of supply sources such as the U.S. and Arctic Circle

(1) "Quantitative conversion": Change in main consumers from developed countries to developing countries



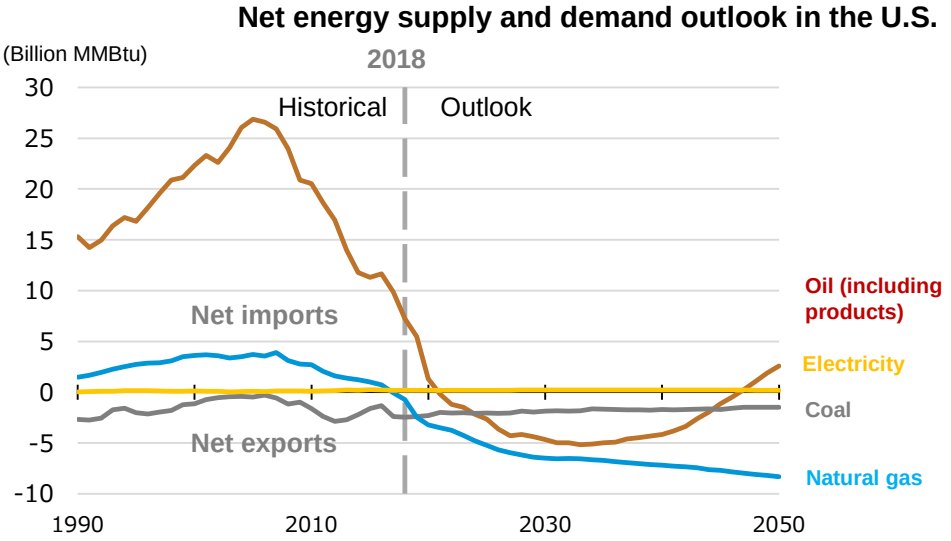
Source: Created based on IEA World Energy Outlook 2018

(2) "Qualitative conversion": Progress in reduction of CO_2 emissions and increased introduction of renewable energy to developing countries



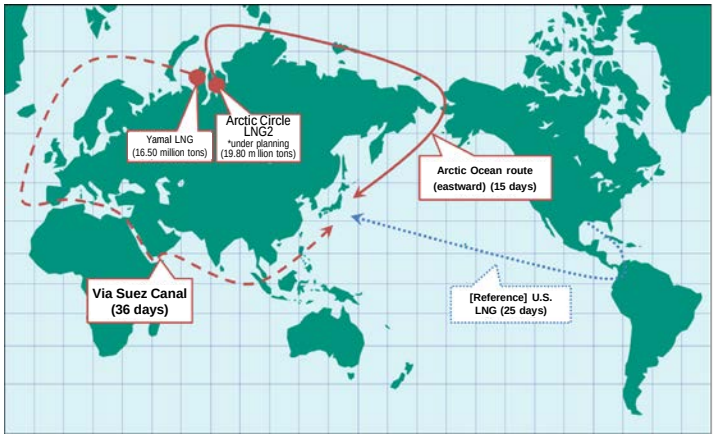
Source: IEA, WEO2018

"U.S. as net energy exporting country and LNG supply from the Arctic Circle"



Source: EIA, AEO2019

New supply of LNG from the Arctic Circle



Source: Material of Resource and Fuel Subcommittee of ANRE

Five changes in recent trends in energy security and geopolitics (2)

Second change: Change in geopolitical risk

(1) Changes related to oil producing countries

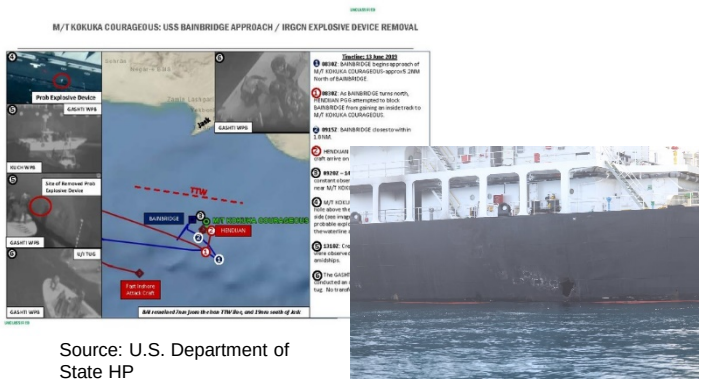
(1) "U.S. foreign policy using energy as leverage"

- Indo-Pacific Strategy
- Countering China and Russia
- Sanctions on Iran, etc.

Source: U.S. Department of State HP. Secretary of State Pompeo making a speech at CERAWEEK

(2) "Tense Middle Eastern situation"

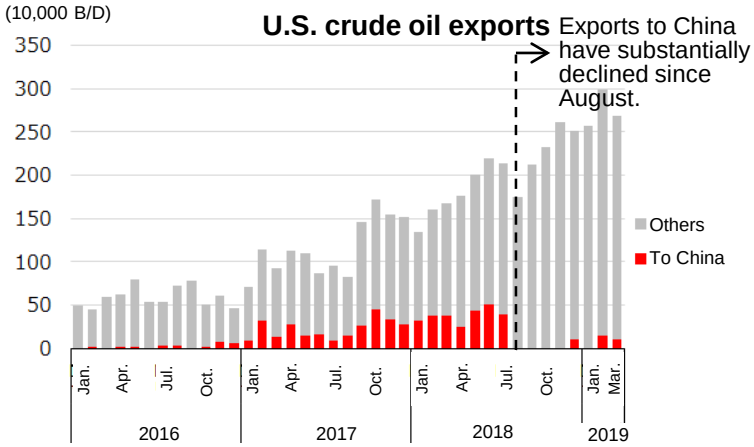
- Tense situation in the Strait of Hormuz



Source: U.S. Department of State HP

(2) Stagnation of free trade

"Trade friction between US and China"



Source: Created based on EIA data

Third change: Change of environment recognition

(1) Effect of Paris Agreement

"Divestment and change of investment orientation

- Presence of financial player/ESG investment

Movements of European financial institutions (example)

- **Divestment:** Withdrawal of investment in resource mining companies where coal mining surpasses 50% of the sales, or power generation operators using coal for more than 50% of power generation
- **Insurance underwriting:** Suspension, in principle, of underwriting insurance from resource mining companies where coal mining surpasses 50% of the sales or power generation operators using coal for more than 50% of power generation

- **Lending policy:** New loans, as well as extended loans, to coal-fired power plants are prohibited. However, loans to power plants with CCS can be considered on a case-by-case basis.

(2) Innovation

"Invigoration of investment in innovation"

- CCUS/carbon recycling
- Major oil companies also making investment toward decarbonization

OGCI Climate Investments

- **Fund of $1 billion** invested by member companies
- Proactive investment in the following three areas planned:
  (1) **Reduction of methane leaks**
  (2) **Reduction of carbon dioxide emissions**
  (3) **Promotion of CCUS**

Source: Material of Resource and Fuel Subcommittee of ANRE

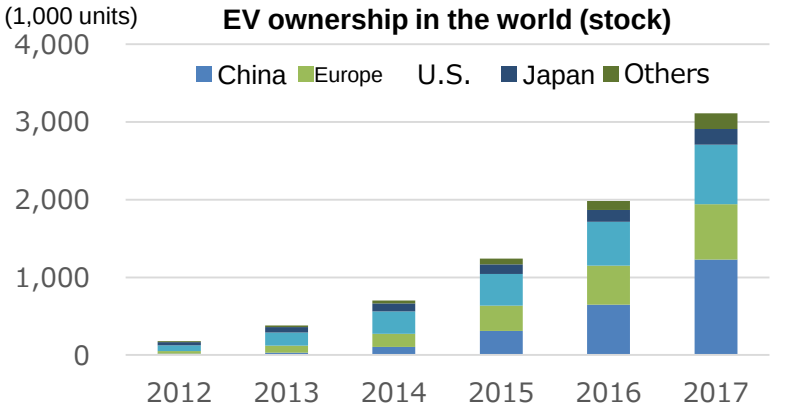
Five changes in recent trends in energy security and geopolitics (3)

Fourth change: Technological changes

(1) Demand

"Change in demand structure brought by technology"

・Electrification and sharing may lead to substantial changes of demand.



Source: IEA, Global EV outlook 2018

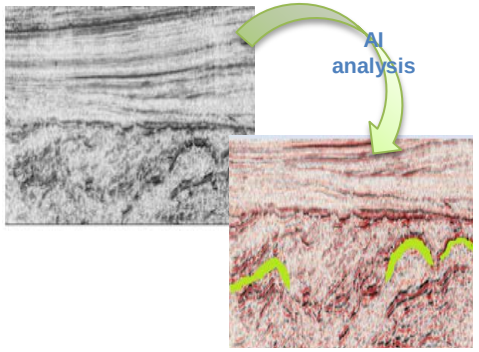
(2) Supply

(1) "Change in investment cost and cycle", (2) "Investment in decarbonization technologies"

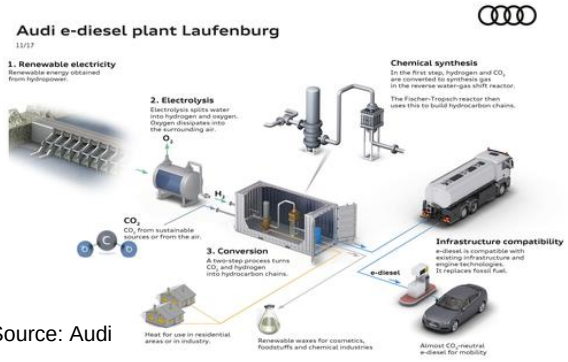
・Use of AI-based mining technology and increased production of shale ⇒ Cost reduction and shortening of investment cycle

・Formation of stable assets that can withstand fluctuation in oil price and stranding of assets

Advancing resource exploration through AI analysis



Synthetic fuel



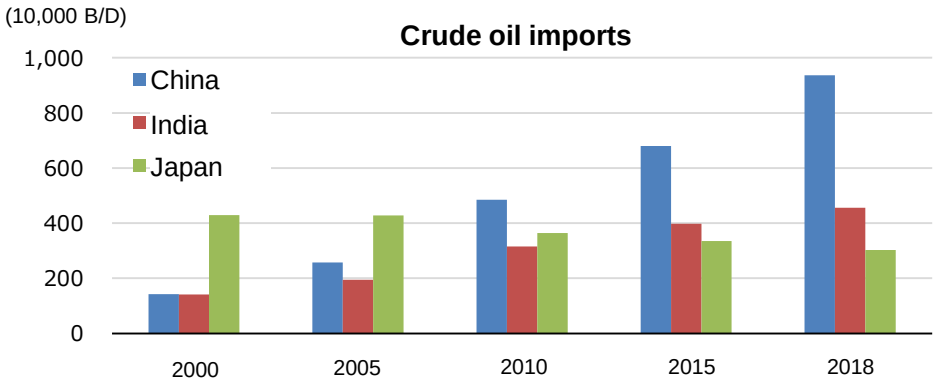
Source: Audi

Fifth change: Change of position of Japan

(1) International

"Decline in relative position as investment target and object of trading"

・Fall in domestic demand ⇒ Decrease in bargaining power



Source: Global Trade Atlas Import code 270900

(2) Domestic

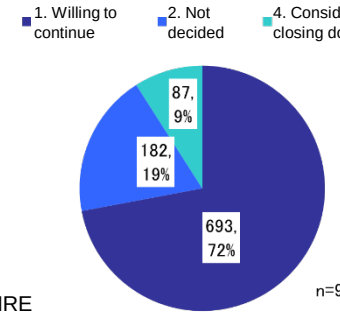
"Stagnation of long-term infrastructure investment and idling of existing facilities and equipment"

・Mid- to long-term maintenance of infrastructure is an issue. ⇒ Problem in areas where service stations (SS) run short of fuel

Municipalities where SSs run short of fuel

	End of FY2015	End of FY2016	End of FY2017
0 place	11	12	10
1 place	71	75	79
2 places	100	101	103
3 places	106	114	120
Total	288 municipalities (+5)	302 municipalities (+14)	312 municipalities (+10)

Willingness of SSs in municipalities where SSs run short of fuel to continue business into future



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Source: Material of Resource and Fuel Subcommittee of ANRE

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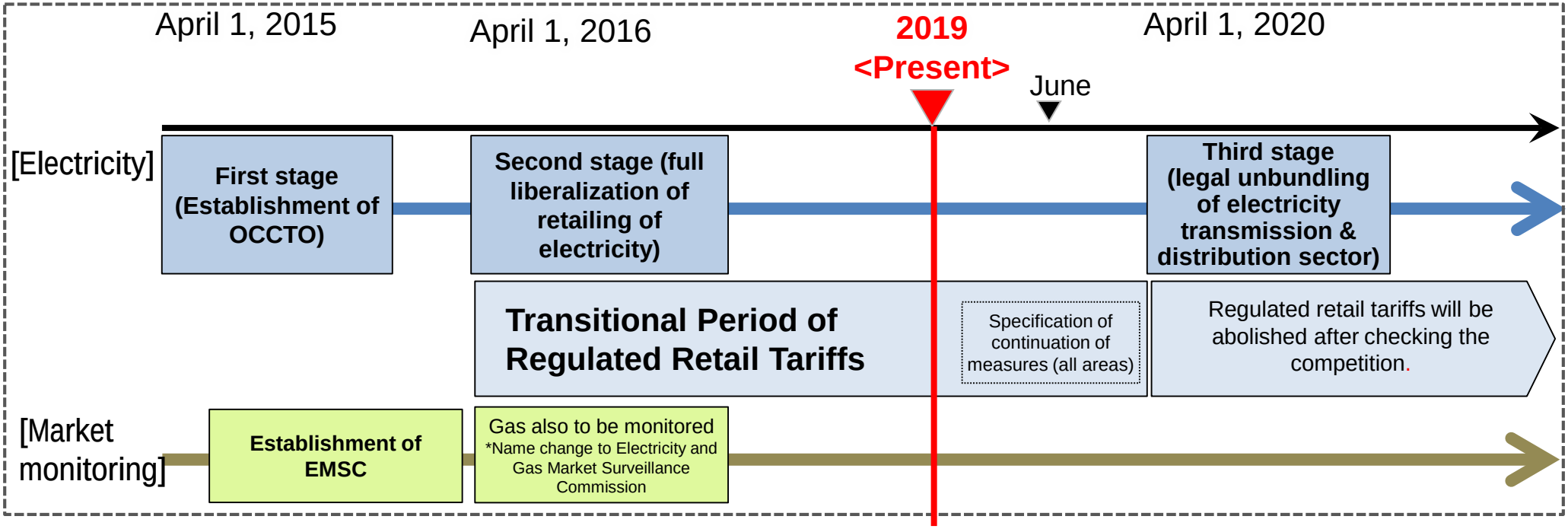
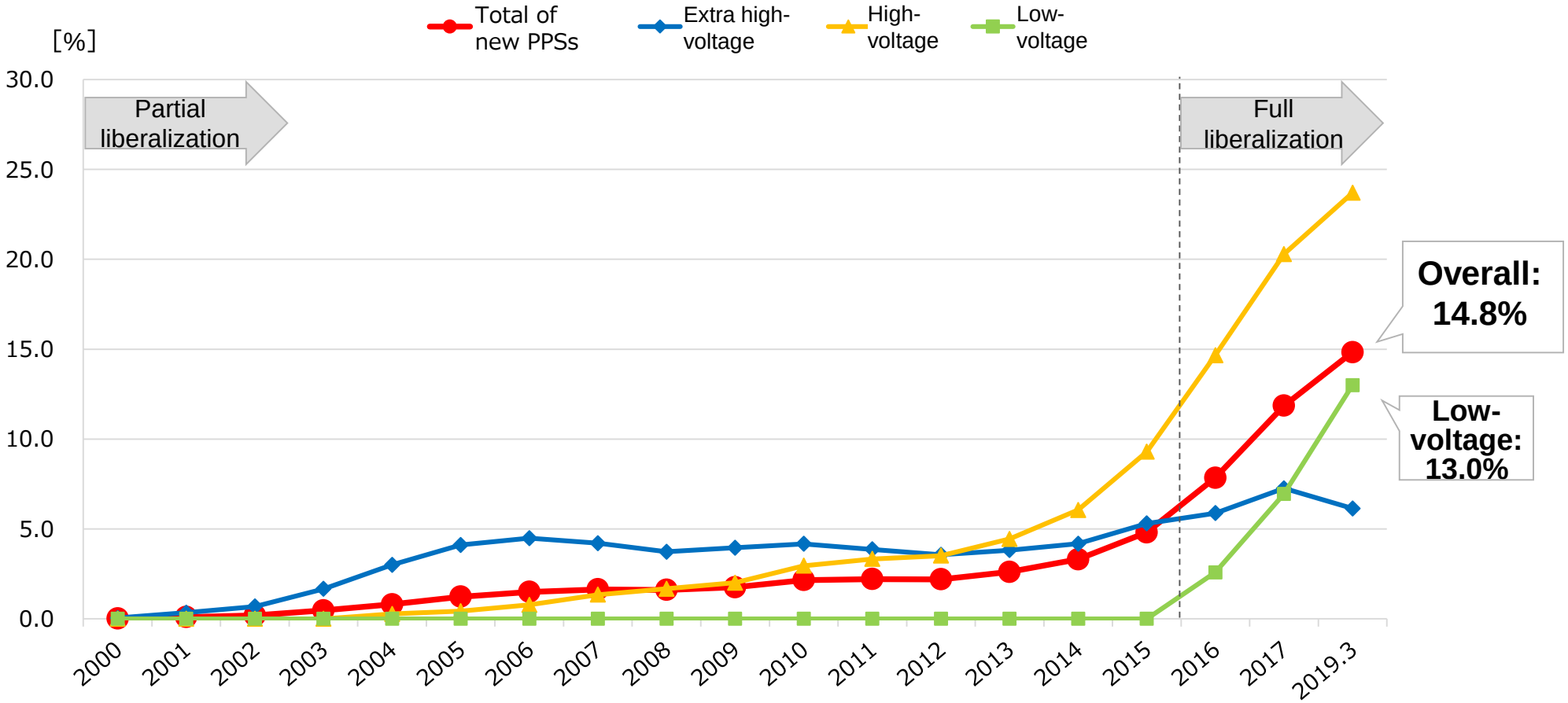
Progress in electricity system reform

- Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) was established in April 2015 and Electricity Market Surveillance Commission (EMSC) was set up in September of the same year.
- **Retailing electricity was fully liberalized** in April 2016. **The share of new power producers and suppliers (PPSs) rose to 15% in 3 years** after the liberalization.
- Transitional period of regulated retail tariffs is planned to continue in all areas, even after 2020.
- The result of verifying the electricity system reform was announced on June 26, 2019
- **Power generation and transmission/distribution are planned to be unbundled in April next year (2020) according to the revised Electricity Business Act**, to ensure impartial use of electrical power networks by renewable energy operators.



Change in share of new power producers and suppliers (PPSs)

- The PPSs' **share of total electricity sold** has surged especially since full liberalization of retailing in April 2016, standing at **about 14.8%** as of March 2019.
- They take up **about 13.0%** of the **share in the low-voltage field, including households**, as of March 2019.

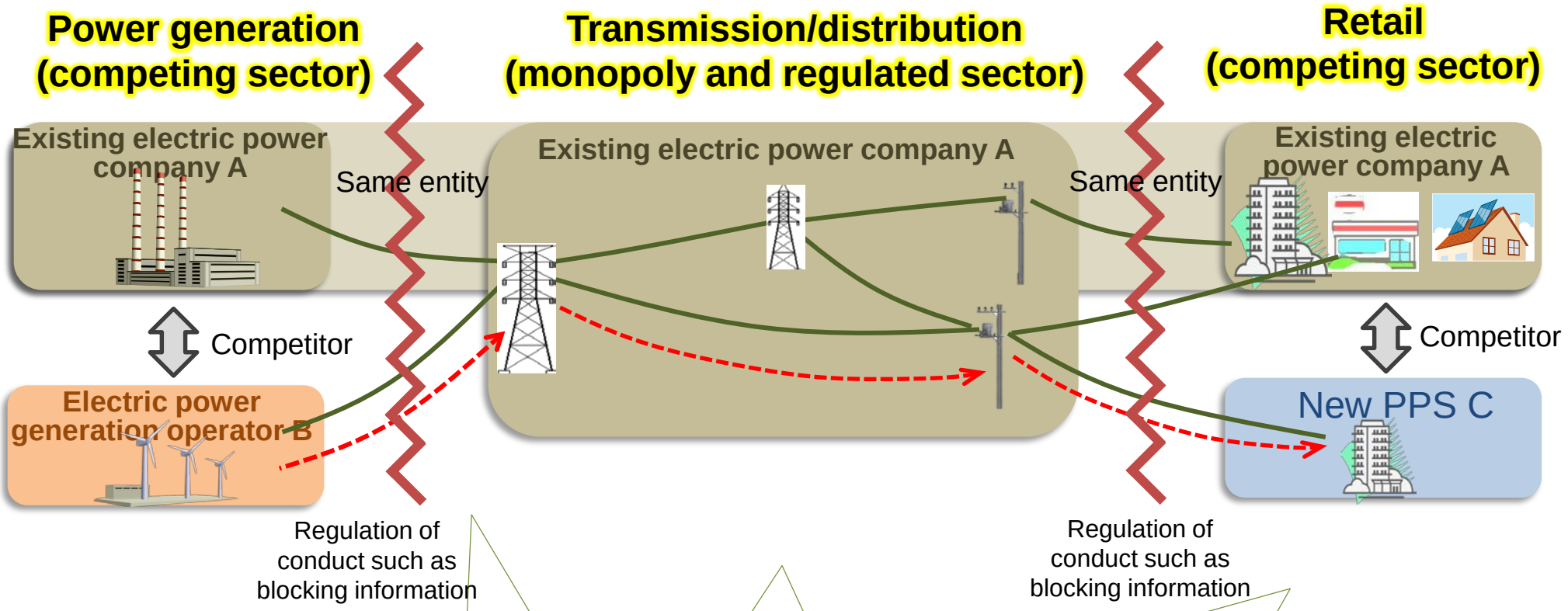


*The "new PPSs" above do not include major electric power companies (former general electric utilities) outside the service area but include the subsidiaries of major electric power companies.
*The share is calculated from electricity sold.

(Source) Electric power survey and statistics, el ectric power trade report

Neutralization of electricity transmission and distribution sector (2020)

- To realize active competition in the electricity market, it is necessary to neutralize the electricity transmission and distribution network sector, so that anyone who pays a proper price (wheeling charge) can use the network in a fair and equal manner.
- The present “Accounting separation” does not make clear internal exchanges between power generation and transmission/distribution as a contract between companies and faces challenges in that external verification is difficult and the rules of transmission are not applied.
- For this reason, **transmission/distribution will be legally unbundled in 2020 to enhance the neutrality of the electricity transmission/distribution sector.**



Example of problem that may impair neutrality

(1) Giving priority to connection by power plant of company A

(2) Wheeling rules not applied

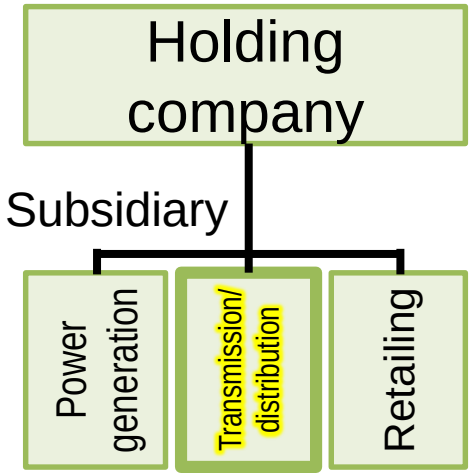
(3) Using information that was gained during power transmission/distribution operation for a purpose other than the business operation of the company

(Reference) Preparations by utilities toward unbundling of electricity transmission/distribution

- **Major electric power companies have already announced** their organizational structure after legal unbundling. **At a shareholder meeting in June this year, they obtained approval for splitting-up.**

<Holding company format>

Tokyo and Chubu



(Example of tradename or name of transmission/distribution operator after split-up)

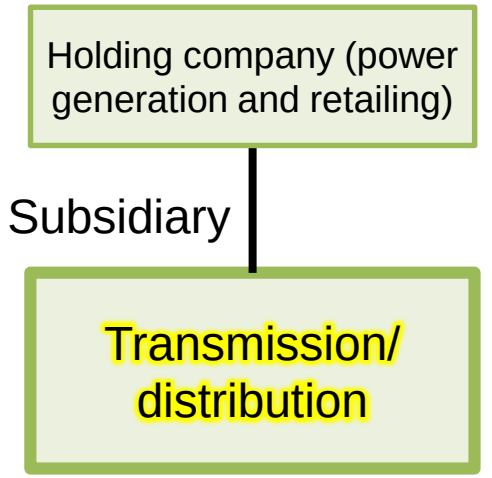
TEPCO Power Grid, Inc.

*TEPCO underwent split in 2016.

<Power generation and retailing parent company format>

Other companies

Hokkaido, Tohoku, Hokuriku, Kansai, Chugoku, Shikoku and Kyushu



Kansai Transmission and Distribution, Inc.

Tohoku Electric Power Network Company, Inc.

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      - Activities toward winning back social trust in nuclear power
   (3) Energy conservation (fuel efficiency standards and thermal power generation)
   (4) Promotion of innovation (hydrogen and CCS)

Direction and present situation of consideration of network policy

Structural change

(1) Opaque demand outlook due to declining population, etc.
⇒ Declination of predictability of investment

(2) Making renewables main electricity source
⇒ Grid reinforcement needed for both C&M
⇒ Increased regional deviation

(3) Reinforced resilience
⇒ Wide transmission area
⇒ Quick recovery from disaster

(4) Aging of facilities and equipment
⇒ Need of investment in renewal

(5) Progress in digitization
⇒ Distribution: Control of distributed resources
⇒ Bidirectional flow of electricity

＋

System reform
(The separation of power generation and transmission)

Characteristics of network business

Direction of network policy

(1) Conversion of way of thinking of creation and operation of network

Diverse players for both power generation and demand, including distributed resources
⇒ Systemic creation of “push type” network suitable to the characteristics of the players
⇒ Some rules needed to balance national burden and stable supply
⇒ Creation of network with use of demand side resources brought into perspective

(2) Investment environment improvement for creating network

Various needs, such as use of renewable energy for main power sources, resilience, aging, digitization, must be satisfied while predictability of investment declines.
⇒Creation of a system that **inhibits public burden and promotes investment in network at the same time**
⇒Conversion into a system corresponding to regional deviation of burden, such as corresponding to renewable energy

(3) Conversion of “value” of network project into next-generation type
Bidirectional flow of electricity as distributed resources spread
: **Separation of functions of “wide-area transmission network” and “distributed distribution network”**
: Conversion of “value” of network project from “kWh” to “kW” and “⊿kW”
: Cost can be reduced further by incorporating external resources into the network.
⇒Conversion into a system with high affinity with reform by these digitization

Present situation of consideration

(1) Creation of network
- Consideration of “push type” network creation rules
- The Hokkaido-Honshu HVDC Link under detailed consideration toward direction of reinforcing 300 MW more (up from 900 MW to 1.2 GW)
- Consideration of network creation rules with use of demand side resources brought into perspective

(2) Cost burden
- Drawing up rules for sharing the cost burden for creating the network throughout Japan (FIT charging system is under consideration for the effect deriving from renewable energy)

(3) Wheeling system
- Consideration of a wheeling system that inhibits public burden and promotes network investment at the same time

(4) System corresponding to conversion into next-generation type
- Consideration of institution and system supporting reforms such as digitization and function separation

(5) Disaster response
- Consideration and preparation of role sharing in case of disaster

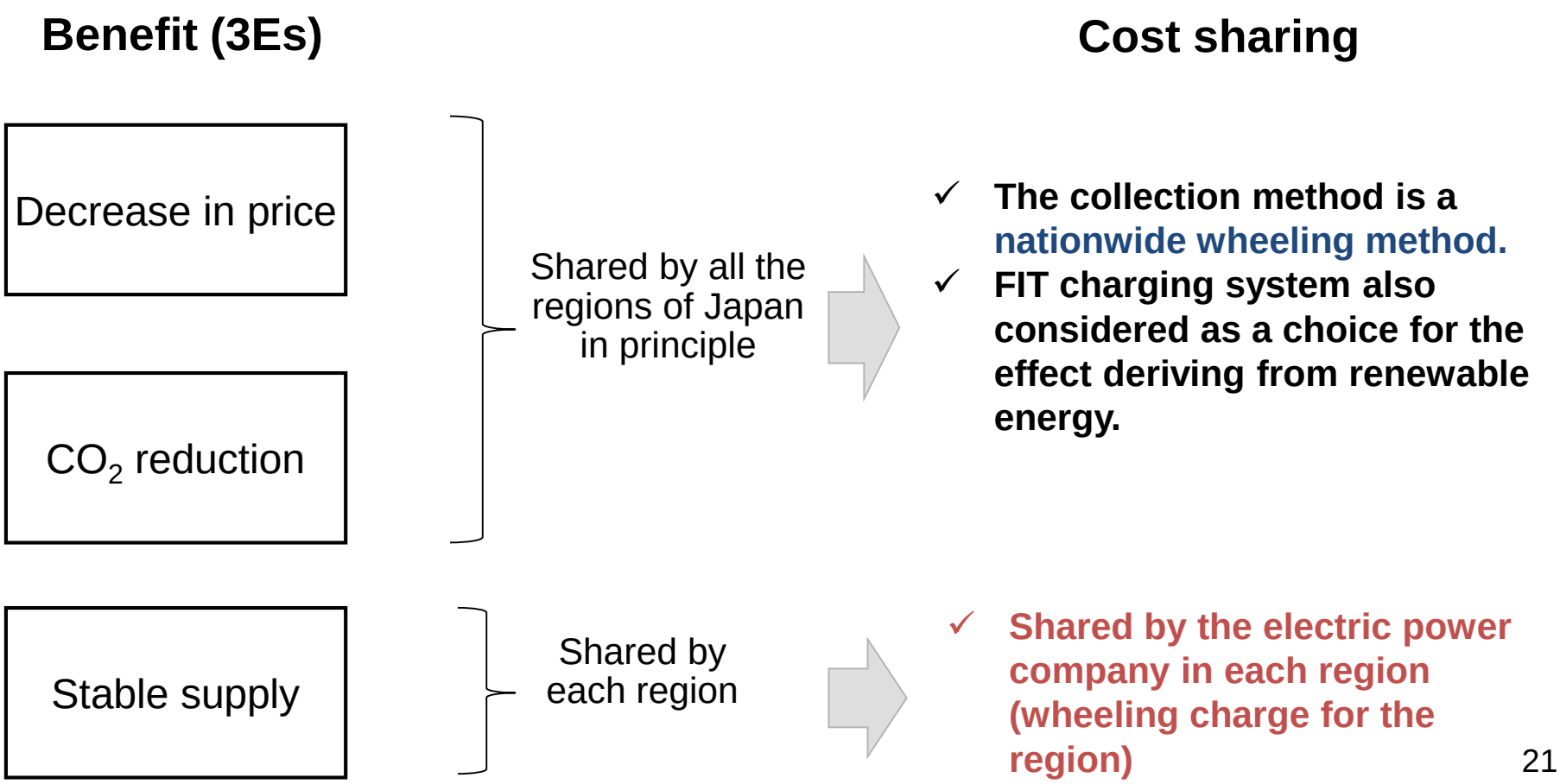
(Reference) Conversion of power grid creation into push type

- Consideration of converting a **“pull type” grid development, which meets each demand for a power source**, into a **“push type” that systematically responds to demand, taking the potential for the power source into consideration**, is needed to promote massive introduction of renewable energy power sources while inhibiting public burden.

Grid creation reflecting potential access needs	Introduction of batch study process ✓ General electricity transmission and distribution utilities take the lead in proposing a grid reinforcing process for efficient realization of grid creation.
Grid creation meeting the scale and characteristics of renewable energy	Introduction of scheme for securing power grid for offshore wind ✓ Change course to a scheme in which the government suppresses the necessary grid capacity in advance, taking into consideration the characteristics of offshore wind power generation Study of consideration to small-scale, stable renewable energy ✓ Discussion about the need of consideration to small-scale, stable renewable energy in future reinforcement of power grids
Grid creation foreseeing mid- to long-term potential	Consideration of basic viewpoint for future reinforcement of power grids ✓ Discussion about basic concept of mid- to long-term grid creation Introduction of cost-benefit analysis of interconnection between regions ✓ Making a decision on reinforcement of facilities and equipment, taking into consideration power source potential in each area, and introduction of a scheme to get all the regions of Japan to share the cost burden

(Reference) Rules for sharing cost burden for interconnections between regions in the future

- Of the benefits of 3Es accompanying reinforcement of interconnections, what if, in principle, **the public reaps** the **benefits brought by a wide-range merit order**? In such a case, how about considering **FIT charging system as a choice** to bear the burden corresponding to the effect deriving from renewable energy (Decrease in price and CO_2 reduction)?
- How about having the **electric power company** (general electricity transmission and distribution utility) **in the region that receives the benefit of reinforcement of stable supply share the cost** for the reinforcement?

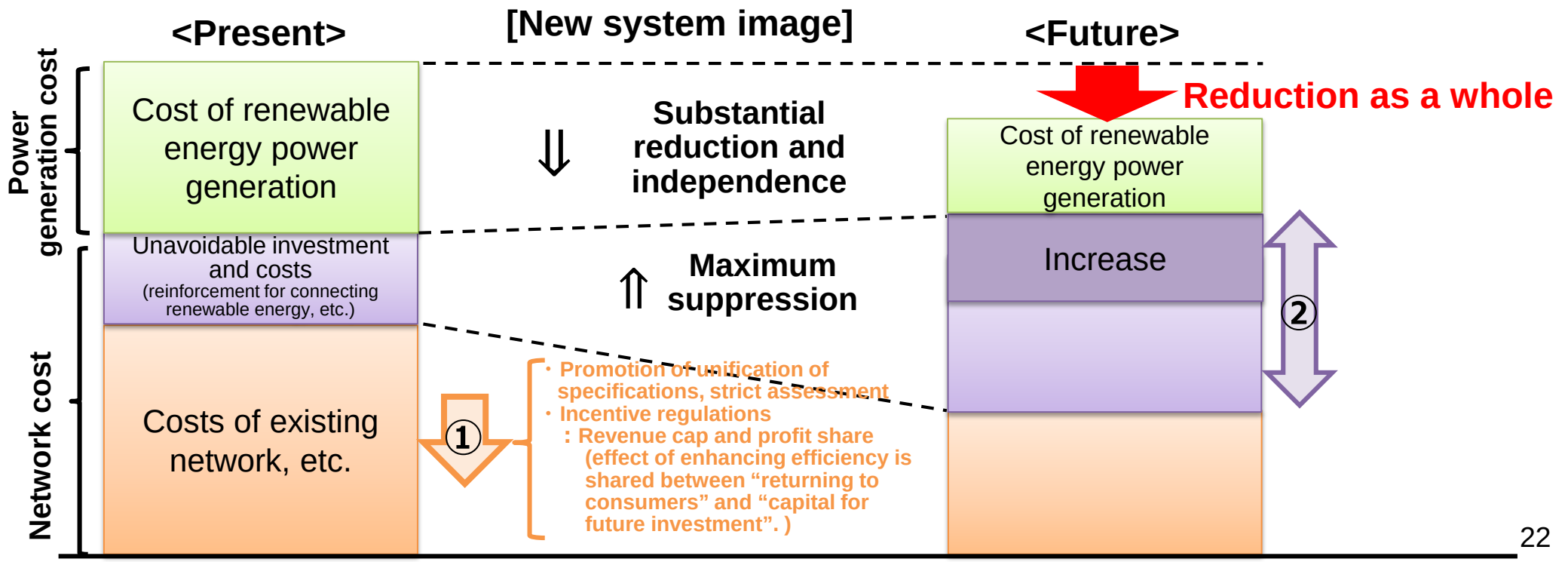


(Illustration) Direction of reviewing wheeling charge system (draft)

- How about considering the **introduction of European type "incentive regulation (revenue cap and profit share)"** to use renewable energy as the main power source and reinforce resilience, and creating a wheeling system that **strikes a balance between "cost inhibition" and "investment environment improvement"**?

(1) **Cost inhibition**: **Sharing** the effect of enhancing the efficiency between **"returning to consumers" and "capital for future investment"** while **suppressing the unit price through promotion of unification of specifications** by each company
(⇒ To **urge** the operators **to make efforts to enhance the efficiency**, such as imaginative and original work and cooperation with other operators)

(2) **Investment environment improvement**: **Creating a separate framework for investment and costs unavoidable for operators**, such as for reinforcement of connecting renewable energy



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Basic principle for future study toward use of renewable energy as a main power source

- A shift from the FIT system has been proceeding in countries that introduced the FIT system earlier than Japan. Japan should consider reviewing the FIT system, **taking into consideration the results and challenges the FIT system brought**, in order to **introduce many types of renewable energies and make them remain in the electric power system in a sustainable manner**.
- This study will be moved forward with the **following three principles**:

3Es+S | **Significance of renewable energy**

↓

Expanding introduction of renewables as "main power sources" and getting them to stay

↓

Three basic principles for designing system

1. **(1) Balancing between further cost reduction, alleviation of surcharges, and expansion of renewable introduction**
2. **(2) Long-term stability**
3. **(3) Integration into electric power system and adaptation to changing demand**

Challenges of renewable energy becoming the main electricity source

Renewable energy as a main power source

Problem / Direction of Strategic Plan	Main efforts undertaken so far	Future direction (under discussion)
Power generation cost • 2-fold more than in Europe • Surcharges at 2 trillion yen/year required for raising the renewable energy share by 5% (10%→15%) → Future: + 1 trillion yen/year required for raising the share by 9% (15%→24%) **Acceleration of cost reduction and independence from FIT**	**Handling of non-operating approved projects** • Non-residential solar PV projects that **were approved in FY2012 to 2014** and have not reached the operation preparation stage by a certain time **are to be awarded reduced prices.** • **In addition, measures to secure early operation start** → Policy to handle the non-residential solar PV projects **approved in FY2015 or 2016** in the same manner **Moving forward price targets and expanding range of subjects to bidding** • Consideration started at the Procurement Price Calculation Committee with an eye to move forward a target price of **7 yen/kWh for supplying non-residential solar PV by 2030** and **expanding** the range of subjects to auction to **"2,000 kW or more"**. → **METI** decided to **achieve a target price of 7 yen/kWh by 2025, 5 years earlier**, and expand the range of subjects to auction to **"500 kW or more"**	**Institution suitable for the characteristics of power sources** **Appropriate introduction of existing approved projects and reduction of surcharges** (Thorough response to non-operating approved projects and promotion of development of new, low-cost projects) **Consideration of policy measures suitable for the characteristics of power sources** (Growth models for competitive power sources/ models as locally used power sources)
Business environment • Immature environment for long-term stable power generation • Locational constraints on offshore wind power generation **Securing long-term stable business operations**	**Ensuring long-term stable business operation** • **Setup of information communication meetings for local governments to share** examples of creation or ordinances, etc. → **Establishment of a working group for expert study** on a **method of securing expenses for solar PV facility disposal** (external funding in principle) **Preparation of rules for using general sea areas (the act on promotion of utilization of sea areas)** • Preparation of **rules for long-term occupation of general sea areas**, as well as **auction schemes**, to expand introduction of **offshore wind power generation** → **Implementation of the act on promotion of utilization of sea areas** and **preparation of promising zones** based on information supplied from local governments	**Appropriate business disciplines** **Consideration of appropriate business disciplines for responsible and long-term stable power sources** (Materialization of a mechanism that secures reserving funds for solar PV facility disposal)
Construction of next-generation power network supporting mass introduction of renewable energy **Grid constraints** • Existing grids fail to match potential renewable energy power generation locations • Structurally decreasing grid demand • Expanded introduction of variable renewable energy **Flexibility** **Steady implementation of action plans**	**Further utilization of existing power grids** • **Introduction of mechanism for computing the spare capacity based on past performance** • **Prior application of utilizing the capacity by inter-tripping in emergency condition** → Increase by about 46.3GW in available capacity **Network cost reform in the age of mass introduction of renewable energy** • Mechanism to promote **thorough reduction of network costs** • **Improvements of system environment toward the transition to the next-generation network** → Committee to deliberate the way of cost-sharing of developing interconnections (**FIT charging system**) and conversion into "push type" grid development (**consideration given to small-scale stable renewable energy**)	**Conversion to next-generation power network** **Consideration of systemic, efficient creation of ideal power network based on distribution of land suitable for renewable energy generation** (Reinforcement of interconnections/grid development in accordance with scale and characteristics of renewable energy such as offshore wind power generation/securing investment in next-generation power network) **Measures for optimization of curtailment** (Consideration of appropriate range of renewables subjects for curtailment)

Future direction toward use of renewable energy as a main power source (1)

I. Institution suitable for the characteristics of power sources

(1) Policy measures suitable for the characteristics of power sources

- To introduce more types of renewable energy in the future and secure their longevity, they need to be **independently introduced into electricity markets as competitive power sources** and **long-term stable business operations need to be ensured as disciplined power sources**.
- Renewable energy can also contribute to **regional revitalization and reinforcement of resilience**. It is therefore important to improve a business environment for renewable energy to be utilized regionally.

(1) Growth Models for competitive power sources ⇨
- Utilized **nationwide** as **cost competitive power sources**
- Introduced systemically and continuously with the **cost reduction through auction schemes**

(2) Models as power sources used regionally ⇨
- Utilized for **private consumption** or **cogeneration** while **coordinating with regional policies**
- **Reinforcing regional resilience** in the case of disasters or emergency situations

- **It is necessary to improve an environment** where **models for utilizing renewable energy with supply and demand combined** can take root in each region, from the viewpoint of **securing energy supply in neighboring regions in the case of disasters or emergency situations** and **enhancing the efficiency of the whole system including the reduction of load on the grid and surcharges**.

(2) Thorough measures for non-operating approved projects

- Non-operating approved non-residential solar PV projects that do not reach an operation start preparation stage in a specific time **in FY2012 to 2014 (40, 36, or 32 yen/kWh)** as well as **the FY2015 project (29/27 yen/kWh)** should be **appropriately changed in procurement prices** and launched earlier by **setting time limits on operation start.**

→ Promotion low-cost new project development, including renewable energy other than solar PV

Future direction toward use of renewable energy as a main power source (2)

II. Securing proper business disciplines

Establishment of a mechanism that secures reserving funds for solar PV facility disposal

- Following policy direction has been already taken: **(1) externally reserved funds in principle and (2) securing funds by collecting them at source**.
- **Detailed considerations** such as on the level and start time of reserving funds and possibility of approving internal reservation function **have been started by a working group of experts.**

III. Conversion into next-generation electric power network

(1) Systemic grid reinforcement in accordance with the scale and characteristics of renewable energy such as offshore wind power generation

- Consideration of a **mechanism that systemically reinforces** grids as necessary in order **to generate electricity in accordance with the scale and characteristics of a power source using renewable energy and to minimize the total cost of the network** ("**push type**" grid development in line with potential)

(2) Framework for cost-sharing of next-generation electric power network

- The need for the reinforcement of interconnections between regions, which can contribute to the expansion of renewable introduction, will be decided through cost-benefit analysis, and the cost will be shared nationwide in principle (nationwide wheeling system and FIT charging system to be considered).

(3) Fair and flexible grid operation

- To ensure fairness between renewable power sources and flexibility for grid operation, **the appropriate range of renewable curtailment** will be considered.

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Condition of Japanese nuclear power plants

As of July 1, 2019

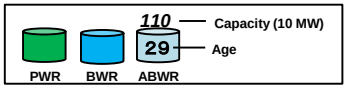
Restarted 9 reactors
In operation: 8, suspended: 1

Passed NRA review for permission for changes in reactor installation 6 reactors
(Date of approval)

Under NRA review 12 reactors
(Date of application)

Application not filed 9 reactors

Already decided/discussed to be decommissioned 24 reactors



(Date of restart)

Tokyo EPCO **Kashiwazaki Kariwa**
110 33, 110 28, 110 25, 110 24, 110 29, 136 22, 136 21 (Dec. 27, 2017)

Hokuriku EPCO **Shika**
54 25, 121 13 (Aug. 12, 2014)

JAPC **Tsuruga**
36, 116 32 (Nov. 5, 2015)

Kansai EPCO **Mihama**
34, 50, 83 42 (Oct. 5, 2016)

Kansai EPCO **Ohi**
118, 118, 118 27 (Mar. 14, 2018), 118 26 (May 9, 2018)

Kansai EPCO **Takahama**
83 44 (Apr. 20, 2016), 83 43 (Jun. 6, 2017), 87 34 (May 17, 2017), 87 34

Chugoku EPCO **Shimane**
46, 82 30 (Dec. 25, 2013), 137 (Aug. 10, 2018)

Kyushu EPCO **Genkai**
56, 56, 118 25 (Mar. 23, 2018), 118 21 (Jun. 16, 2018) Suspended

Kyushu EPCO **Sendai**
89 34 (Aug. 11, 2015), 89 33 (Oct. 15, 2015)

Hokkaido EPCO **Tomari**
58 30, 58 28, 91 9 (Jul. 8, 2013)

Shikoku EPCO **Ikata**
57, 57, 89 24 (Aug. 12, 2016)

J-POWER **Ohma**
138 (Dec. 16, 2014)

Tokyo EPCO **Higashidori**
139

Tohoku EPCO **Higashidori**
110 13 (Jun. 10, 2014)

Tohoku EPCO **Onagawa**
52, 83 23 (Dec. 27, 2013), 83 17

Tokyo EPCO **Fukushima Daiichi**
46, 78, 78, 78, 78, 110

Tokyo EPCO **Fukushima Daini**
110, 110, 110, 110
Tokyo EPCO has revealed a plan to consider decommissioning all the reactors at Fukushima Daini Nuclear Power Station (Jun. 14, 2018).

JAPC **Tokai/Tokai Daini**
17, 110 40 (Sep. 26, 2018)

Chubu EPCO **Hamaoka**
54, 84, 110 31 (Jun. 16, 2015), 114 25 (Feb. 14, 2014), 138 14

Reduction of electricity rate after restart

- **Kansai Electric reduced the electricity rate twice, by about 4% or 5% at a time, on the back of restarting nuclear power plants and reduction of the fuel cost for thermal power generation.**
- **Kyushu Electric also reduced the electricity rate by about 1%**, citing a reduction of the fuel cost for thermal power generation because of the restart of nuclear power plants.

	Restarted plants	Reduction (Note 1)	Reduction of thermal power generation fuel cost
In the case of Kansai Electric	Units 3 & 4 at Takahama Power Station	**-4.29%** (August 2017)	**-41 billion yen** (Note 2)
		⇨ **Reduction effect of 2.76 million yen/year** for industrial use (factory, etc.)	
	Units 3 & 4 at Ohi Power Station	**-5.36%** (July 2018)	**-99 billion yen** (Note 2)
		⇨ **Reduction effect of 3.24 million yen/year** for industrial use (factory, etc.)	

(Note 1) Average reduction of overall retail price (regulated and liberalized sectors)
(Note 2) Example of contract power of 900 kW and monthly use of 3,240 MWh

Source: Created from data on website of Kansai Electric

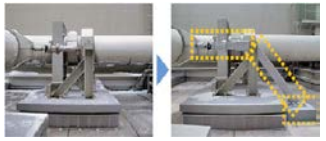
Improvement of nuclear power safety

- The **core damage frequency has substantially been decreased** by safety measures meeting the new regulatory standards.
- Operators will come up with **voluntary safety measures (risk assessment and management)** with an eye to **establishment of risk governance,** and the central government and industry will support their measures **to improve safety further**.

Establishment of risk governance

(Continuous effort to lower risk through assessment and management of risk)

Safety measures meeting new regulatory standard and their effect (examples)

	Power source measures	Earthquake measures	Tsunami measures
			
	Installation of air-cooled emergency power generator	Reinforcement of piping facility	Construction of protection wall
Resulting			
Core damage frequency*	$1.4\times10^{-5}\Rightarrow7.2\times10^{-7}$ **About 1/19**	$3.7\times10^{-7}\Rightarrow1.1\times10^{-7}$ **About 1/3**	$4.0\times10^{-5}\Rightarrow1.6\times10^{-7}$ **About 1/250**
Containment failure frequency*	$1.4\times10^{-5}\Rightarrow1.7\times10^{-7}$ **About 1/82**	$3.7\times10^{-7}\Rightarrow6.6\times10^{-8}$ **About 1/5**	$4.0\times10^{-5}\Rightarrow1.2\times10^{-7}$ **About 1/330**

*Probabilistic risk assessment (PRA) result of report on the first safety improvement assessment of unit 3 of Kansai Electric's Takahama Power Station (submitted on January 10, 2018) (Internal PRA, earthquake PRA, tsunami PRA)

Voluntary safety measures (examples)

Voluntary safety measures using risk assessment

- **Voluntarily implement safety measures that must be taken and given priority**, according to the importance they have for safety, including **reduction in the core damage frequency**, from **the result of probabilistic risk assessment (PRA).**

Source: Kansai Electric

Voluntary activities to ensure safety based on actual workplace

- **Cross-departmental discussion is held to improve awareness and actual performance of employees**, so that they understand risks and dangerous factors at workplace and create a common understanding on safety culture.

Source: Kyushu Electric

Maintenance and reinforcement of nuclear technology and human resources (creation of innovation)

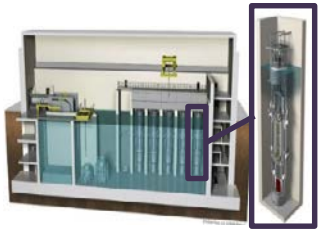
- Reinforcement of **support to technical development** toward pursuing reactors with excellence in **safety, economic efficiency, and flexibility**
  (**NEXIP project: N**uclear **E**nergy × **I**nnovation **P**romotion)

Innovative nuclear technology development

■ Fast reactor
・Promotion of competition of various fast reactor technologies based on strategic roadmap

Fast reactor

■ Innovative reactor
・Support of development of innovative nuclear power technology responding to social problems (FY2019 budget: 650 million yen)



Small modular reactor

High temperature gas reactor

Collaboration between research institutes/ Promotion of use of private sector

■ Activation of private sector activities by utilizing the Japan Atomic Energy Agency (JAEA)
・Sharing and supply of opinions and information on data and intellectual property
・Sharing of test and research facilities

Joyo: Experimental fast reactor

International cooperation and business alliance

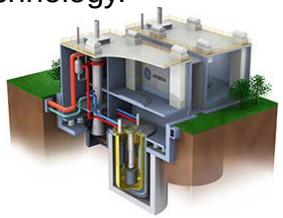
France

・Development of sodium cooled fast reactor
・Study of **other various concepts**
・R&D of **simulation and experiment**

U.S.

・**GAIN** initiative promoting development of innovative nuclear technology
・In response to this support, **small modular reactors** are expected to start commercial operation in 2026.

・Construction of a new **Versatile Test Reactor (VTR)** is scheduled for maintaining domestic technology.



Activities toward **development of human resources and dialogue with regulators** need to be organically aligned to promote **nuclear innovation**.

Promotion of spent fuel storage measures, interim storage and reprocessing

- The government requested at “the liaison council for promoting spent fuel measures” of the top management of electric power companies that **each operator strengthen cooperation with others** and **enrich and reinforce spent fuel storage measures for the whole of Japan**.
- **Inspection** of reprocessing facilities by the Nuclear Regulation Authority has entered the **final stage** and **Japan Nuclear Fuel Limited (JNFL)** is making preparation for completion of a reprocessing facility under a new management system in January this year.

Spent Fuel Storage Measures

(1) Present

Spent fuel: Approx. 18,000 tons / Storage capacity: Approx. 24,000 tons = Approx. 75%

(2) Main measures

Margin year(*)

Ikata Power Station Unit 3 operating
710 tons/1,080 tons — 11 years
＋500 tons Dry storage (applying) → 36 years

Genkai Nuclear Power Station Units (3) and (4) operating
910 tons/1,130 tons — 3 years
＋290 tons Re-racking (applying)
＋440 tons Dry storage (applying) → 14 years

Tokai Daini Power Station Under safety construction
370 tons/440 tons — 3 years
180 tons (installed) **＋70 tons** Dry storage (inspecting/manufacturing) → 6 years

Hamaoka Nuclear Power Station Units (3) and (4) under review
1,130 tons/1,300 tons — 2 years
＋400 tons Dry storage (applying) → 8 years

Mutsu interim storage facility
＋3,000 tons Dry storage (applying)

(*) Time until the storage capacity of the site is filled, assuming the restart of all plants on the site, and the replace of fuel every 16 months

Prospect of reprocessing facility, etc.

JNFL Rokkasho Reprocessing Plant

Apr. 1993 Started construction
Dec. 1999 Started business
Mar. 2006 Active test → Stopped vitrification test
May 2013 Finished vitrification test
Jan. 2014 Applied for New Regulatory Standards

1st half of 2021 scheduled for completion
(announced in December 2017)

Operational capacity：MAX ▲800 tons/year
(planned 40 years, total▲32,000 tons)

JNFL MOX fuel plant

Oct. 2010 Started construction

1st half of 2022 scheduled for completion
(announced in December 2017)

Operational capacity : MAX 130 tons/year

Safe and smooth decommissioning

- An **increasing number** of nuclear reactors are **getting into the decommissioning processes** since 2011. So, the utility companies must carry out these decommissioning works safely and smoothly **through cooperation with other companies, reuse of useful materials, and dialogue with regulators**.

Cooperation between companies

Mutual cooperation agreement between the five utilities in western Japan (April 2016)

To enhance work efficiency by using common specifications and designs, or leasing equipments mutually

⇨ **Cooperation between all utilities is being considered.**

Toshiba-AECOM (U.S.) alliance (June 2019)

To create synergy of Toshiba's technology and construction experiences and the planning and management experiences of AECOM (engineering company)

⇨ **Cooperation with foreign companies for the knowledge and know-how**

Reuse of useful materials

Clearance system

Metal with radioactive concentration confirmed to be less than a specified limit is allowed to be reused by the system.
Currently, however, utilities voluntarily limit to use until the system is accepted by society.

Table

Bench

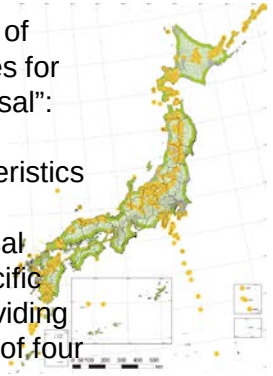
⇨ **Further expansion of reuse in the electric power industry (construction material, etc.)**

Realization of final disposal of high-level radioactive waste

- **Dialogue activities continue throughout Japan**, triggered by the publication of the “Nationwide Map of Scientific Features for Geological Disposal”, toward realization of final disposal of high-level radioactive waste. In addition, **the government takes the lead** in carrying out those activities **in proactive international cooperation with major nuclear power user countries that face this common challenge with each other**.

Dialogue activities throughout Japan

- Explanatory meetings have been held throughout Japan since last May. Detailed **dialogue activities are being conducted mainly in “green coastal areas”** (areas on the scientific characteristic map where a possibility that favorable characteristics can be confirmed is relatively high) since last fall.
- **The social effect on the region of deep geological disposal of high-level radioactive waste and activities to ensure safety** are also explained in detail, based on the **interest of participants**.



“Nationwide Map of Scientific Features for Geological Disposal”: Map showing the scientific characteristics related to deep geological disposal according to specific standards and dividing Japan into areas of four colors

Explanatory meeting

Cooperation with nuclear power user countries

- **Sharing experiences and information on dialogue activities in each of the nuclear power user countries** and promoting research cooperation and personnel exchange in those countries
- **First international round-table conference is scheduled to be held in the middle of October in Paris**, followed by adoption of a “**basic strategy**” and “**collection of best practices**”.

Joint press conference of “G20 ministerial meeting in Karuizawa” (June 2019)

Building relationships of mutual trust with municipalities with nuclear power plants

- **Municipalities** where operation or construction of nuclear power plants has been suspended **have seen negative economic repercussions**. Therefore, the central government will **build a relationship of mutual trust with these municipalities through sincere dialogue** and **provide them with appropriate support** including creation of new industries and employment.

Example of grant use

■ Grant for public relations and survey
FY2019 budget: 900 million yen
(**about 70 million yen increase** from FY2018)

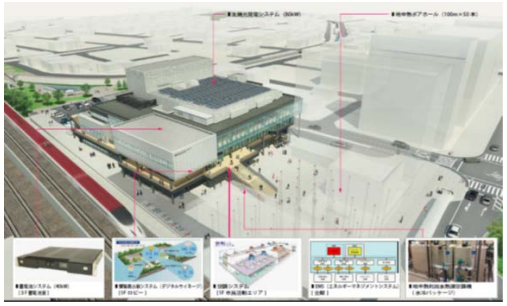
Public relations are carried out to explain activities to ensure the safety of nuclear power plants to the residents in the neighboring areas.
Providing support to venues of dialogues with various parties concerned (regional coexistence platform) started this year.

Nuclear PR brochures created by municipalities

Example of subsidy use

■ Subsidy for work to promote understanding of advancing and converting energy structure
FY2019 budget: 5.62 billion yen
(**about 600 million yen increase** from FY2018)

Support the creation of new businesses in renewable energy field where private businesses and the municipality hosting a nuclear power plant are cooperating in the municipality or neighboring areas.



[Satsuma-Sendai City, Kagoshima]
Project to introduce next-generation energy system to Sendai Station Convention Center

[Tsuruga City, Fukui]
Renewable energy-derived hydrogen station development project

1. **Recent trends in energy**
   (1) Movements toward energy transition and decarbonization
   (2) Recent trends in energy security and geopolitics

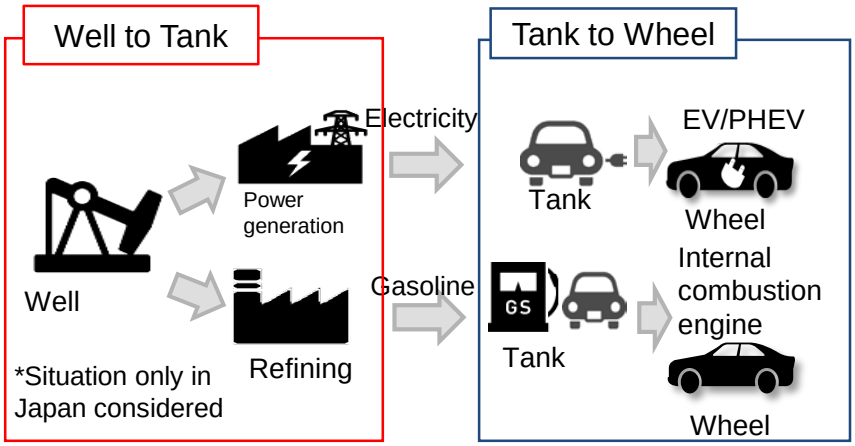
2. **Study of policies toward energy transition**
   (1) Progress in liberalization of electricity market
   (2) Activities toward decarbonized energy system
      - Electricity network policy
      - Use of renewable energy as main power source
      - Activities toward winning back social trust in nuclear power
   (3) Energy conservation (fuel efficiency standards and thermal power generation)
   (4) Promotion of innovation (hydrogen and CCS)

Top Runner Program (new fuel efficiency standards for passenger vehicles)

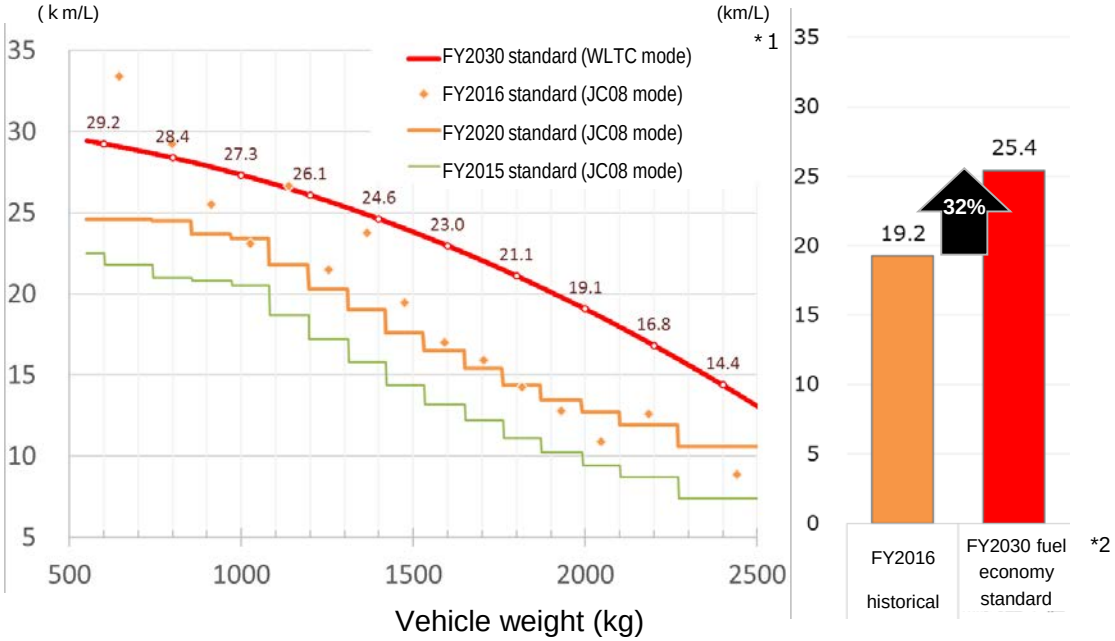
- New standard expecting an improvement of 32% from the fuel economy recorded in FY2016 by FY2030 was decided (June 2019*).
- Electric vehicles and plug-in hybrid vehicles, as well as gasoline-powered vehicles, hybrid vehicles, and LPG vehicles, have been newly added as subjects to the standard.
- The concept “Well to Wheel”, which considers the energy consumption in the production stage of gasoline and electricity, was introduced to evaluate on a common axis the “fuel efficiency” of both gasoline-powered vehicles and electric vehicles. Power generation efficiency and other parameters are set, taking the prospect of energy mix into consideration, because the target year is FY2030.

*At a joint meeting of: the Working Group on Classification Standards for Automobiles of the Energy Efficiency and Conservation Subcommittee of the Committee on Energy Efficiency and Renewable Energy under the Advisory Committee for Natural Resources and Energy; and the Subcommittee on Standards for Automobiles Energy Efficiency of the Automobiles Committee under the Land Traffic Committee of the Transport Policies Council.

Introduction of concept “Well to Wheel” that considers the energy consumption, such as gasoline and electricity, in the production stage



Transition of fuel efficiency standard
(standard by weight and standard by reference value)



Source: The performance values were created based on the data of the Ministry of Land, Infrastructure, Transport and Tourism
*1 Fuel efficiency in the WLTC mode and that in the JC08 mode cannot be compared simply. There are vehicles whose fuel efficiency in the WLTC mode in a region where the fuel economy is good is lower than the fuel consumption in the JC08 mode.
*2 The estimated value of FY2030 fuel efficiency standard was calculated on the assumption of shipment of passenger vehicles by vehicle weight in FY2016

Enhancing efficiency of thermal power generation

- The fifth Strategic Energy Plan clearly states that action will be taken to accelerate “fade out for inefficient coal-fired power plants, including limitations on new construction”.
- At Working Group on Classification Standards for Thermal Power Generation held last year, it was decided to (1) require a newly constructed plant to report “design efficiency on the assumption of using coal in the place of byproducts” not only when the plant burns biomass but also when it burns a mix of byproduct and coal, and (2) **evaluate** a newly constructed plant, which burns a mix of byproducts and coal, **based on the design efficiency that does not deduct the energy quantity of biomass fuel and byproducts**.
- Three patterns are studied toward materialization of a joint action scheme of plural operators. The concept of trading rules, such as power generation efficiency, is presented for each pattern.

◆ Review of plant construction standards by the Energy Efficiency Act

New plants that burn biomass or byproducts together with coal are evaluated based on design efficiency that does not deduct energy quantity such as biomass fuel.

Design efficiency evaluated before

If the main fuel type is coal (example)

$$\frac{40}{\text{(Electricity obtained from power generation facility)}} = 42.1\%$$

$$\frac{100}{\text{(Energy input to power generation facility)}} - \left(\frac{5}{\text{Energy of biomass fuel and byproducts to be input to power generation facility}}\right)$$

Design efficiency to be evaluated in future (newly constructed plants only)

$$\frac{40}{\text{(Electricity obtained from power generation facility)}} = 40.0\,\%$$

$$\frac{100}{\text{(Energy assumed to use fossil fuel such as coal instead of biomass fuel and byproducts to be input to power generation facility)}}$$

The construction standard for coal of 42% is not satisfied.

◆ Design efficiency in units of newly constructed plant

Fuel type	Design efficiency (standard) (power generation end, HHV)	Rationale for setting
Coal	**42.0%**	**Set based on the value of ultra super critical (USC) that has already been in operation as a commercial plant without economical or reliability problems**
Oil or other fuel	39.0%	Set based on the power generation efficiency of the state-of-the-art thermal power plant using oil, etc.

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- In order to achieve goals set in the Basic Hydrogen Strategy,

(1) Set of new targets to achieve (specs for basic technologies and cost breakdown goals), establish approach to achieving target

(2) Establish expert committee to evaluate and conduct follow-up for each field

		Goals in the Basic Hydrogen Strategy	Setting of targets to achieved	Approach to achieving target
Use	Mobility	FCV 200 k by 2025 800 k by 2030	2025 ● Price difference between FCV and HV (¥3 million → ¥0.7 m)	• Regulatory reform and developing technology
			● Cost of main FCV system (FC ¥20,000/kW → ¥5,000/kW; Hydrogen storage ¥0.7 m → ¥0.3 m)	
		HRS 320 by 2025 900 by 2030	2025 ● **Construction and operating costs** (Construction cost ¥350 m → ¥200 m; Operating cost ¥34 m → ¥15 m)	• Consideration for creating nation wide network of HRS • Extending hours of operation
			● **Costs of components for HRS** (Compressor ¥90 m → ¥50 m; Accumulator ¥50 m → ¥10 m)	
		Bus 1,200 by 2030	Early 2020s ● Vehicle cost of FC bus (¥105 m → ¥52.5 m)	• Increasing HRS for FC bus
			* In addition, promote development of guidelines and technology development for expansion of hydrogen use in the field of FC trucks, ships and trains.	
	Power	Commercialize by 2030	2020 ● Efficiency of hydrogen-fired power generation (26%→27%) ※1 MW scale	• Developing of high efficiency combustor, etc.
	FC	Early realization of grid parity	2025 ● Realization of grid parity in commercial and industrial use	• Developing FC cell/stack technology
Supply	Fossil Fuel +CCS	Hydrogen cost ¥30/Nm^3 by 2030 ¥20/Nm^3 in future	Early 2020s ● Production: Production cost from brown coal gasification (¥several hundreds/Nm^3→ ¥12/Nm^3)	• Scaling-up and improving efficiency of brown coal gasifier • Scaling-up and improving thermal insulation properties
			● Storage/Transport : Scale-up of liquefied hydrogen tank (thousands m^3→50,000 m^3) Higher efficiency of liquefaction (13.6 kWh/kg→6 kWh/kg)	
	Green H_2	System cost of water electrolysis ¥50,000/kW in future	2030 ● Cost of electrolyzer (¥200,000/kW→¥50,000/kW)	• Demonstration in model regions for social deployment utilizing the achievement in the demonstration of Namie, Fukushima
			● Efficiency of water electrolysis (5 kWh/Nm^3→4.3 kWh/Nm^3)	• Development of electrolyzer with higher efficiency and durability

Roadmap to carbon recycling technology

*Formulated June 2019

Objective

- Technology roadmap was created for the purpose of accelerating innovation by setting the objective, technical issues, and time frame for developing carbon recycling technology and sharing them with a wide range of parties concerned both at home and abroad, such as governments, private businesses, investors, and researchers.
- To gather wisdom from all over Japan, especially from experts and engineers in each technical field, gaining cooperation from ministries and agencies concerned

Point

○ Basic structure

- Clarification of the present technical situation and issues to be solved to reduce cost of energy and products that can use CO_2 as a resource. Making clear steps to technological progress
- Setting cost goals of 2030 and 2050 in a bid to realize costs equivalent to those of the existing products

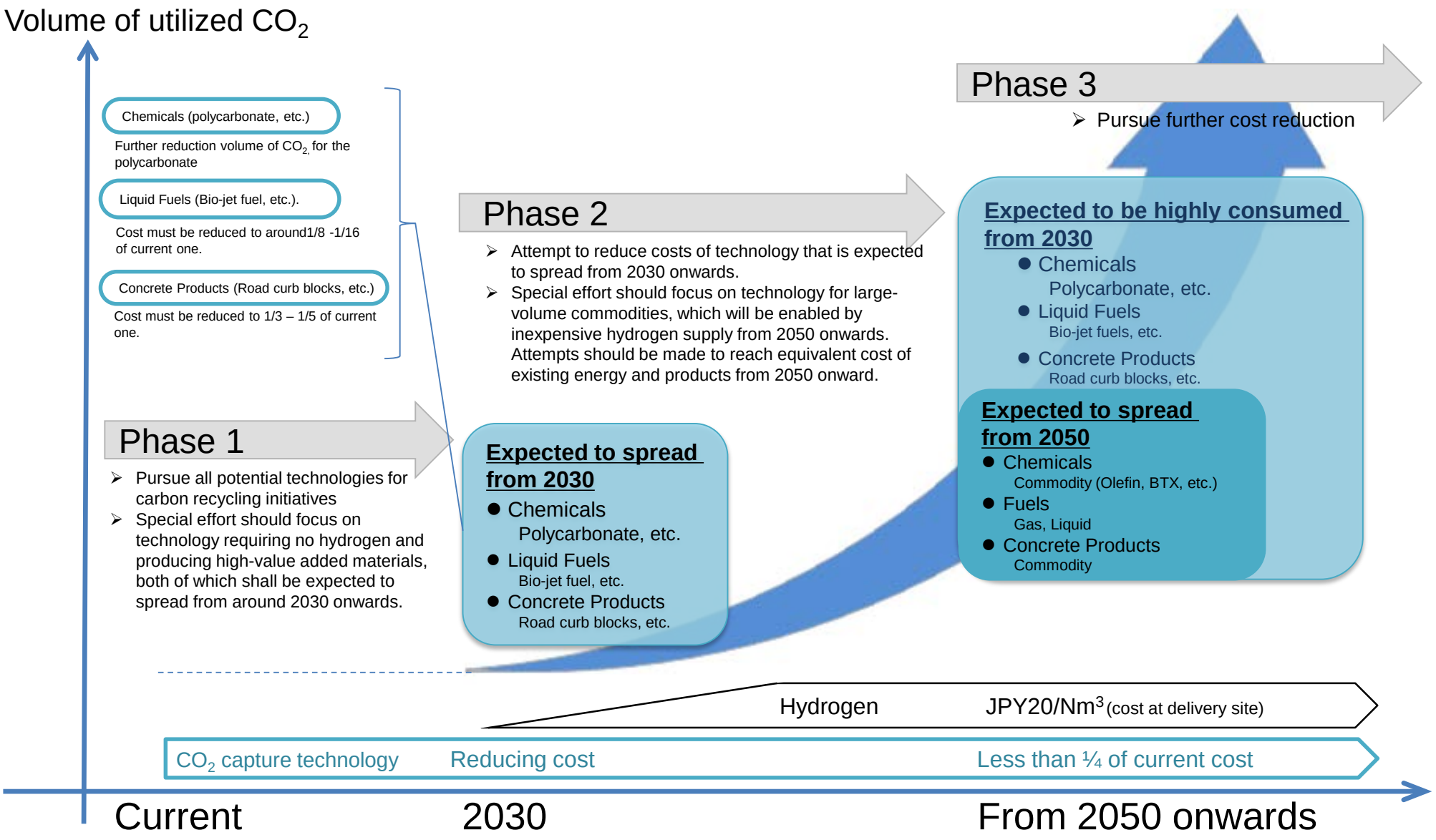
○ Time frame

Phase 1 (present to 2030):
- Pursuit of all technologies
- Special focus on technology that can be disseminated early (concrete, chemical products (polycarbonate), and bio jet)

Phase 2 (2030 to 2050):
- Reduction of costs of Phase 1 technology
- Putting into practical use the technology that need low-price hydrogen (artificial photosynthesis, methanation, etc.)

Phase 3 (2050 and after): Disseminate in earnest of carbon recycling technology

Roadmap for Carbon Recycling Technology



<Review process> Be flexible in the addition of technology based on the state of international technology development obtained through the International Conference on Carbon Recycling among Industry-Academia-Government, or proposals of new technology. The roadmap should be reviewed in five years as needed, take into account the revision of the “Long-term Strategy for Growth Strategy based on the Paris Agreement (provisional translation)”.

Review Meeting for Evaluating the Potential and Feasibility of Energy and Environmental Technologies

- Promoting innovation, including cost reduction for existing technologies, is important to realize a decarbonated society by 2050, based on the Paris Agreement*Put together June 2019
- Regarding the key innovative technologies in energy and environmental fields, especially those that can contribute to massive CO_2 reduction, the present situation of R&D and practical utilization are evaluated from the viewpoints of their potential and feasibility. Bottlenecks restricting the application of fundamental research for social implementation are extracted and long-term directions for R&D toward practical use is presented.

Issues based on the potential/feasibility evaluation

<Hydrogen>
- Supply of low-cost (the price equivalent to natural gas (including environmental value)) and low-carbon hydrogen for production, transportation, and storage, which is necessary for expanding industrial use (e.g., iron/steel manufacturing and production of chemicals)

<CCUS>
- Reducing consumption of energy and cost for CO_2 capture
- Economic incentives for, and social acceptance of CCS technology
- Close examination of CO_2 reduction by CCU, hydrogen supplying method (with consideration of the price and quantity), and enhancing the efficiency of the reaction processes
- Potential of negative emission technology (such as DAC and BECCS)

<Renewable energy and energy storage>
- Securing adjustment capability toward large-scale introduction of renewable energy, and reducing cost for large scale installation of batteries for grids to maximize the use of renewable energy
- Flexibility of thermal power generation
- Improving potential of the adjustment capability on the demand side, including electrification in the industrial process

<Power electronics>
- Substantial cost reduction of next-generation semiconductors (including whole systems), improving performance of passive components, advancement of mounting technologies, etc.
- Clarification of targets according to the specific application

Long-term directions for research and development for practical use

<Hydrogen>
- Further reduction of hydrogen production cost (continuing pursuit for innovative technological seeds such as water electrolysis, artificial photosynthesis, hydrogen production that does not emit CO_2 from fossil resources, IS process, and utilization of biomass)
- Direct synthesis of hydrocarbons from water and CO_2 (e.g., methane or methanol) without pure hydrogen
- Drastic reduction of energy necessary for the synthesis of, and dehydrogenation from hydrogen carrier

<CCUS>
- Reducing energy consumption required for CO_2 capture, technologies that simplify or even eliminate the CO_2 capturing process, and direct use of exhaust gas
- Securing appropriate locations for CCS, proper CO_2 transportation with consideration of emission source, and optimized monitoring
- Direct synthesis of hydrocarbons from water and CO_2 (e.g., methane or methanol) without use of pure hydrogen [reprinted]
- Use of CO_2 for mineralization that does not require hydrogen
- Objective, neutral LCA evaluation
- Objective evaluation of negative emission technologies such as DAC

<Renewable energy and energy storage>
- Cost reduction of large-scale energy storage technology (the cost equivalent to that for installing a pumped hydro power generation)
  (Low-price flow battery, improvement of the safety of lithium-ion batteries, improvement of the performance of solid-state batteries, secondary use of automobile batteries, improvement of the efficiency of thermoelectric conversion, and cost reduction for large-scale heat storage)
- Short-time output adjustment of thermal power generation (including hydrogen-fired generation) and improvement of the partial load efficiency
- Pursuit for potential of the adjustment capability on the demand side (e.g., close examination of potential of industries that can be electrified, including increasing demand response, cost reduction of distributed energy resources, low-cost and high-efficiency hydrogen storage, and integrated digital control technology)
- Promotion of electrification which offers high value-added production (technological development in various manufacture process such as electrical heating, drying, synthesis, and separation)

<Power electronics>
- Developing next-generation semiconductors, enlarging the diameter of wafers and improving yields, using common/standardized parts and circuits, and cost reduction by introducing mass-production technology
- Promotion of basic research and development for power electronics devices, including passive components and mounting technology, as well as semiconductors, to improve functions and performance

Research and development suitable for practical use

- ✓ Promotion of both technology aimed at development in a short or middle term, and innovative technology that can solve any issues (including cost issue) all at once from a concept completely different from the past
- ✓ Setting of technical issues based on the requirements from society or user
- ✓ At the stages of basic research and feasibility survey, promoting competition among the technologies, which consist of multiple R&D approaches to cover a wide range of technological seeds, to give a priority to the hopeful technologies that potentially bears fruit
- ✓ Giving priority to the stance and needs of users in terms of technical issues, especially “cost”
- ✓ Appropriate supports, such as financial support, depending on the technological levels by classifying the technology readiness level (TRL)
- ✓ Selection of technologies upon objectively evaluating effectiveness for reducing greenhouse gas emission at entire life cycle basis that includes dissemination in the market (LCA), after disclosing prerequisite of the assessment.
- ✓ Returning to basic research if a problem is found during technological development or verification, and cooperation between industries and universities

(Reference) Identifying technological fields that can substantially reduce CO_2 emissions

Sectors emitting CO_2 in large quantities	Process & products	Mass of CO_2 emissions	Main factors for CO_2 emissions	Examples of alternative technologies
Electricity	Thermal power generation	460 Mt	✓ Burning of coal or oil	✓ Renewables and energy storage ✓ CCS ✓ Power electronics ✓ Nuclear power
Automobile	Internal combustion	186 Mt	✓ Burning of gasoline or diesel	✓ Electric vehicle ✓ Fuel cell vehicle
Iron and steel	Blast furnace	120 Mt	✓ Burning of coal ✓ Reduction by coal	✓ CCS ✓ Hydrogen reduction
	Electric furnace	7 Mt	✓ Use of electricity	✓ Renewable energy
Chemicals	Petrochemistry	31 Mt	✓ Cracking of naphtha	✓ CCU ✓ CO_2-free hydrogen
	Ammonia	3 Mt	✓ Reforming of natural gas for hydrogen production	✓ CO_2-free hydrogen
Non-metallic minerals	Cement	40 Mt	✓ Burning of calcium carbonate	✓ Combustion ash + CCU ✓ CCS
Total mass of CO_2 emissions		820 Mt		

Technological fields

- Hydrogen
- CCUS
- Renewables and energy storage
- Power electronics

* Overlapping CO_2 emissions between the electricity and each sector are excluded.