Energy Transition and NEA Cooperation

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Contents

1． Key points of the current energy mix based on the 4th Basic Energy Plan

(1) The premise of the energy mix for 2030

- The Ministry of Economy, Trade and Industry (METI) released the Long-term Energy Supply and Demand Outlook (namely Energy Mix for 2030) based on the 4th Basic Energy Plan in July 2015.

- **The Premise is;**

1) **The energy self-sufficiency rate** should be realized at the level before the March 2011 disaster (to around 25%).

2) **Electricity costs** should be lowered from the present level.

3) **The greenhouse gas emission reduction target** should be comparable to European and U.S. targets, leading the world.

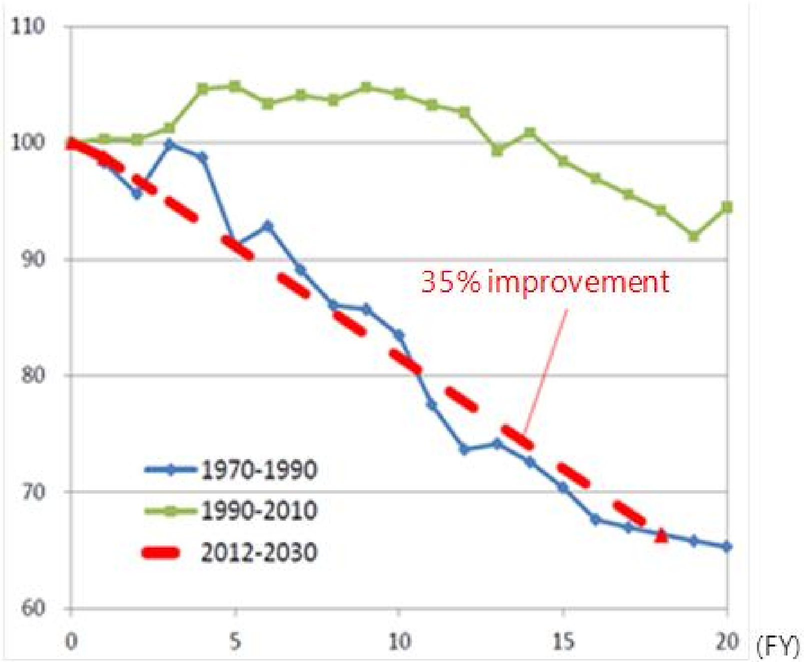
⇒ At the same time, **the dependence on nuclear power generation** should be lowered as much as possible.

Promotion of Energy Conservation
：Improvement of Ambitious Energy Efficiency

❖ The Ministry of Economy, Trade and Industry (METI) promulgated **"the Long-term Energy Supply and Demand Outlook"** in July 2015.

■ Thorough energy conservation measures would reduce final energy consumption by 13% to 326 million kl.
■ Energy conservation measures would be accumulated to improve energy efficiency as much as just after the oil crises.

【Energy efficiency improvement】



Energy efficiency=final energy consumption/real GDP

Further energy conservation (3 points)

① "Facility Renovation"

② "IT Utilization"

- FEMS (Factory Energy Management System)
- BEMS (Building 〃)
- HEMS (Home 〃)
- ITS (Intelligent Transport Systems)

③ "Energy Conservation in Buildings"

(Source) METI, ANRE "Long-term Energy Supply/Demand Outlook, Related Documents" the Long-term Energy Supply and Demand Outlook Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy, (11th meeting) Document 3, p.66 (July 16, 2015)

2030 Energy Supply and Demand Structure : Difference Between 2010 and 2015 Versions

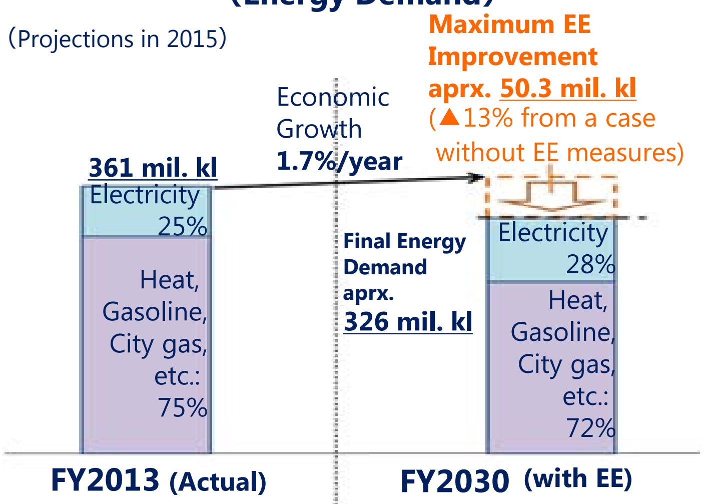
<1> Energy Demand and Primary Energy Supply Structure

- **(Energy Supply) Nuclear and renewable energy had a combined share of aprx. 40% (37%) in the 2010 version of the target energy for 2030, against 24.3% in the 2015 version. The nuclear share in the 2015 version was halved from the 2010 version. Priority shifted from heavy dependence on nuclear energy to diversification.**

	① Economic Growth	② Energy Conservation	③ Energy Self-Sufficiency Ratio	④Energy-related CO_2 Emissions
2010 Ver.	(2007→2020) aprx. **2%/year** (2020→2030) aprx. **1.2%/year**	N.A.	aprx. **40%** (37%)	**730 mil. t-CO_2)**
2015 Ver.	(2013→2030) **1.7%/year**	**Improving EE by 35% in 20 years** (same as the level after "oil crisis")	**24.3%**	**927 mil. t-CO_2)** **(Down 25% from FY2013)**

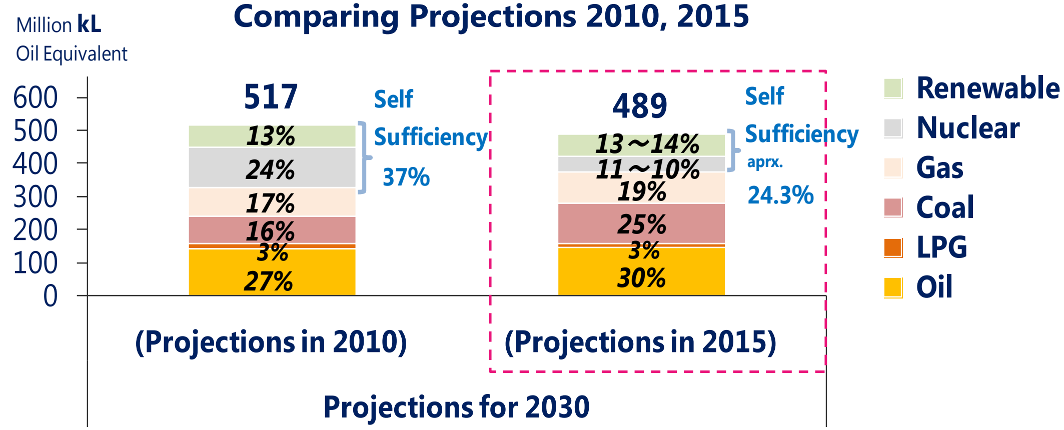
(Energy Demand)

(Projections in 2015)



N.B: EE stands for "Energy Efficiency"

(Primary Energy Supply) Comparing Projections 2010, 2015



(Source) (Projections in 2010) Joint Meeting, (The 2nd) Coordination Subcommittee, (The 4th) Basic Energy Planning Subcommittee, Advisory Committee for Agency for Natural Resources and Energy "Energy Supply and Demand Outlook in 2030" (June, 2010)
(Projections in 2015) METI "Long-term Energy Supply/Demand Outlook" (July 16, 2015)

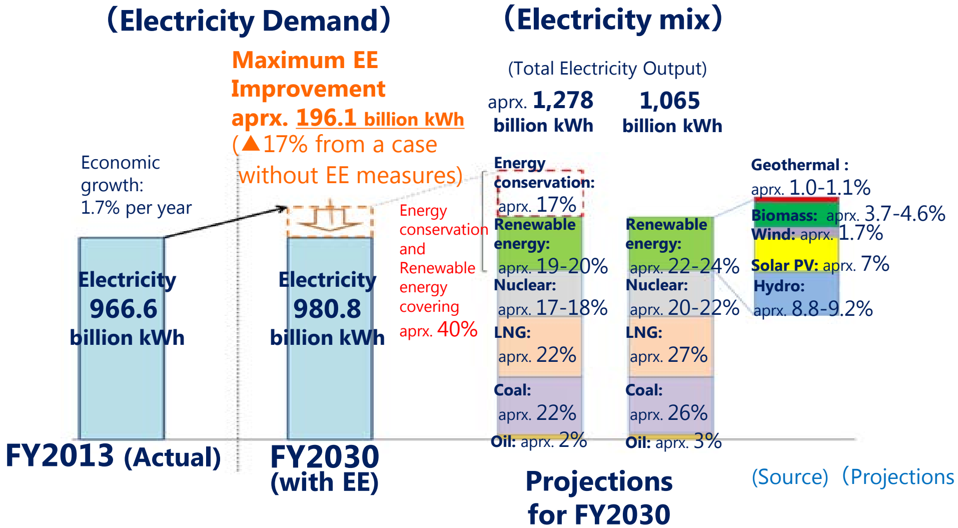
2030 Energy Supply and Demand Structure
: Difference Between 2010 and 2015 Versions
＜2＞ Electricity Mix

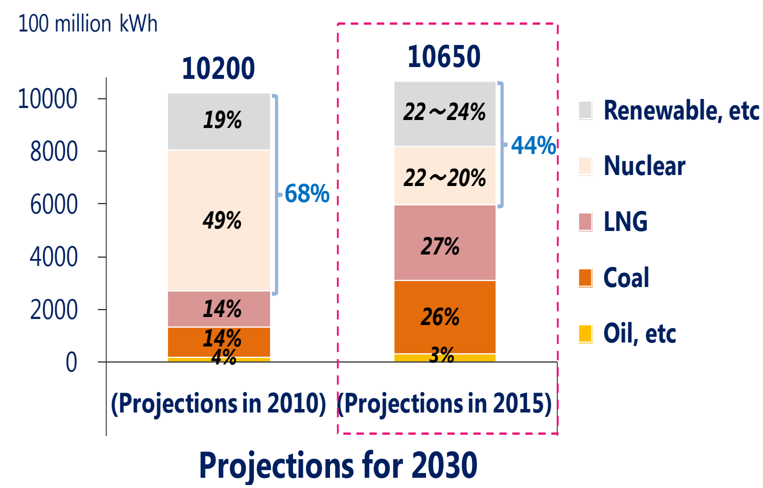
● (Electricity Mix) Nuclear and renewable energy had a combined share of 68% in the 2010 version against 44% in the 2015 version. Nuclear energy's share was cut by 30% (from 49% to 20-22%). Priority shifted from heavy dependence on nuclear energy to **diversification**.

	①Energy Conservation	② Nuclear Energy's Share	③Renewable Energy's Share	④ Electricity Cost
2010 Ver.	N.A.	aprx. 50% (49%)	aprx. 20% (19%)	N.A.
2015 Ver.	Total power generation 17%	20-22%	22-24%	Down 2-5% from FY2013

(2015 version)

- Thorough energy conservation and maximum renewable energy expansion is set to cover aprx. 40% of total electricity generation, with nuclear energy's share of the electricity mix reduced substantially (from 29% before the March 2011 disaster to 20-22%).
- Base load share: 56% (against 63% before the March 2011 disaster)





(Source) (Projections in 2010) Joint Meeting, (The 2nd) Coordination Subcommittee, (The 4th) Basic Energy Planning Subcommittee, Advisory Committee for Agency for Natural Resources and Energy "Energy Supply and Demand Outlook in 2030" (June, 2010)
(Projections in 2015) METI "Long-term Energy Supply/Demand Outlook" (July 16, 2015)

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1． Key points of the current energy mix based on the 4th Basic Energy Plan

(2) How much we could achieve the current energy mix ?

Current status of three numerical targets upon energy mix decision ⇒ Slow but steady progress

① Improving energy self-sufficiency rate

Target*1 : 6% in FY2014 ⇒ **24.3% in FY2030**

Current*2 : **12.3% at FY2019-end** (IEEJ outlook) --- **half achieved**

② Electricity costs (Fuel cost ＋ FIT purchase cost ＋ grid stabilization cost)

Target*1 : Reducing costs by FY2030 **(down 2-5% from FY2013)**
9.7 trillion yen in FY2013 (0.5 trillion yen in FIT purchase cost and 9.2 trillion yen in fuel and other costs)

Current*2 : **7.5 trillion yen in FY2019** (IEEJ outlook)
Down 22.7% from FY2013 --- **well achieved, but when oil price goes up?**
(2.3 trillion yen in FIT purchase cost and 5.3 trillion yen in fuel*3 and other costs)

*3 Assumptions for the end of FY2019
Crude oil price 67 $/bbl (CIF national average)

③ Reducing energy-related CO_2 emissions

Target*1 : Reducing emissions in **FY2030 by 21.9% from FY2013**

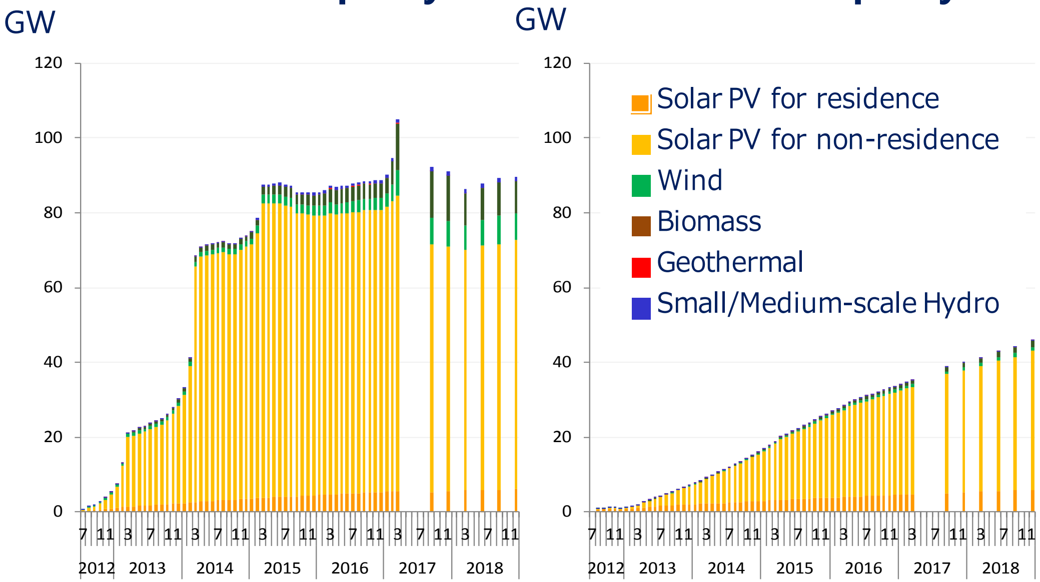
Current*2 : **Down 13.5% in FY2019** (IEEJ outlook) --- **60% achieved**

(Sources) *1 METI, "Long-term Energy Supply and Demand Outlook (July 2015)," published on July 16, 2015;
*2 IEEJ, "Economic and Energy Outlook of Japan through FY2019," 431st Forum on Research Works on Dec. 21, 2018

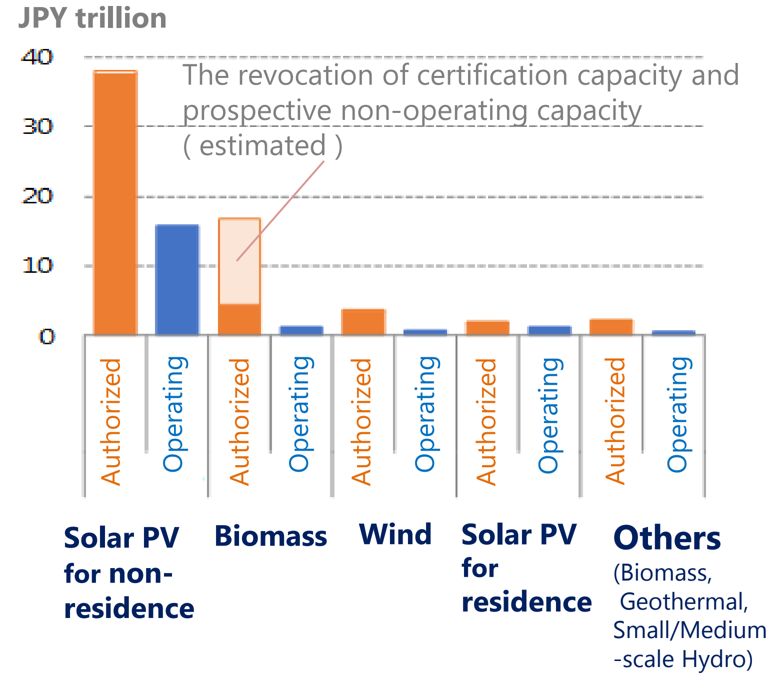
Renewable energy’s lopsided development and high costs

Feed-in Tariff (FIT) development

【Authorized capacity】 【Installed Capacity】



Japan's total FIT surcharge



- Consumer burden related to renewable electricity generation is soaring.
- The rapid increase in solar power with high purchase price is greatly increasing the burden. The total consumer burden for the next 20 years will reach **63 trillion yen** by operating just the **89.8 GW** capacity installed and licensed as of the end of **December 2018**. This inevitable burden is equivalent to a **3.7 yen/kWh** rise in tariffs, **or 22% for industrial and 16% for residential sectors**.
- **However, excluding** the revocation of certification capacity and the biomass capacity recognized as difficult to realize from barriers concerning long-term stable fuel procurement, the cumulative total amount is **51 trillion yen**.
This inevitable burden is equivalent to a **3.0 yen/kWh** rise in tariffs, **or 18% for industrial** and **13% for residential sectors**.

Source: Agency for Natural Resources and Energy, “Status of Introduction of Renewable Electricity Generation Facilities (end of December. 2018)”, Apr. 2019*

Nuclear energy's slow progress

Status of Nuclear Reactors Approved After Implementation of New Regulatory Standards (on July 8, 2013) (8 in operation, 1 offline, 6 in review)

Status	Company	Reactor	Adj. operation	Commercial operation	Suspension duration	Notes
In operation	Kyushu E.P.	**Sendai 1**	①August 2015 ②December 2016 ③June 3, 2018	①9/10/2015-10/6/2016 ②1/6/2017-1/29/2018 **③6/29/2018-**	Regular checkups ①10/6/2016-1/6/2017 ②1/29/2018-6/29/2018	
In operation	Kyushu E.P.	**Sendai 2**	①October 2015 ②February 2017 ③Aug.31, 2018	①11/17/2015-12/16/2016 ②3/24/2017-4/23/2018 **③9/28/2018-**	Regular checkups ①12/16/2016-3/24/2017 ②4/23/2018～9/28/2018	
In operation	Kansai E.P.	**Takahama 3**	①January 2016 ②June 2017 **③Nov.9, 2018**	①2/26/2016-3/10/2016 ②7/4/2017-8/3/2018 **③12/7/2018～**	①District court order 3/10/2016-3/28/2017 ②8/3/2018～12/7/2018	Takahama Units 3 and 4 were shut down due to a district court temporary injunction order for suspension. After a high court cancelled the temporary injunction order on March 28, 2017, they will restart after ❹ passing checkups.
In operation	Kansai E.P.	**Takahama 4**	①February 2016 ②May 2017 ③Sep.3, 2018	(March 2016 ❹Suspension for checkups) ①6/16/2017-5/18/2018 **②9/28/2018-**	①District court order 3/10/2016-3/28/2017 ②5/18/2018～9/28/2018	
In operation	Shikoku E.P.	**Ikata 3**	①August 2016 **②Oct.30, 2018**	①9/7/2016-10/3/2017 **②11/28/2018～**	Regular checkups 10/3/2017- 11/28/2018 (H.C. ordered the temporary injunction (12/13/2017～9/25/2018))	On Dec. 2017, Hiroshima High Court ordered the temporary injunction against operation of Ikata 3, under the regular statutory checkups within 13 months after commercial operation. **Sep. 25, 2018, High court allows restart of Ikata 3 reactor.**
Offline	Kansai E.P.	**Ohi 3**	①March 2018 **(②June. 2019)**	①4/10/2018-4/11/2019 (②July. 2019)	**Regular checkups** **①4/11/2019～ (July 2019)**	Resuming operation after regular checkups within 13 months after commercial operation
In operation	Kyushu E.P.	**Genkai 3**	①March 2018	**①5/16/2018-**		
In operation	Kansai E.P.	**Ohi 4**	①May 11, 2018	**①6/5/2018-**		
In operation	Kyushu E.P.	**Genkai 4**	①June 19, 2018	**①7/19/2018-**		

In review	Kansai E.P.	**Takahama 1**	❶❷Approved ❸Before application	Pursuing restart in or **after August 2019**
In review	Kansai E.P.	**Takahama 2**	❶❷Approved ❸Before application	Pursuing restart in or **after March 2020**
In review	Kansai E.P.	**Mihama 3**	❶❷Approved ❸ In review	Pursuing restart in or **after March 2020**
In review	TEPCO	**kashiwazaki-kariwa 6/7**	❶Approved ❷ In review ❸ In review	
In review	JAPC	**Tokai Daini**	❶❷Approved ❸ In review	

（As of Apr. 11, 2019）

2． Key points of the 5th Basic Energy Plan

(2) Outline of the 5th Basic Energy Plan : Chapter 1

Chapter 1: Structural Issues, Changes in Circumstances, and Policy Timeframe

Section 1: Structural issues faced by Japan

1. **Vulnerability due to high dependency on overseas energy resources**
2. **Mid- to long-term changes in the energy demand structure** (population decline, etc.)
3. **Instability of resource prices** (increased energy demand in emerging countries, etc.)
4. **Increasing global greenhouse gas emissions**

Section 2: Changes in energy environments (2030)

1. **Start of inter-technology competition for decarbonization**
   (renewable energy, fossil fuels, nuclear, etc.)
2. **Geopolitical risks increased by technology changes**
3. **Intensified competition between nations and firms**

Section 3: Achievement of an optimal energy mix by 2030 and its relation with the 2050 scenario

(Omitted)

2． Key points of the 5th Basic Energy Plan

(2) Outline of the 5th Basic Energy Plan : Chapter 2

Chapter 2: Basic Policies and Measures towards 2030

Section 1: Basic policies ⇒ Seeking to securely implement energy mix for 2030

Section 2: Policy measures towards 2030

1.	Promotion of securing of resources:	⇒ Promotion of independent development of fossil fuel and mineral resources and establishment of a robust industrial system Independent development ratio (oil/natural gas): 27%(2016)→40%(2030) Methane hydrate: Seeking commercialization between 2023 and 2027
2.	Realization of a thorough energy efficient society:	⇒ Using artificial intelligence, internet of things, big data, etc.
3.	Efforts for the utilization of renewable energy as the major power source:	⇒ Initiatives to develop renewable energy into major power source
4.	Re-establishment of the nuclear energy policy:	⇒ Sincere remorse, restoration of public trust, reconstruction of Fukushima continuous safety improvement, spent nuclear fuel measures
5.	Efficient and stable use of fossil fuel:	⇒ Introducing regulatory measures while promoting voluntary initiatives
6.	Fundamental reinforcement of measures for realizing a hydrogen society:	⇒ Implementation of measures based on the Basic Hydrogen Strategy
…	…	
10.	Development of energy industry policy:	⇒Expanding markets for storage batteries, hydrogen, fuel cells and other technologies for which Japan has taken global leadership

Section 3: Promotion of technology development

- Energy technology development plan/roadmap

Section 4: Enhancement of communication with all levels of the society

- Expanding interactive communications

2． Key points of the 5th Basic Energy Plan

(2) Outline of the 5th Basic Energy Plan : Chapter 3

Chapter 3: Efforts for Energy Transitions and Decarbonization towards 2050

Section 1: Ambitious multiple track scenario – Pursue every option

(Note) Electricity system examples

① Variable Renewable Energy (Solar PV, Wind)
＋ electricity storage, hydrogen storage

② Converting overseas resources into hydrogen or synthetic gas

③ Existing carbon-free power sources (hydro, geothermal heat, nuclear energy)
⇒ Nuclear: Pursuing safer, economical and flexible reactors

④ Distributed systems integrated with digital technology

Section 2: Designing of The 2050 Scenario

・**Energy security: Improving resources self-sufficiency rate**
+ raising technology self-sufficiency rate, securing diversification

Section 3: Issues faced by each option and priorities in response thereto

・**Nuclear: to restore social trust, developing backend technologies**

Section 4: All-out efforts to realize the scenario

Comparison of Long-Term Strategies – Ambitious Aims in Japan On Par With the US/Europe; Emphasis on Implementation and Flexible

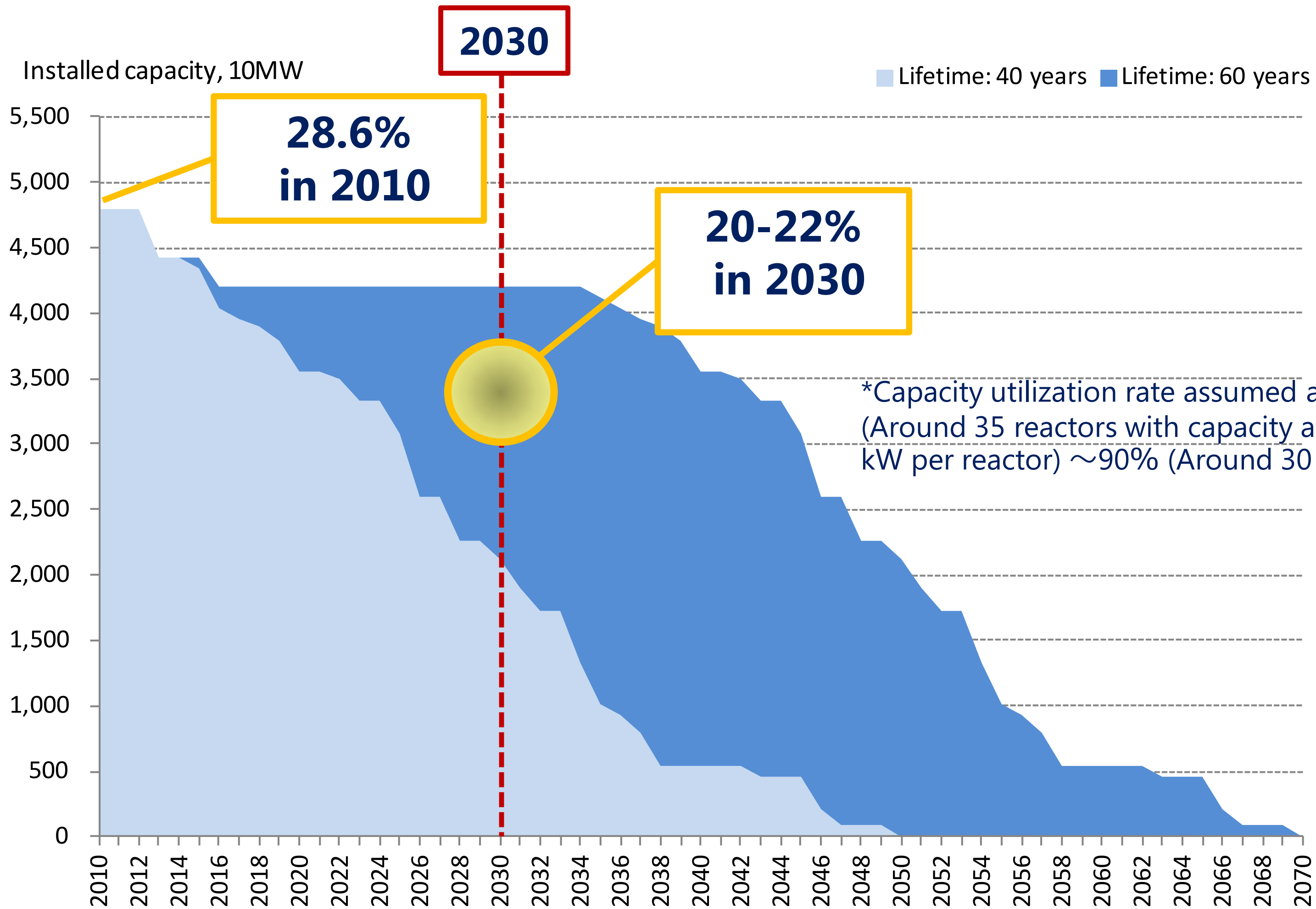
※Quantitative values reflect scenario ranges in the long-term strategy and country goals

		US	Canada	UK	France	Germany	Japan
Concept (ensuring flexibility)		**Ambitious vision** for achieving reduction goals (not intended as policy formulation)	**Information** for discussion (not a policy blueprint)	**Reference for actions** over the next few years from a path review (difficult to make long-term forecasts)	**Possible path** to reaching the goals (not an action plan)	**Direction** for lowering emissions (not a master plan)	**Initiative** for energy transition (**ambitious scenario**)
Goals and policy direction	Reduction goal	▲80% or more (vs. 2005)	▲80% (vs. 2005)	▲80% or more (vs. 1990)	▲75% (vs. 1990)	▲80~95% (vs. 1990)	▲80%
	Zero emissions: Variable renewable energy	●Infrastructure and regulatory assistance needed (55~65% in renewables)	●Requires further expansion of wind, photovoltaic, and hydro power (50~80% in renewables)	●Assistance for sea-based wind and other new market entry	●More flexibility needed to integrate renewable energy	●Optimization of variable renewables via sector coupling (80% in renewables)	●Ultrahigh efficiency renewable energy development; storage battery and hydrogen stored power development
	Zero emissions: Stable renewable Energy, Nuclear	●Extend operation periods and make next-generation nuclear power investments (17~26%)	●Planning to invest $25 billion in nuclear power over the next 15 years (5~50%)	●Assistance for innovations to develop next-generation nuclear power	●Raising nuclear power to 50% (Energy Conversion Act)		●Stable renewable energy development ●Safe reactors and back-end technology development
	Zero emissions: Thermal (CCS, hydrogen)	●Presents a broad range (CCS: 0~25%)	●Includes CCS (CCS: 0~10%)	●End thermal power without CCS by 2025	●CCS is vital to an extreme zero emissions scenario	●No support for new coal thermal plants	
	Thermal and transport Electrification; Hydrogen CCUS	●Electrification advances (45~65%) ●Possibility of hydrogen having an important role in areas where electrification is difficult	●Electrification widely needed to lower emissions (40~72%) ●CCS leeway in high emission industries ●Possibility of using hydrogen in heavy industry and ships	●Promote heat pump and EV usage ●Lead in CCUS technology ●Use hydrogen in FCVs and industry and consumer heat supply	●Electrification is important in energy savings ●Utilize CCS in high emission industries	●Electrification of automotive and consumer thermal uses (about 30%) ●Hydrogen and CCUS contribute to decarbonization in heavy industries	●Advanced HP development, EV/PHV development ●Hydrogen recycling system development and FCV development
	Energy savings	●Improve efficiency of the entire energy system (▲24~30%; vs. 2005)	●Improve efficiency of the entire energy system (▲5~35%; vs. 2014)	●Lift energy savings of all households to a certain level	●Significant energy savings required in all areas (▲50%; vs. 1990)	●Robust decoupling of economic growth and energy consumption (▲50%; vs. 2008)	●Lead development of a distributed energy system (Compact decarbonization power, vehicle storage battery usage, AI and IoT usage, automated driving, demand control, etc.)
	Overseas contribution	●Contributing via expansion of US product markets	●Promoting international contributions (0~15%)	●Leading the world in environmental investment	●Contributions by French companies through overseas development assistance	●Maintaining and strengthening developing country investments	●Low-carbon promotion investments + decarbonization developments
Implementation mechanism		Periodic review	Periodic review	Carbon budget	Carbon budget	Scientific verification and dialogue with the public sector	**Decarbonization system costs and risk assessment + Scientific review**

(Source) METI, ANRE "Structure of the 5th basic energy plan (draft), etc." Natural Resources and Fuel Committee (27th Meeting), Advisory Committee for Natural Resources and Energy, Document 1, p.3 (May 16, 2018)

Need for new and additional nuclear plants
: Will the target nuclear share be maintained at 20-22% ?

❖ Extension of lifetime or construction of new reactors is required

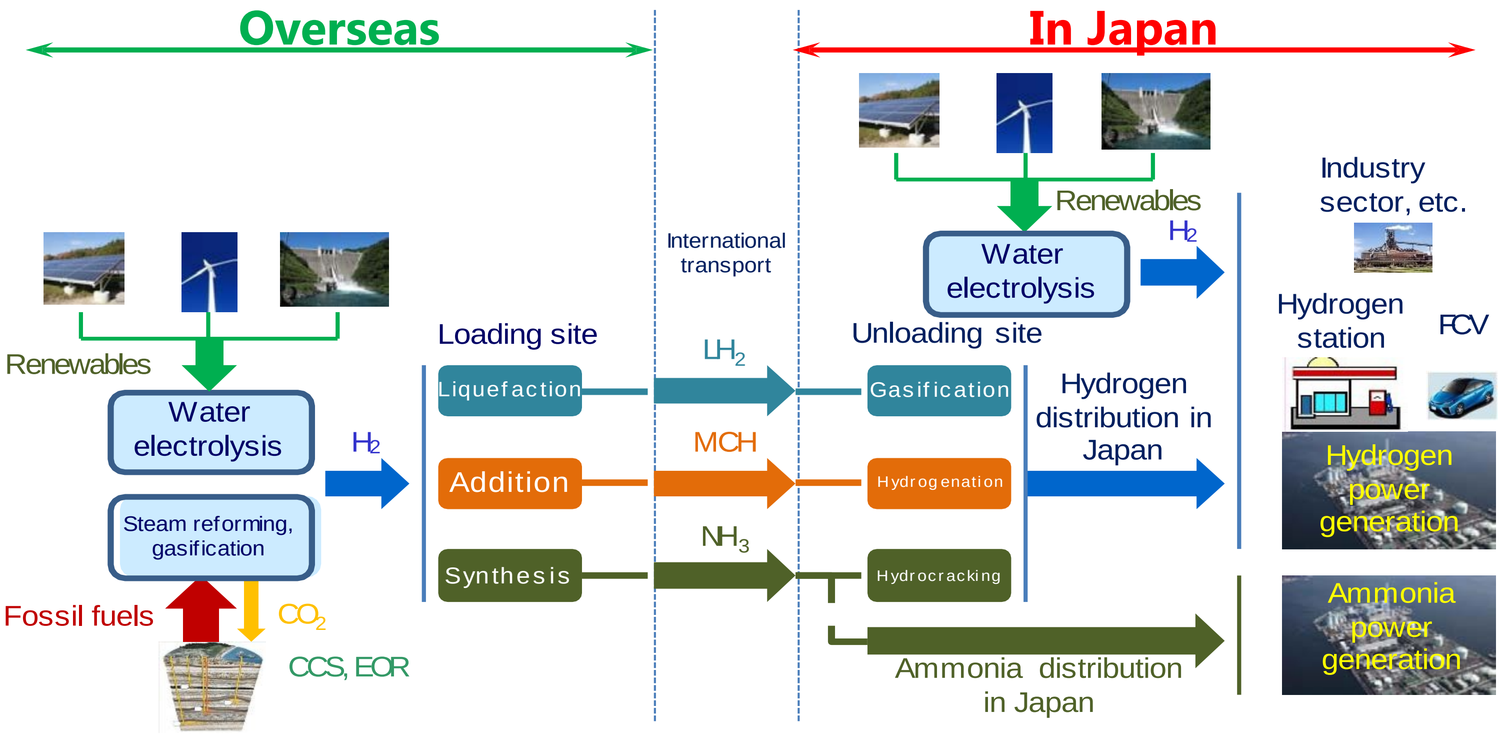


*Capacity utilization rate assumed at 70% (Around 35 reactors with capacity at 1 million kW per reactor) ～90% (Around 30 reactors)

Technology Options (hydrogen)

- Production technology has been almost established.
- Three options exist for transportation (energy carriers) : under demonstration
- The economically rational realization of CCS is the initial key to hydrogen or ammonia production from fossil fuels: Still in the demonstration stage.

(Note) Zero carbon hydrogen can be produced from RE as well



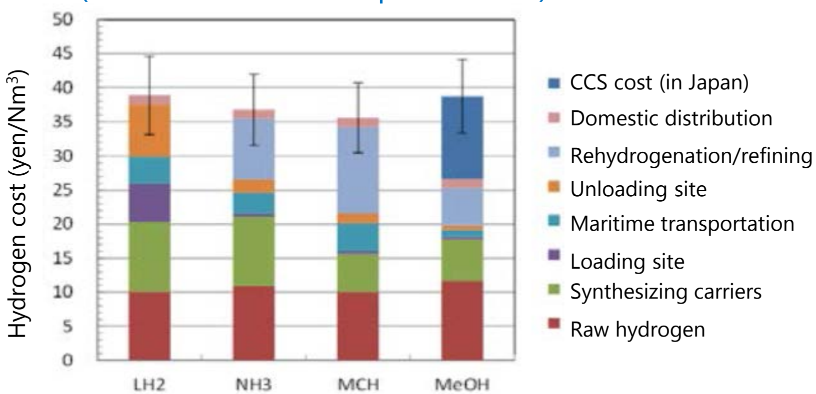
Note: LH2 stands for liquefied hydrogen and MCH stands for methylcyclohexane.

Source: IEEJ

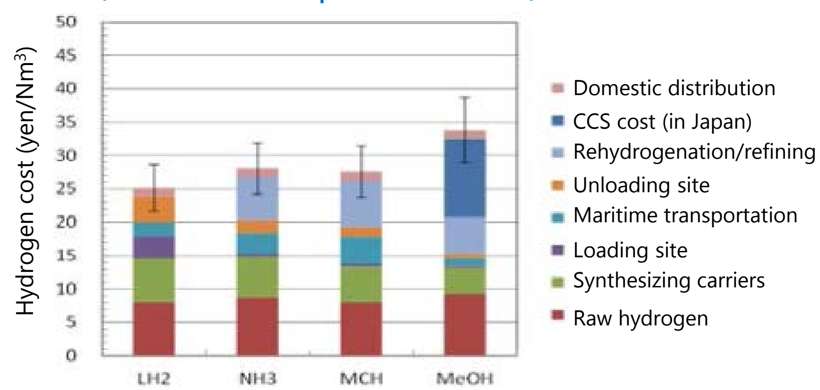
Hydrogen Cost Reduction

- Although cost estimates differ depending on energy carrier and technological advancement assumptions, raw material and equipment costs must be substantially reduced.

(Research and development case)

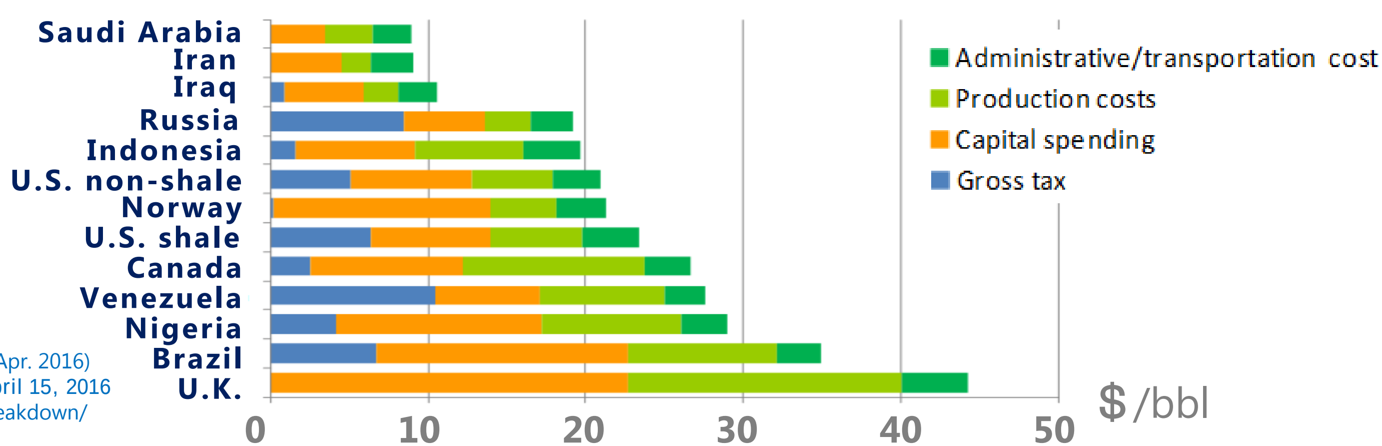


(Maximum expansion case)



Source: Energy carrier system survey and research – assessment of energy carrier systems' economic efficiency and analysis of their characteristics under a leading hydrogen use research and development project, by the Institute of Applied Energy under contract from the New Energy and Industrial Technology Development Organization

Oil and Gas Production Costs



Source: Rystad Energy, Ucube (as of Apr. 2016)
The Wall Street Journal, Published April 15, 2016
http://graphics.wsj.com/oil-barrel-breakdown/

3． Possible Cooperation in North East Asia

(1) Energy Security

1) High Dependence on Middle East

-> Help ME be Stabilized

2) "Belt and Road" and " Free and Open Indo-Pacific Strategy"

-> Two cooperation need to be enhanced in a complementary manner

-> North East Asia Power Grid

(2) Economic Efficiency (Affordability)

1) Avoiding "Asian Premium" of LNG

-> Elimination of Destination Clause and Establishing Asian LNG market/price index

2) Coordinated upstream activity of oil and gas

3) Learning adequacy of market reform

3. Possible Cooperation in North East Asia

(3) Environment

1) Prevention of Pollution

-> Desulfurization, Denitrification

2) Realizing Paris Agreement

-> Transfer of Traditional Eco-friendly Technology
ex. Energy Efficiency , Renewable energy and nuclear

-> Development of new technology
ex. USC , Hydrogen , carbon recycling

(4) Safety

1) Sharing objective facts

-> Death print of Energy

2) Harmonization of nuclear safety regulation

Conclusion

1. **The current energy mix for 2030 was determined in 2015, based on the 4th Basic Energy Plan.**
   It would take some more time to achieve this energy mix because of slow progress of reoperation of nuclear reactors and high cost of renewable energy.

2. **The 5th Basic Energy Plan was determined in 2018 and the message are;**
   1) the current energy mix toward 2030 need to be maintained.
   2) we should have multiple scenario of energy mix toward 2050 such as
   ① Variable Renewable Energy (Solar PV, Wind) ＋ electricity storage, hydrogen storage
   ② Converting overseas resources into hydrogen or synthetic gas
   ③ Existing carbon-free power sources (hydro, geothermal heat, nuclear energy)
   ⇒ Nuclear: Pursuing safer, economical and flexible reactors
   ④ Distributed systems integrated with digital technology

3. **Energy Cooperation in North East Asia need to be put into practice.**

The Deathprint of Energy

Energy Source	Mortality Rate (deaths/trillion kWh)
Coal – global average	100,000
Coal – China	170,000
Coal – U.S.	10,000
Oil	36,000
Natural Gas	4,000
Biofuel/Biomass	24,000
Solar	440
Wind	150
Hydro – global average	1,400
Hydro – U.S.	5
Nuclear – global average	90
Nuclear – U.S.	0.1

Source: J. conca, Forbes 2016/9/30

- The table lists estimates of the mortality rate for each energy source as deaths per trillion kWhs generated over the last 40 years.
- The numbers are a combination of direct deaths and epidemiological estimates and are an amalgam of many sources

(note) **Japan** used about 1 trillion kWh in 2014, 32% from coal
U.S. used about 4 trillion kWh in 2015, 33% from coal

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On the 29th January 2019, the Think Tanks and Civil Societies Program at the University of Pennsylvania (U.S.) released its "2018 Global Go To Think Tank Index Report", the most comprehensive ranking of the world's top think tanks.

In the ranking for **2018**, **the Institute of Energy Economics, Japan (IEEJ)** **is ranked 2nd in the world** in the category of **Energy and Resource Policy Think Tanks.**

Past Ranking	3rd → (2014)	1st → (2015)	3rd → (2016)	**2nd (2017/18)**

"2018 Global Go To Think Tank Index Report"(p.123)
http://repository.upenn.edu/think_tanks/

IEEJ Website

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