Climate Change, Energy Conservation and "Total Cost minimizing Approach"

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Prof. Masakazu Toyoda

Chairman and CEO, The Institute of Energy Economics, Japan (IEEJ)

Contents

1. What happened with Energy demand & supply situation after Fukushima Accident

Current Status

All the nuclear power plants were shut down after the accident .
Now under new regulatory regime, **the reoperations is taking place gradually**, **with only 5 reactors in operation** out of 54 before the accident as of mid June.

What consequences could risk , relating to "3E"?

- **Vulnerable to Energy supply disruptions** -> **Energy Security**
- **Energy price upsurge and volatility** -> **Energy Efficiency**
- **CO2 emissions** -> **Environment**

***1** (Source) "Report by Electricity Supply-Demand Verification Subcommittee," P.40, April 2016, Electricity Supply-Demand Verification Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy
***2** (Source) "FY2014 Greenhouse Gas Emissions (final data)," April 15, 2016, Ministry of Environment.
The final data will be formally submitted to the secretariat of the U.N. Framework Convention on Climate Change. The final data may be subject to change as a result of future revisions of annual data regarding various statistics and the revision of calculation methods, among other factors.

Impact on 3E

E① Energy Security is deteriorating (Energy Security)
E② Electricity Prices are Rising (Economic Efficiency)

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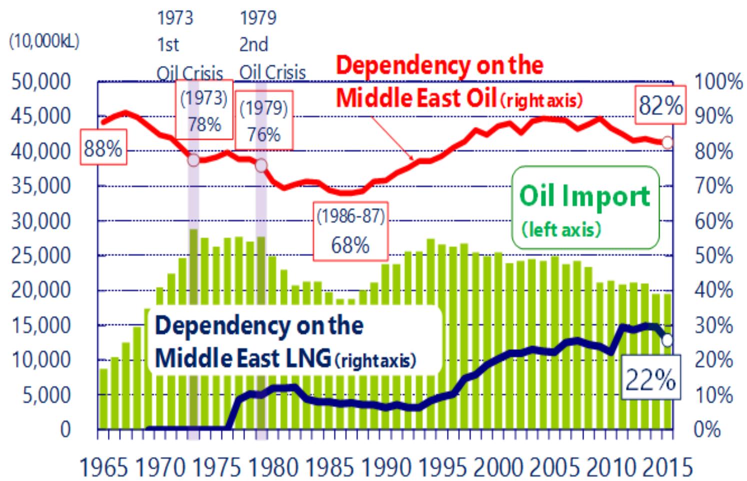
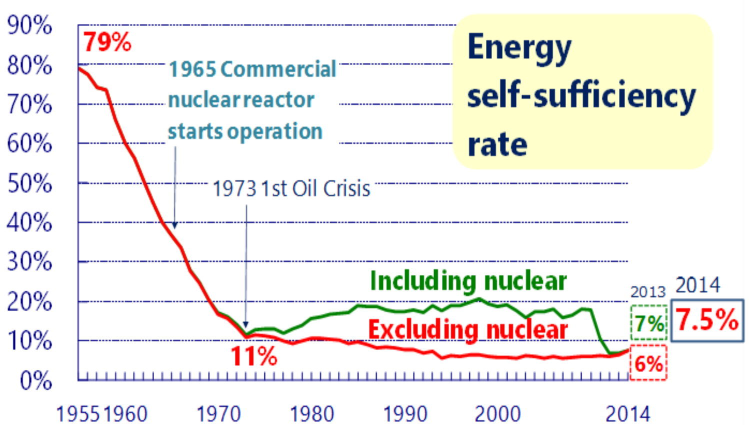
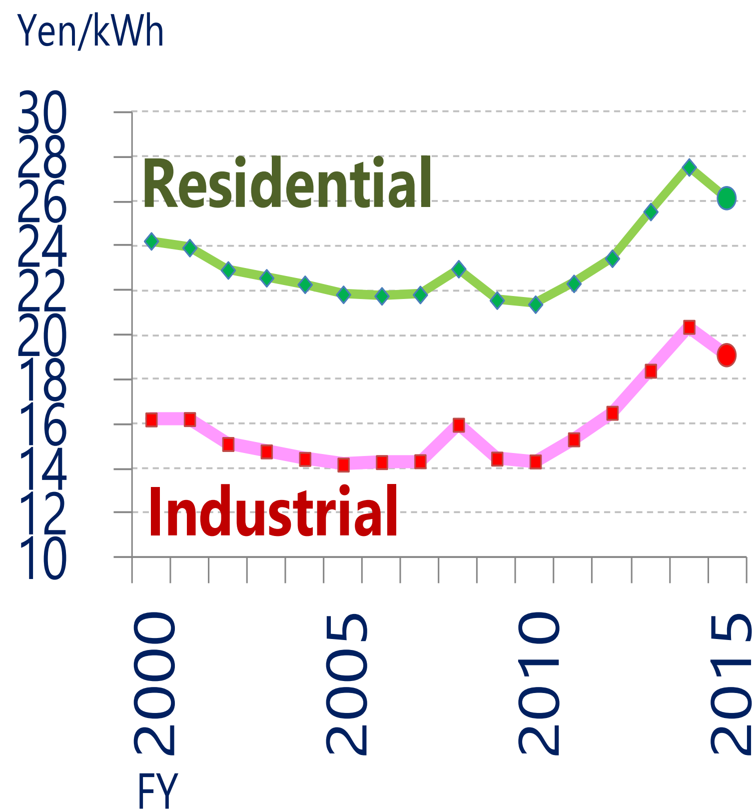
Energy Security





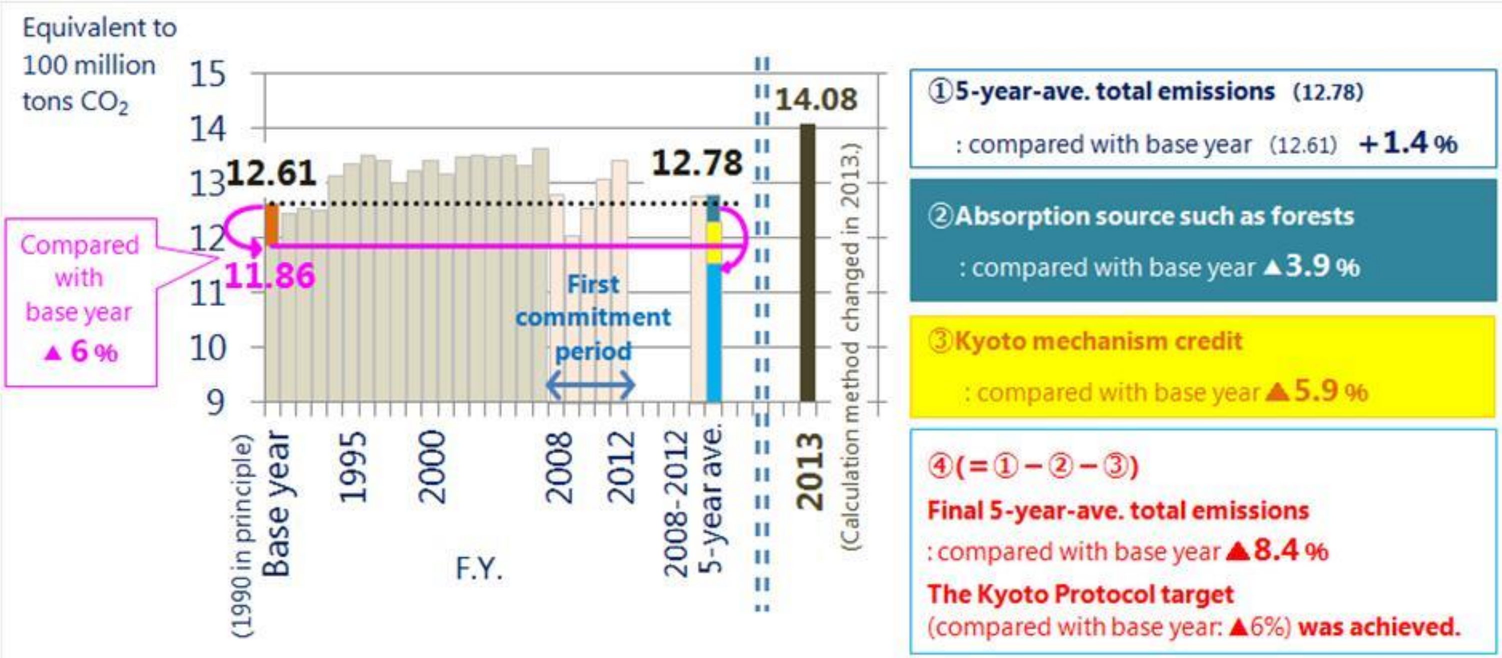
Electricity prices



(Source) IEEJ "Handbook of Energy & Economic Statistics in Japan"

Impact on 3E

E③ Increasing Emissions of Greenhouse Gases (Environment)



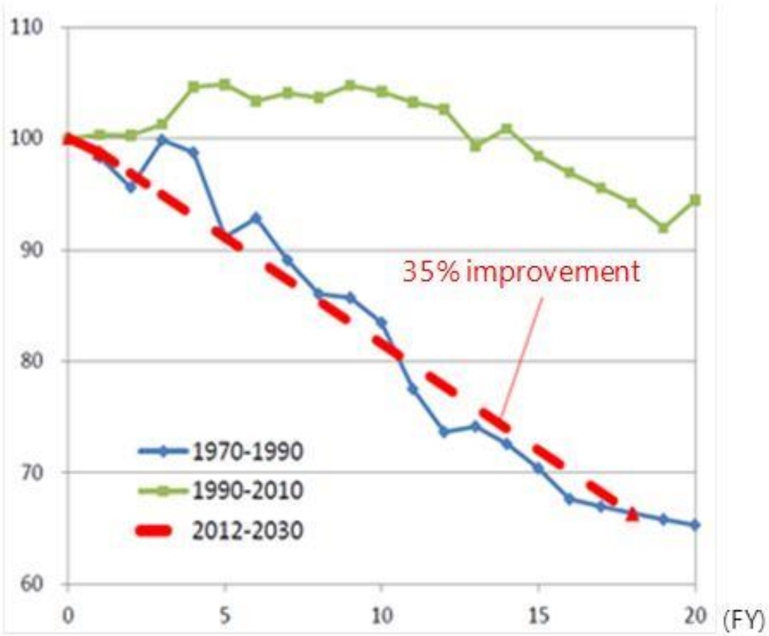
- To attain **the target** of reducing greenhouse gas emissions for **the Kyoto Protocol first commitment period (2008-2012) by 6% from the base year (1990)** prescribed by the Protocol, Japan has **achieved a 5-year average of 8.4% reduction** including forest absorption (3.9% reduction) and **the Kyoto Mechanism credit purchase (5.9%).**
- .The total credit purchase **$ 5.8 billion yen (for the 5 years from 2008 to 2012)** **based on the average transaction unit prices on the carbon market and the yen/dollar currency rates during the said period.** (IEEJ estimation)

Based on "Progress of Kyoto Protocol Target Achievement Plan", Global Warming Prevention Headquarters*, July 1, 2015 and "Greenhouse Gas Emissions (definitive values) in FY2012", Low-carbon Society Promotion Office, Policy Planning Division, Global Environment Bureau, Ministry of Environment, April 15, 2014
*Established at the Cabinet by the Cabinet Decision on December 19, 1997, headed by the Prime Minister, and with other members all Ministers of State.

2. Challenges to address Climate Change in Japan
1) Promotion of Energy Conservation toward 2030

- 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】



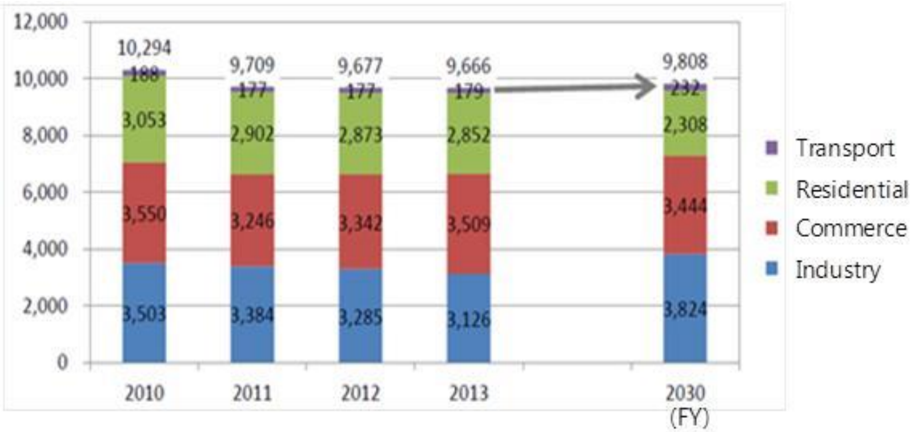
Energy efficiency=final energy consumption/real GDP

Electricity demand (100 million kWh)

	FY2013		FY2030			
			Reference		Energy conservation	
Industry	3,126	32%	4,284	36%	3,824	39%
Commerce	3,509	36%	4,387	37%	3,444	35%
Residential	2,852	30%	2,909	25%	2,308	24%
Transport	179	2%	189	2%	232	2%
Total	9,666	100%	11,769	100%	9,808	100%

※Numbers for FY2030 are estimates.

Changes in electricity demand (100 million kWh)



(Source) Document 3 "Long-term Energy Supply/Demand Outlook, Related Documents" p.66 (left chart) and p.69 (right chart) at 11th meeting (July 16, 2015) of the Long-term Energy Supply and Demand Outlook Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy

Specific Energy Conservation Assumptions

■ Energy savings in each sector would be accumulated to save energy consumption by 50.3 million kl

<Major energy conservation measures in each sector>

Industry sector <Down about 10.42 million kl>

- **4 major industries (steel, chemicals, cement, paper-pulp)**
  ⇒ Promoting low-carbon society action plans
- **Promoting plant energy management**
  ⇒ Improving energy efficiency through visualization of manufacturing lines
- **Developing and introducing innovative technologies**
  ⇒ Introducing COURSE50 (CO_2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50) to cut CO_2 emissions by some 30% through hydrogen reduction of iron ore, blast furnace gas CO_2 separation, etc.)
- **Cross-industry introduction of highly efficient equipment**
  ⇒ Low-carbon industrial furnaces, high-performance boilers, etc.

Transport sector <Down about 16.07 million kl>

- **Diffusing next-generation vehicles, improving fuel efficiency**
  ⇒ One of every two vehicles would be a next-generation vehicle
  ⇒ Fuel cell vehicles: More than 100,000 units in maximum annual sales
- **Traffic flow measures**

Commerce sector <Down about 12.26 million kl>

- **Energy-saving buildings**
  ⇒ Energy conservation standard adaptation requirement for new buildings
- **Introducing LED lights and organic light emitting displays**
  ⇒ Diffusing LED and other highly efficient lights
- **BEMS building energy management system for energy management**
  ⇒ Introducing BEMS for a half of buildings
- **Promoting national movements**

Residential sector <Down 11.6 million kl>

- **Energy-saving housing**
  ⇒ Energy conservation standard adaptation requirement for new housing
- **Introducing LED lights and organic light emitting displays**
  ⇒ Diffusing LED and other highly efficient lights
- **BEMS building energy management system for energy management**
  ⇒ Introducing BEMS for all houses
- **Promoting national movements**

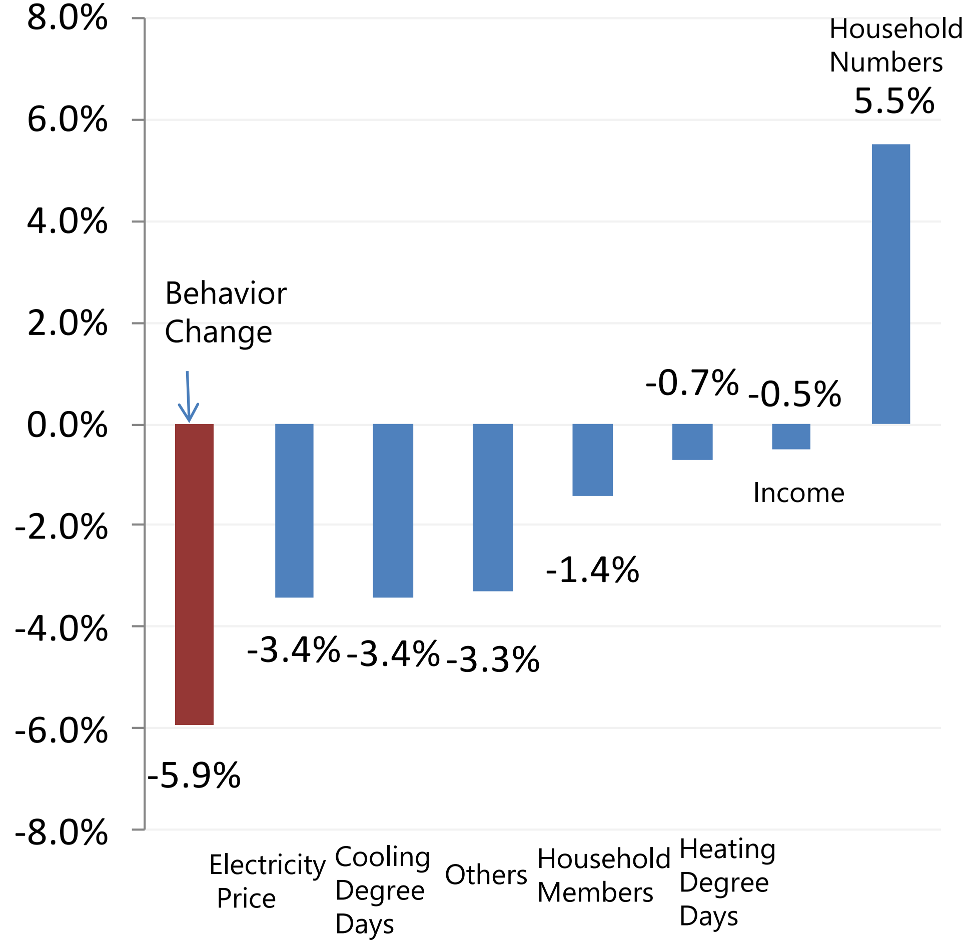
(Note) The key issues include **"Facility Renovation"**, **"IT Utilization"**, and **"Energy Conservation in Buildings"** as well as the introduction of **"Benchmarking Systems"**. Regulations and Incentives are essential .

(Source) Document 3 "Long-term Energy Supply/Demand Outlook, Related Documents" p.21 at 11th meeting (July 16, 2015) of the Long-term Energy Supply and Demand Outlook Subcommittee, Strategic Policy Committee, Advisory Committee for Natural Resources and Energy

Impacts of Behavioral Changes for Electricity Demand after Fukushima in Japan

Electricity Demand Change (Residential)	• ▲13% in 2015 (compared with 2010) • Declined at 2.3% /year (2010-2015)
Factor Analysis	• Impacts from Behavior change represents the largest at ▲5.9%

Factors affecting Electricity Demand Change in 2015 (compared with 2010)



Source: Satoshi KABE (2016) "How to analyze the electricity demand change after the Great East Japan Earthquake" http://criepi.denken.or.jp/jp/serc/denki/pdf/20160912.pdf

2. Challenges to address Climate in Japan
2) Making an Energy Mix, and the "3E+S" policy

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Basic Policy Direction (Energy Mix, July 16, 2015)

1) Policy standpoints for long-term energy supply/demand outlook

⇒ The outlook provides a desirable future picture of energy supply and demand to be realized through measures implemented for the policy targets for energy security (stable supply), economic efficiency(energy cost), environmental friendliness and safety (**3E+S**) based on the Basic Energy Plan which was approved at Cabinet Meeting in April 2014. This time, an outlook for 2030 is being developed.

2) Policy goals on energy mix formulation

① The energy self-sufficiency rate should be higher than before the March 2011 Great East Japan Earthquake (around 25%).

② Electricity costs should be lowered from the present levels.

③ The greenhouse gas emission reduction target should be comparable to major economies, such as EU and the US levels. Japan need to take global leadership in cutting emissions.

⇒ At the same time, Japan should reduce its dependence on nuclear power generation as far as possible.

3) Regular revision

⇒ The energy mix should be revised as necessary at least to meet the Basic Energy Plan review coming every 3 years.

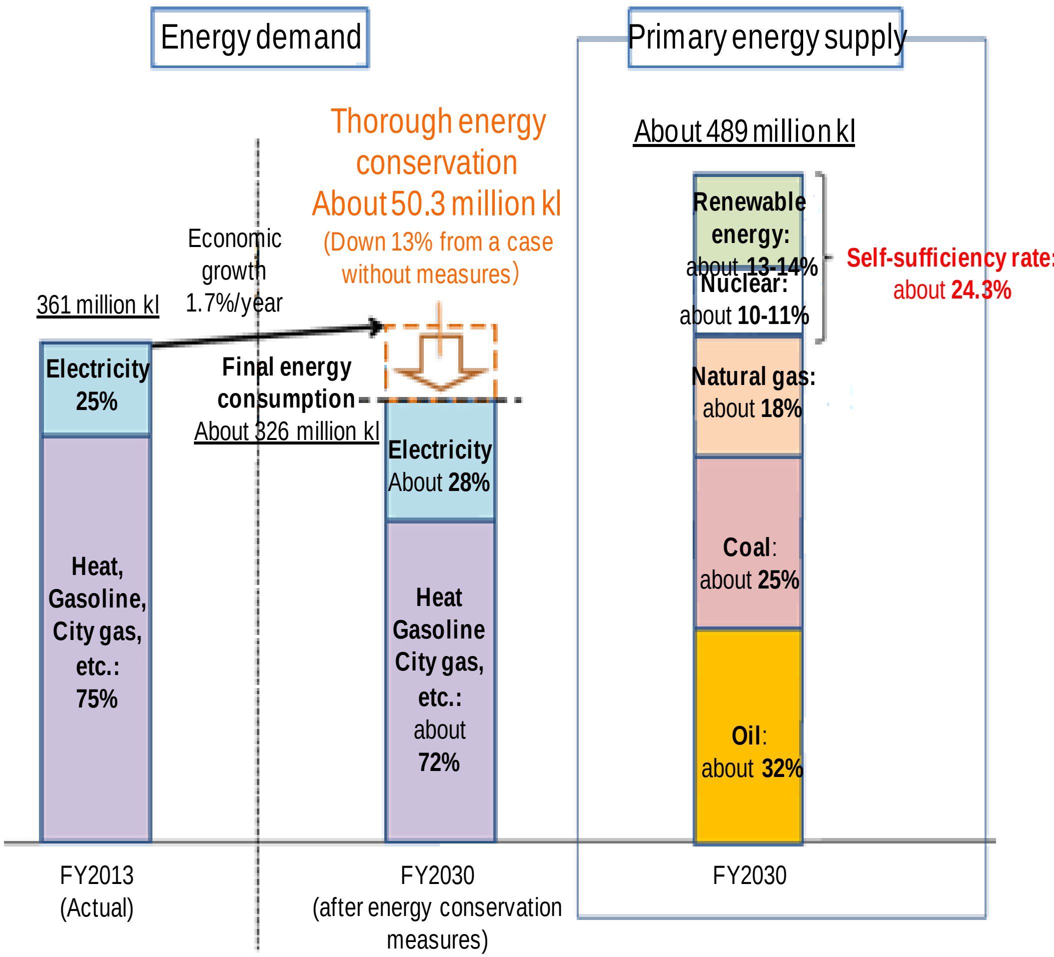
Energy Mix (Energy Supply/Demand Structure) in 2030
<I> Primary Energy

<1> Energy demand and primary energy supply structure

○ While energy demand growth is projected in line with economic growth (**an average 1.7%**), energy efficiency is expected to improve as much as after the oil crises thorough energy conservation (**35% in 20 years**).

◎ **Energy supply/demand structure improvement**
(energy self-sufficiency rate:
6% in 2014 ⇒**24.3%** in 2030)

◎ **Energy-related CO_2 emissions**: **down 21.9%** from 2013

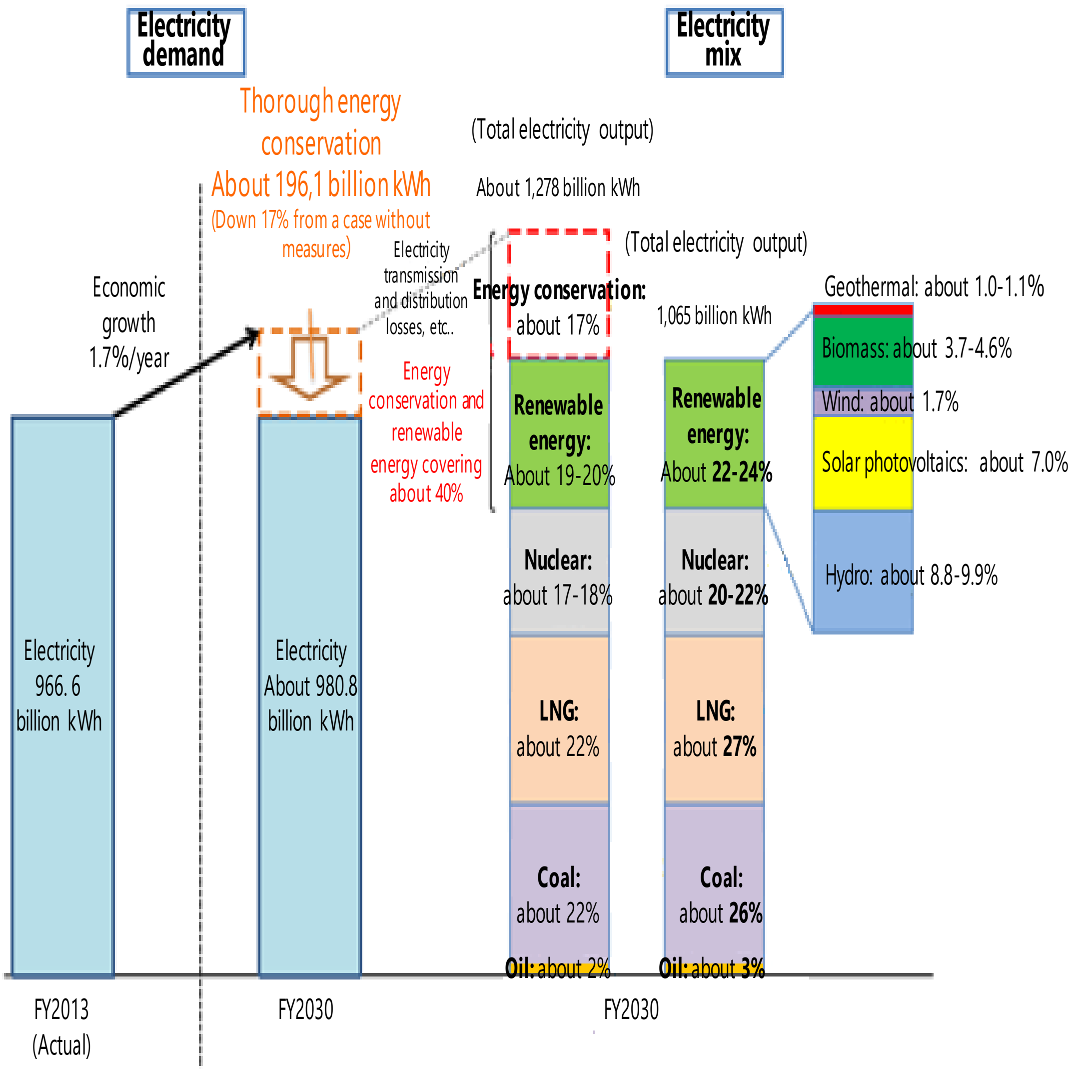


(Source) METI "Long-term Energy Supply/Demand Outlook" p.5 (July 16, 2015)

Energy Mix (Energy Supply/Demand Structure) in 2030 <II> Electricity Mix

<2> Electricity mix

- ○ Thorough energy conservation (electricity savings) and the maximum renewable energy diffusion will cover **about 40%** of electricity demand, reducing the dependence on nuclear power generation substantially (from **29%** before the 3/11 disaster to **20-22%**).
- ○ Base load share: **56%** (**63%** before the 3/11 disaster)
- ◎ **Electricity costs** to **decline by 2-5%** from the present level



(Source) METI "Long-term Energy Supply/Demand Outlook" p.7 (July 16, 2015)

Presenting the GHG Emissions Reduction Target for Paris Agreement : Is it really comparable to US and EU?

	Paris Agreement (2015)	Kyoto Agreement (1997)
a. Participating Countries	INDC*submitting countries : **192** (As of Apr. 19, 2017)	Countries with reduction duties: **37** (US has not ratified)
b. Setting Targets	**Bottom up**	**Top down**
c. Compliance	**No binding mechanism but 5 year review**	**Legally binding**

*INDC（Intended Nationally Determined Contributions）

Comparison of major countries' INDC

	From 1990	From 2005	From 2013	GHG emissions per GDP (kg/dollar GDP) 2012 Actual	GHG emissions per GDP (kg/dollar GDP) 2025/2030 Estimated
Japan (Target Year 2030)	▲18.0%	▲25.4%	**▲26.0%**	0.28	0.16
U.S. (Target Year 2025)	▲14～16%	**▲26～28%**	▲18～21%	0.45	0.27～0.28
EU (Target Year 2030)	**▲40%**	▲35%	▲24%	0.31	0.17

■ The U.S. submitted a reduction target compared with 2005 and the EU a target compared with 1990.

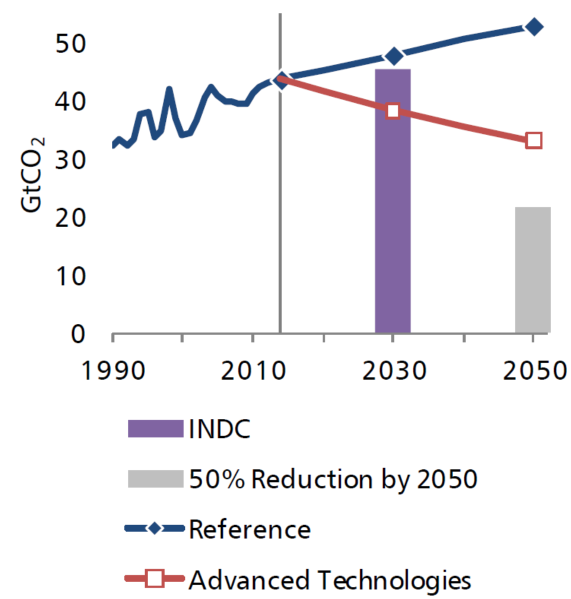
(Source) Reference Document 1 "Draft Commitment-related Materials" p.3-4 at 7th joint meeting (April 30, 2015) of the subcommittee on post-2020 global warming measures, Global Environment Subcommittee, Central Environment Council, and the working group on intended nationally determined contributions, Global Environment Subcommittee, Committee on Industrial Science and Technology Policy and Environment, Industrial Structure Council

3. Paris Agreement : Advantages and disadvantages
1) A step towards global action of success

❖ Evaluation of Paris Agreement

Good!! ☺☺☺	Over 180 countries, including emerging countries such as China and India, agreed to take actions to reduce emissions. Using bottom-up approach to add individually set reduction targets rather than a top-down approach used by Kyoto agreement where the reduction targets were set first and then allocated to the countries. Method is to evaluate the total target numbers every five years and decide any additional efforts if necessary.
Challenges ☹☹☹	Global GHG emissions will increase from the current level.

❖ GHGs emissions



GHG emissions in 2030 under submitted INDC which are set voluntarily by each country are expected to increase from the current level of emissions. Trend will be subdued but 50% reduction by 2050 cannot be achieved.

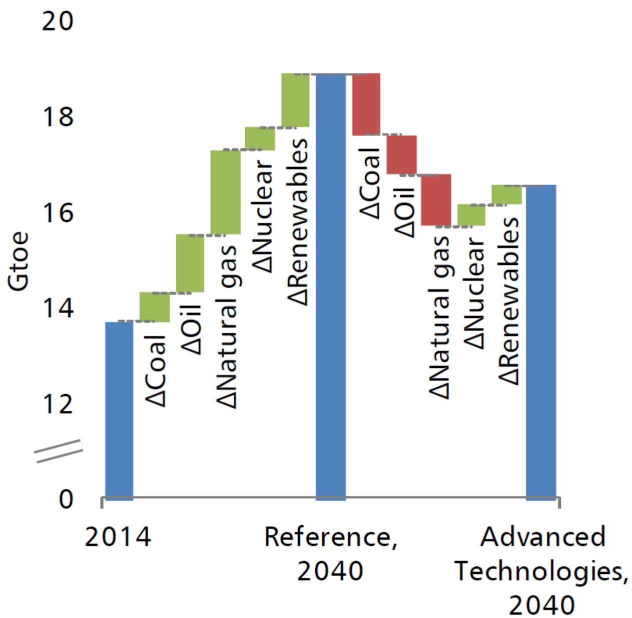
It is necessary to achieve the target agreed under the Paris Agreement and further reduce emissions. It is essential to promote reduction worldwide via technology transfer as well as technology innovation.

(Source) IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

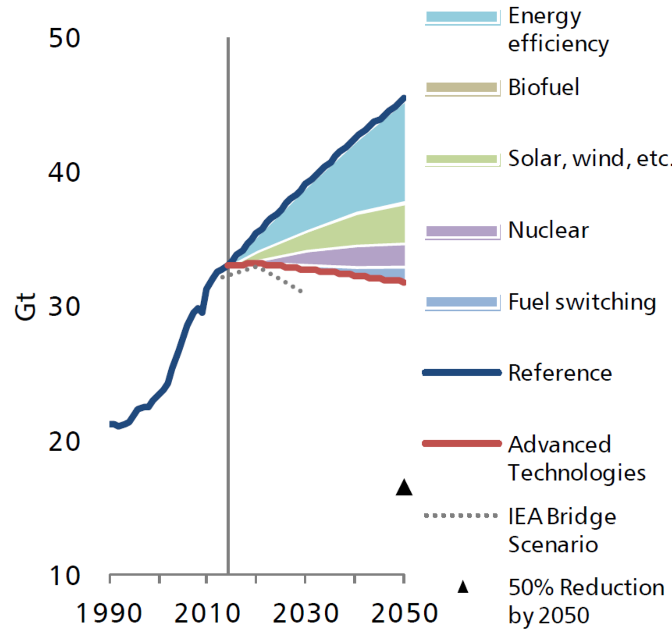
3. Paris Agreement : Advantages and disadvantages

2) Further Global Actions May Reduce CO_2 by about 4% more(IEEJ Outlook), but this is not sufficient.

❖ Changes in primary energy consumption



❖ CO_2 emissions and reduction



In the Advanced Technologies Case where the maximum possible CO_2 reduction measures (assuming social acceptance) are introduced, energy consumption in 2040 is smaller than the Reference Case by 2,343 Mtoe or 12%.

CO_2 emissions in the Advanced Technologies Case will peak at around 2020 and will start to decline after. By 2050, emissions will be reduced by 3.8% from 2014 level and by 13.7 Gt from the Reference Case level which is equivalent to 42% of the global emissions.

(Source) IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

Assumption for Ad.Tech. Scenario :Maximum Introduction of advanced tech.in light of the existing plan（2040）

2014→ 2040 (Reference 2040)

	Developped Countries	Developping Countries
Indsustry	100% diffusion of BAT by 2040	
Transportation	Cost reduction of fuel efficient Vehicle. Diving range of EV doubles	
[Fuel efficiency: P. cars [Sales ratio CEV:P.cars]	16.2 km/L → 31.2 (23.7) 5% → 78% (52%)	14.1 km/L → 26.5 (19.3) 6% → 77% (35%)
House& Business	100% sales ratio of BAT by 2040	
Thermal Power [Efficiency]	Introduction of better plant than USC. Incld. IGFC etc. gas: 48.1% → 54.1% (53.7%) coal: 37.5% → 42.7% (42.0%)	Almost 100% introduction of USC and some IGCC etc. & Finance Assist. gas: 35.8% → 52.1% (50.3%) coas: 36.2% → 40.7% (40.4%)
Nuclear Power [Capacity]	Maintain appropriate wholesale price 2015: 309 GW → 358 (297)	Finance Assist. 2015: 90 GW → 489 (315)
Renewable Power [Capacity]	Reduction of System cost and Back up cost Efficnet use of grid system Wind : 215 GW → 709 (487) Solar PV: 136 GW → 702 (455)	Reduction of system cost and back up cost + Finance assist Upgrading of electricity system Wind: 151 GW → 1,055 (388) Solar PV: 39 GW → 731 (266)
Bio fuel for . Vehicle [Consumption]	Difusion of next generation bio fuel Expanded diffusion of FFV 50 Mtoe → 106 (83)	Cost reduction of Bo fuels Compatibility with Agri. policy 23 Mtoe → 69 (37)

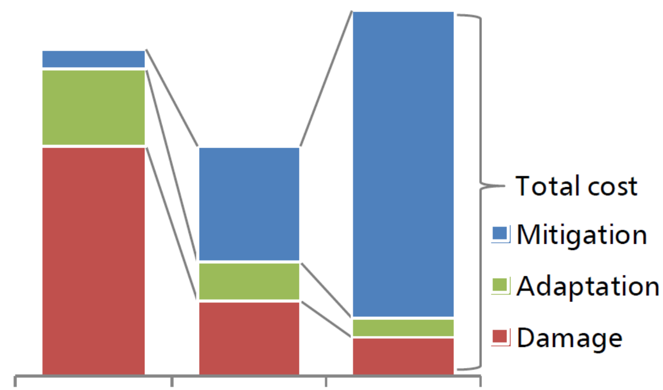
BAT: Best available technology, CEV: Clean energy vehicle, FFV: Flex fuel vehicle,
USC: Ultra-supercritical, IGFC: Integrated coal gasification fuel cell combined cycle, IGCC: Integrated coal gasification combined cycle

4. We may need a new approach :"Total Cost Minimizing Approach"
1) What is " Total Cost Minimizing Approach"

Mitigation + Adaptation + Damage = Total cost

Mitigation	Typical measures are GHG emissions reduction via energy efficiency and non-fossil energy use. Includes reduction of GHG release to the atmosphere via CCS. These measures ***mitigate*** climate change.
Adaptation	Temperature rise may cause sea-level rise, agricultural crop drought, disease pandemic, etc. ***Adaptation*** includes counter measures such as building banks/reservoir, agricultural research and disease preventive actions.
Damage	If mitigation and adaptation cannot reduce the climate change effects enough to stop sea-level rise, draught and pandemics, ***damage*** will take place.

Image of total cost for each path



	Path 1	Path 2	Path 3
Mitigation	Too small	Reasonable	Too big
Adaptation	Big	Medium	Small
Damage	Big	Medium	Small

Without any measure against climate change, no mitigation cost incurs. On the other hand, adaptation costs and damage will become massive. Tough mitigation measures will reduce adaptation costs and damage but mitigation costs will be notably big.

Climate change issue is a long-term challenge which influences vast areas for many generations. From the sustainability point of view, combination of different measures which reduces the total cost of mitigation, adaptation and damage is important.

(Source) IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

4. We may need a new approach :"Total Cost Minimizing Approach"
2) Possible Challenge for " Total cost minimizing Approach"

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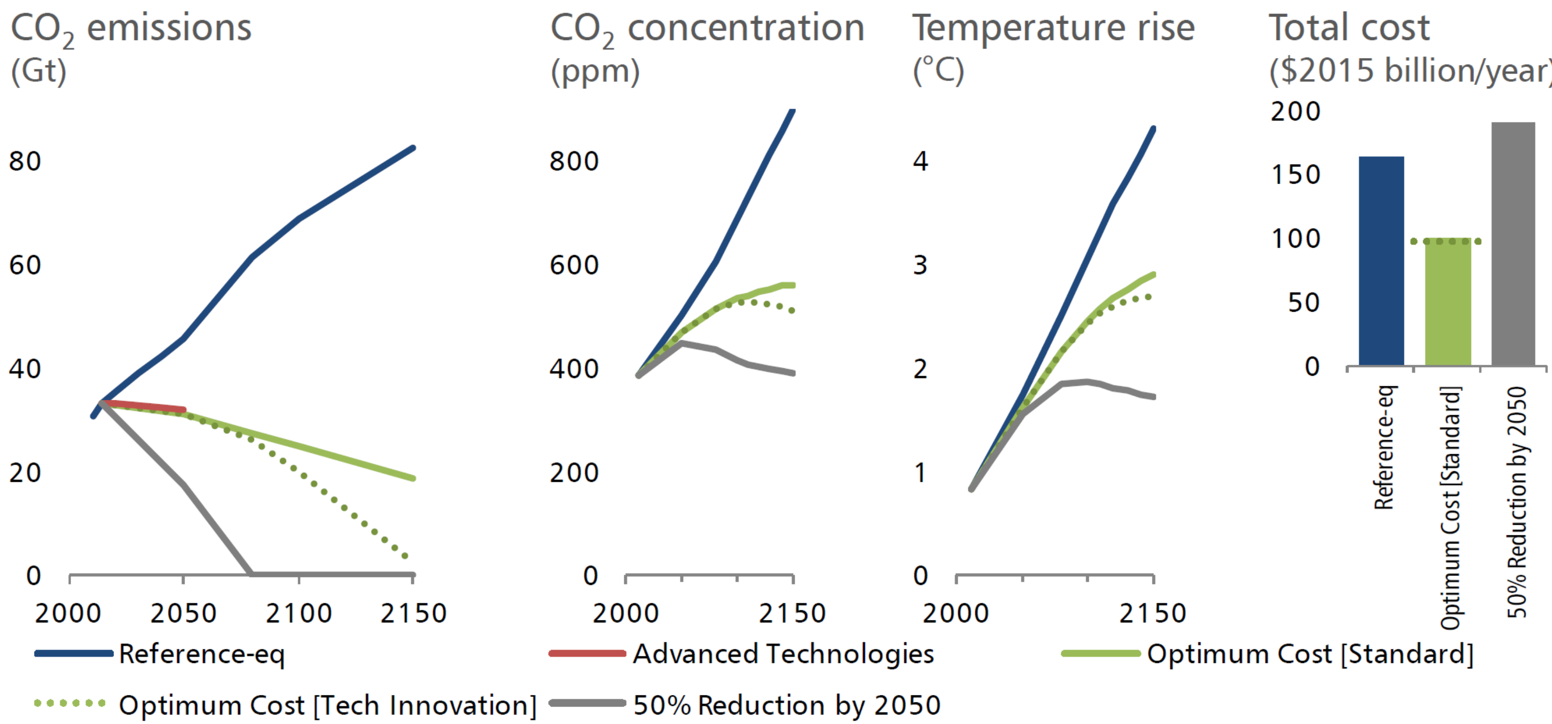
❖ In the ultra long-term paths



CO_2 emissions of the Optimum Cost Path will be much lower than the Reference Case equivalent emissions but not as low as the 50% Reduction by 2050 Case emissions. Emissions in 2150 will be 50% lower than the current level and temperature will rise by about 3℃.

If technology innovations reduce mitigation, temperature rise reaches the peak of 2.7℃ around 2150 and will start to go down. Total cost will be around $100 billion which is much lower than both Reference Case equivalent and 50% Reduction by 2050 Case.

Note: Estimated with climate sensitivity set as 3°C. If CS is 2.5°C, then temperature will rise by 3.7°C, 2.5°C and 1.4°C, respectively for the three cases, namely Reference Case equivalent, Optimum Cost with innovation and 50% Reduction by 2050 Cases, by 2150.

(Source) IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

4. We may need a new approach :"Total Cost Minimizing Approach"

3) New Innovation needed for " Total cost minimizing approach" (examples)

Technology		Overview	Challenges
Holding down CO_2 generation	**Next-generation reactors**	Very high temperature, fast and other Generation 4 reactors, as well as small and medium-sized reactors, are under international development at present.	Expanding support for research and development of next-generation nuclear reactors
	Nuclear fusion	Nuclear fusion of hydrogen and other elements with low nuclear numbers will generate energy as the sun does. Deuterium as fuel for nuclear fusion is abundantly and universally present. Spent fuel like high-level radioactive waste will not be generated.	Technology to trigger continuous nuclear fusion and contain such reaction within a certain space, energy balance and cost cuts, fundraising and international cooperation arrangements for large-scale development
	Solar power from space (SPS)	The technology will generate electricity through solar photovoltaics in outer space with more abundant solar radiation than on Earth and use microwaves to transmit electricity to Earth for consumption.	Wireless energy transmission technology, cutting costs for transporting materials to outer space
Fixing CO_2 or eliminating atmospheric CO_2	**Hydrogen production and utilization**	Fossil fuel conversion through steam reforming will produce hydrogen with CCS used for storing CO_2.	Cutting hydrogen production costs, improving hydrogen production efficiency, developing necessary infrastructure
	Fixing or utilizing CO_2 (CCU)	Electrochemical, photochemical, biochemical and thermochemical methods will be used to turn CO_2 into carbon compounds as chemical materials. Atmospheric CO_2 could be eliminated.	Improving quantity and efficiency for fixing or utilizing CO_2

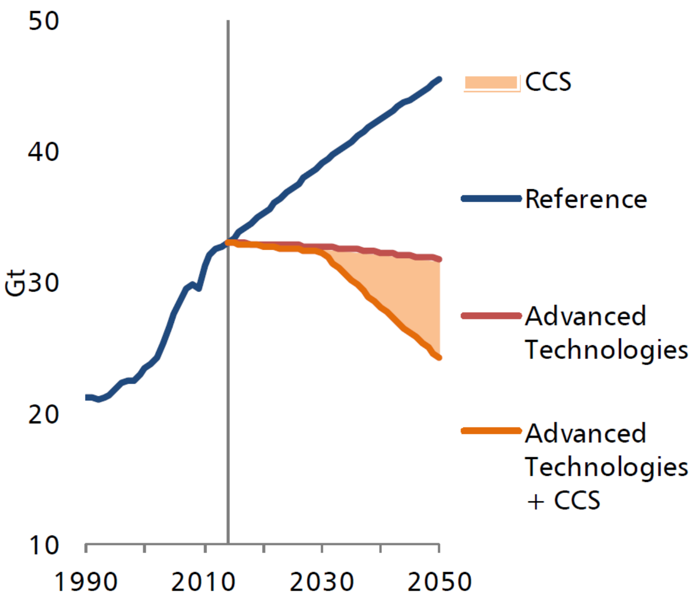
CCS stands for Carbon dioxide Capture and Storage, meaning capturing and storing CO_2.
CCU stands for Carbon dioxide Capture and Utilization, meaning effective utilization of CO_2.

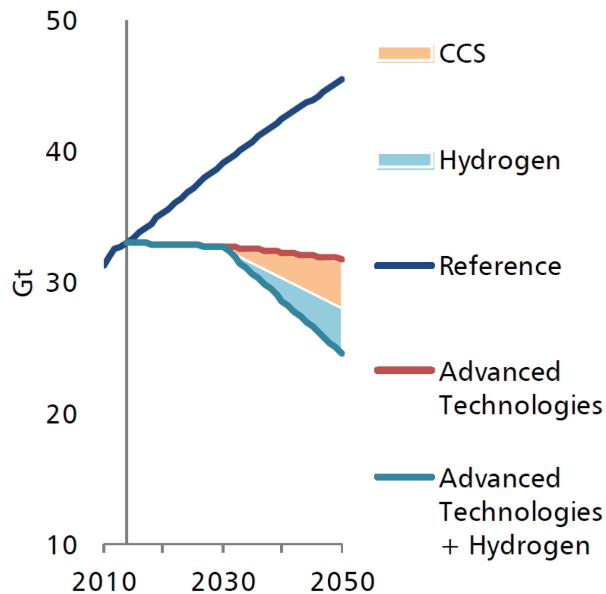
(Source) IEEJ "Asia / World Energy Outlook 2016" (Oct. 2016)

4. We may need a new approach :“Total Cost Minimizing Approach”

4) There is a Road for “ Total cost minimizing approach”
: The Case of Zero carbon hydrogen +CCS as an example

❖ CO_2 emissions and reduction





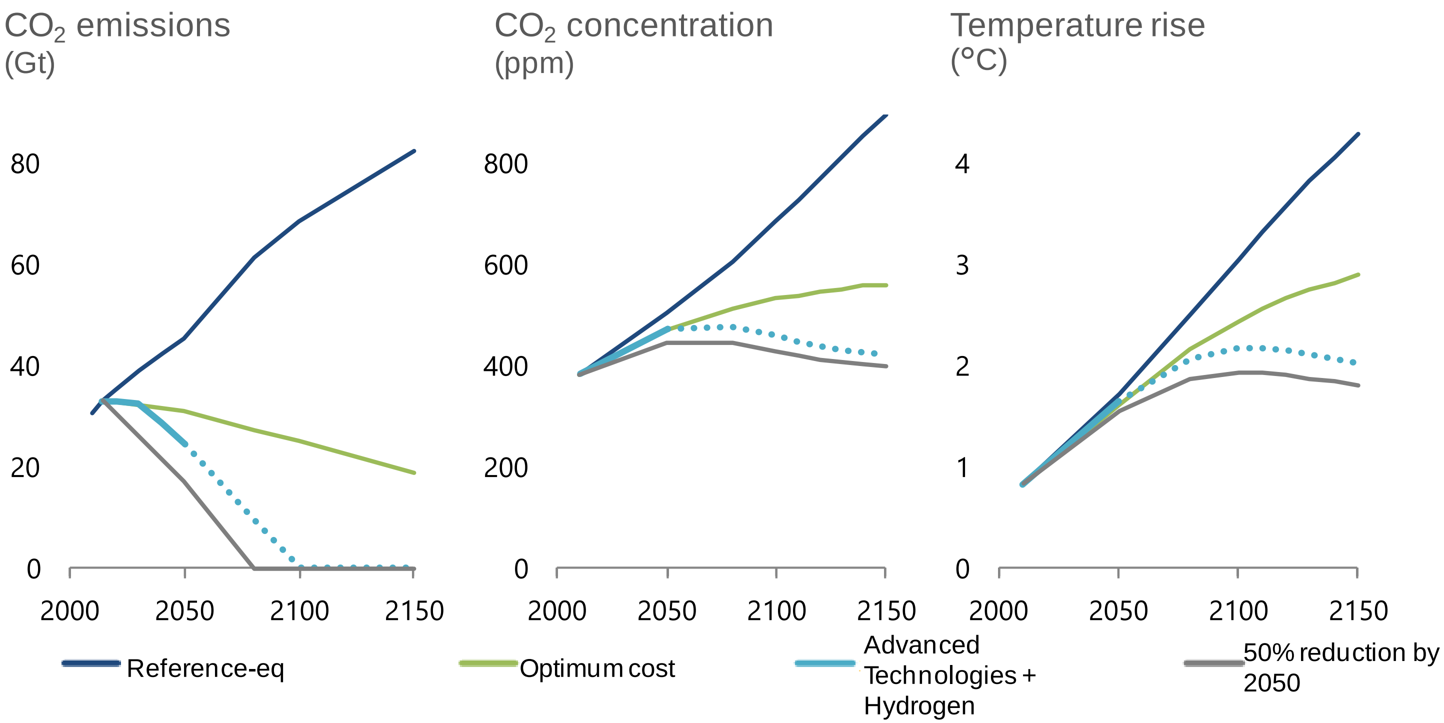
Although there are not small numbers of technical and economical hurdles to be overcome both for CCS and for hydrogen, about 7 Gt of CO_2 can be reduced by 2050.

CCS, however, does not contribute to secure directly energy supply. Hydrogen requires more exhaustible resources such as coal and natural gas for its production. There is no perfect technologies/energy source to solve all of the problems.

(Source) IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

4. We may need a new approach :"Total Cost Minimizing Approach"
5) Hydrogen, as an example, May Become a Promising Option

❖ In the ultra long-term paths (Higher Hydrogen Scenario)



CCS and hydrogen, though having technological and economic problems to be solved, are expected to contribute to cutting CO_2 emissions by some 7 Gt in 2050.

If technological innovation allows the CO_2 emission reduction trend to be maintained, the temperature rise will peak at around 2.2 ℃ in 2100 and fall back to around 2.0 ℃ in 2150.

Note: "Advanced Technologies + Hydrogen" means the "Higher Hydrogen Scenario" in the body.

(Source) IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

Conclusion

1. After Fukushima Accident, Japan faced the serious energy challenges in terms of 3E, particularly Environment.

2. In order to address Climate Change, Japan tried first to promote further energy conservation, including "behavior policy", although its energy efficiency is already the world top class. Since this is not sufficient to address Climate Change, Japan also made an energy mix in a balanced manner with renewable energy, nuclear energy, coal, gas and Oil.

3. Paris Agreement is a great step to the global action for success, but still it is only a step. In order to let economic growth and measures for Climate Change coexist, we may need " Total cost minimizing approach".

4. This new approach need to focus on promoting "innovation to develop new zero carbon technology" Zero-carbon hydrogen from fossil fuels with CCS would be one good example.

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http://eneken.ieej.or.jp/en

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