IEEJ Outlook 2019

—A Japanese View on World Energy Future—

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Contents

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

Structure of IEEJ Outlook 2019

(1) Energy demand / supply and climate change up to 2050

Overviewing world energy market up to 2050 based on the "Reference Scenario" and the "Advanced Technologies Scenario"

Reference Scenario

Reflects past trends with the current energy and environment policies.
Does not reflect any aggressive policies for low-carbon measures.

Advanced Technologies Scenario

Assumes introduction of powerful policies to enhance energy security and address climate change issues.
The utmost penetration of low-carbon technologies is assumed.

2℃ Cost Minimizing Scenario

Address Climate Change in the way that the total cost (Damage , Adaptation + Mitigation)
can be minimized with a constraint of achieving 2℃ target>

(2) Risk and impact of energy supply disruptions

(3) No New Coal-fired Power Plant Case

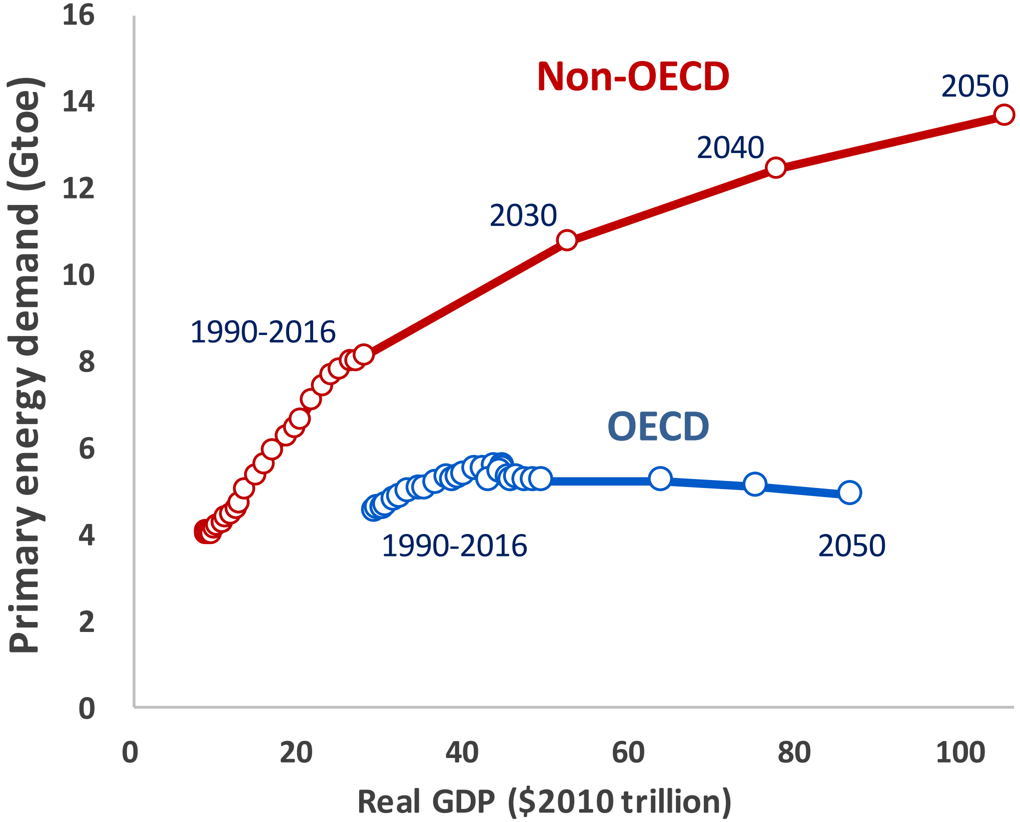
(4) Challenges for Japan's Energy Policy : The 5th Basic Energy Plan

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

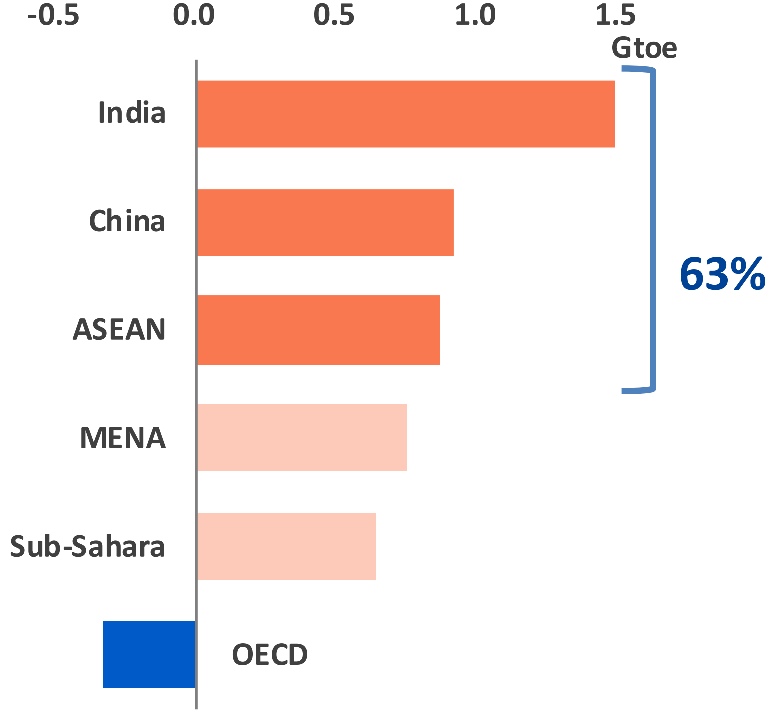
Reference Scenario

1.Dramatic growth of energy demand in Asia

❖ Primary energy demand vs. real GDP



❖ Change in energy demand (2016-2050)



* MENA: The Middle East and North Africa

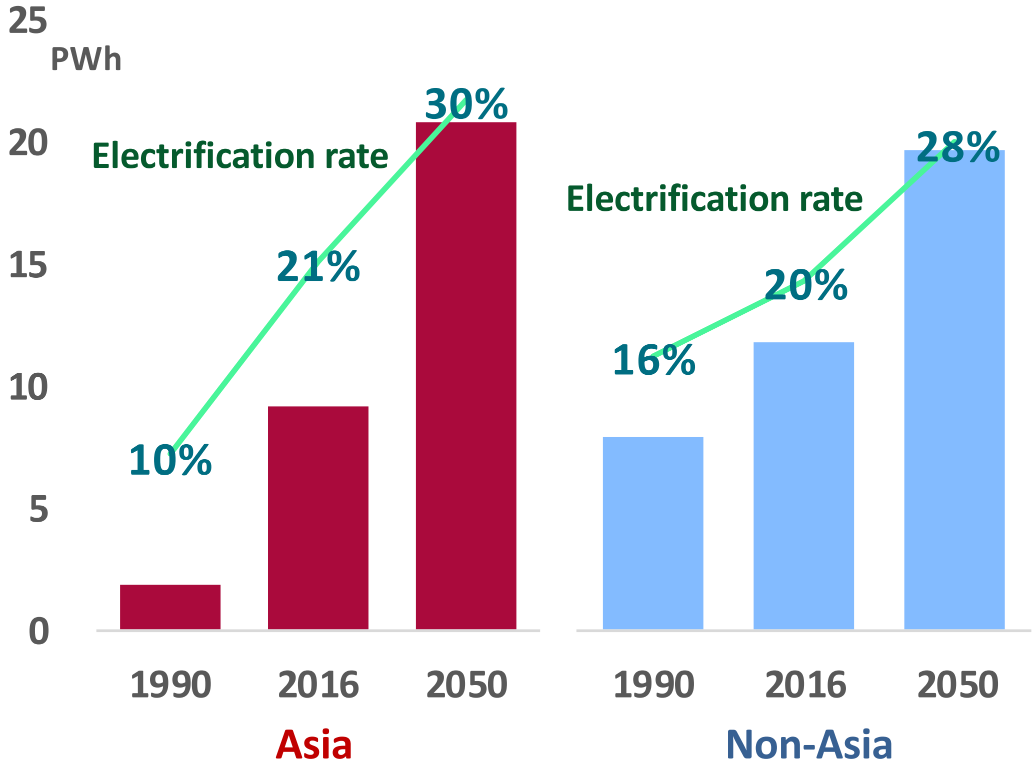
- ◆ The global primary energy demand will increase by 1.4 times in 2050.
- ◆ The net increase in energy demand can be entirely attributable to non-OECD.
- ◆ In OECD, decoupling between growth of the GDP and energy consumption proceeds.
- ◆ 63% of the increment come from China, India and the ASEAN countries.
- ◆ Share of Asia in the global primary energy demand will increase from 41% to 48%.

Source: “IEEJ Outlook 2019” (IEEJ, October 2018)

Reference Scenario

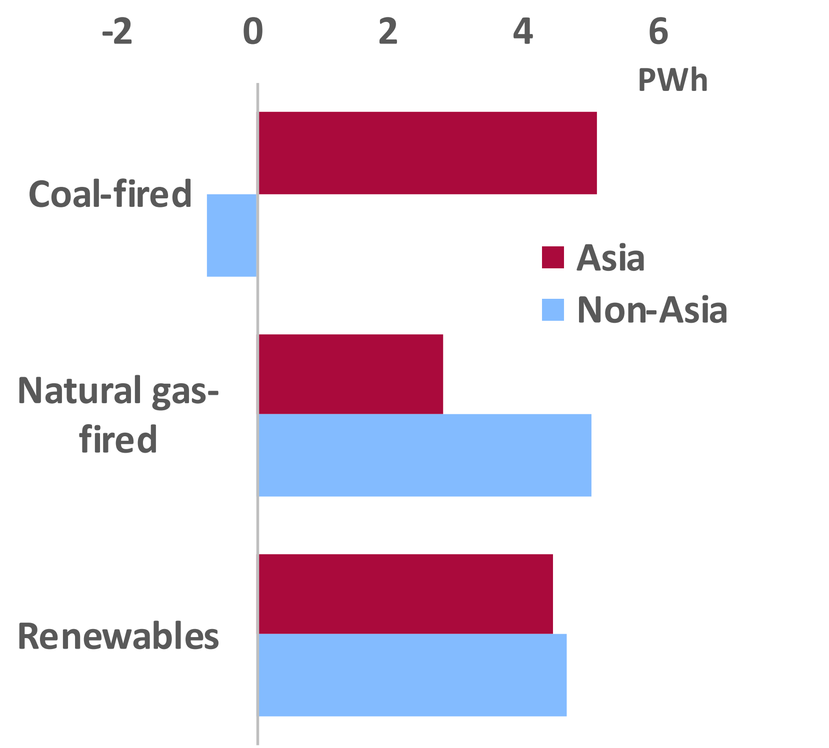
2.Growth of dependence to electricity

Electricity demand and electrification rate



* Electrification rate: Share of electricity in the final energy consumption

Change in electricity generation (2016-2050)

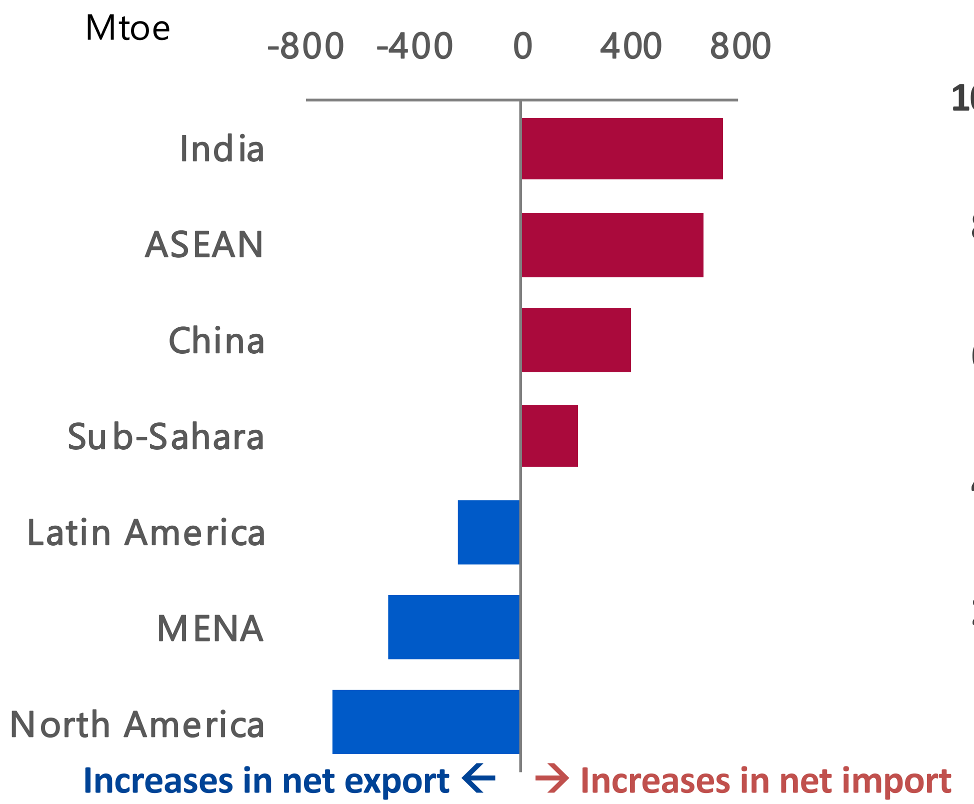


- 60% of the increment in the primary energy demand will be consumed for power generation.
- The global electricity demand will double in 2050, and 60% of the increment will occur in Asia.
- In Asia, electrification rate will increase to 30% in 2050, and 40% of electricity demand will be covered by coal, which can be obtained plentifully and inexpensively.
- Except for Asia, natural gas-fired power generation will be applied more than the coal-fired.

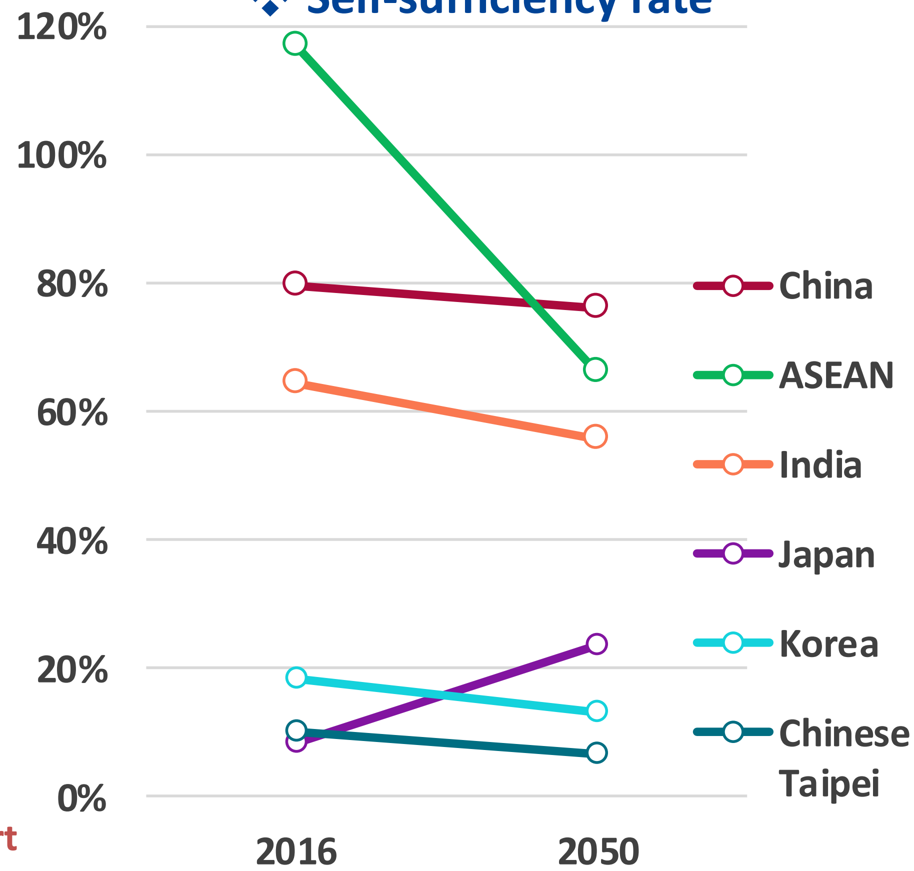
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

3.Increase of energy imports in Asia

Increase of net import energy (2016-2050)



Self-sufficiency rate



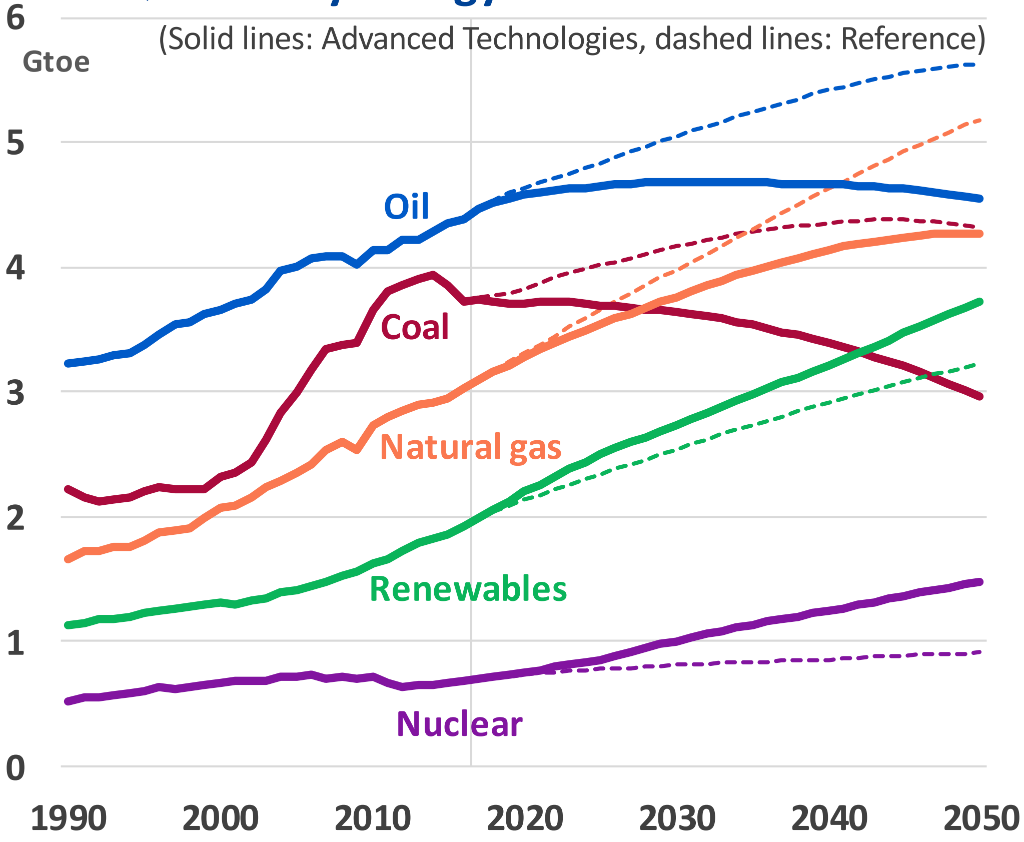
- Energy imports of Asia will increase dramatically.
- 80% of energy traded globally will be consumed in Asia.
- United States will be a net exporter in the middle of the 2020s.
- Self-sufficiency rate in Asia will decrease from 72% to 63%. This tendency is remarkable for ASEAN, which will be a net importer in the first half of the 2020s.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

Advanced Technologies Scenario

4. Coal declines while oil hits peak in 2030

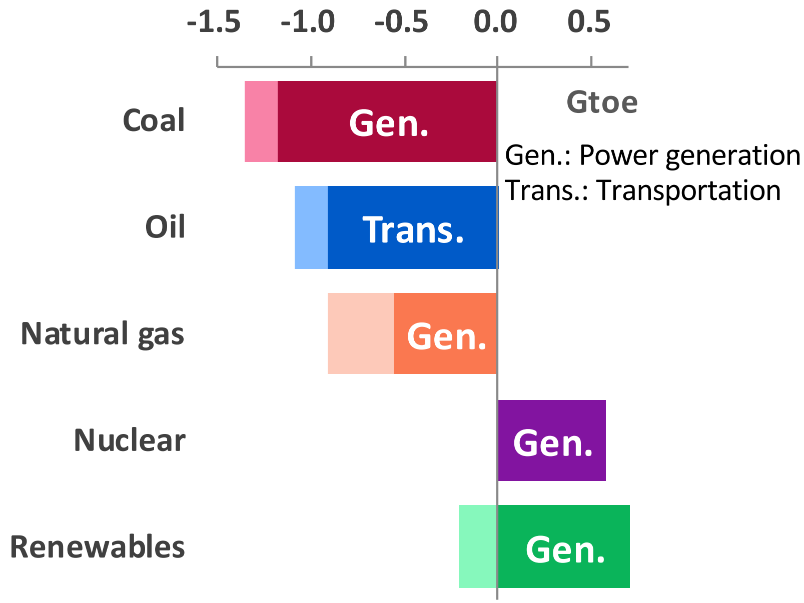
Primary energy demand



Advanced Technologies Scenario

It is assuming preparation and implementation of more ambitious strategies or programs for energy security, mitigation of climate change and so on.

Comparison with the Reference



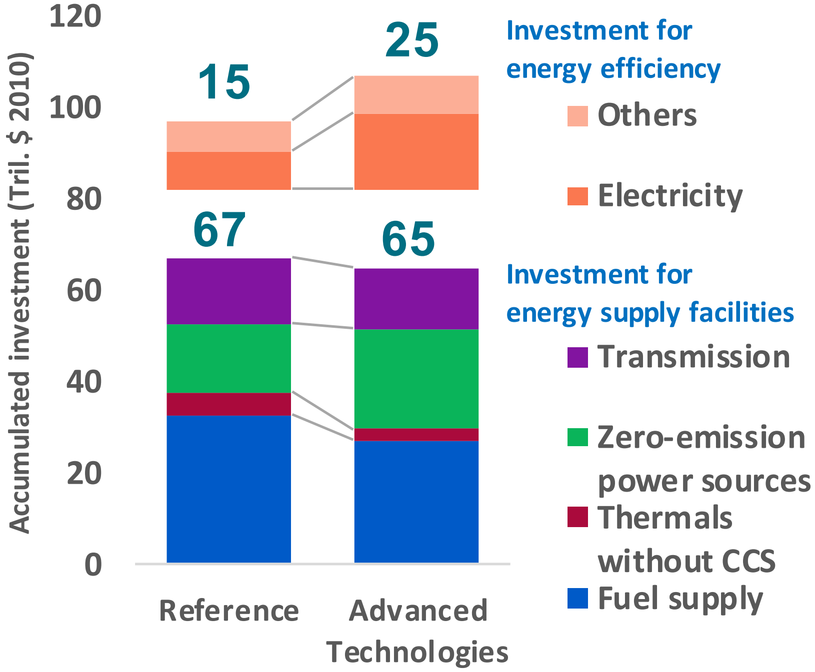
In the Advanced Technologies Scenario…

- Coal consumption will decrease remarkably (especially, for power generation).
- Oil consumption will decrease after peaking in 2030.
- Although share of fossil fuel in energy consumption will decrease from 81% to 69% in 2050 (to 79% in the Reference Scenario), high dependency on fossil fuel continues.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

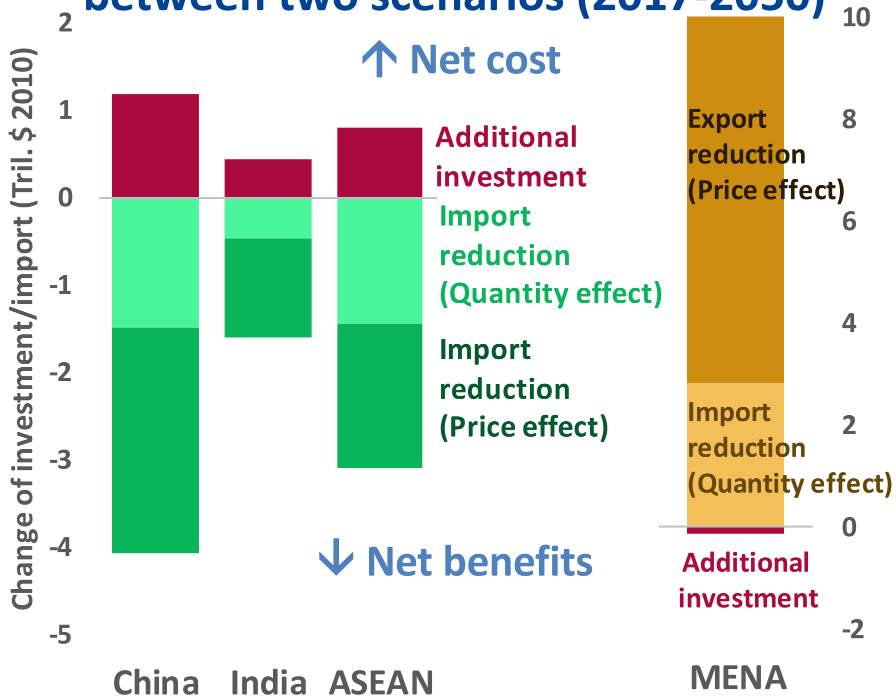
5.Required investment for energy supply

❖ Required investment (2017-2050)



* "Electricity" includes the saving through electrification.

❖ Difference of benefits and cost between two scenarios (2017-2050)



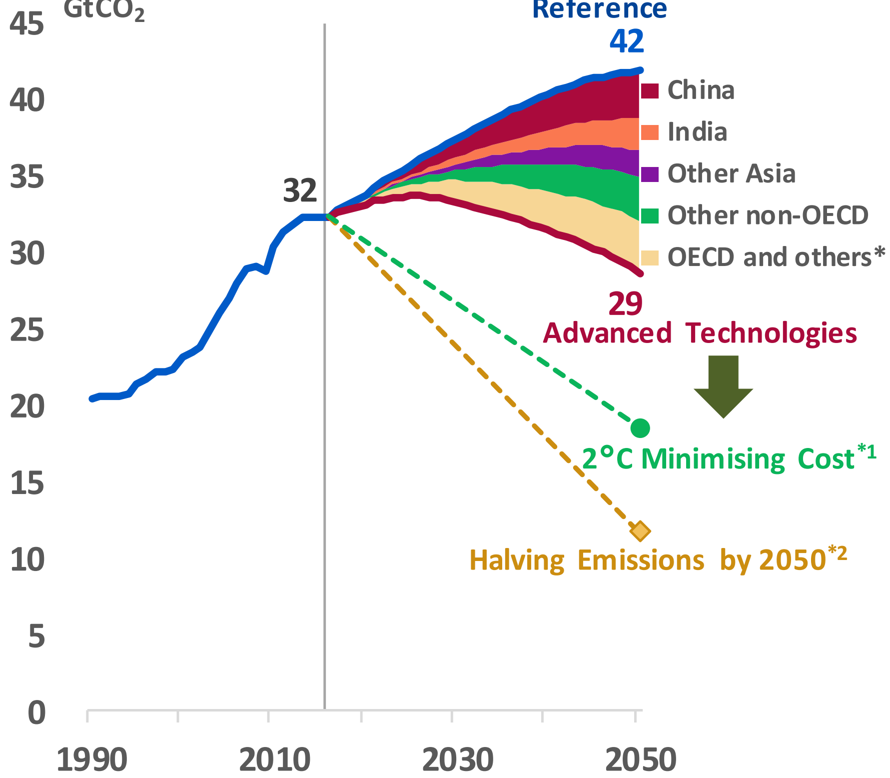
* MENA: The Middle East and North Africa

- ◆ In the Reference Scenario, $67 billion of investment is required for the energy supply facilities (1.5% against GDP).
- ◆ In the Advanced Technologies Scenario, $8 billion of investment is additionally required.
- ◆ In Asia, additional investment can be covered by the savings through reduction of fuel imports.
- ◆ In the Middle East, decreases in revenues from oil and natural gas export will be much more than decreases in the upstream investment.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

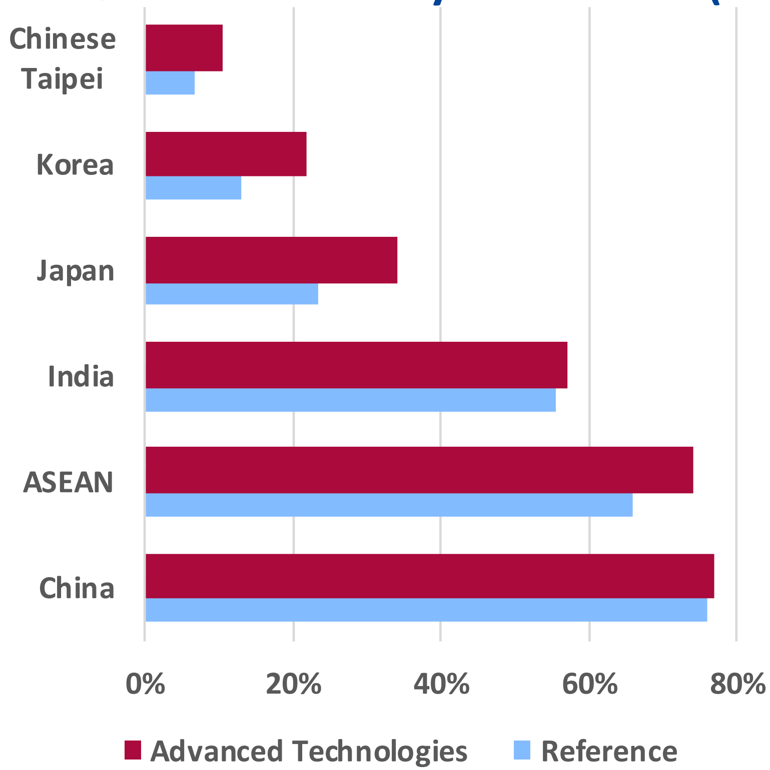
6.Improve environmental and security issues

Energy-related CO_2 emissions



* Includes international bunkers.
*1 Refer "IEEJ Outlook 2018". *2 This path represents an emission path in the RCP2.6 scenario summarised in the fifth Assessment Report by IPCC.

Self-sufficiency rate in Asia (2050)



In the Advanced Technologies Scenario…

- CO_2 emissions will peak in the mid-2020s and will decrease by 11% in 2050 from 2016. However, to maintain temperature rise caused by the climate change within 2 degree Celsius, additional programs and innovative technologies are required.
- Compared with the Reference Scenario, self-sufficiency rate in Asia will improve by 3%p in 2050.

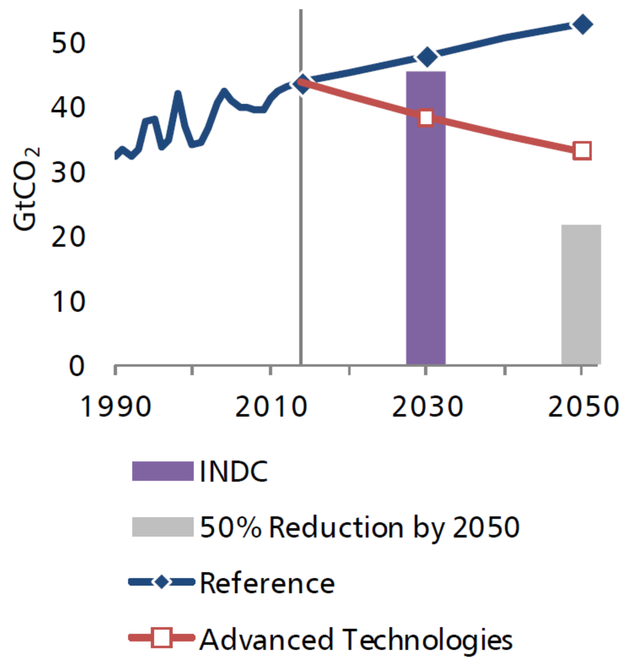
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

7.Paris Agreement : A Step Towards Global Action

❖ 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.

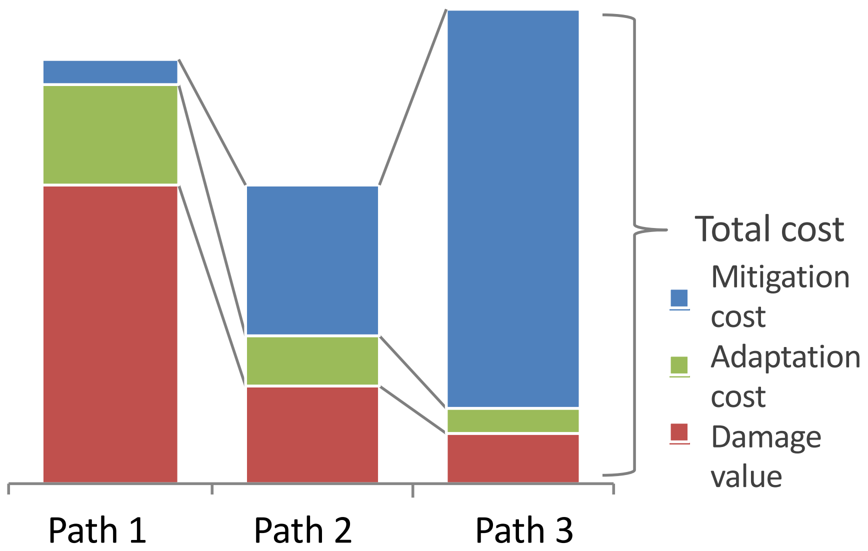
Source: IEEJ "Asia/World Energy Outlook 2016" (Oct. 2016)

8.Rule for ultra long-term: Reduce the total cost

❖ 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.

❖ Illustration 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 measures against climate change, the mitigation cost is small, while the adaptation and damage costs become substantial. Aggressive mitigation measures on the other hand, would reduce the adaptation and damage costs but the mitigation costs would be notably colossal.

The climate change issue is a long-term challenge influencing vast activities over many generations. As such, and from a sustainability point of view, the combination (or the mix) of different approaches to reduce the total cost of mitigation, adaptation and damage is important.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

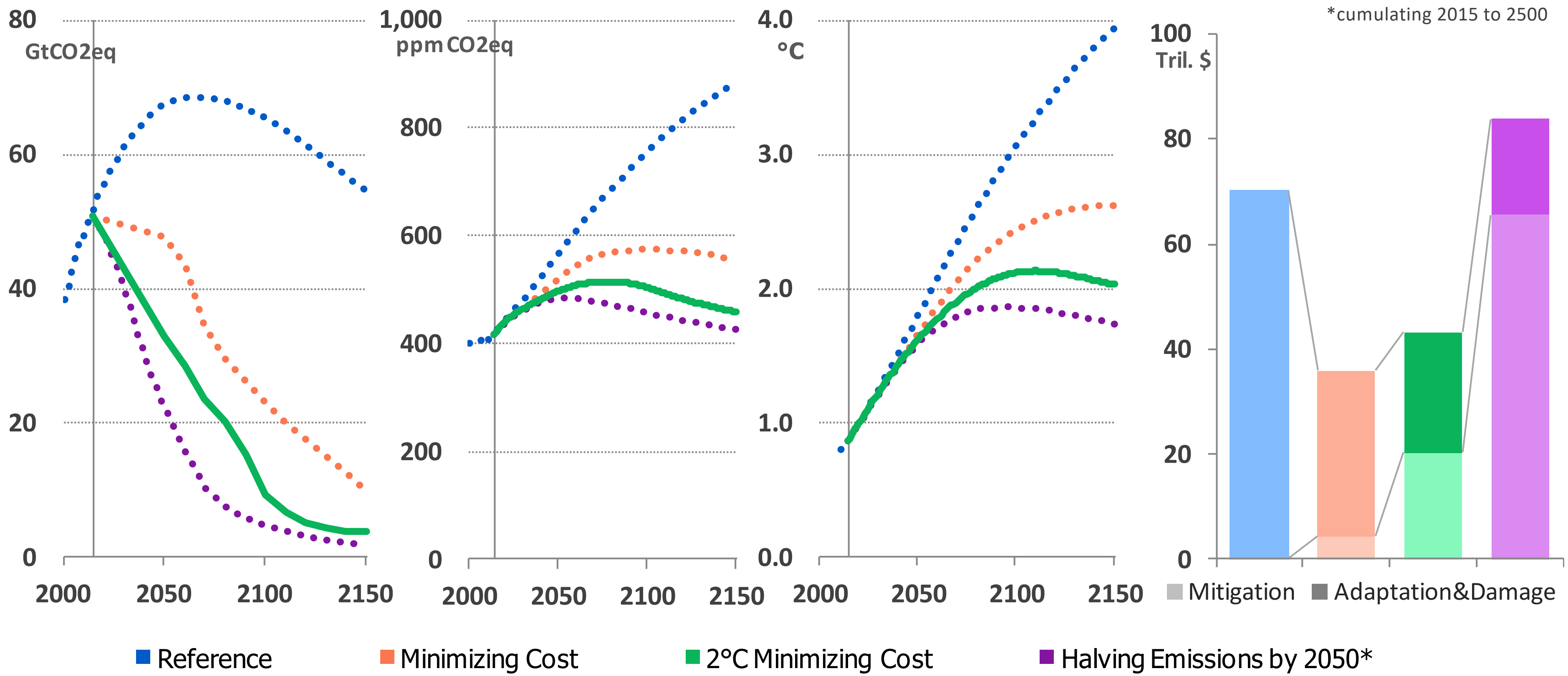
9.Another path to “2°C target”

❖ GHG emissions

❖ GHG concentrations (incl. aerosol, etc.)

❖ Temperature rise (vs. 1850-1900)

❖ Total cost (cumulative present value*)



“2°C Minimising Cost Path,” for example, is a path that minimise total cost under the condition of 2°C temperature rise in 2150. Its total cost is 20% higher than the Minimising Cost Path without the temperature limit. GHG emissions decrease by 30% in 2050 and needs almost zero-emissions after 2100. Temperature rises to just over 2°C in 2100 and then declines to 2°C.

* Emissions path reflected “RCP 2.6” in the 5th Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC).

Source: “IEEJ Outlook 2019” (IEEJ, October 2018)

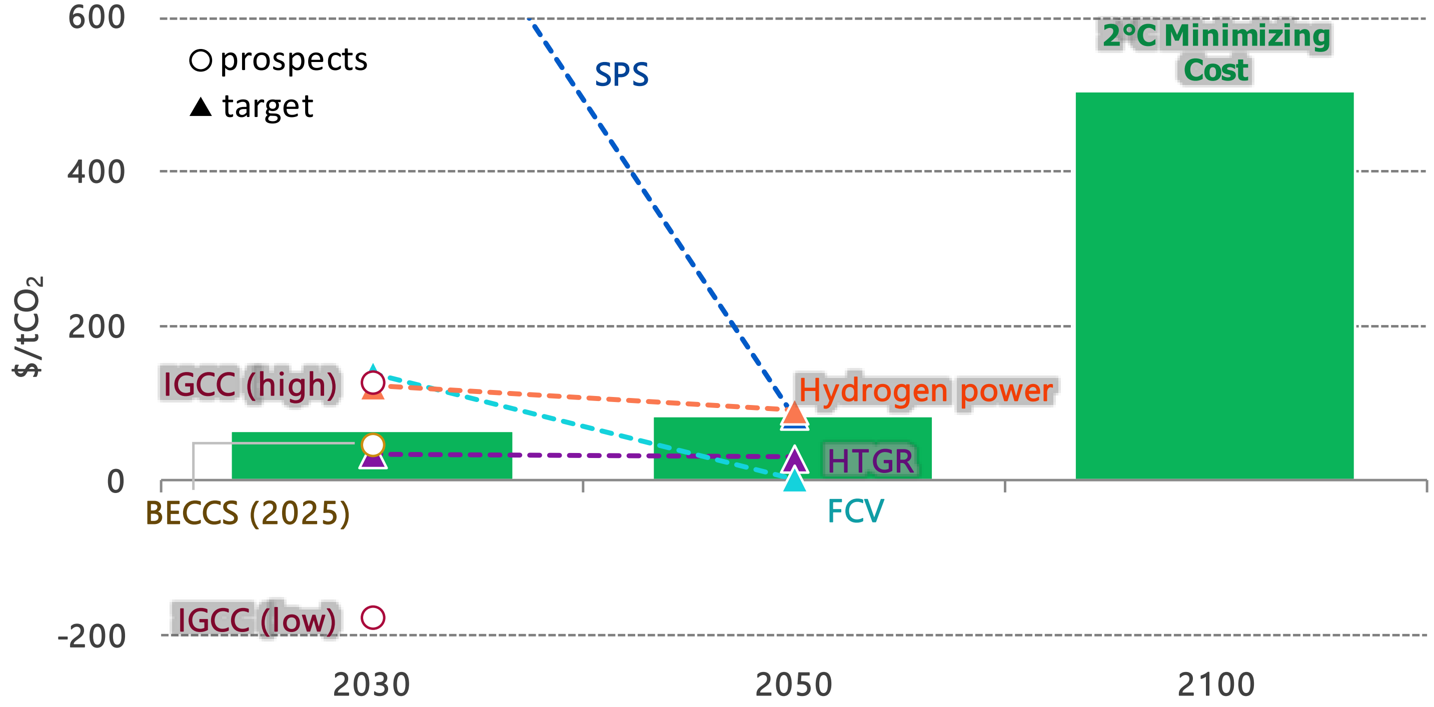
10.Technology Development for Ultra Long-term

Technologies		Description	Challenges
Technologies to reduce CO_2 emissions	Next Generation Nuclear Reactors	Fourth-generation nuclear reactors such as ultra-high-temperature gas-cooled reactors(HTGR) and fast reactors, and small- and medium-sized reactors are now being developed internationally.	Expansion of R&D support for next generation reactors
	Nuclear fusion reactor	Technology to extract energy just like the sun by nuclear fusion of small mass number such as hydrogen. Deuterium as fuel exists abundantly and universally. Spent nuclear fuel as high-level radioactive waste is not produced.	Technologies for continuously nuclear fusion and confining them in a certain space, energy balance, cost reduction, financing for large-scale development and establishment of international cooperation system, etc.
	Space Photovoltaic Satellite (SPS)	Technologies for solar PV power generation in space where sunlight rings abundantly above than on the ground and transmitting generated electricity to the earth wirelessly via microwave, etc.	Establishment of wireless energy transfer technology, reduction of cost of carrying construction materials to space, etc.
Technologies to sequestrate CO_2 or to remove CO_2 from the atmosphere	**Hydrogen production and usage**	**Production of carbon-free hydrogen by steam reforming of fossil fuels and by CCS implementation of CO_2 generated.**	**Cost reduction of hydrogen production, efficiency improvement, infrastructure development, etc.**
	CO_2 sequestration and usage (CCU)	Produce carbon compounds to be chemical raw materials, etc. using CO_2 as feedstocks by electrochemical method, photochemical method, biochemical method, or thermochemical method. CO_2 can be removed from the atmosphere.	Dramatic improvement in quantity and efficiency, etc.
	Bio-energy with carbon capture and storage (BECCS)	Absorption of carbon from the atmosphere by photosynthesis with biological process and CCS.	It requires large-scale land and may affect land area available for the production of food etc.

Source: IEEJ "IEEJ Outlook 2018" (Oct. 2017)

11.Lower Cost is Key for Innovative Technologies

❖ CO_2 Reduction Cost by Innovative Technology



Note: Cost (=carbon price) for “2° C Minimizing Cost " is the highest cost of the technology adopted at each year. Refer to the main report for detail.

Implicit carbon price for “2° C Minimizing Cost" is $85/t$CO_2$ in 2050. The target costs for innovative technologies, such as BECCS, hydrogen power, FCV, HTGR, SPS, are within the range of the carbon price. The 2 degree target can be reached using these technologies. International collaboration is dispensable and it is important to enhance R&D from the long term view.

Source: IEEJ “IEEJ Outlook 2018” (Oct. 2017)

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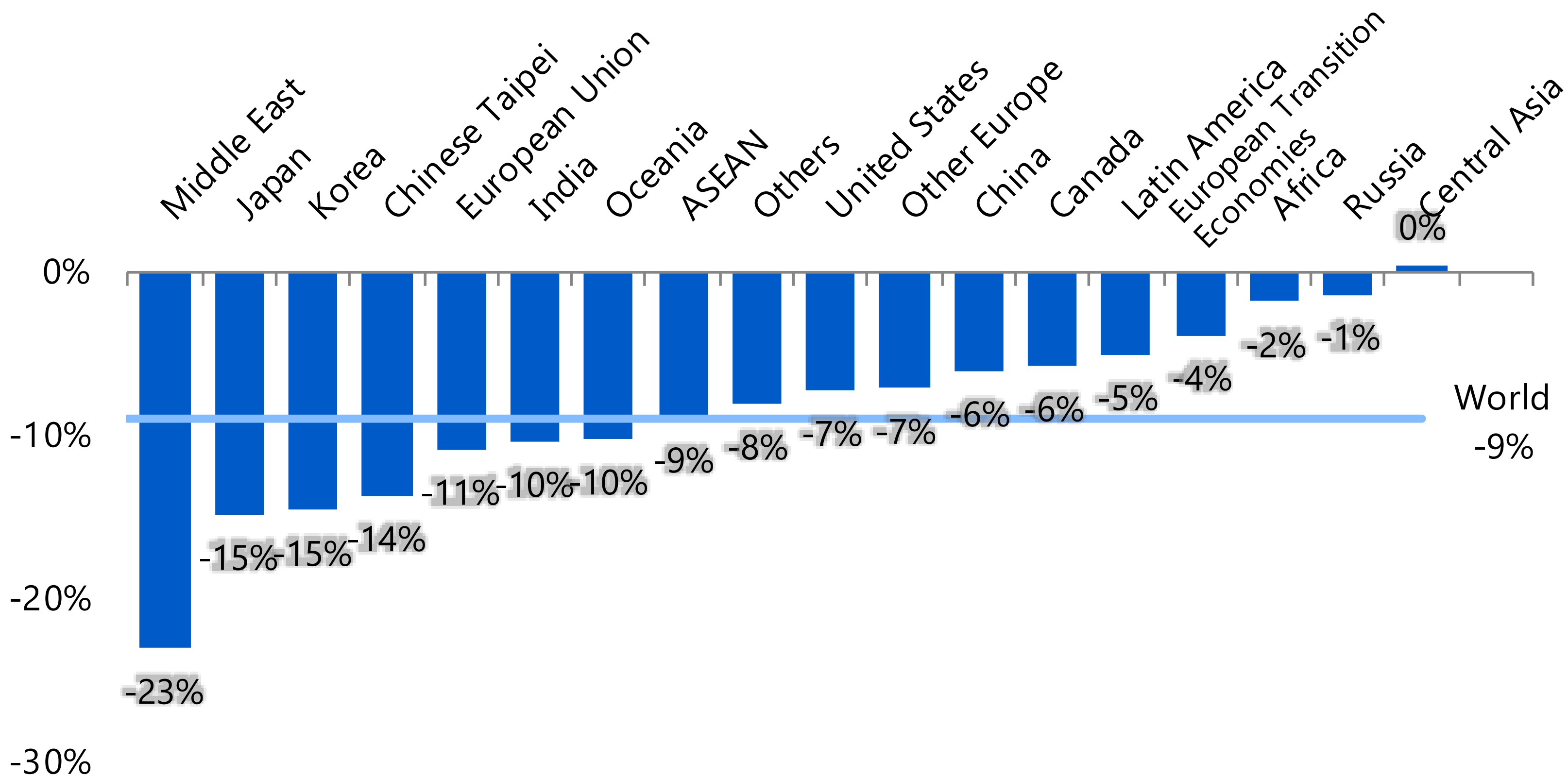
Source: “IEEJ Outlook 2019” (IEEJ, October 2018)

1. Impacts of the disruption of oil supply on economy

- The disruption of oil supply has major impacts.
- If crude oil production in the Middle East falls by 10 Mb/d and other countries or regions cannot fill in the gap, the global economy would shrink by 9%.
- Except for the Middle East, the epicentre of supply disruptions, Japan, Korea and Chinese Taipei would suffer the most damage.

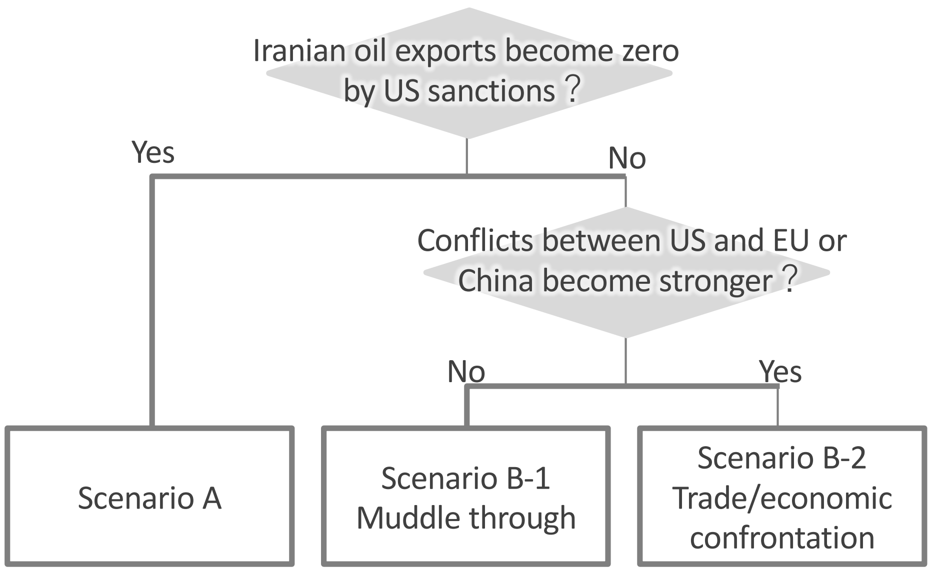
❖ Impact of a 10 Mb/d decline in crude oil production in the Middle East on real GDP



Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

2. Impacts of sanctions against Iran on international oil market

- Key result of scenario analysis on the impacts, up around 2020, of US re-imposition of economic sanctions against Iran.
- In the scenario where Iranian crude oil exports (about 2.5 Mb/d) are totally eliminated, oil prices rise due to shortage of OPEC spare capacity.
- In the scenario where trade friction starting from US escalates, world's economic slowdown relaxes oil supply-demand, and eventually pushes down oil prices.



❖ Points of the scenario analysis

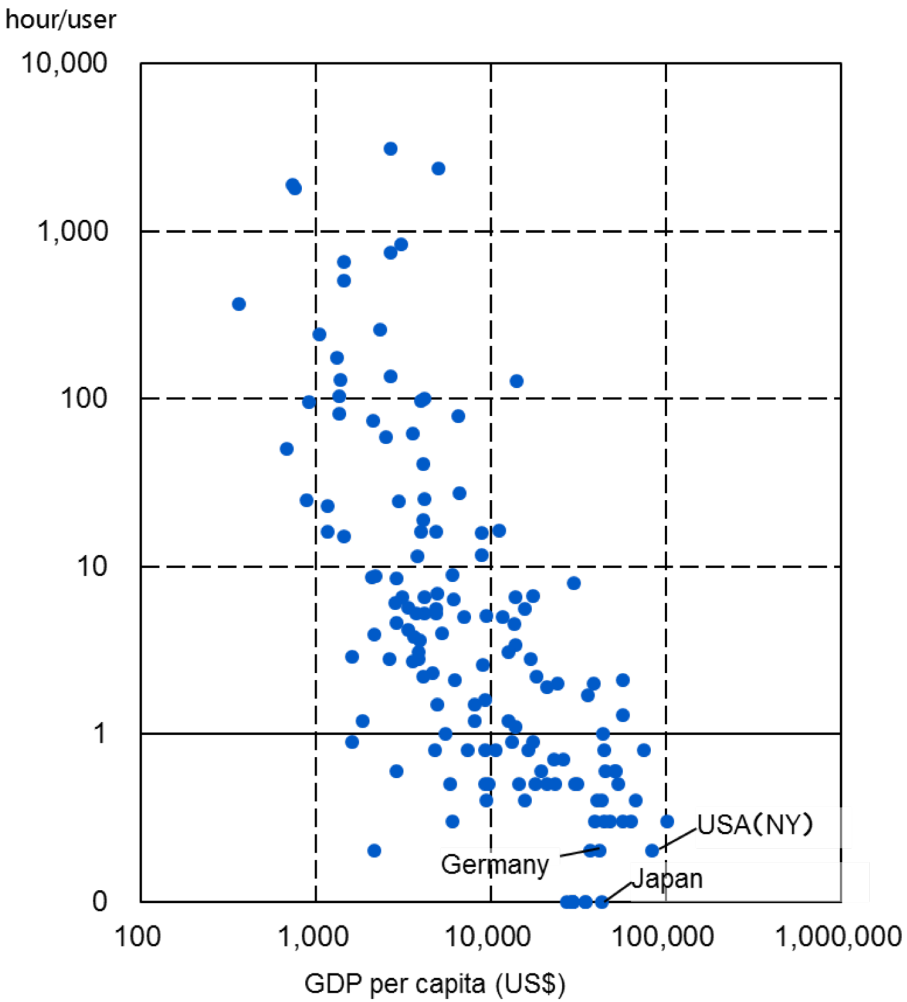
	Scenario A	B-1	B-2
Oil market	Tight supply-demand balance and shortage of OPEC spare capacity	Relatively calm market condition thanks to production increase from Saudi Arabia, etc.	Oversupply due to economic slowdown
Oil price	80-100$/bbl or more depending on circumstances	70-80$/bbl	50$/bbl
Other energy	LNG demand decline with the rise of prices. Coal becomes more competitive.	-	Lower LNG price materialise potential demand. FIDs of new liquefaction plans are postponed.

Source: IEEJ, Scenario analysis on the impacts of sanctions against Iran on international oil market, August 2018

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

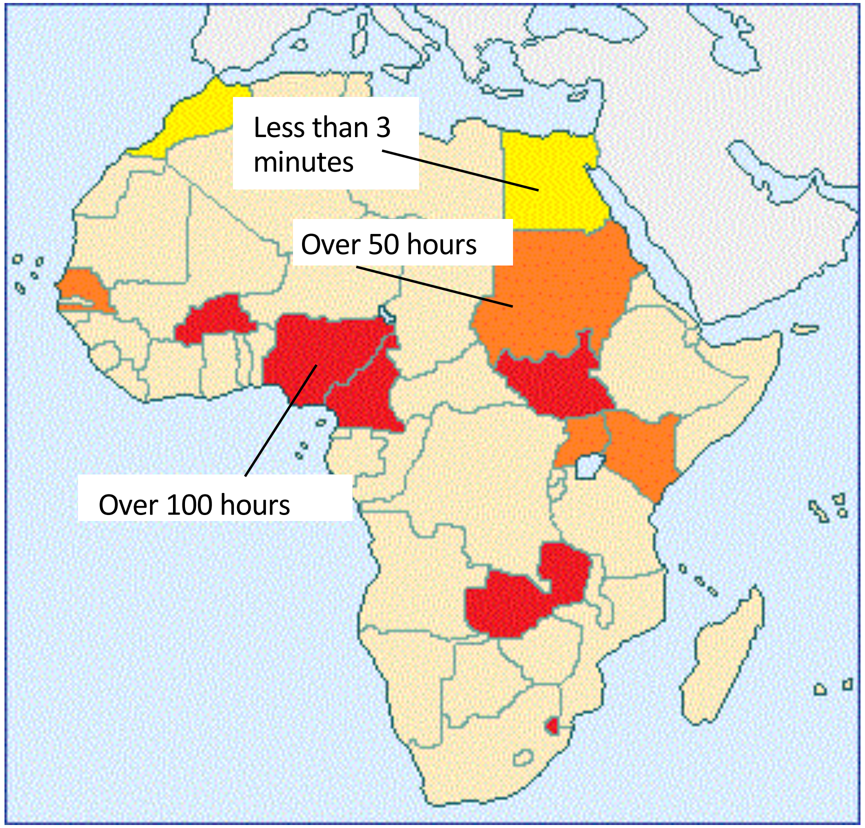
3.International comparison of power outage

❖ Income level and power outages (2015)



Source: World Bank "Doing Business database", "World Bank Open Data"

- Power outages vary widely by region. Sub-Saharan, island states, and South Asia tend to be long.
- The countries where power outages exceeded 1,000 hours (11% per year) in 2015 are Iraq, Comoros, Eritrea, Nigeria, Pakistan, South Sudan, and Swaziland.



Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

4. New threat for power supply

Structural risk

- **The increasing dependence on a specific energy source**
  - ✓ While regions which depend on gas-fired power generation have increased in the United States and natural gas is supplied by pipeline, the supply risk caused by natural gas supply disruption becomes more evident.
- **The "duck curve" of net load due to the expansion of solar PV**
  - ✓ In California and Japan where introduction of solar PV power generation is expanding, the duck curve of net load which the peak load comes twice a day is progressing. Requirement for electricity supply capacity is increasing that can follow, particularly, steep rise of electricity demand from daytime to early evening.
- **The shutdown of power plants due to economic feasibility**
  - ✓ There is a risk of unexpected large-scale closure of power generation capacity in the short term due to its economic feasibility. In the United States, during 2012 to 2017, large capacities (coal-fired: 55 GW, gas-fired: 36 GW, nuclear: 5 GW) were closed due to unfavourable market condition. Unbundled power business structure is challenging the transmission system operator or the reliability assessment organisation to capture such plans.

Sudden risk

- **Cyber attacks**
  - ✓ In Ukraine, power outage occurred due to cyber attacks in December 2015 and December 2016. Power system control was hacked and ended up power outage. When capacity of virtual power plants (VPPs), connecting distributed power generators via open network, increases in the future, cyber attacks can possibly risk VPP system.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

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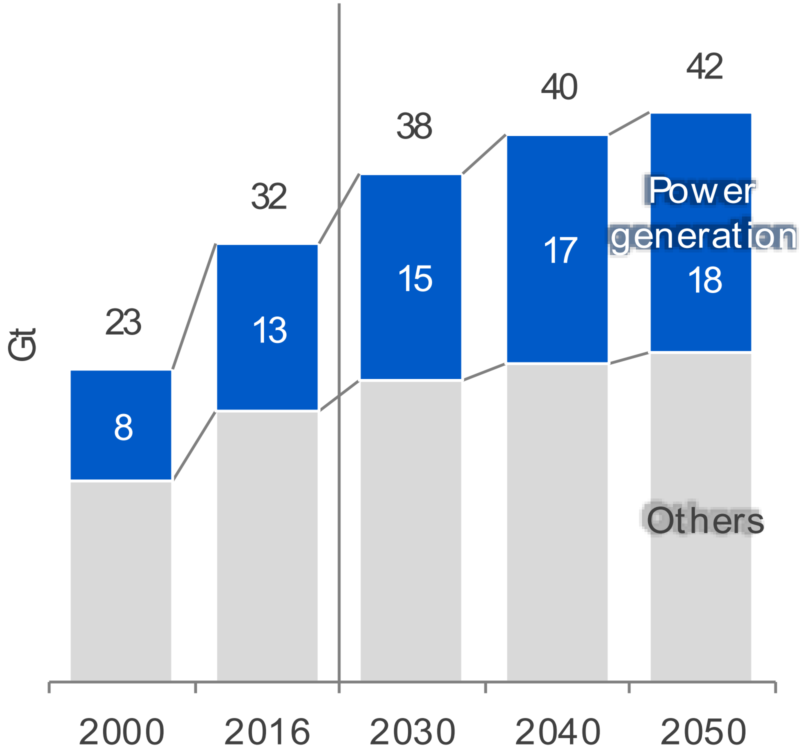
(3) No New Coal-fired Power Plant Case

We simulated a hypothetical case in which all new coal-fired power plants would be banned from construction after 2020 without exception assuming two patterns for the substitution; a) natural gas-fired power generation, b) solar PV / wind power generation.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

1． Decarbonisation in power sector is required

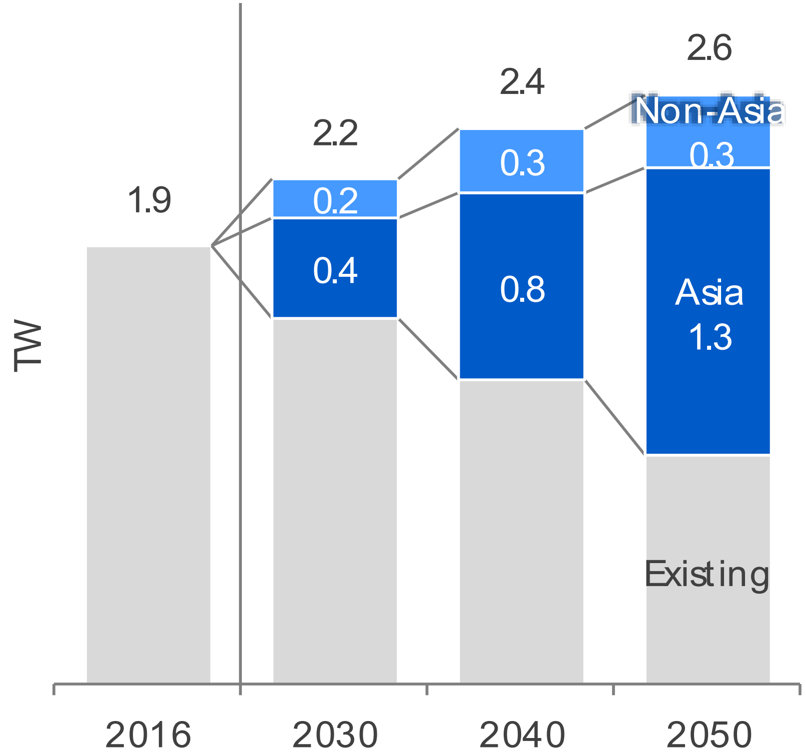
❖ **CO_2 direct emissions** [Reference Scenario]



Of additional emissions in 2050 (9.6 Gt), more than half (5.2 Gt) comes from power sector.

ESGs and divestment movements discourage investment for coal-fired power plant.

❖ **New coal-fired power plant capacity** [Reference Scenario]



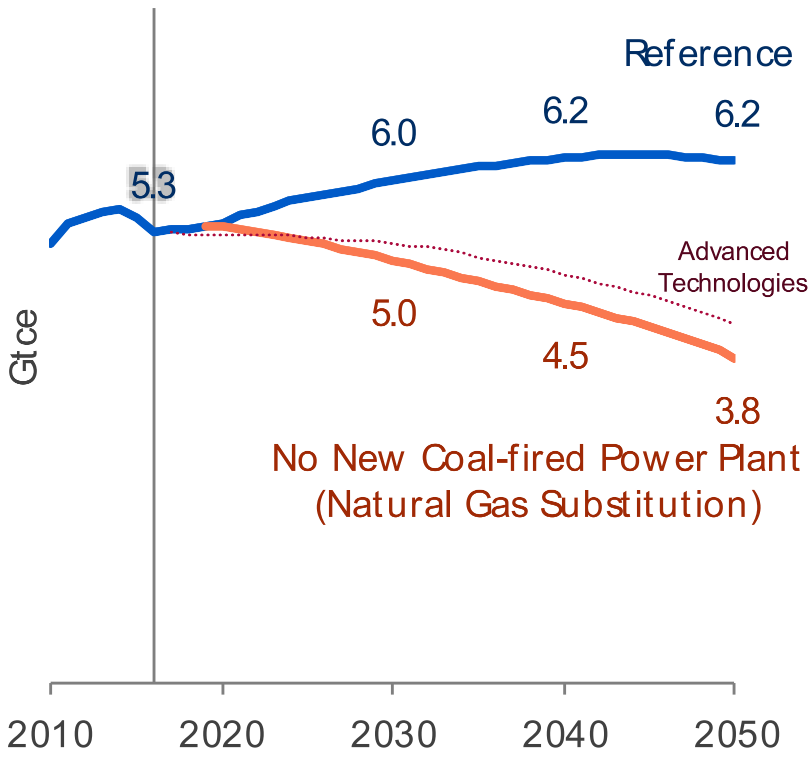
In the Reference Scenario, coal keeps the largest share in power generation mix.

In 2050, 1.6 TW of new coal-fired power plants were built after 2020 exist. → Without them?

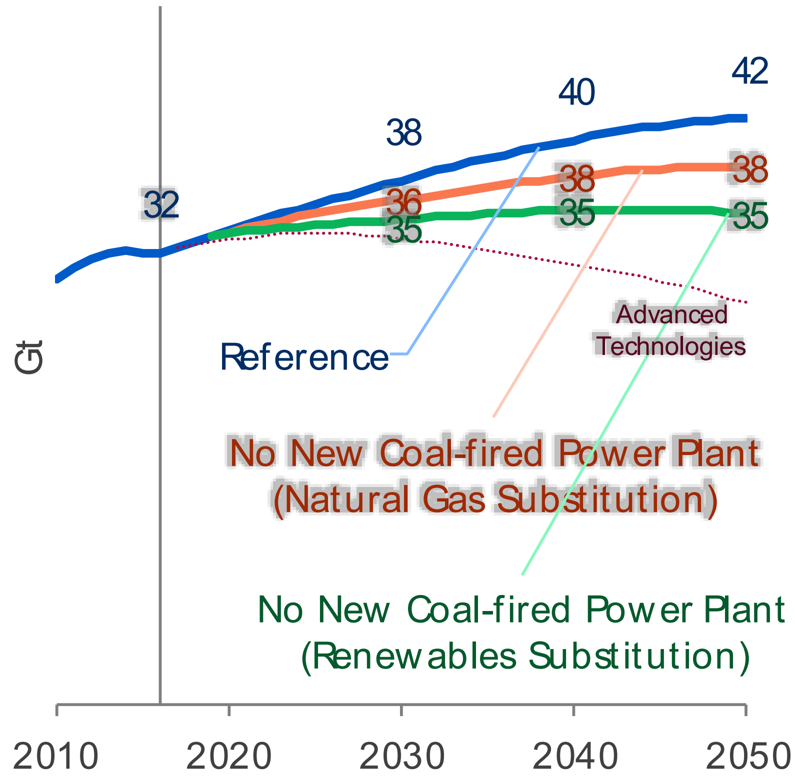
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

2.Pros of ban on new coal-fired power plant construction

❖ Primary consumption of coal



❖ CO_2 emissions



The reduction of 2.3 Gtce in 2050 is comparable to the current production of China.

It leads to reduction of local pollutants.

CO_2 reduction in 2050 is 3 Gt (Natural Gas Substitution), or 7 Gt (Renewables Substitution).

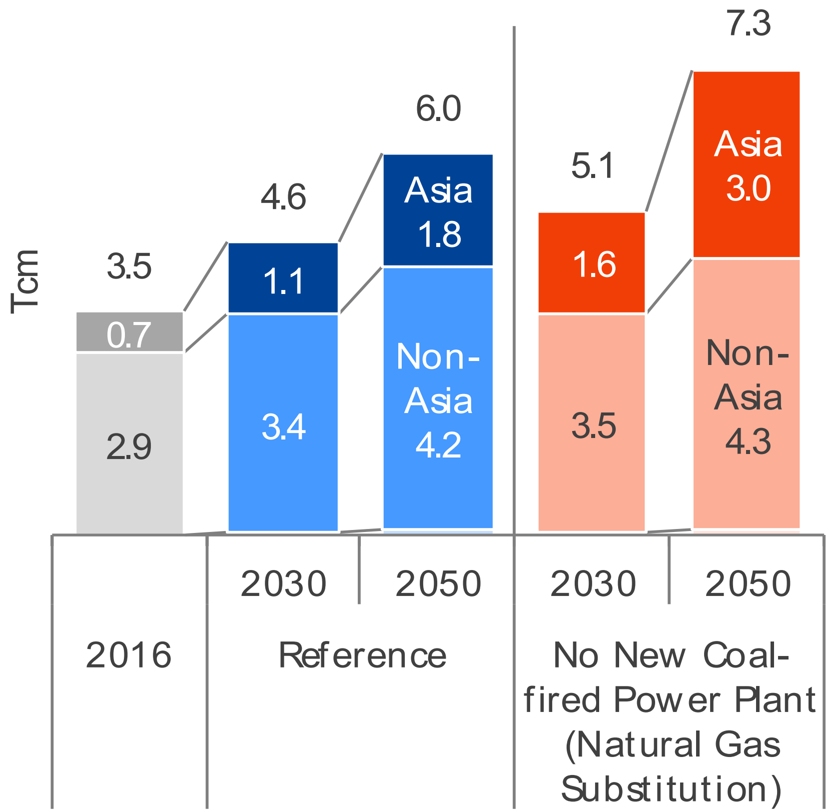
However, even in the latter case, CO_2 emissions are not less than the current level.

Note: Consumption of coal in the Renewables Substitution is almost same as that of the Natural Gas Substitution.

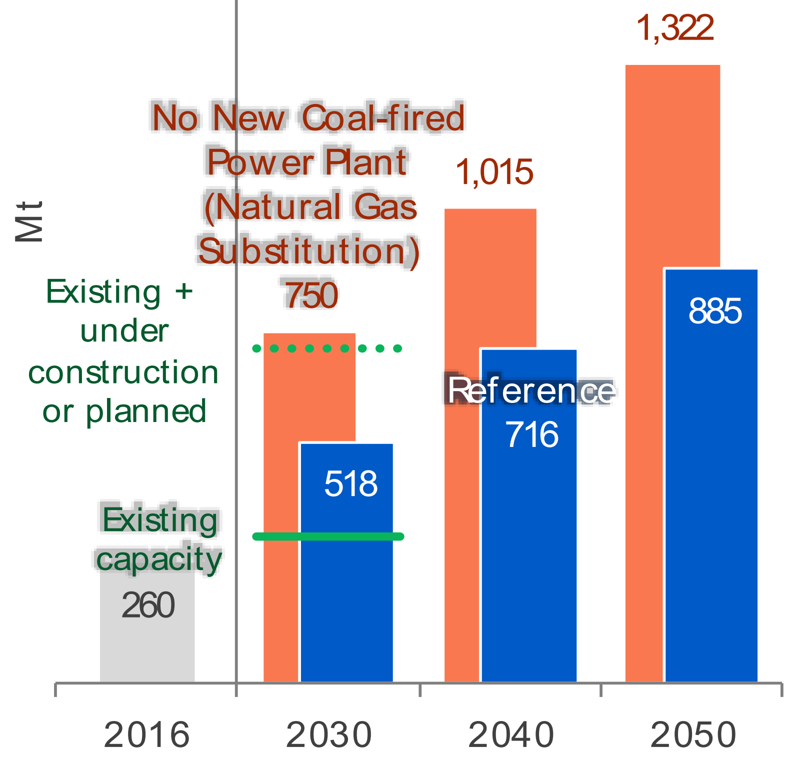
Source: “IEEJ Outlook 2019” (IEEJ, October 2018)

3. Substitution of natural gas requires dramatic expansion of supply

❖ Natural gas supply



❖ LNG demand



Natural gas consumption in 2050 reaches twice the current level. Cumulative consumption until 2050 may exceed the proven reserves.

All possible resources need to be developed no matter how difficult.

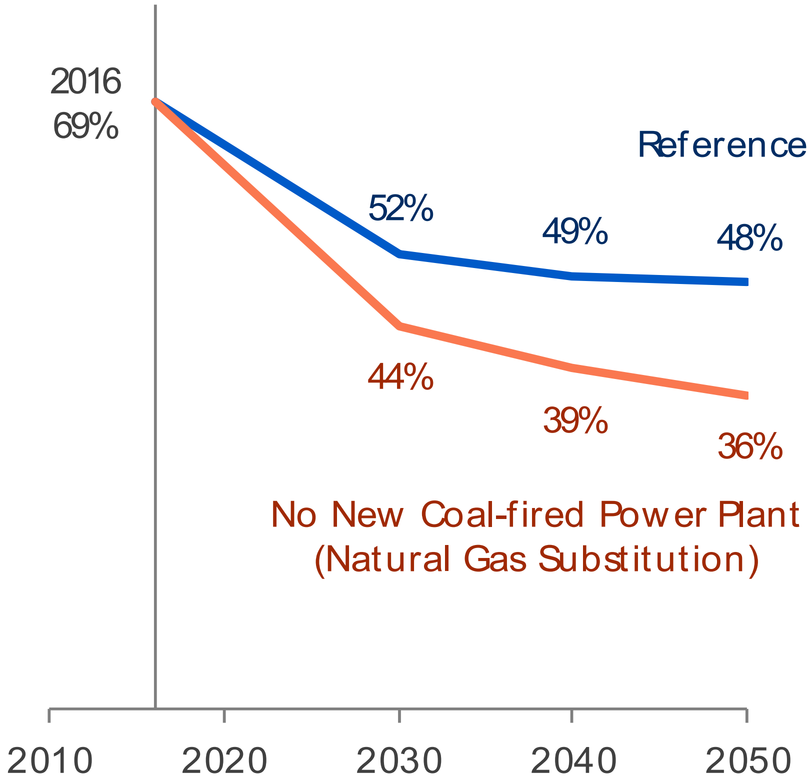
LNG demand in 2030 is 3 times the current level.

To meet enormous demand, even LNG projects without definite developed plan need to come into operation.

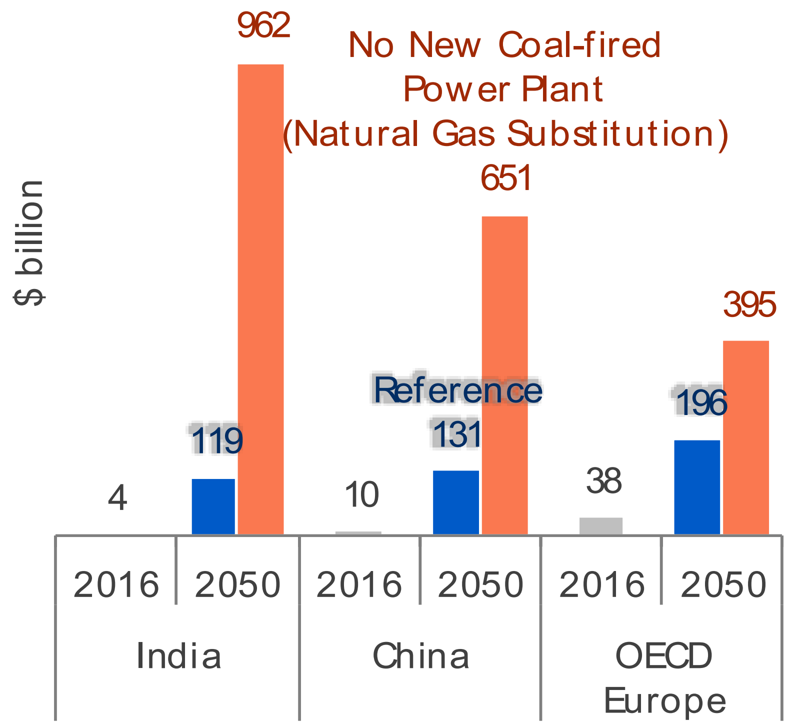
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

4. Challenges are not only the supply chains…

❖ Natural gas self-sufficiency rate (Asia)



❖ Net import spending of natural gas



Even if these rapid increases in production and trade can be realised, Asia will face energy security problems.

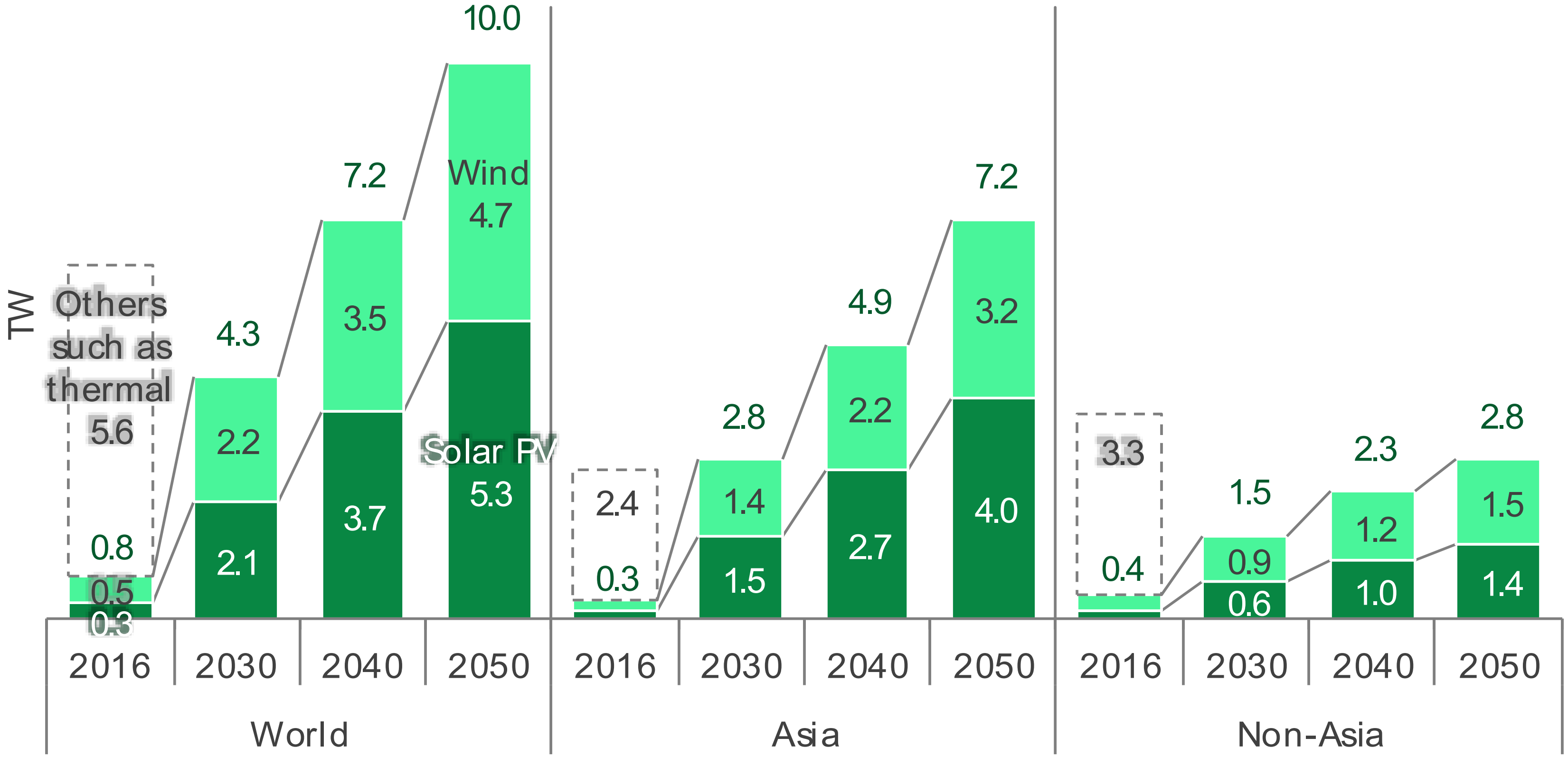
Self-sufficiency rates of natural gas fall to half of the current level.

If natural gas prices rise due to drastic increase of demand, undesired effects reach non-Asia such as OECD Europe, in which natural gas demand slightly increases.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

5.Substitution of solar PV / wind requires unprecedented capacity expansion

❖ Solar PV and wind power generation capacity
[No New Coal-fired Power Plant (Renewables Substitution) Case]



Even if efficient storage and transmission technologies without any loss become available worldwide, 10 TW of solar PV and wind power generation capacity combined is required in 2050.

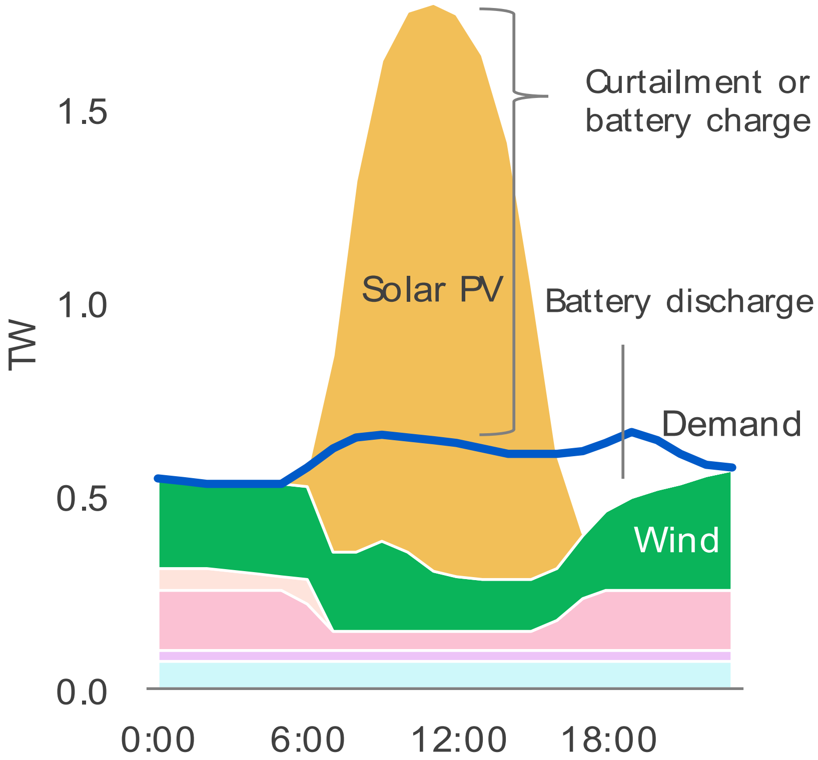
In Asia, solar PV and wind power generation capacity combined reaches 7.2 TW, 2.7 times the current total generation capacity. Sustainable measures to promote mass adoption are essential.

Source: “IEEJ Outlook 2019” (IEEJ, October 2018)

6. Keep an eye on electricity security

❖ Electricity balance in India «indicative»

[No New Coal-fired Power Plant (Renewables Substitution) Case, 2050]

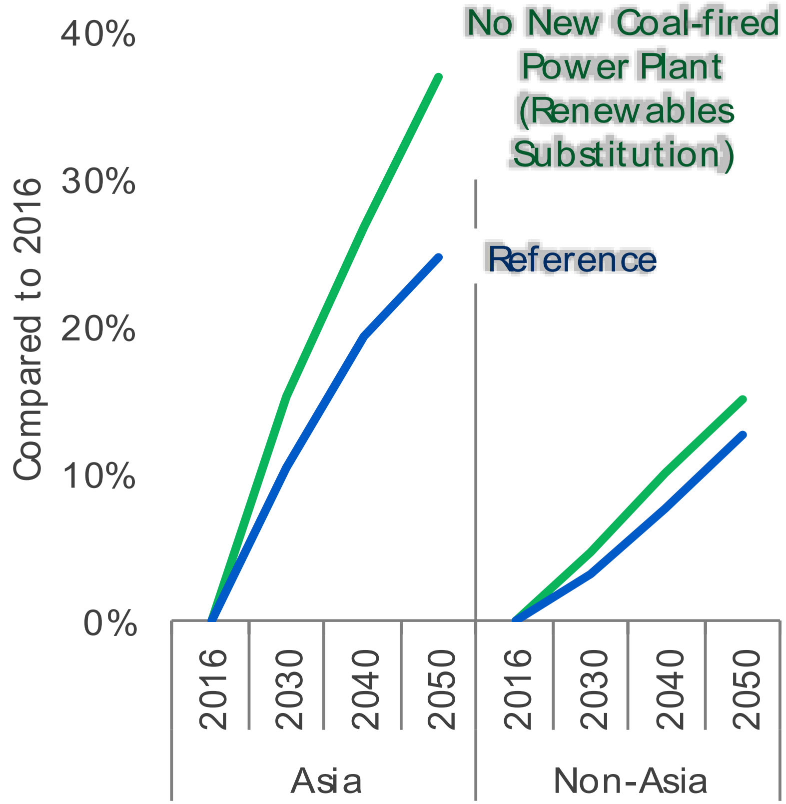


Electricity supply and demand must always be balanced.

Urgent subjects are technical study on frequency, voltage, transient stability, etc. under massive introduction of variable power sources.

Note: Shape of demand load curve is based on the current curve.

❖ Electricity cost «indicative»



It is necessary to make preparation, such as facility implementation and operation alteration for massive introduction of variable renewables.

In Asia, despite cost increase, avoid energy poverty and a decline in competitiveness.

Note: does not include levies for renewable power source promotion.

Source: “IEEJ Outlook 2019” (IEEJ, October 2018)

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Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

Points of "The 5th Strategic Energy Plan"

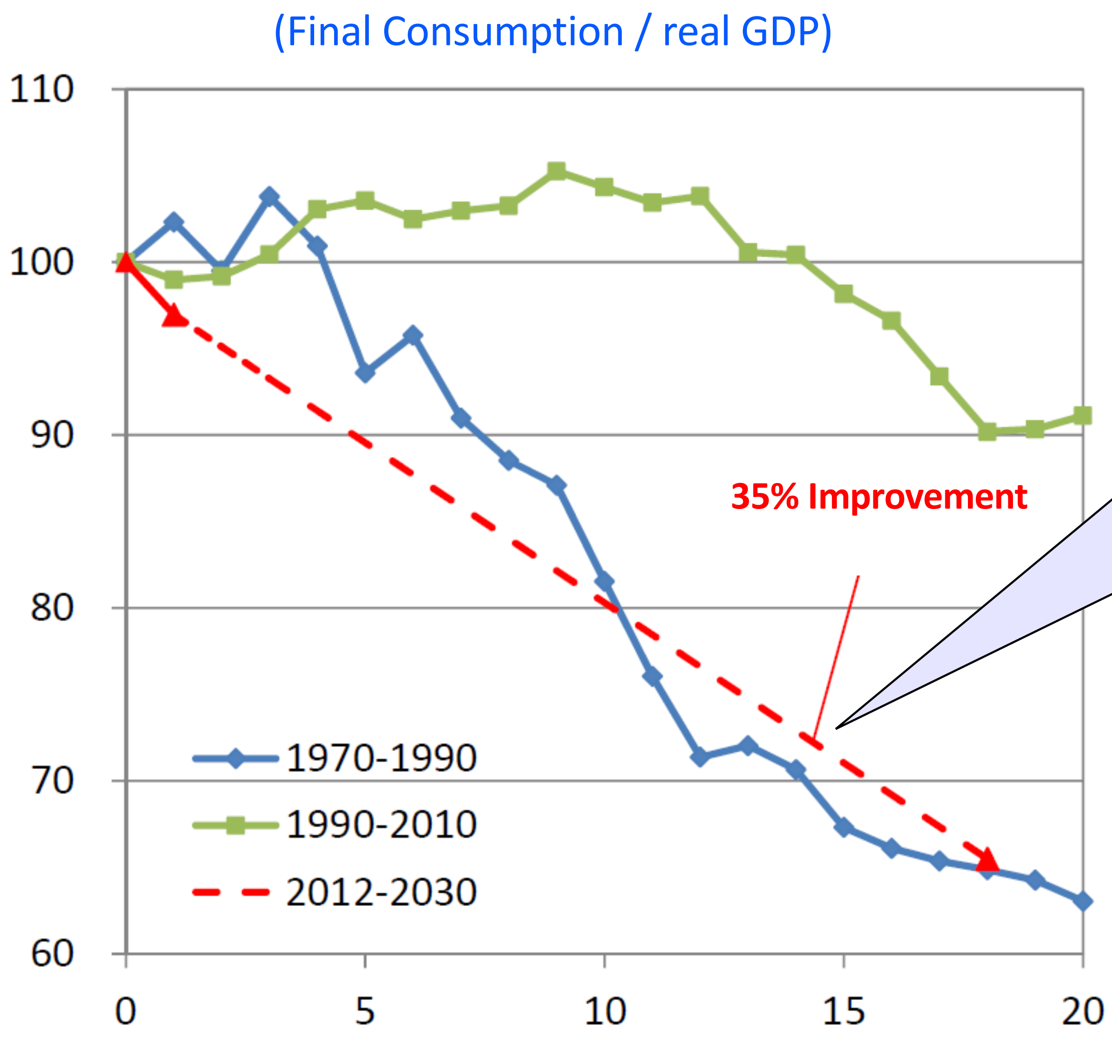
1) Re-confirmation of the "2030 Energy Mix Target"

* Speed to achieve the target is not fast, but …

2) Longer-term policy perspectives up to 2050

* Renewable energy : "major source of power generation"
* Energy efficiency: best use of "AI, IoT, Big Data, etc"
* Nuclear Power: Rebuilding confidence by safer, more economically competitive and flexible new reactor
* Fossil fuel : Cleaner use to zero-carbon use in such form of hydrogen
* In short, strategic emphasis need to be on innovative technology

Energy Efficiency to be Improved Drastically



- Replacement of manufacturing facilities
- Full utilization of IT, AI, IoT
- Building energy efficiency improvement

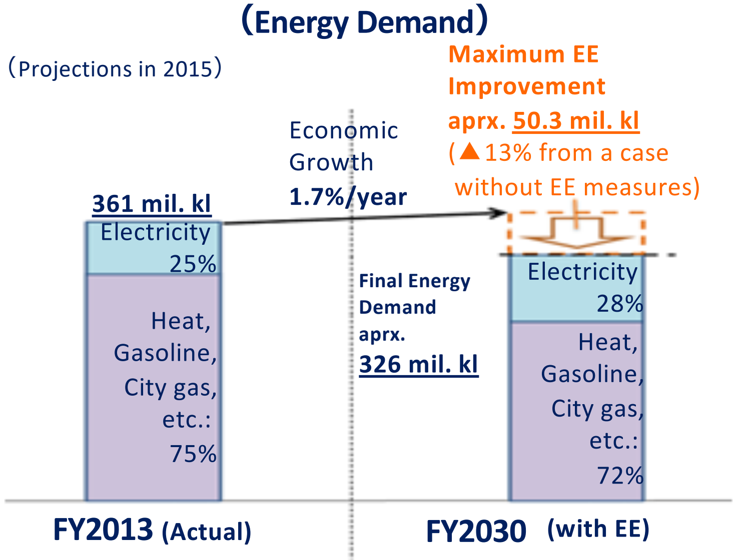
Source: from documents discussed at the
"Long-term Energy Outlook Sub Committee", 10th Session (1st June 2015)

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

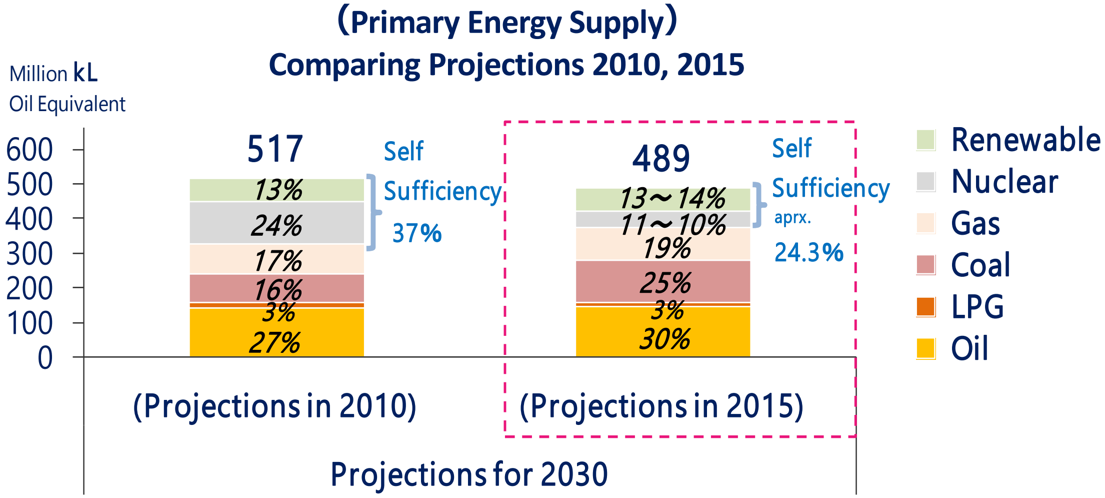
<1> Energy Demand and Primary Energy Supply Structure

- **(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)



N.B: EE stands for "Energy Efficiency"



(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

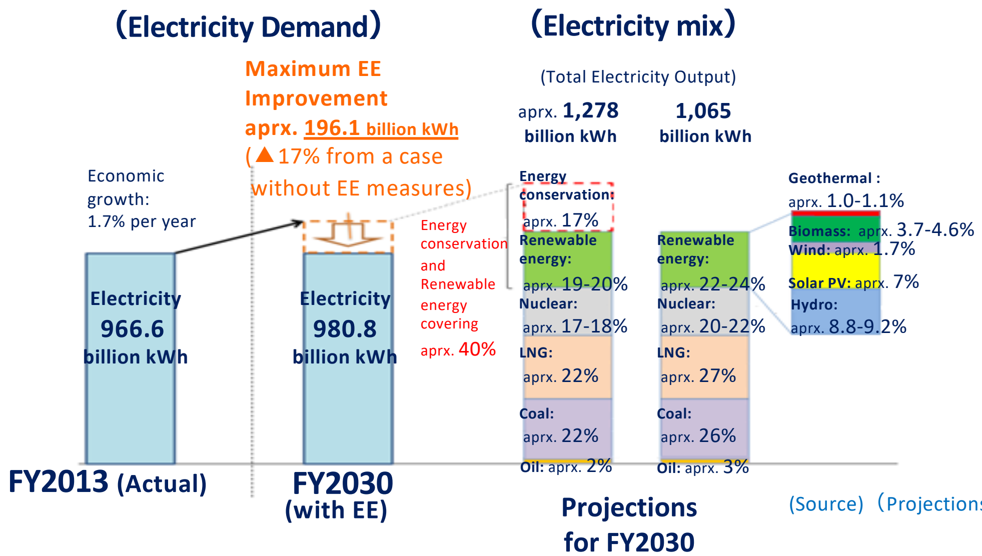
<2> Electricity Mix

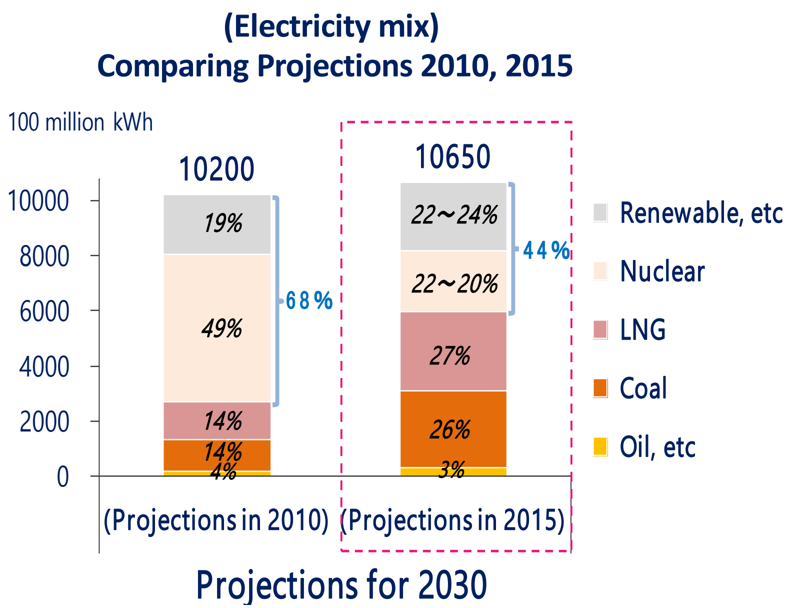
- **(Electricity Mix) Nuclear and renewable energy had a combined share of 68% in the 2010 version against 44% in the 2015 version. Nuclear energy's share was cut by 30% (from 49% to 20-22%). Priority shifted from heavy dependence on nuclear energy to diversification.**

	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)

How to assess current status of achievement of Energy Mix : Slow but steady progress

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

①Improving energy self-sufficiency rate

Target : 6% in 2014 ⇒ 24.3% in 2030

Current : 12.8% at FY2019-end (IEEJ outlook)

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

Target : Reducing costs by 2030 (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 : 7.7 trillion yen at in FY2019 (IEEJ outlook)

Down 20.4% from FY2013

(2.3 trillion yen in FIT purchase cost and 5.4 trillion yen in fuel* and other costs)

* Oil import CIF price is assumed to average $69/bbl in FY2019.

③Reducing energy-related CO_2 emissions

Target : Reducing emissions in 2030 by 21.9% from FY2013

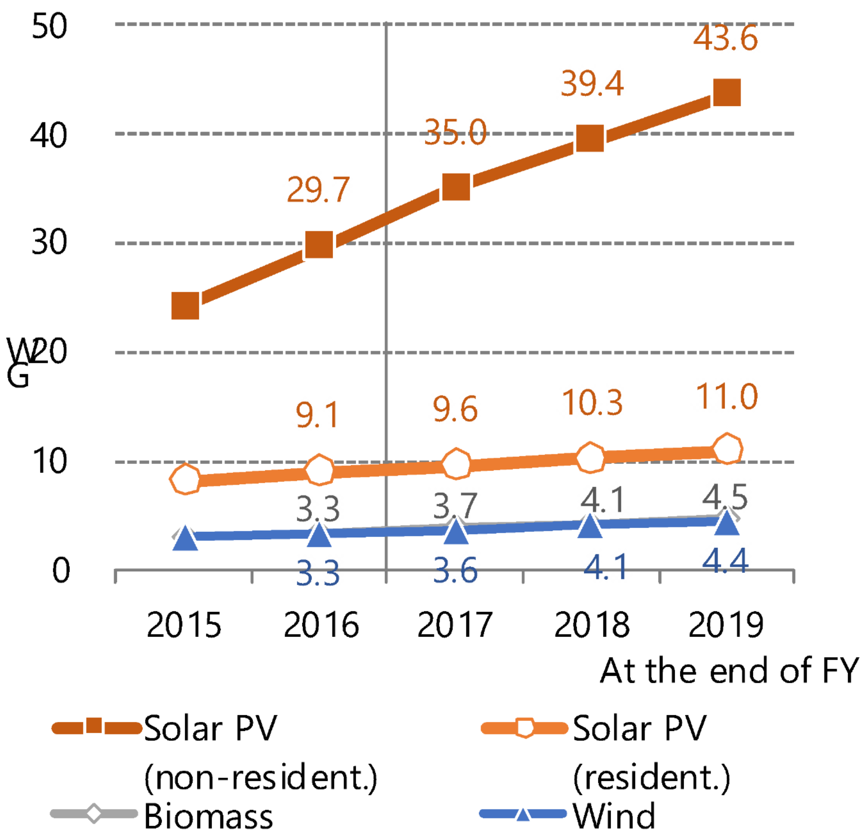
Current : Down 13.1% in FY2019 (IEEJ outlook)

(Sources) METI, “Long-term Energy Supply and Demand Outlook (July 2015),” published on July 16, 2015;
IEEJ, “Economic and Energy Outlook of Japan through FY2019,” 429th Forum on Research Works on July 26, 2018

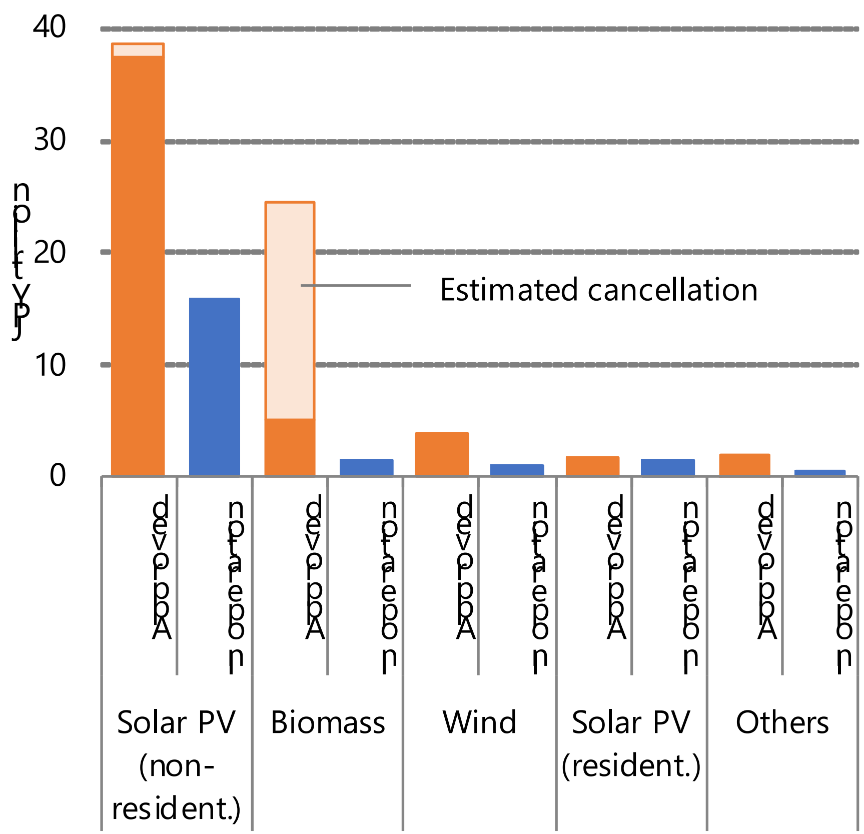
Huge Economic Burden by FIT Surcharge

- As of End March 2017, FIT Approved capacity reached at 105 GW, of which some capacity will be canceled.
- If all the approved capacity will be in operation, cumulative FIT surcharge will reach at JPY 50 trillion.

Installed Capacity in Operation of RE Generation



Cumulative Burden of FIT over 20 Years



(Note) Capacity approved and in operation at the end of September 2017

Source: Akira Yanagisawa "Economic and energy outlook of Japan through 2019"(IEEJ, July 2018)

IEE JAPAN

Nuclear energy's slow progress in Japan

Status of Nuclear Reactors Approved After Implementation of New Regulatory Standards (on July 8, 2013) (7 in operation, 2 stopped, 6 under screening)

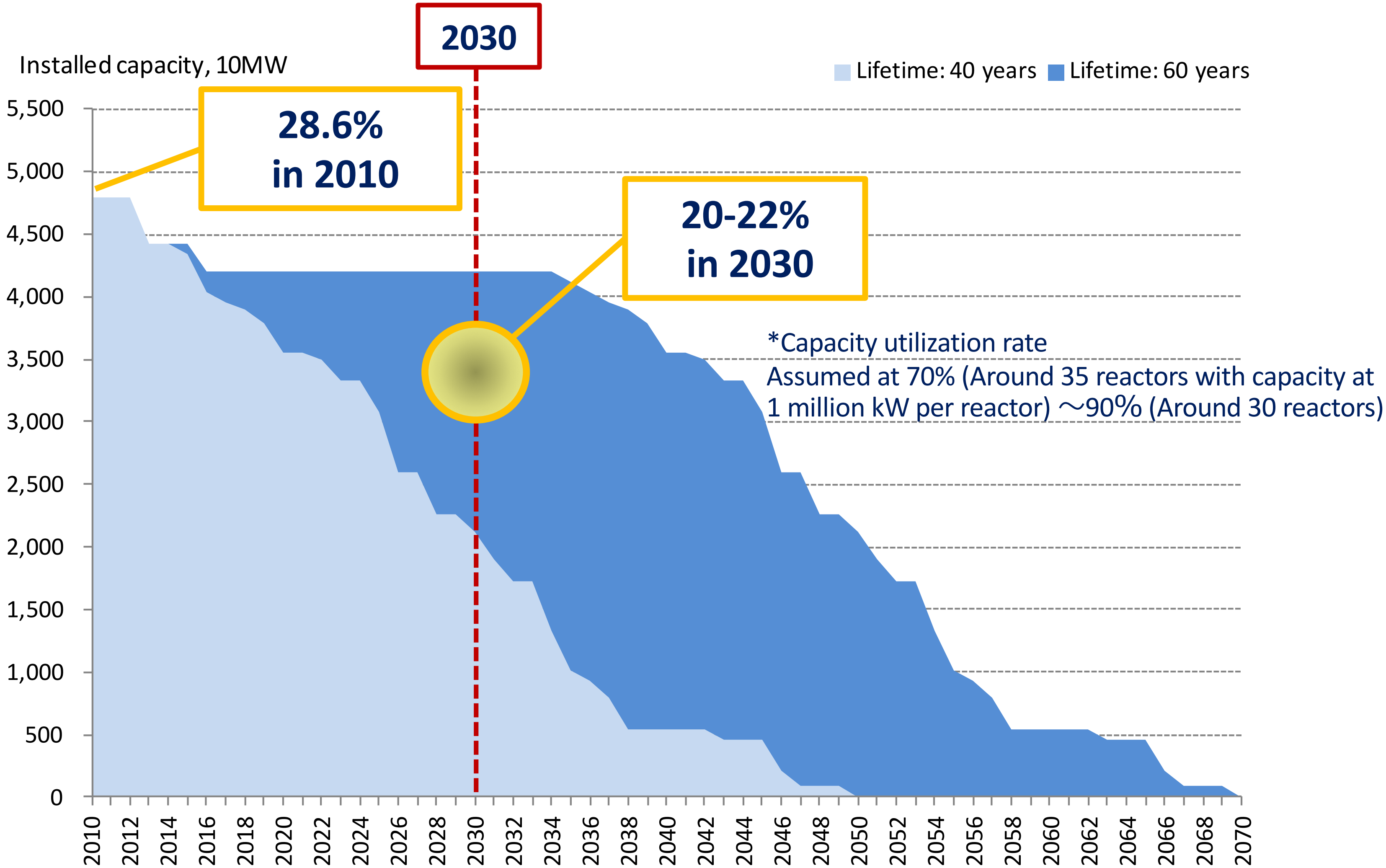
Status	Company	Reactor	Adj. operation	Commercial operation	Suspension duration	Notes
In operation	Kyushu E.P.	Sendai 1	①August 2015 ②December 2016 ③June 3, 2018	①9/10/2015-10/6/2016 ②1/6/2017-1/29/2018 **③6/29/2018-**	Regular checkups ①10/6/2016-1/6/2017 ②1/29/2018-6/29/2018	Resuming operation after regular checkups within 13 months after commercial operation
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	Resuming operation after regular checkups within 13 months after commercial operation
Stopped (regular checkups)	Kansai E.P.	Takahama 3	①January 2016 ②June 2017 **(③Nov. 2018)**	①2/26/2016-3/10/2016 ②7/4/2017-8/3/2018 (③Dec. 2018)	①District court order 3/10/2016-3/28/2017 **②8/3/2018～**(Dec. 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	
Stopped (regular checkups)	Shikoku E.P.	Ikata 3	①August 2016 **(②Oct.30, 2018)**	①9/7/2016-10/3/2017 **(②Nov. 2018)**	Regular checkups 10/3/2017-(Nov. 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.
In operation	Kansai E.P.	Ohi 3	①March 2018	**①4/10/2018-**		
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-**		

Status	Company	Reactor	Screening status	Notes
Under screening	Kansai E.P.	Takahama 1	❶❷Approval ❸Before application	Pursuing restart in or after August 2019
Under screening	Kansai E.P.	Takahama 2	❶❷Approval ❸Before application	Pursuing restart in or after March 2020
Under screening	Kansai E.P.	Mihama 3	❶❷Approval ❸Under screening (application on Mar. 17, 2015)	Pursuing restart in or after March 2020
Under screening	TEPCO	kashiwazaki-kariwa 6/7	❶Approval ❷Under screening (application on Sep. 27, 2013)、❸Before application	
Under screening	JAPC	Tokai Daini	❶Approval ❷Under screening (application on Sep. 27, 2013)、❸Before application	

（As of Oct. 22, 2018）

Challenge to secure a 20-22% nuclear share

❖ **Extension of lifetime or construction of new reactors is required**



Conclusion

(1) Energy demand / supply and climate change up to 2050

The world growth center shifts to Asia. With that, it is extremely difficult to halve the emission by 2050. The total cost minimizing approach is worth pursuing. Cooperation in technological development is essential .

(2) Risk and impact of energy supply disruptions

If oil supply disruption takes place in the Middle East by 10 Mb/d, the global economy would shrink by 9%. The impact of electricity supply disruption may be more local but cyber attacks may have wider impact.

(3) No New Coal-fired Power Plant Case

If all new coal-fired power plants are banned from construction after 2020, the substitution by natural gas-fired power plant would increase demand for gas substantially while the substitution by solar PV / wind power would damage the economic growth. Are we ready to cope with such impact?

(4) Challenges for Japan's Energy Policy "The 5th Basic energy Plan"

" 2030 Energy Mix" has been confirmed although the progress n not speedy enough and strategic emphasis is on technological development for 2050 target.

Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

We provide part of our cutting-edge research results on energy and the environment on our website free of charge.

On the 31st January 2018, the Think Tanks and Civil Societies Program at the University of Pennsylvania (U.S.) released its "2017 Global Go To Think Tank Index Report", the most comprehensive ranking of the world's top think tanks.

In the ranking for **2017**, **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)**

"2017 Global Go To Think Tank Index Report"(p.105)
http://repository.upenn.edu/think_tanks/

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