

A Japanese View on World Energy Future: IEEJ Outlook 2019

Presentation at the Session II
The 9th IEA-IEF-OPEC Symposium on Energy Outlooks

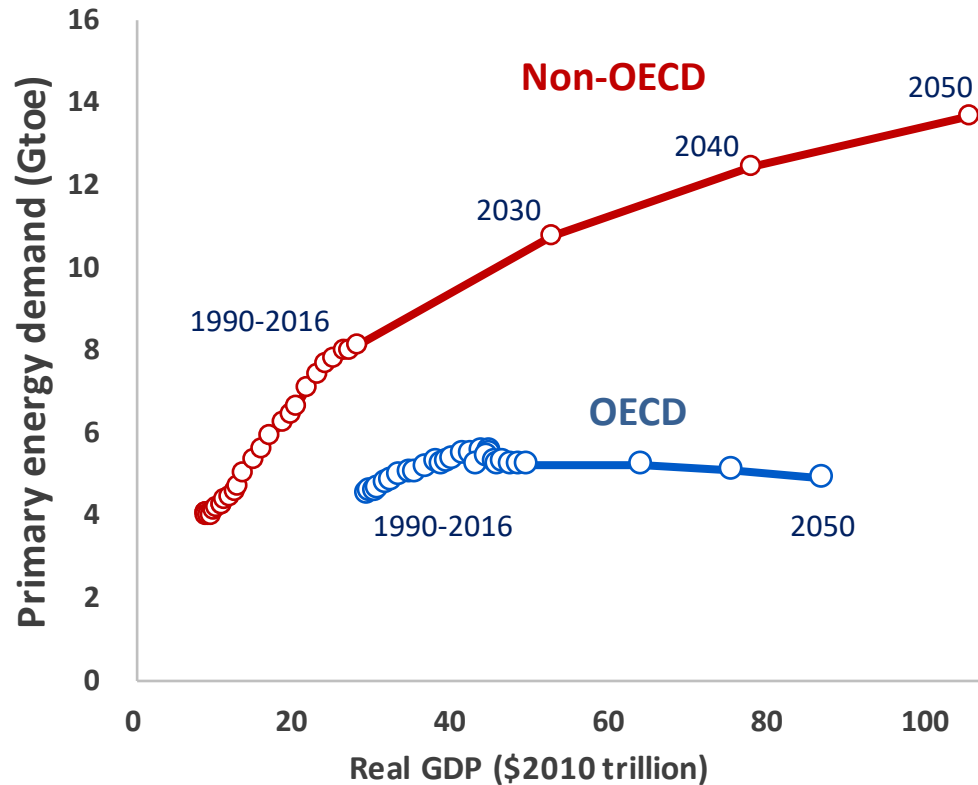
February 27th, 2019

Dr. Ken Koyama

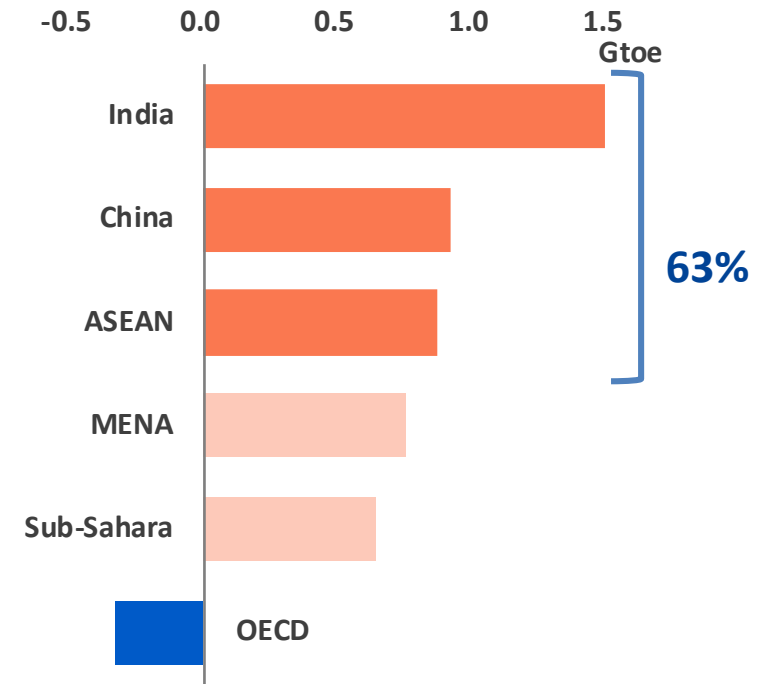
Chief Economist
Institute of Energy Economics, Japan

Dramatic growth of energy demand in Asia

❖ Primary energy demand vs. real GDP



❖ Change in energy demand (2016-2050)



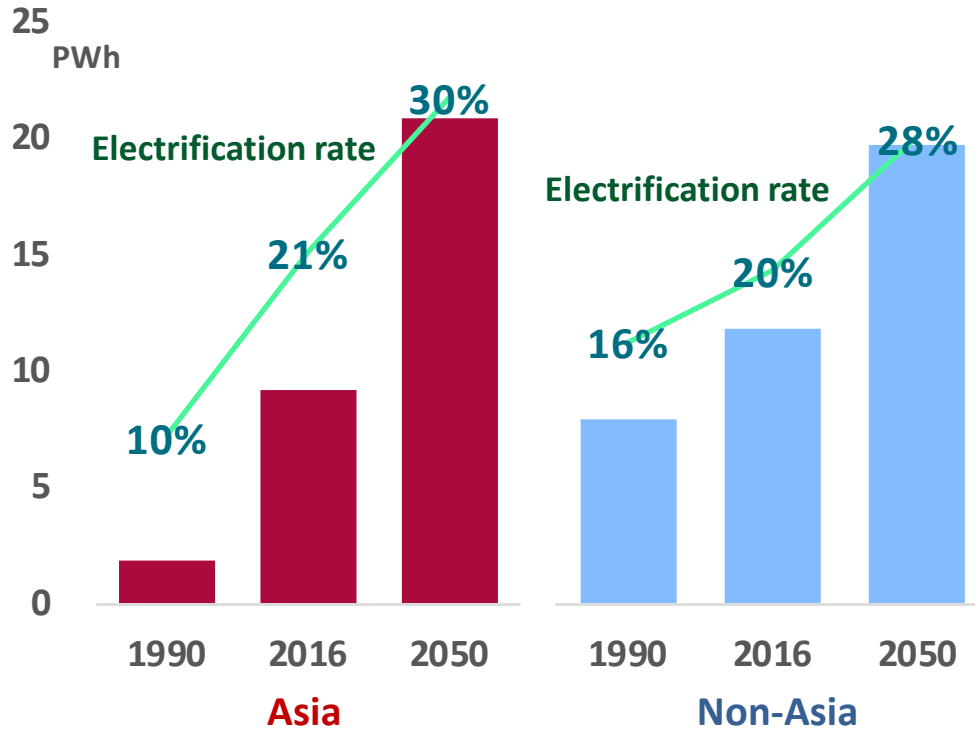
* MENA: The Middle East and North Africa

- ◆ 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%.

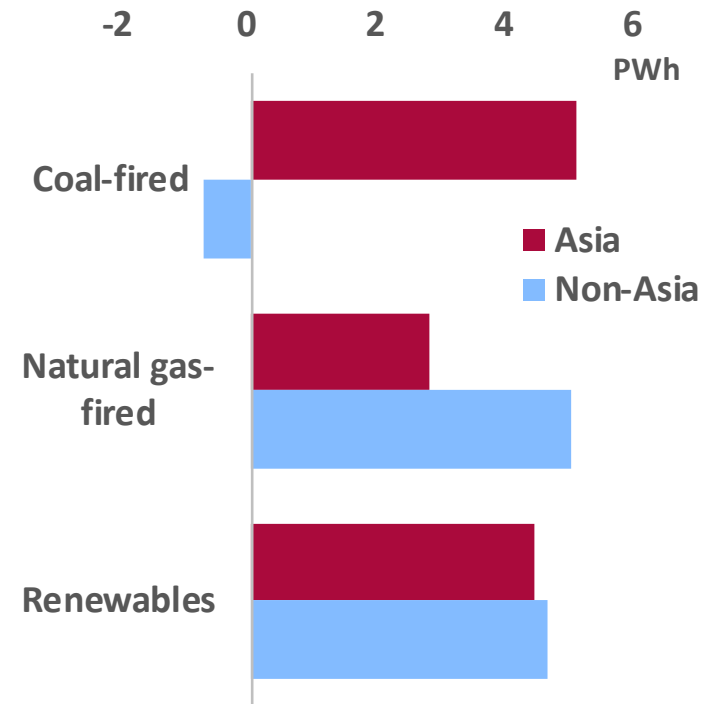
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

Growth of dependence to electricity

❖ Electricity demand and electrification rate



❖ Change in electricity generation (2016-2050)

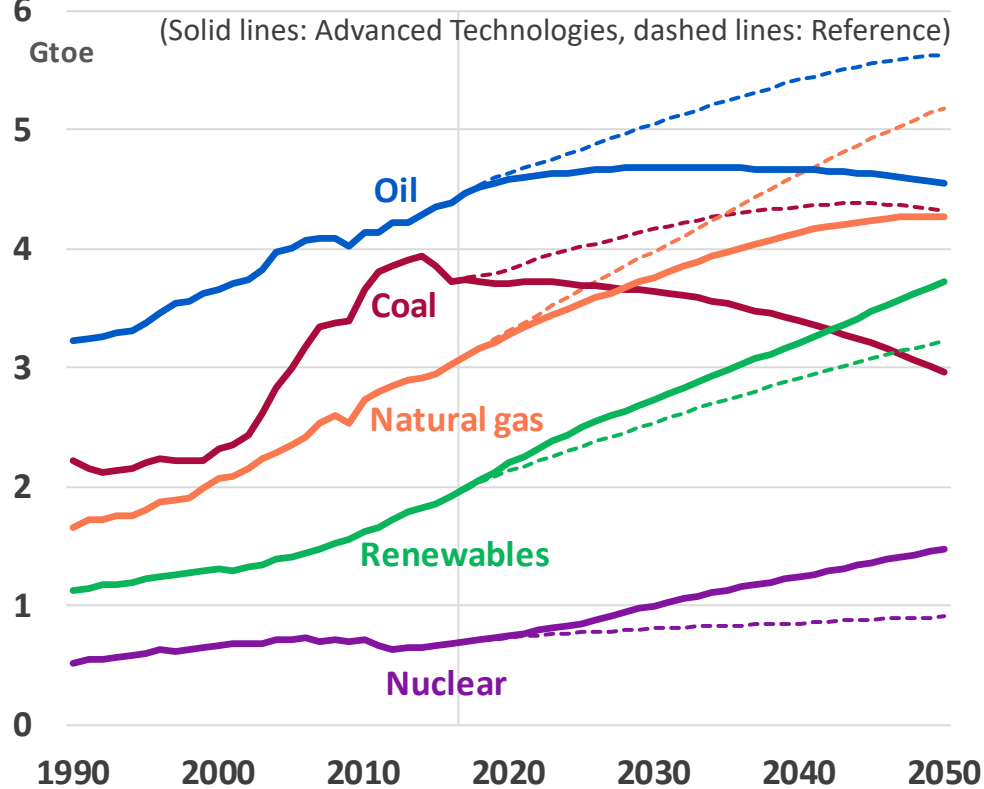


* Electrification rate: Share of electricity in the final energy consumption

- ◆ 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.

Coal declines while oil hits peak in 2030

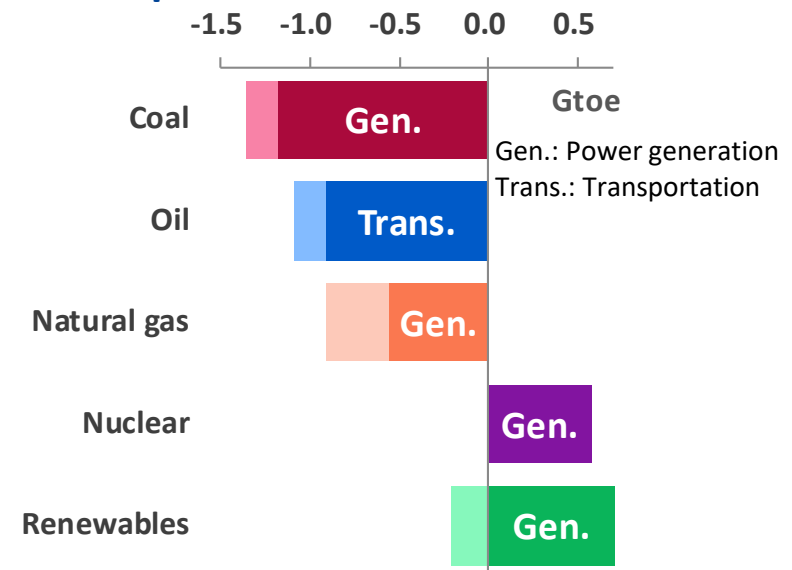
❖ Primary energy demand



● 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.

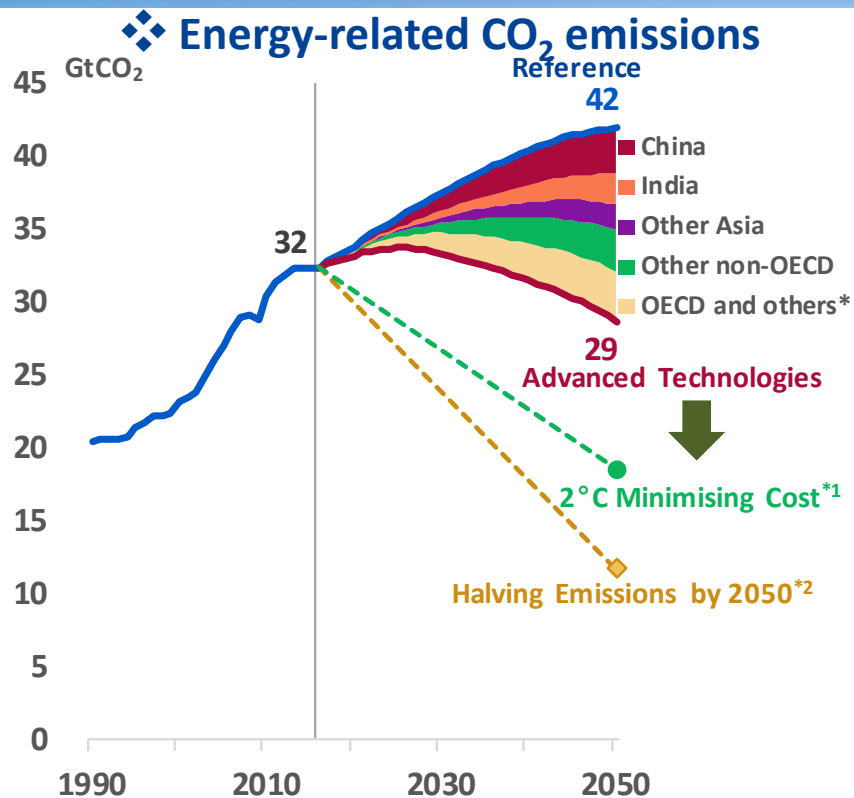
❖ Comparison with the Reference



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.

Improve environmental and security issues



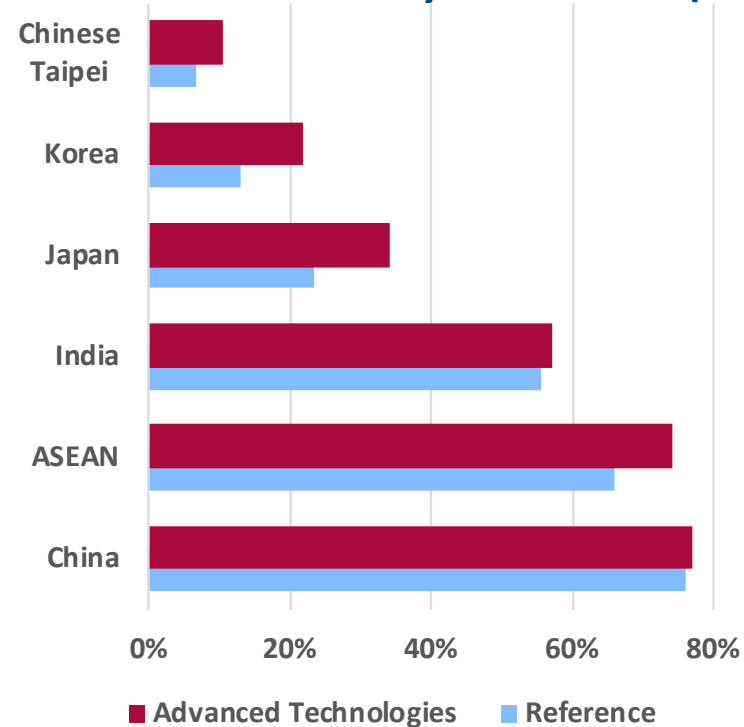
* Includes international bunkers.

*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.

In the Advanced Technologies Scenario...

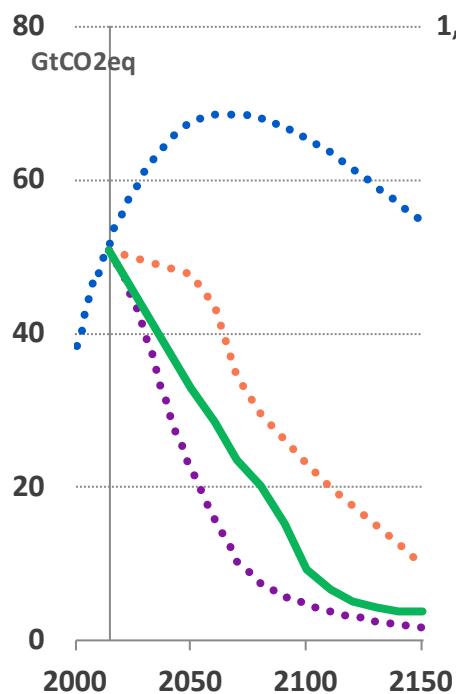
- ◆ CO₂ emissions will peak in the mid-2020s and will decrease by 11% in 2050 from 2016. However, to maintain temperature rise caused by the climate change within 2 degree Celsius, additional programs and innovative technologies are required.
- ◆ Compared with the Reference Scenario, self-sufficiency rate in Asia will improve by 3%p in 2050.

❖ Self-sufficiency rate in Asia (2050)



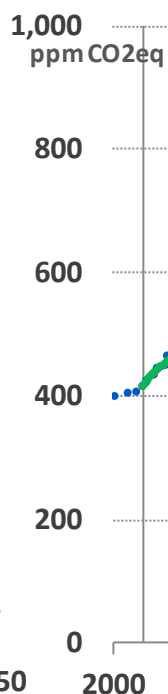
Another path to “2°C target”

❖ GHG emissions



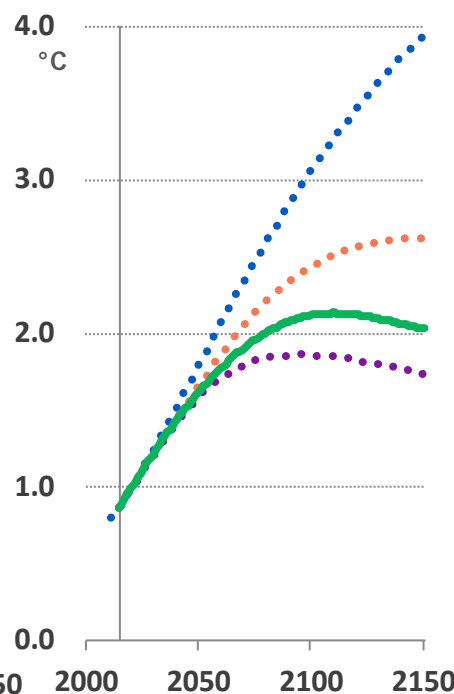
■ Reference

❖ GHG concentrations (incl. aerosol, etc.)



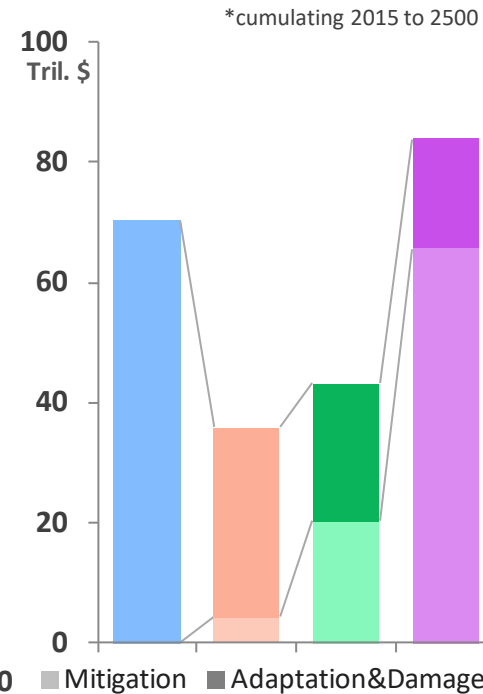
■ Minimizing Cost

❖ Temperature rise (vs. 1850-1900)



■ 2°C Minimizing Cost

❖ Total cost (cumulative present value*)



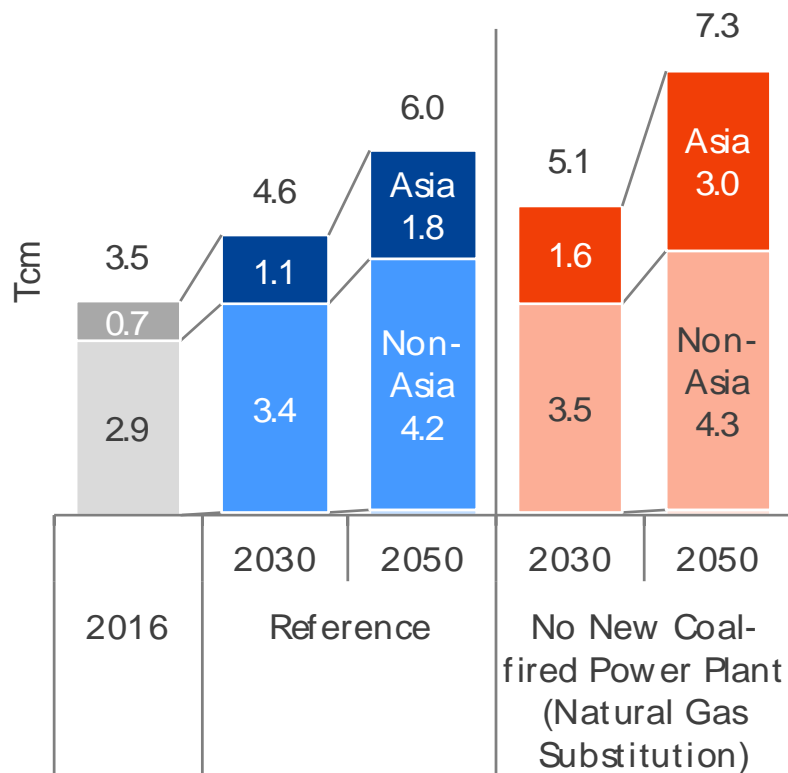
■ Halving Emissions by 2050*

“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.

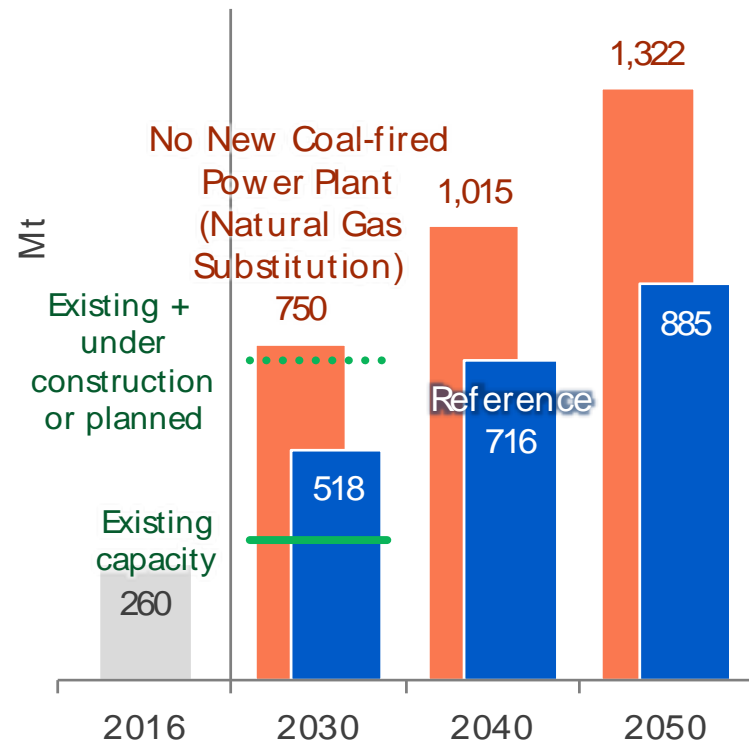
* Emissions path reflected “RCP 2.6” in the 5th Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC).

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.

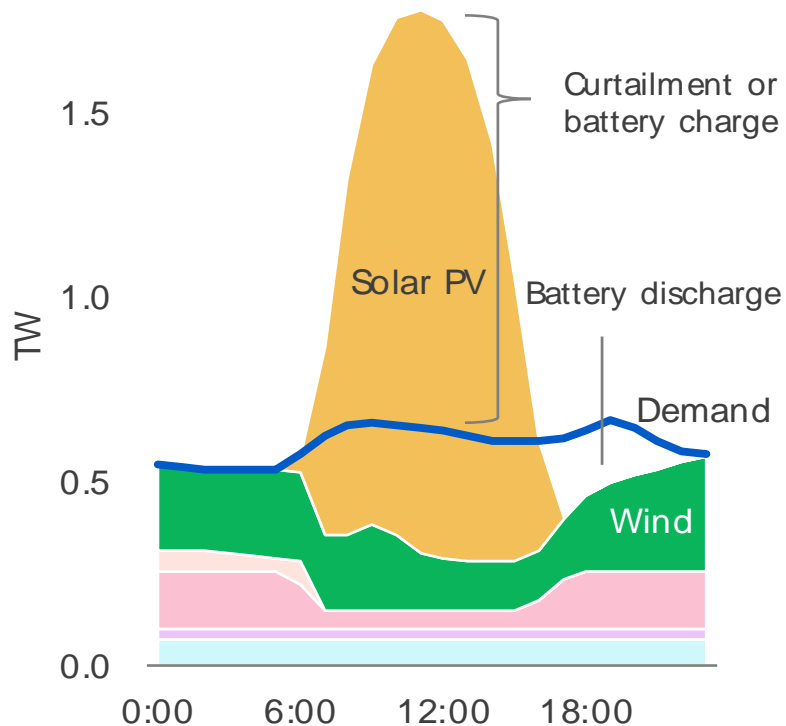
LNG demand in 2030 is 3 times the current level.

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

Keep an eye on electricity security

❖ Electricity balance in India «indicative»

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

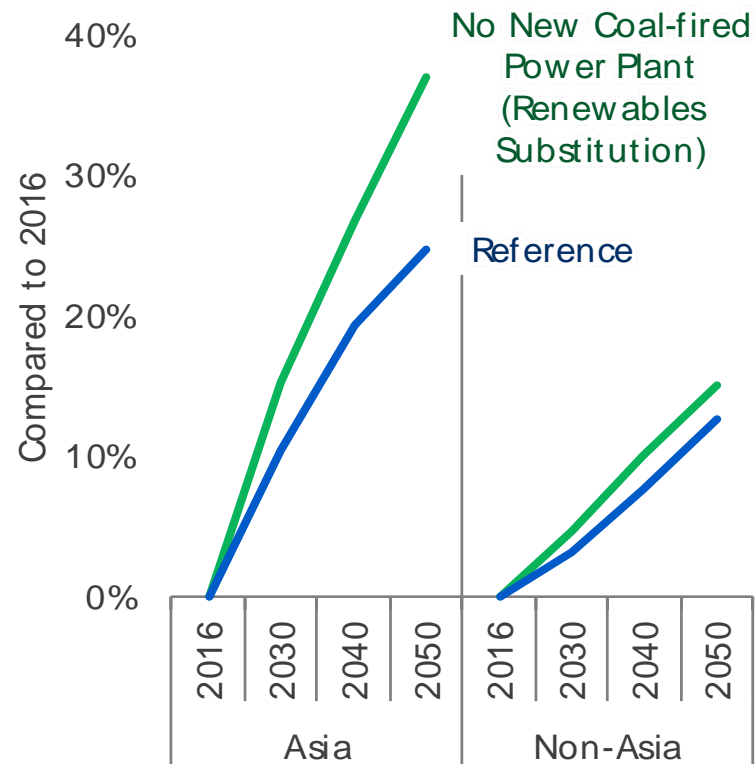


Electricity supply and demand must always be balanced.

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)

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) Risk and impact of energy supply disruptions

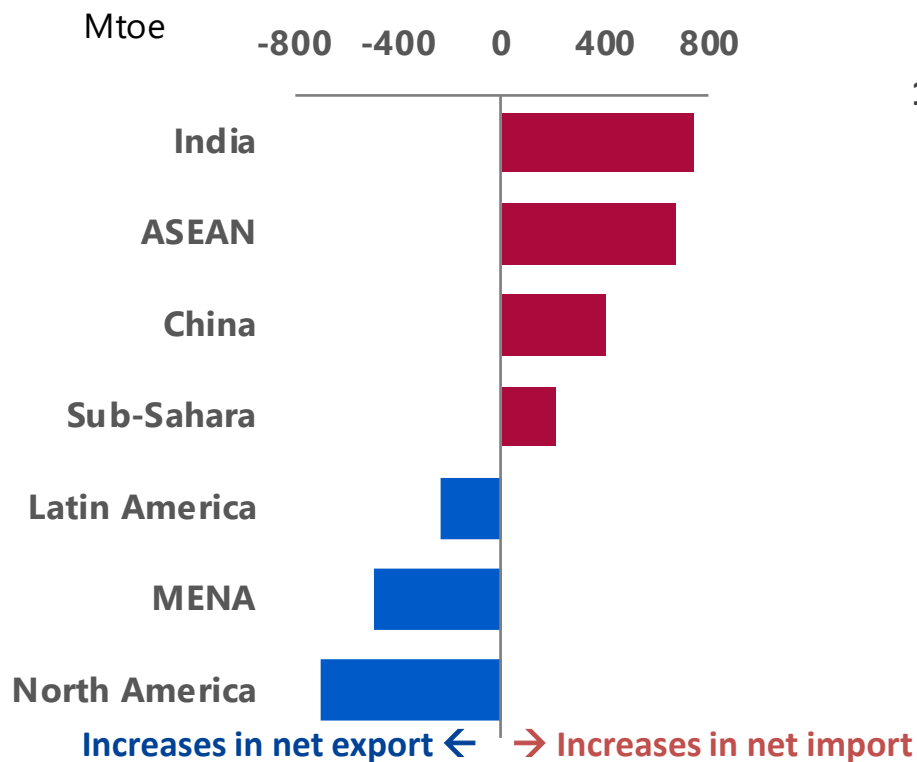
We discuss risks and measures for energy supply disruptions considering the characteristic of two energy sources; oil which has been at the heart of the traditional energy security debate and electricity which is expected to increase the role of energy supply in the future.

(3) No New Coal-fired Power Plant Case

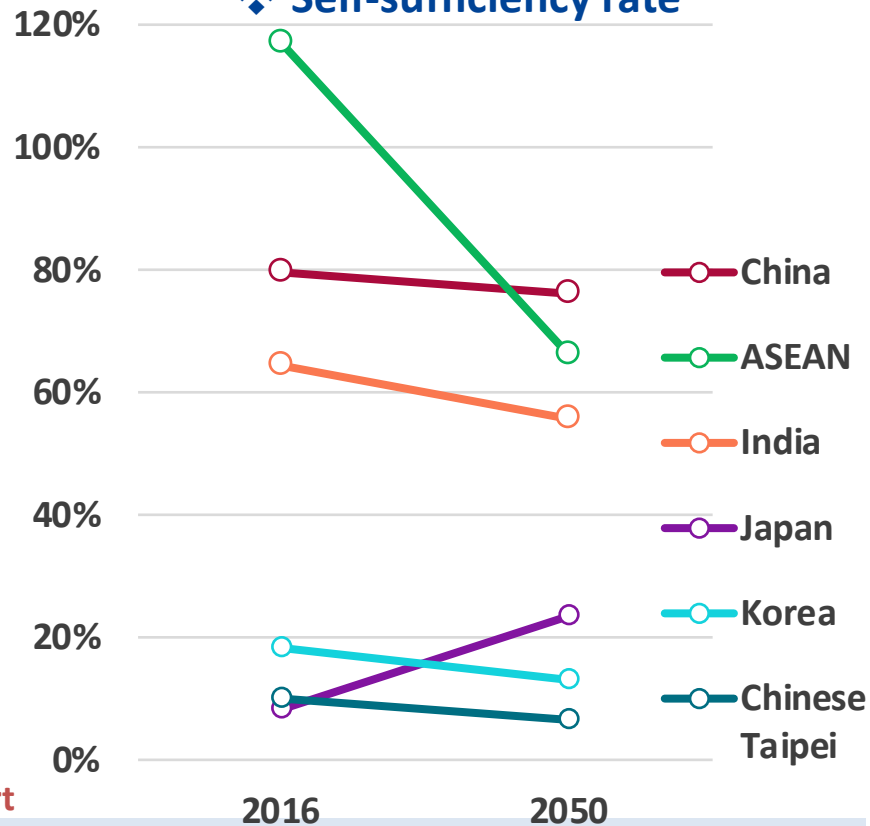
We simulated a hypothetical case in which all new coal-fired power plants would be banned from construction after 2020 without exception assuming two patterns for the substitution; a) natural gas-fired power generation, b) solar PV / wind power generation.

Increase of energy imports in Asia

❖ Increase of net import energy (2016-2050)



❖ Self-sufficiency rate

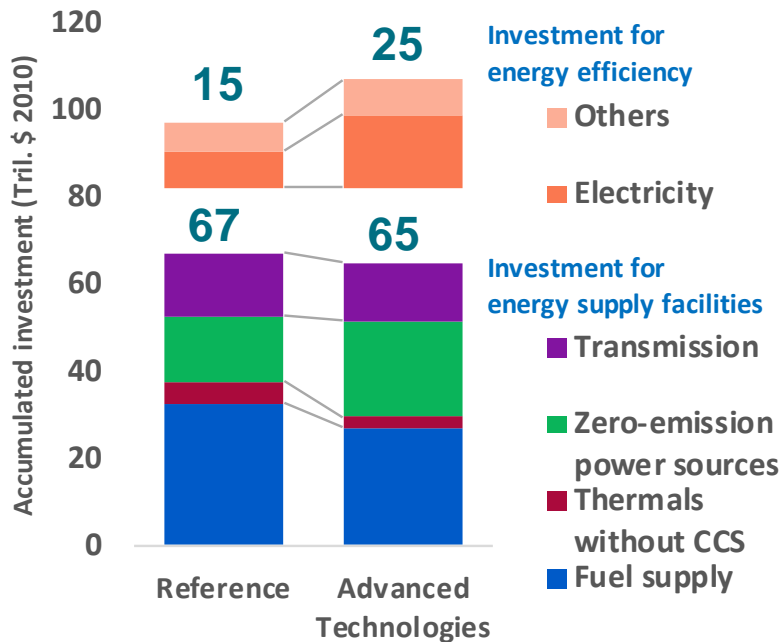


- ◆ Energy imports of Asia will increase dramatically.
- ◆ 80% of energy traded globally will be consumed in Asia.
- ◆ United States will be a net exporter in the middle of the 2020s.
- ◆ Self-sufficiency rate in Asia will decrease from 72% to 63%. This tendency is remarkable for ASEAN, which will be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

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

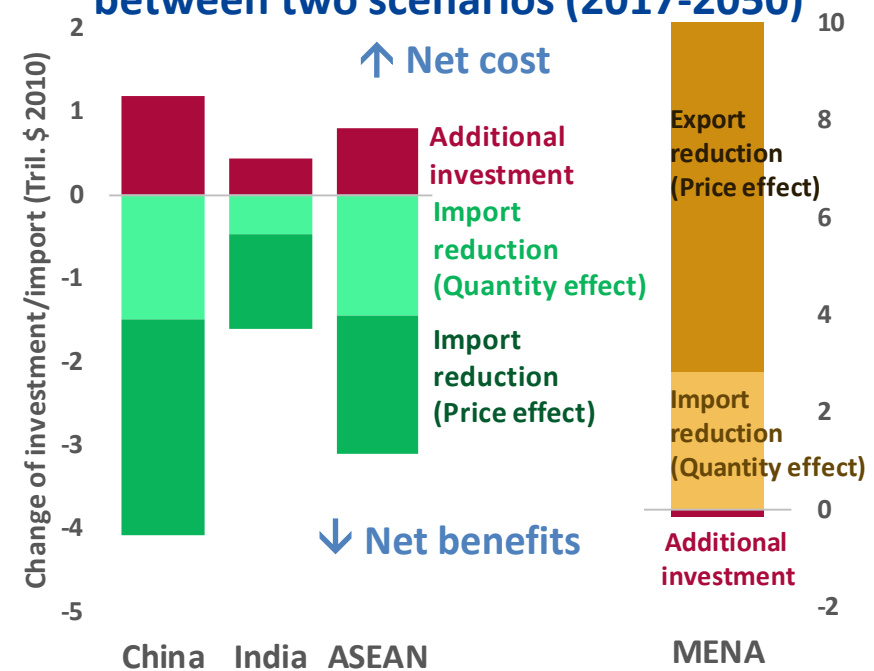
Required investment for energy supply

❖ 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)

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

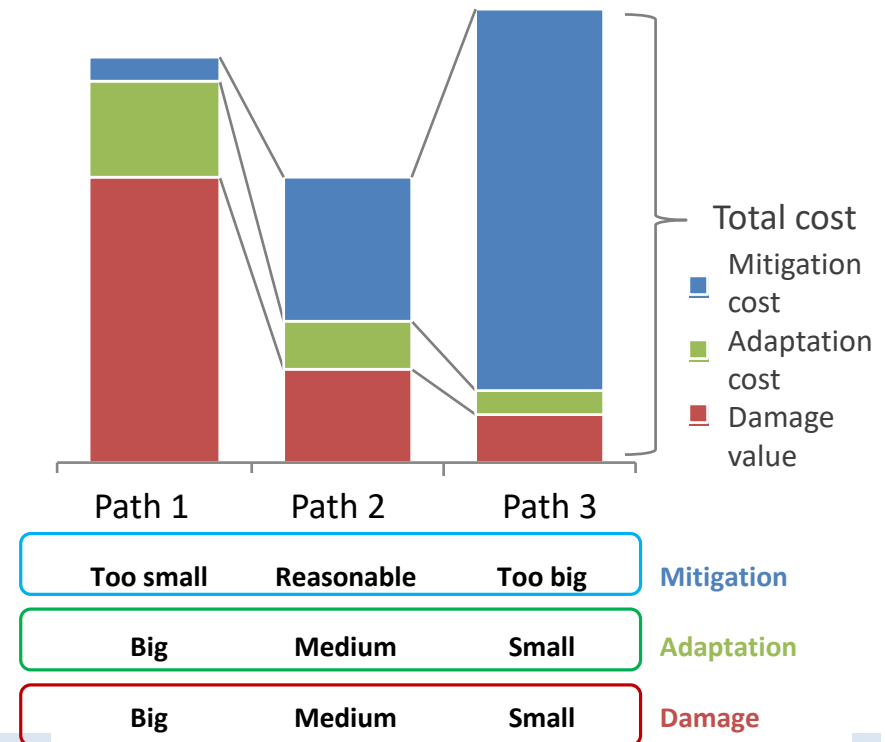
Temperature rise may cause sea-level rise, agricultural crop drought, disease pandemic, etc.

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



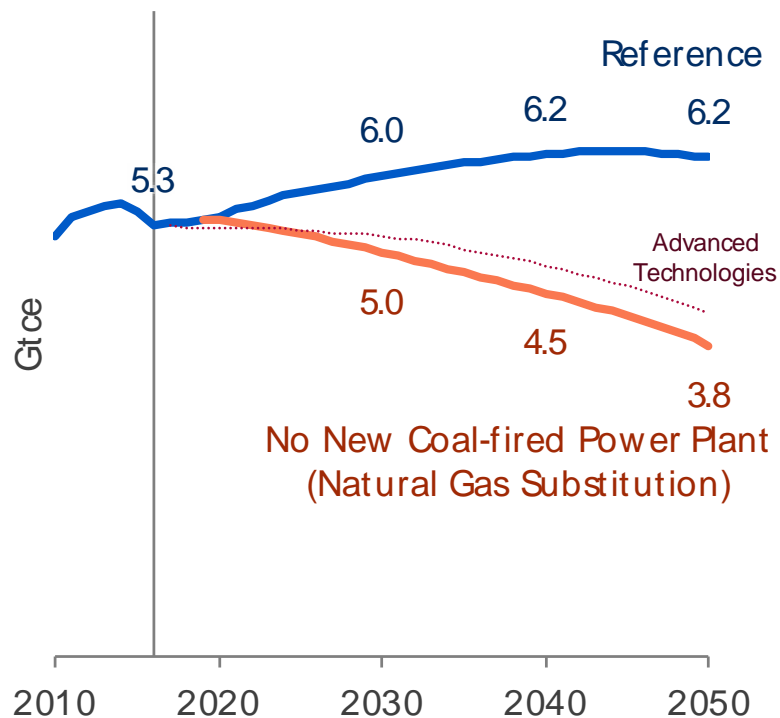
Without measures against climate change, the mitigation cost is small, while the adaptation and damage costs become substantial. Aggressive mitigation measures on the other hand, would reduce the adaptation and damage costs but the mitigation costs would be notably colossal.

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)

Pros of ban on new coal-fired power plant construction

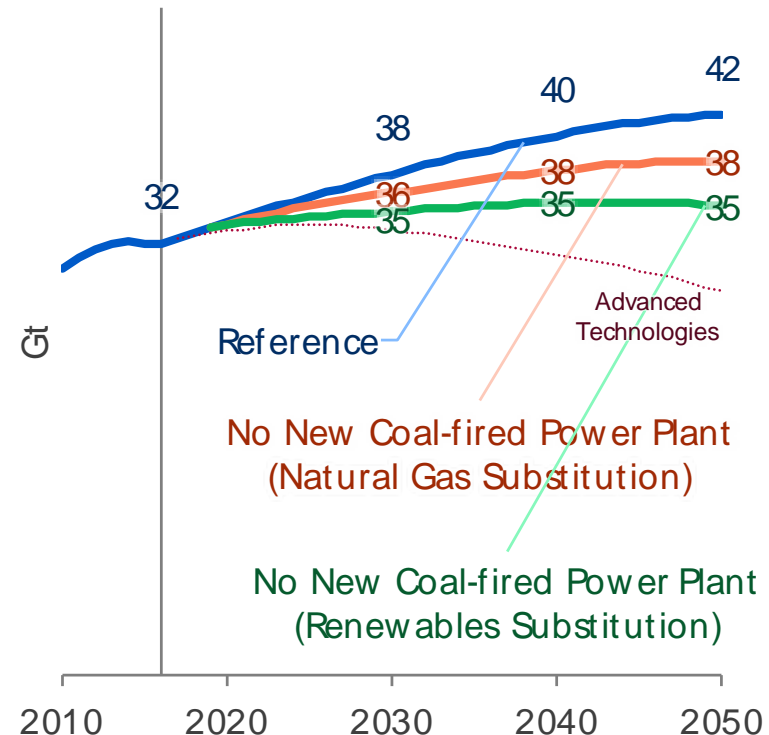
❖ Primary consumption of coal



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

It leads to reduction of local pollutants.

❖ CO₂ emissions



CO₂ reduction in 2050 is 3 Gt (Natural Gas Substitution), or 7 Gt (Renewables Substitution).

However, even in the latter case, CO₂ emissions are not less than the current level.

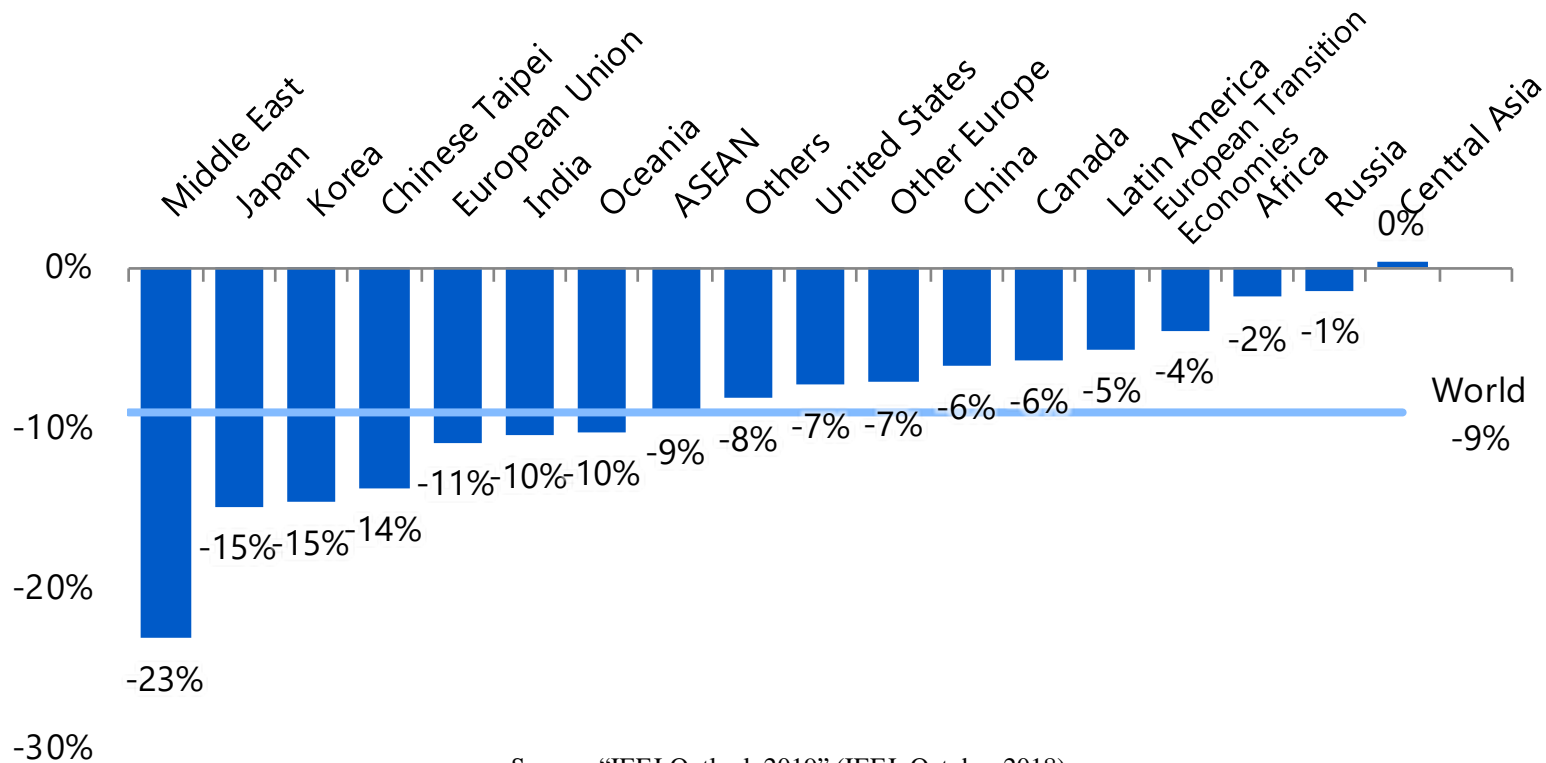
Note: Consumption of coal in the Renewables Substitution is almost same as that of the Natural Gas Substitution.

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

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)

New threat for power supply

Structural risk

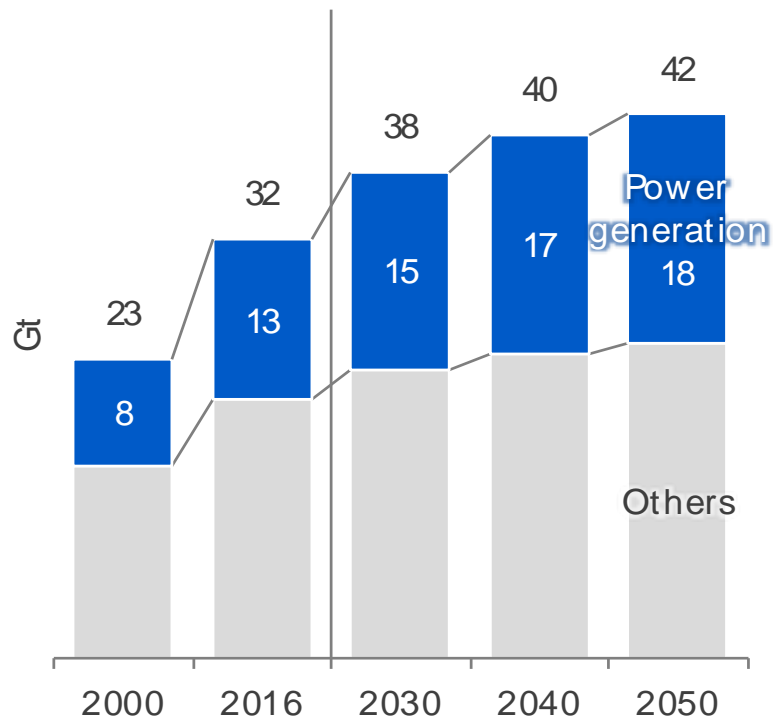
- **The increasing dependence on a specific energy source**
 - ✓ While regions which depend on gas-fired power generation have increased in the United States and natural gas is supplied by pipeline, the supply risk caused by natural gas supply disruption becomes more evident.
- **The “duck curve” of 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.
- **Cyber attacks**

Sudden risk

- ✓ 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.

Decarbonisation in power sector is required

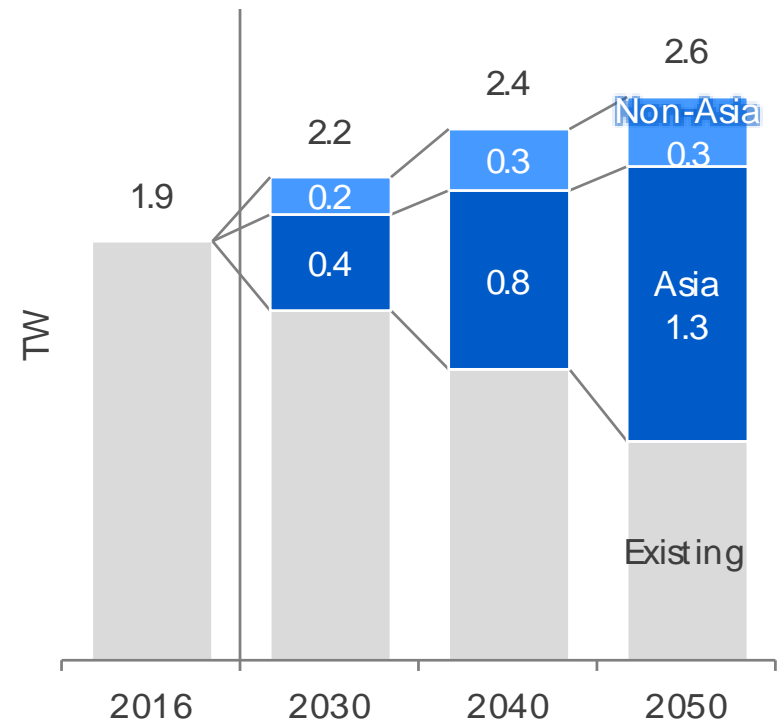
❖ CO₂ direct emissions [Reference Scenario]



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)