SIEW2018

IEEJ Outlook 2019

Energy transition and a thorny path for 3E challenges

Energy, Environment and Economy

Singapore, 1 November 2018

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The Institute of Energy Economics, Japan

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Energy supply / demand and climate change up to 2050

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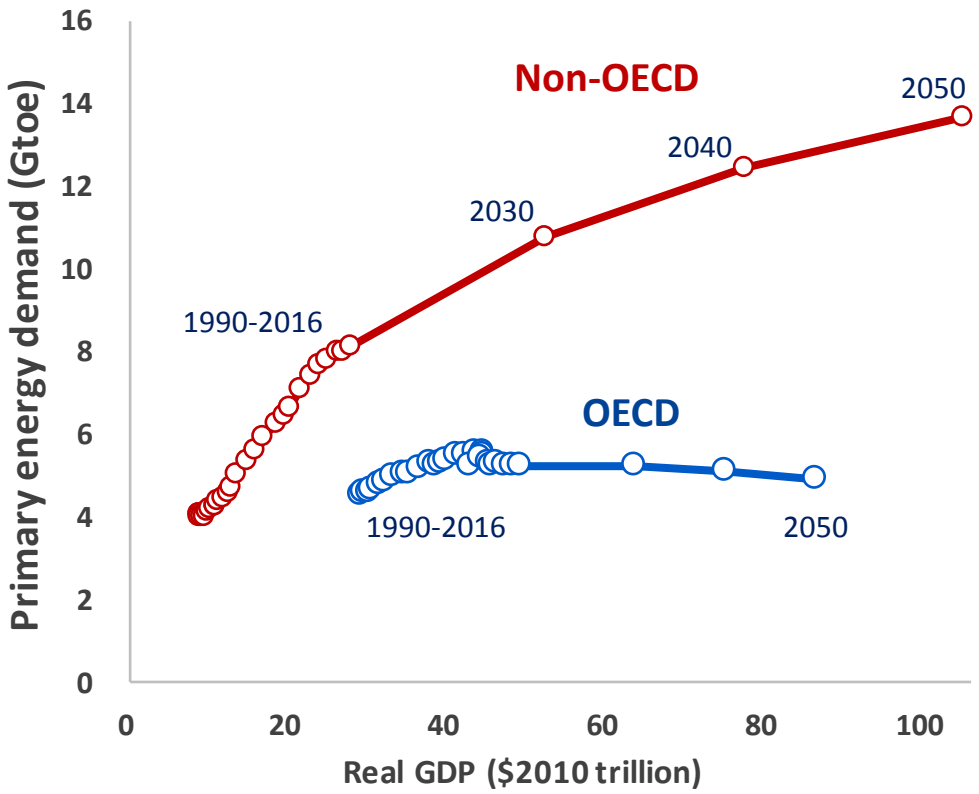
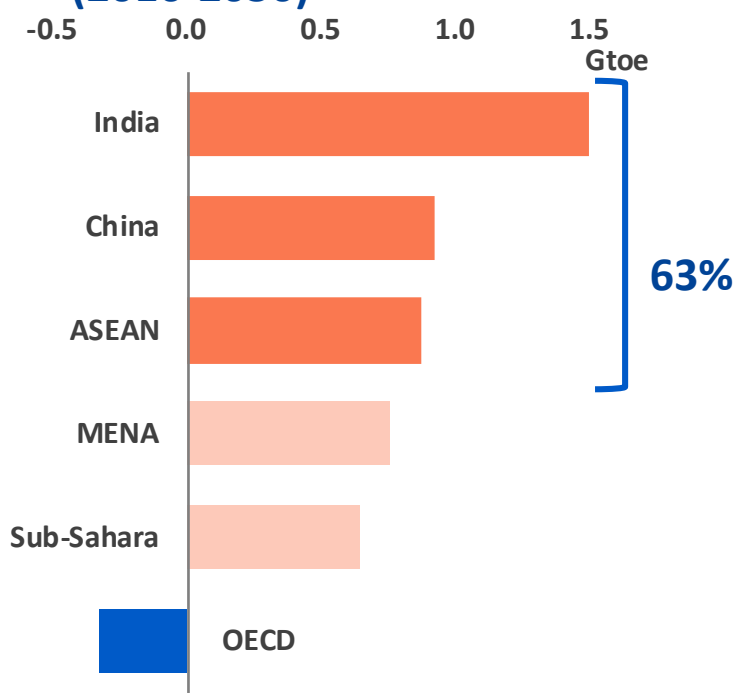
Dramatic growth of energy demand in Asia

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%.

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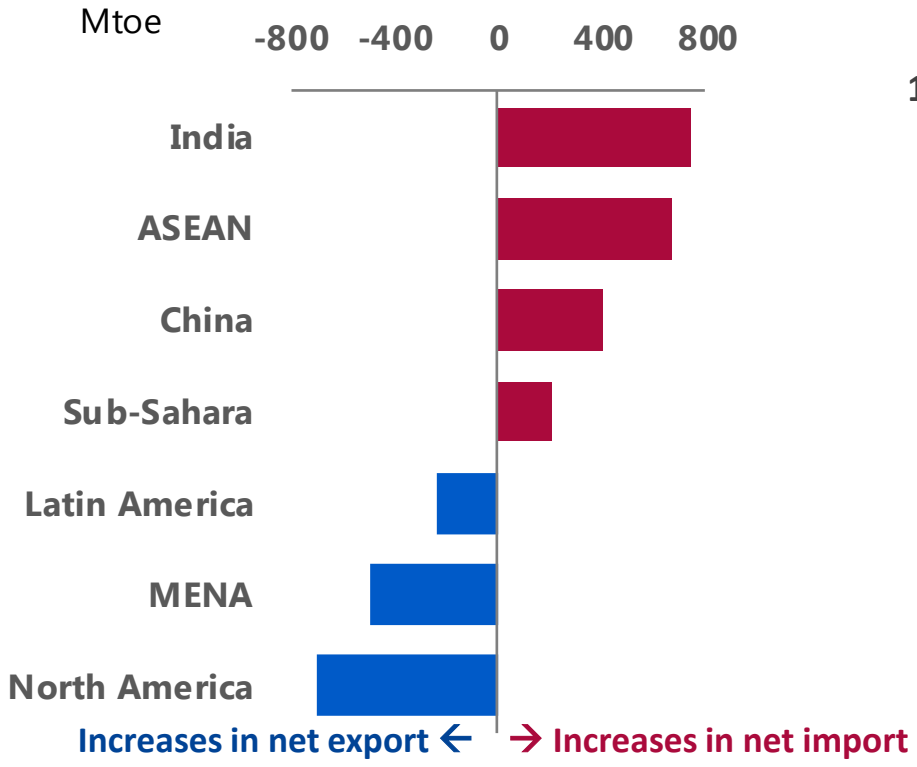
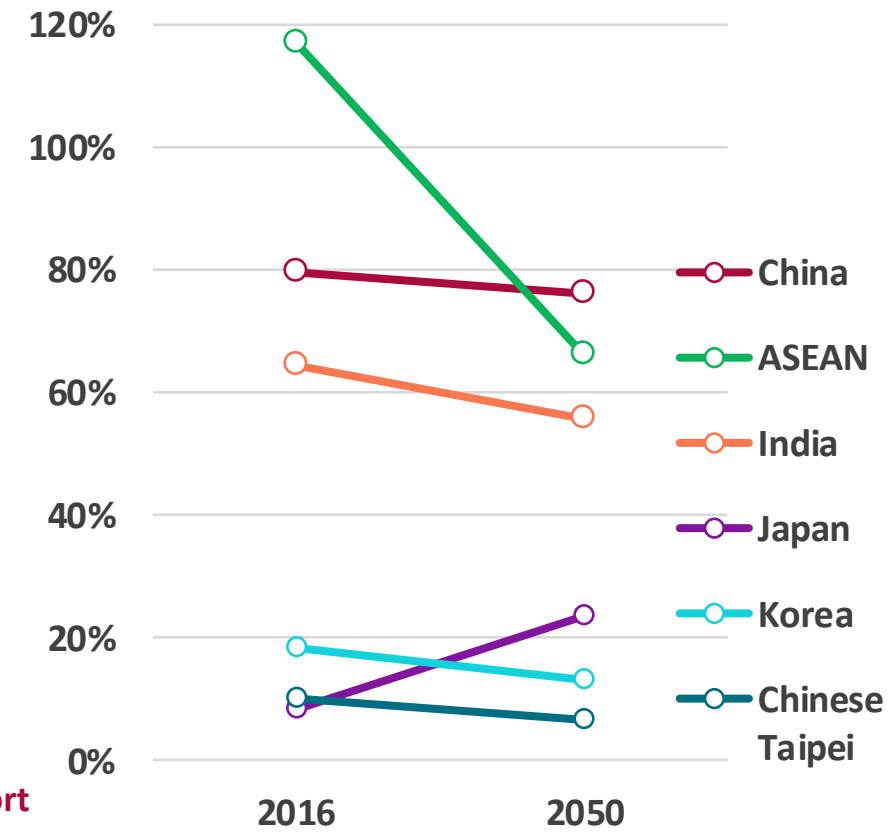
Increase of energy imports in Asia

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.

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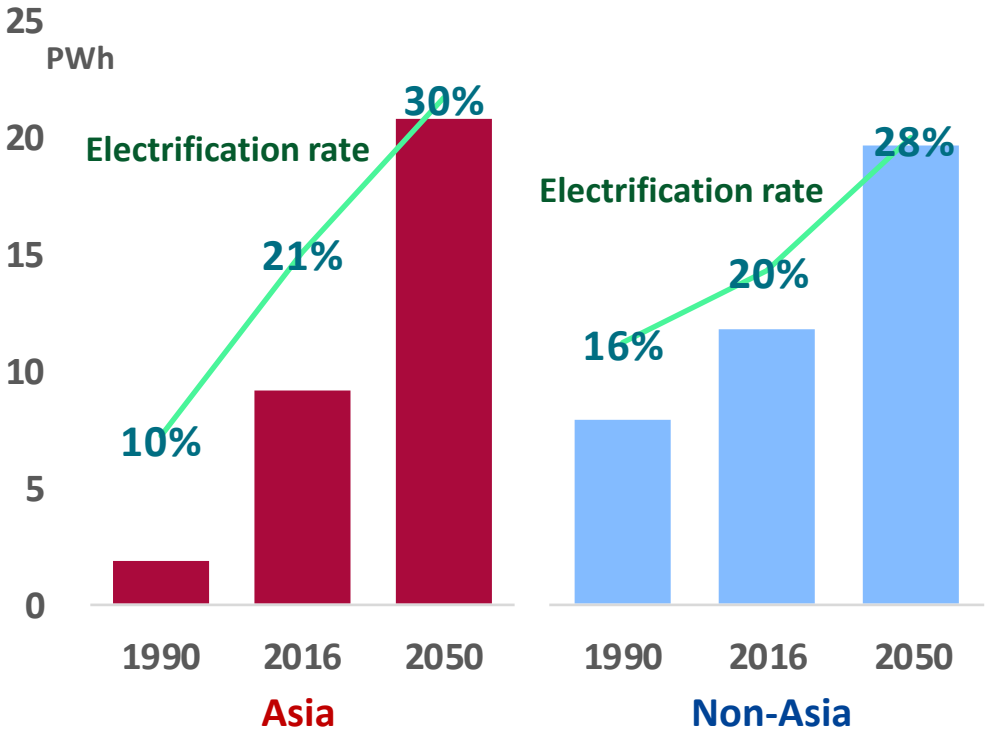
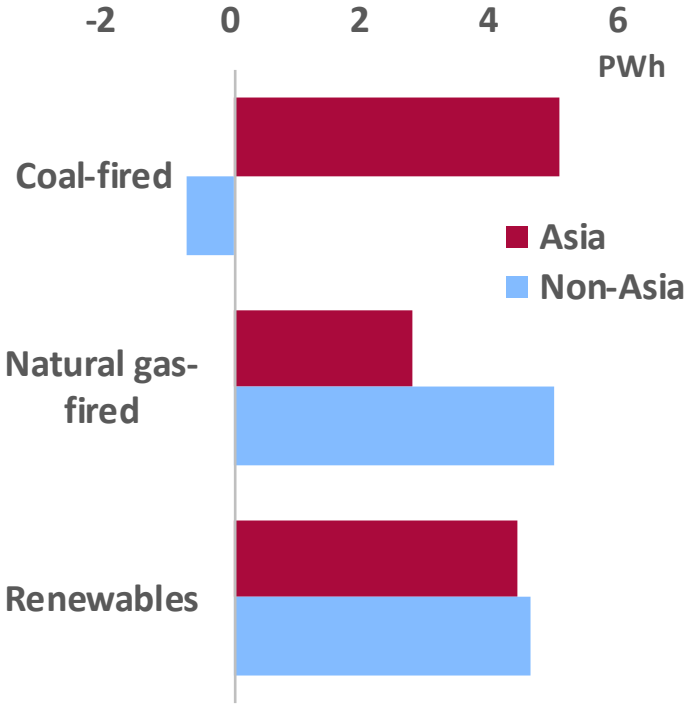
Global Dependence on Electricity Grows

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.

Source: IEEJ Outlook 2019」（October 2018）

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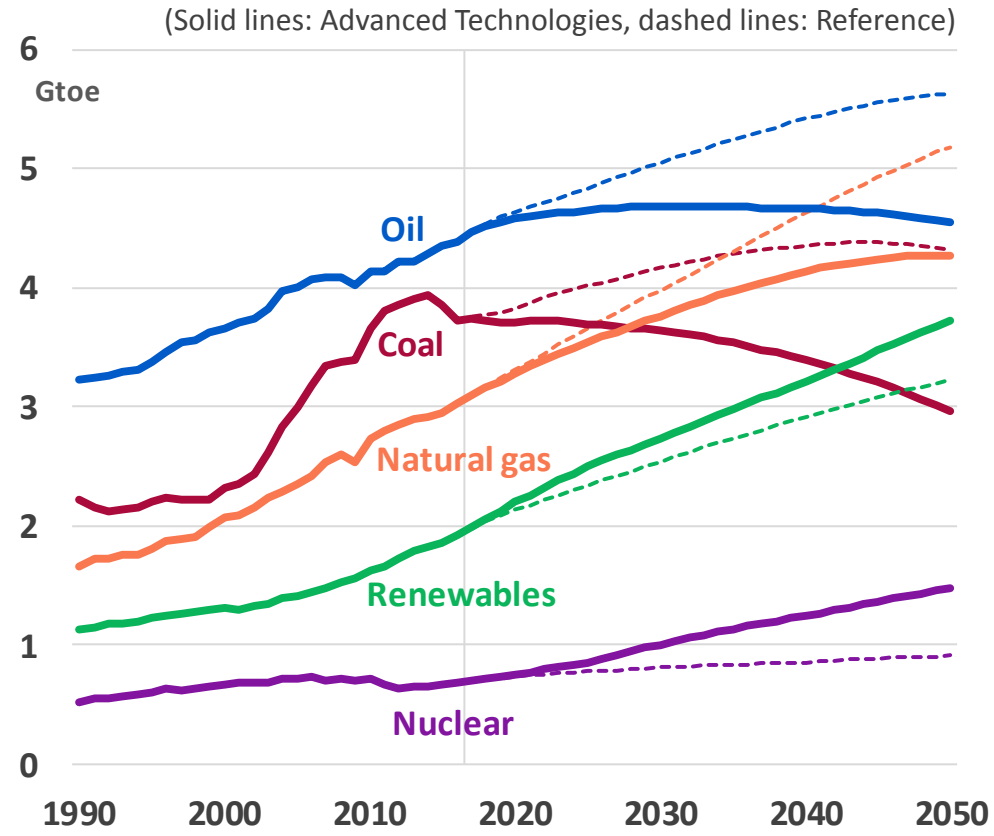
Coal declines while oil hits peak in 2030

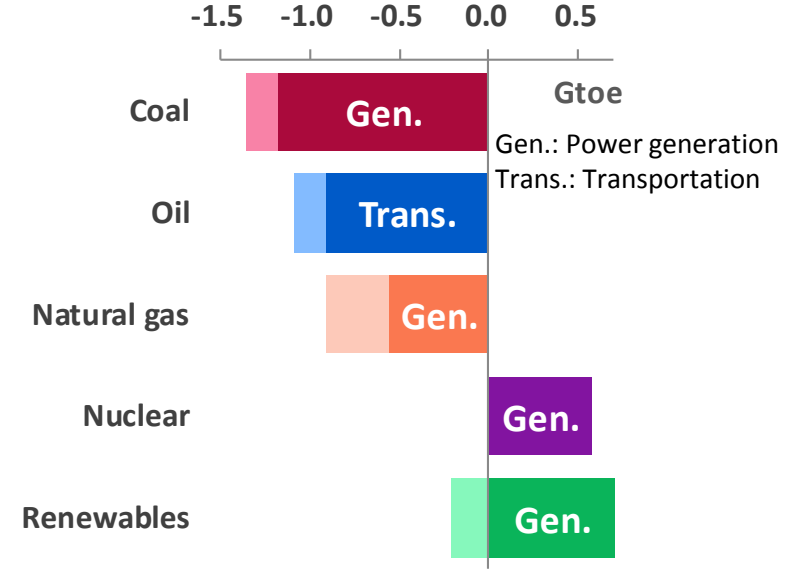
❖ Primary energy demand



● 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.

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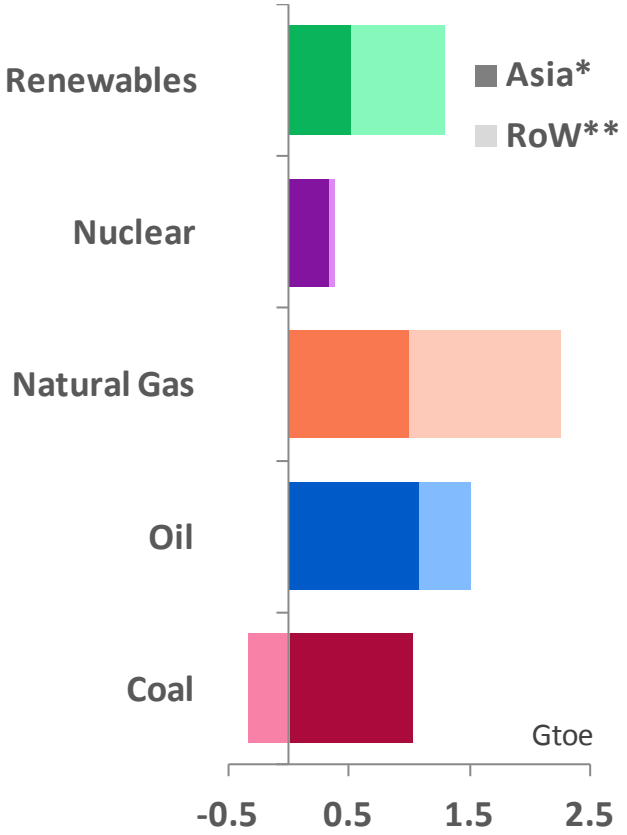
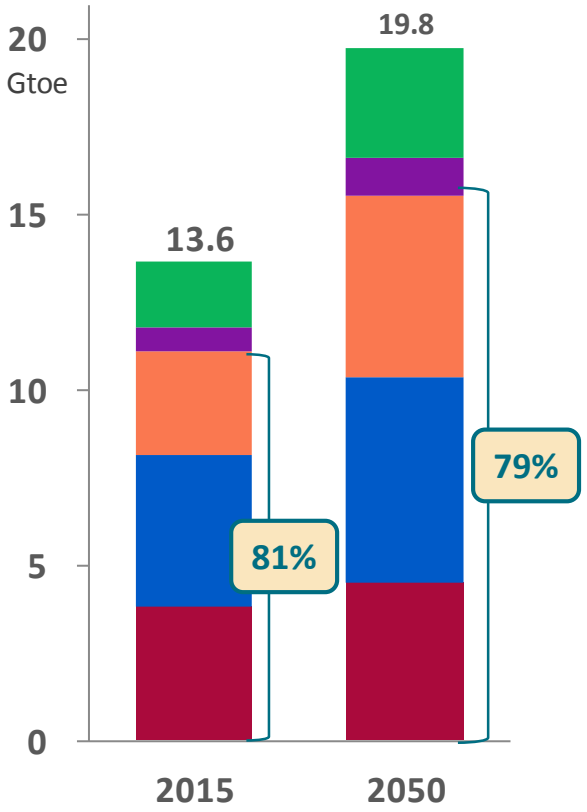
Global High Dependence on Fossil Fuels Continues

❖ Growth in Primary Energy

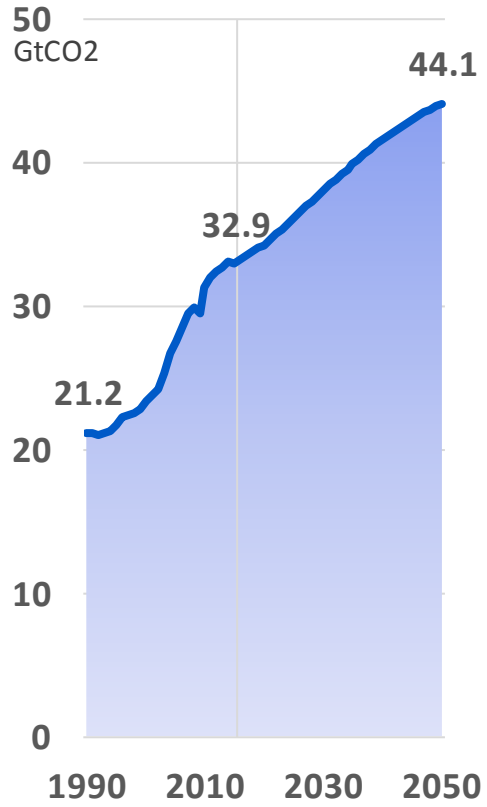


* Non-OECD Asia, **Rest of the world

❖ Energy Mix



❖ Energy-related CO_2



Sixty percent of the growth in electricity demand will be met by thermal power generation, especially natural gas. Asia leads the large global increase in fossil fuels required for power generation as well as for transportation. The high dependence on fossil fuels remains unchanged and energy related CO_2 emissions increase by 34% by 2050.

Source: IEEJ Outlook 2019」(October 2018)

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Uncertainty and Instability Continue in MENA

Terrorist attacks in Paris & Belgium…

US recognition of Jerusalem as a capital.

Situation in/out of Iraq after the war

Iran's Nuclear Development

Lift of economic sanction and Iran's return to market⇒US withdrawal

Opacity of Peace in the Middle East

Gaza Conflict

Refugee issue in Europe

Armed conflicts over IS

Air raid by Russia

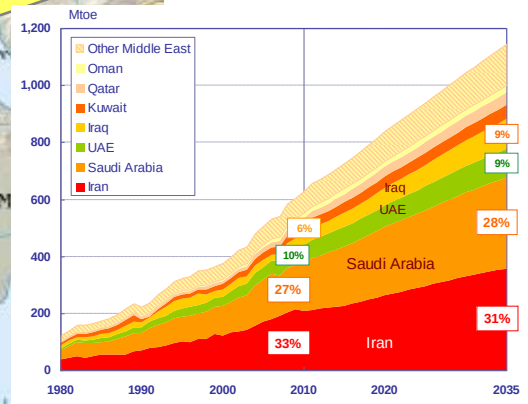
Russian air force downed by Turkey

Increasing domestic energy demand and its repurcussions

Wide spread Arab Spring movements

Tension between Saudi Arabia and Iran

Issues in Syria, Yemen and Egypt



Spread of protests and/or discontent among Arab citizens against US

Insecurity factors surrounding current ME Governments /systems.

Arrest and imprisonment of Royal Families and Cabinet Ministers by KSA Anti Corruption Committee (Nov. 2017)

Potential threats of terrorists' attack on oil facilities

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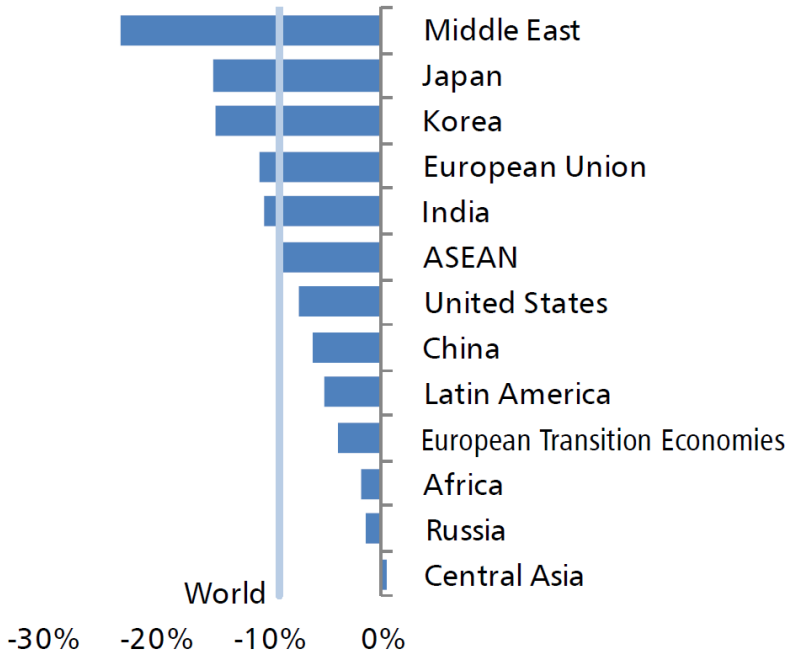
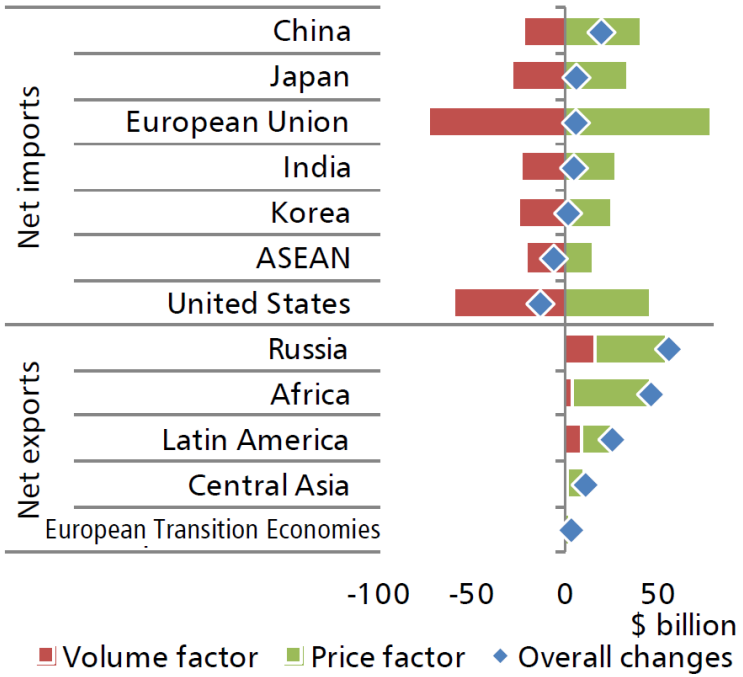
Energy Security

Oil Supply Disruption (10 Mb/d) : Serious Damage to the World Economy

Real GDP



Crude oil net export value



Note: Crude oil exports from the Middle East diminishes by $139 billion.

In the situation where crude oil production in the Middle East drops unexpectedly and by large amount while other countries/regions are unable to increase the production to replace the lost volume, the world economy will shrink by 9%. It hits countries such as Japan and Korea which are dependent on imported oil the most.

Despite the increase in export value, the economy of the non-Middle East exporting regions will not manage to avoid being hit by the depression pressure.

Source: IEEJ, Asia/World Energy Outlook 2016, Oct. 2016

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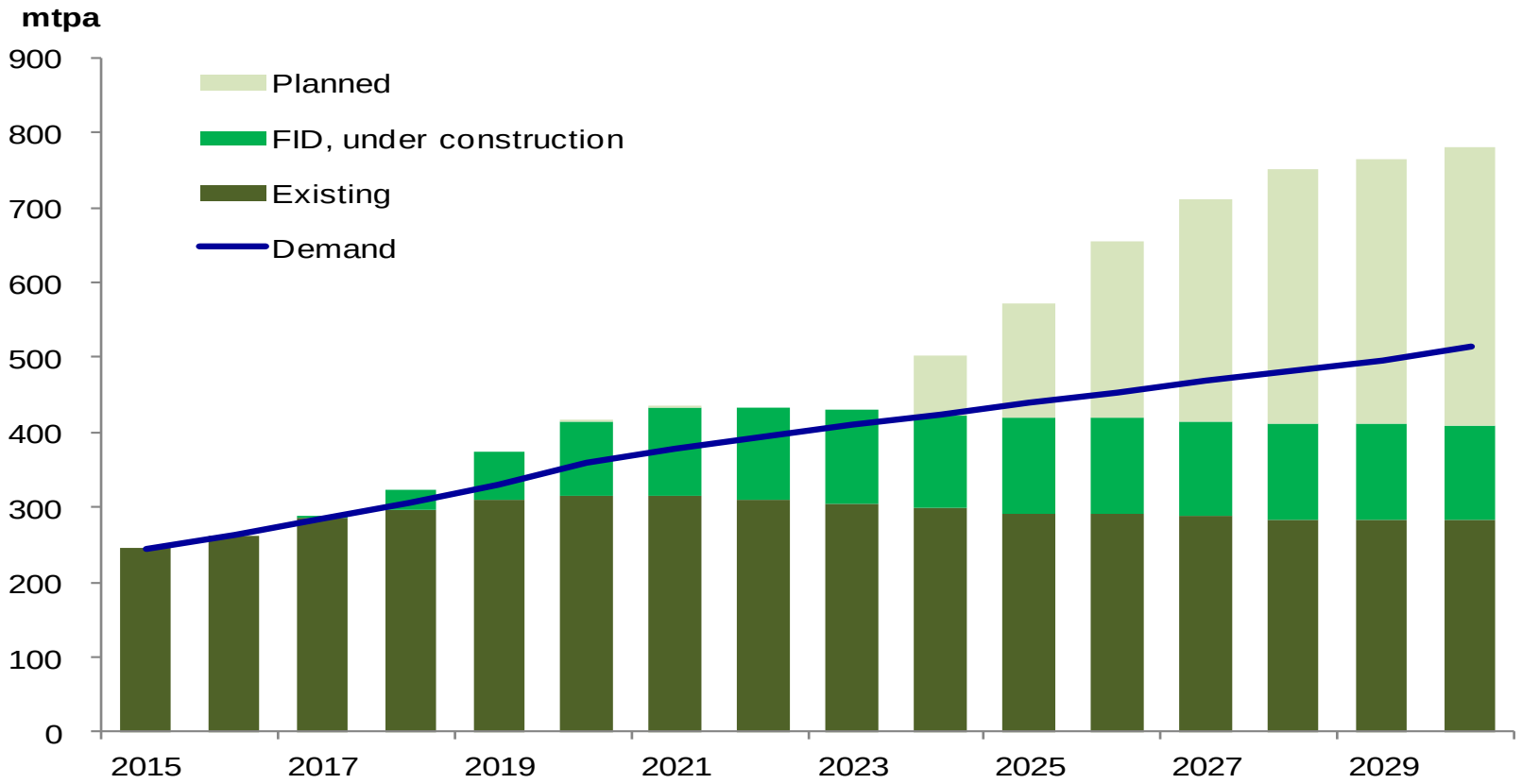
World LNG Supply-Demand Outlook

- Supply surplus is likely to continue in the medium term (~2024).
- Realization of planned capacity in a timely manner is needed to keep the demand and supply balanced beyond the mid-2020s.
- Qatari expansion of its capacity may greatly contribute to maintain the balance.



Source: Yoshikazu Kobayashi, "The Role of Natural Gas in Japan and Asia" (September 11, 2017)

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Paris Agreement : A step towards global action but

❖ Evaluation of Paris Agreement

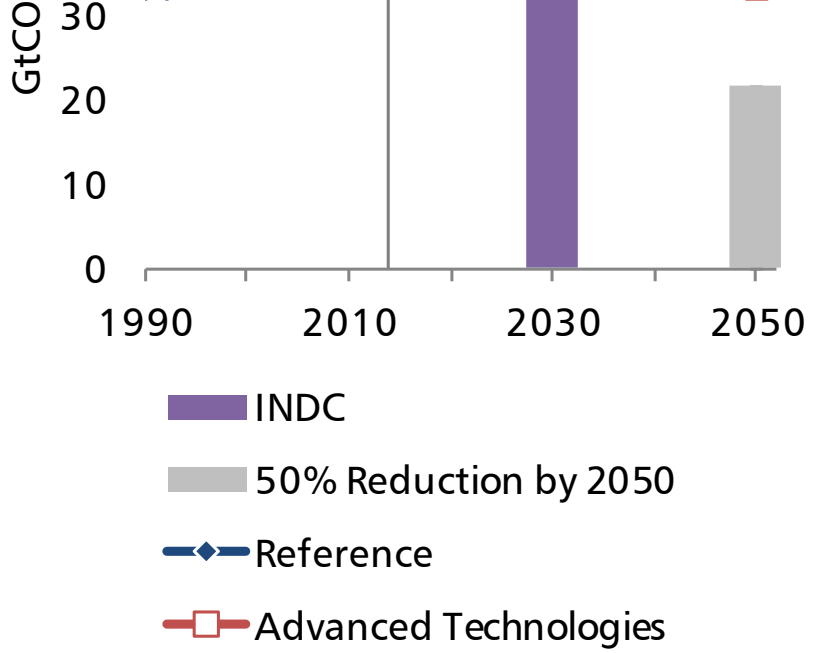
Good!! ☺☺☺

Over 180 countries, including China and India, agreed to take actions using bottom-up approach.

Challenges ☹☹☹

Global GHG emissions will increase from the current level.

❖ GHGs emissions



Source: IEEJ, Asia/ World Energy Outlook 2016

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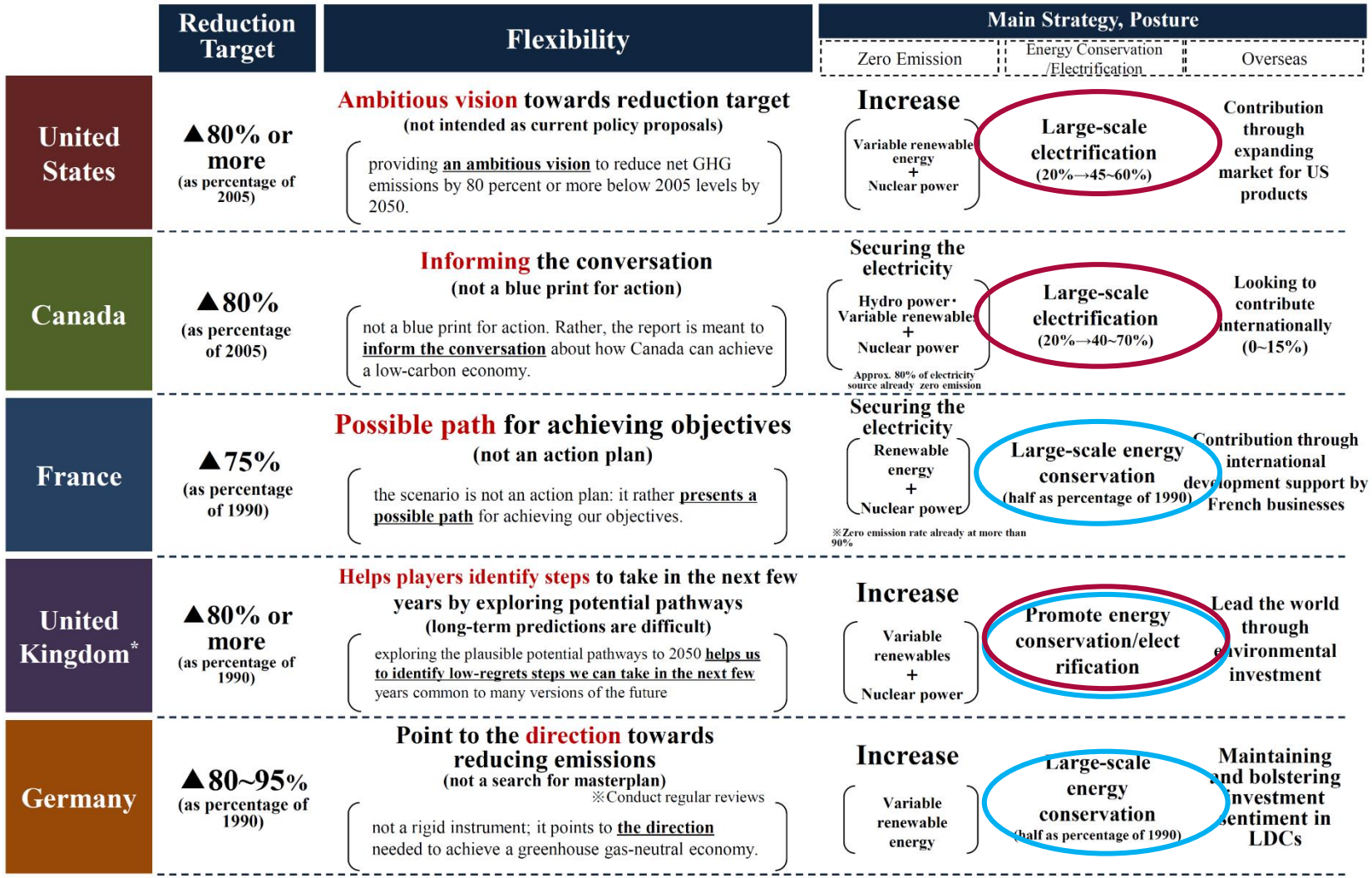
The strategies of major countries for 2050

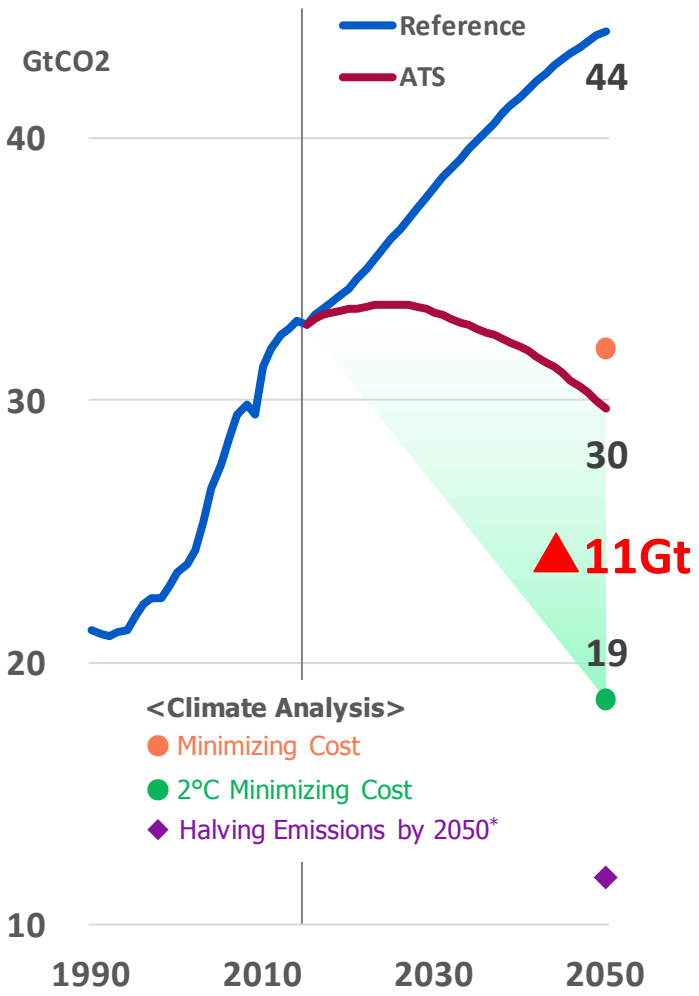


* Not yet submitted to UNFCCC as long-term strategy. Created from *The Clean Growth Strategy* (November 2017).

(Source) Agency for Natural Resources and Energy, METI(Ministry of Economy, Trade and Industry), Document 3 "Global Warming" p. 3 at 6th Round Table for Studying Energy Situations (Feb. 19, 2017)

Further CO_2 reductions from Advanced Technologies Scenario

❖ Energy-related CO_2 emissions



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

❖ Examples of technologies for further reductions

1) CO_2-free hydrogen (refer to Asia/World Energy Outlook 2016)

- **Hydrogen-fired power generation: 1 GW x 3,000 units**
- **Fuel cell vehicles: 1 billion units**

(H_2 demand of 800 Mt/yr corresponds 3 times of today's LNG)

2) Negative-emission technology

- **BECCS (Biomass-fired power generation): 0.5 GW x 2,800 units**

(Fuel supply of 2,000 Mtoe/yr needs land of 2.85 million km^2)

3) Zero-emission power generation and factories with CCS

-10 $GtCO_2$ (Maximum reduction volume by substituting for thermal power generation without CCS)

- **SPS: 1.3 GW x 2,300 units**

or
- **HTGR: 0.275 GW x 8,700 units**

or
- **Nuclear fusion reactor: 0.5 GW x 4,500 units**

or
- **Thermal power generation with CCS: 2,800 GW**

(Estimated CO_2 storage potential is over 7,000 Gt)

＋

-1 $GtCO_2$

- **CCS: Installed in 20% of factories and plants**

(iron & steel, cement, chemicals, pulp & paper, refinery and GTL/CTL)

Source: IEEJ Outlook 2019 (October 2018)

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Impact of banning construction of new coal-fired power plants

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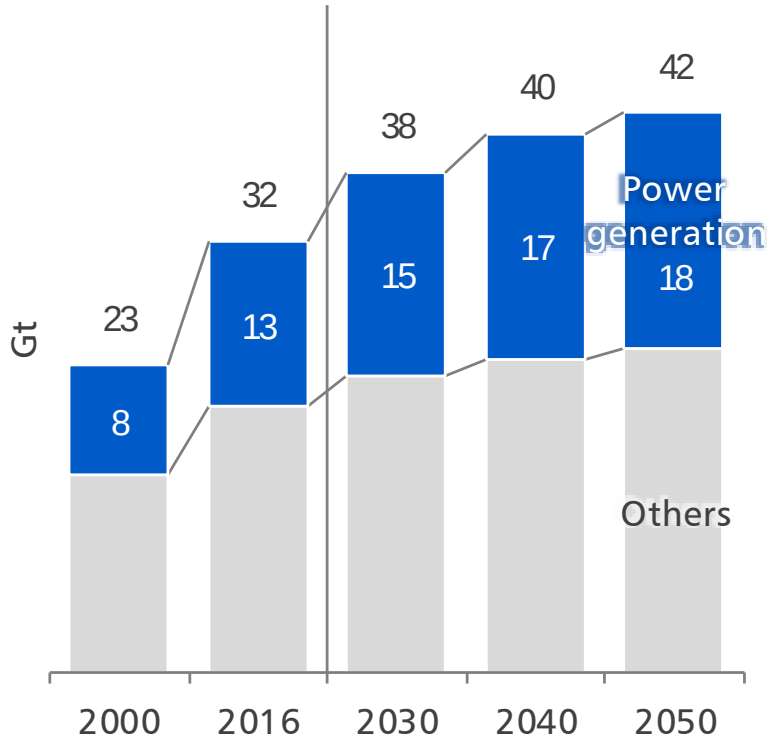
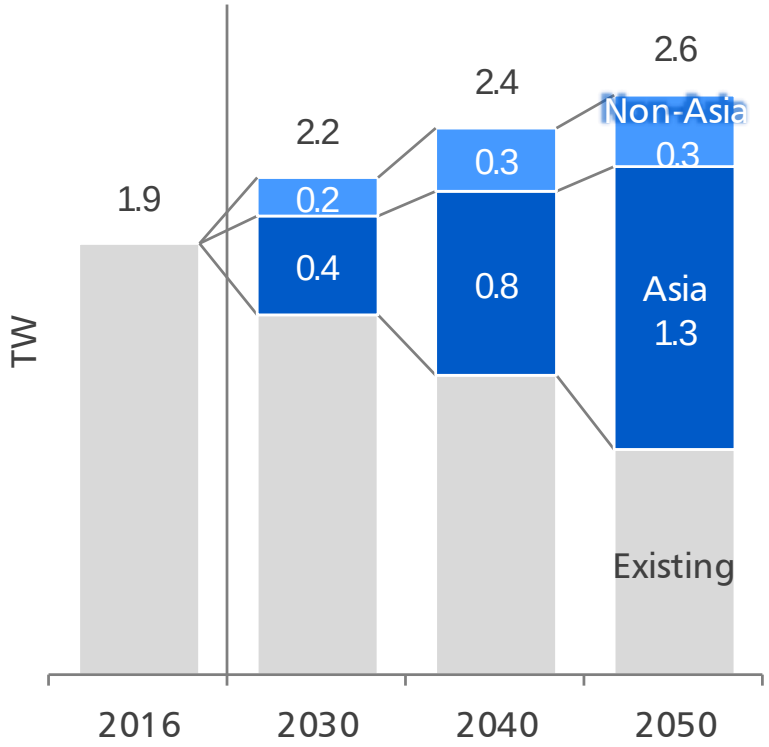
Decarbonisation in power sector is required

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



❖ **New coal-fired power plant capacity** [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.

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?

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No New Coal-fired Power Plant Case
—— a hypothetical option in the future

There are a lot of problems to be worked on to accomplish the shift from coal.

However, such problems in the real world are set aside in this case study.

No New Coal-fired Power Plant Case

A hypothetical case in which all new coal-fired power plant construction would be banned after 2020.

Two patterns with different substitution options (natural gas; solar PV / wind) for coal-fired power generation are prepared:

No New Coal-fired Power Plant (Natural Gas Substitution) Case

No New Coal-fired Power Plant (Renewables Substitution) Case

Judging from base-load function of coal-fired power generation, nuclear can be supposed as one of the substitution options. However, world-wide nuclear penetration requires challenges on technology transfer, matured regulation, and non-proliferation, which are difficult to overcome in short period. In addition, today's coal phase-out opinions rarely suppose the substitution of nuclear. Therefore, just two patterns (natural gas and renewables) are prepared in this case study.

Discuss effects of banning the construction of new coal-fired power plants, in terms of energy supply-demand balances and economics.

⚠

No New Coal-fired Power Plant Case does not indicate prospect or feasibility of the coal-fired power plant ban.

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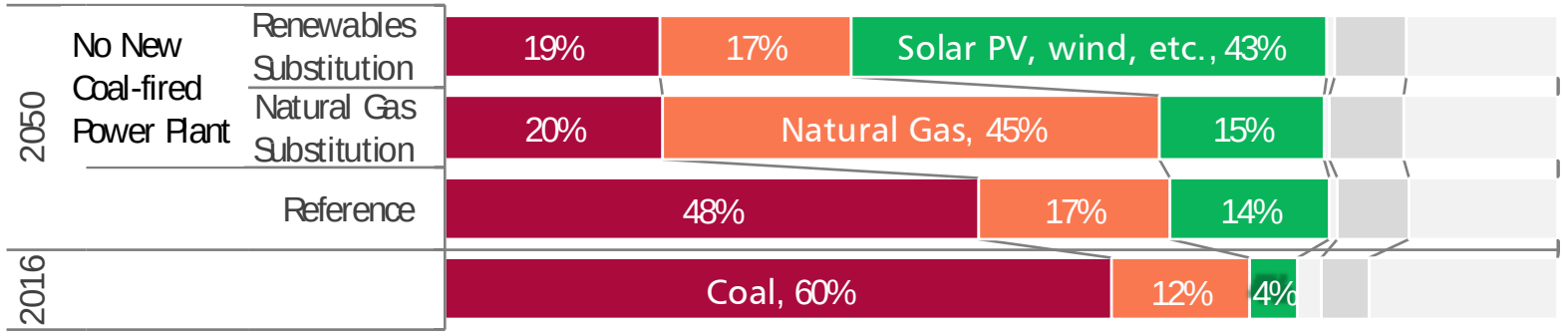
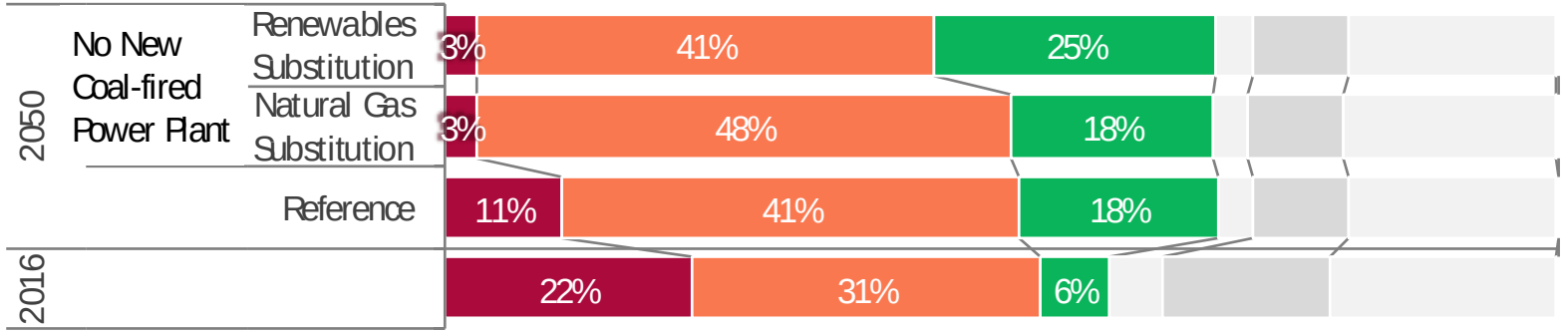
Drastic transition of power generation mix! Especially in Asia!!

❖ Power generation mix

Asia



Non-Asia



Since Asia largely depends on coal-fired power generation, abolishment of coal-fired power plant construction means drastic transition of power generation mix.

On the other hand, transition is relatively limited in non-Asia. Even if solar PV and wind substitute for coal-fired power generation, natural gas remains the largest share.

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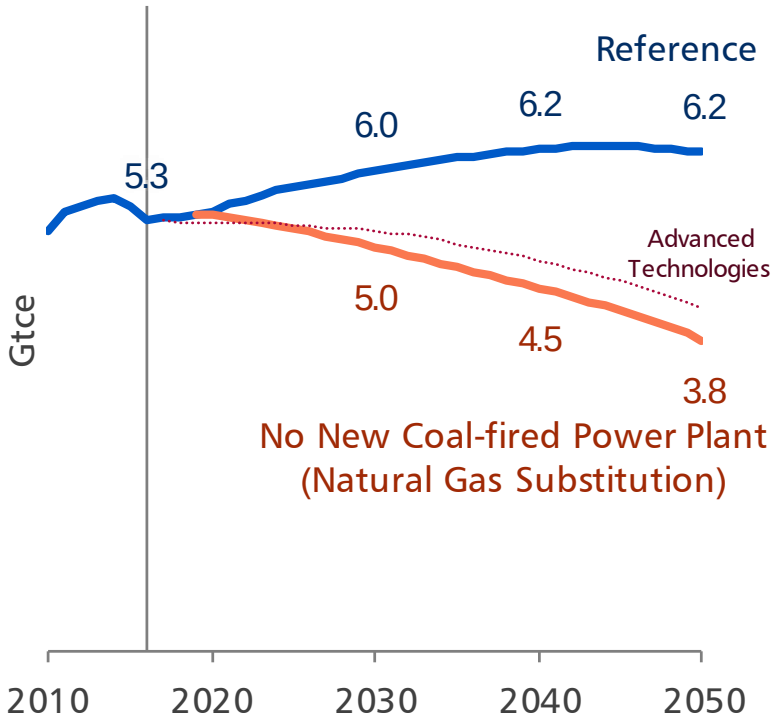
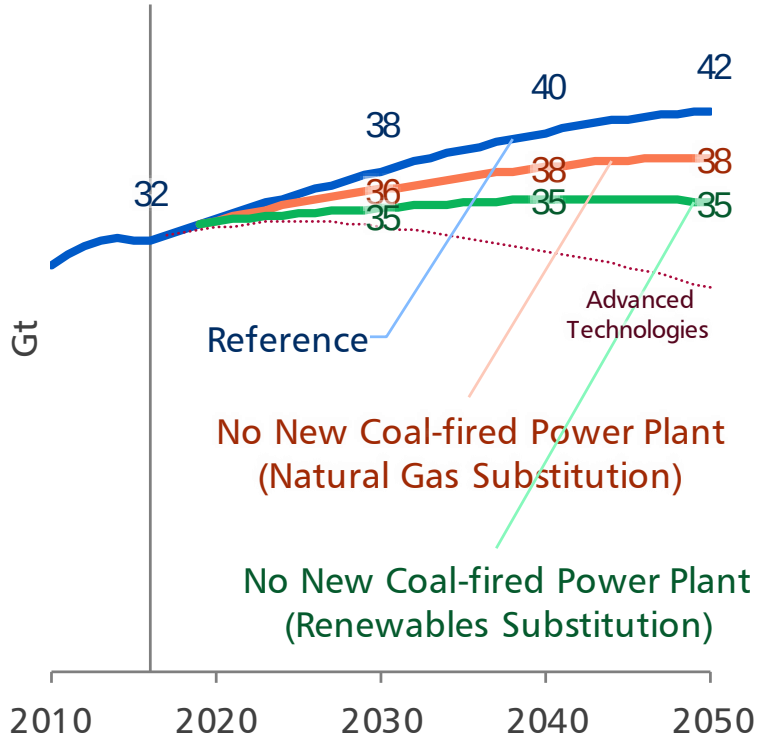
Pros of ban on new coal-fired power plant construction

❖ 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.

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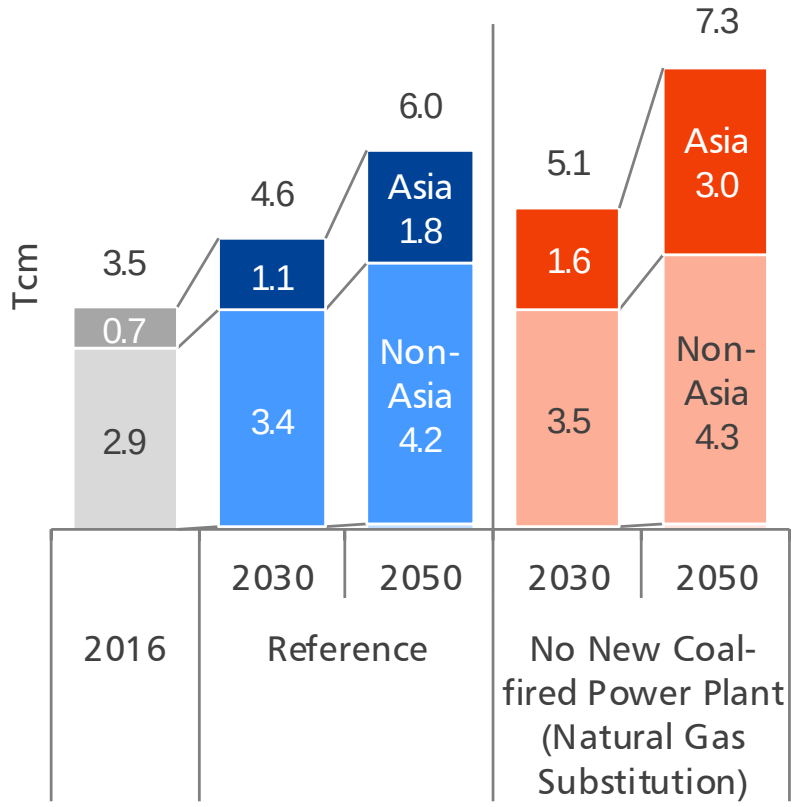
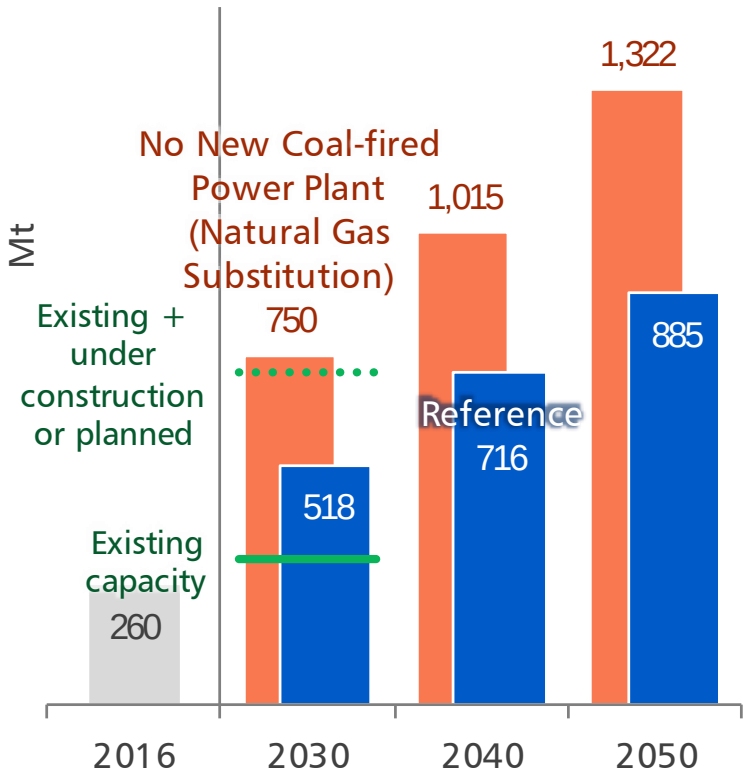
Substitution of natural gas requires dramatic expansion of supply

❖ 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.

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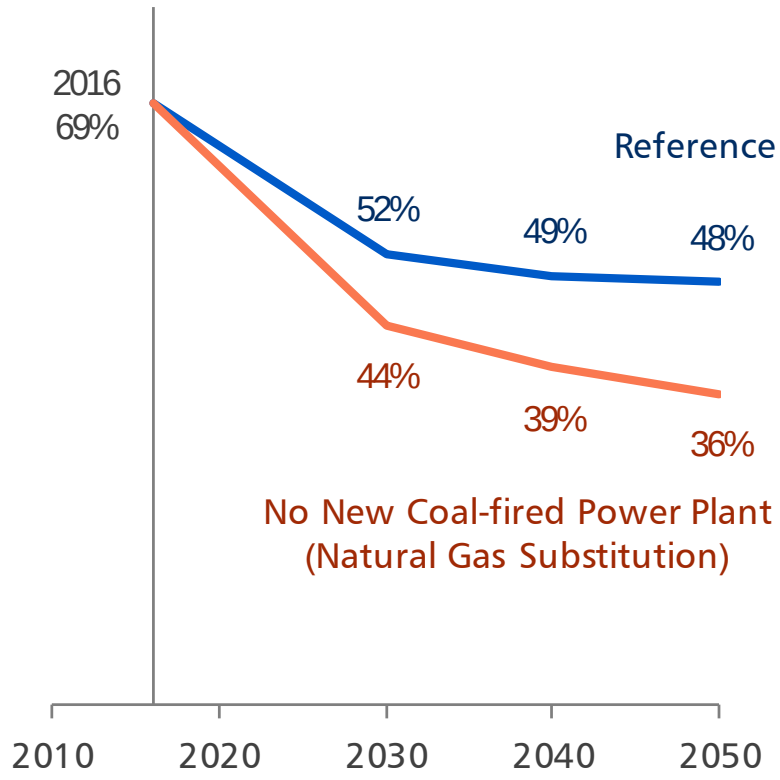
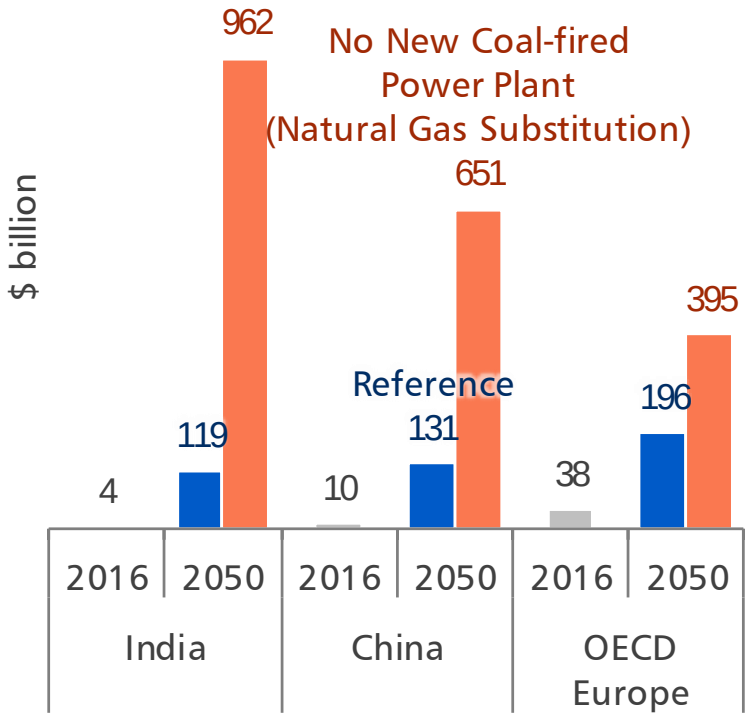
Challenges are not only the supply chains…

❖ 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.

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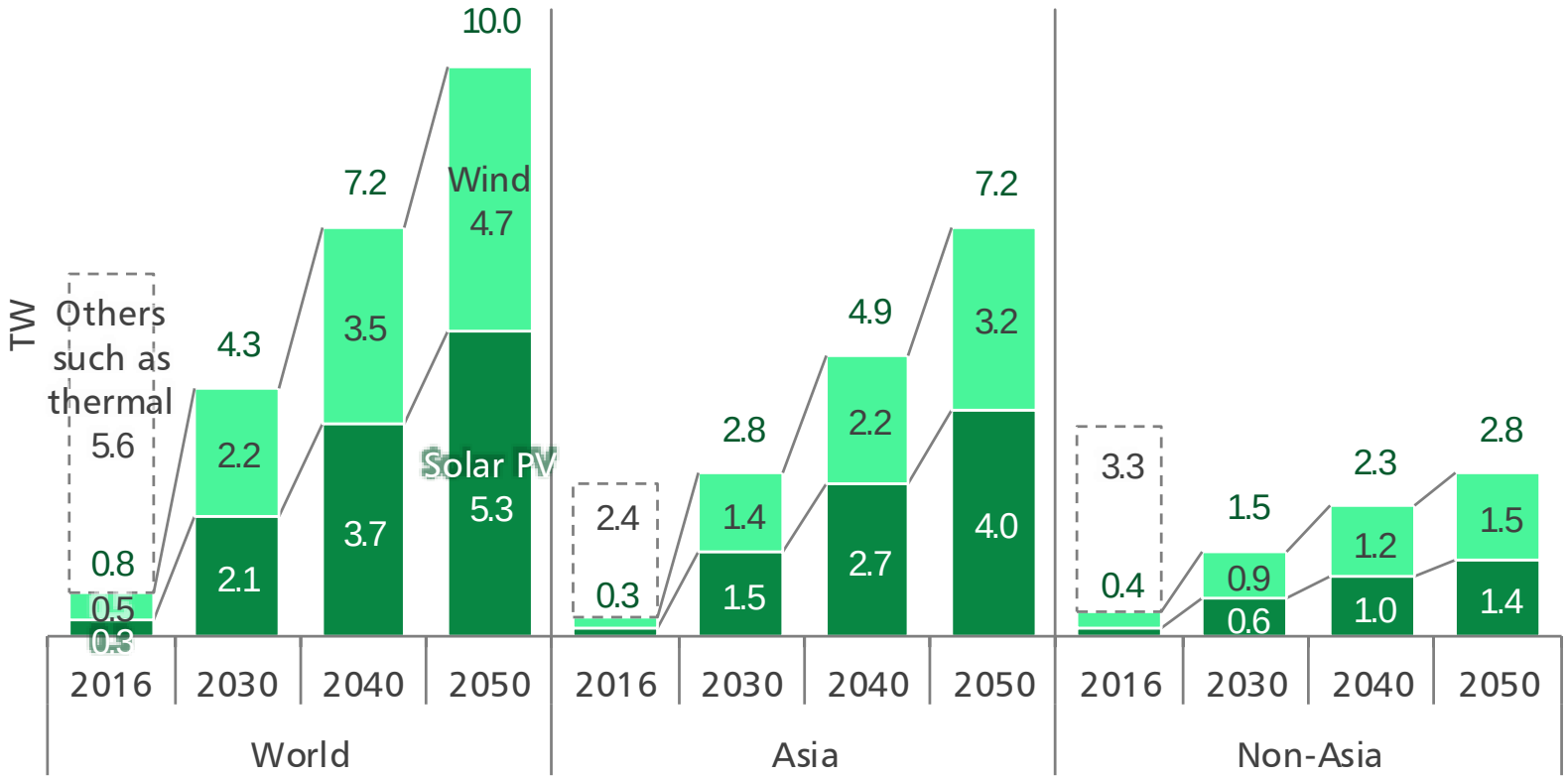
Substitution of solar PV / wind requires unprecedented capacity expansion

❖ **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.

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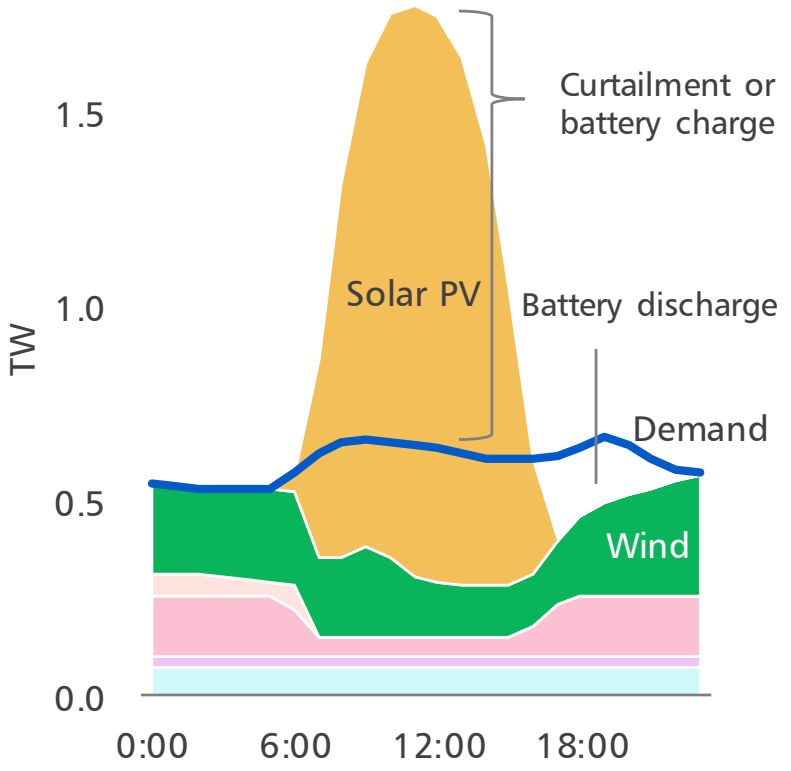
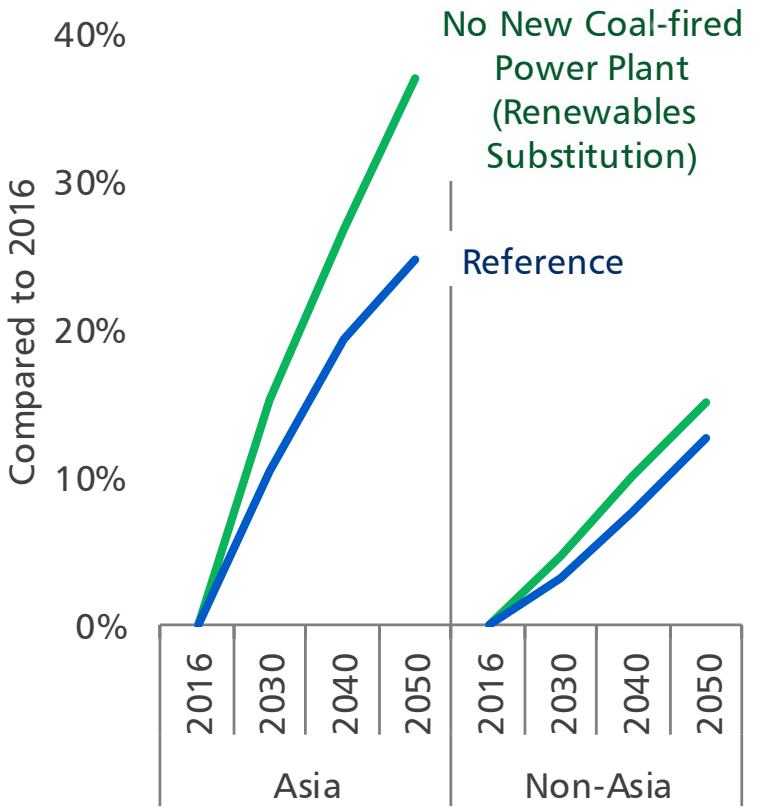
Keep an eye on electricity security

❖ Electricity balance in India «indicative»

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



❖ Electricity cost «indicative»



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.

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

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

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Victoria concordia crescit
(Victory comes from harmony)

An entire ban on construction of coal-fired power plants

☺
3 Gt～7 Gt of
CO_2 reduction

☹
Drastic increase of alternative energy demand

Energy security challenges such as natural gas / electricity stable supply, economics, etc.

!

The country should promote to abolish coal-fired power generation that can do so.

If difficult, or with better CO_2 reduction measures, they should assess their priorities, making effort quickly to replace low-efficiency coal-fired power plants with high-efficiency ones and reduce dependency on coal-fired power generation.

Always keep in mind……

Are you prepared to support for the drastic energy transition in developing Asia?

Think it over.

Shift from coal-fired power generation is only one means, and that the end is to address climate change.

On a larger scale,

Climate change is one of humanity's great challenges, but not the only one.

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