12th IEEJ/CNPC Seminar

IEEJ Outlook 2019

Energy transition and a thorny path for 3E challenges

Energy, Environment and Economy

Singapore, 1 November 2018

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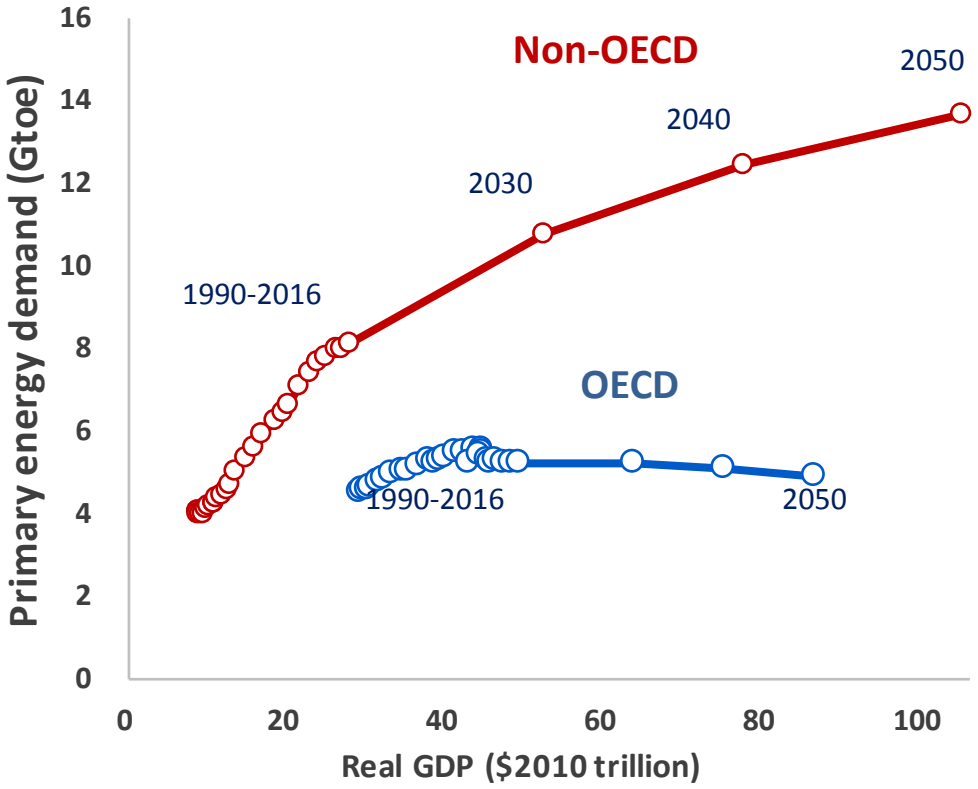
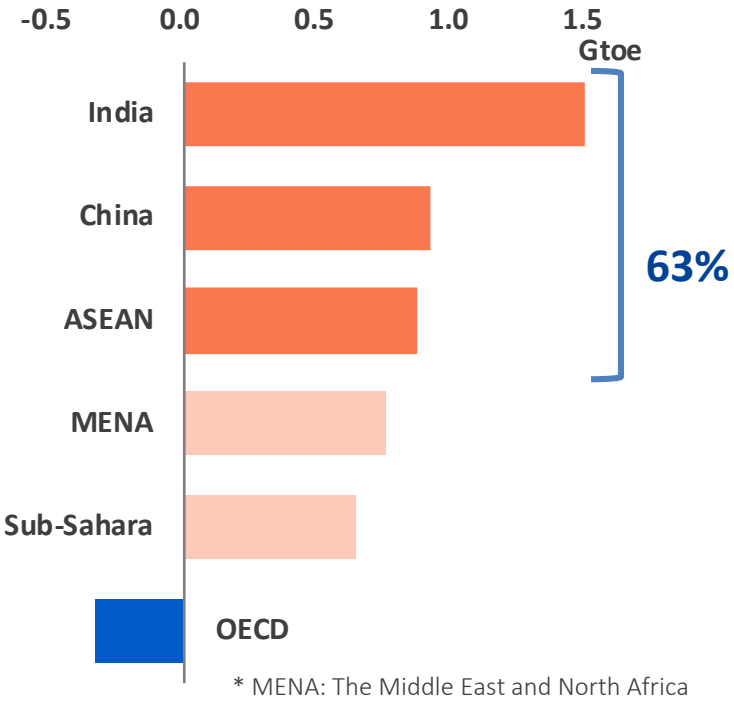
Energy supply / demand and climate change up to 2050

Dramatic growth of energy demand in Asia

Primary energy demand vs. real GDP



Change in energy demand (2016-2050)

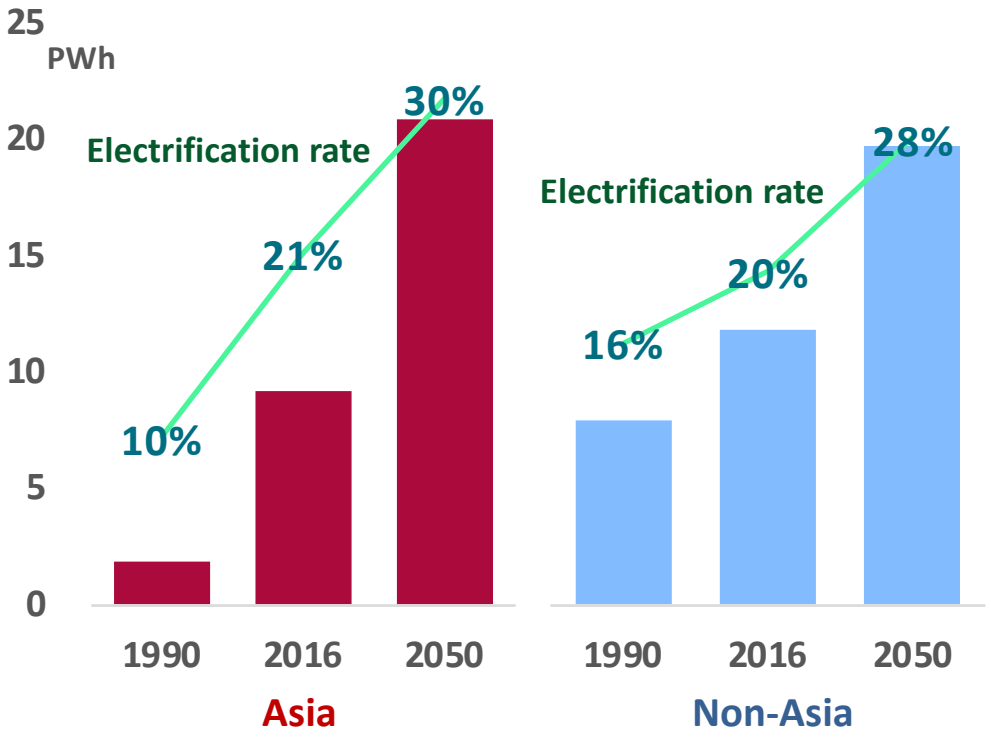


* MENA: The Middle East and North Africa

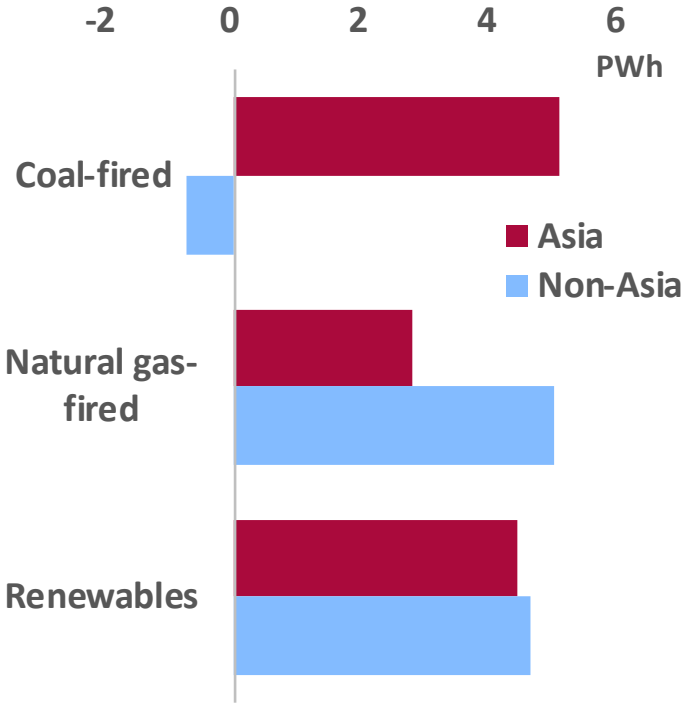
- The global primary energy demand will increase by 1.4 times in 2050.
- The net increase in energy demand can be entirely attributable to non-OECD.
- In OECD, decoupling between growth of the GDP and energy consumption proceeds.
- 63% of the increment come from China, India and the ASEAN countries.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

Growth of dependence to electricity

Electricity demand and electrification rate



Change in electricity generation (2016-2050)

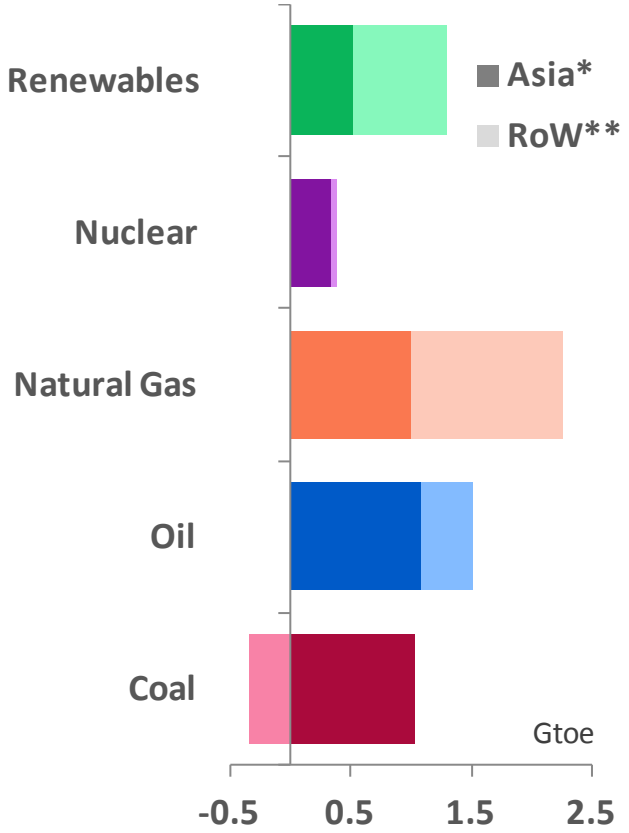


* Electrification rate: Share of electricity in the final energy consumption

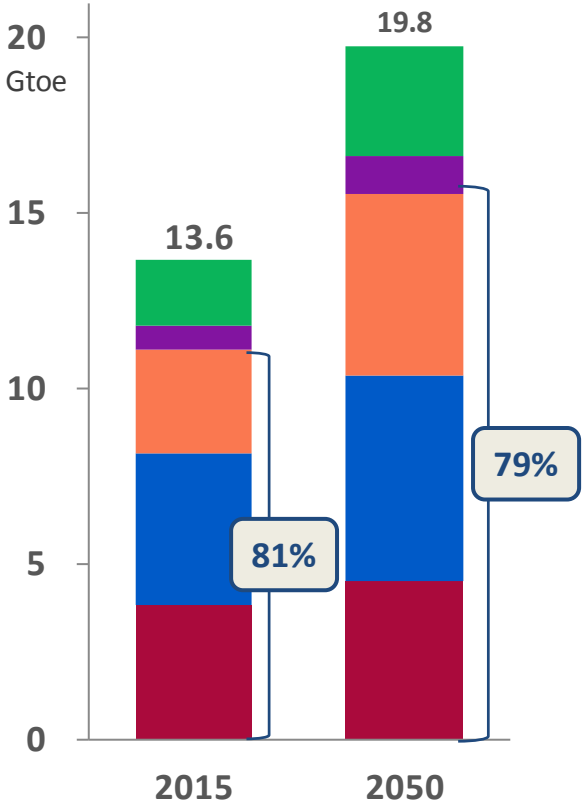
- 60% of the increment in the primary energy demand will be consumed for power generation.
- The global electricity demand will double in 2050, and 60% of the increment will occur in Asia.
- In Asia, electrification rate will increase to 30% in 2050, and 40% of electricity demand will be covered by coal,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

High dependence on fossil fuels continues

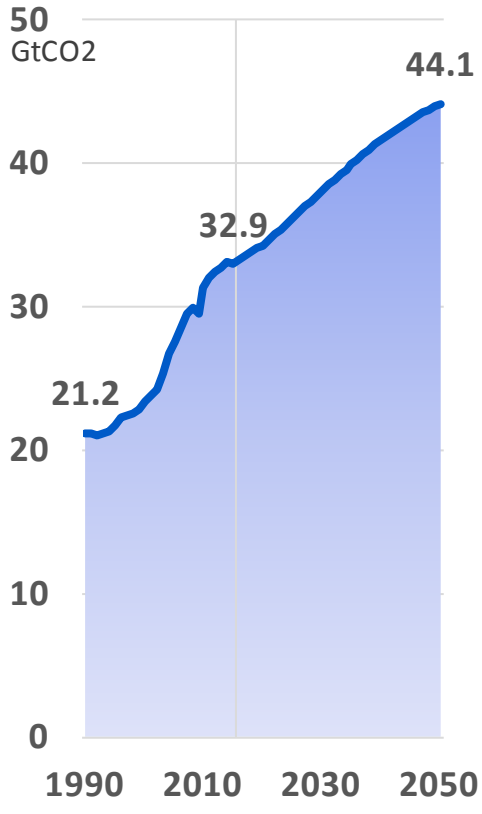
❖ Growth in Primary Energy



❖ Energy Mix



❖ Energy-related CO_2

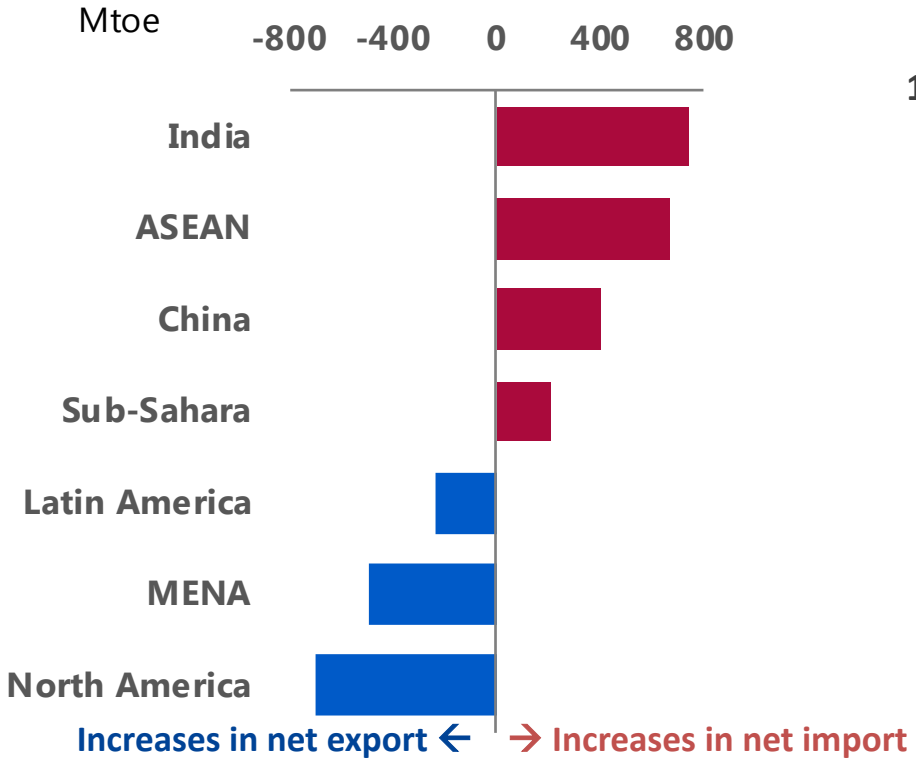


* Non-OECD Asia, **Rest of the world

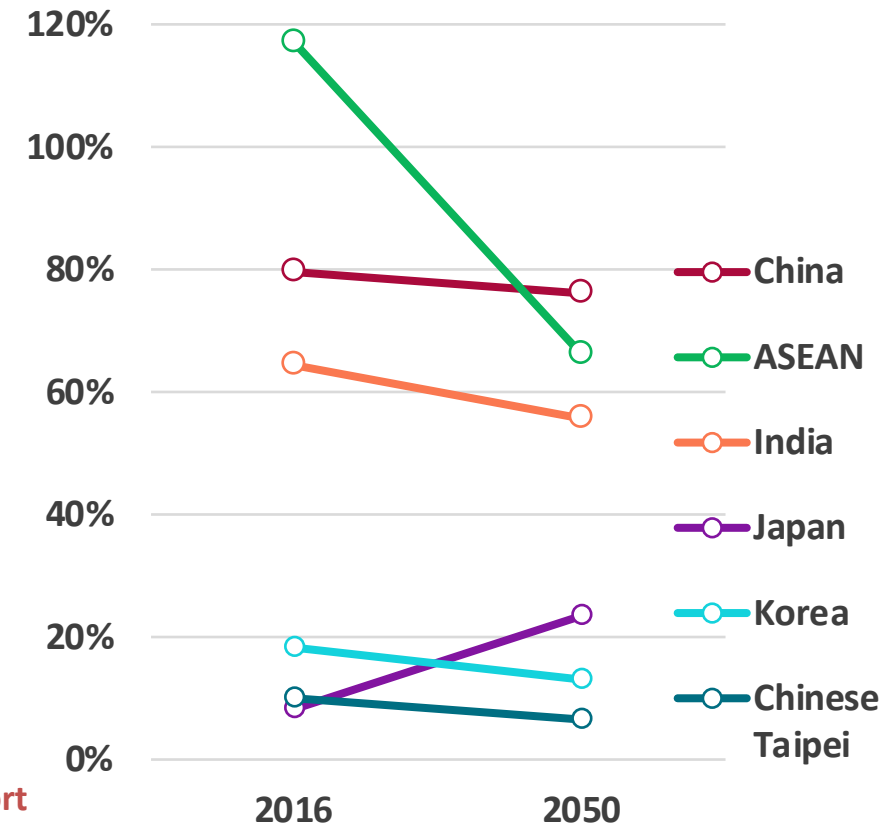
Sixty percent of the growth in electricity demand will be met by thermal power generation, especially natural gas. Asia leads the large global increase in fossil fuels required for power generation as well as for transportation. The high dependence on fossil fuels remains unchanged and energy related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

Increase of energy imports in Asia

Increase of net import energy (2016-2050)



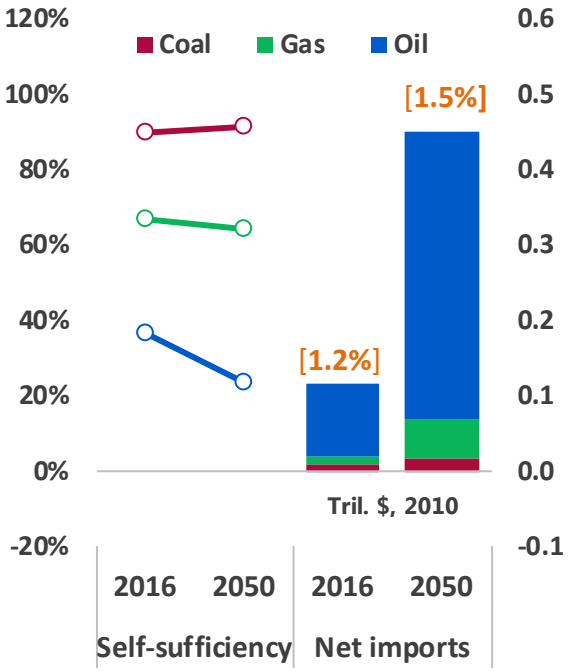
Self-sufficiency rate



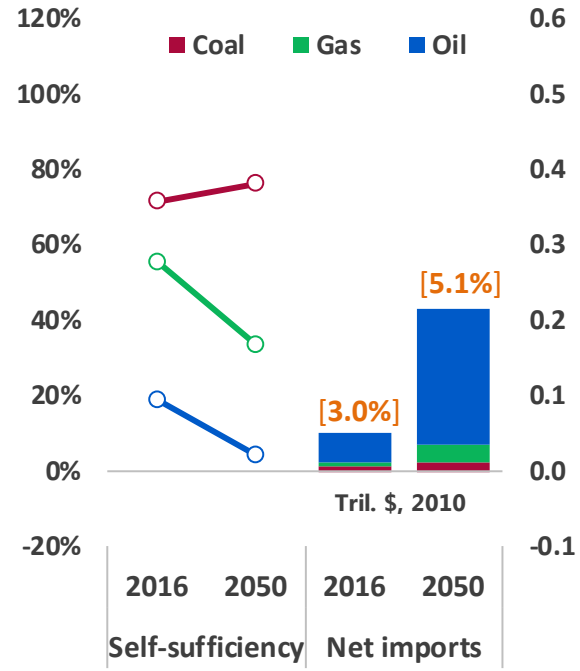
- Energy imports of Asia will increase dramatically.
- 80% of energy traded globally will be consumed in Asia.
- United States will be a net exporter in the middle of the 2020s.
- Self-sufficiency rate in Asia will decrease from 72% to 63%. This tendency is remarkable for ASEAN, which will be a net importer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

Increase of oil import spending in Asia

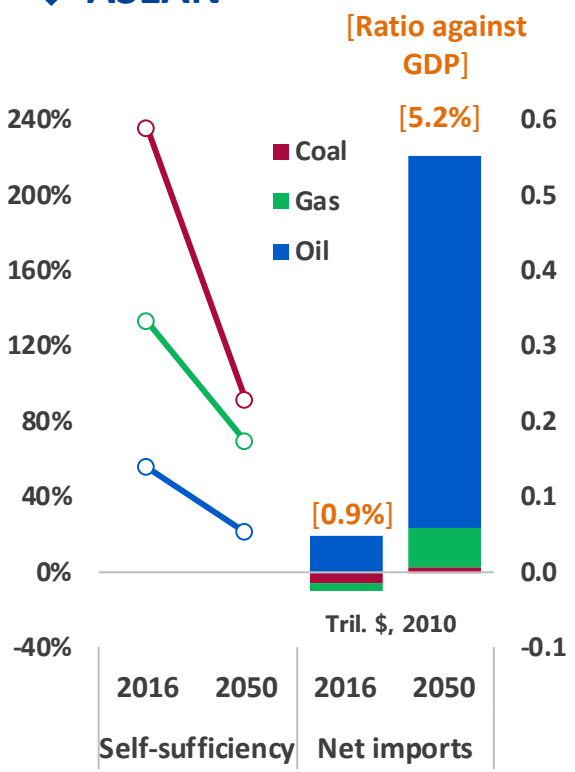
China



India



ASEAN



In Asia…

- Self-sufficiency rate of oil will decrease from 28% to 14%, due to increase of consumption for transportation. Self-sufficiency rate of natural gas will also decrease remarkably.
- Self-sufficiency rate of coal will be maintained at a level of 80%.
- The amount of oil import will increase remarkably, and the total amount of energy import will grow from 1.6% to 3.0% against the GDP (from 0.9% to 5.2% in the ASEAN).

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

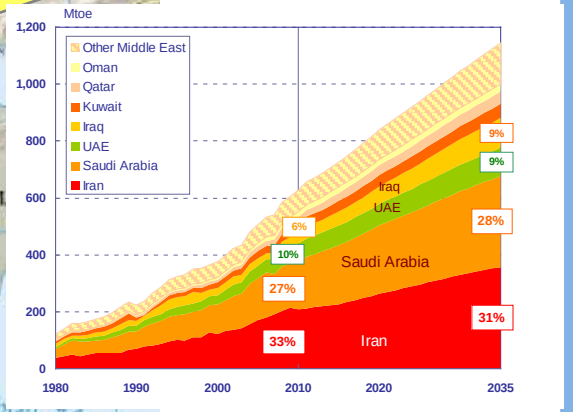
Russian air force downed by Turkey

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

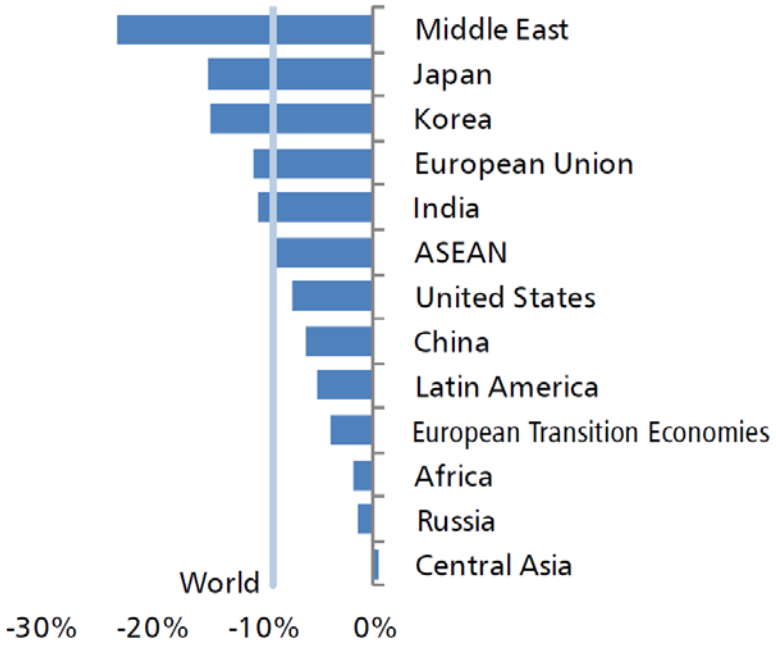
Causes of oil supply disruptions

- Oil supply disruptions have been at the heart of the traditional energy security debate.
- Various supply disruptions have occurred at each stage of production, transport, and domestic supply due to accidents, failures, natural disasters, or structural factors affecting society and the economy as a whole. And the risks remain present.

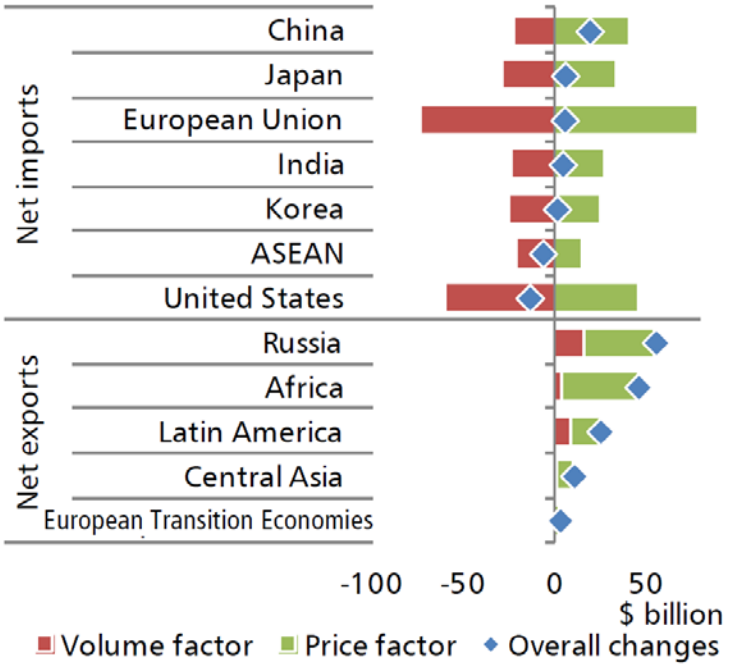
	Risks	Examples
Production	• Destruction or shutdown of production facilities due to unanticipated events such as accidents, failures or natural disasters • Destruction of production facilities and suspension of operations due to political upheavals and terrorism • Halting exports by political will or strategy	1973: OAPEC countries imposed an embargo on exports to the United States and the Netherlands. 2005: Hurricanes shut down oil production facilities in the U.S. Gulf Coast 2018: Exports of crude oil from Libya were partially reduced because of suspension of production and the blockade of ports due to internal strife.
Transportation	• Destruction or shutdown of facilities due to unanticipated events such as accidents, failures or natural disasters • Destruction or suspension of transportation (ships, pipelines, etc.) by terrorism or piracy • Interruption of transport routes by political will, strategy and military action	1984 - 1988: The “tanker war” by Iran and Iraq 2011: Destruction of gas pipelines from Egypt to Israel by terrorist attacks 2018: Attacks on crude oil tankers by Yemeni militants
Domestic Supply	• Destruction or shutdown of supply facilities due to unpredictable events such as accidents, failures or natural disasters • Destruction of supply facilities and suspension of operations due to terrorism	2011: Oil supply suspension due to the damage of oil refineries and oil depots and the destruction of ports, railways and roads caused by the Great East Japan Earthquake

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.

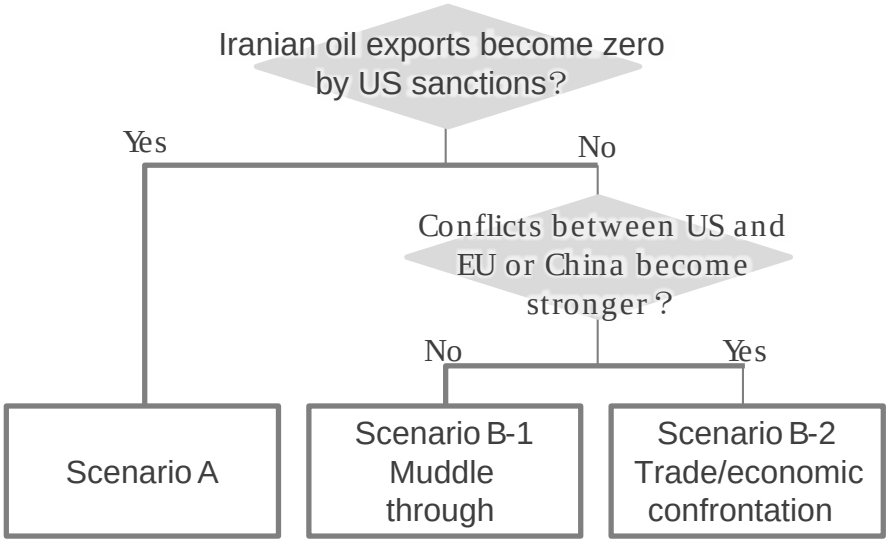
In the situation where crude oil production in the Middle East drops unexpectedly and by large amount while other countries/regions are unable to increase the production to replace the lost volume, the world economy will shrink by 9%. It hits countries such as Japan and Korea which are dependent on imported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

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

New threat for power supply

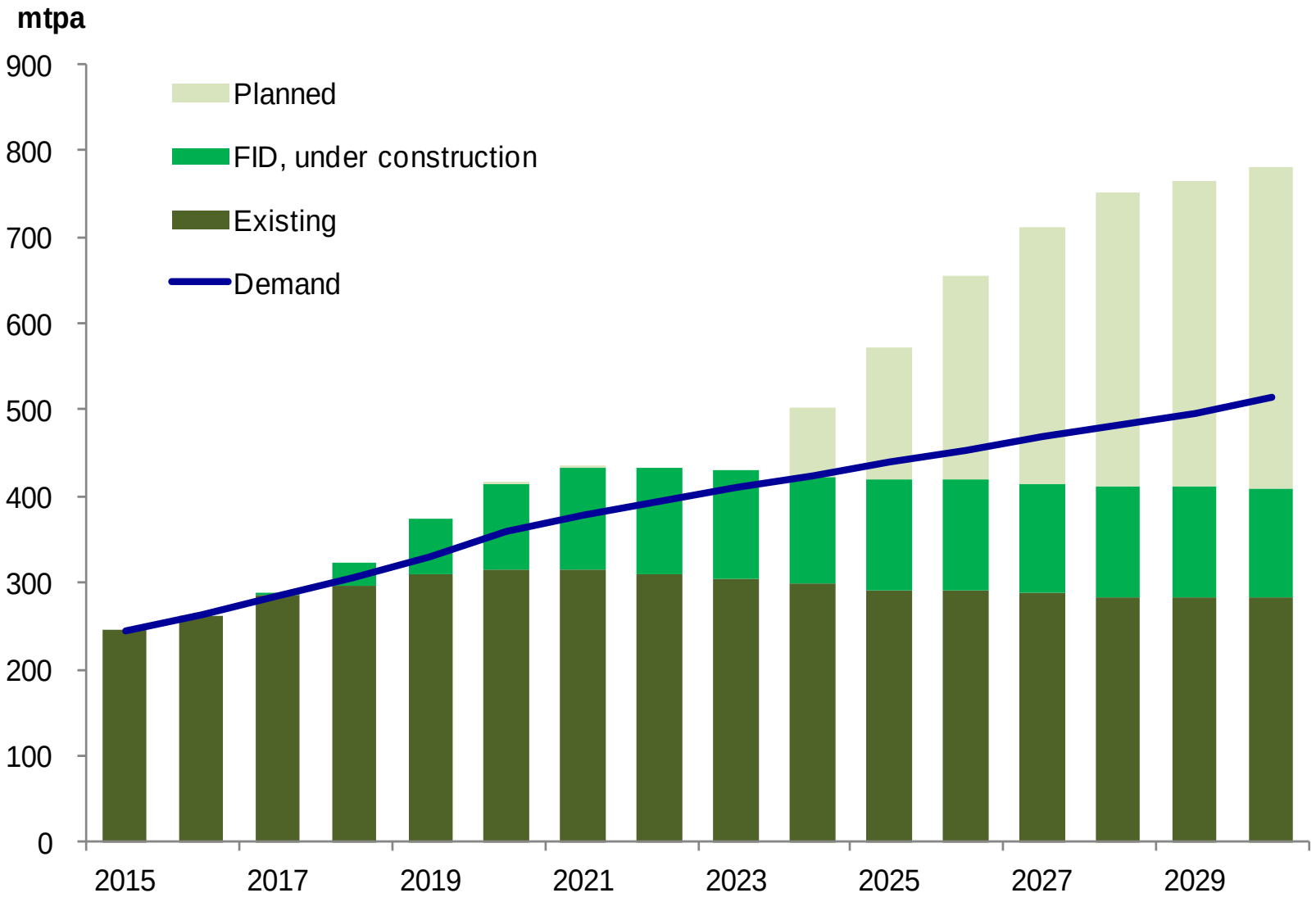
Structural risk

- **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.

World LNG Supply-Demand Outlook

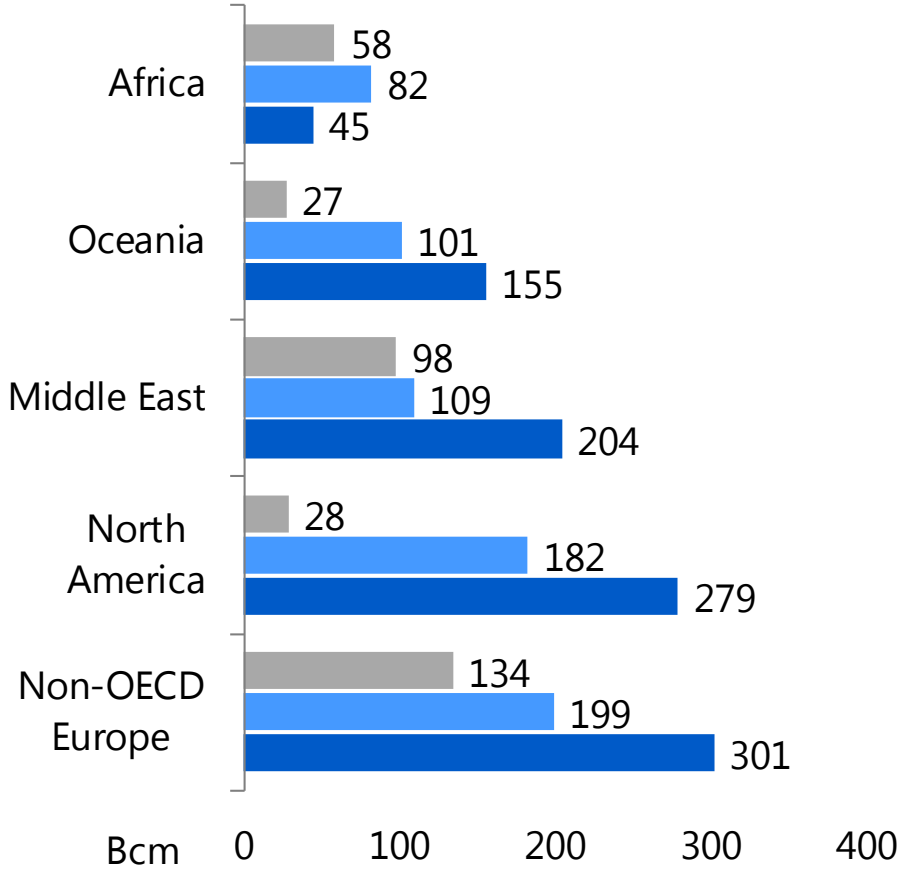


Source: Yoshikazu Kobayashi, “The Role of Natural Gas in Japan and Asia” (September 11, 2017)

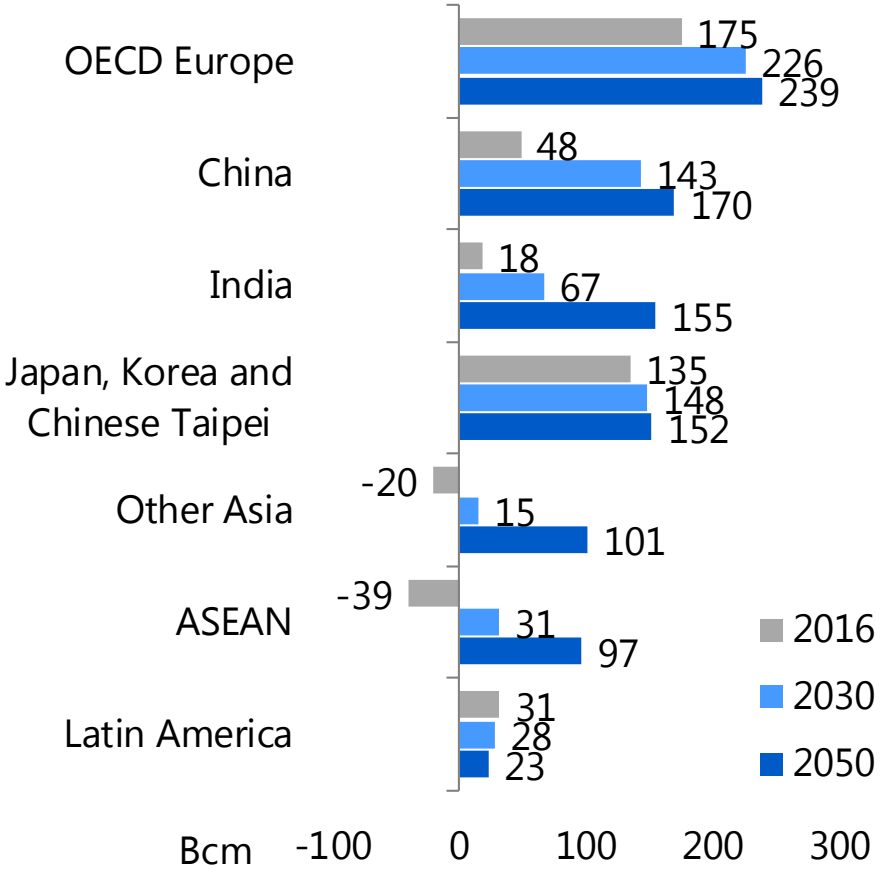
Natural gas net exports / imports

Reference Scenario

Net exports (2050)

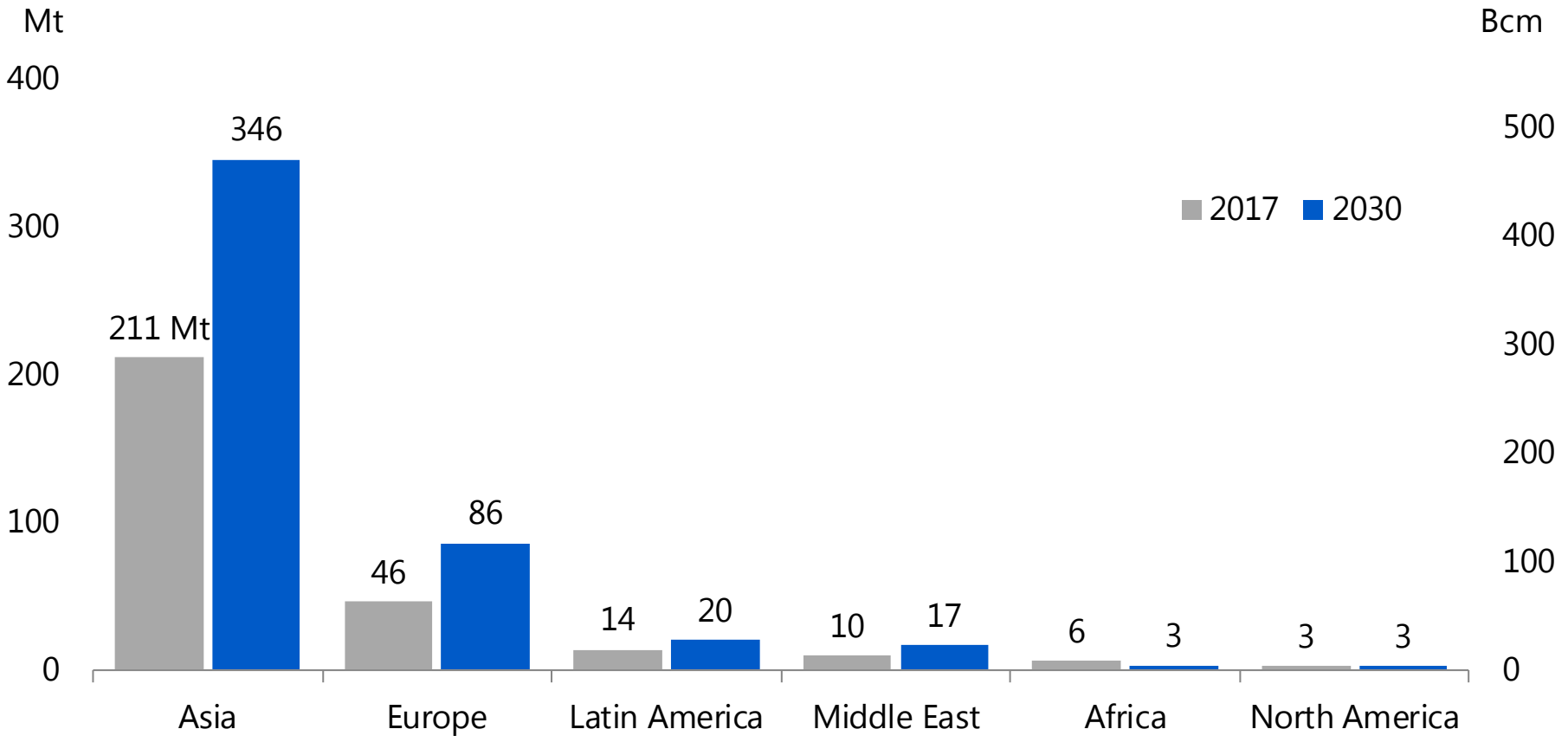


Net imports(2050)



LNG imports

Reference Scenario



Paris Agreement : A step towards global action but…

❖ Evaluation of Paris Agreement

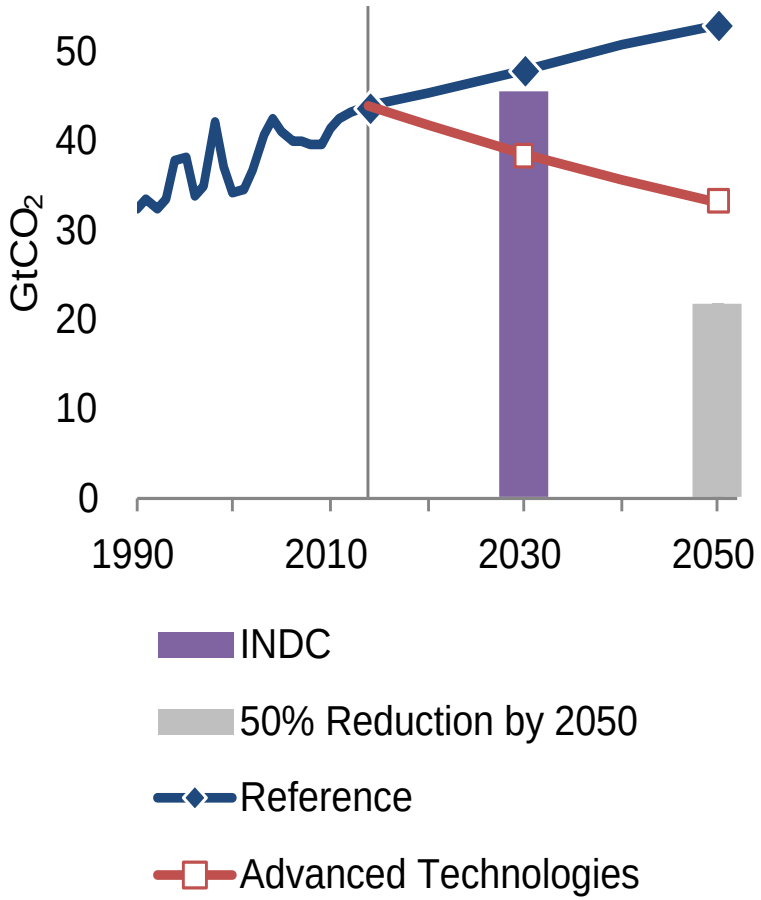
Good!! ☺☺☺

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

The strategies of major countries for 2050

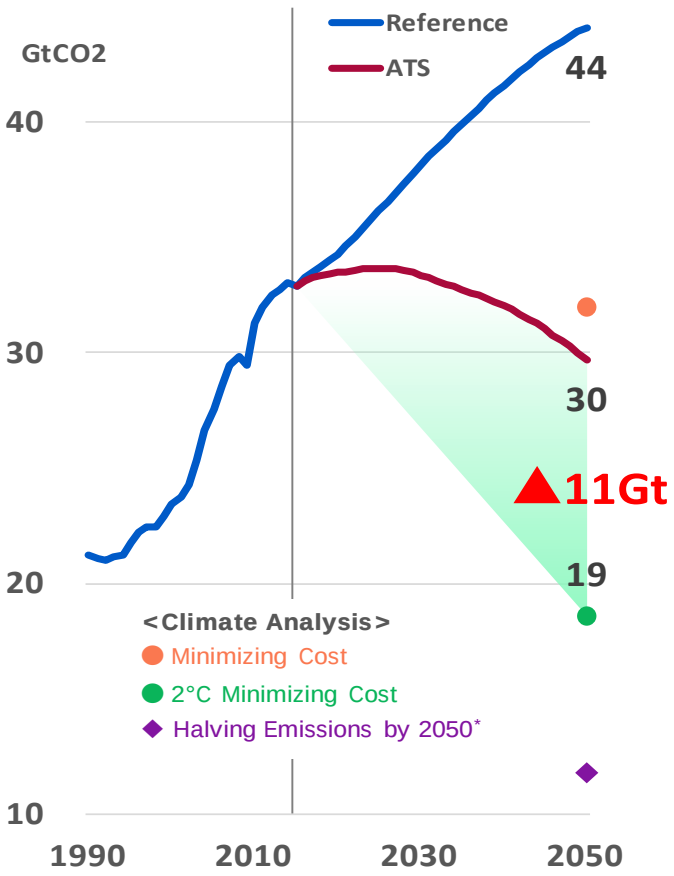
	Reduction Target	Flexibility	Main Strategy, Posture: Zero Emission	Main Strategy, Posture: Energy Conservation /Electrification	Main Strategy, Posture: Overseas
United States	▲80% or more (as percentage of 2005)	**Ambitious vision towards reduction target** (not intended as current policy proposals) providing **an ambitious vision** to reduce net GHG emissions by 80 percent or more below 2005 levels by 2050.	**Increase** Variable renewable energy + Nuclear power	Large-scale electrification (20%→45~60%)	Contribution through expanding market for US products
Canada	▲80% (as percentage of 2005)	**Informing the conversation** (not a blue print for action) not a blue print for action. Rather, the report is meant to **inform the conversation** about how Canada can achieve a low-carbon economy.	**Securing the electricity** Hydro power・Variable renewables + Nuclear power Approx. 80% of electricity source already zero emission	Large-scale electrification (20%→40~70%)	Looking to contribute internationally (0~15%)
France	▲75% (as percentage of 1990)	**Possible path for achieving objectives** (not an action plan) the scenario is not an action plan: it rather **presents a possible path** for achieving our objectives.	**Securing the electricity** Renewable energy + Nuclear power ※Zero emission rate already at more than 90%	Large-scale energy conservation (half as percentage of 1990)	Contribution through international development support by French businesses
United Kingdom*	▲80% or more (as percentage of 1990)	**Helps players identify steps to take in the next few years by exploring potential pathways** (long-term predictions are difficult) exploring the plausible potential pathways to 2050 **helps us to identify low-regrets steps we can take in the next few** years common to many versions of the future	**Increase** Variable renewables + Nuclear power	Promote energy conservation/electrification	Lead the world through environmental investment
Germany	▲80~95% (as percentage of 1990)	**Point to the direction towards reducing emissions** (not a search for masterplan) ※Conduct regular reviews not a rigid instrument; it points to **the direction** needed to achieve a greenhouse gas-neutral economy.	**Increase** Variable renewable energy	Large-scale energy conservation (half as percentage of 1990)	Maintaining and bolstering investment sentiment in LDCs

* 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 ❖ 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: 1.3GW 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)

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

Source: IEEJ Outlook 2019 (October 2018)

Hydrogen: Key Technology for Energy Transition

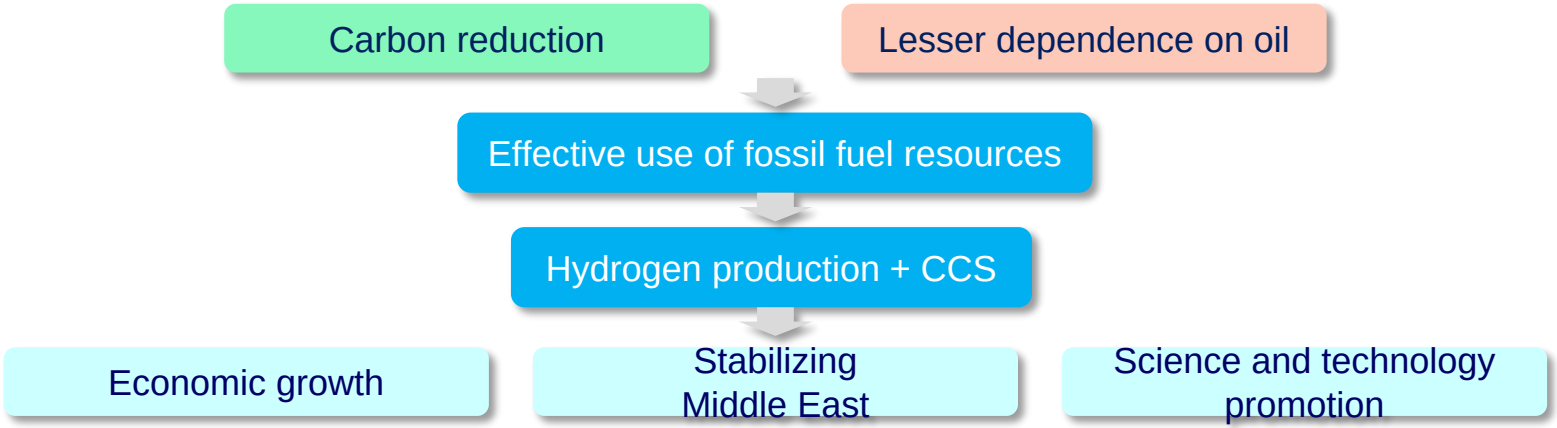
Potential of Hydrogen

Molecules to electrons

- Energy transition includes shifting away from fossil fuels to electricity.
- High hopes are placed on hydrogen as a carrier of zero-carbon energy.
- Hydrogen can be produced from renewable energy, fossil fuels, and nuclear.

Important Role of Hydrogen

- Number one priority is addressing Climate Change
- Potential benefits :
  - to stabilize fossil fuel rich economies in Post-Oil-Age
  - to connect energy importing Asian countries with energy exporters in the zero-emission world
  - to store surplus renewable electricity

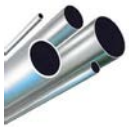


Source: IEEJ

Examples of Potential Hydrogen Users: Demand Creation is Required

Industrial Use

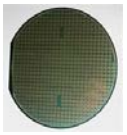
- Large-scale use
  15 billion Nm^3/y for oil refining, petrochemicals, ammonia, etc. in Japan
- Small-scale use
  300 million Nm^3/y in Japan at present



Stainless steel bright annealing

Glass

Hydrogenated fat, margarine



Semiconductor

Energy Use

- FCV, hydrogen station

800,000 units @2030
: 800 million Nm^3

- Hydrogen burning power generation

1GW=2-3 billion Nm^3

- Industry sector

For steelmaking (hydrogen reduction steelmaking), boilers, burners, etc. in future

- Natural gas pipeline

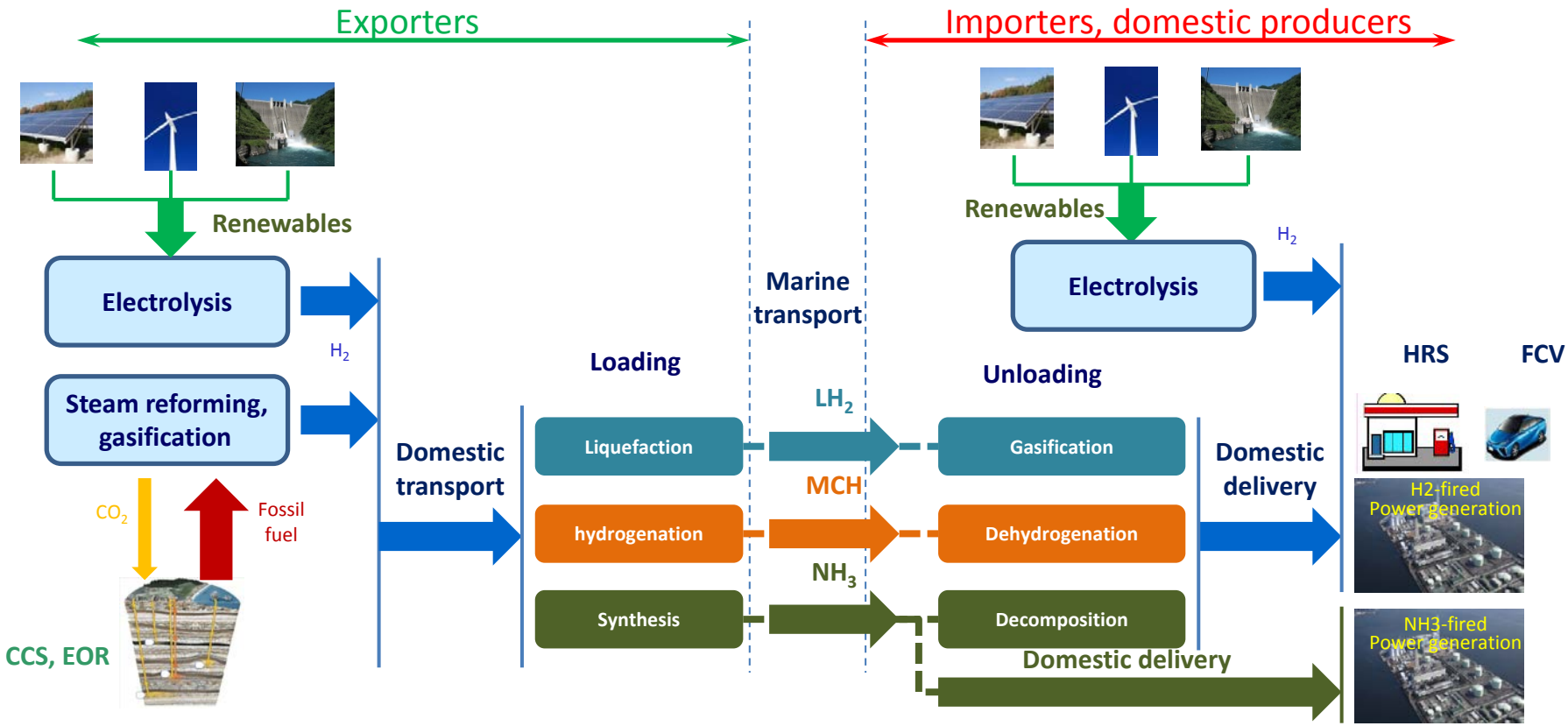
Hurdles are lower for synthetic methane

- Buildings sector

Future hydrogen town?

Large Scale H_2 Is Essential

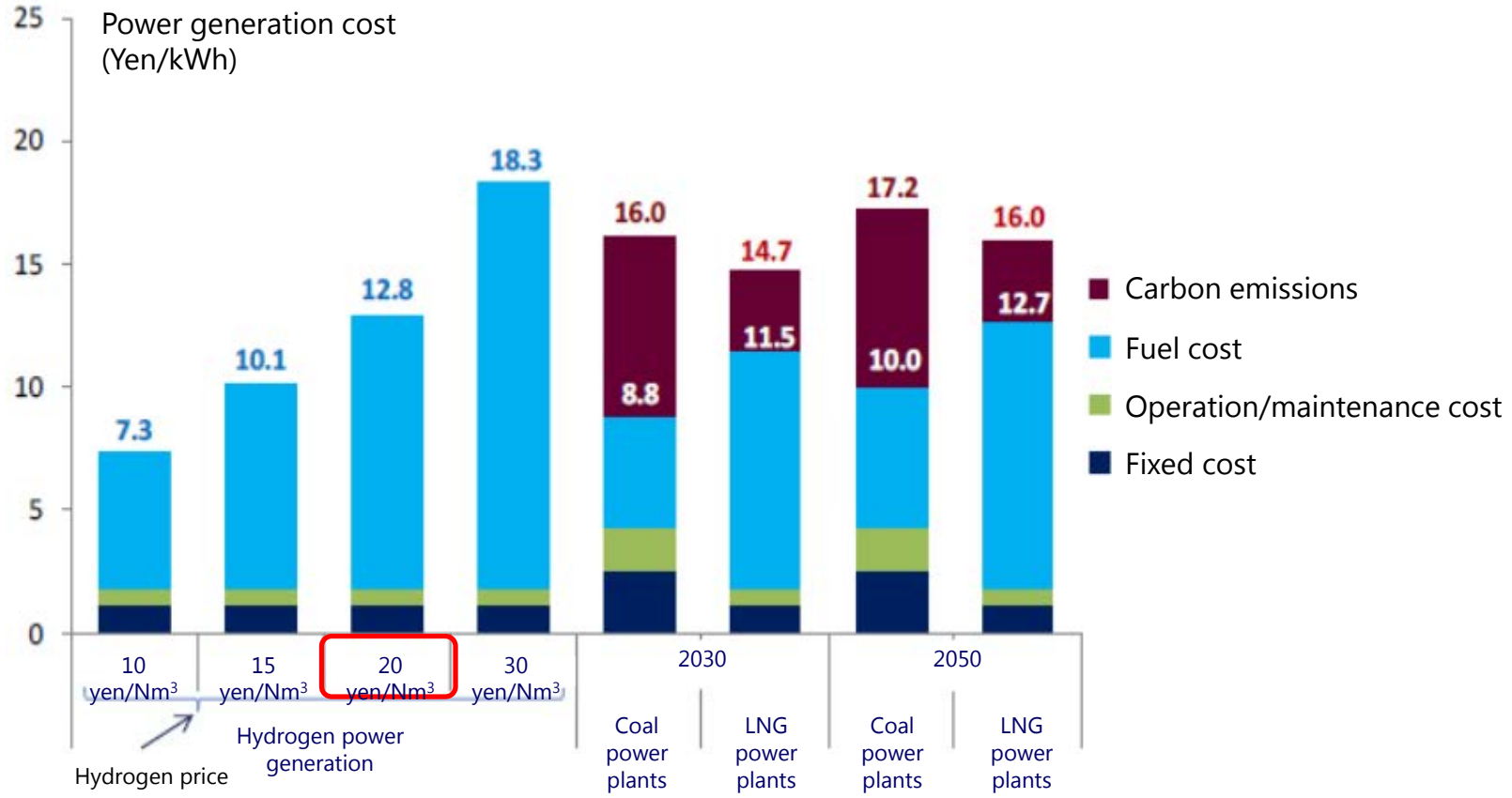
- In terms of economics, large-scale supply chain is *sine qua non*
- Transport has three options, liquefied hydrogen (LH_2), methylcyclohexane (MCH) and ammonia (NH_3).



Note: LH_2 is liquefied hydrogen, MCH is methylcyclohexane, NH_3 is ammonia

Target Hydrogen Import Cost

- Given Japan's hydrogen use for power generation, the desirable hydrogen CIF import price is 20 yen /Nm^3 or less.
  The Japanese government has set its target at 30 yen /Nm^3.



Source: IEEJ

Summary

1. **De-carbonization still a long way**

2. **Importance of "３Ｅ＋Ｓ" in Asia is increasing**

3. **Need to keep addressing oil supply disruption. Addressing power supply disruption is a new challenge.**

4. **A variety of innovative technologies development and large-scale cost reductions are prerequisite in meeting the 2c' target (de-carbonization by the end of the century).**

＊Hydrogen is a promising technology for countries and sectors and across different energy sources.

Thank you for your attention!

IEEJ Website

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