Opportunities and Challenges in Global Energy Transition

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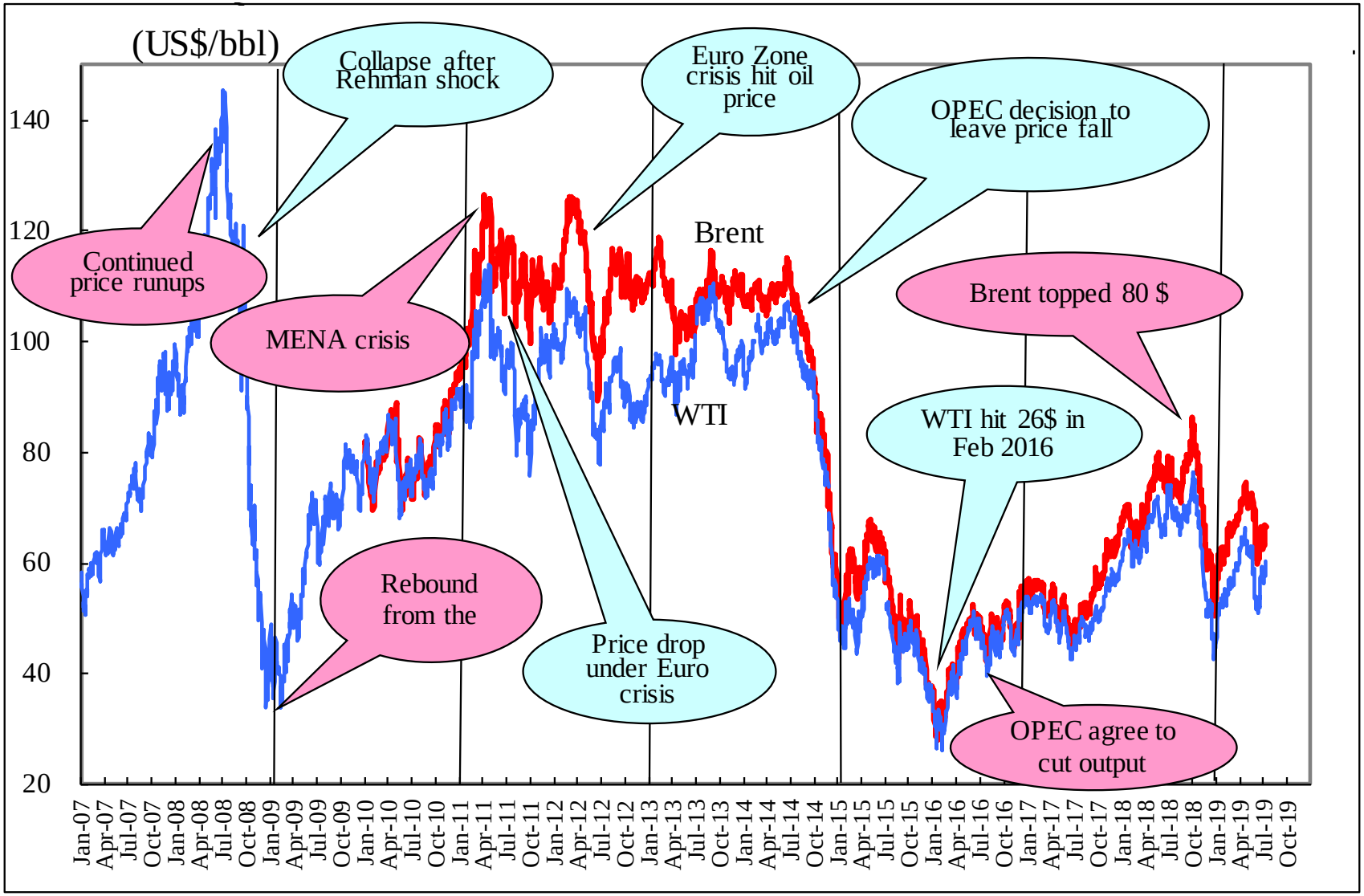
Global energy transition in the past

- **19th century: Coal became dominant under Industrialization**
- **20th century: "the century of oil"**
  - ✓ Background factors: economic competitiveness, supply potential, convenience, technology advancement, etc.
- **1970s: Oil crisis and oil substitution policy**
  - ✓ Enhancement of energy security policy in OECD resulted in energy diversification (away from oil)
- **21st century: What's next after "the century of oil"?**
  - ✓ Need to address environment and energy security problems
  - ✓ Technology development/deployment in renewable, ZEV, etc.
  - ✓ Possibility to develop new unconventional energy sources
- **World energy future heavily depends on the above conditions/uncertainties**

Emerging global energy landscape

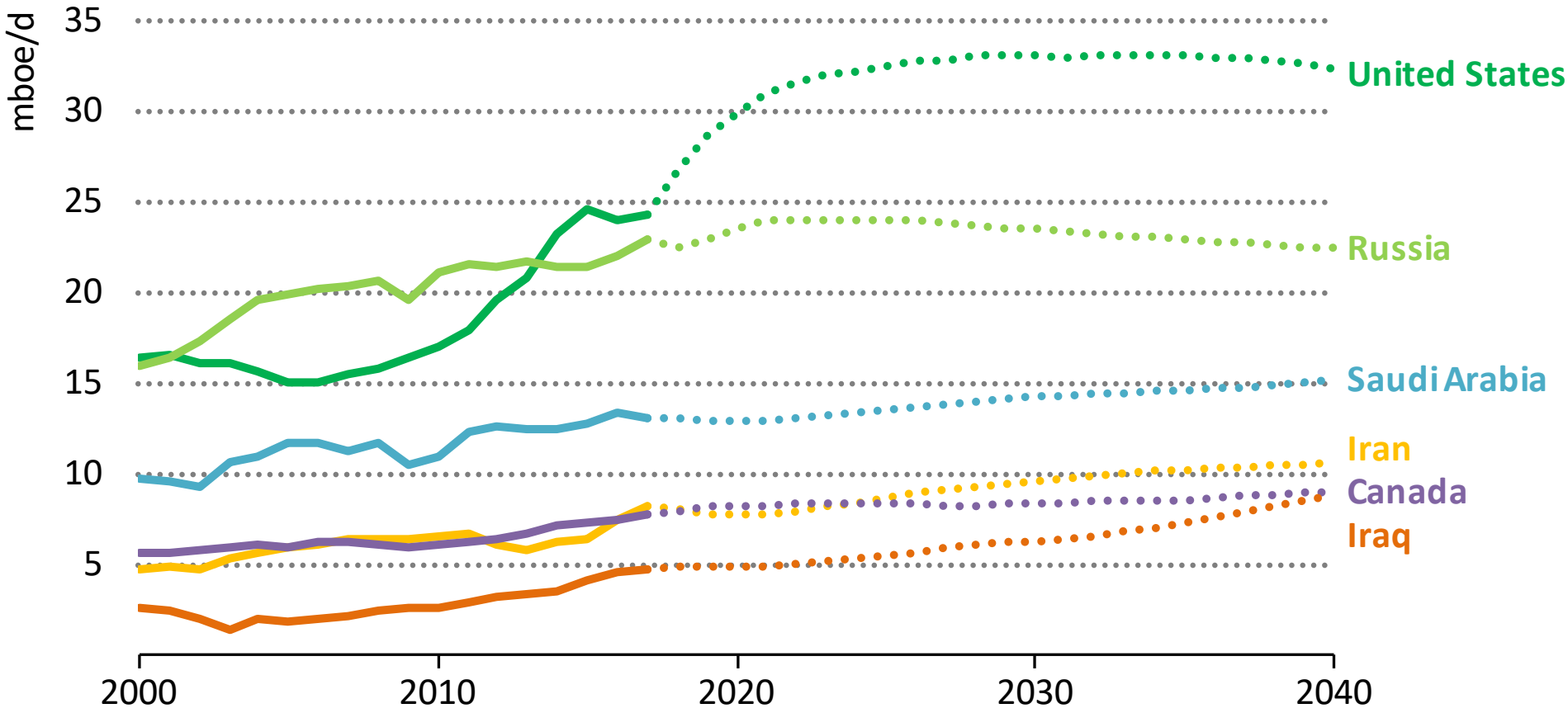
- Volatile crude oil price
- Impacts of US "Shale Revolution"
- Asia as a gravity center of world energy demand
- Energy Geopolitics revisited
- Climate change and air pollution as emerging risks
- Expectation for advanced and innovative technology
- Complicated roles played by market, government and technology

Crude Oil Price Volatility



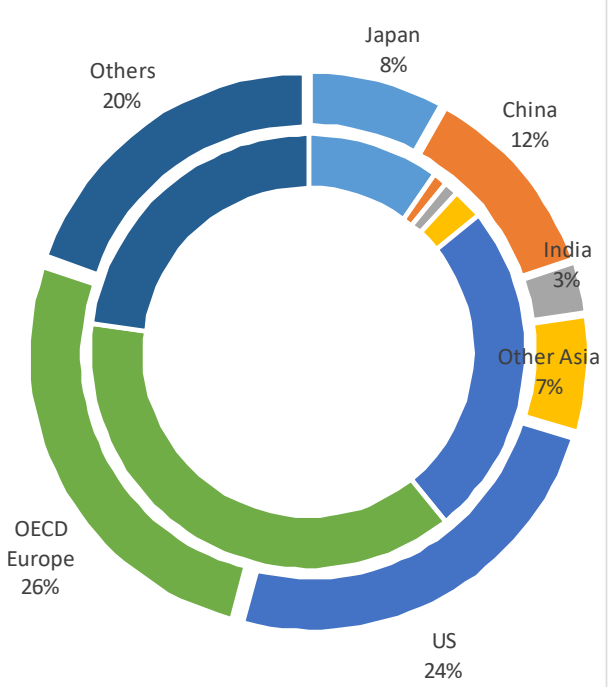
Source: NYMEX data, etc.

US, the largest oil & gas producer (NPS)

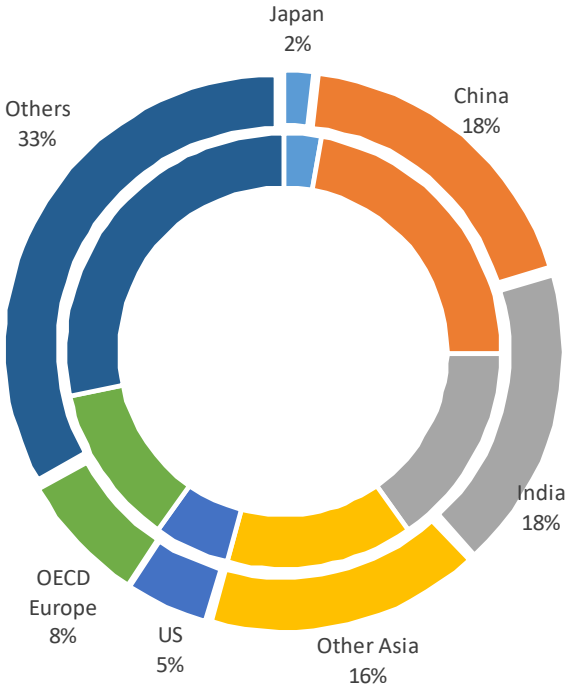


Source: IEA "World Energy Outlook 2018"

Asia, as a Gravity Center of the World



(Inside circle for 1971, outside for 2015)



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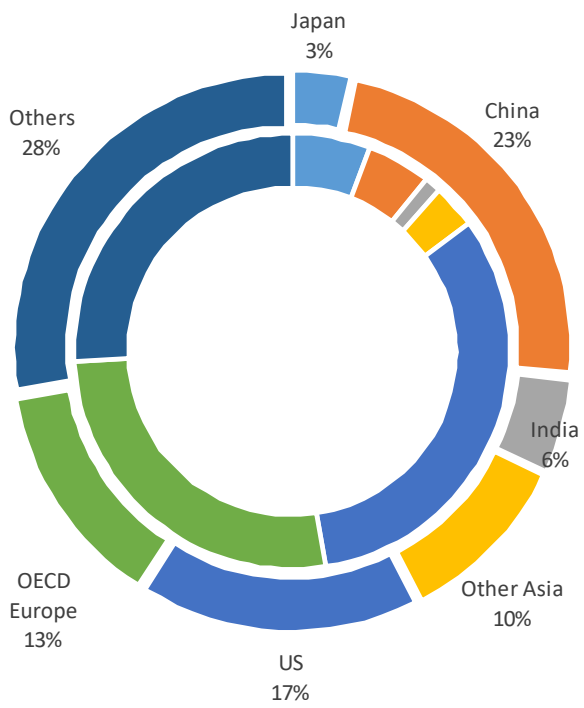


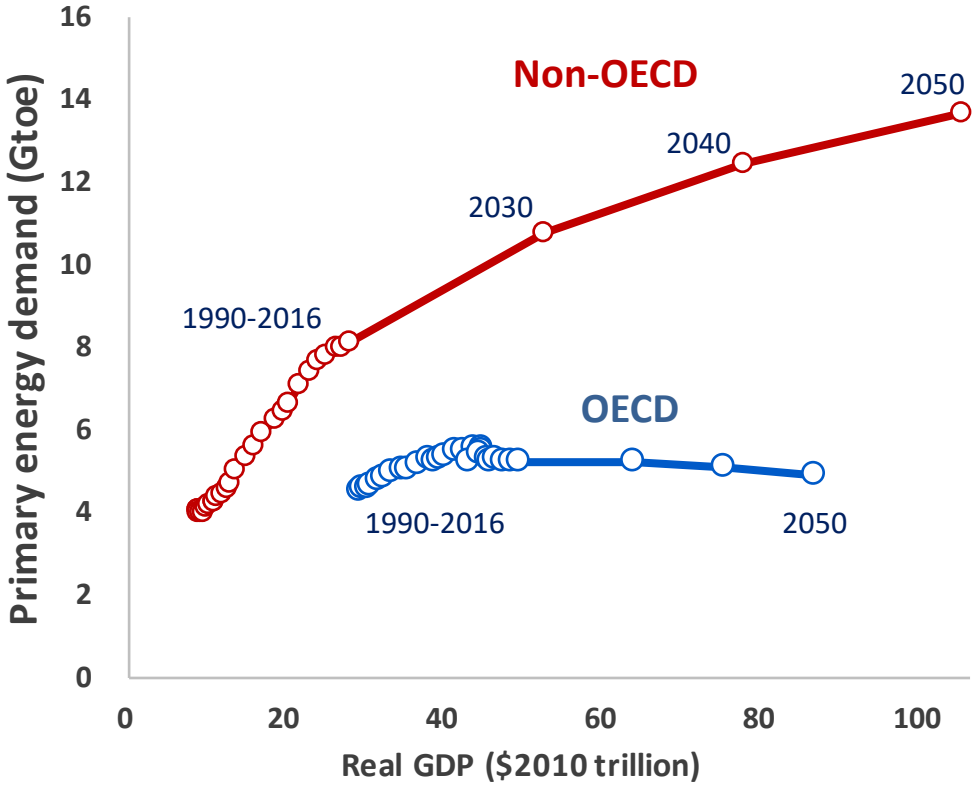
(Inside circle for 1971, outside for 2017)

Source: Prepared from various statistics from World Bank, UN and BP

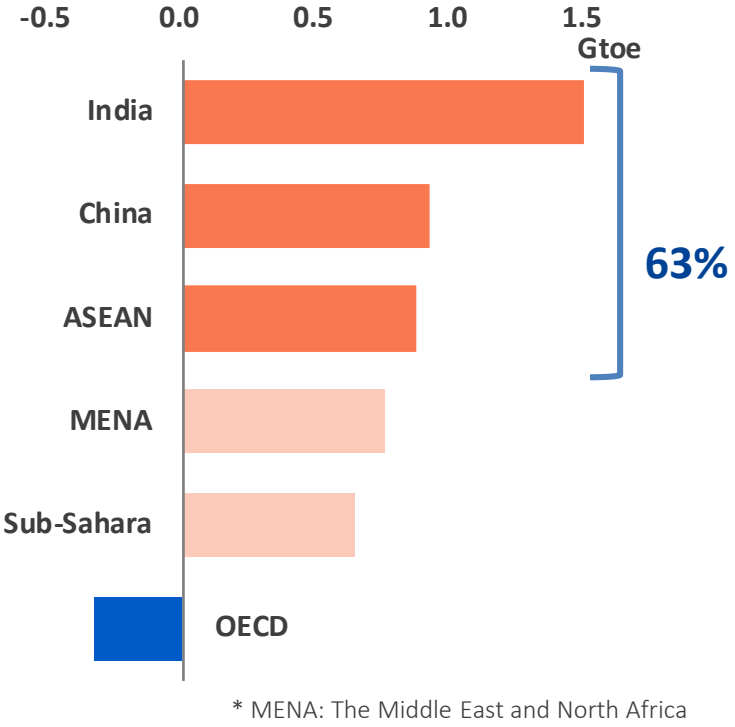
Reference Scenario

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

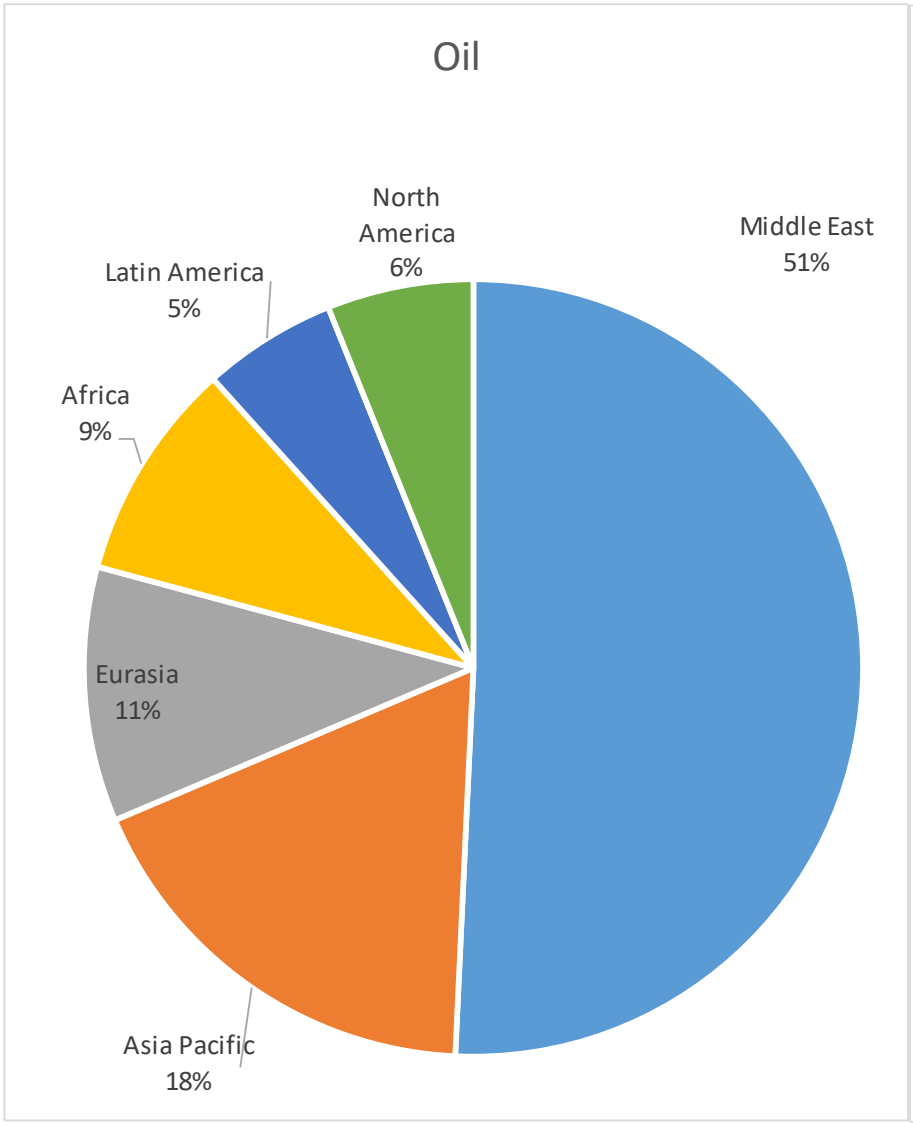
- The global primary energy demand will increase by 1.4 times in 2050.
- The net increase in energy demand can be entirely attributable to non-OECD.
- In OECD, decoupling between growth of the GDP and energy consumption proceeds.
- 63% of the increment come from China, India and the ASEAN countries.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

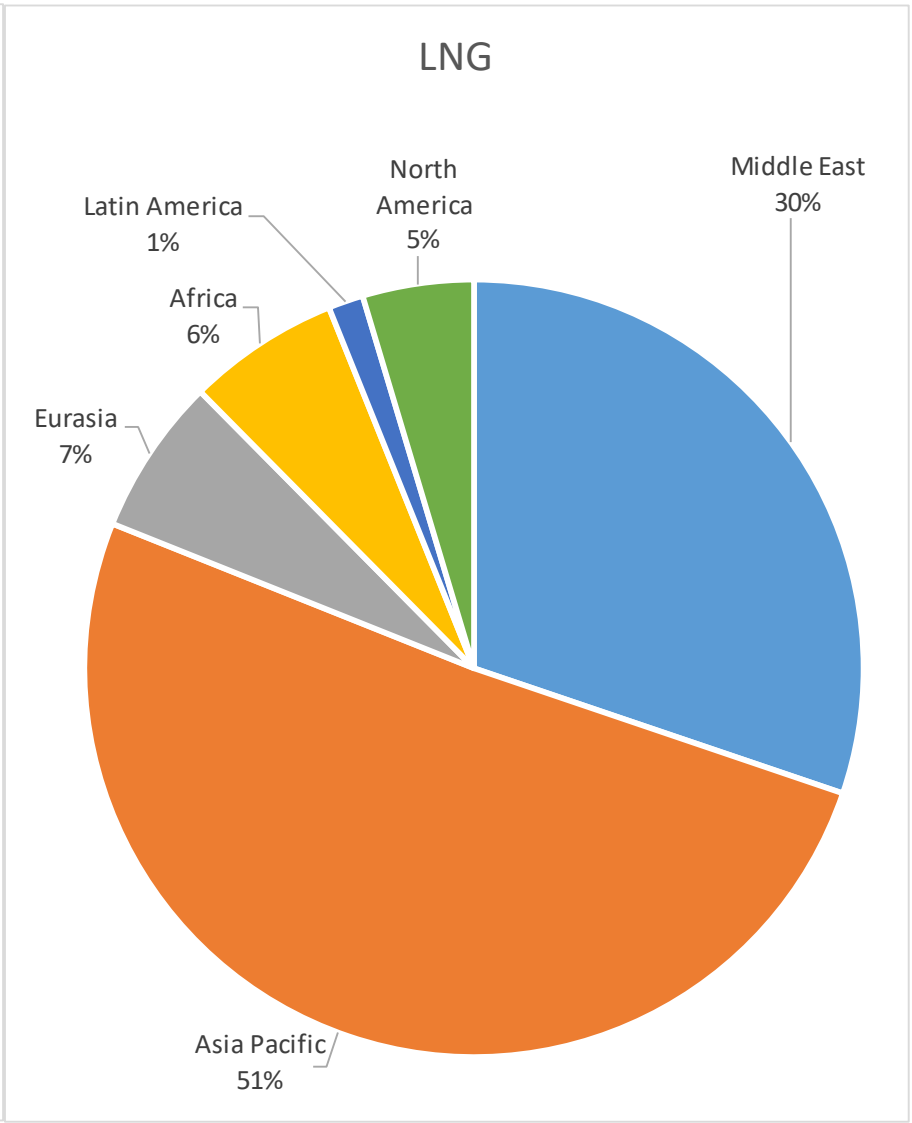
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

Asia's Challenges for "3E+S"

- **Rising import dependence and energy security**
  - High oil import dependence. Gas import dependence rising
  - High Middle East dependence, Sea-lane dependence
- **High coal dependence and environment loads**
  - Challenges for both climate change and pollution problems
- **Need for energy market reform**
  - Japan leads the way. Reform for both energy market and NOCs
- **Challenges for nuclear power program**
  - Impacts of Fukushima. Ambitious nuclear power program in China, India, etc. with challenges for safety and public acceptance

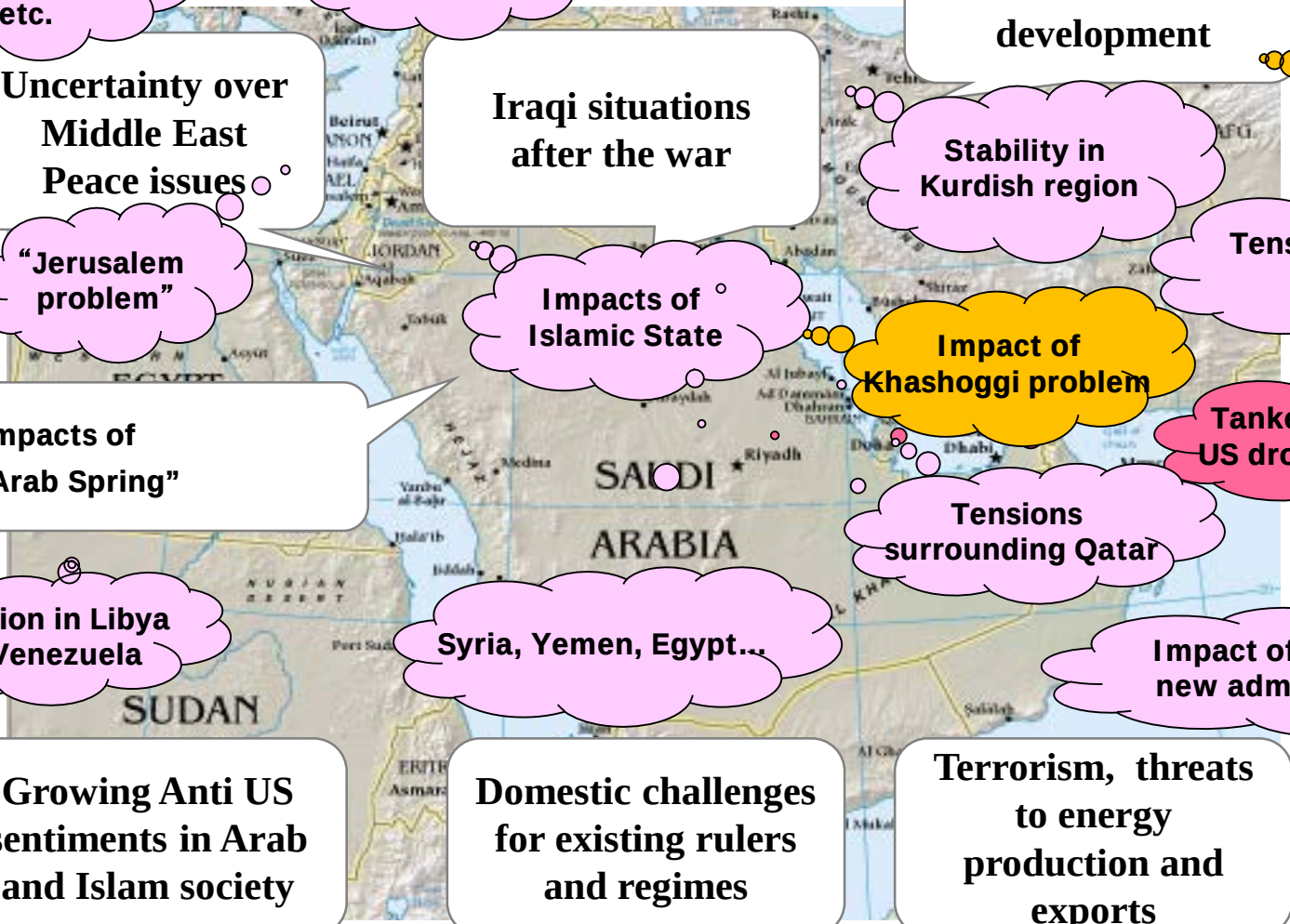
Asia's Middle East Dependence (2018)





Source: Prepared from "BP Statistical Review of World Energy 2019"

Instability in the Middle East

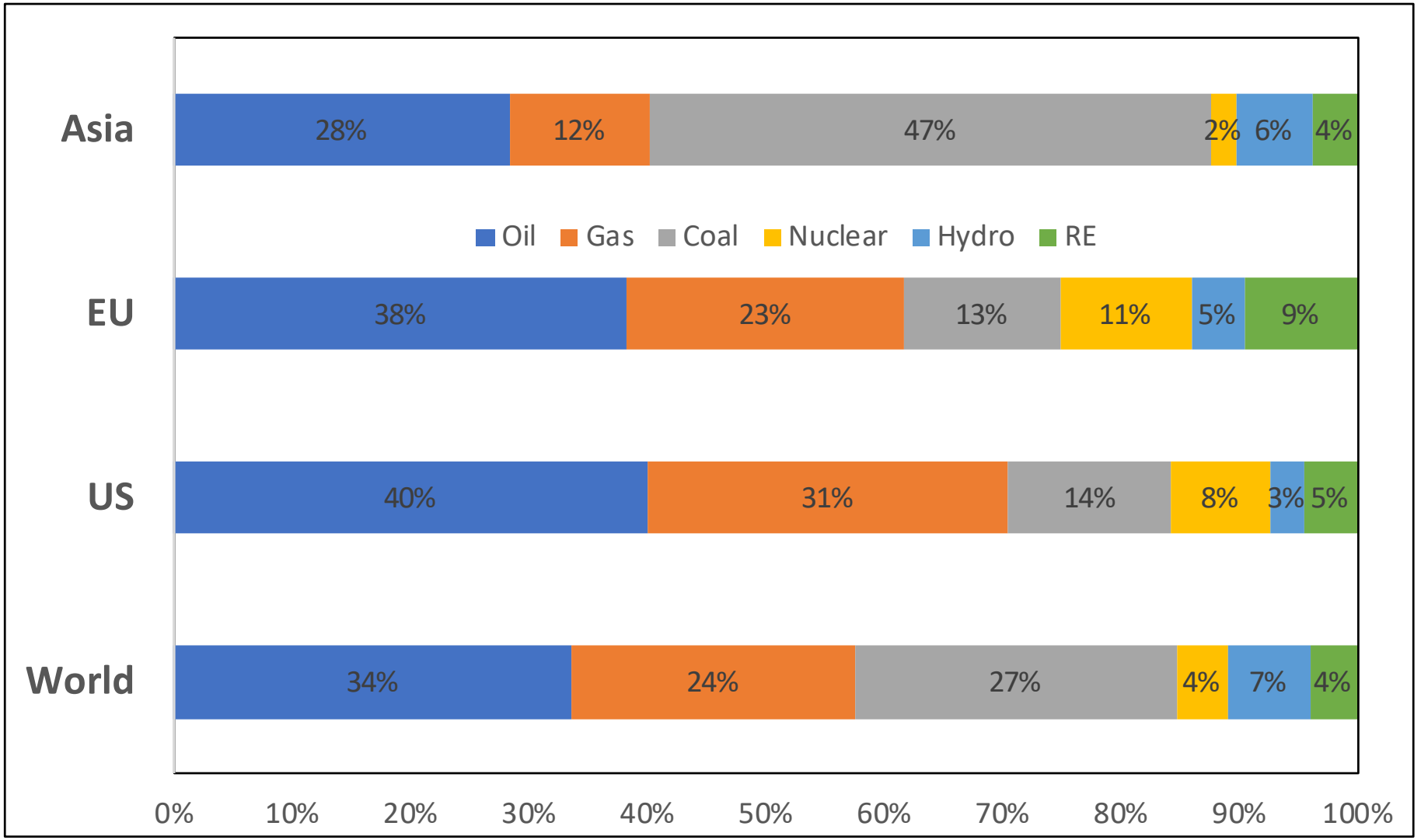


Source: Prepared by IEEJ

Strait of Hormuz, a critical oil and LNG transit route

- Oil transit: over 20 MB/D (about 20% of global supply)
- LNG transit: 83 million ton (about 30% of global supply)

Asia, heavily dependent on coal



Source: Prepared from "BP Statistical Review of World Energy 2019"

Environmental challenges in Asia

- *Growing energy/power demand*
- *Climate change and air pollution*

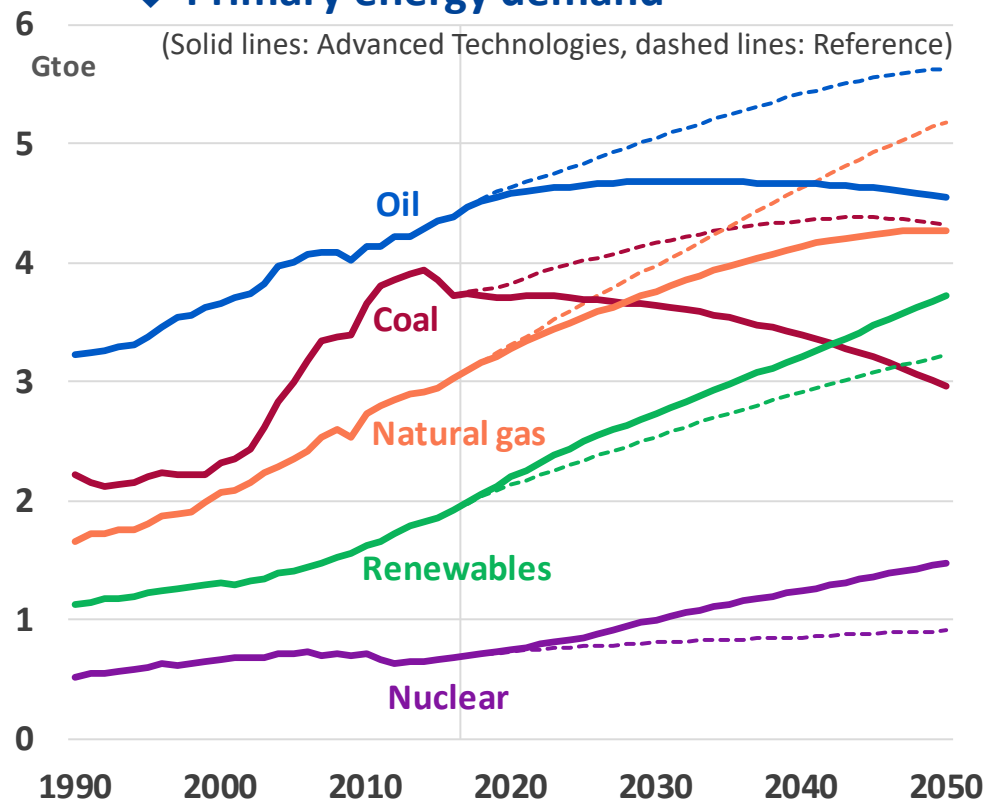
NDC under Paris Agreement

Party	Date of submission	Target type	Reduction target	Base year	Target year	Coverage
EU	Mar 6 2015	Absolute emissions	40%	1990	2030	GHG
United States	Mar 31 2015	Absolute emissions	26～28%	2005	2025	GHG including LULUCF
Russia	Apr 1 2015	Absolute emissions	25～30%	1990	2030	GHG
China	Jun 30 2015	GDP intensity	60～65% Total emission peak out before 2030	2005	2030	CO_2
Japan	Jul 17 2015	Absolute emissions	26%	2013	2030	GHG
Indonesia	Sep 24 2015	Reduction from BAU	29%	BAU	2030	GHG
Brazil	Sep 30 2015	Absolute emissions	37% (43% for 2030)	2005	2025	GHG
India	Oct 1 2015	GDP intensity	33～35%	2005	2030	GHG

Air pollution in China

Coal declines while oil hits peak in 2030

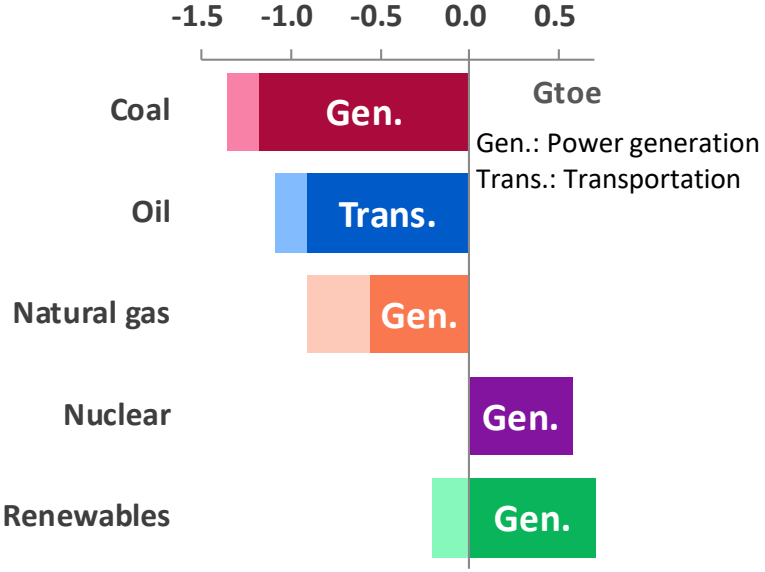
❖ Primary energy demand



● 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



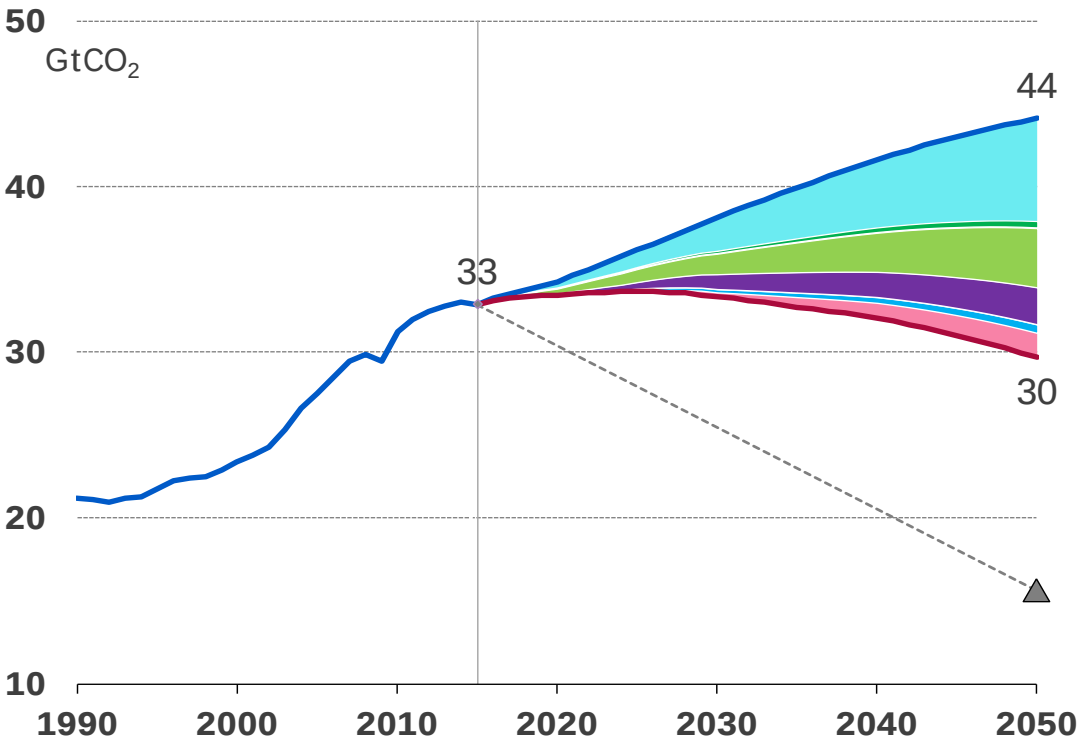
In the Advanced Technologies Scenario…

- ◆ 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.

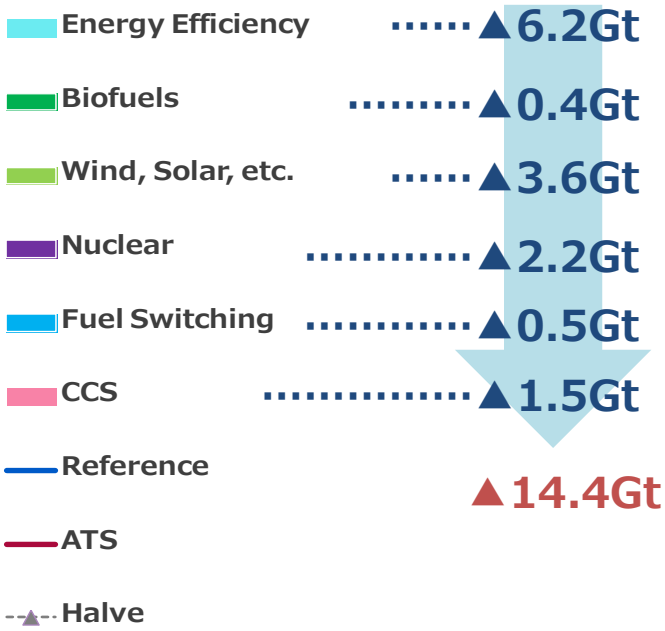
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

CO_2 emissions peak in the middle of 2020s

❖ Energy-related CO_2 Emissions



❖ Reductions by technology

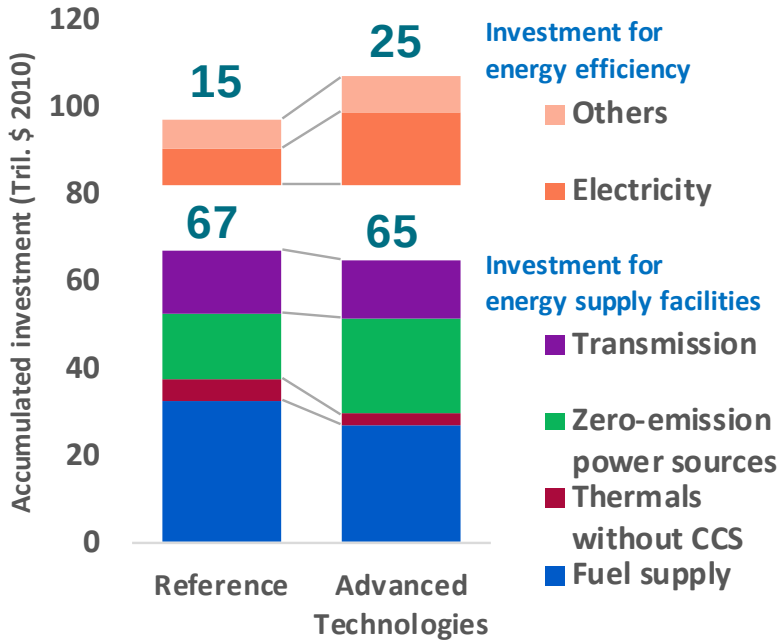


Energy-related CO_2 emissions in ATS decline after the 2020s but are still very far from reaching half of current levels by 2050. Efficiency is the most contributor for CO_2 reductions from the reference. Two-thirds of the total reductions are electricity-related technologies, including non-fossil power, thermal power with CCS and energy efficiency in power supply/demand.

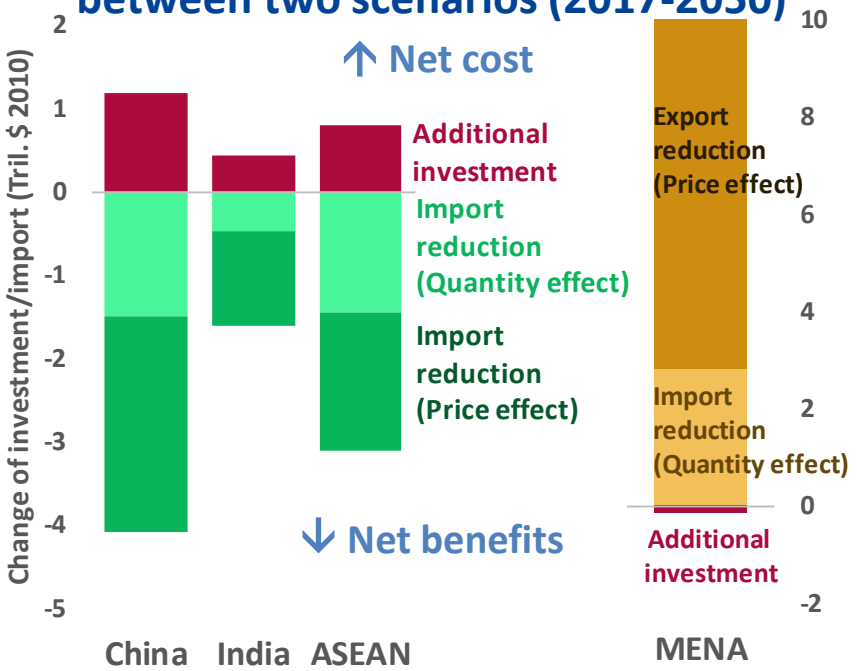
Source: IEEJ "IEEJ Outlook 2018" (Oct. 2017)

Required investment for energy supply

Required investment (2017-2050)



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



* "Electricity" includes the saving through electrification.

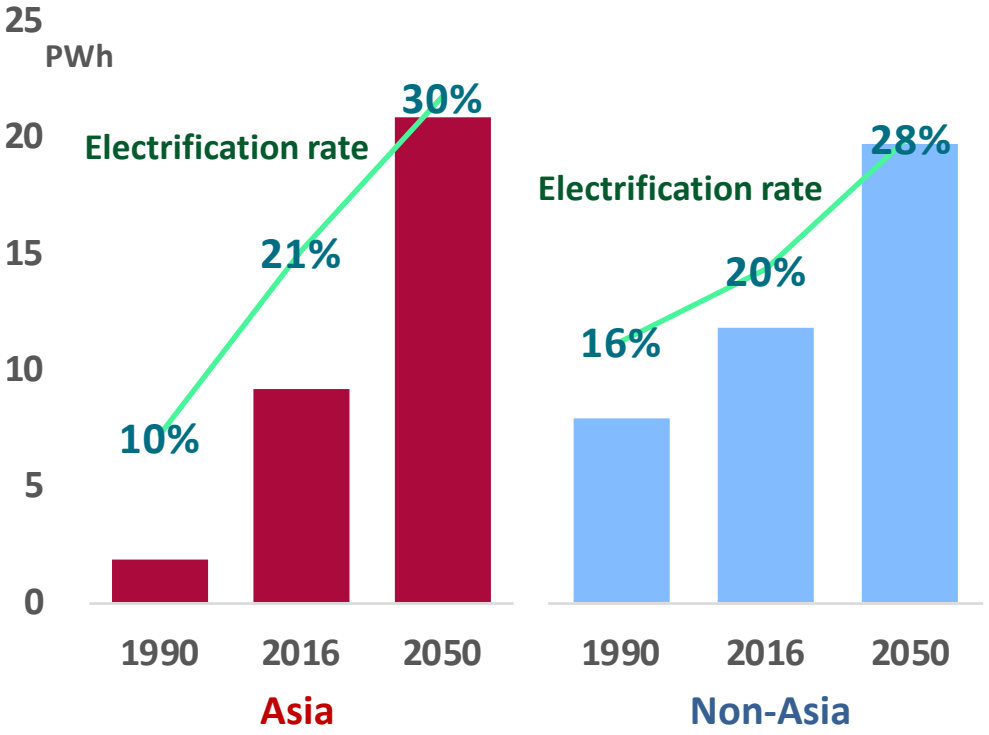
* MENA: The Middle East and North Africa

- 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.

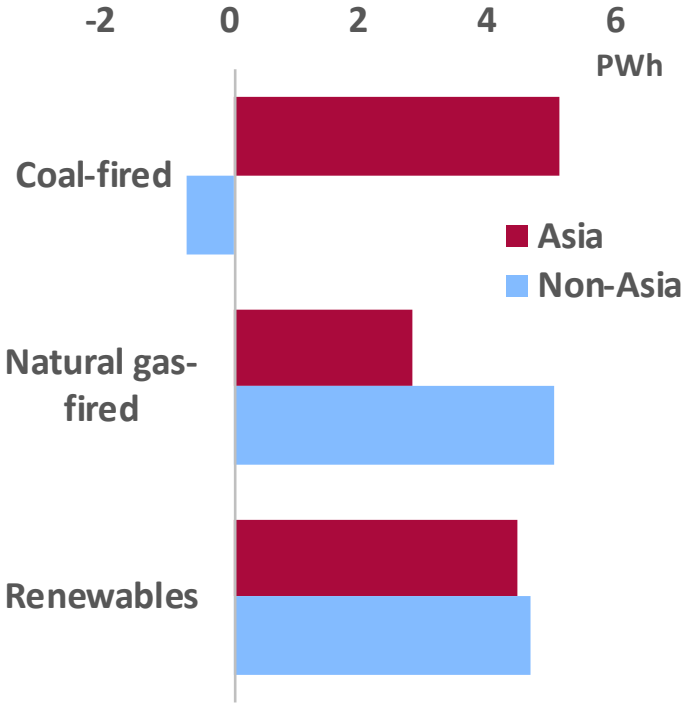
Source: "IEEJ Outlook 2019" (IEEJ, October 2018)

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.

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

Why the energy market regulated?

■ Natural monopoly

- ➢ Economy of scale

■ Energy, regarded as “special commodity”

- ➢ Externalities
- ➢ “Too important to be left for market mechanism”

What actually done to reform market?

■ Privatization (if applicable)

- State dominant companies to be exposed to market forces
- "Principal-Agent theory"

■ Deregulation

- Introduction of competition (power generation, retail)
- Creation of wholesale (spot) market
- Unbundling
- Remove tariff/profit control
- Regulator to check/monitor competition situation
- Etc.

■ Impact

- Market mechanism starts to function
- Pricing principle: "Full-cost pricing (cost-pass-on)" to "Market driven"

Conditions for competitive market

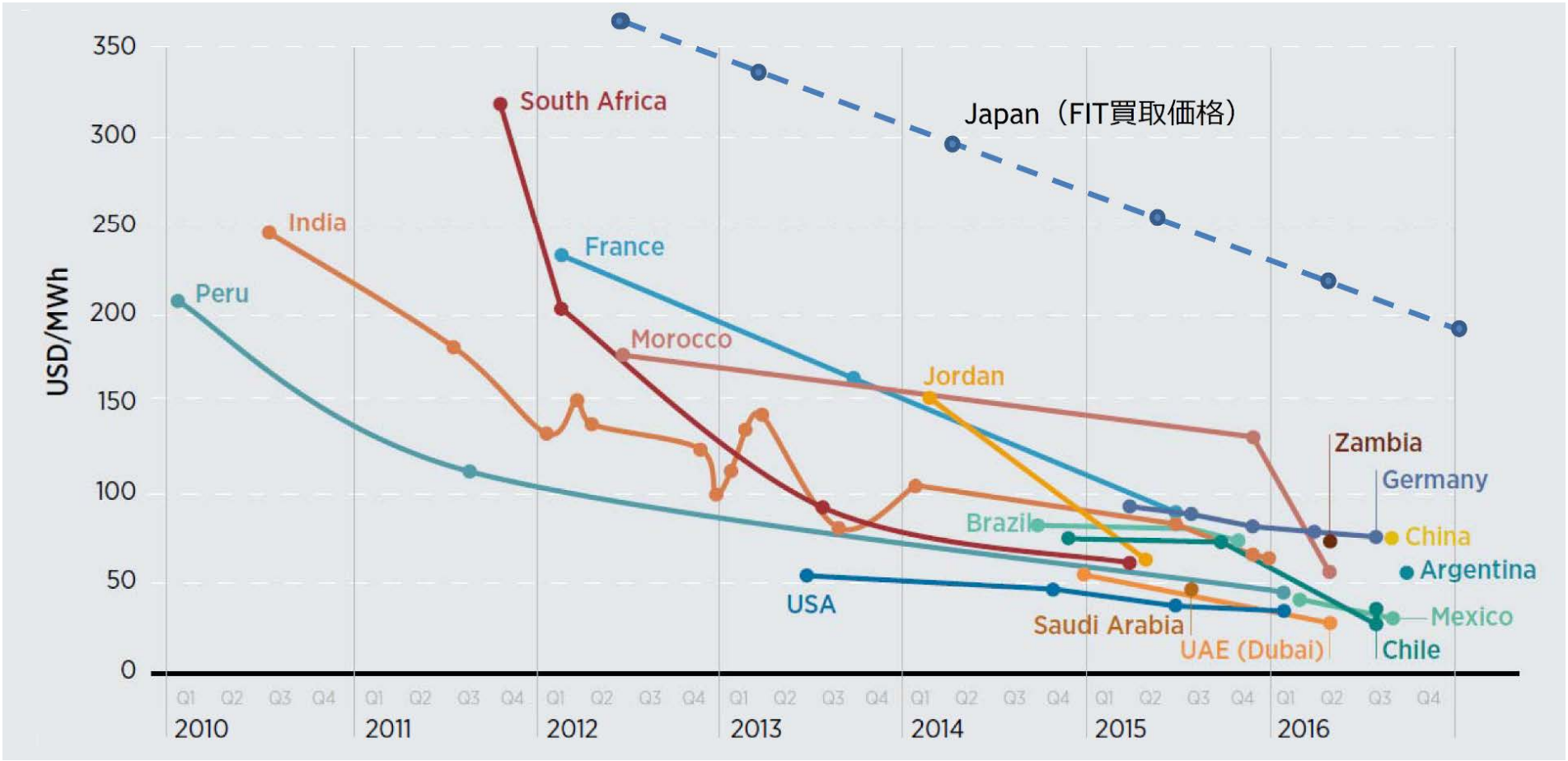
- **Multiple (large numbers of) and diversified players**
- **Liquid trading**
- **Mechanism to avoid or limit "market power" and manipulation**
- **Transparent and reliable market design and regulation**

- **Benefits:**
  - **Transparent price signals based on electricity (kWh) supply-demand balances**
  - **Promote market efficiency via the effects of competitive price**
  - **Industry (corporate) streamlining and rationalization**
  - **Etc.**

Liberalized market and "Energy Mix"

- **Liberalization tends to lead to cost minimization**
- **Investment in "Zero-emission" power generation may not be regarded as "cost minimum"**
- **New mechanism required to address the challenges**
  - **UK: Introduction of "FIT/CFD"**
  - **US (states level): Introduction of "ZEC"**
  - **US considers to support "baseload power"**

Declining PV bid price and Japan's FIT tariff



IEEJ add data to IRENA「Renewable Energy Auctions Analyzing 2016」

Source: "Outlook for renewable energy" IEEJ (July 2017)

Implications of large inflow of RE

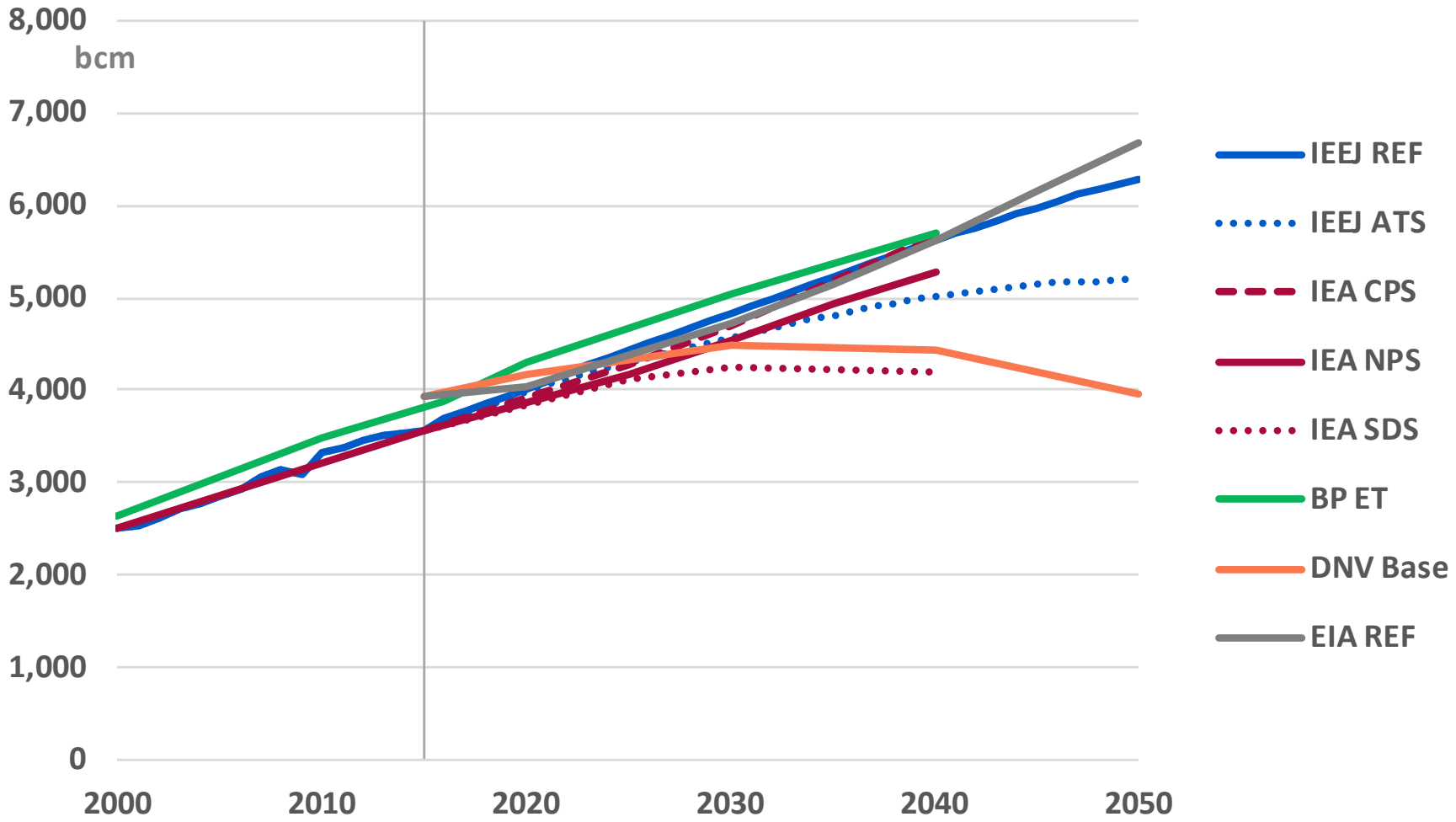
Price

- Inflow of policy-supported RE (zero MC) pushed supply curve in wholesale electricity market ("merit-order principle")
- Supply-demand adjustment through grid connectivity (where available)
- Lower prices in wholesale market
- Negative impact on the economy of fossil fuel power generation and incumbent utilities

Intermittency

- Create new challenges to adjust intermittency
- Problem for electricity supply-demand stability?
- IEA starts to focus on electricity security of supply

Difference in Natural Gas Demand Projections



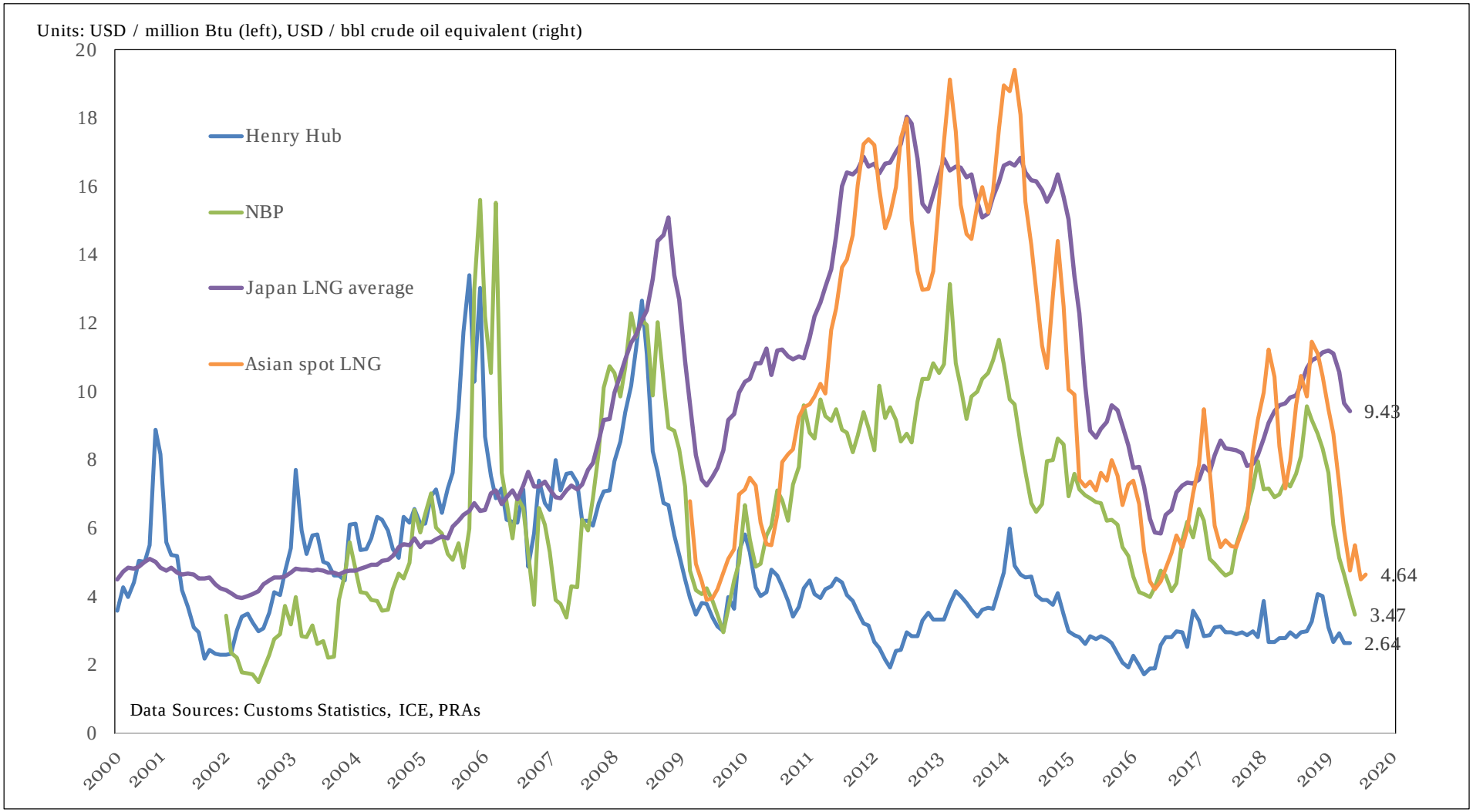
*DNV projection includes NGLs

Source: Prepared by Shigeru Suehiro, IEEJ (October 2018)

Factors to affect Gas/LNG Demand in Asia

- Economic growth
- Need to protect environment
- Lower price
- Competition against coal
- Future of nuclear power
- Competition against renewable energy
- Competition with LPG
- Impact of power/gas market reform
- Pipeline vs. LNG

Asia LNG: Gaps between contract and spot price



Source: Prepared from data from US/EIA and others

Issues for LNG Pricing in Asia

- Given the dominance of the existing contracts, JCC pricing likely to remain dominant mechanism in Asia at least up to early 2020s
- But tide is changing:
  - ✓ Over-suppled market
  - ✓ Inflow of US LNG with HH pricing will increase in Asia
  - ✓ Spot/short-term trading continue to grow
  - ✓ Initiatives to create hubs and new price discovery in Asia
  - ✓ Power and gas market reforms in Japan and Asia
- Major Asian buyers such as JERA have a strategy to diversify pricing
- Buyers continue to search for possible alternatives to JCC and the share of JCC pricing will be reduced
- So far there is no clear answer as to what is the best alternative
- Uncertainties over both prices linked to JCC and spot LNG prices

Summary and Conclusion

■ Global energy challenges

- ➢ Emerging risks/threats to energy security and sustainability

■ Global energy transition and its implication

- ➢ Uncertainty over oil and gas demand
- ➢ But oil and gas will continue to play an important role in energy mix

■ Rising Asia' importance in world energy market

- ➢ Increasing presence with rising demand and imports

■ Need to response to decarbonization

- ➢ Importance of cleaner energy and innovative technology