Energy supply/demand up to 2050

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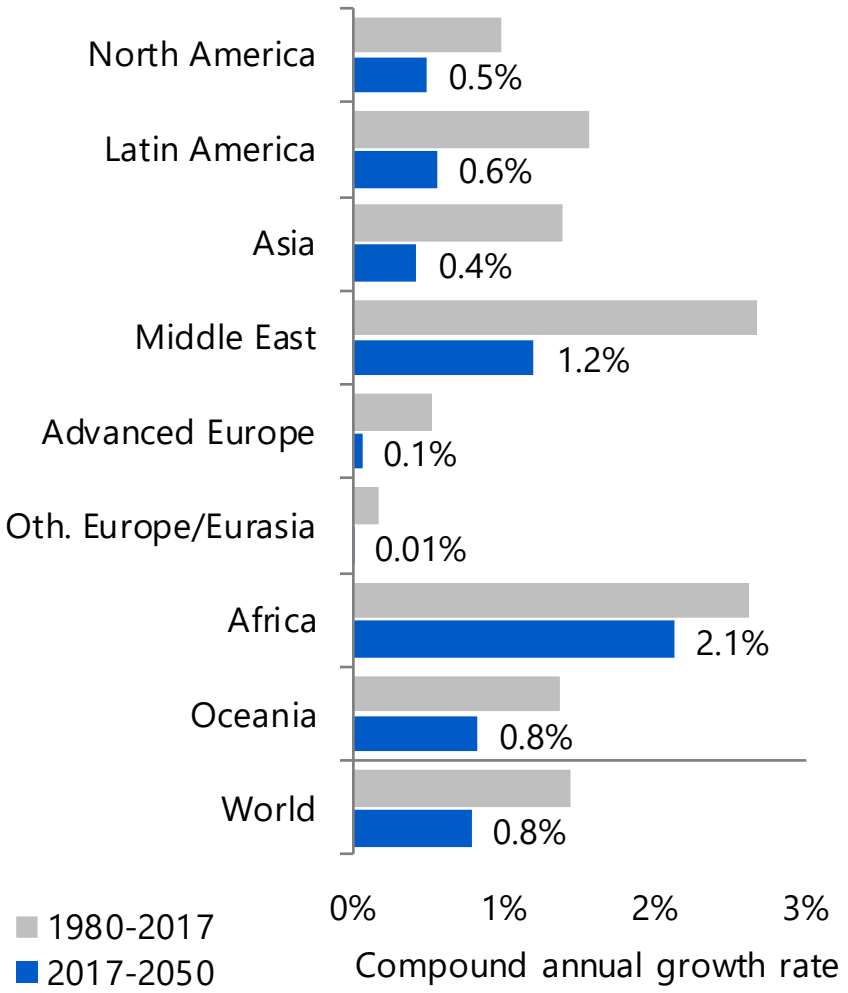
Basic scenarios in IEEJ Outlook

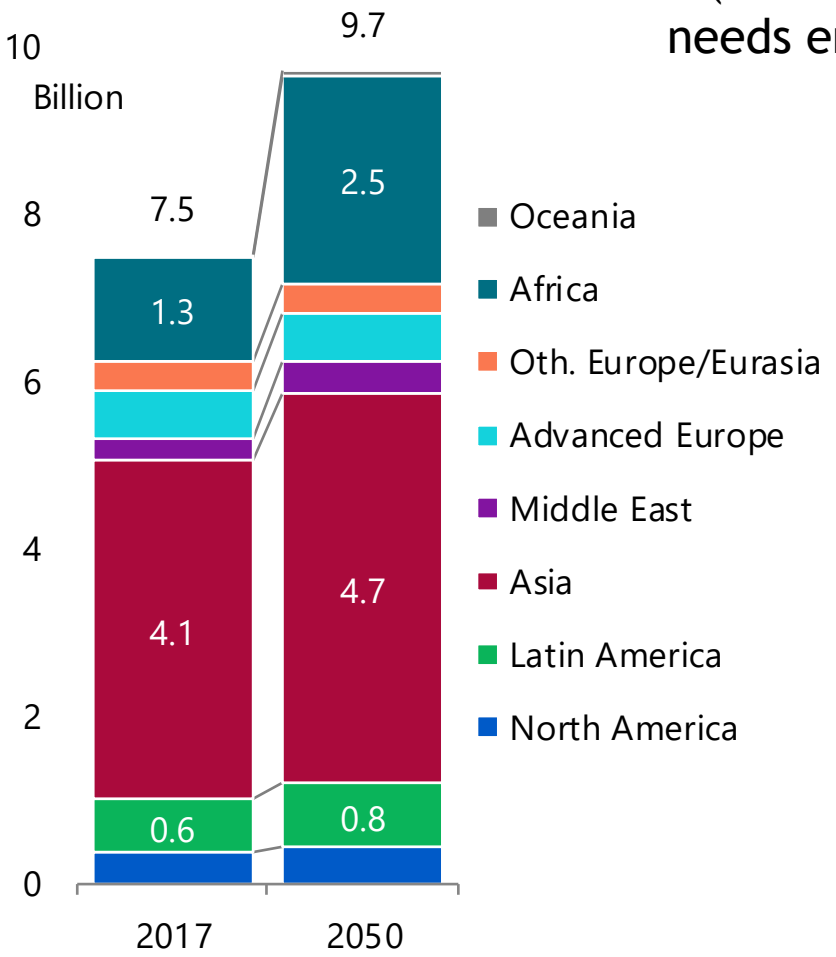
	Reference Scenario	Advanced Technologies Scenario
	Reflects past trends with technology progress and current energy policies, without any aggressive policies for low-carbon measures.	**Assumes introduction of powerful policies** to address energy security and climate change issues with the utmost penetration of low-carbon technologies.
Social-economy structure	Stable growth led by developing economies despite slower population growth. Rapid diffusion of energy consuming appliances and vehicles due to higher income.	
International energy price	**Oil** supply cost increases along with demand growth. **Gas** price convergences among Europe, N. America and Asia markets. **Coal** keeps unchanged with today's level.	Slower price increase due to lower demand growth (coal price decreases).
	[LNG in Asia] Higher/lower price cases	
Energy policies	Gradual reinforcement of low-carbon policies with past pace.	Further reinforcement of domestic policies along with international collaboration.
Energy technologies	Improving efficiency and declining cost of existing technology with past pace.	Further declining cost of existing and promising technology.

Population

CAGR



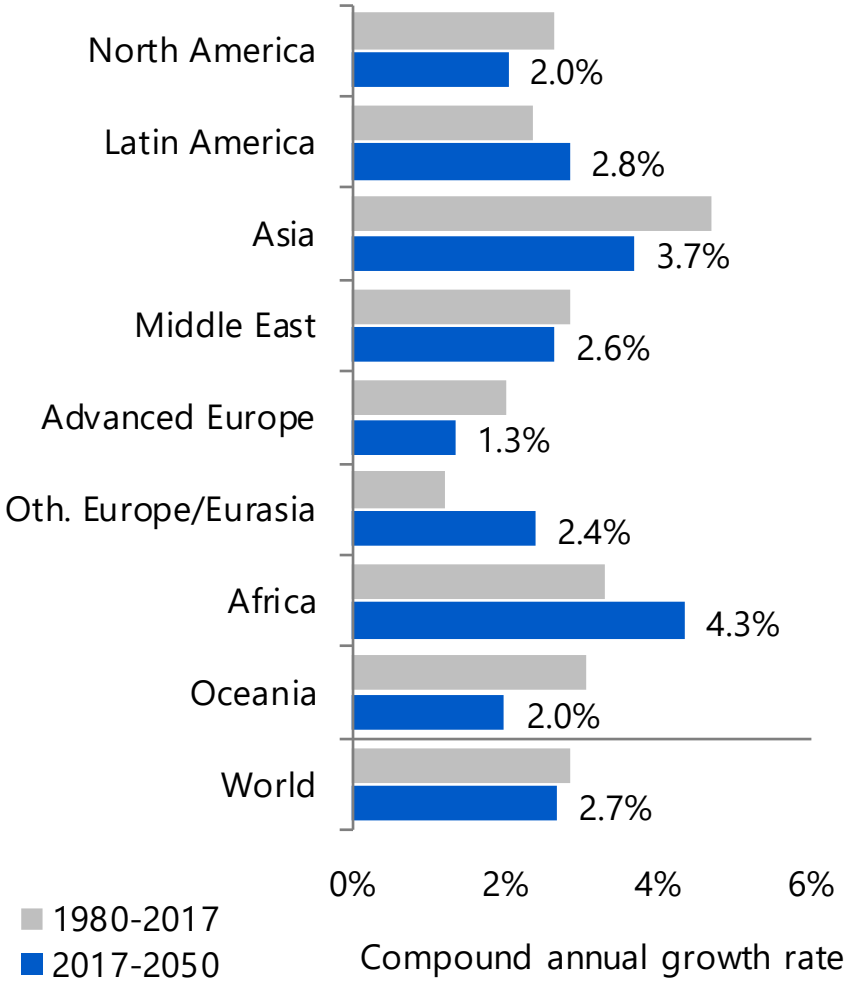
Composition



4 (not 3) billion more needs energy access

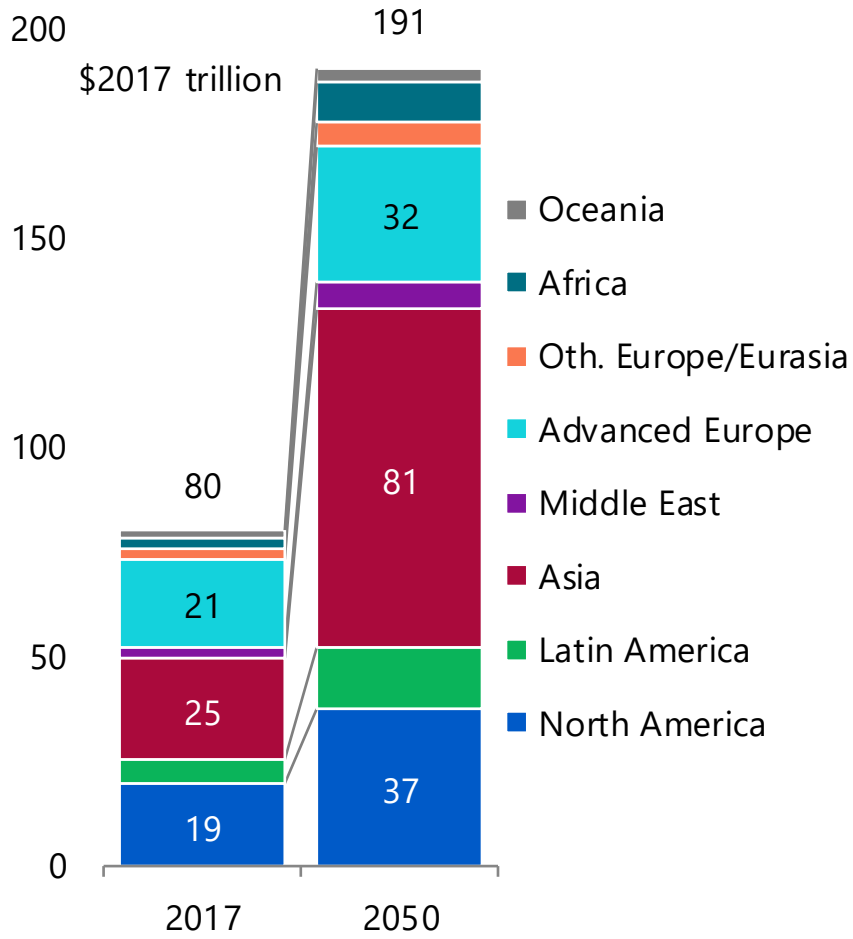
Real GDP

CAGR



Composition

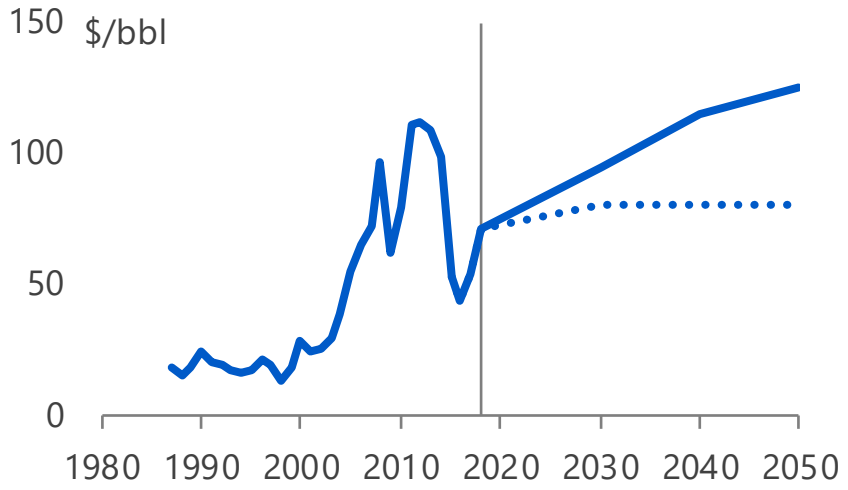
Decoupling required



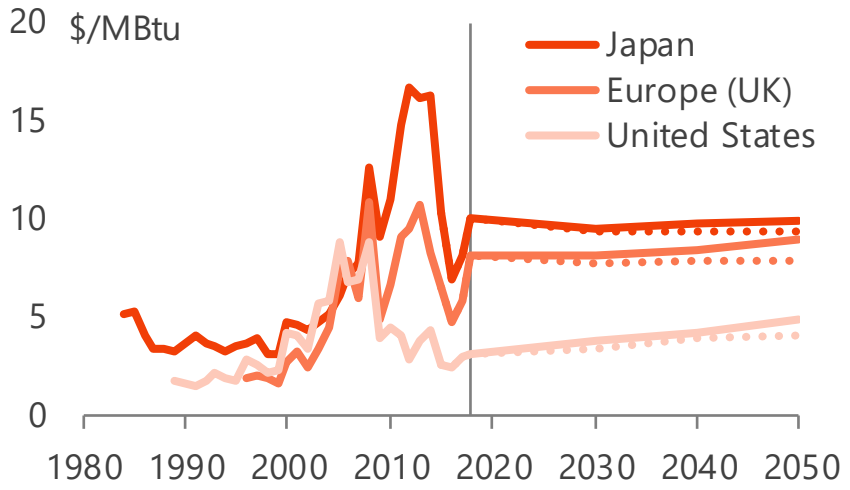
International energy prices

Reference :
Advanced Technologies :

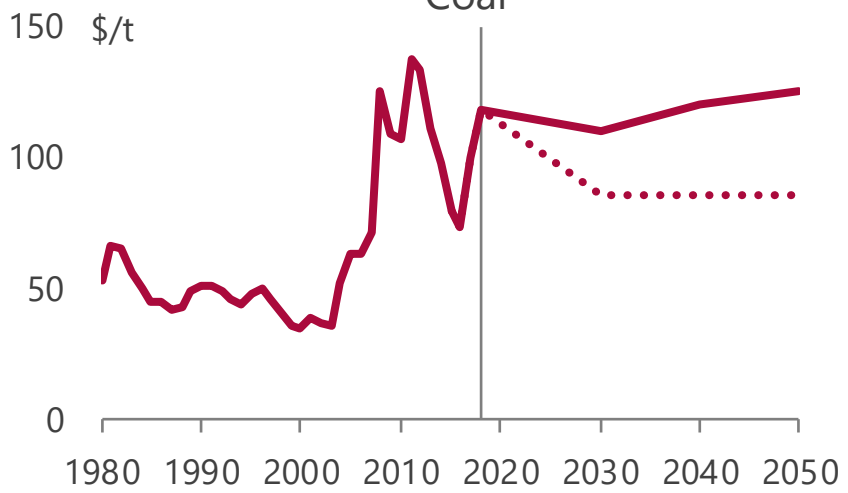
Crude oil



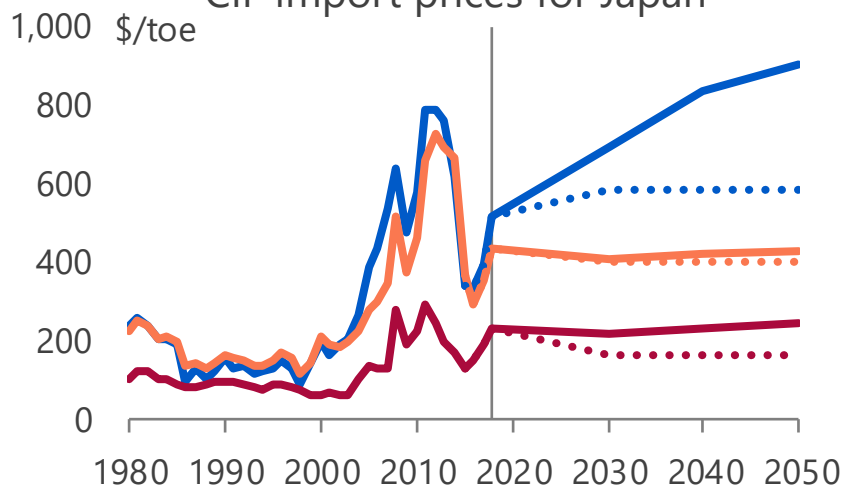
Natural gas



Coal



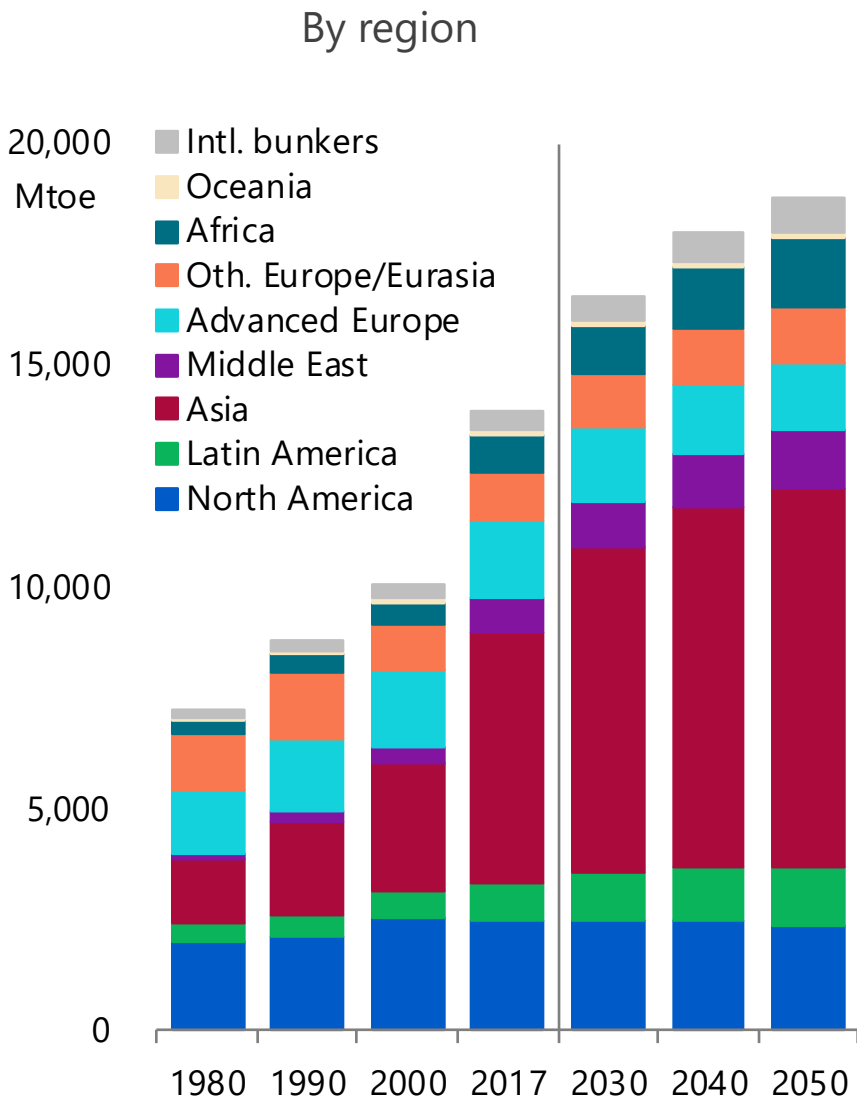
CIF import prices for Japan

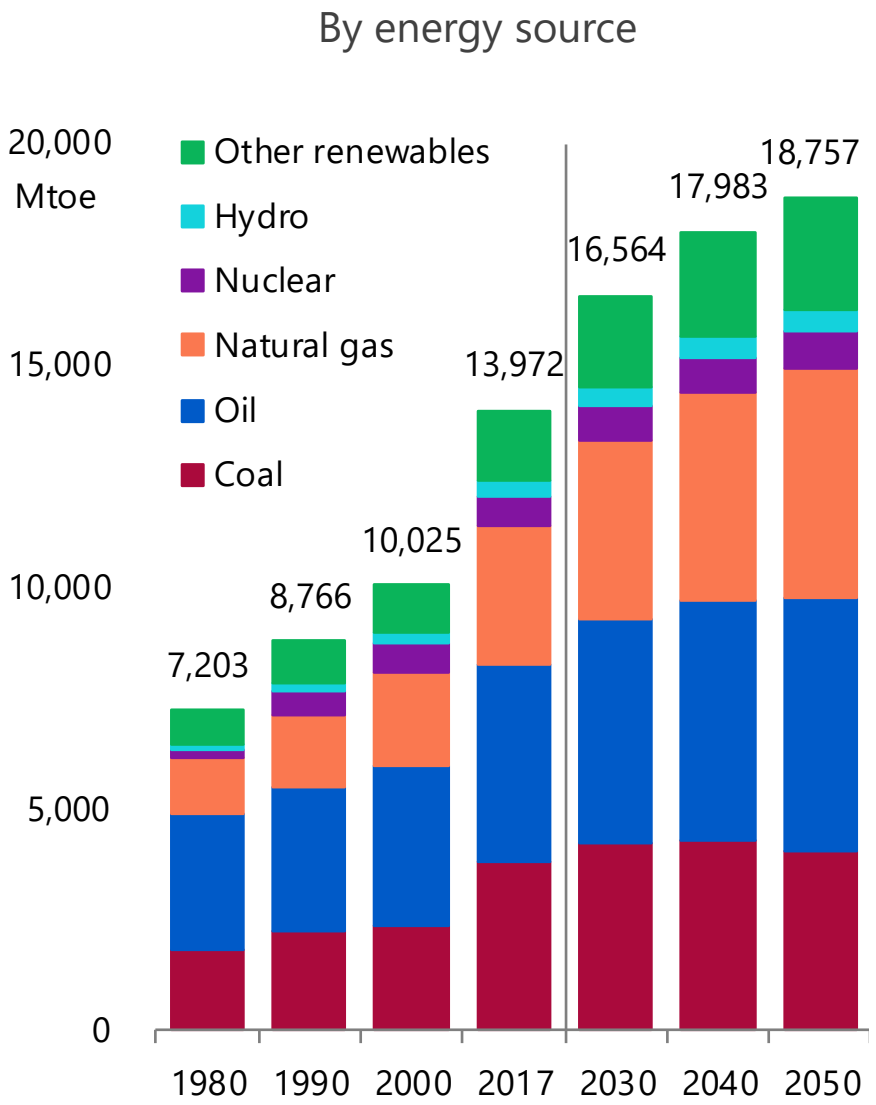


Moderate assumption

Note: Historical prices are nominal. Assumed future prices as real in $2018.

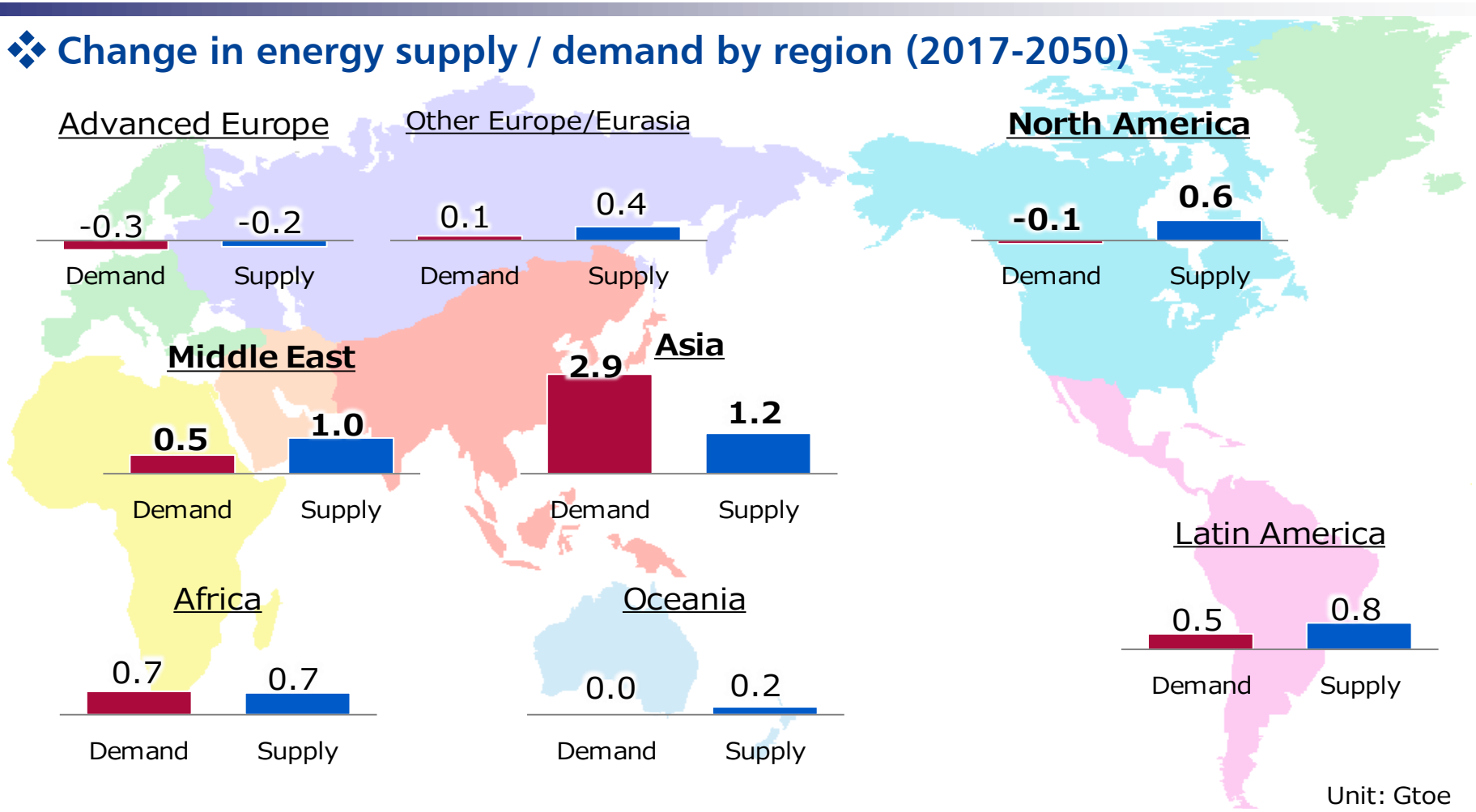
Primary energy consumption





Growth in demand overwhelms supply in Asia

❖ Change in energy supply / demand by region (2017-2050)

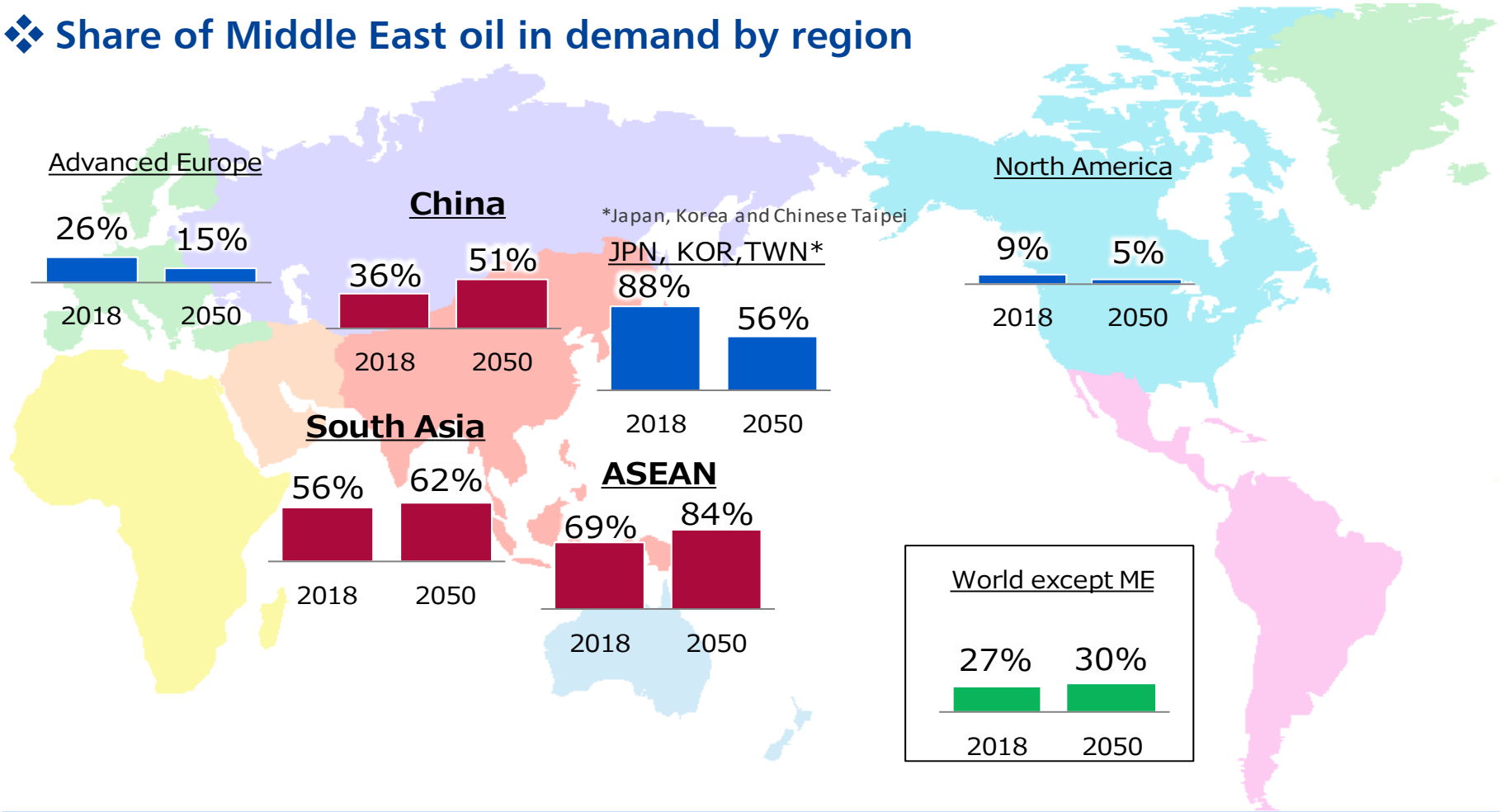


Over 60% of global demand growth comes from Asia. Meanwhile its energy supply cannot catch up, resulting in dropping energy self sufficiency from 72% to 61%.

North America and the Middle East increase surplus export capacity and enlarge their presences as energy suppliers.

Only Asia pushes up dependence on ME

❖ Share of Middle East oil in demand by region

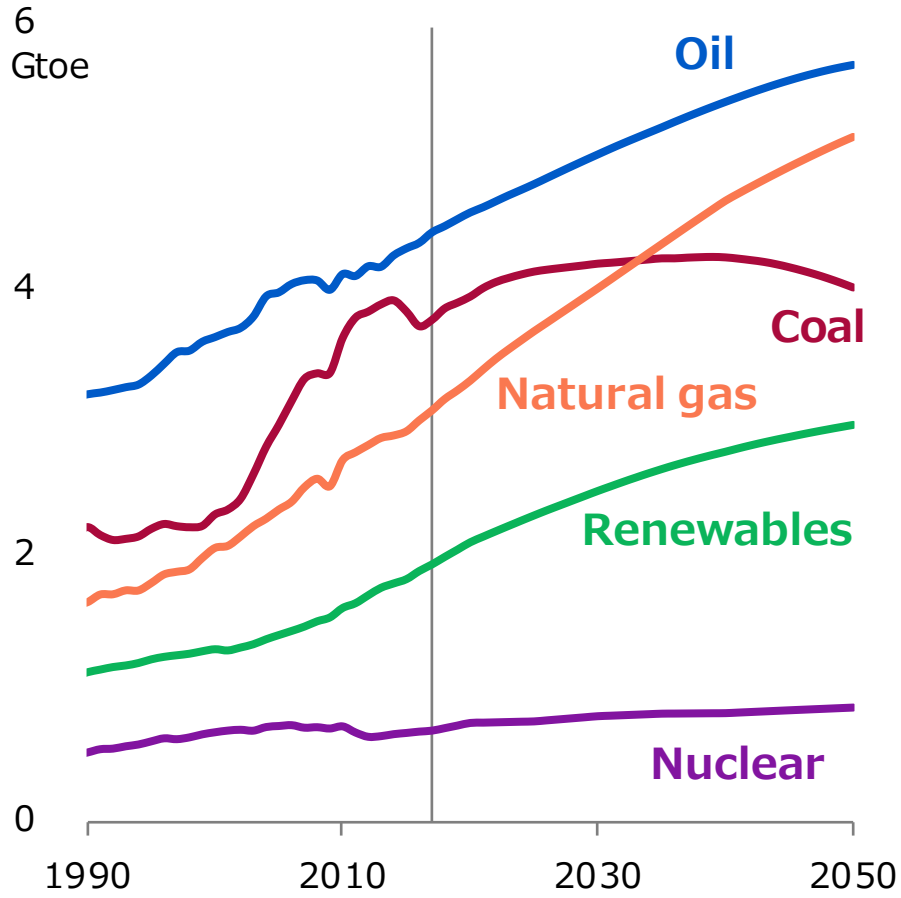


Developing Asia increases dependence on Middle East oil and mitigating risk of supply disruption remains one of the priority issues.

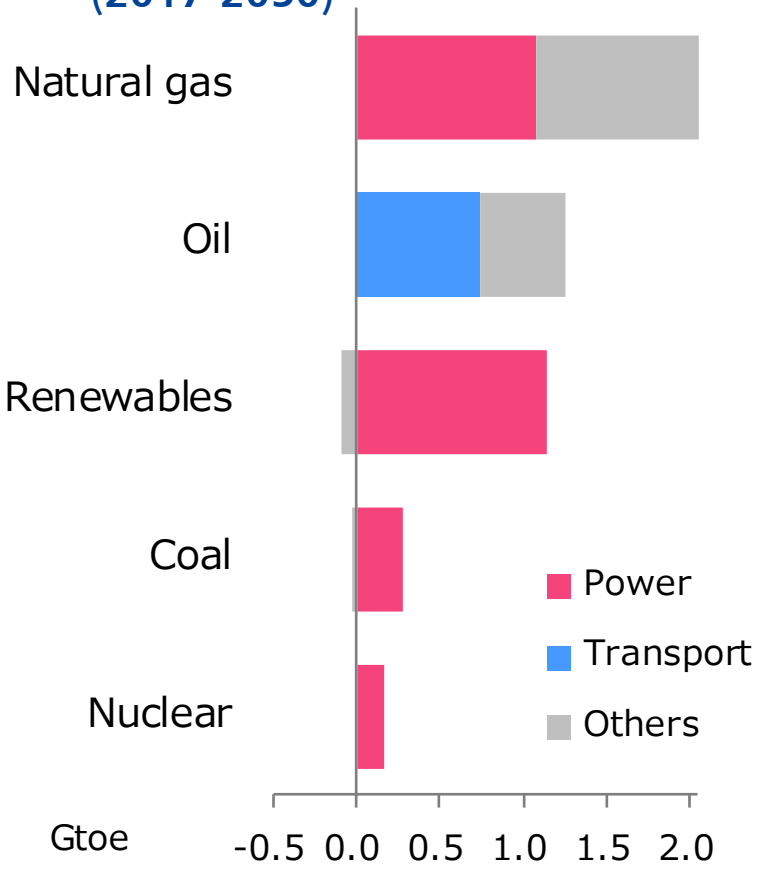
Meanwhile, North America and Advanced Europe reduce the dependence rapidly but would be affected by higher oil price when emergency due to higher dependence at the global level.

Dependency to fossil fuels remains unchanged

❖ Primary energy demand



❖ Change in energy demand (2017-2050)

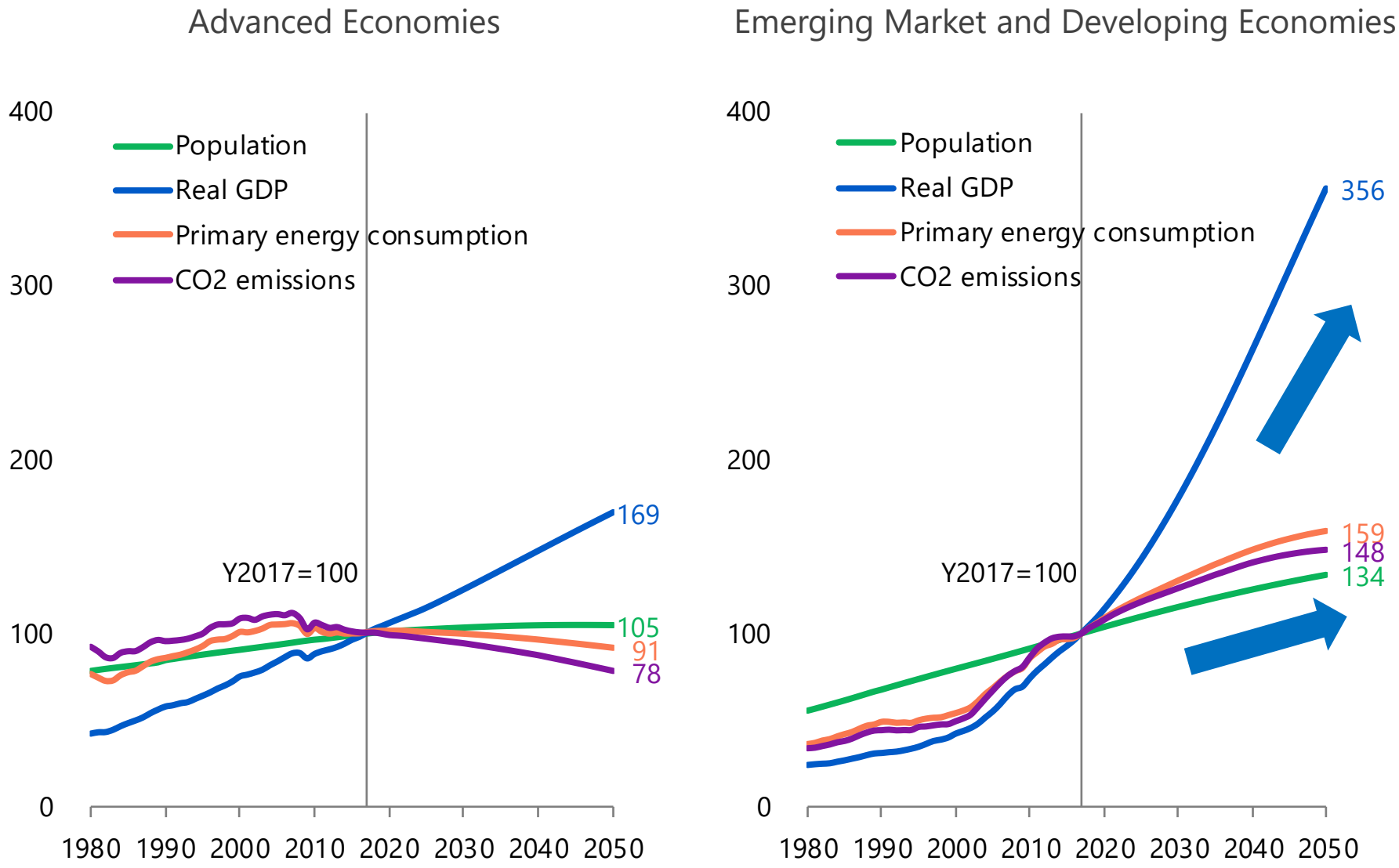


Natural gas increases by 1.7 times especially in the power sector, becoming a second-position energy.

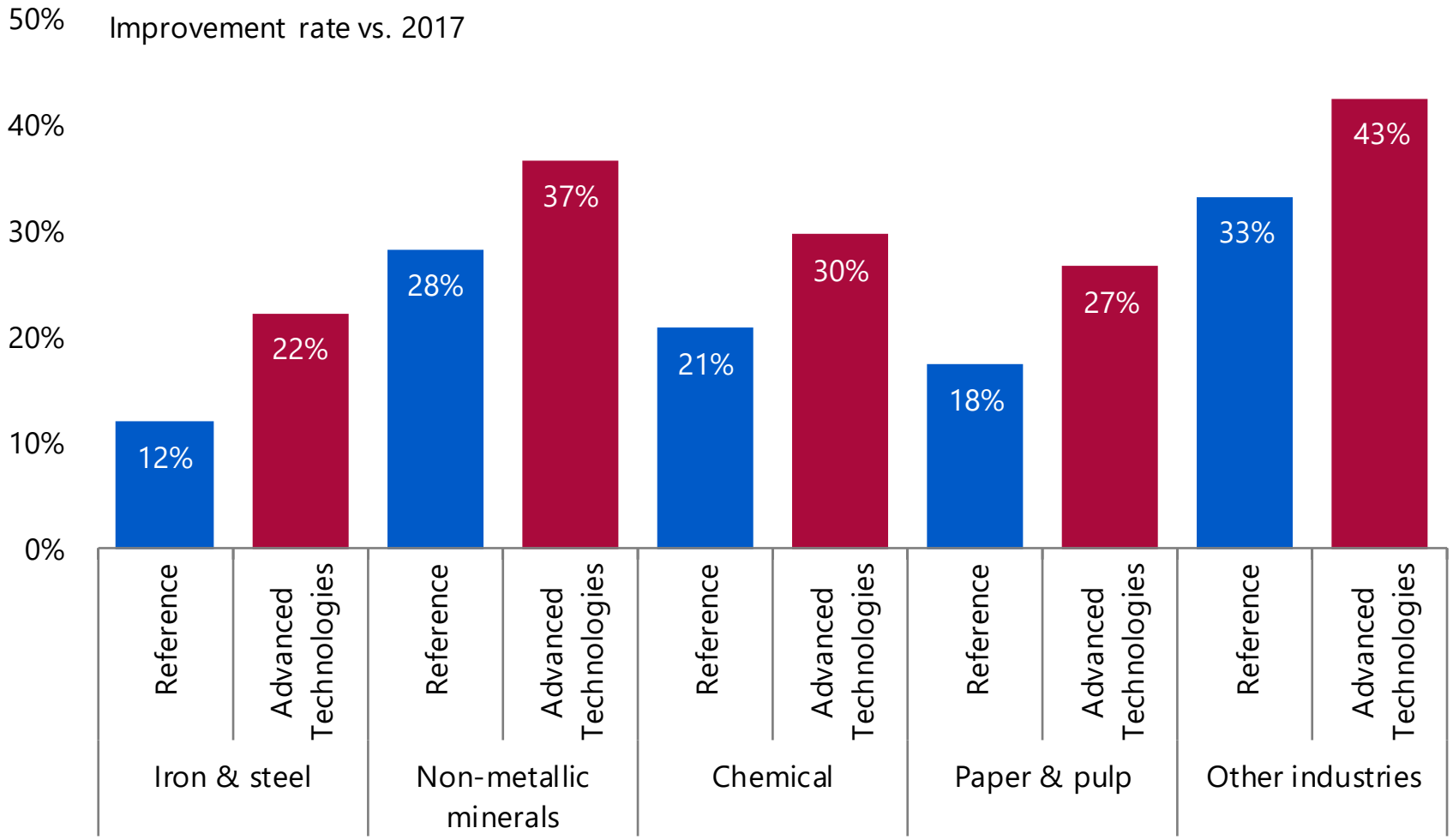
Coal peaks around 2040 and oil remains the most important energy.

Renewables grow rapidly but their share of primary demand mix increase only to 16% from 14%. Lessing dependency on fossil fuels progresses slowly.

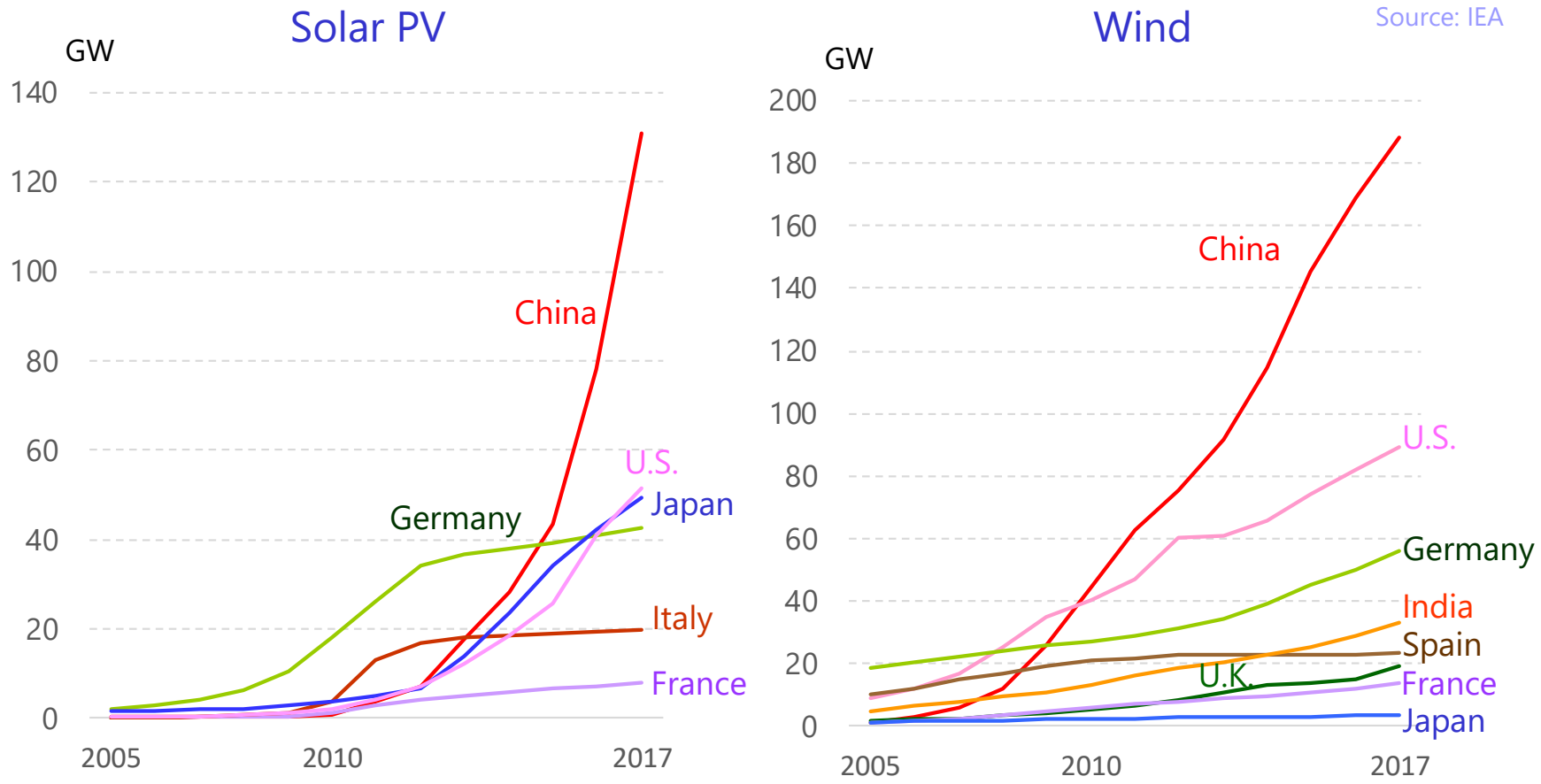
Population, GDP, energy and CO_2



Energy intensity improvement in industry sector



Expanding installed capacity of VREs

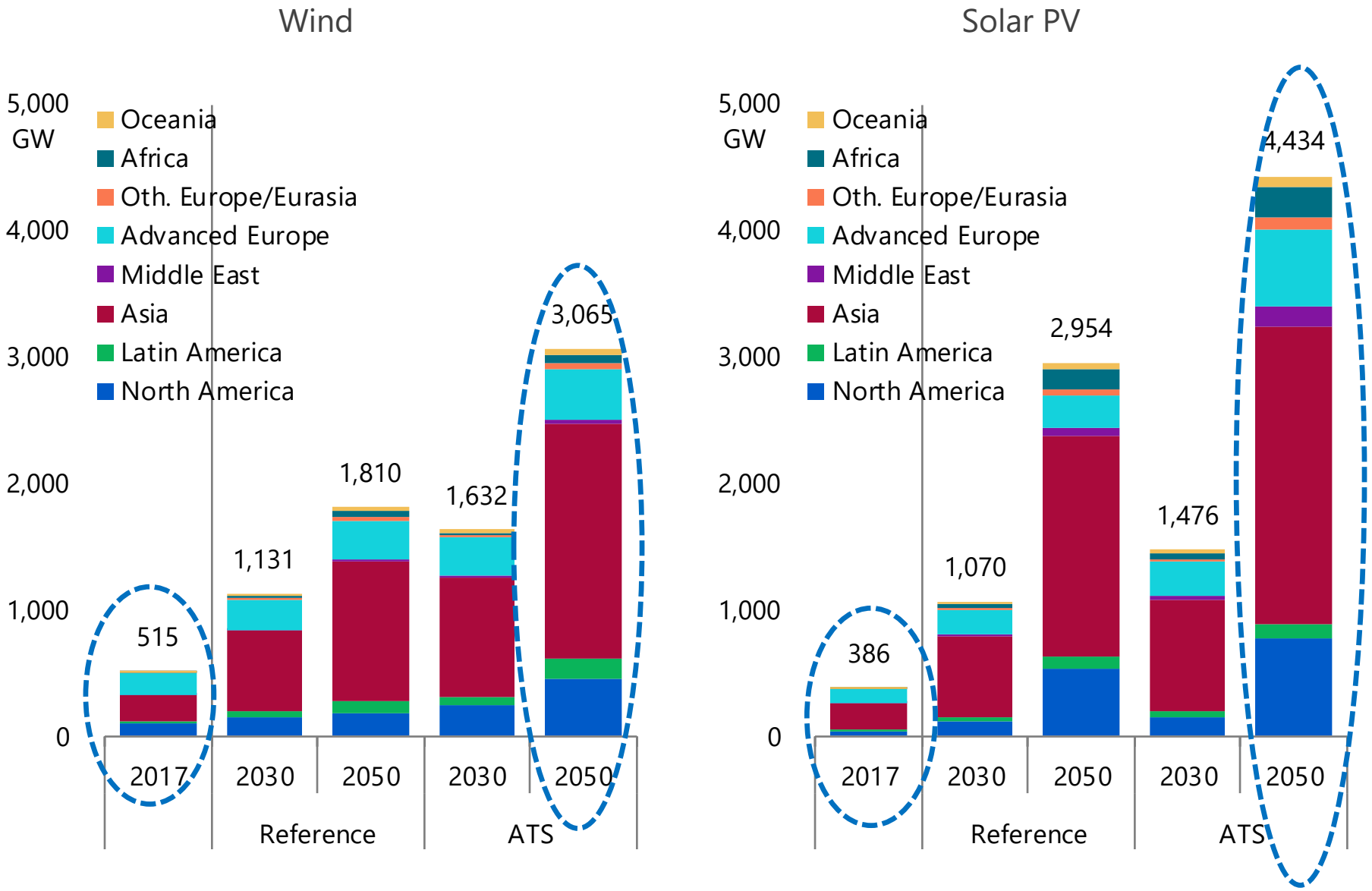


Source: IEA

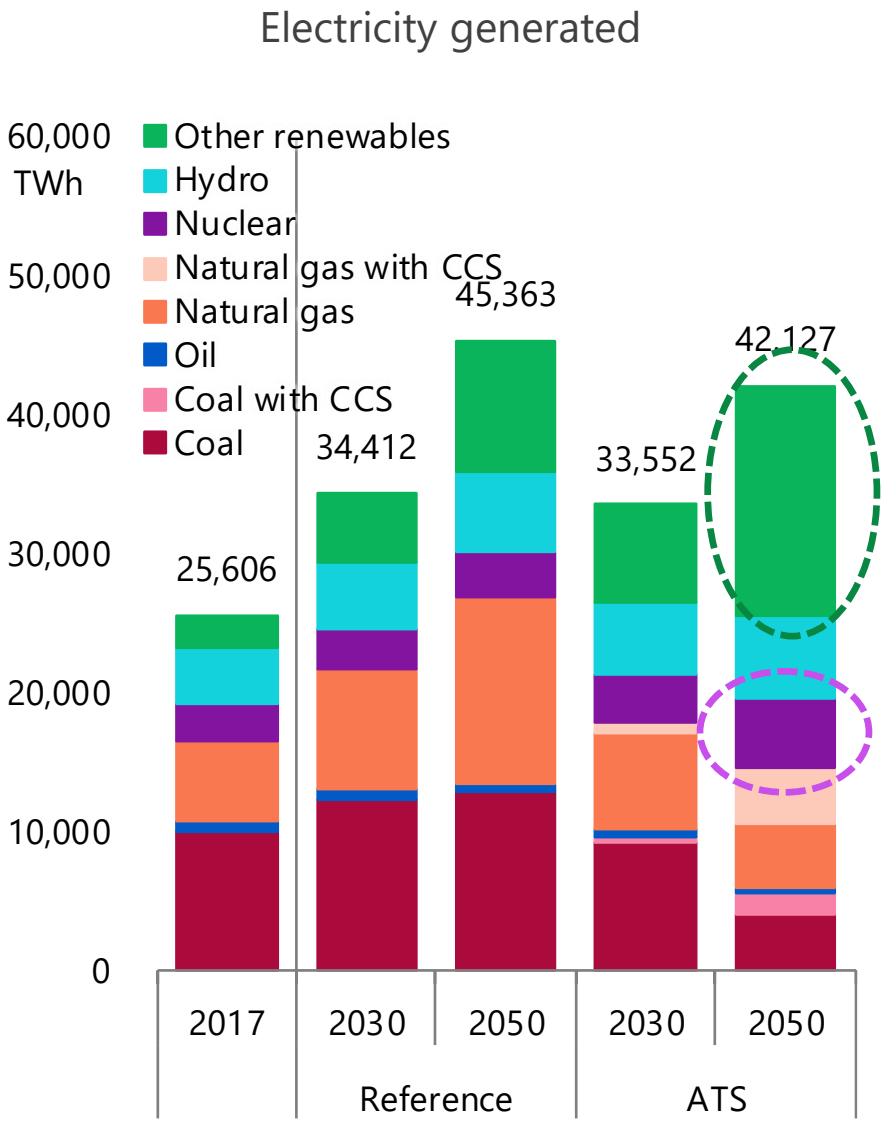
- Recent trends exhibit rapid expansion of the power generating capacities of ***Variable Renewable Energies (VREs)***, such as solar and wind, due to continuous cost declines and growing concerns over climate change issues.

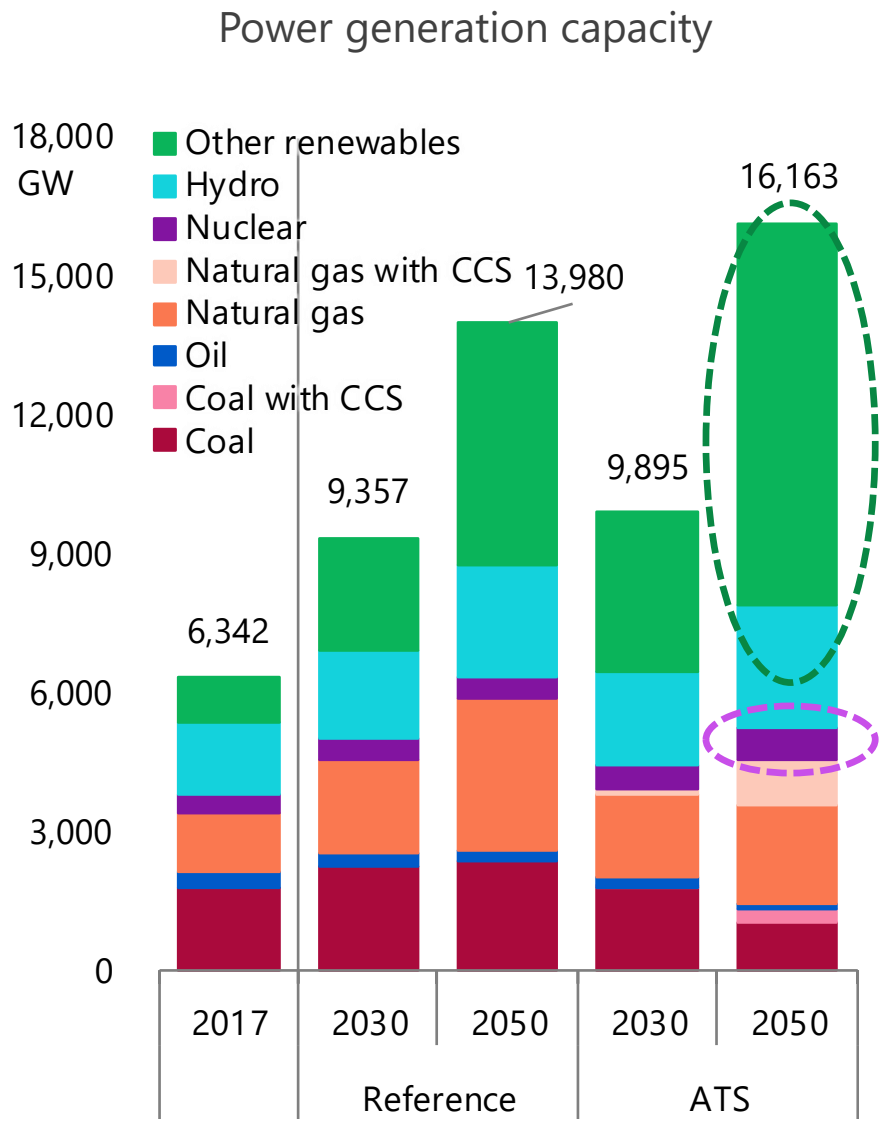
- VREs are expected to continue the rapid expansion in the long-term, although we should anticipate several challenges as stated below.

Wind and solar PV power generation capacity



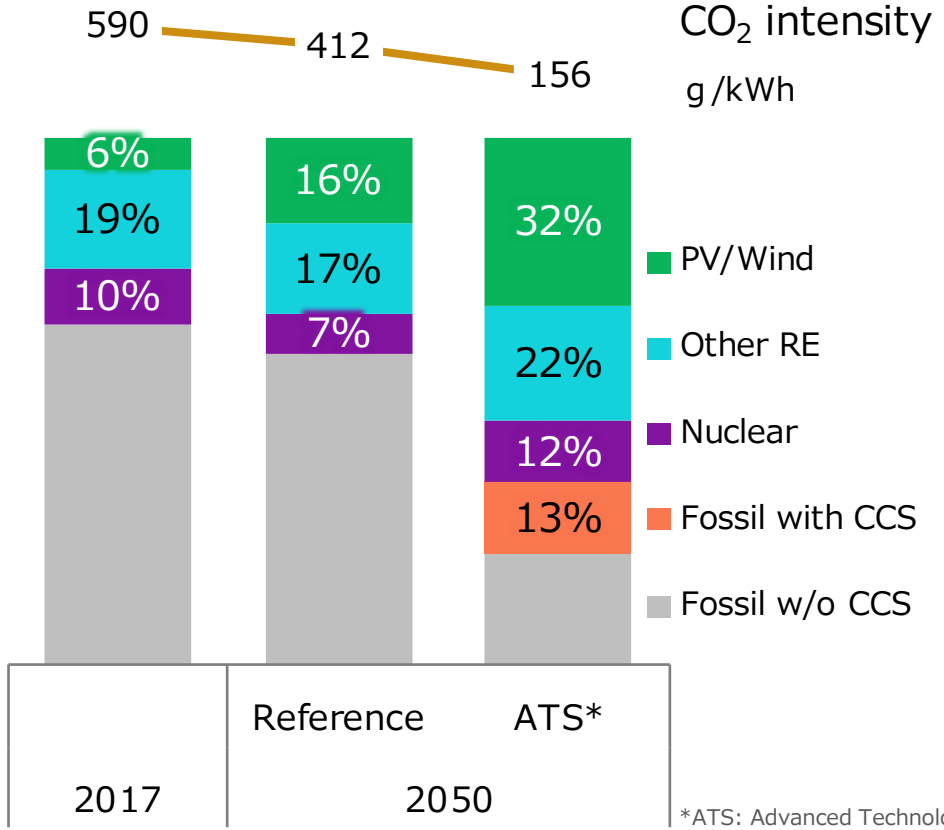
Power generation mix





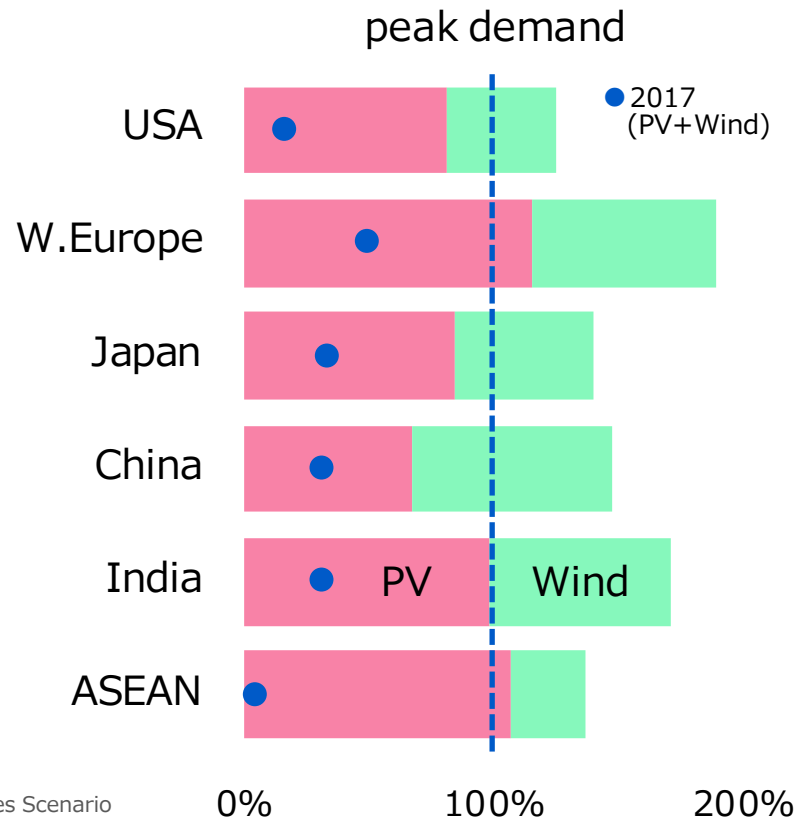
VRE capacity surpass peak demand

❖ Power mix and CO_2 intensity



*ATS: Advanced Technologies Scenario

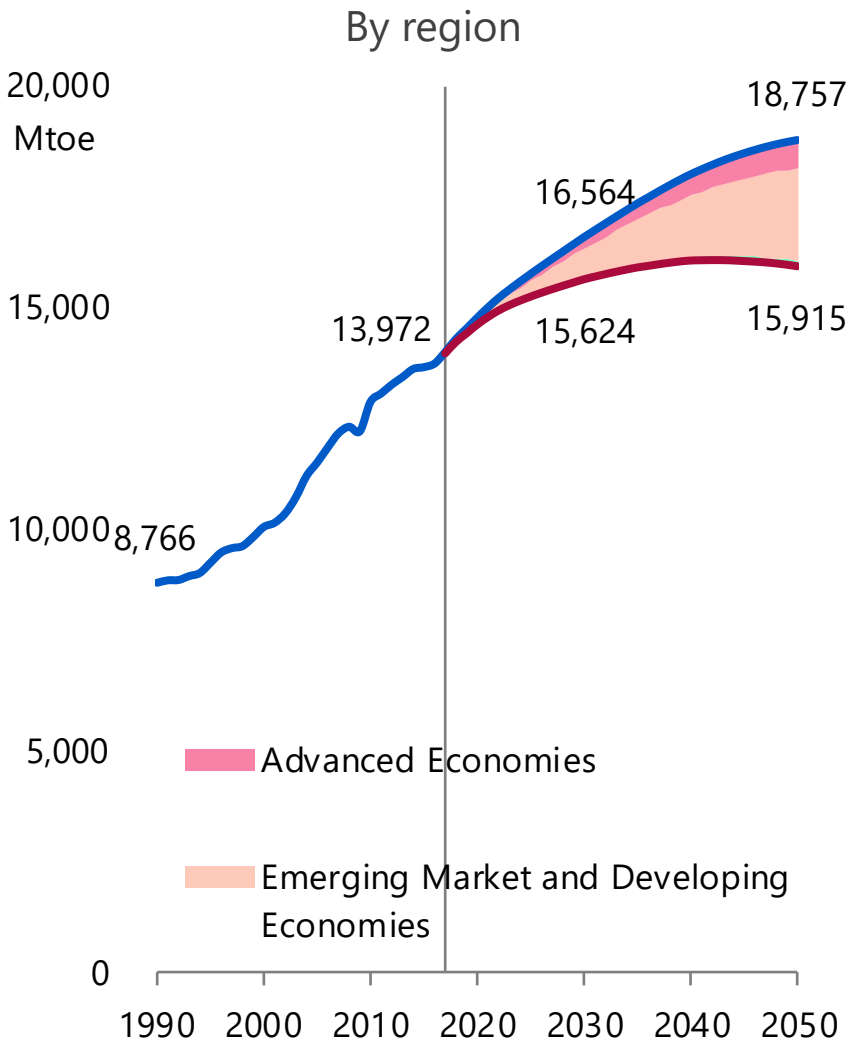
❖ Ratio of capacity to peak demand (2050, Advanced Tech.)

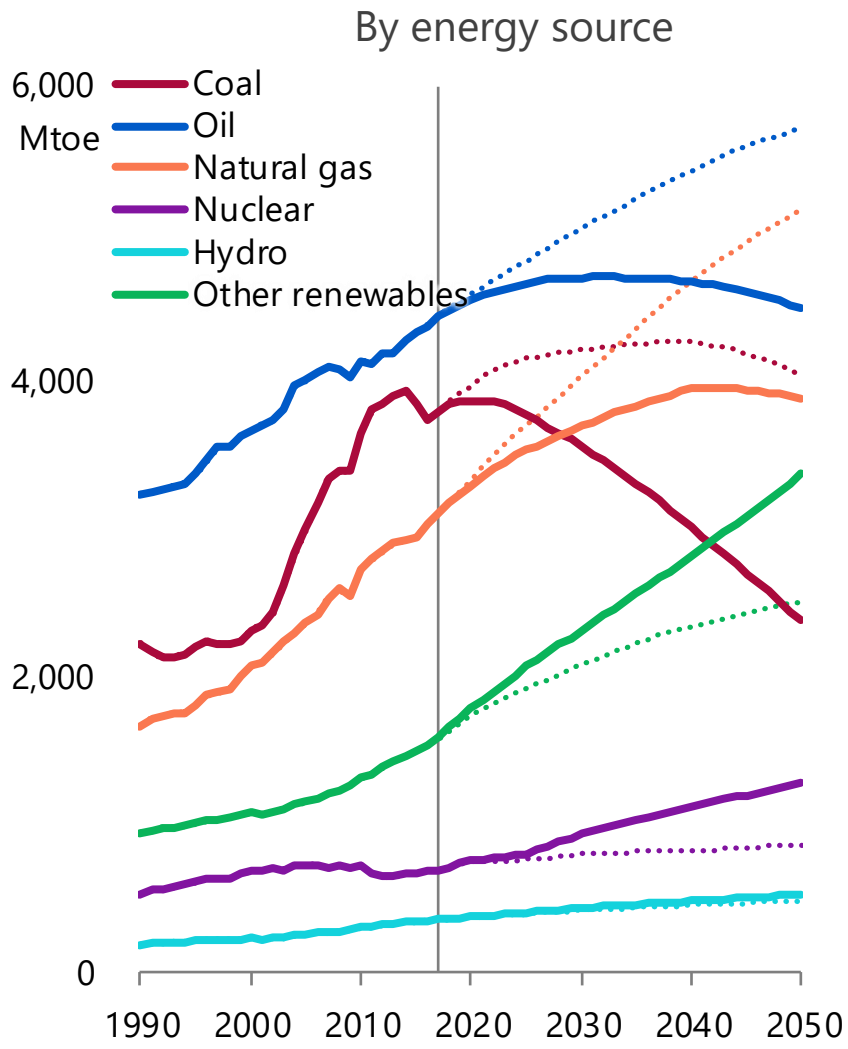


Zero-emission power generation (renewables, nuclear and fossil thermal with CCS) dominates 80% of power generation mix in the Advanced Technologies Scenario.

Generation capacity of variable renewable energy (VRE), such as solar PV and wind, exceeds peak electricity demand. Some regions need system stability measures, such as battery storage.

Primary energy consumption

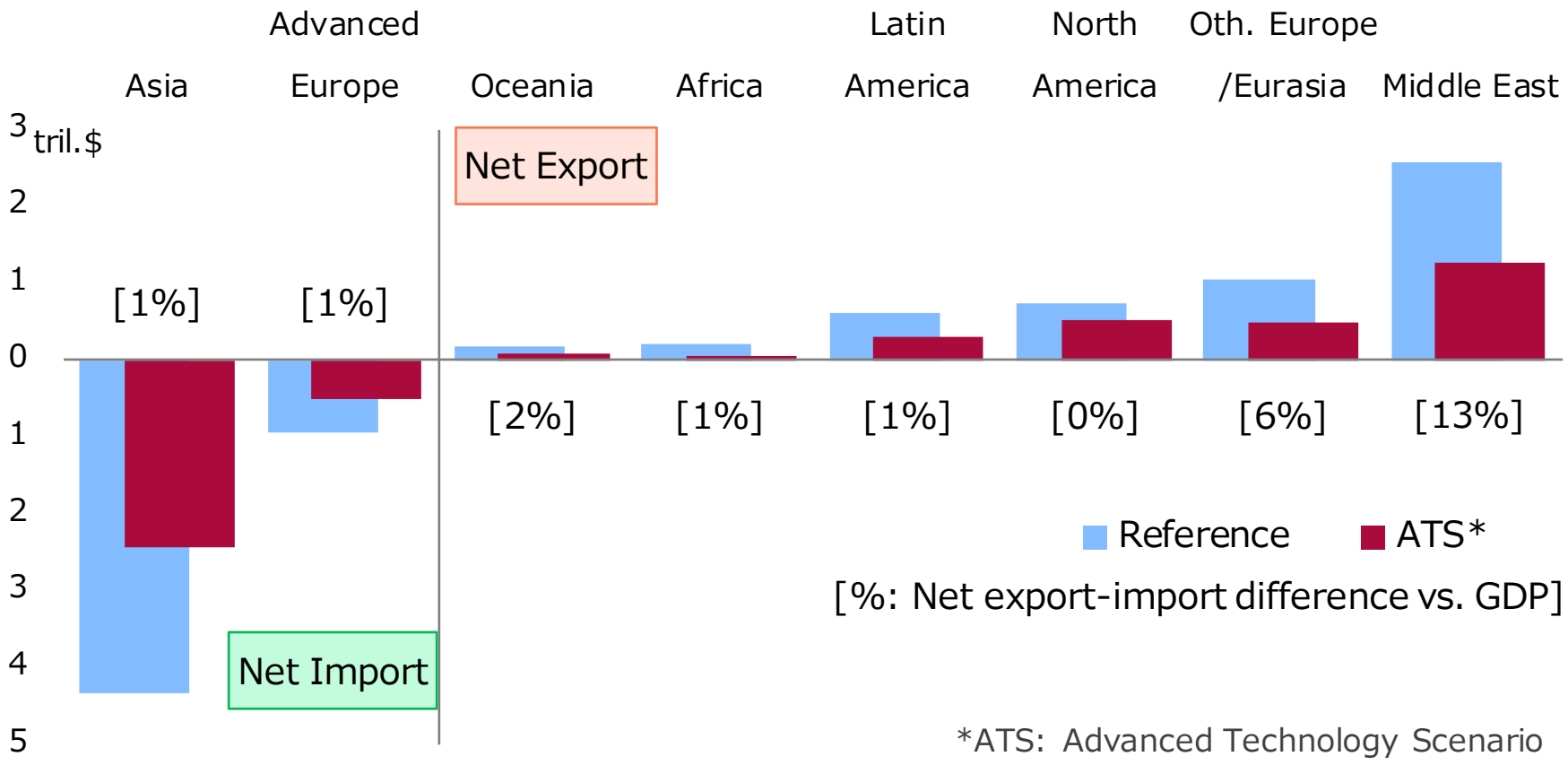




Note: Solid lines stand for Advanced Technologies Scenario and dotted lines stand for Reference Scenario.

Unclear oil revenue for the Middle East

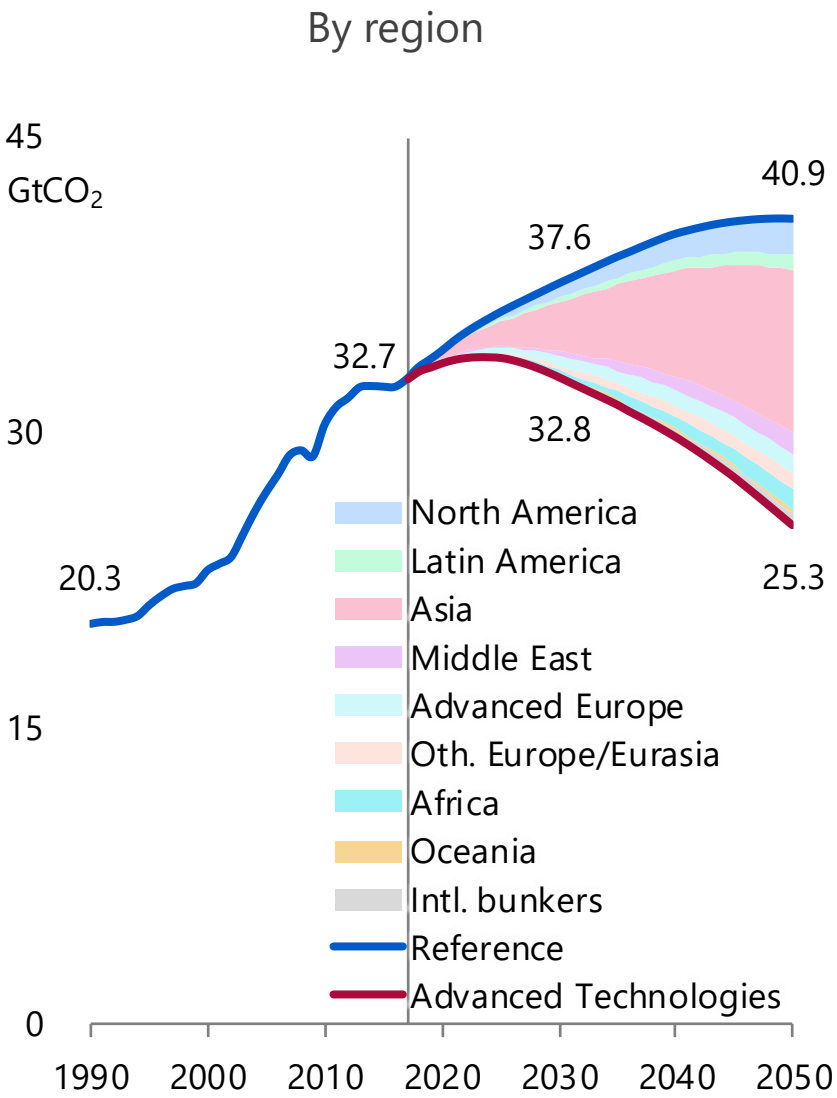
❖ Net energy exports / imports by region (2050)

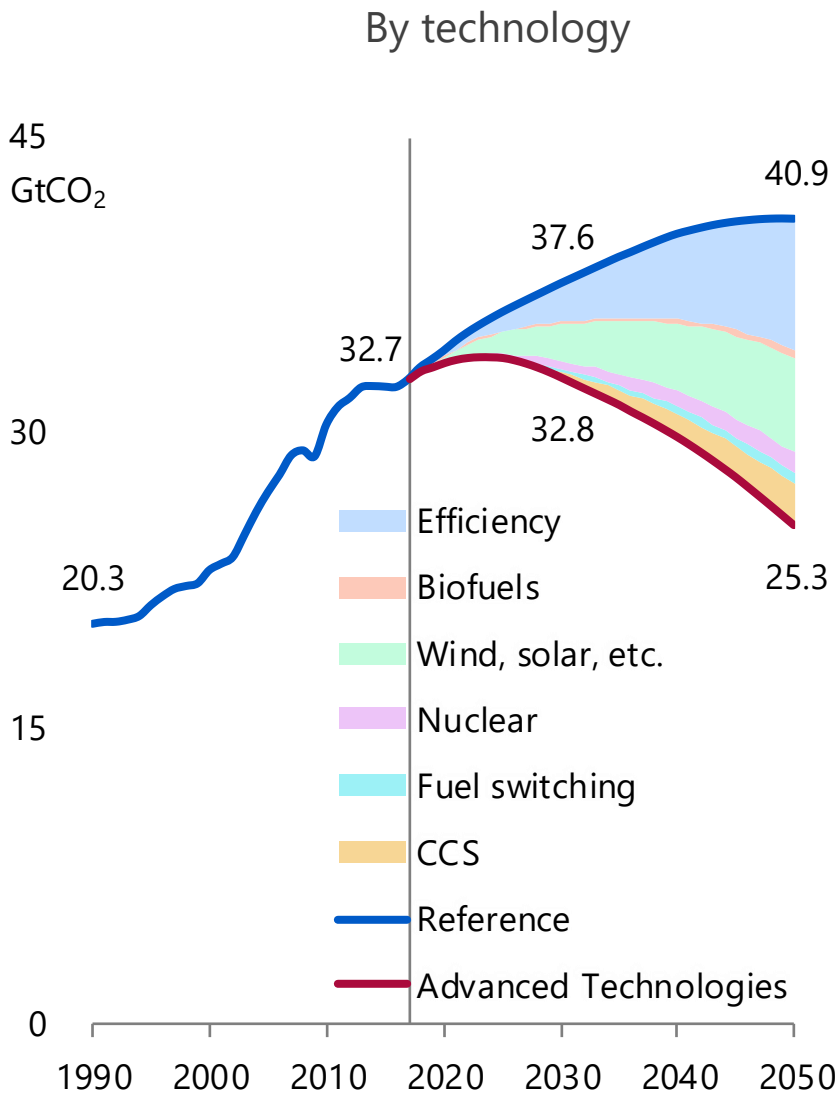


In the Advanced Technologies Scenario, demand growth of fossil fuels slows and prices are lower than in the Reference Scenario.

Asia and Advanced Europe can reduce net import bills a lot. Meanwhile, oil and gas export revenues for the Middle East could decrease by the equivalent to 13% of its GDP.

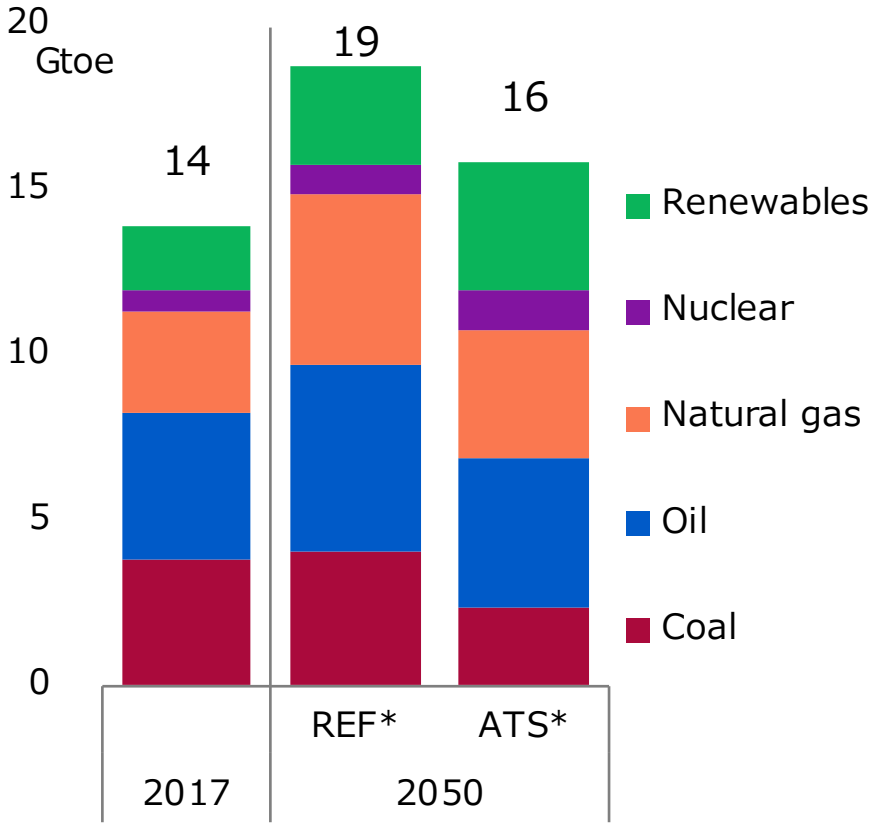
Energy-related CO_2 emissions





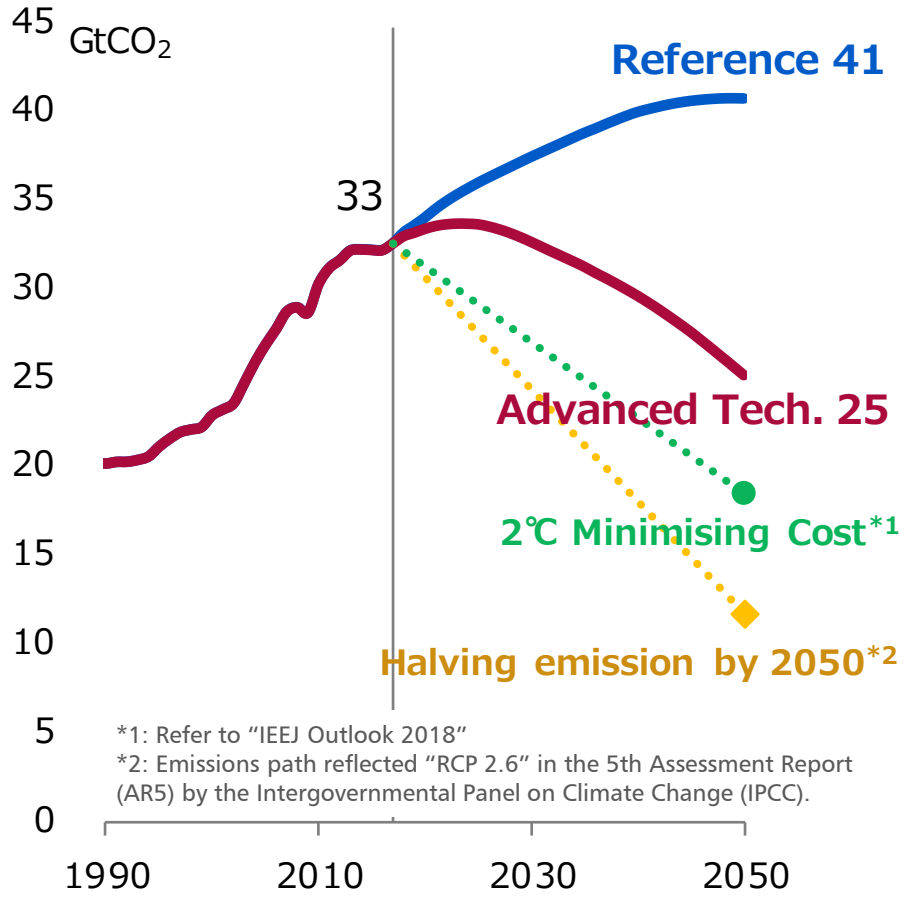
Even after large reduction, 2° C goal still far

❖ Primary energy demand



*REF: Reference Scenario, ATS: Advanced Technologies Scenario

❖ Energy-related CO_2 emissions



*1: Refer to "IEEJ Outlook 2018"
*2: Emissions path reflected "RCP 2.6" in the 5th Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC).

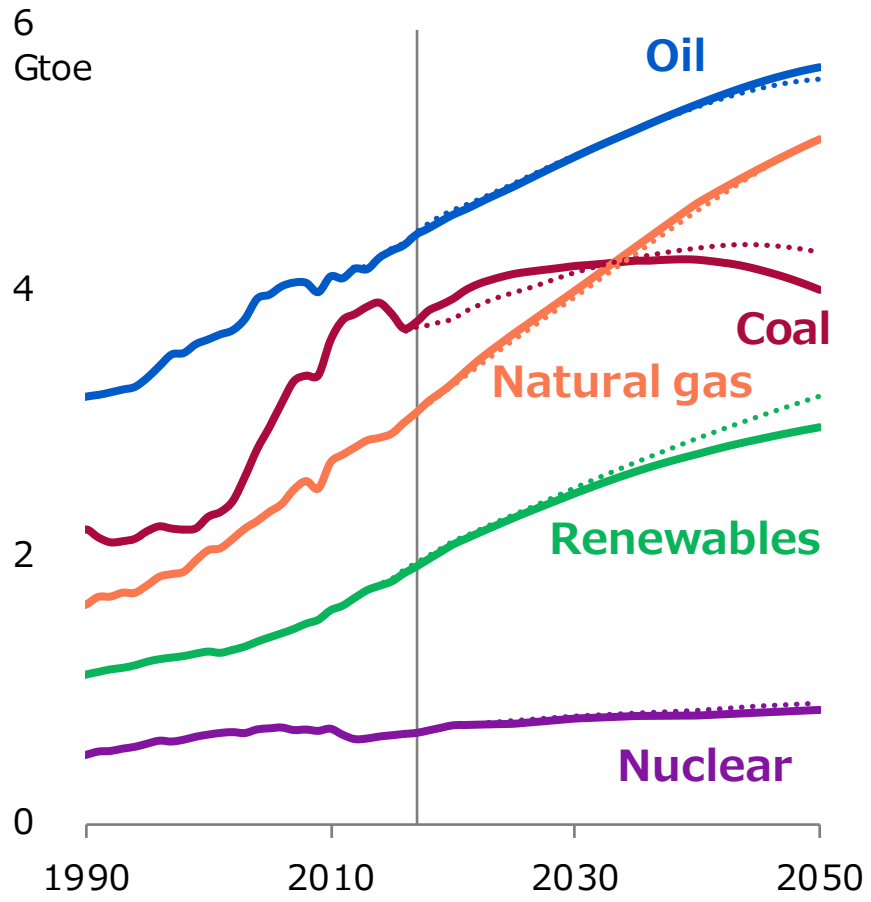
In the Advanced Technologies Scenario, dependence on fossil fuels drops to 70%, still high level.

Energy-related CO_2 emissions peak at the middle of 2020s and decrease by 23% vs. 2017 in 2050.

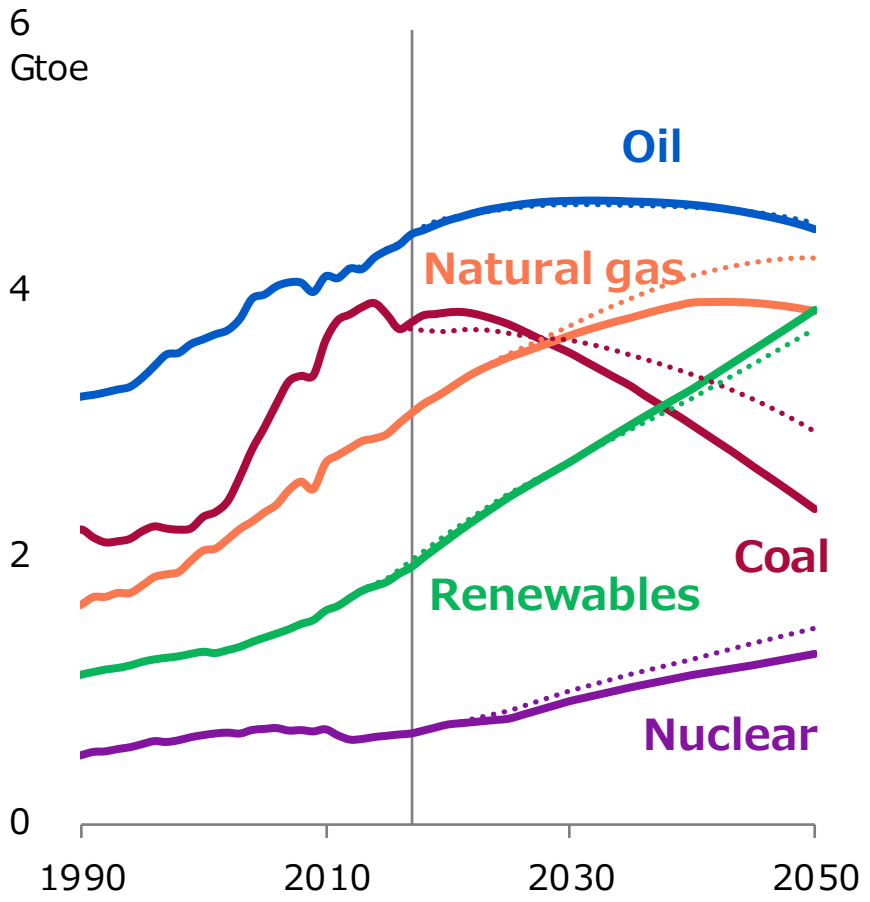
To keep temperature rise to below 2 degrees Celsius, additional programs and innovative technologies are required.

Comparison with IEEJ Outlook 2019

❖ Reference Scenario



❖ Advanced Technologies Scenario

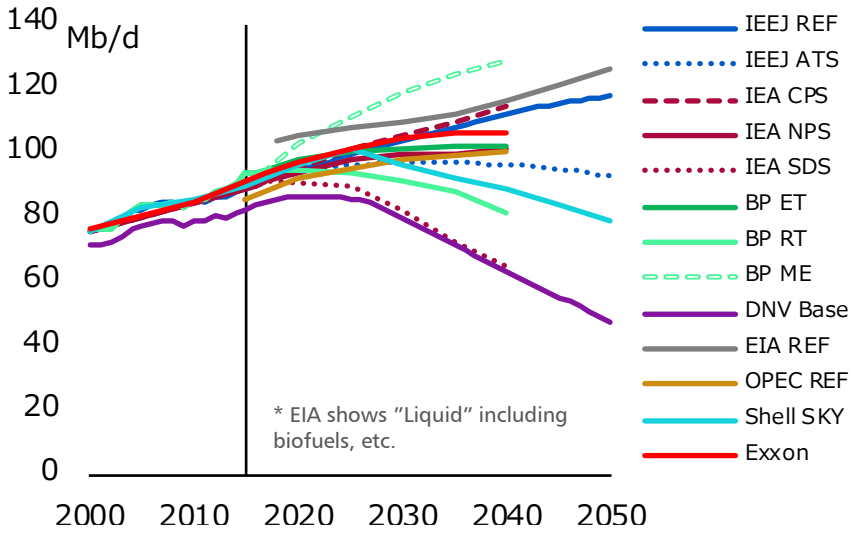


* Primary energy demand
Solid lines: IEEJ Outlook 2020
Dotted lines: IEEJ Outlook 2019

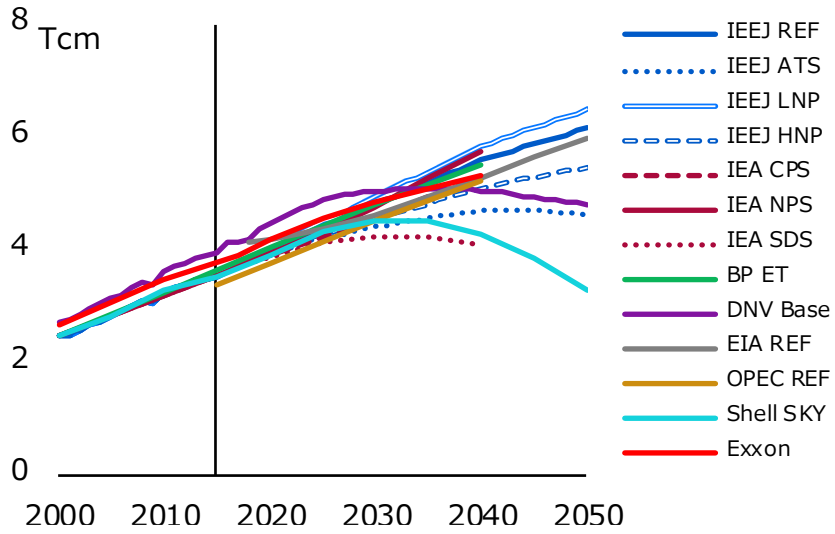
Reference material

Comparison with other institutes (1)

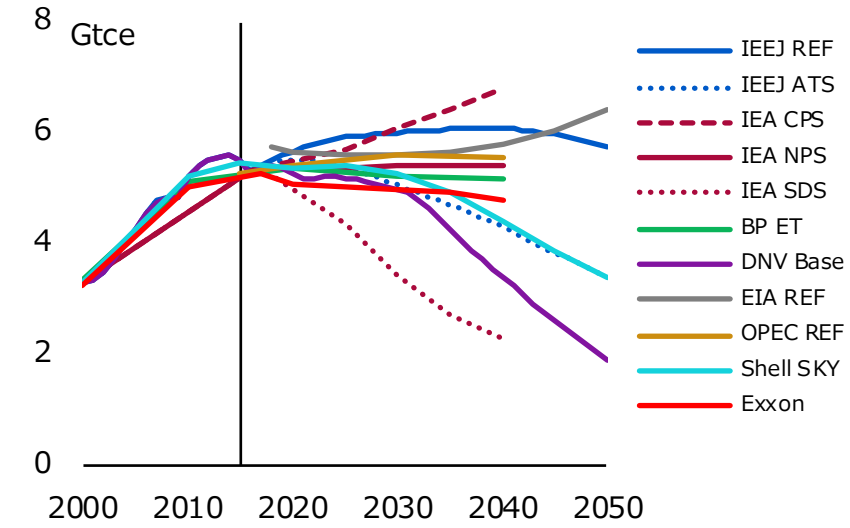
Oil



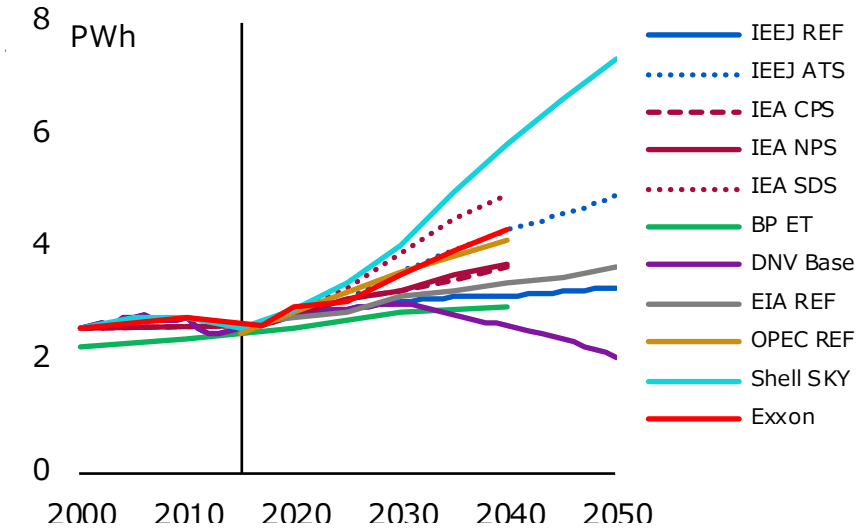
Natural gas



Coal



Nuclear



Summary

- ✓ Only emerging and developing economies increase energy demand.
- ✓ In Asia, demand growth overwhelms supply growth and it increases energy imports. Dependence on ME oil increases
- ✓ The Middle East urgently needs of shifting away from an economy that depends on oil export revenues.
- ✓ In the Advanced Technologies Scenario, generation capacity of VRE exceeds peak demand.
- ✓ Dependence on fossil fuels is still high, resulting in falling short of the 2°C goal. **R&D for innovative technologies is required**.

Challenges for the power sector under high penetration of variable renewable energies

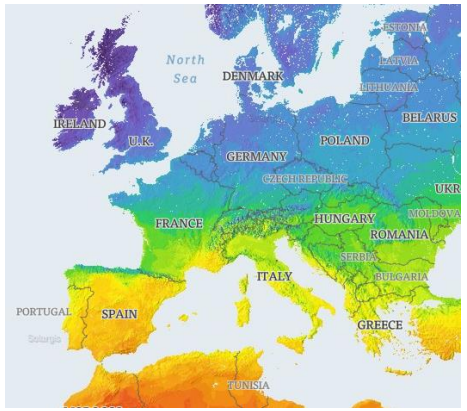
Distributed VRE resources

※1: Obtained from the "Global Solar Atlas 2.0", a free, web-based application is developed and operated by the company Solargis s.r.o. on behalf of the World Bank Group, utilizing Solargis data, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalsolaratlas.info

※2: Obtained from the "Global Wind Atlas 2.0", a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU) in partnership with the World Bank Group, utilizing data provided by Vortex, with funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalwindatlas.info

Solar

Europe

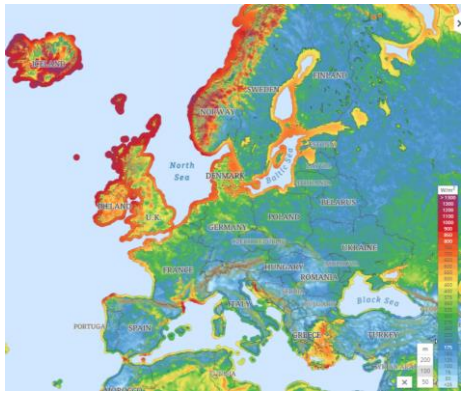


ASEAN

Source:
Global Solar Atlas※1

Wind

Europe

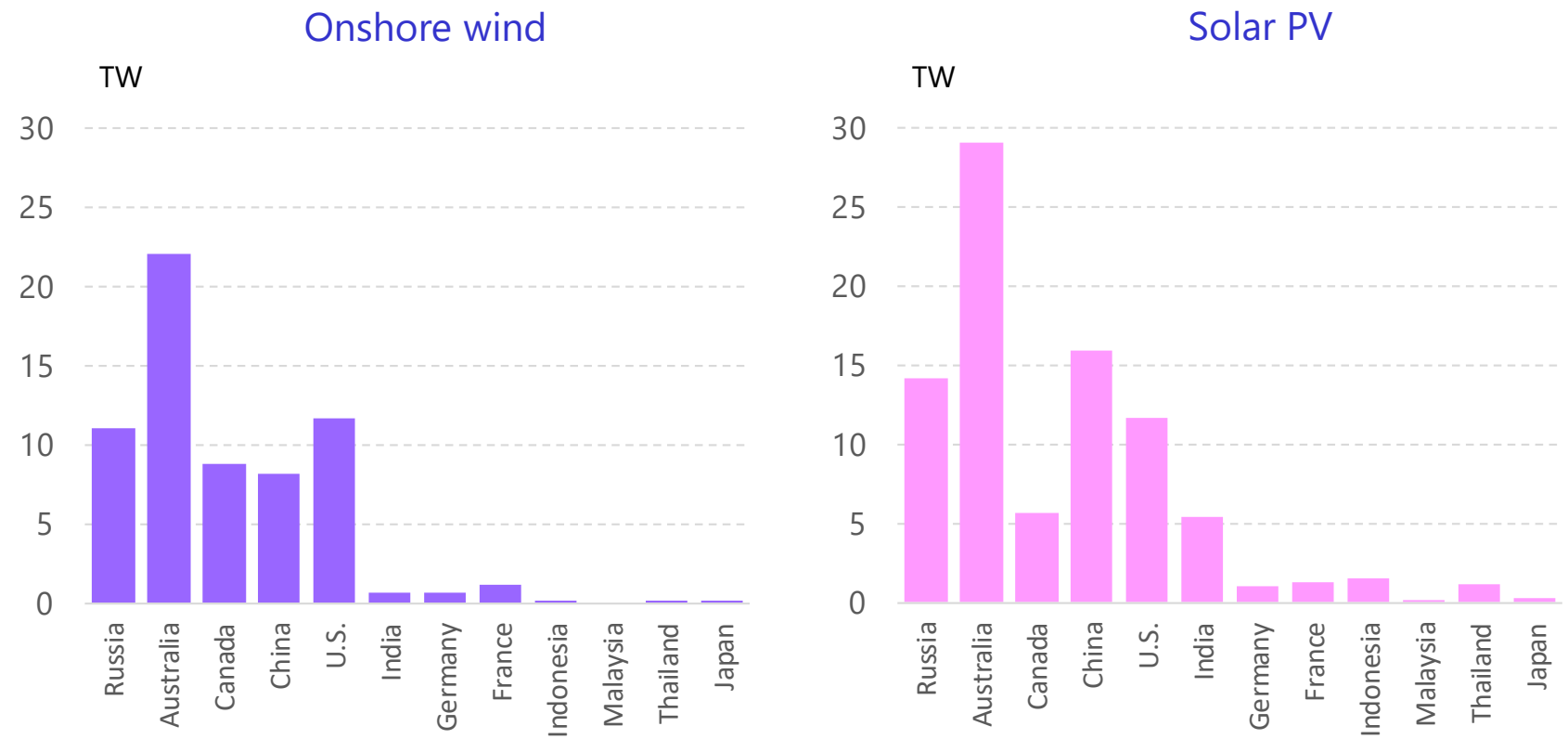


ASEAN

Source:
Global Wind Atlas※2

· ***VRE resources differ significantly across regions.*** While wind power resources are abundant in Europe, ASEAN countries see relatively scarce resources except for those in specific areas in Vietnam and the Philippines.

Estimated VRE resources for selected countries

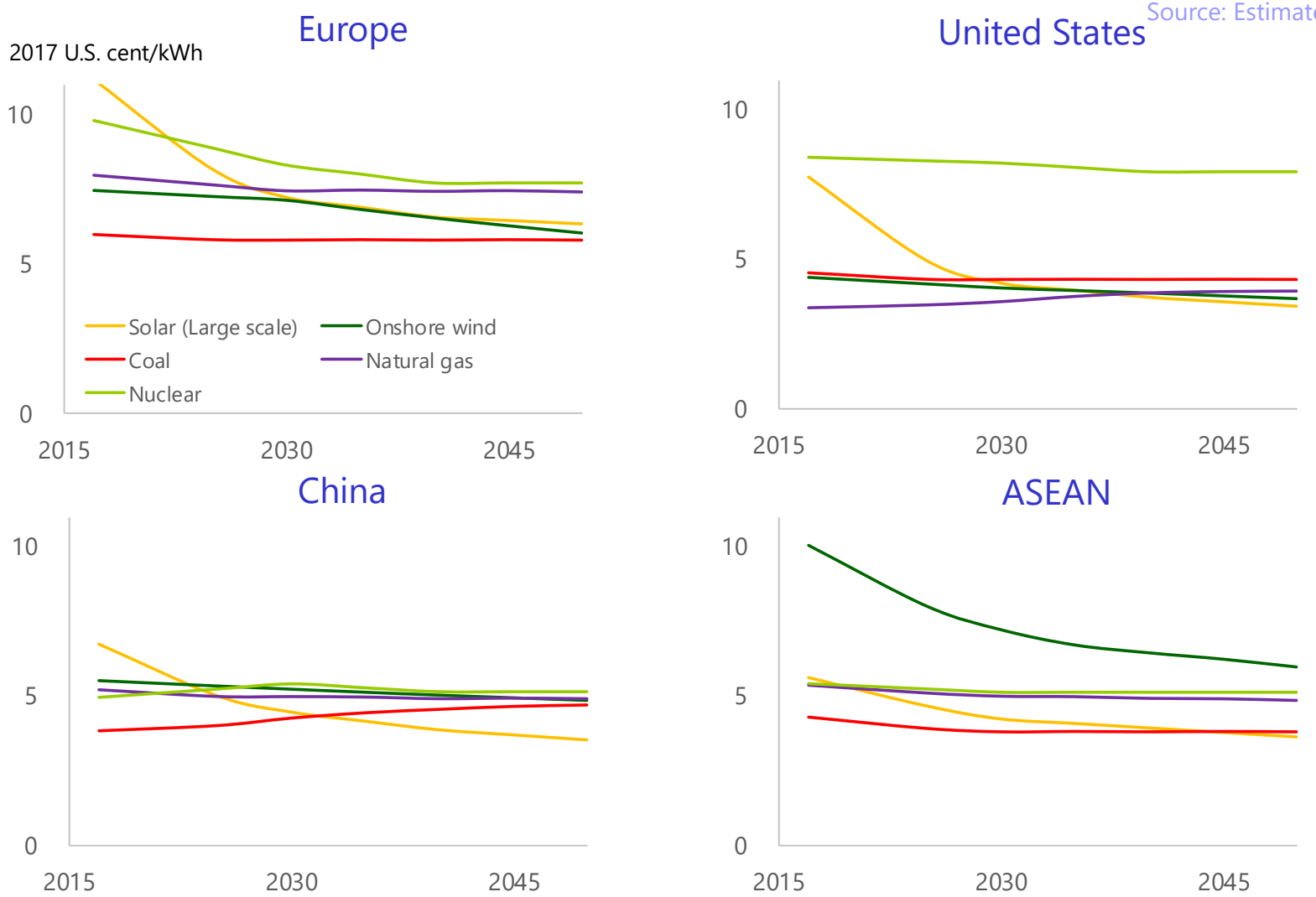


Source: Estimated by IEEJ using GIS data

- Huge VRE resources exist in the countries with large geographic areas, such as Russia, Australia, China, and U.S. Total wind and solar resources can cover all the global energy demand.
- Solar resources are relatively scarce in high-latitude countries, whereas most Asian countries are not endowed with large wind resources.

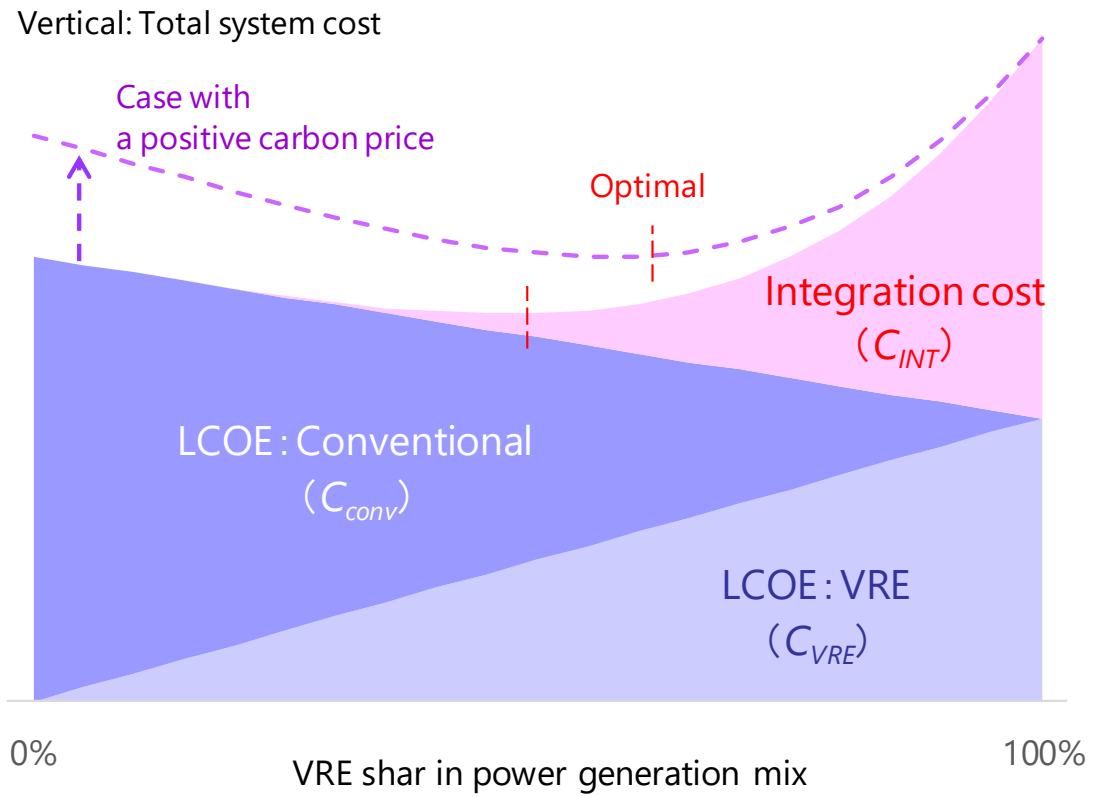
Levelized cost of electricity **generation** (LCOE)

Source: Estimated by IEEJ



- Levelized Cost of Electricity (LCOE) is a metric that has long been used for assessing the specific cost of power generating facilities.
- The LCOE of VREs has been declining rapidly over decades. By 2050, ***the LCOE of solar PV is expected to become lower than that of conventional technologies***, in many region across the world.

System integration cost: A **conceptual illustration**



- If the LCOE of VRE is smaller than that of conventional power sources, the "traditional" power generation cost, which represents the costs proportional to the LCOEs, shown as C_{conv}+C_{VRE} in the above figure, declines with increasing share of VRE.

- However, high penetration of VRE requires additional cost related to the necessity of power storage, VRE output curtailment, and grid extension, etc., known as ***system integration costs***, indicated by C_{INT} as illustrated above.

Summary: Good News and Not So Good News for VRE

- ✓ The **generating cost** of wind and solar PV has been declining rapidly.
  - ➢ By 2050, solar PV is expected to become cheaper than conventional.

- ✓ Renewable energy is **not evenly distributed** in the world.
  - ➢ **Solar** resources are relatively scarce in high-latitude countries, whereas most Asian countries are not endowed with large **wind** resources

- ✓ At high VRE penetration rates , **system integration costs** rapidly increase.
  - ➢ **System integration costs** are related to
    - ✓power **storage**,
    - ✓output **curtailment**,
    - ✓**grid extension**, etc.

- ✓ In conclusion, for a successful bulk introduction of VRE, "**an enabler**" is still required.

Perhaps digitalisation ?

Thank you very much for your attention!