APEC Energy Demand and Supply Outlook 7th Edition

Selected economies RE Outlook

The 53rd Meeting of APEC Expert Group on New and Renewable Energy Technologies

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Who are we and what do we do?

APERC is the energy research arm of Asia-Pacific Economic Cooperation (APEC)

- Fostering a common understanding of energy challenges facing APEC member economies
- Researchers from 2/3 of APEC's 21 economies
- Located in Tokyo, Japan

Two flagship publications:
- Annual Energy Overview
- Triennial Energy Demand and Supply Outlook
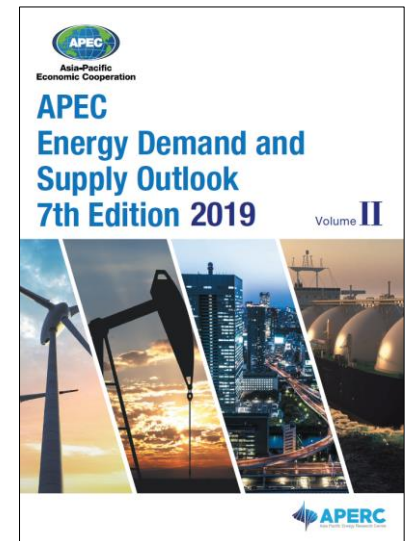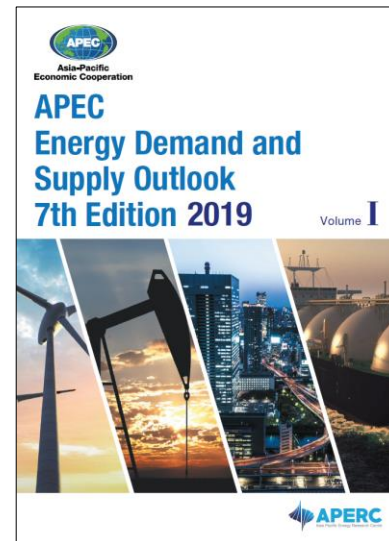
Key APEC-wide trends through 2050

- Final energy demand (FED) continues to grow, driven mainly by buildings and transport.

- Fossil fuels continue to account for at least half of FED and total primary energy supply (TPES) in 2050, in all scenarios.

- Electricity demand rises in all scenarios.

- The APEC energy intensity goal is met, but the renewable share doubling goal is not.

- Efficiency, renewables, nuclear and CCS (carbon capture and storage) are all required for COP 21 goals.

Rising GDP, population and oil prices

GDP, population and world oil price in all scenarios, 2000-50

Sources: APERC analysis, IEEJ (2018) and UN Population (2018).
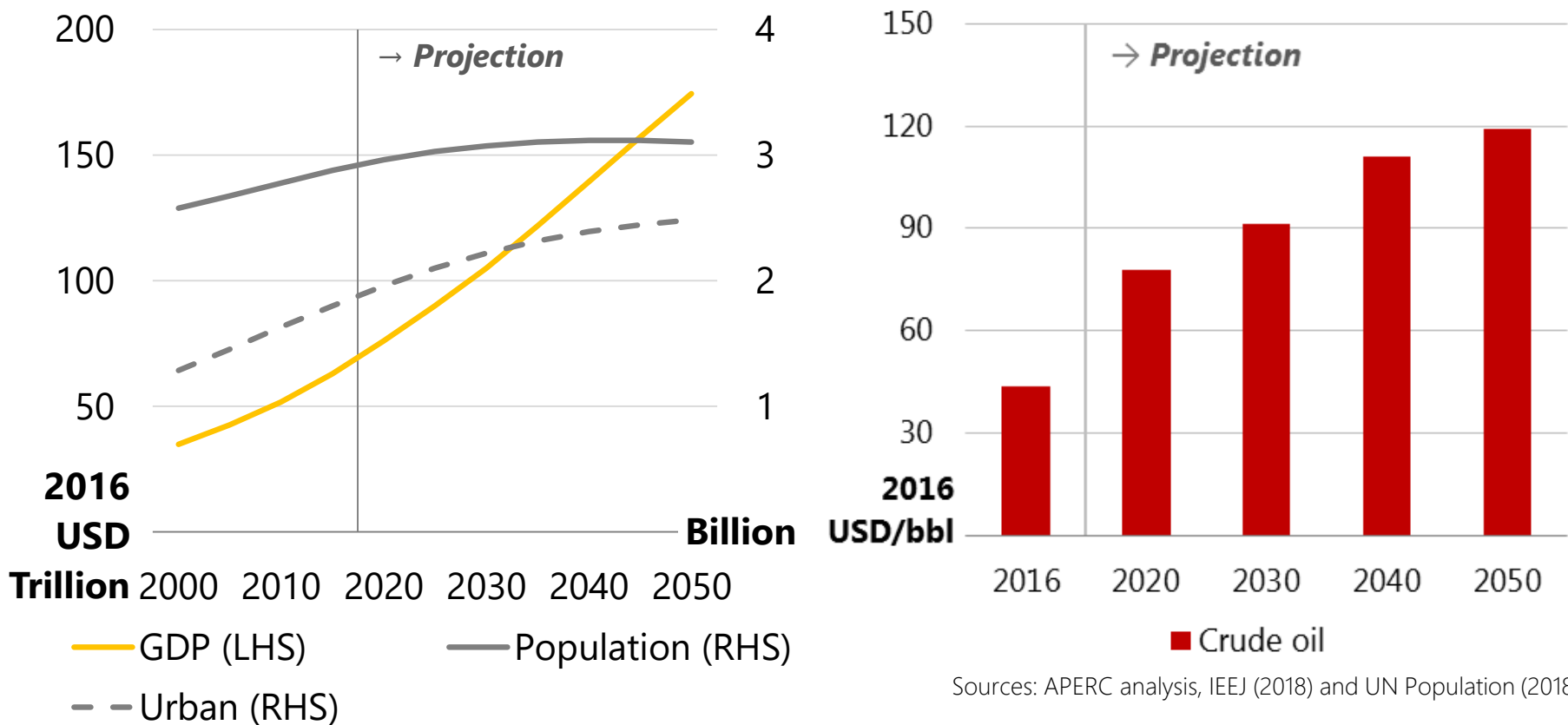
APEC real GDP in 2050 rises to about 2.7 times that of 2016. Population exceeds 3 billion by 2023. World oil prices increase steadily.
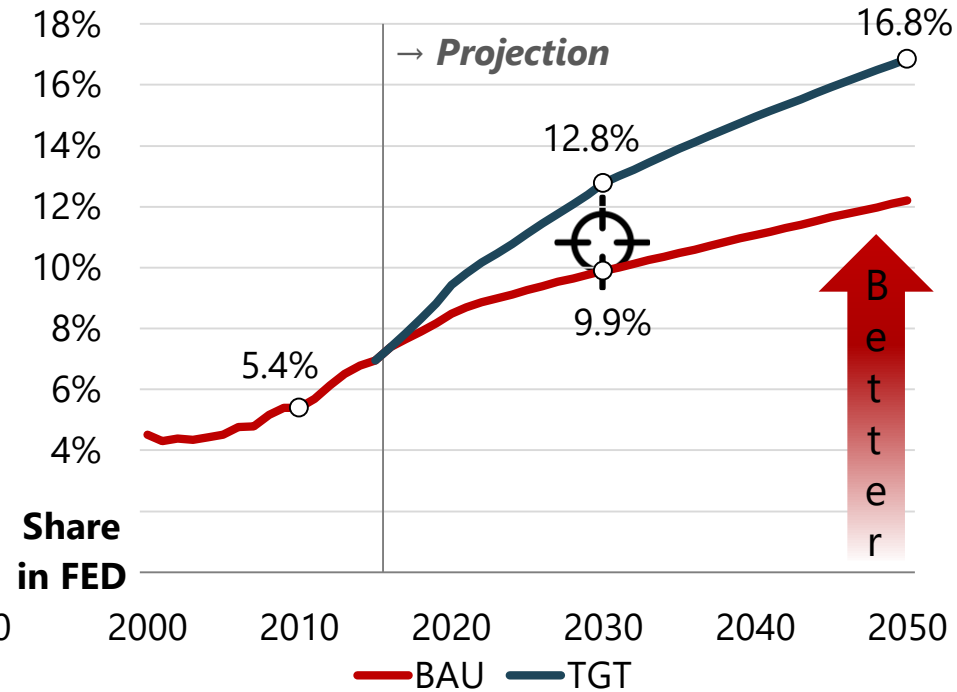
Scenarios

Business-as-Usual (BAU)	APEC Target (TGT)	2-Degrees Celsius (2DC)
Recent trends and current policies.	Pathway that achieves APEC-wide goals to • reduce energy intensity 45% by 2035 • double the share of renewables by 2030.	Pathway that provides a 50% chance of limiting the average global temperature rise to 2°C.
Provides a baseline for comparison.	Explores implications of alternative scenarios and identifies gaps to overcome.	

APEC has two aspirational energy goals

Energy Intensity Goal (2005-35)

→ *Projection*

Better

53%
57%
70%

Index (2005=100)

BAU   TGT
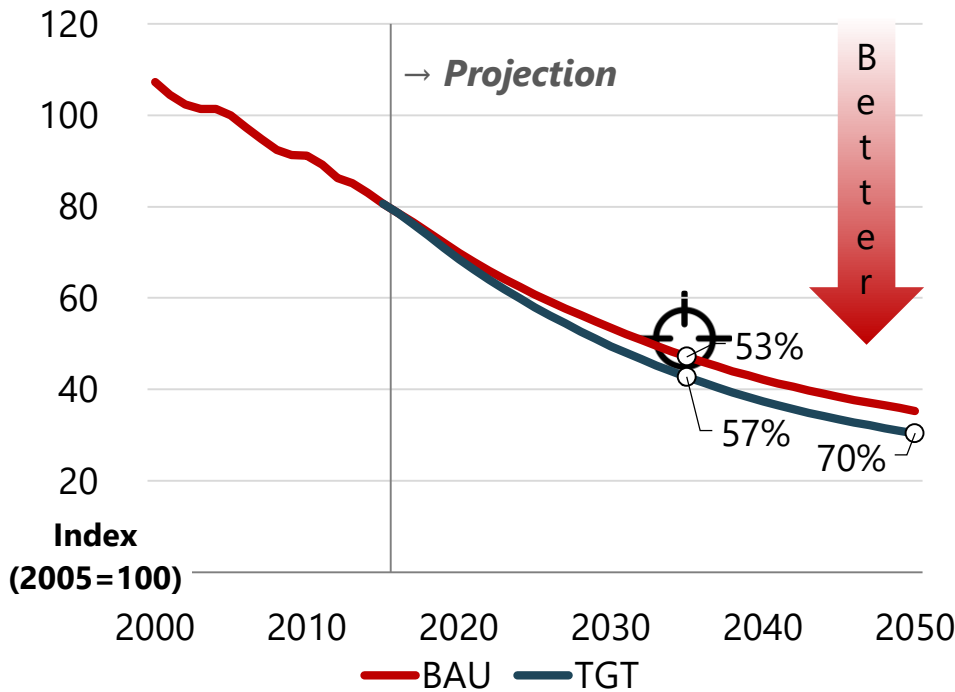
Renewable Share Goal (2010-30)

→ *Projection*

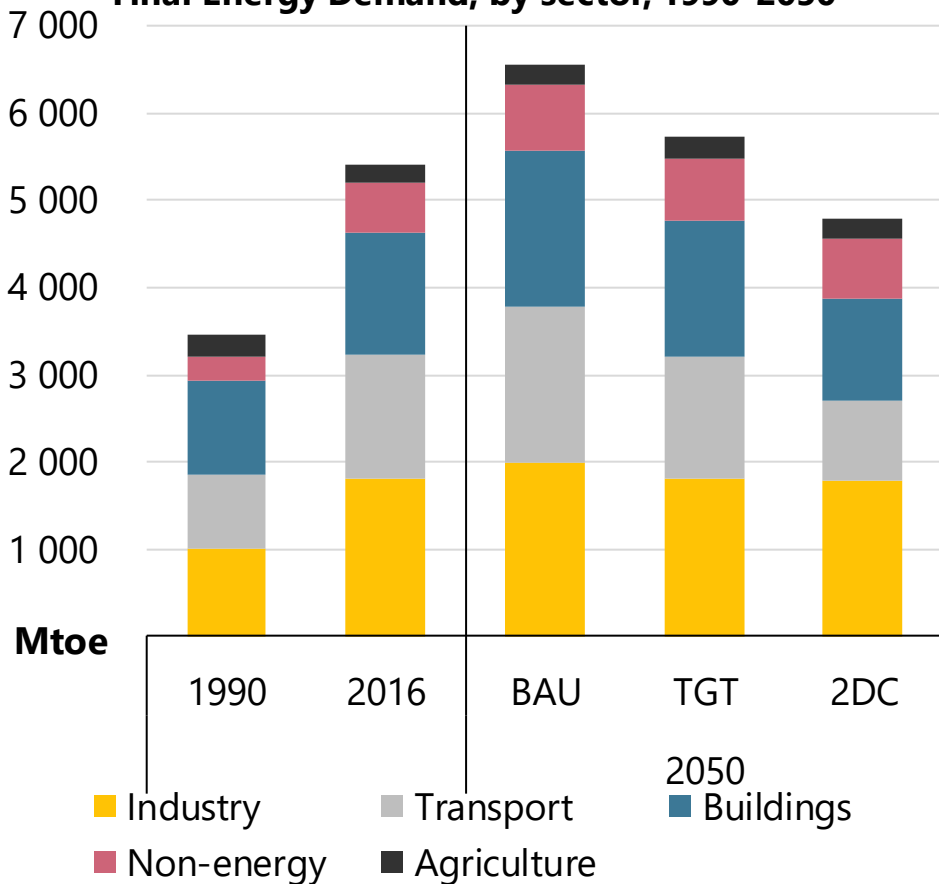16.8%
12.8%
9.9%
5.4%

Better

Share in FED

BAU   TGT

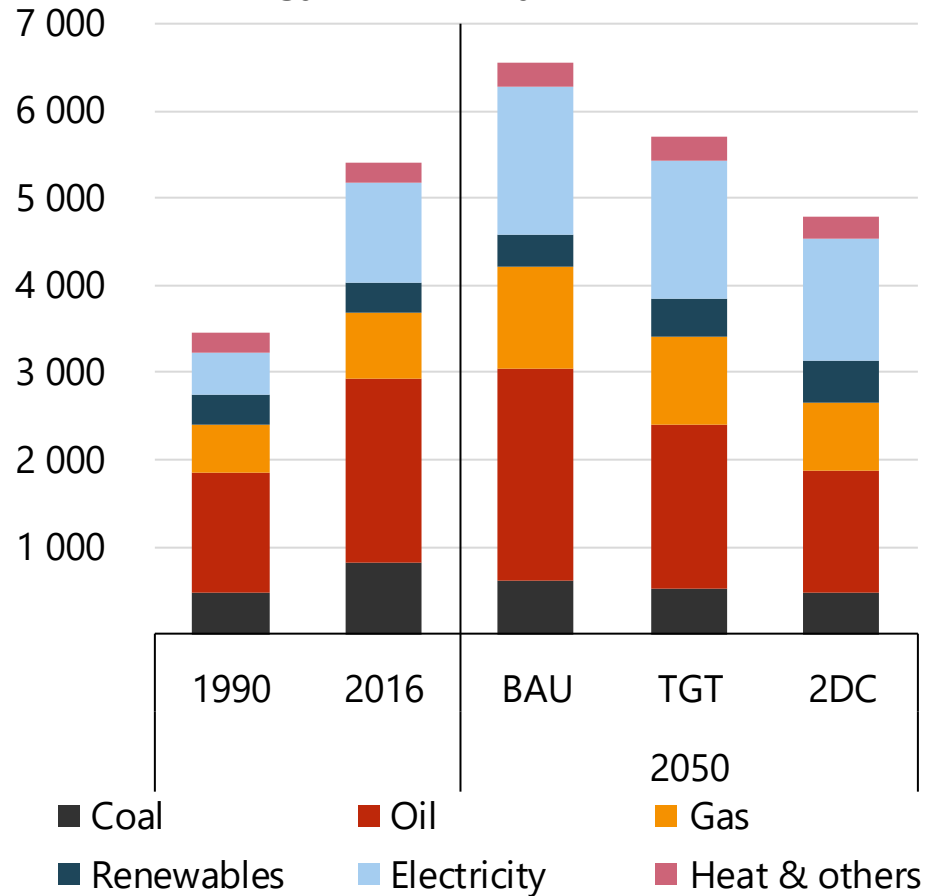Sources: APERC analysis and IEA (2018).

FED falls (mainly transport), but renewable supply increases (mainly solar), which has a two-fold impact on the renewables goal.

FED is subject to technology assumptions
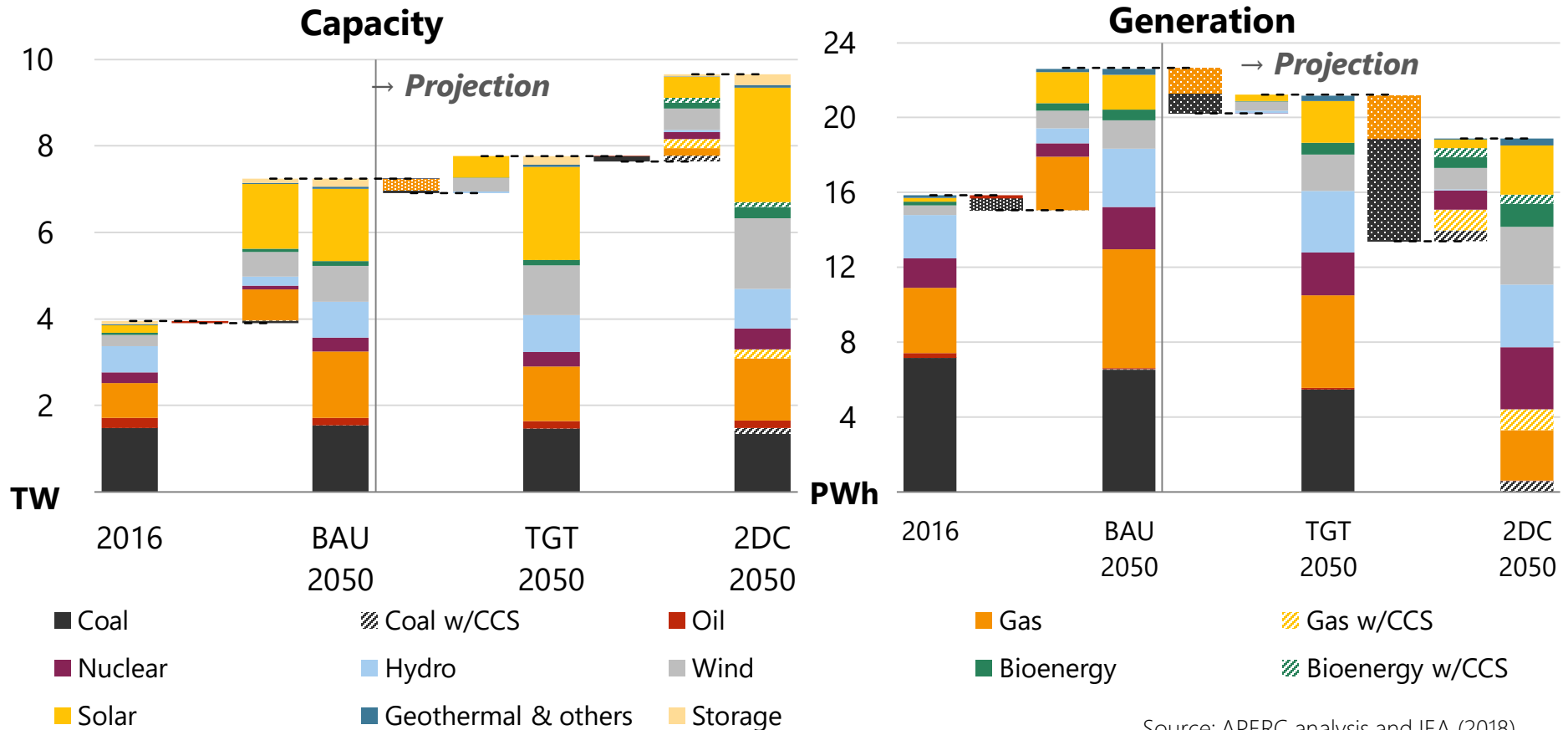

Final Energy Demand, by sector, 1990-2050

Final Energy Demand, by fuel, 1990-2050

The role of electricity will increase

# Range of technologies and fuels required in the 2DC

Power capacity and electricity generation by fuel, 2016-50

CCS for fossil fuel and biomass plants are key to decarbonising the electricity sector while storage supports renewables integration.

Source: APERC analysis and IEA (2018)

CO$_2$ emission trajectory flattens over time
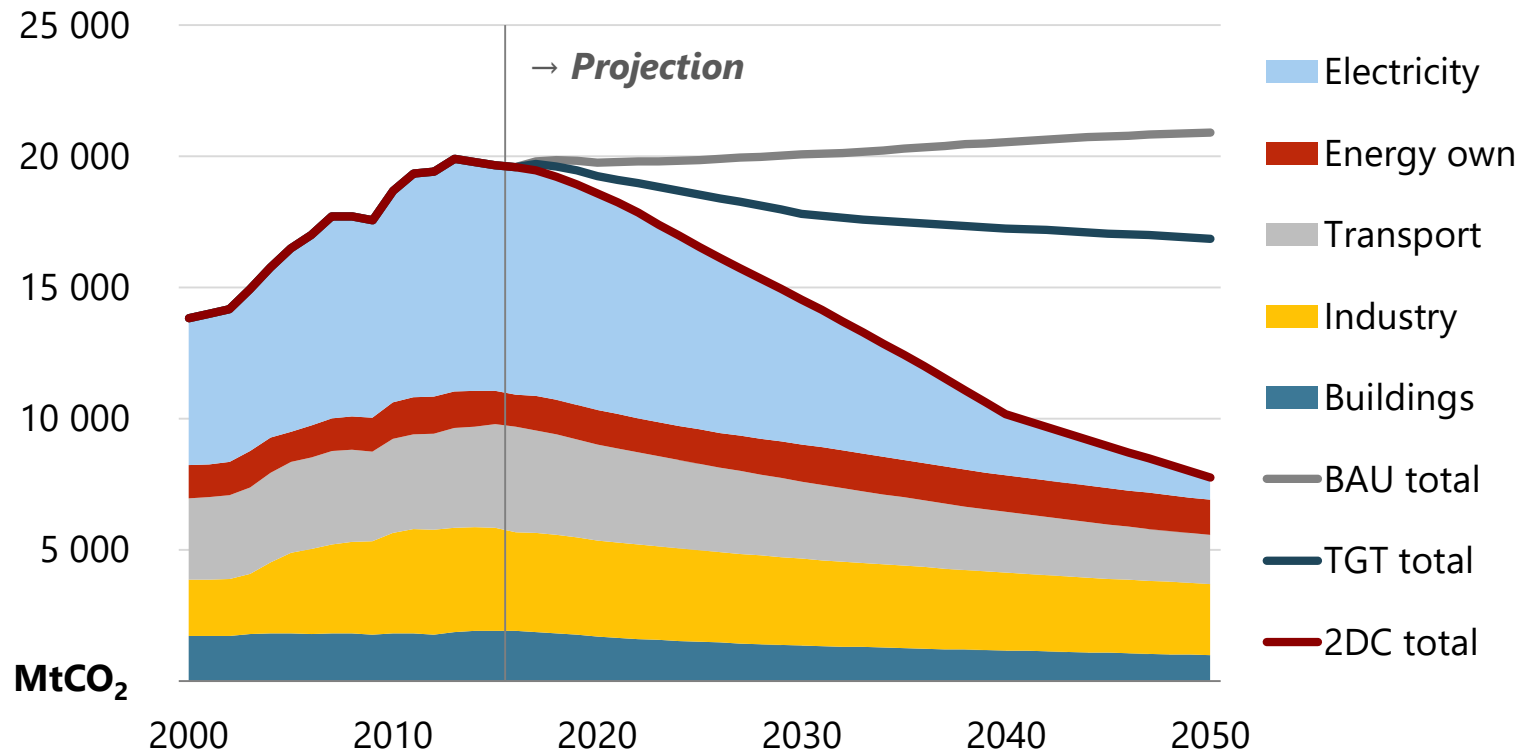
APEC economies CO$_2$ emissions from fuel combustion, 1971-2017
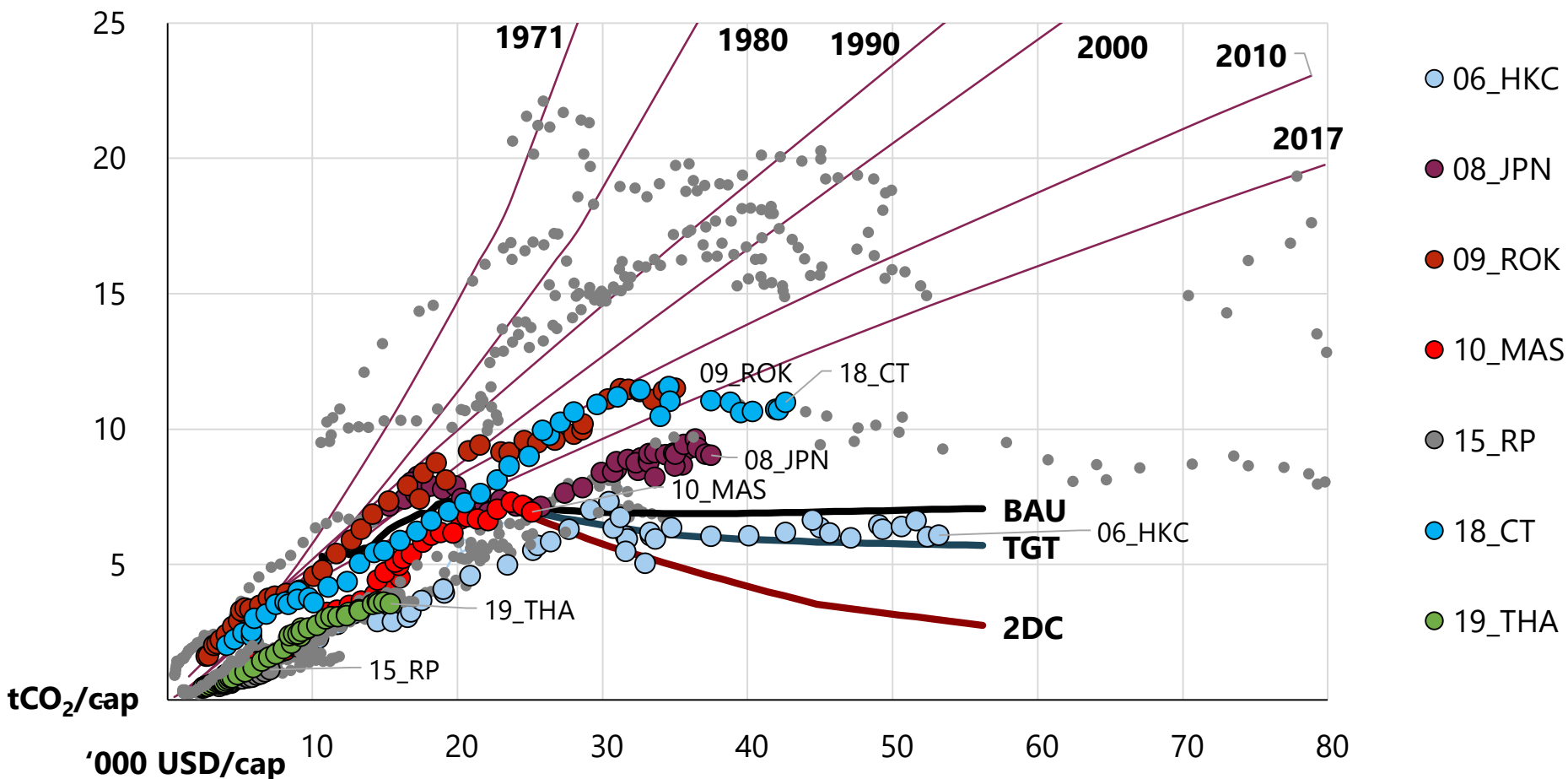
Sources: APERC analysis, IEA (2019)

In 2DC, CO₂ emissions fall below 2016 levels

Total CO₂ emissions by sector in the 2DC, 2016-50

→ *Projection*

Legend: Electricity, Energy own, Transport, Industry, Buildings, BAU total, TGT total, 2DC total

Sources: APERC analysis, IEA (2016 and 2018), IPCC (2018) and UNFCCC (2018).

Electricity sector decarbonisation drives a 2.6% per annum decrease in CO₂ emissions. Industry decarbonisation is challenging.
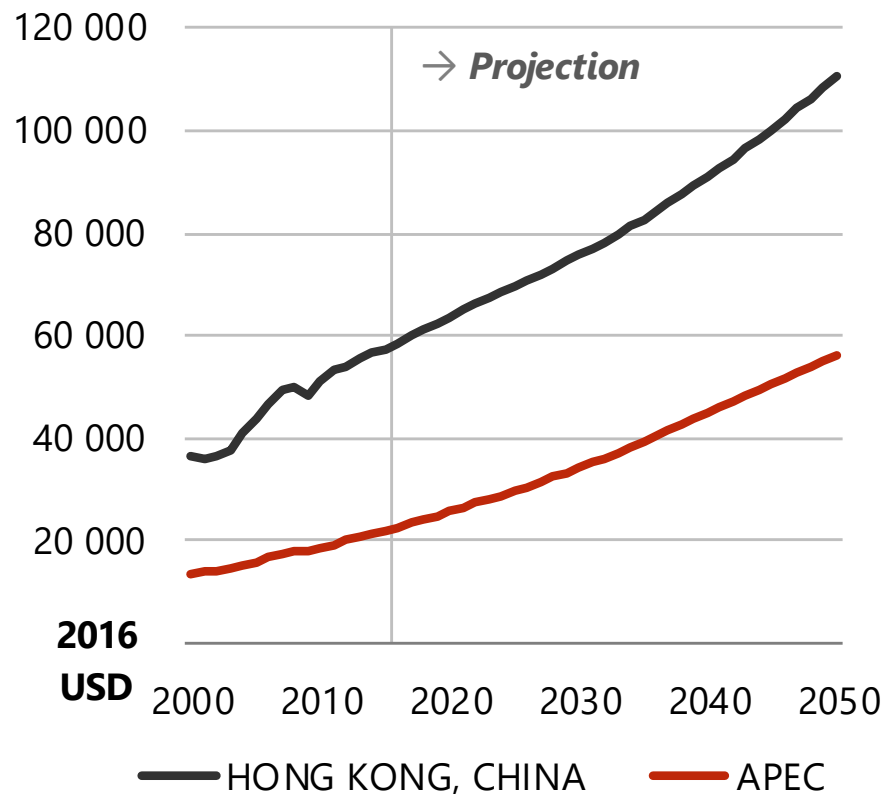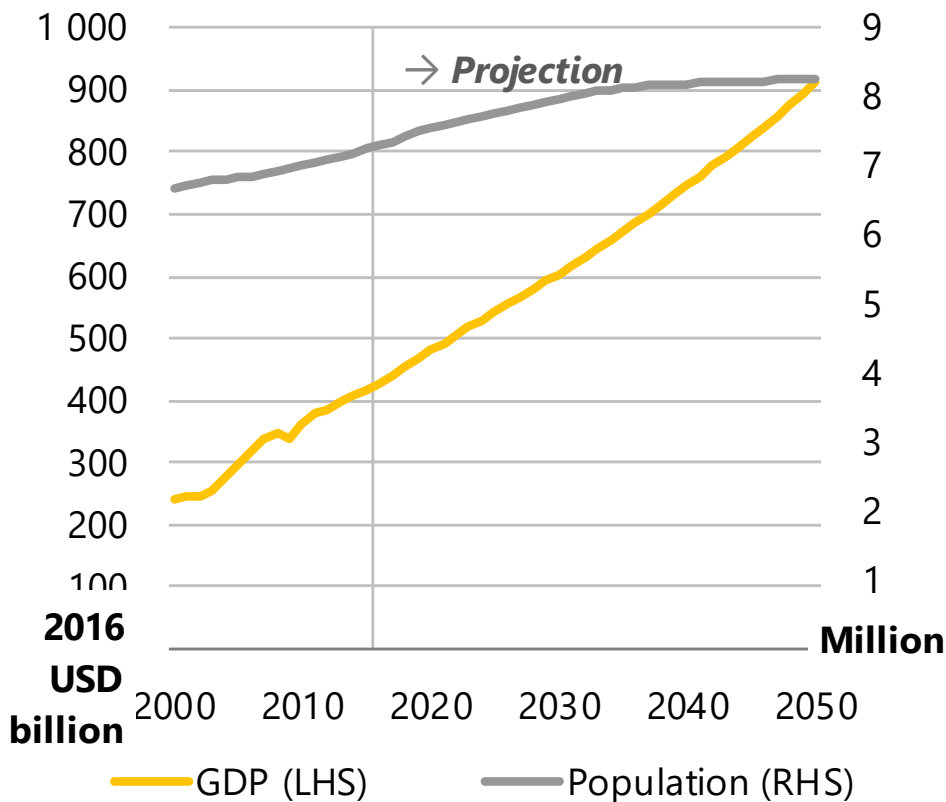
Hong Kong, China Outlook

Key findings

- The buildings sector accounts for around half of FED over the Outlook period(2016-50).

- Energy-related CO_2 emission intensity reduces by 67%, 73%, and 89% in the BAU, TGT and 2DC respectively.

- Reliance on primary energy product imports continues under all scenarios.

- The economy continues to be a regional shipping and aviation hub.

GDP and population
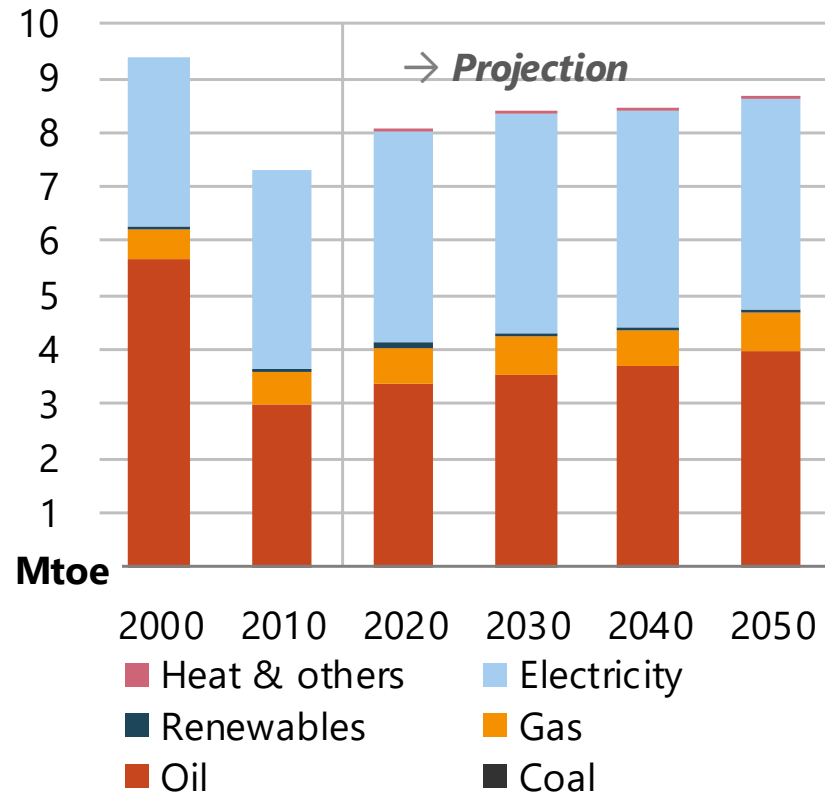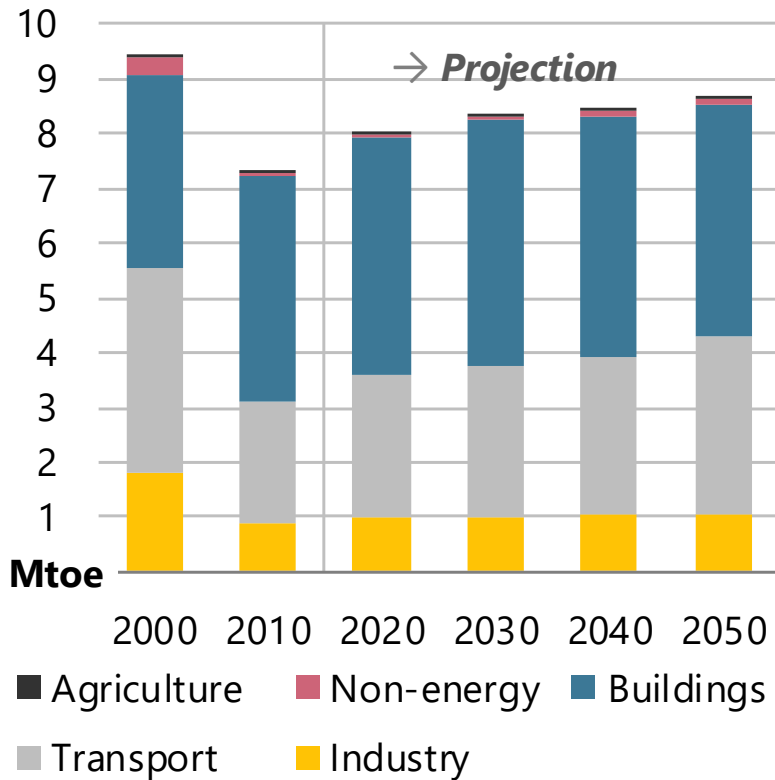
Hong Kong, China • GDP, population and GDP per capita, 2000-50

→ *Projection*

2016 USD billion

Million

— GDP (LHS)   — Population (RHS)

→ *Projection*

2016 USD

— HONG KONG, CHINA   — APEC

Sources: APERC Analysis and IEA (2018).

BAU trends and outlook for energy demand

Final energy demand by sector and fuel, 2000-50

Left chart legend: ■ Agriculture ■ Non-energy ■ Buildings ■ Transport ■ Industry

Right chart legend: ■ Heat & others ■ Electricity ■ Renewables ■ Gas ■ Oil ■ Coal

- *Industry demand flat, buildings flat post-2030 and transport grows.*

- *Fuel mix is nearly constant, oil meets 46% and electricity 45% in 2050.*

Key assumptions and policy drivers of the BAU Scenario

Buildings and industry	• Efficiency improves through stricter building energy codes. • FED is reduced by extending coverage and improving efficiency standards in appliance energy labelling schemes.
Transport	• Public transport, including the train system, develops further. • EV development is supported.
Energy supply mix	• Coal-based power generation falls, replaced by gas. • Electricity imports from mainland China continue.
Power mix	• No nuclear plants are installed. • No new coal-fired plants are installed. • New gas-fired plants replace retiring coal-fired ones.
Renewables	• Exploration and promotion of solar, wind and waste-to-energy power continues. • Feed-in tariffs and Renewable Energy Certificates are implemented to encourage private-sector investment in renewables.
Energy security	• Primary energy imports continue. • Electricity and natural gas imports from mainland China continue. • New offshore LNG terminal is in operation from 2021.
Climate change	• CO_2 emissions intensity falls 65% to 70% from 2005 levels by 2030.

Note: This table summarises the main policies assumed within the BAU Scenario; it is not intended as a comprehensive list of all energy policies.

APERC
Asia Pacific Energy Research Centre
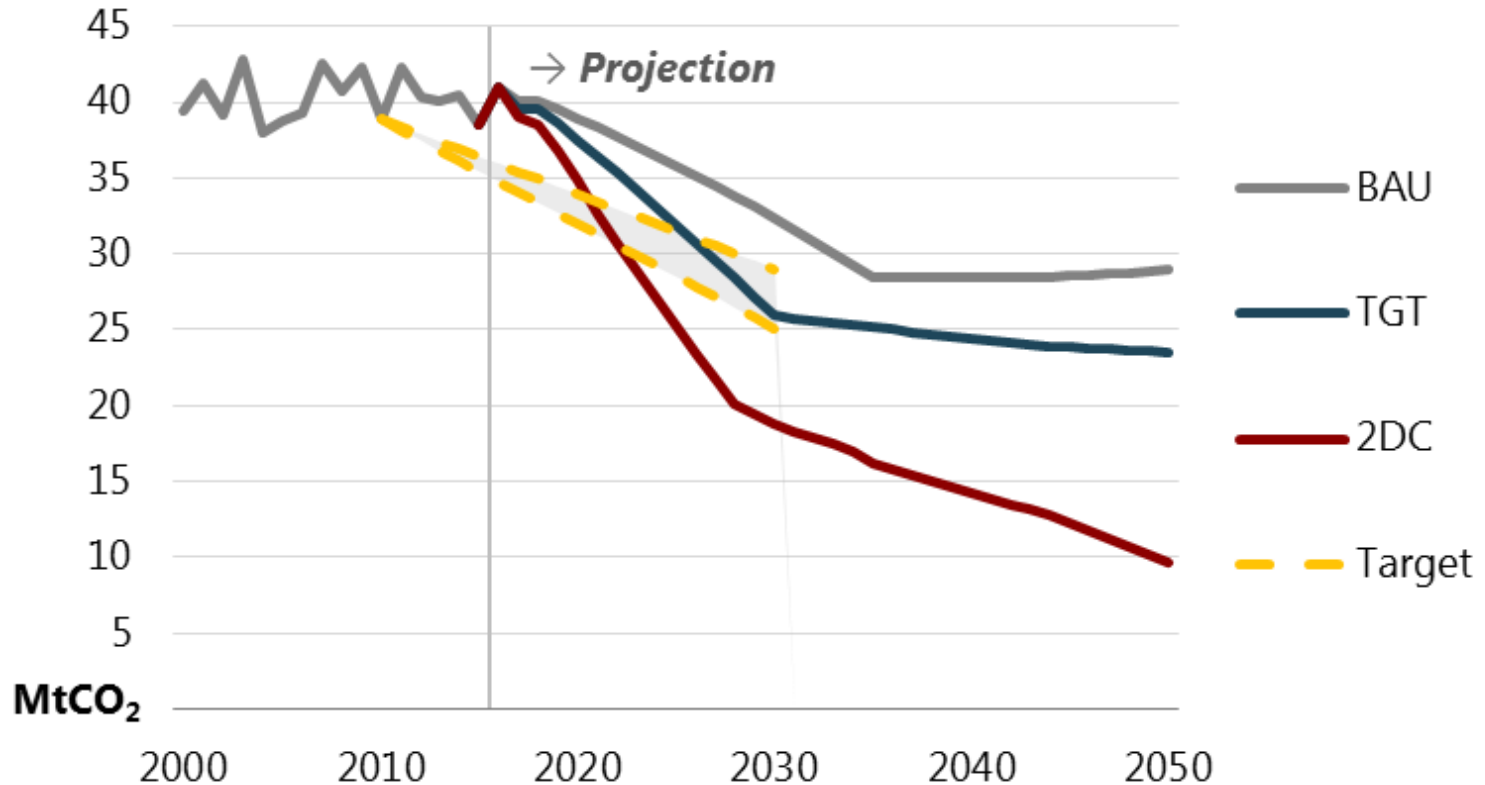
Power sector: Coal replaced by gas

Power capacity and electricity generation by fuel, 2016-50
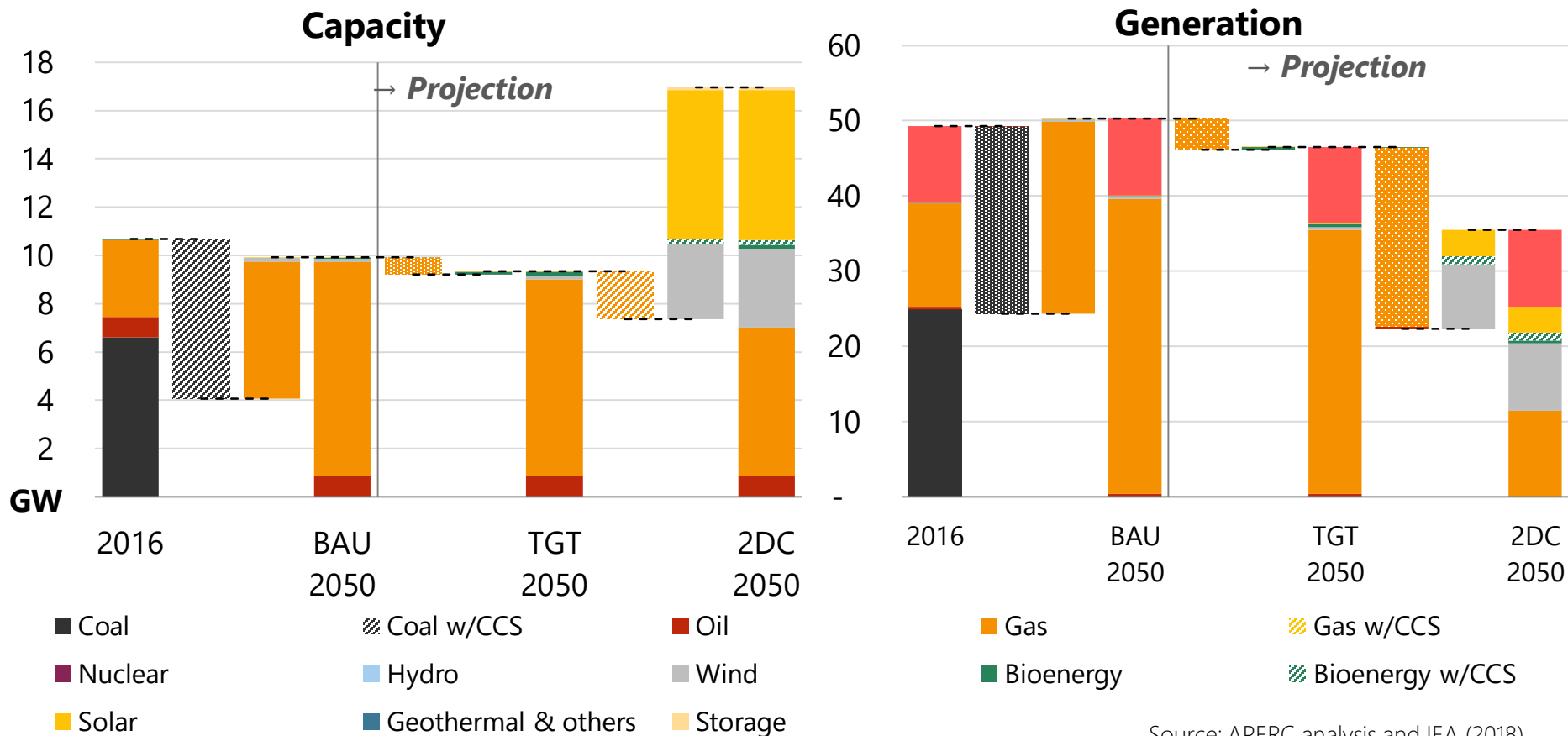
CCS for fossil fuel and biomass plants are key to decarbonising the electricity sector while storage supports renewables integration.

Source: APERC analysis and IEA (2018)
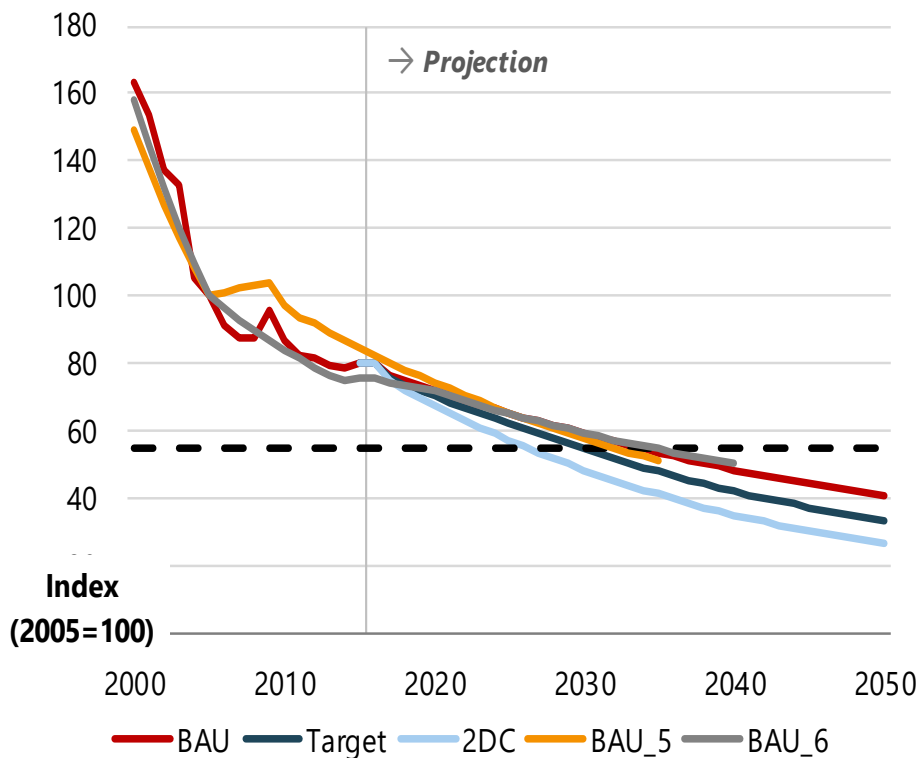
Sustainable energy pathway

CO$_2$ emissions pathways under the BAU, TGT and 2DC, 2000-50
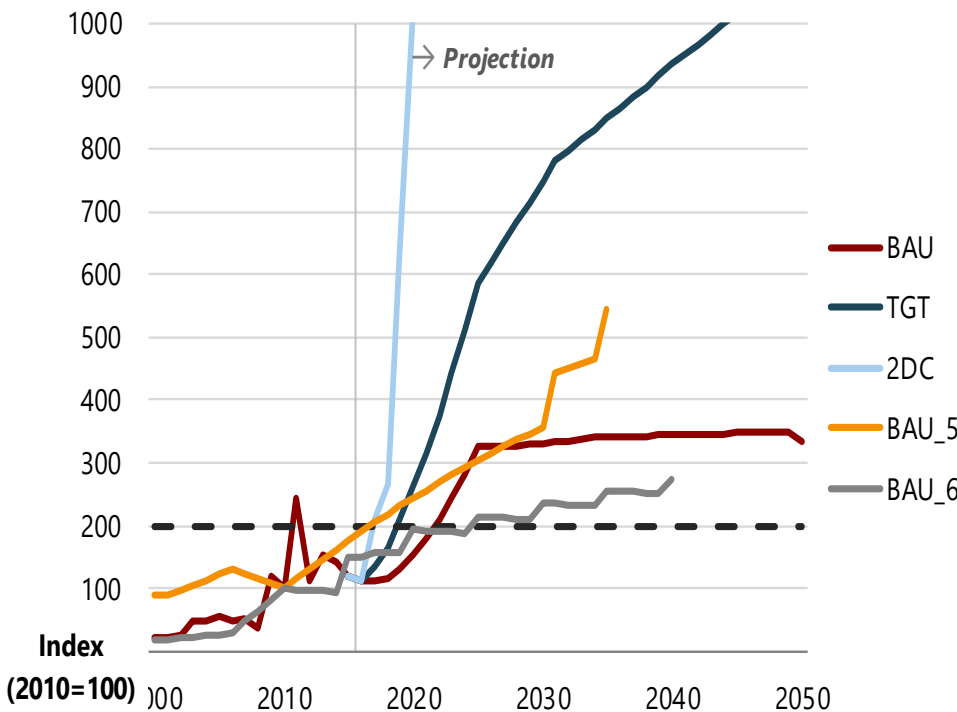

Sources: APERC analysis, IEA (2018a), IPCC (2018) and UNFCCC (2018).

Consistent EI track, low base for RE

Title **Energy intensity target, 2000-2050**

Title **Renewable Doubling Goal Index, FED, 2000-2050**

→ *Projection*

Index
(2005=100)

Index
(2010=100)

BAU — Target — 2DC — BAU_5 — BAU_6

BAU
TGT
2DC
BAU_5
BAU_6

APERC
Asia Pacific Energy Research Centre

Opportunties for policy action

- Improve EE in the buildings sector: (i) appliance efficiency standards, (ii) BEC (Building Energy Code) and (iii) building thermal transfer standards.

- Promote public transportation, improve fuel efficiency and accelerate the shift away from fossil fuel to electrified transportation, particularly freight transport and light vehicles.

- Continue to promote renewables and seek innovative solutions to land constraint issues (such as using reservoirs for solar PV and developing offshore wind farms).

- Closer grid integration with mainland China to tap into more nuclear and renewable energy.

- Accelerate the switching from coal to gas in power sector.

- Explore CCS options for gas-fired power plants

Japan Outlook

GDP and population

Japan • GDP, population and GDP per capita, 2000-50
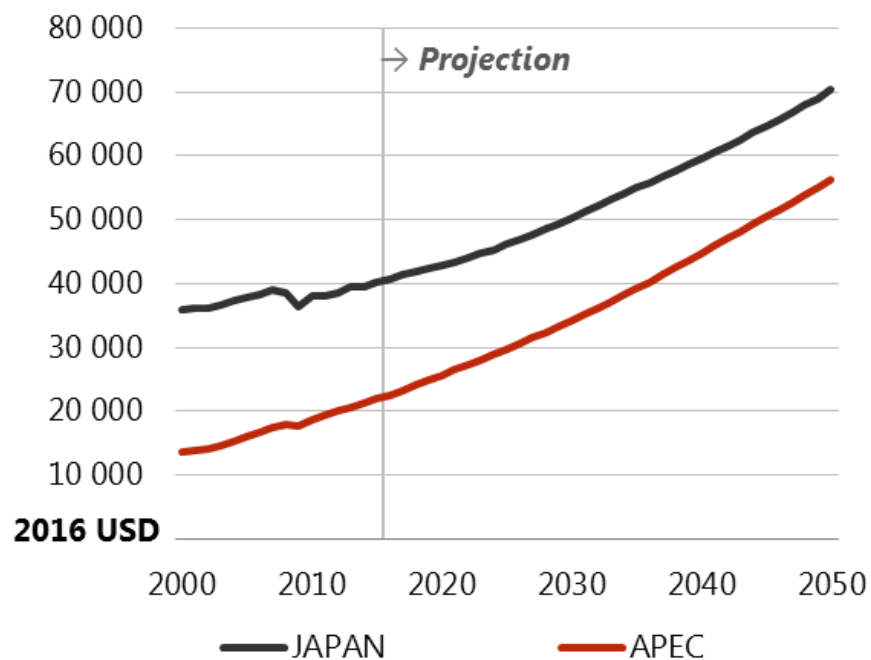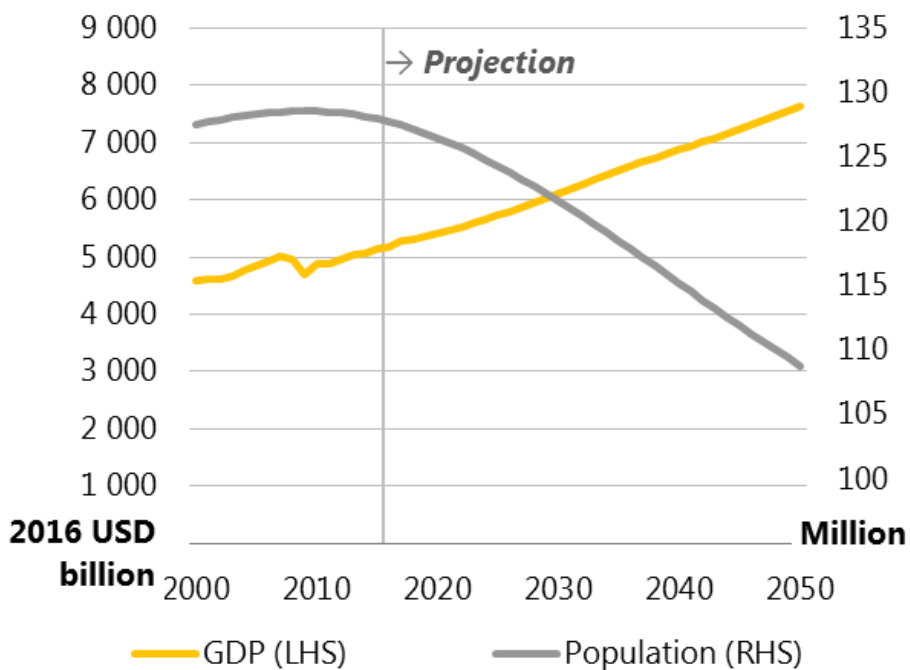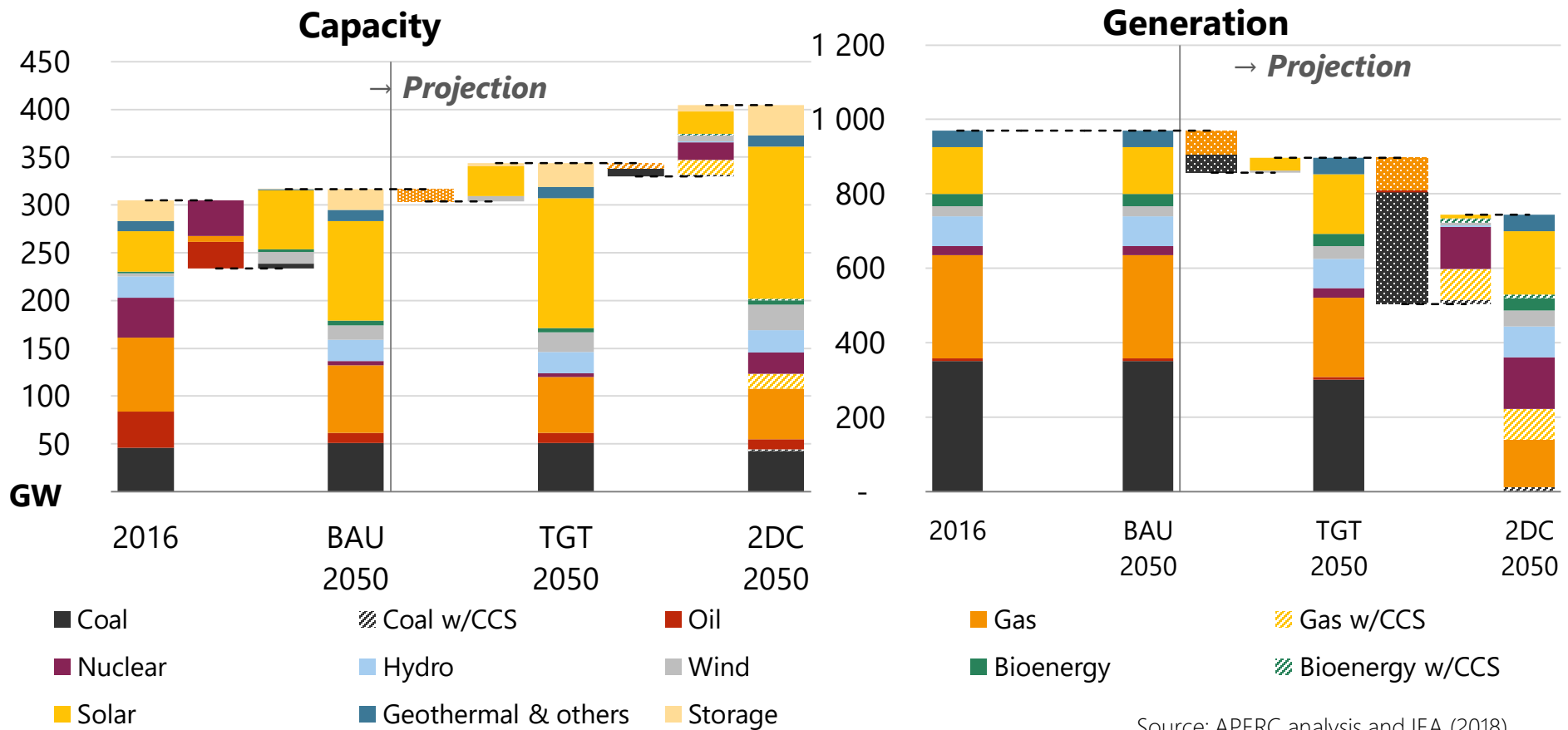

Sources: APERC Analysis and IEA (2018).

Japan's GDP per capita almost doubles over the Outlook period as GDP grows while population decreases.

Power sector develops in line with the plan

Power capacity and electricity generation by fuel, 2016-50

Capacity (GW) — **Generation**

Legend:
- Coal
- Coal w/CCS
- Oil
- Gas
- Gas w/CCS
- Nuclear
- Hydro
- Wind
- Bioenergy
- Bioenergy w/CCS
- Solar
- Geothermal & others
- Storage

Source: APERC analysis and IEA (2018)

CCS for fossil fuel and biomass plants are key to decarbonising the electricity sector while storage supports renewables integration.

TPES in scenarios

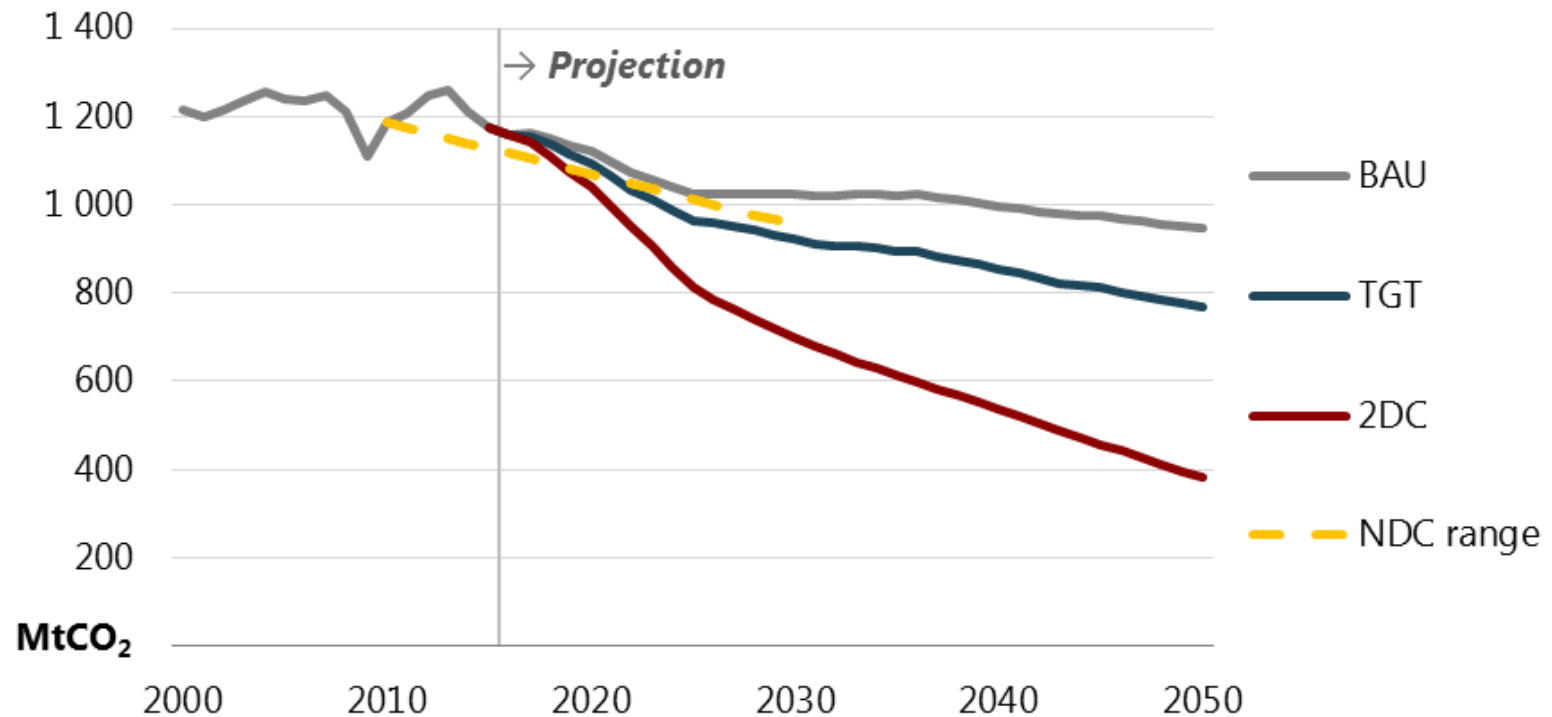Total primary energy supply in 2DC, 2000-50
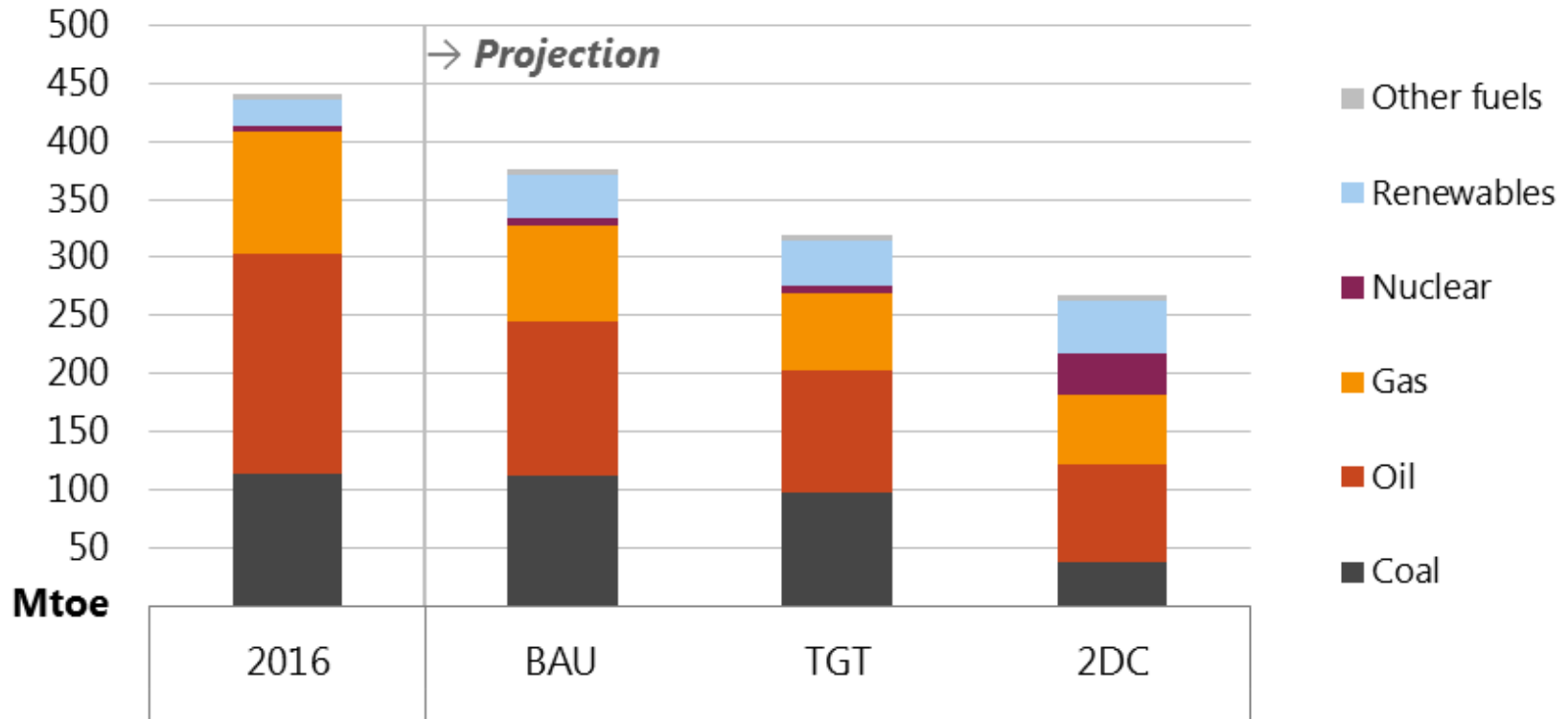
Source: APERC analysis and IEA (2018)

From 436 Mtoe in 2016, TPES declines to 268 Mtoe in 2DC, compared to 375 Mtoe in BAU. The share of renewables is 17% in TGT, 7% more than BAU.

Energy-related CO₂ emission comparison

Total CO2 emissions under BAU, TGT and 2DC, 2000-50 (TPES-based)
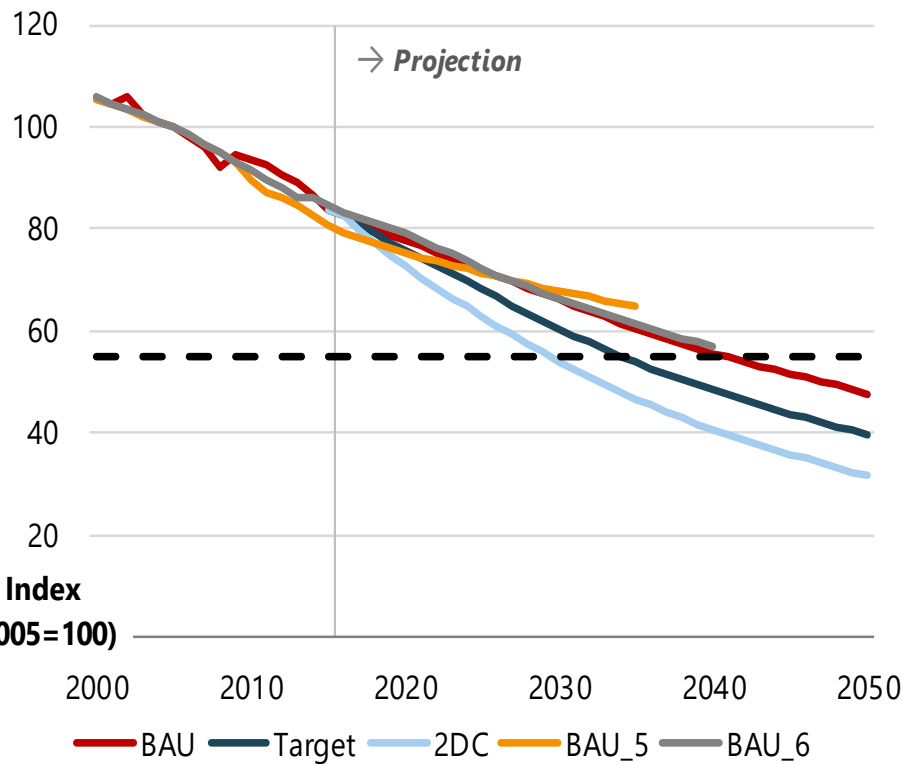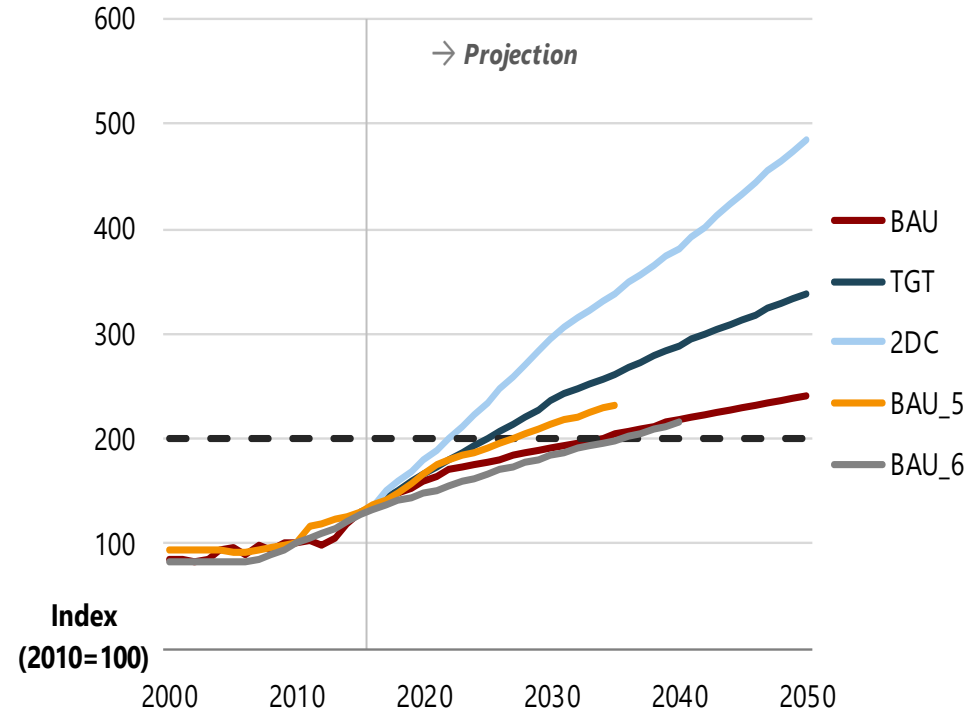

Source: APERC analysis and IEA (2018)

Emissions fall 19% in the BAU, compared to 27% in TGT and 40% in 2DC (2013 vs. 2030). The power sector accounts for two thirds of cumulative reductions in 2DC.

EI 'target' is ambitious, solar PV drives RE

Title Energy intensity target, 2000-2050

→ *Projection*

Index (2005=100)

Legend: BAU, Target, 2DC, BAU_5, BAU_6

Title Renewable Doubling Goal Index, FED, 2000-2050

→ *Projection*

Index (2010=100)
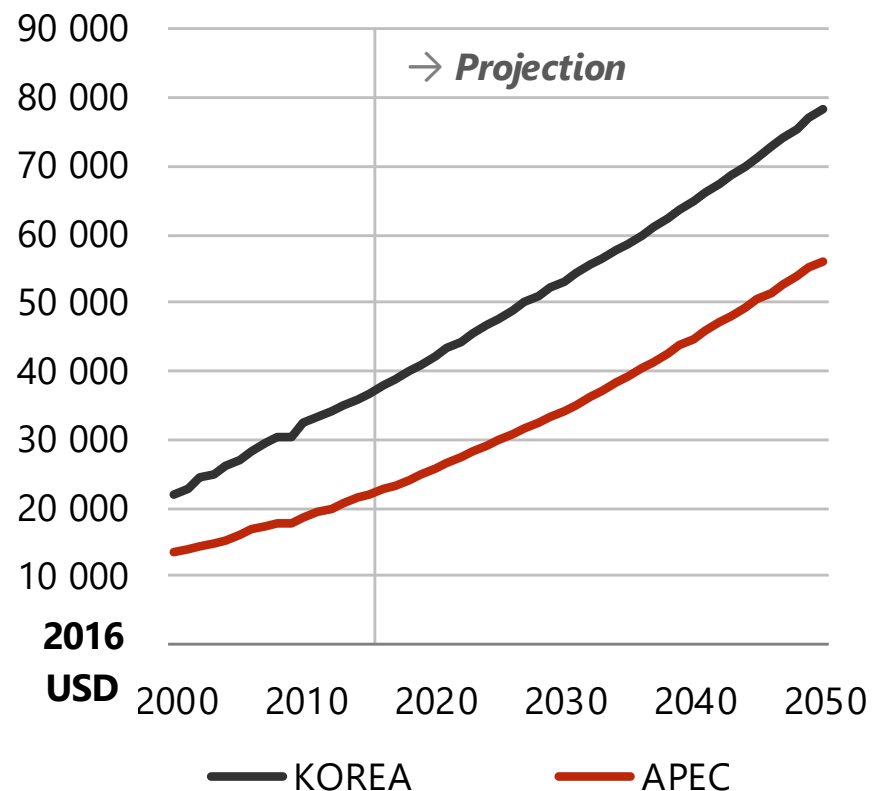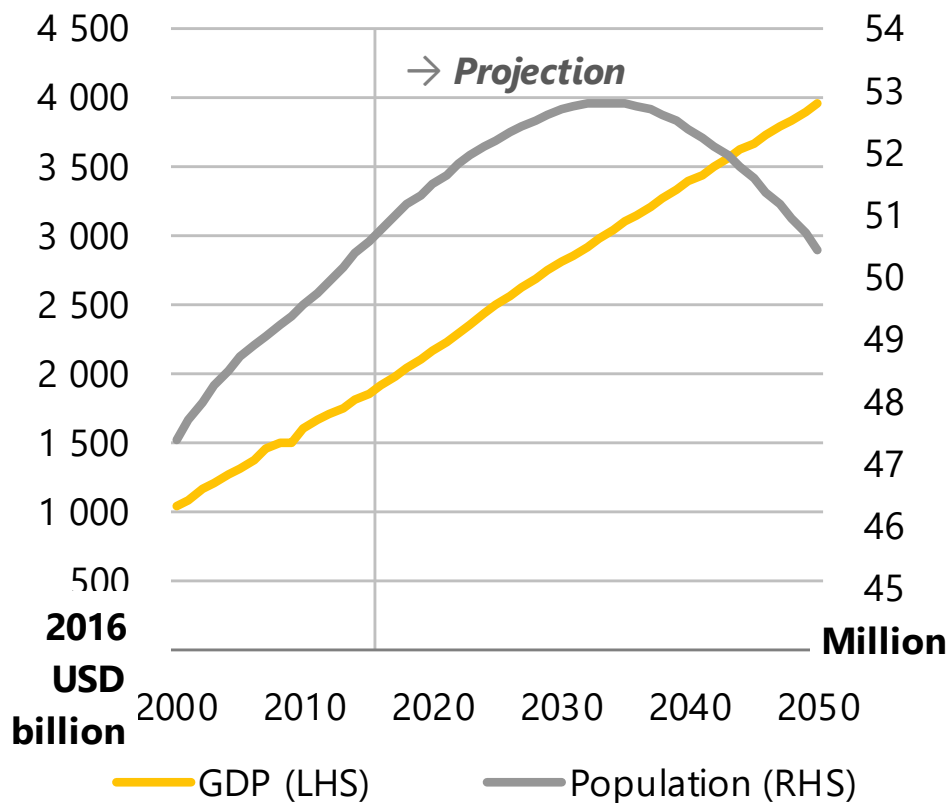
Legend: BAU, TGT, 2DC, BAU_5, BAU_6

Summary

- Ongoing efficiency efforts coupled with modest economic growth and a declining population lead to FED decline of 15% in the BAU

- Increases in solar PV double the share of renewables in power generation in the BAU

- Long-term self-sufficiency rates are a key concern
  - It rises with energy efficiency efforts and renewable growth, but drops after late 2020s due to nuclear retirements according to the '40 year lifetime' rule

- NDC target not met in BAU

- Both emissions and self-sufficiency improve in the 2DC, but come at the cost of heavy capital investment.

Korea Outlook

GDP and population

Korea • GDP, population and GDP per capita, 2000-50

→ *Projection*

GDP (LHS)   Population (RHS)
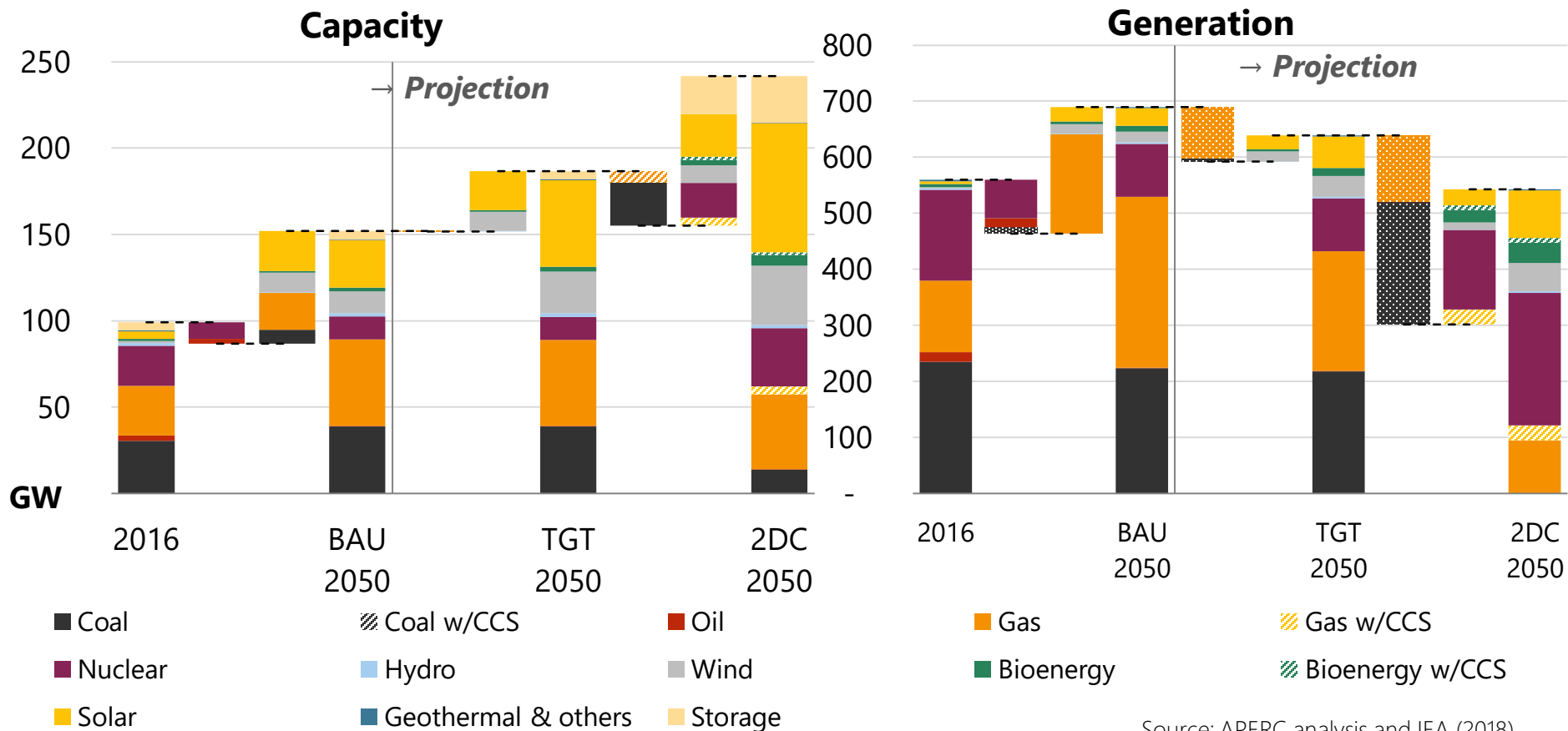
→ *Projection*

KOREA   APEC

Key assumptions and policy drivers

| Buildings	• Energy management systems introduced in new buildings and energy-intensive buildings and factories. • The proliferation of energy efficient appliances that use information and communications technologies, and the introduction of an energy efficiency market allowing people to trade reductions by installing efficient equipment.
Transport	• Mandated biodiesel blend rate of 2.5% in 2015, rising to 3% after 2018.
Energy supply mix	• Higher renewables and LNG shares, and lower nuclear and coal.
Power mix	• No lifetime extensions for existing nuclear reactors. • Cancellation of new reactor construction plans.
Renewables	• The current pace of renewables development is sustained.
Energy security	• Higher renewables share in TPES.
Climate change	• Development of an emissions trading system and emissions target management system.

Stable growth of variable RE

Power capacity and electricity generation by fuel, 2016-50

Source: APERC analysis and IEA (2018)

TPES falls in the 2DC

Total primary energy supply in the 2DC compared with the BAU and TGT
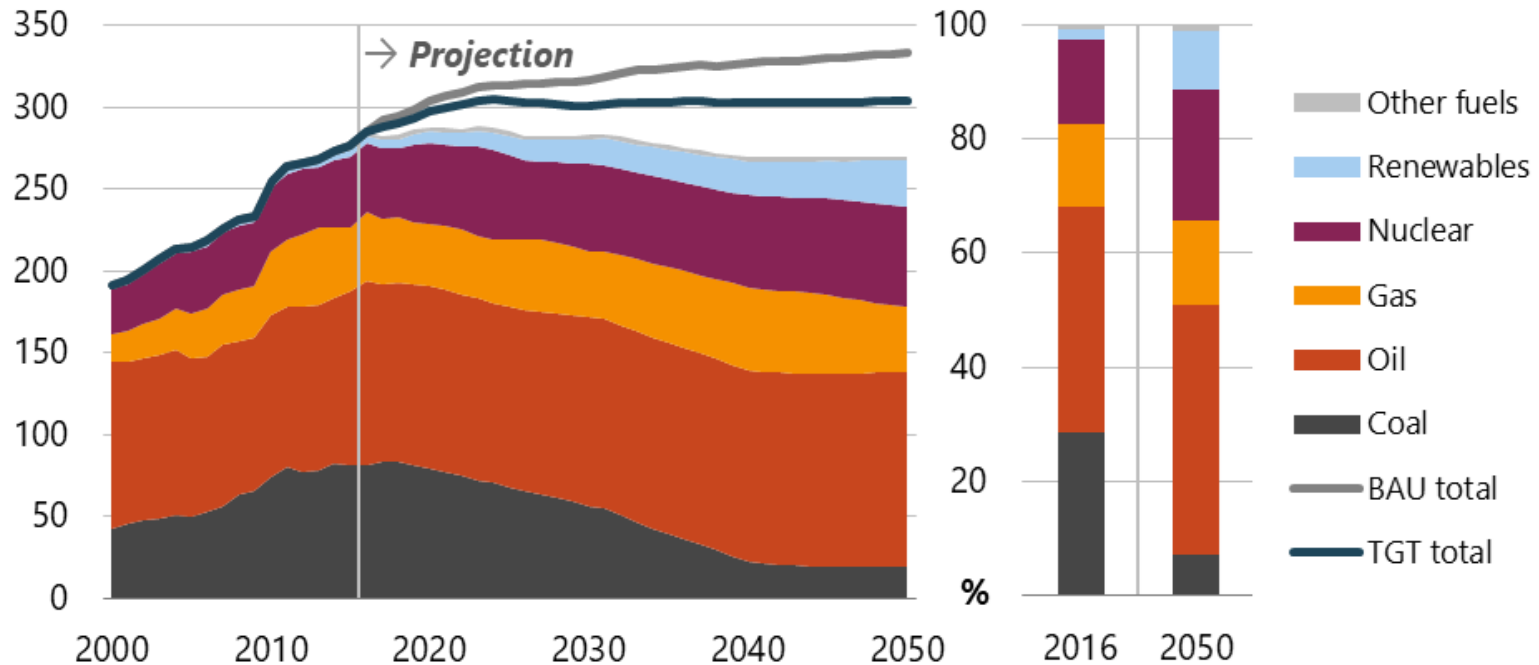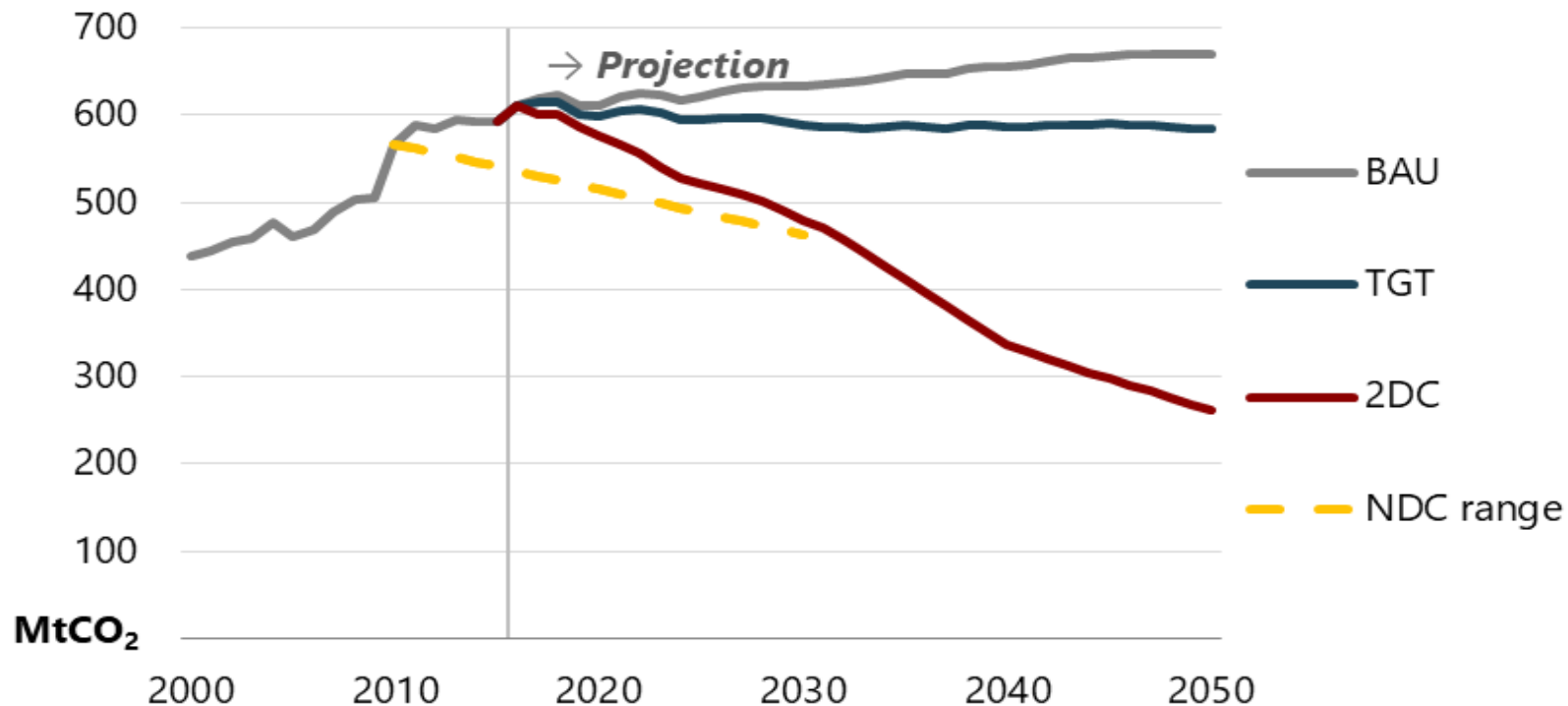

Sources: APERC Analysis and IEA (2018).

The share of coal in TPES is quartered by the end of projection period.

Gas and renewables replace coal.

NDC is not achieved under any scenario

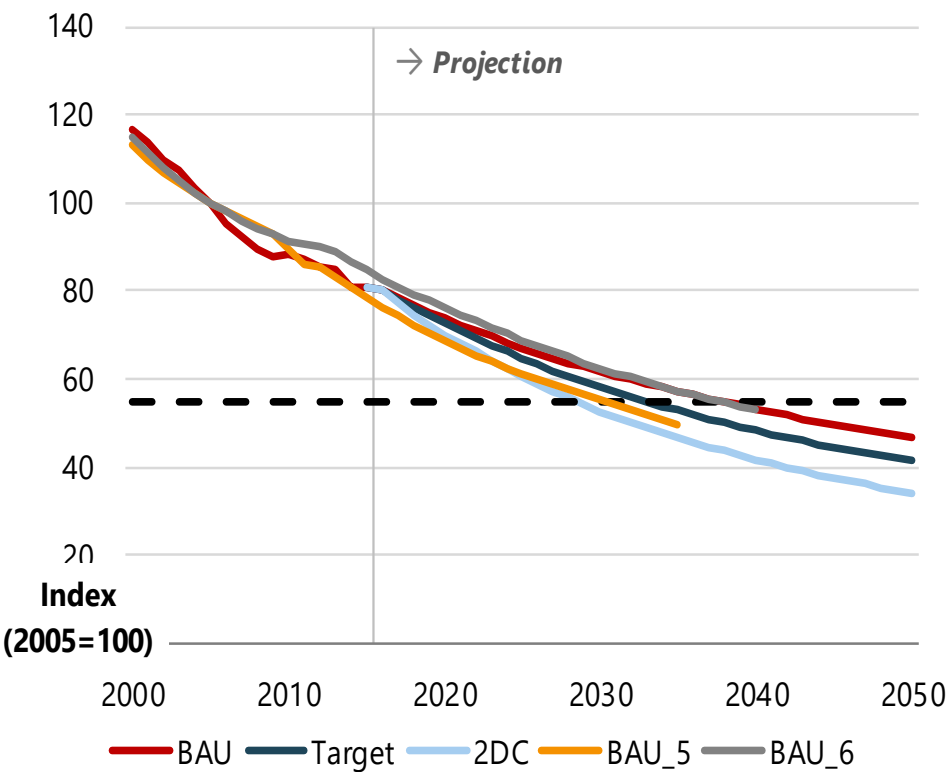CO$_2$ emissions pathways under the BAU, TGT and 2DC

Sources: APERC Analysis and IEA (2018).

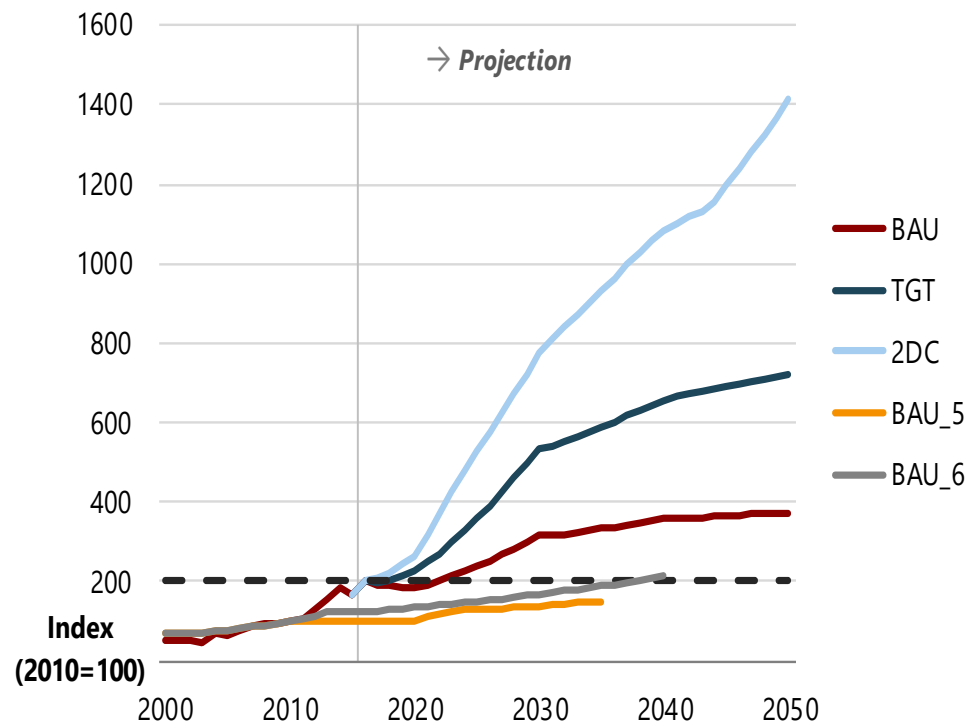*Emissions fall sharply in the 2DC but not enough to achieve NDC.*

Decline in the TGT is limited because of the decrease of nuclear.

Both 'targets' are easy to achieve

Title **Energy intensity target, 2000-2050**

→ *Projection*

Index (2005=100)

BAU — Target — 2DC — BAU_5 — BAU_6

Title **Renewable Doubling Goal Index, FED, 2000-2050**

→ *Projection*

Index (2010=100)

BAU — TGT — 2DC — BAU_5 — BAU_6

Key findings

- FED rises 32% in the BAU, from 179 Mtoe to 235 Mtoe over the outlook period.

- TPES grows marginally under the BAU, is flat under the TGT and shrinks under the 2DC.

- Renewables and natural gas become more important in the electricity sector as nuclear is phased out in stages under the BAU and TGT Scenarios.

- Despite the increasing share of renewables, replacing nuclear with gas generation results in greater energy imports and reduces primary energy self-sufficiency in the BAU and TGT.

- Korea is not projected to meet its NDC commitment under the BAU, TGT and 2DC Scenarios.

Malaysia Outlook

Malaysia's GDP and population continue to grow

Malaysia population and GDP, 2000-50

→ *Projection*

GDP (LHS) — Population (RHS)

MALAYSIA — APEC
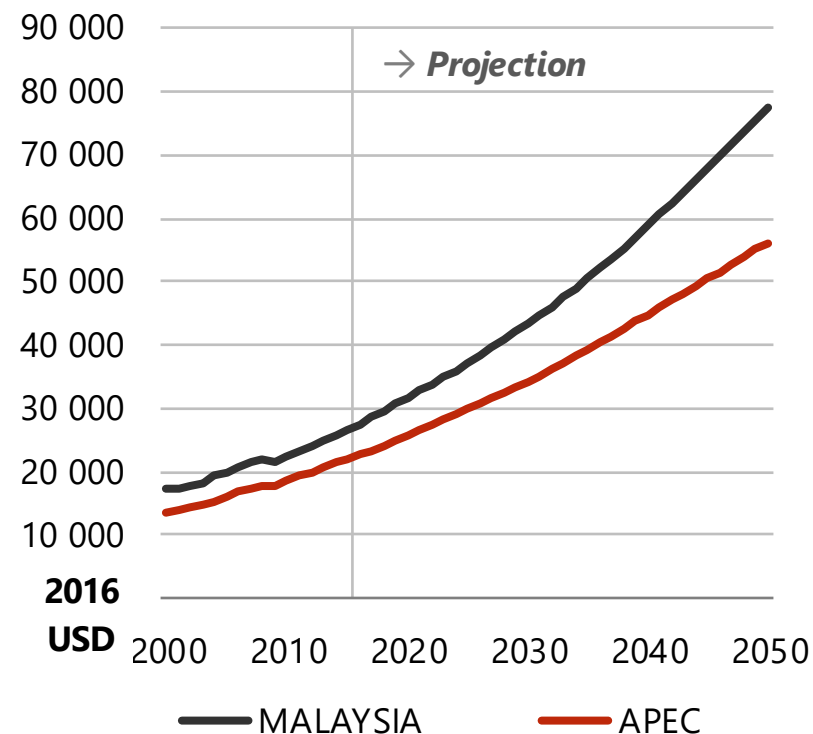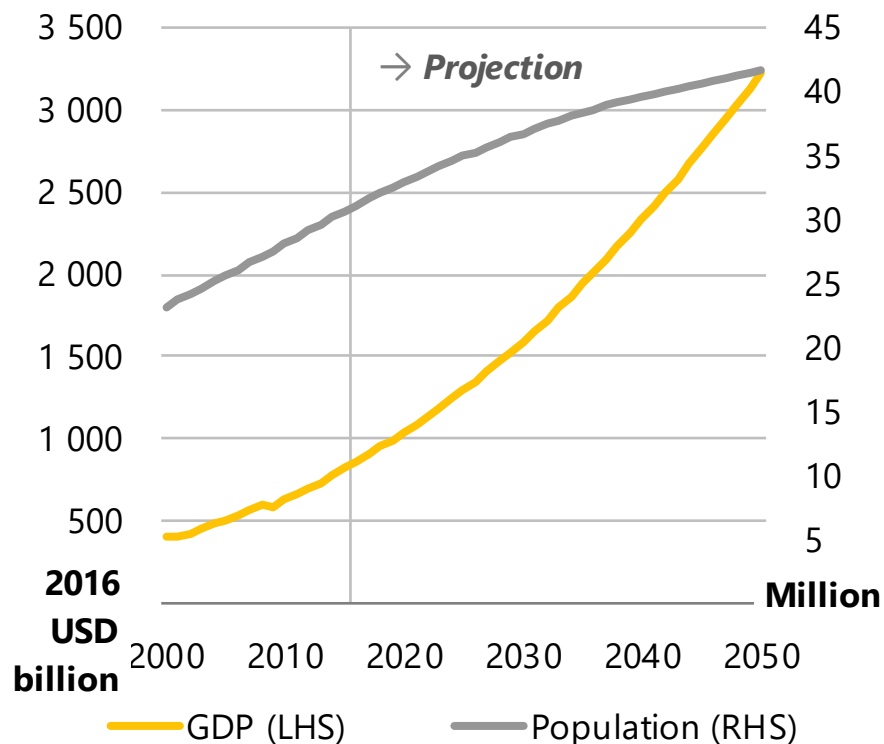
By 2050, with growth rate of population about 0.8% annually, Malaysia's GDP is expected to grow moderately at 3.9% annually.

# Key assumptions and policy drivers under the BAU

Buildings	• Adoption of green building design encouraged. • DSM program maintained. • 11th Malaysia Plan targets achieved. • MEPS and labelling programs expanded, and efficient management of electrical energy regulations implemented. • GTMP implemented.
Industry	• SIT abolished and EToU for electricity introduced.
Transport	• Deployment of hybrid cars and EVs encouraged. • Efficient engine vehicle deployment pursued, as in National Automotive Policy. • New rail projects such as Klang Valley Mass Rapid Transit and High-Speed Rail introduced.
Energy supply mix	• National Depletion Policy on oil and natural gas applied. • ORRR maintained at greater than 1 over the Outlook period. • Oil, natural gas and renewables self-sufficiency optimised.
Power mix	• Use of renewables and coal expanded. • Hydropower projects in East Malaysia completed on schedule.
Renewables	• National Renewable Energy Policy renewables targets achieved, as well as 20% renewables by 2025.
Energy security	• HHI for fuel mix maintained at less than 0.5.
Climate change	• Malaysia's NDC pledge to reduce GHG emissions intensity of GDP by 35% (unconditionally) to 45% (conditionally) by 2030 (relative to the 2005 level).

Notes: DSM = demand-side management. MEPS = minimum energy performance standard. GTMP = Green Technology Master Plan. SIT =Special Industrial Tariff. EToU = Enhanced Time of Use. EV = electric vehicle. Outlook period = 2016-50. HHI = Herfindahl-Hirschman Index. ORRR = Overall Resource Replenishment Ratio (measures discovered reserves versus production; a ratio of 1.0 and above is considered 'healthy'). NDC = Nationally Determined Contribution. GHG = greenhouse gas. This table summarises some of the main policies of the BAU Scenario; it is not intended to be a comprehensive list of all energy policies.

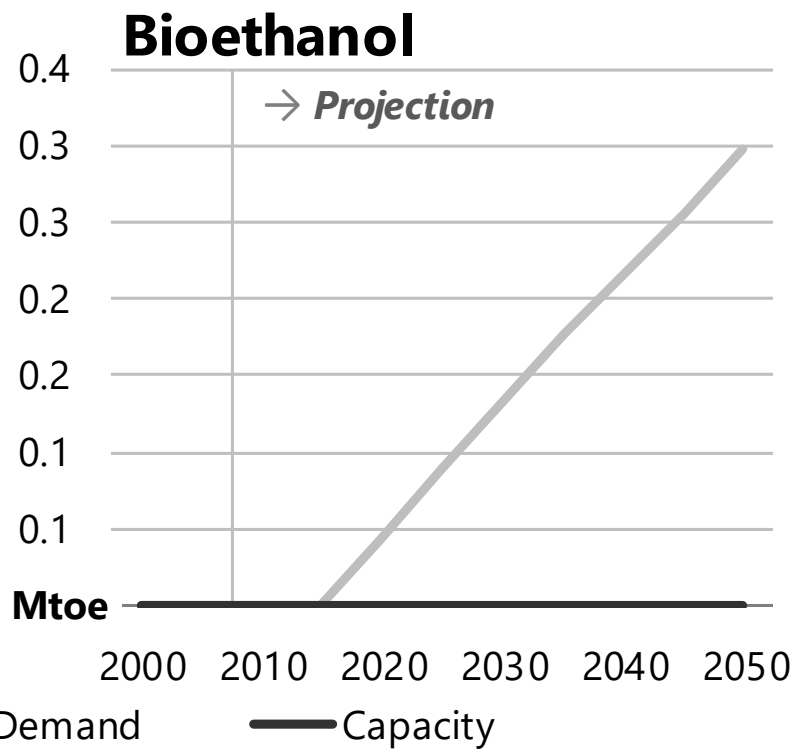Source: APERC analysis

The role of hydro, biomass and solar

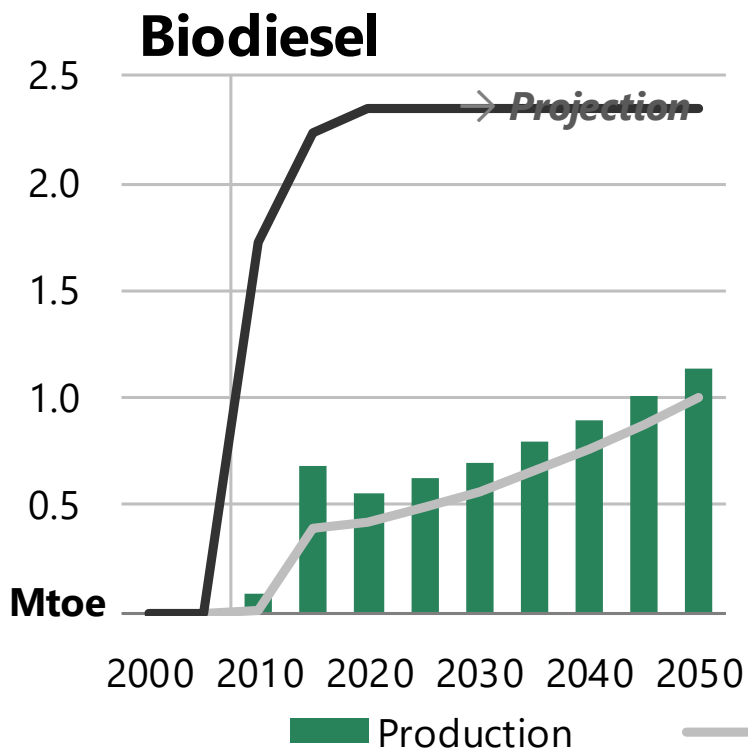## Power capacity and electricity generation by fuel, 2016-50
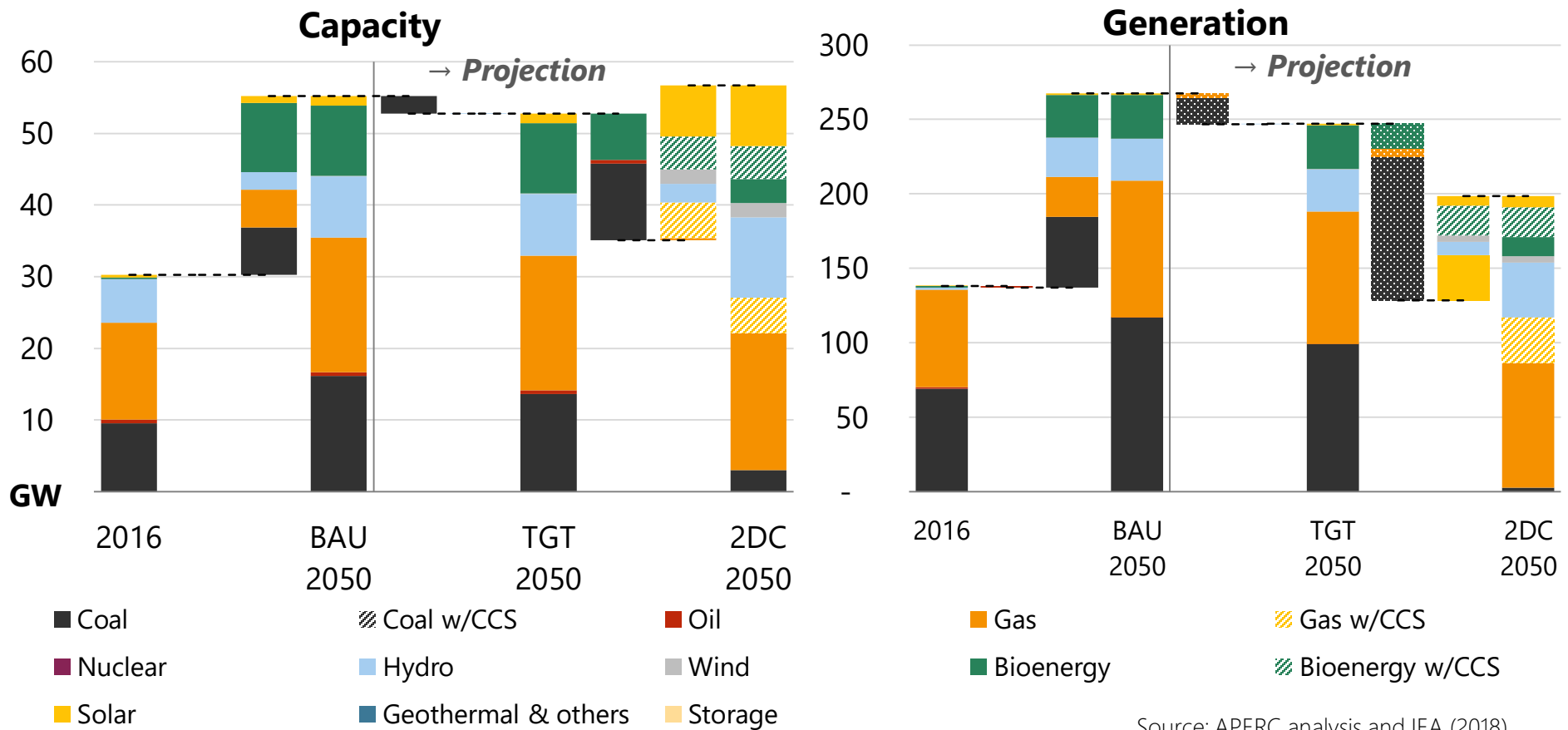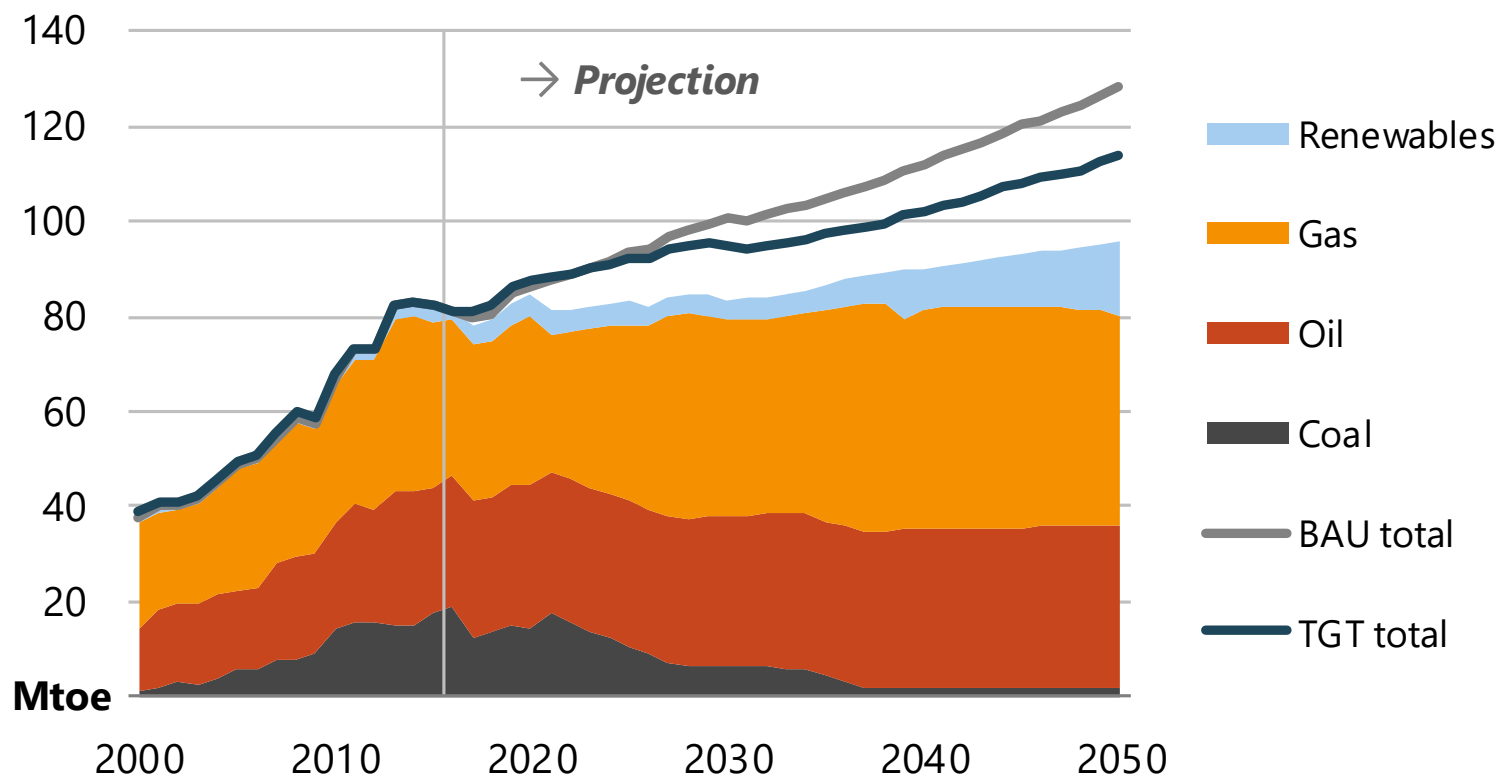

Source: APERC analysis and IEA (2018)

2DC: Sufficient biodiesel capacity

2DS

Biodiesel

Bioethanol

Production Demand Capacity
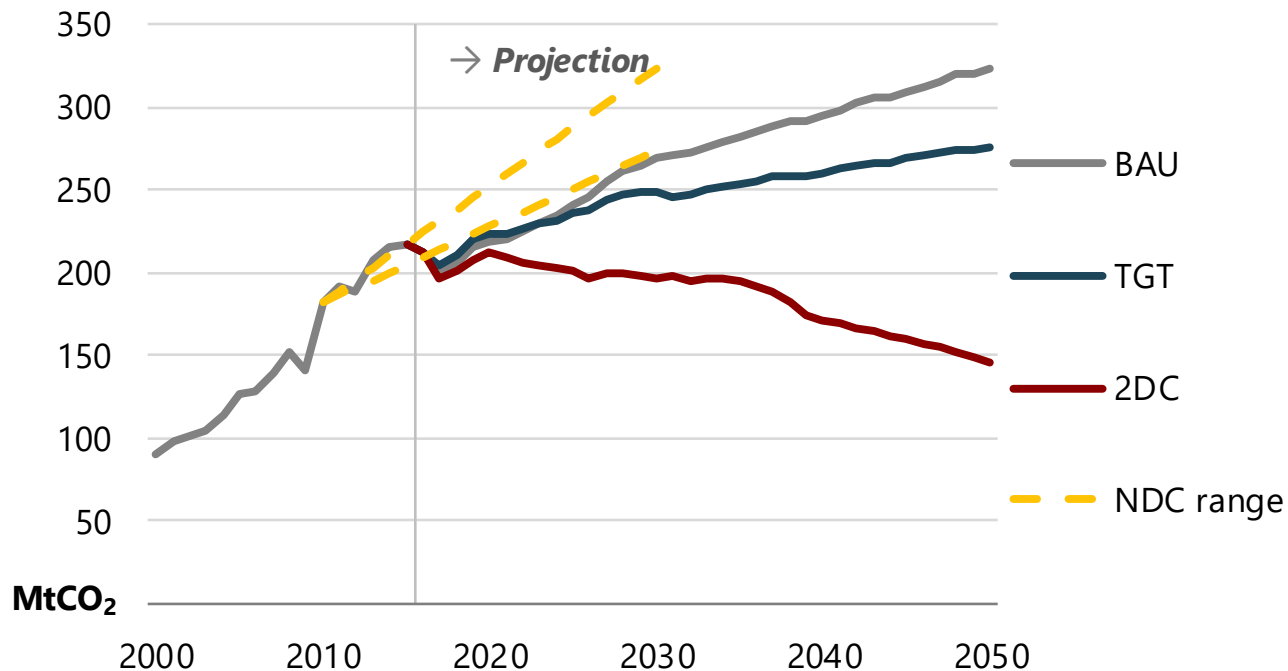
2DC: Coal substitutes by gas and renewable

Total primary energy supply in the 2DC compared with the BAU and TGT, 2000-50

The share of renewables increases by more than five times from 2016, reaching 16% in 2050 in the 2DC.

Sources: APERC analysis and IEA (2018).

Sustainable energy pathway

CO$_2$ emissions pathways under the BAU, TGT and 2DC, 2000-50

→ *Projection*

350
300
250
200
150
100
50
MtCO$_2$

BAU
TGT
2DC
NDC range
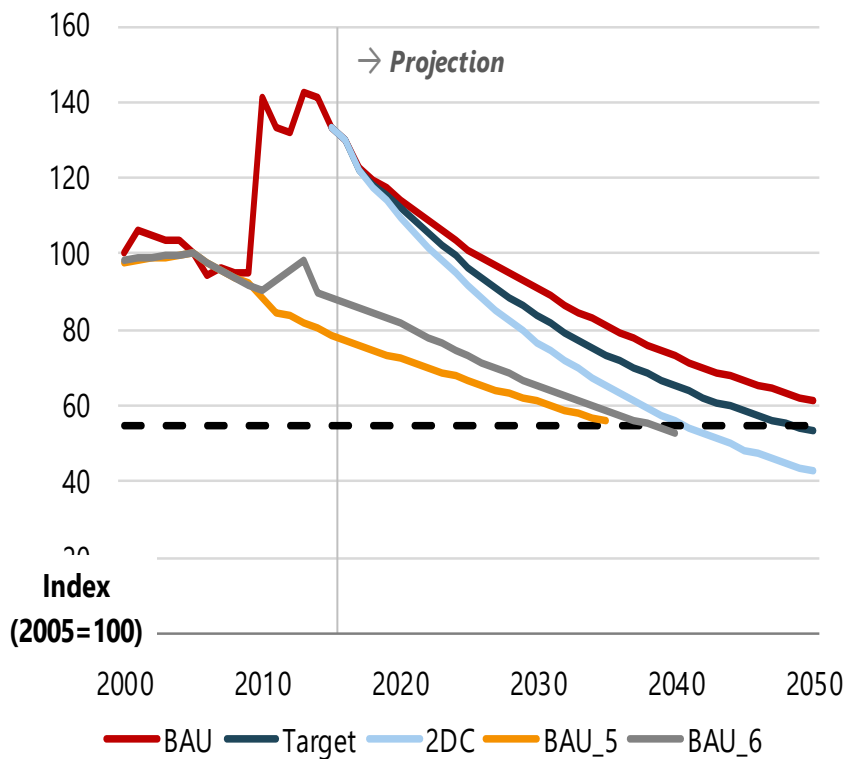
2000 2010 2020 2030 2040 2050

Both the unconditional and conditional targets are achieved in all three scenarios by 2030.
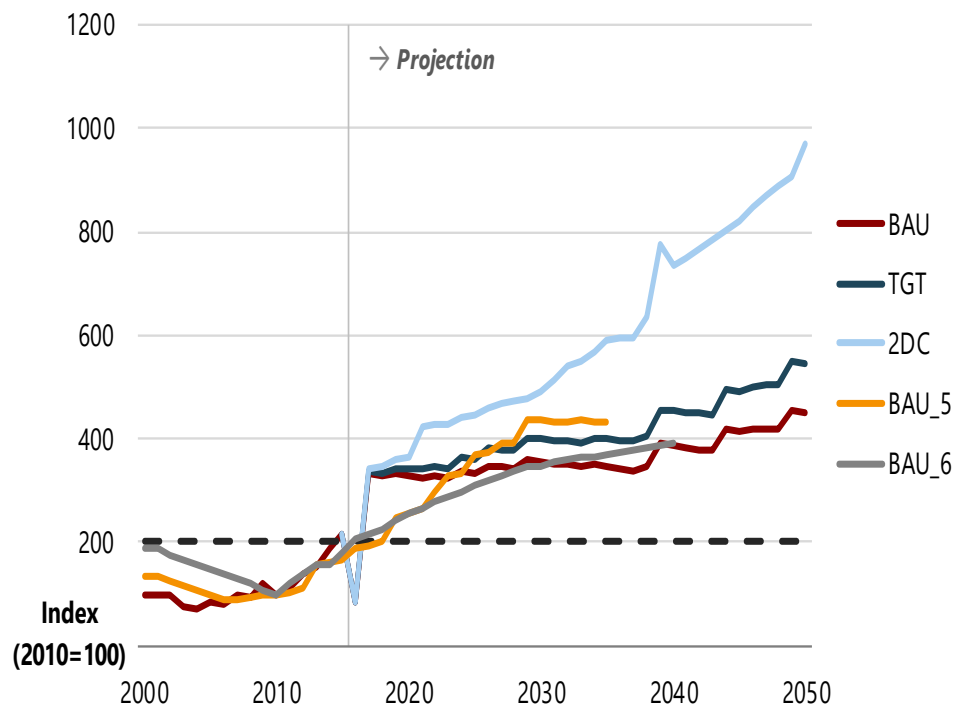
Note: NDC = Nationally Determined Contribution (to the COP21 Paris Agreement). The 7th Edition calculates CO2 emissions from fuel combustion activities and a portion of industrial process emissions as defined by the IPCC. Agricultural and industrial emissions (other than for fuel combustion), other upstream fossil fuel production emissions, fugitive emissions and LULUCF are excluded. This figure includes the range between conditional and unconditional NDCs, where applicable. All NDCs have been rebased to 2010 by APERC to enable comparison.

Sources: APERC analysis and IEA (2018).

Numbers consistency issues

Energy intensity target, 2000-2050

→ *Projection*

Index
(2005=100)

— BAU — Target — 2DC — BAU_5 — BAU_6

Renewable Doubling Goal Index, FED, 2000-2050

→ *Projection*

Index
(2010=100)

— BAU
— TGT
— 2DC
— BAU_5
— BAU_6

Opportunities for policy action

- Malaysia could help double the share of renewable energy in the APEC energy mix overall while also raising its own energy security

- Clear sectoral goals for energy efficiency would support the government's 2DC ambitions

- Balancing energy exports and imports is an opportunity for policy makers to take a long-term view of energy planning and policy design

- Data availability is foundational to policy analysis and design

- Reforming domestic energy subsidies can help make the energy system more efficient and productive.
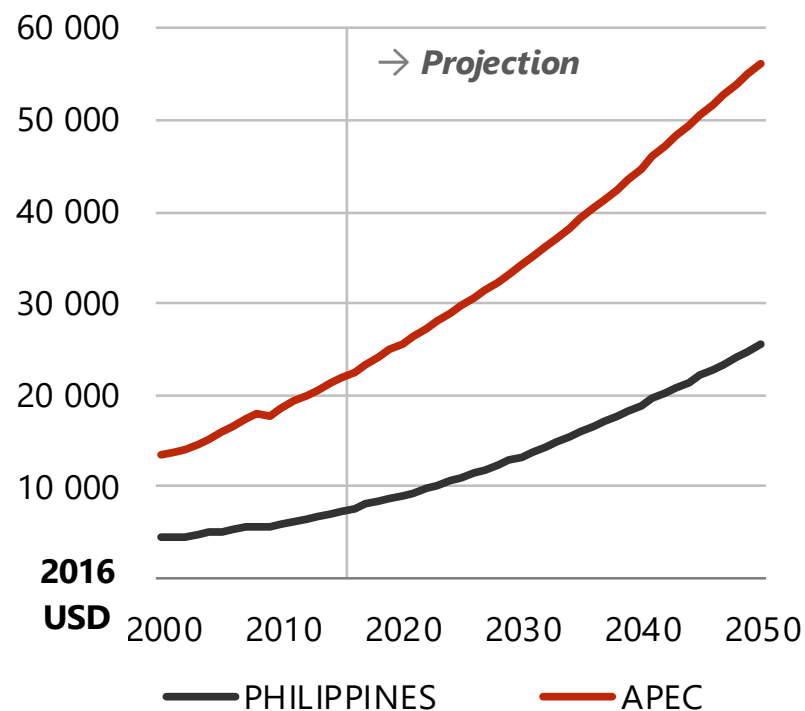
Philippines Outlook

Key drivers: GDP and population

Philippines • GDP, population and GDP per capita, 2000-50
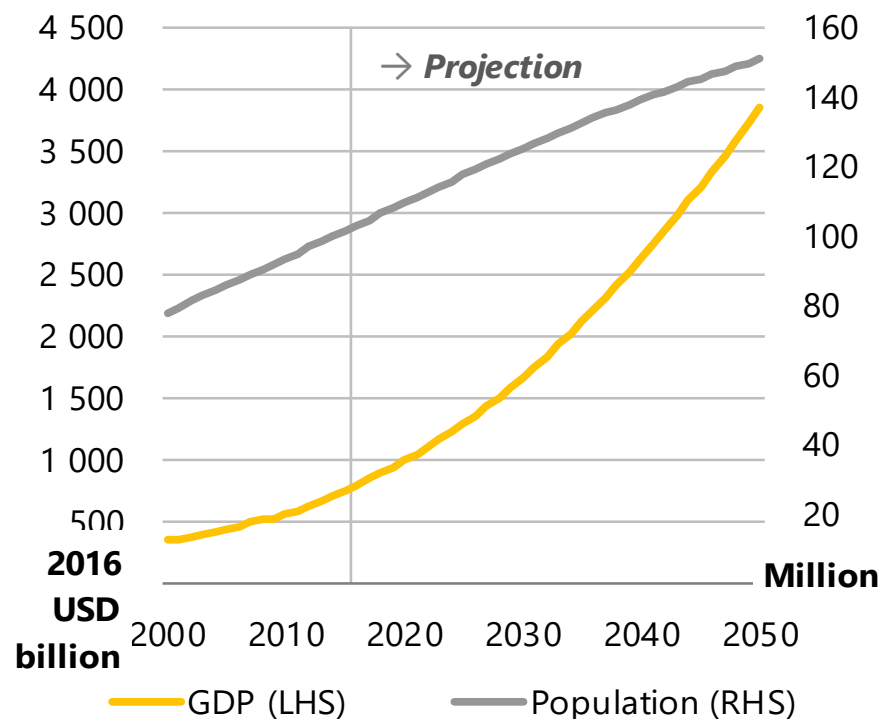
→ *Projection*

GDP (LHS)   Population (RHS)

Sources: APERC analysis, OECD (2018), UN DESA (2018) and World Bank (2018a and 2018b).
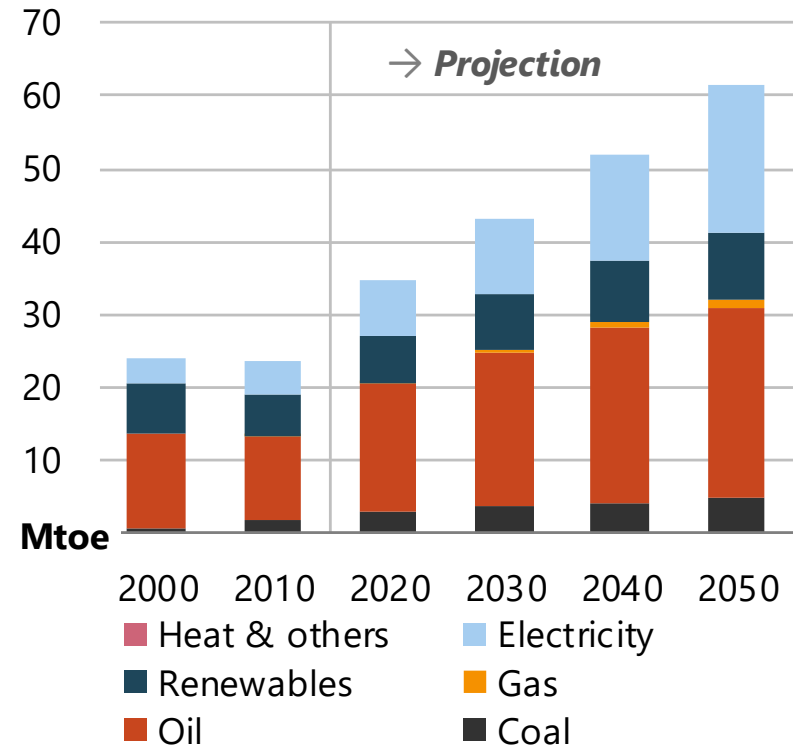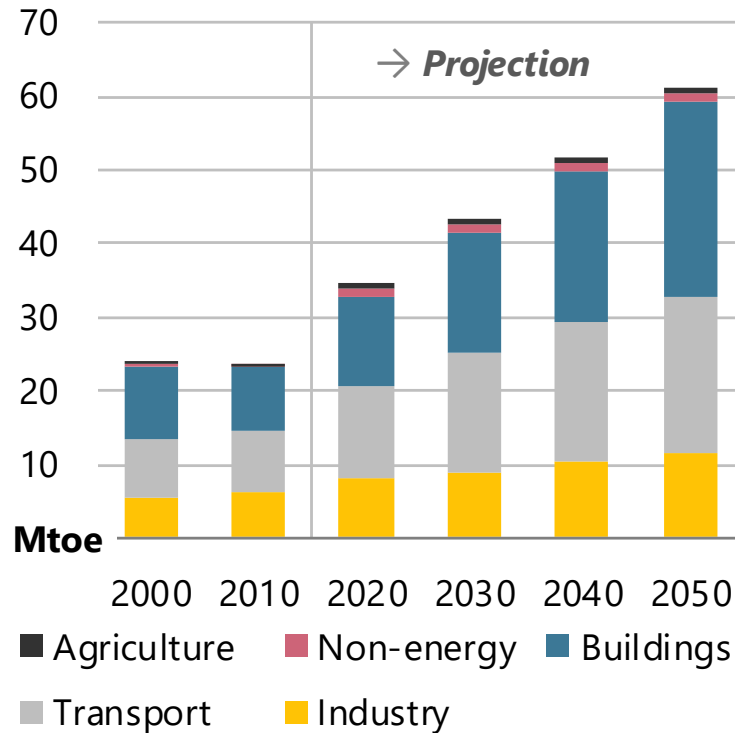

→ *Projection*

PHILIPPINES   APEC

Sources: APERC analysis, OECD (2018), UN DESA (2018) and World Bank (2018a and 2018b)

One of the fastest-growing economies in APEC, with a CAGR of 5.6% over the past decade and a projected CAGR of 4.7% over the Outlook period

FED grows rapidly to support growing requirements

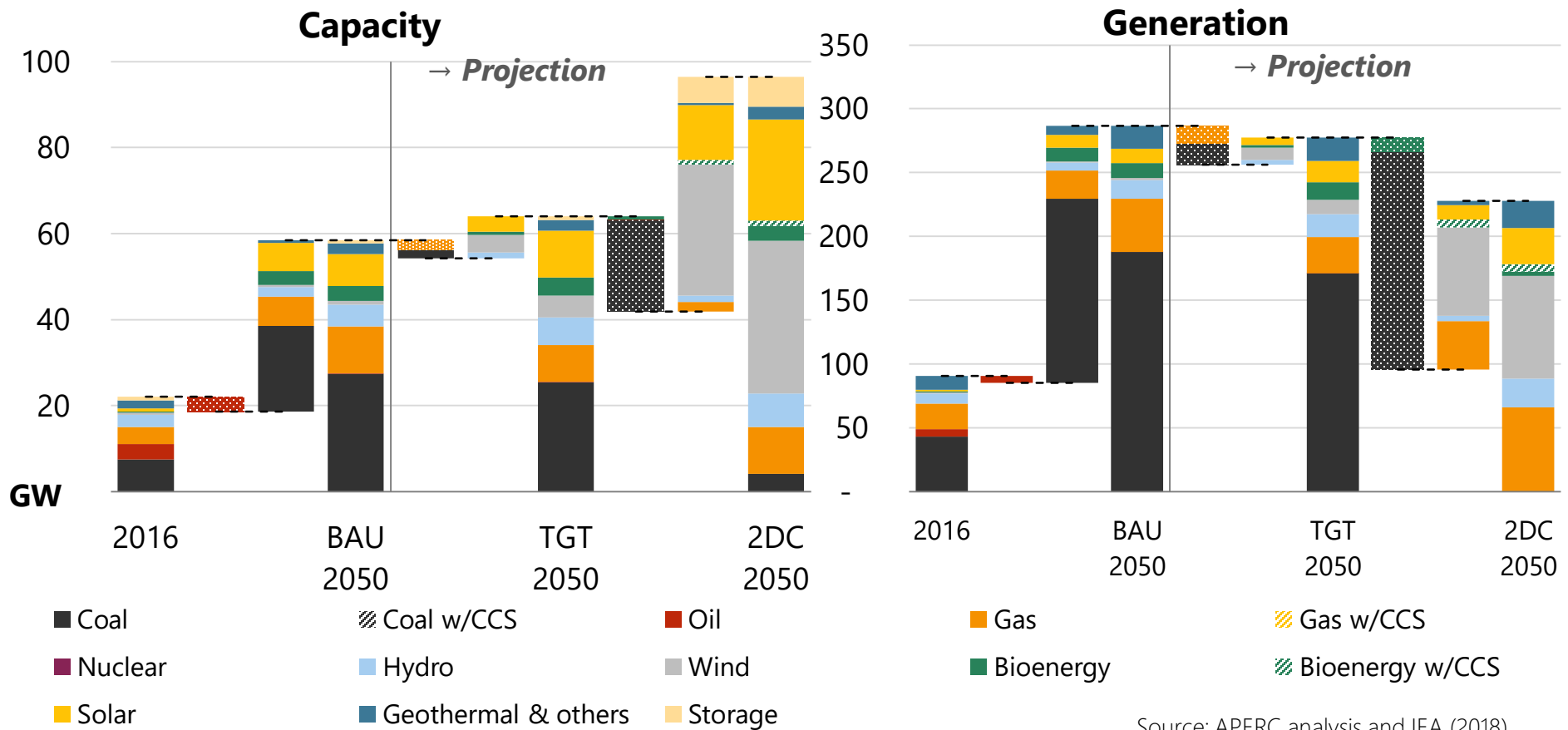## Philippines • Final energy demand by sector and fuel in the BAU, 2000-50

Sources: APERC Analysis and IEA (2018).

Buildings final energy demand (FED) doubles over the Outlook period and oil continues to dominate the final energy mixes.
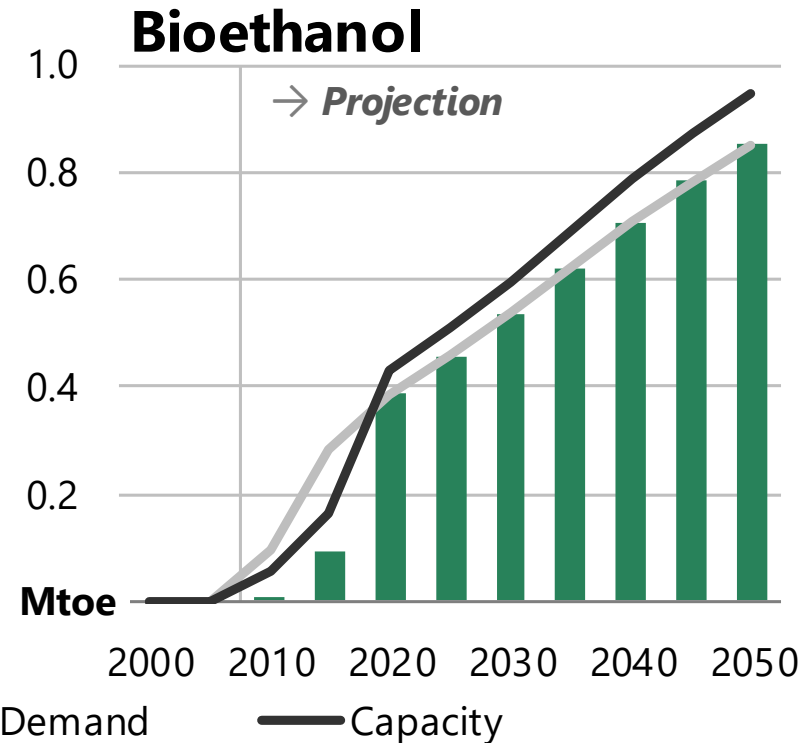
Decommissioning of coal; building wind

Power capacity and electricity generation by fuel, 2016-50

Capacity → *Projection*

Generation → *Projection*

Legend:
- ■ Coal
- ▨ Coal w/CCS
- ■ Oil
- ■ Gas
- ▨ Gas w/CCS
- ■ Nuclear
- ■ Hydro
- ■ Wind
- ■ Bioenergy
- ▨ Bioenergy w/CCS
- ■ Solar
- ■ Geothermal & others
- ■ Storage

Source: APERC analysis and IEA (2018)

Well-utilised biodiesel and bioethanol plants

2DS

Biodiesel / **Bioethanol**

→ *Projection*

Legend: ■ Production — Demand — Capacity
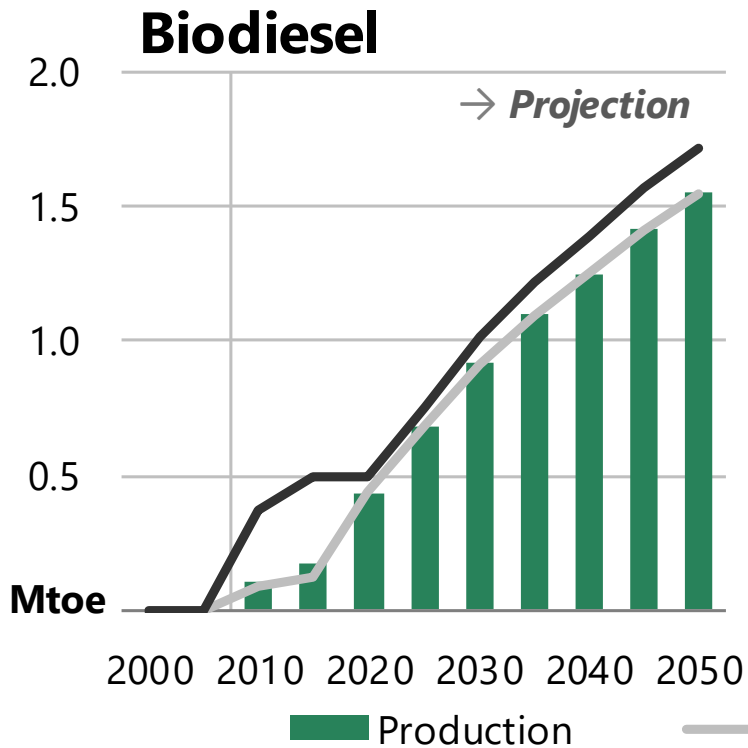
The NDC is not achieved under any scenario

Philippines • Energy-related CO_2 emissions by scenario, 2000-50

→ *Projection*

Legend:
- BAU
- TGT
- 2DC
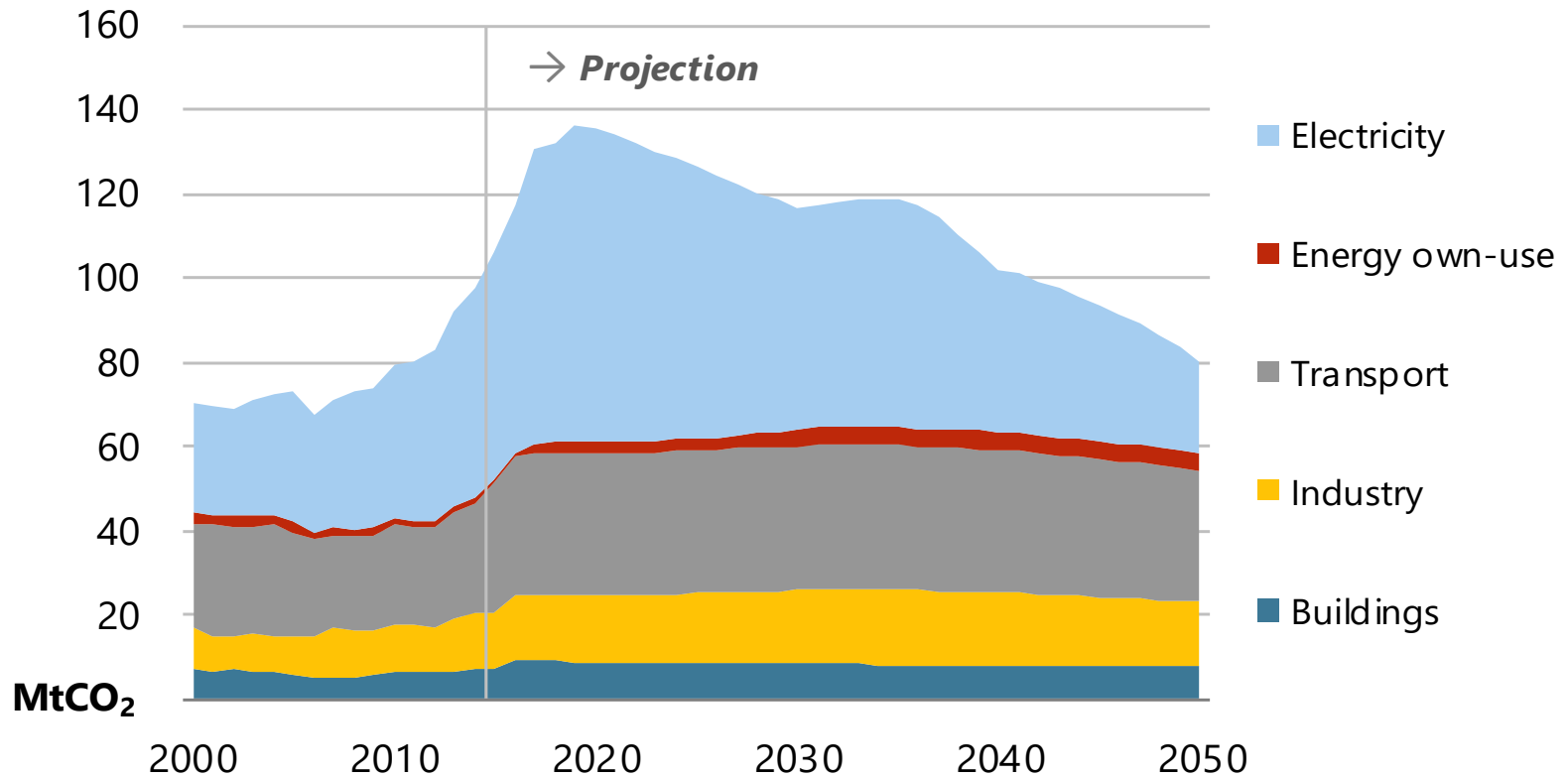- NDC range

MtCO$_2$
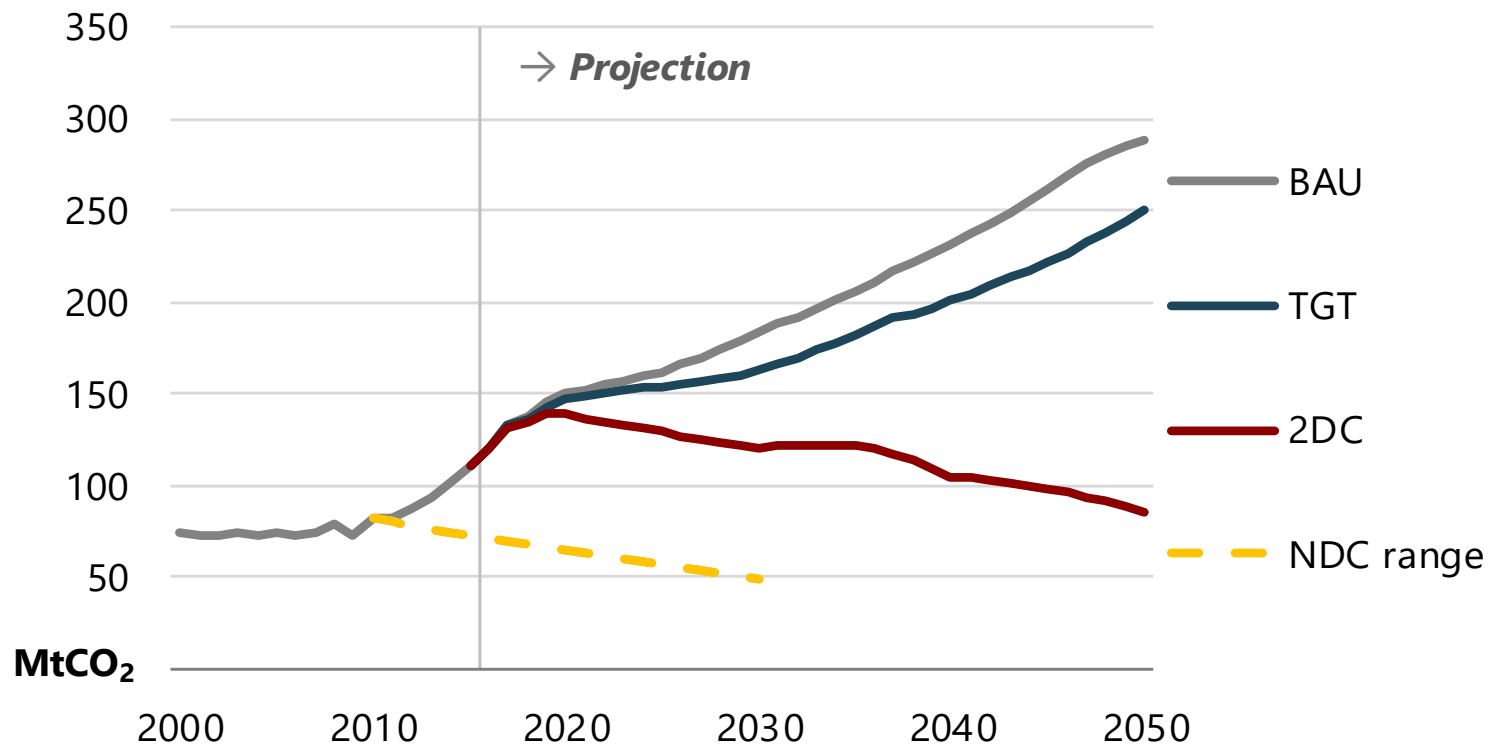
Effort beyond emission intensity improvement needed throughout the energy sector to achieve emission reductions.

EIOU lag behind all other sectors

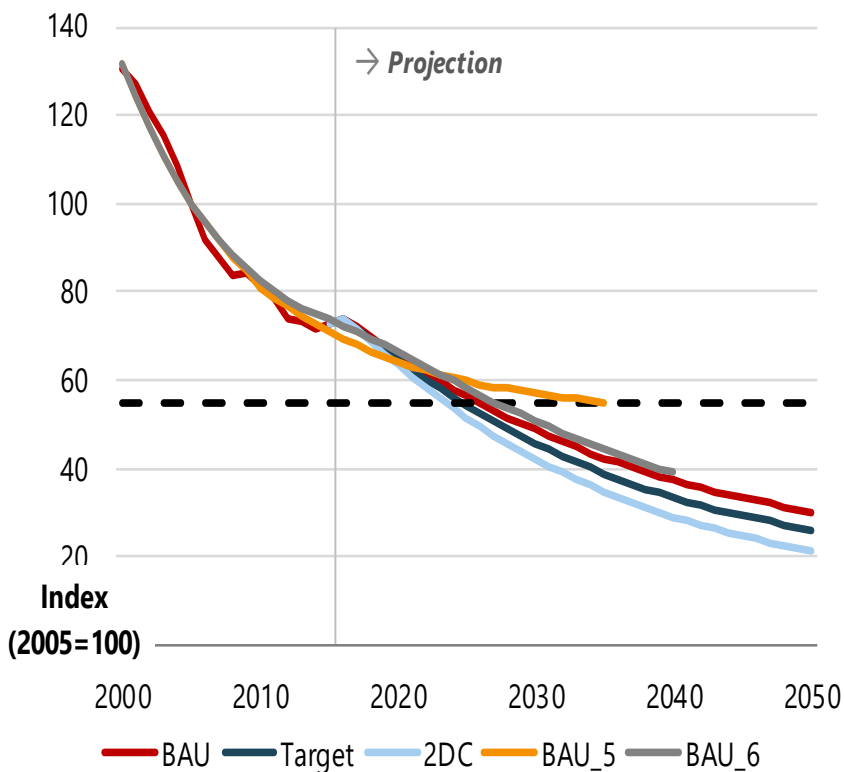Philippines • Energy related CO_2 emissions by sector in the 2DC, 2000-50

→ *Projection*

Legend:
- Electricity
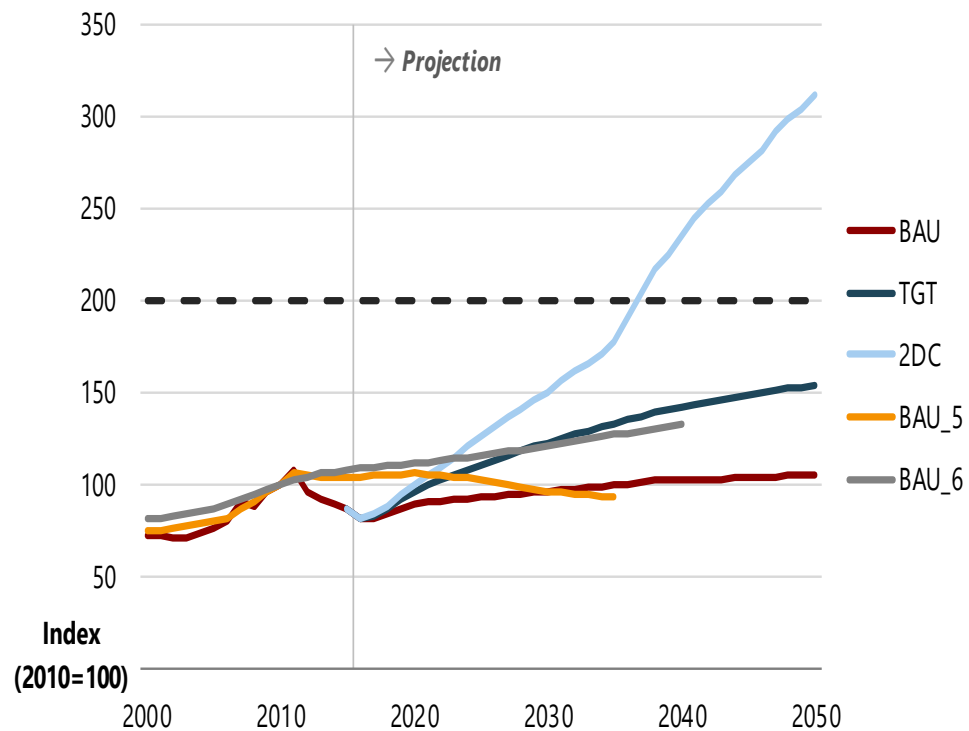- Energy own-use
- Transport
- Industry
- Buildings

Power, transport and industry drive emission declines. Further efforts from energy industry own-use (EIOU) needed to decarbonise the Philippines energy system.

Despite demand growth, EI target is on track

Title **Energy intensity target, 2000-2050**

→ *Projection*

Index
(2005=100)

Legend: BAU, Target, 2DC, BAU_5, BAU_6

Title **Renewable Doubling Goal Index, FED, 2000-2050**

→ *Projection*

Index
(2010=100)

Legend: BAU, TGT, 2DC, BAU_5, BAU_6

Final thoughts

- Decent progress on renewables, but coal still dominates in BAU—more USC or advanced USC, CCS anytime soon?

- Room for improvement on the energy efficiency, especially buildings and transport sectors. Energy Efficiency and Conservation Act should be implemented soonest.

- Higher capital expenditure for a 2DC pathway, especially in buildings and transport, but significant fuel cost savings.

- Despite efforts NDC is not achieved on schedule—additional policy measures beyond 2DC.

Chinese Taipei Outlook

Key findings

- The 2DC achieves INDC and Greenhouse Gas Reduction and Management Act targets. The TGT only achieves INDC target.

  - INDC target: reduce CO_2 emissions by 20% below 2005 level by 2030.

  - Greenhouse Gas Reduction and Management Act target: reduce CO_2 emissions by 50% below 2005 level by 2050.

- Chinese Taipei's TPES peaks at 111 Mtoe in 2020 in the BAU Scenario and gradually declines to 99 Mtoe in 2050 as energy demand decelerates, especially in industry and buildings.

- Energy intensity improves by 37% from 2016 to 2050 in the BAU, 44% in the TGT and 50% in the 2DC. The largest reduction is in transport as more advanced vehicles, particularly EVs, replace conventional ones.

Key drivers: GDP and population

Chinese Taipei • GDP, population and GDP per capita, 2000-50

→ *Projection*

GDP (LHS) — Population (RHS)
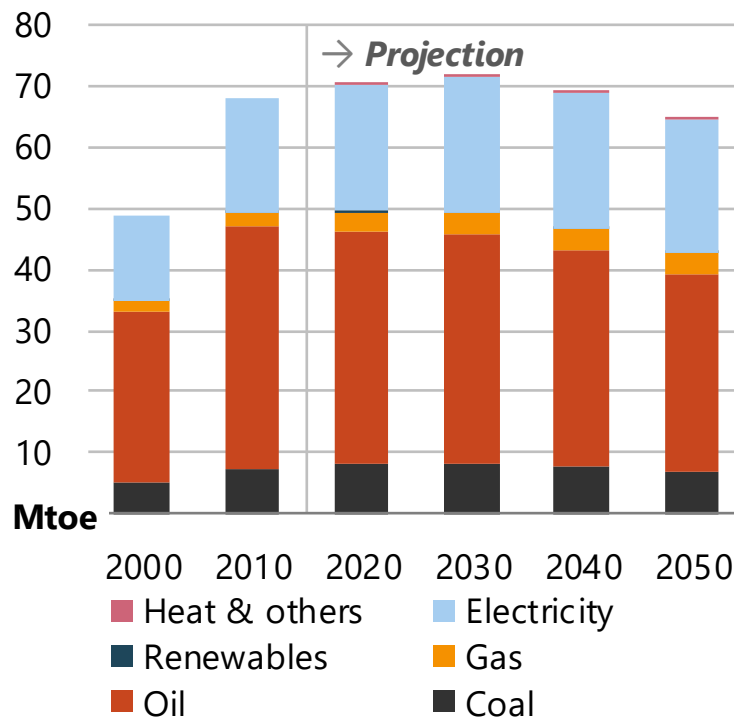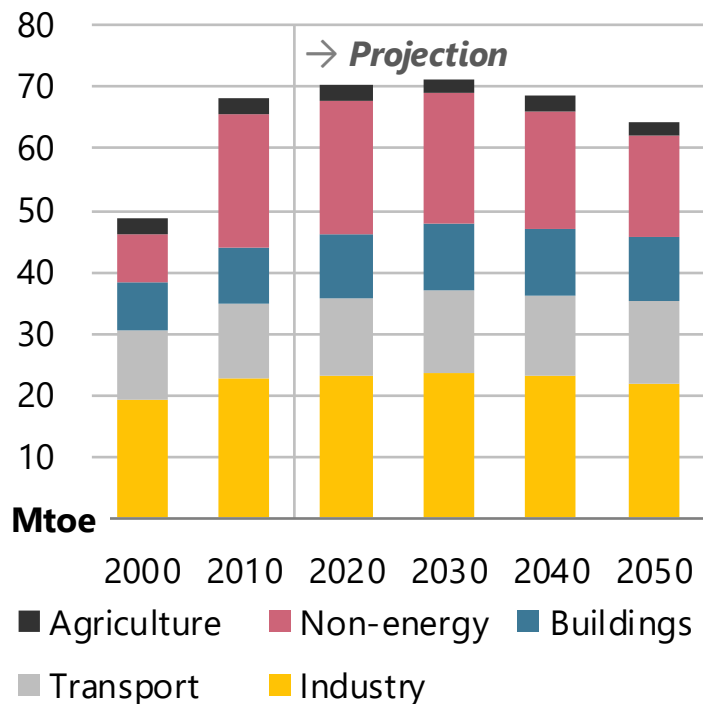
→ *Projection*

CHINESE TAIPEI — APEC
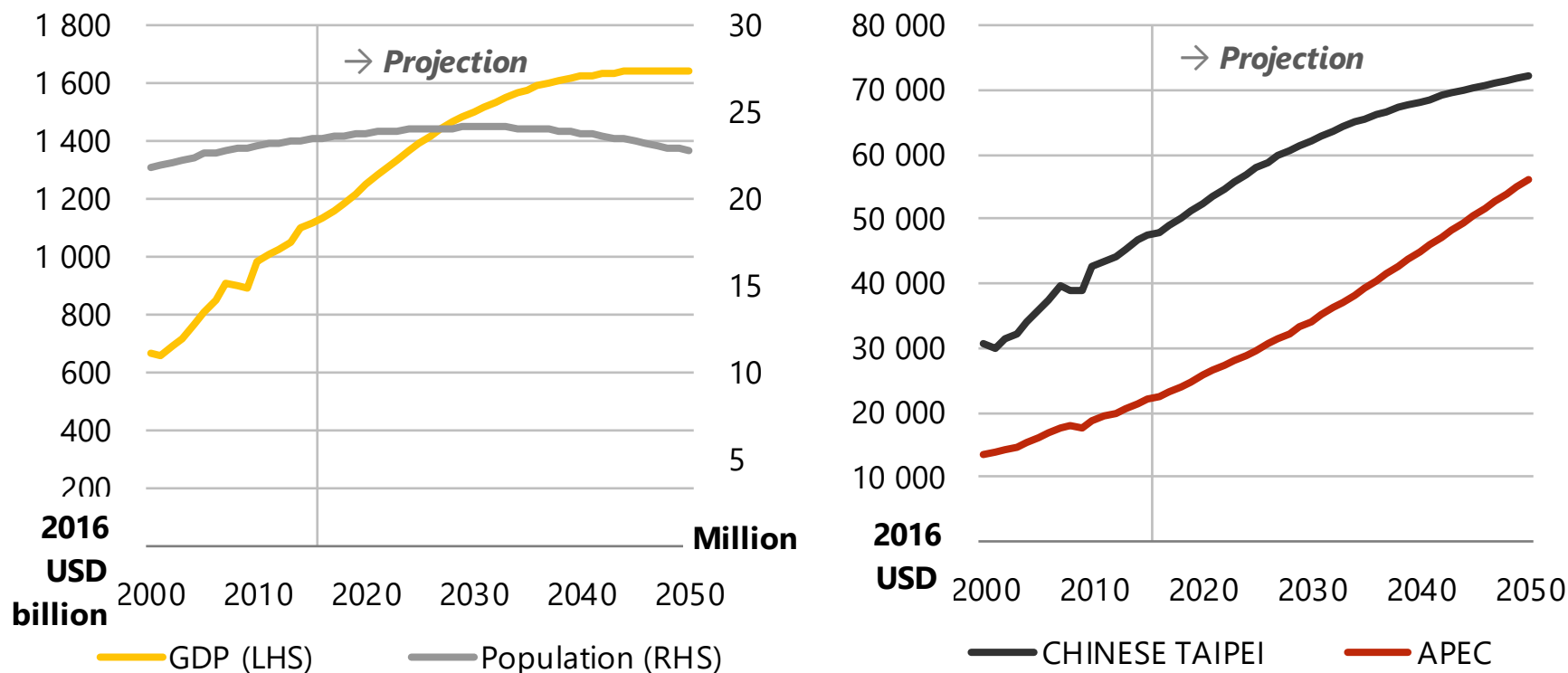
Sources: APERC Analysis and IEA (2018).

Low birth rate leads to a decline in population from 2033. We still see GDP per capita grows as GDP outgrows population.

FED peaks at 2020 and gradually declines

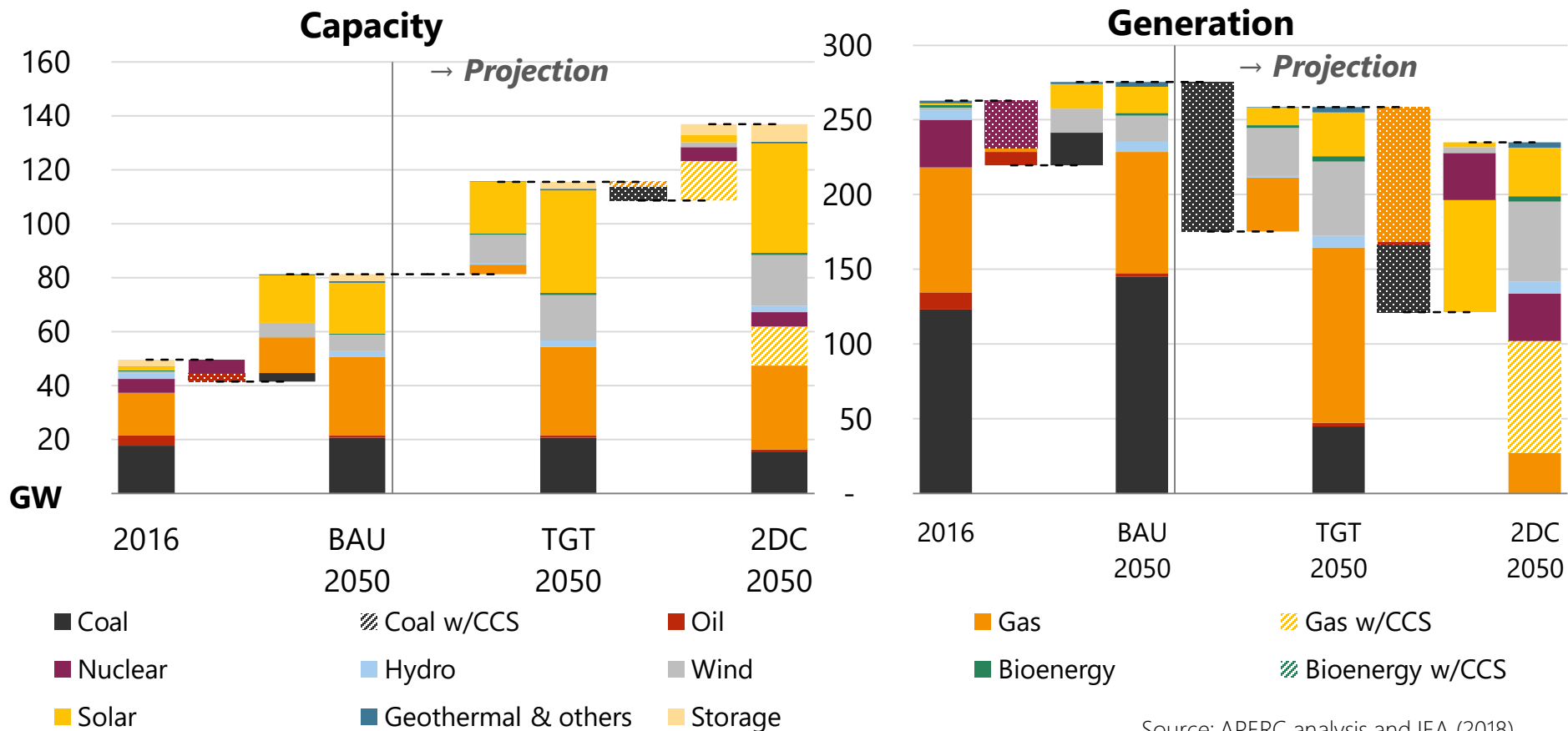Chinese Taipei• Final energy demand by sector and fuel in the BAU, 2000-50

Sources: APERC Analysis and IEA (2018).

Industry (chemical and petrochemical and machinery)and non-energy sectors are the main drivers of FED growth.
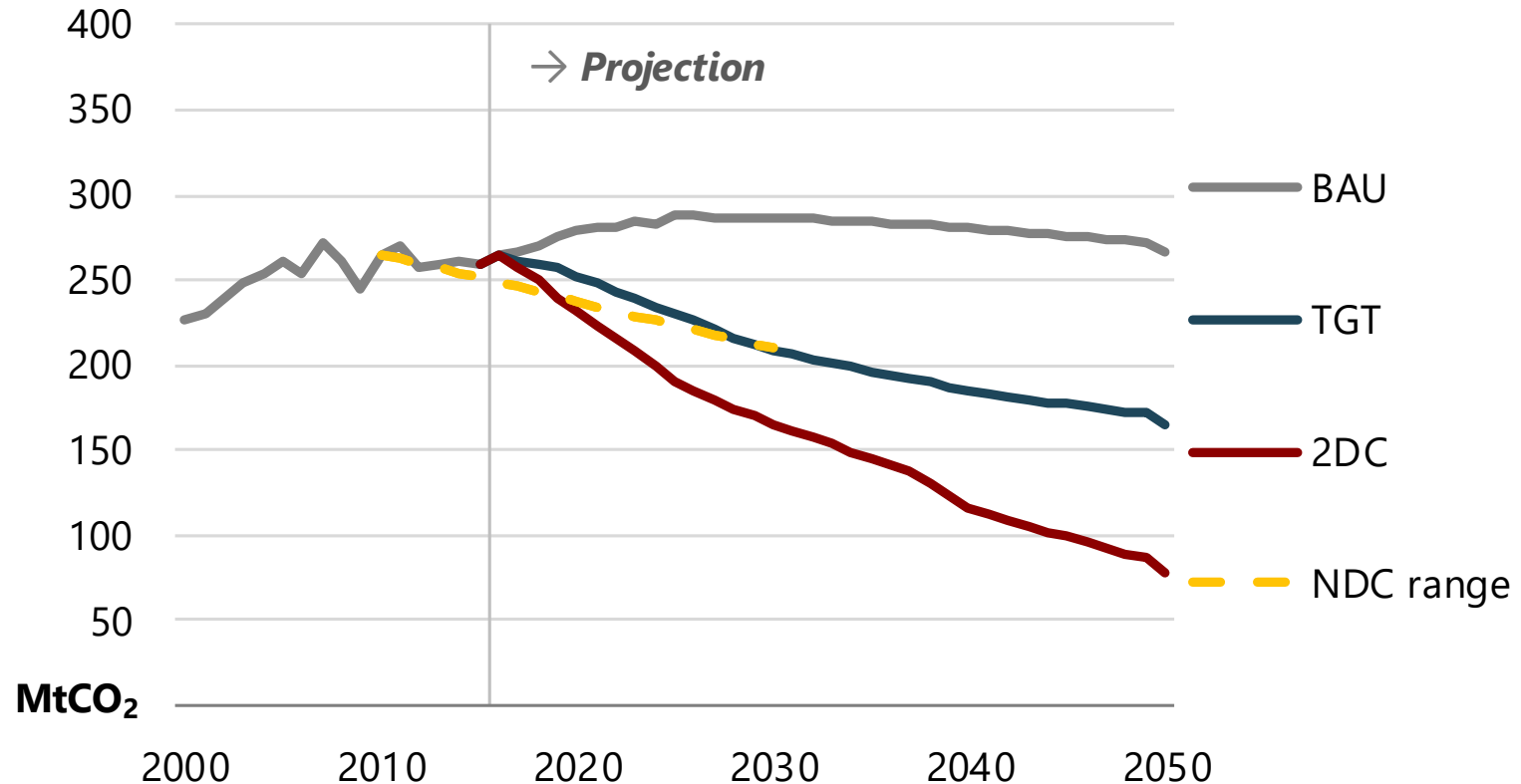
Decommissioning of coal; building wind

Power capacity and electricity generation by fuel, 2016-50

INDC is achieved under the TGT and 2DC

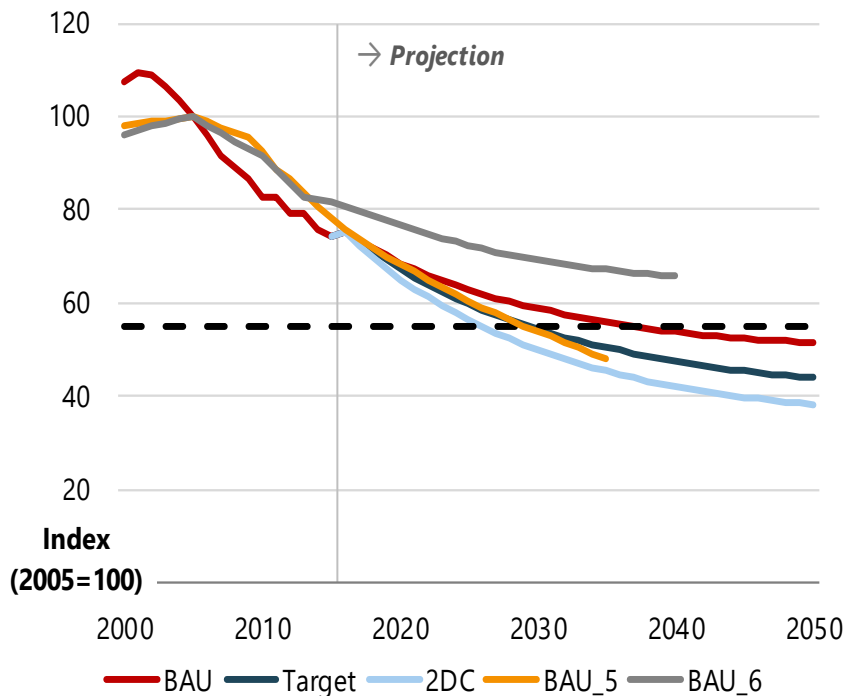**Chinese Taipei • Energy related CO_2 emissions by scenario, 2000-50**

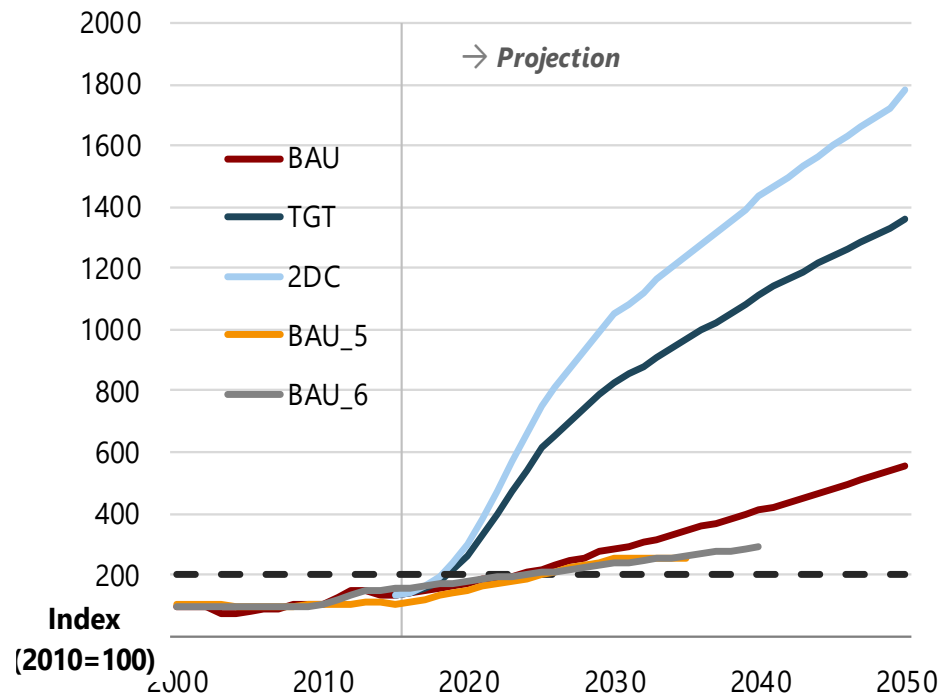Sources: APERC Analysis and IEA (2018).

Gas with CCS and phasing out coal are the key drivers in the decarbonisation path. But is it realistic in Chinese Taipei?

Flat demand, good targets progress

Title **Energy intensity target, 2000-2050**

→ *Projection*

Index (2005=100)

BAU — Target — 2DC — BAU_5 — BAU_6

Title **Renewable Doubling Goal Index, FED, 2000-2050**

→ *Projection*

- BAU
- TGT
- 2DC
- BAU_5
- BAU_6

Index (2010=100)
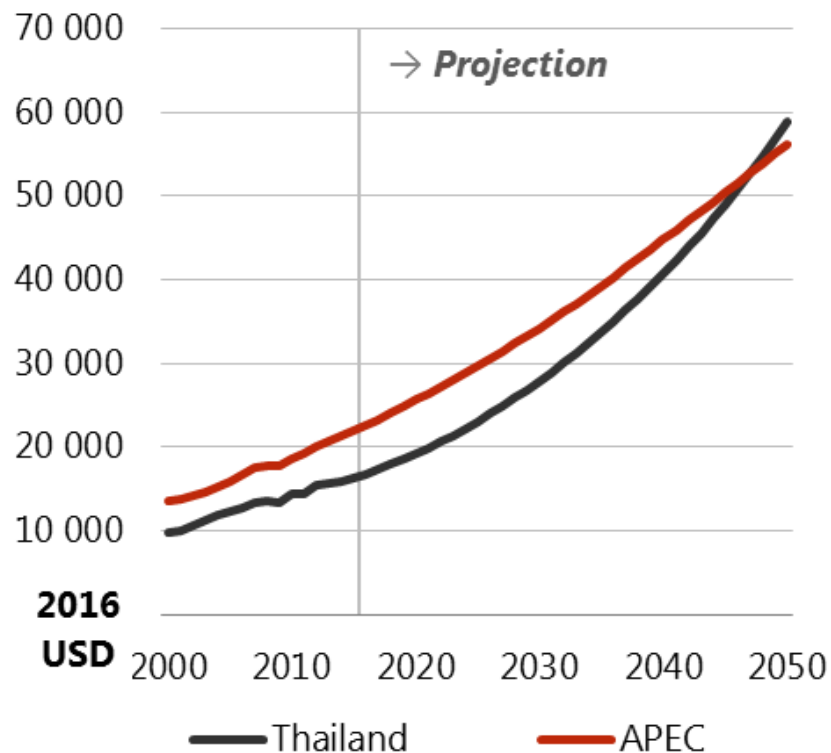
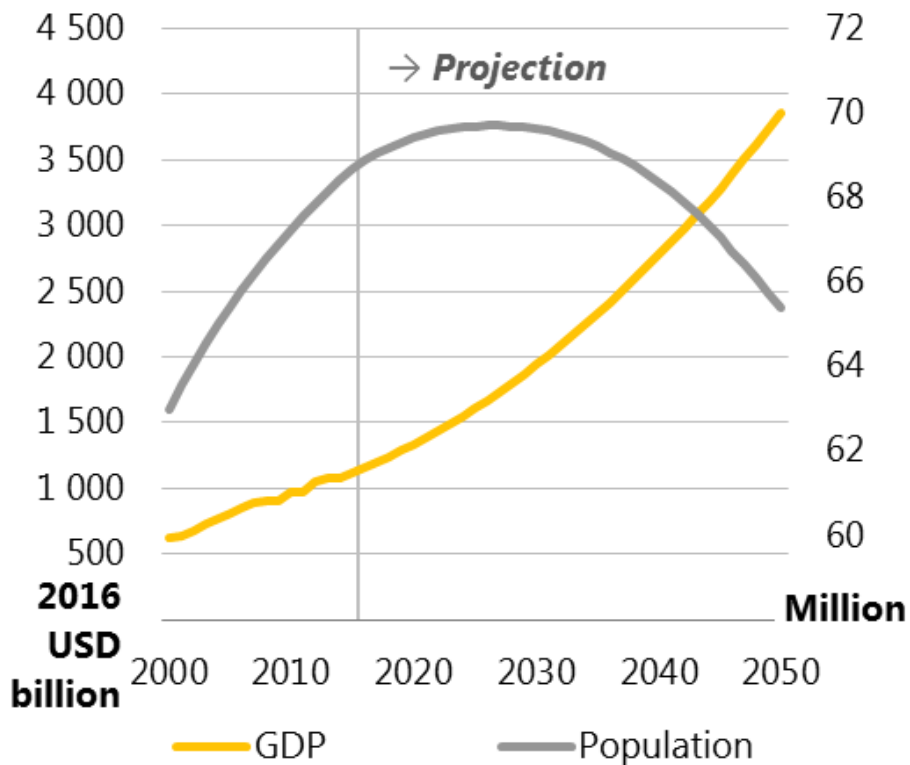Sources: APERC Analysis and IEA (2018). **59**

Thailand Outlook

Key drivers: GDP and population

Thailand • GDP, population and GDP per capita, 2000-50

Sources: APERC Analysis and IEA (2018).

GDP per capita more than triples over the Outlook period as GDP grows strong while population decreases from 2030 onwards.

Demand grows steadily through the Outlook

Thailand • Final energy demand by sector and fuel in the BAU, 2000-50
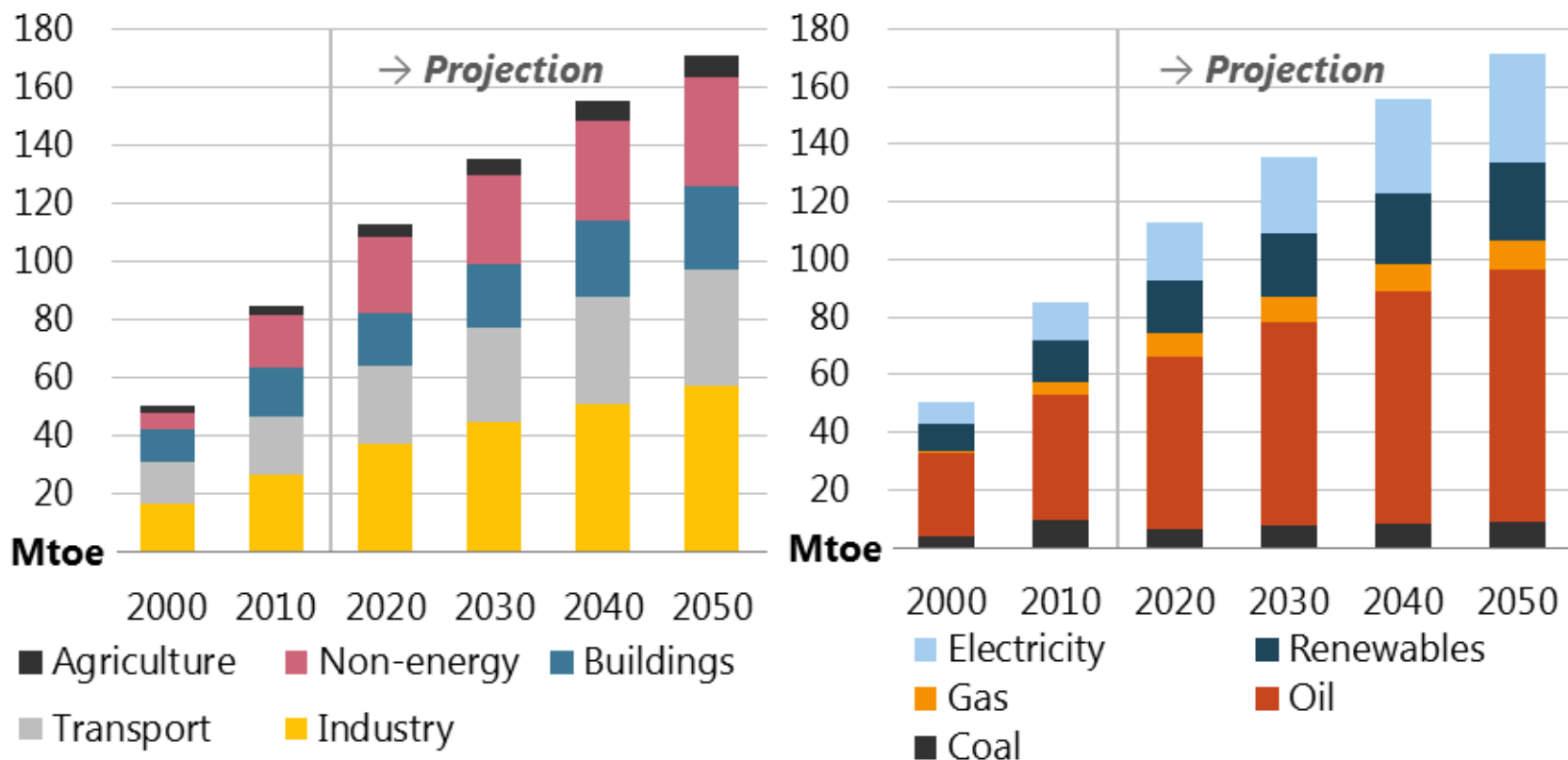
Sources: APERC Analysis and IEA (2018).

Industry and transport largely dominate in the BAU as population and GDP both increase. Oil shares over 50% of demand over the Outlook period.

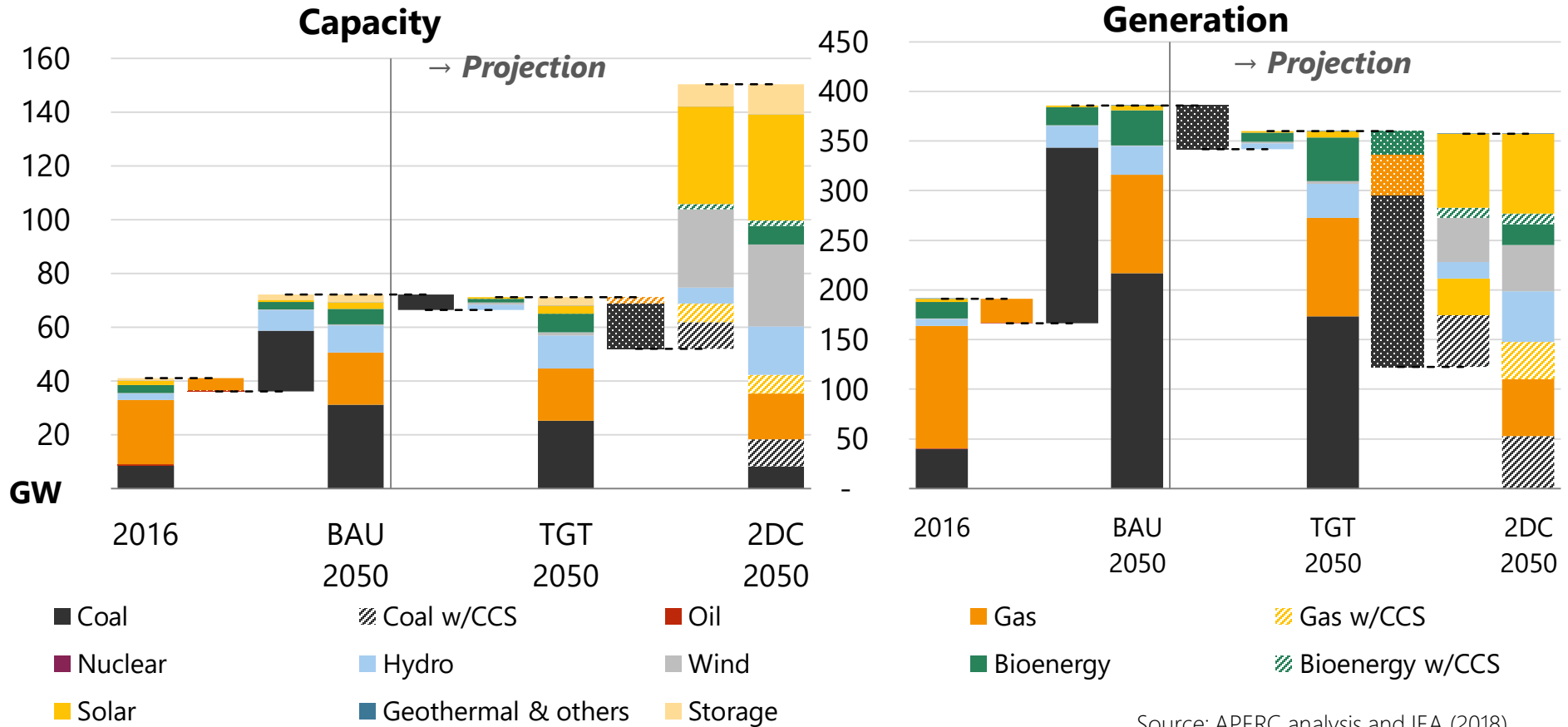# Huge VRE additions in 2DC

Power capacity and electricity generation by fuel, 2016-50

Source: APERC analysis and IEA (2018)

Bio-refining capacity depends on a scenario

2DS

Biodiesel

→ *Projection*

3.0
2.5
2.0
1.5
1.0
0.5
Mtoe

2000 2010 2020 2030 2040 2050

Bioethanol

→ *Projection*

1.5

1.0

0.5

Mtoe

2000 2010 2020 2030 2040 2050

■ Production — Demand — Capacity
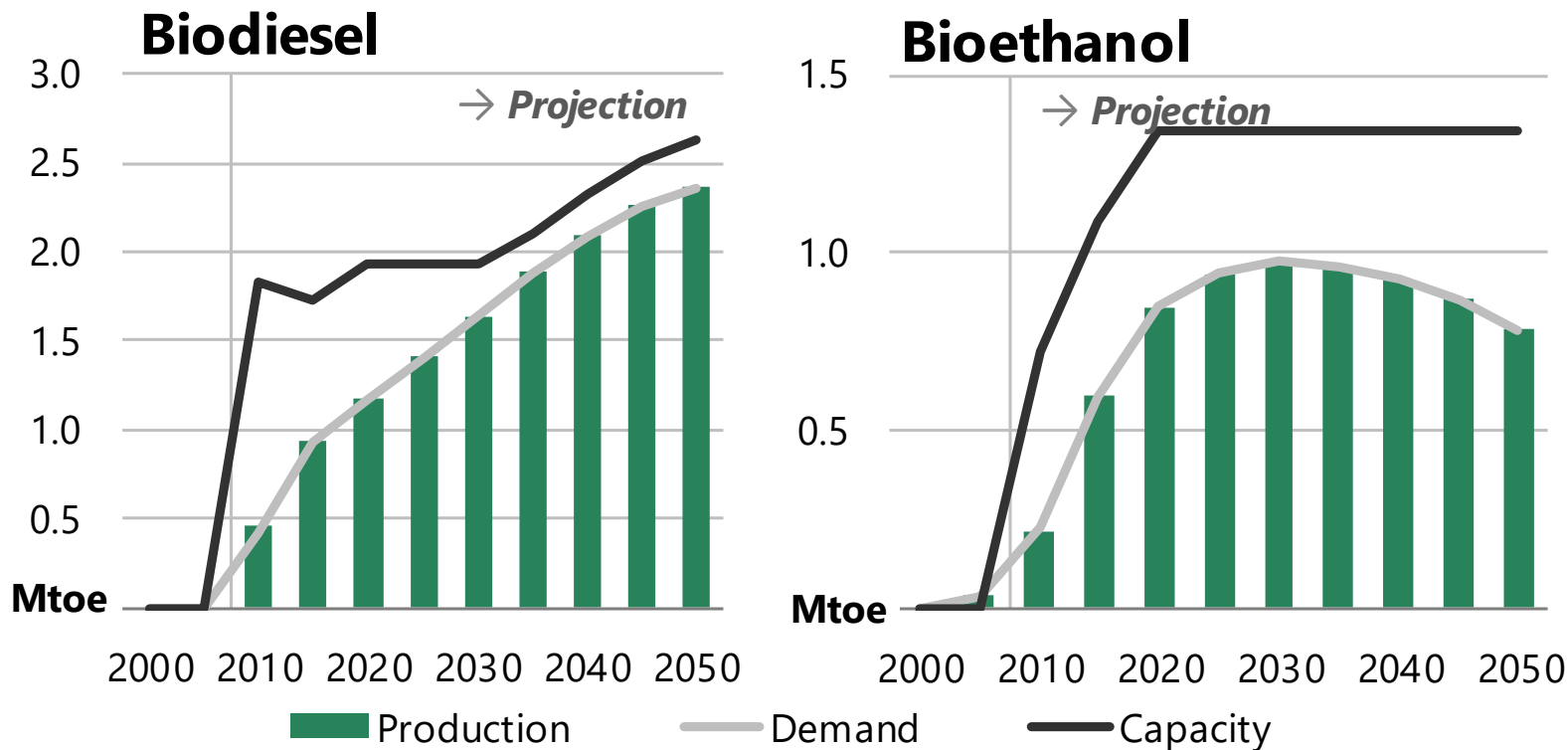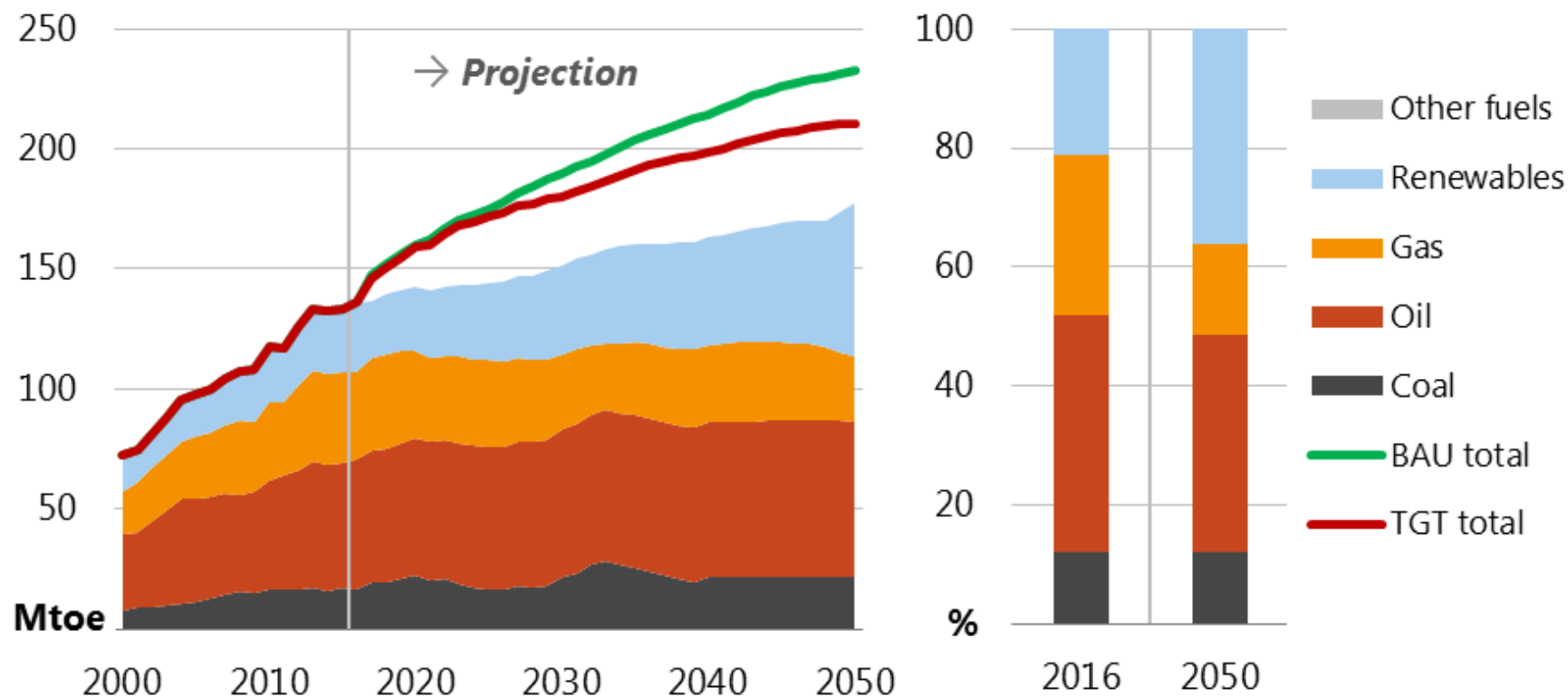
But fossil fuels still dominate supply in 2DC

Thailand • Total primary energy supply by fuel in the 2DC, 2000-50

Sources: APERC Analysis and IEA (2018).

Fossil declines but still dominates supply mix. Renewables increases its share to 37% over the Outlook period.

The NDC is narrowly missed in the BAU

Thailand • Energy related CO_2 emissions by scenario, 2000-50
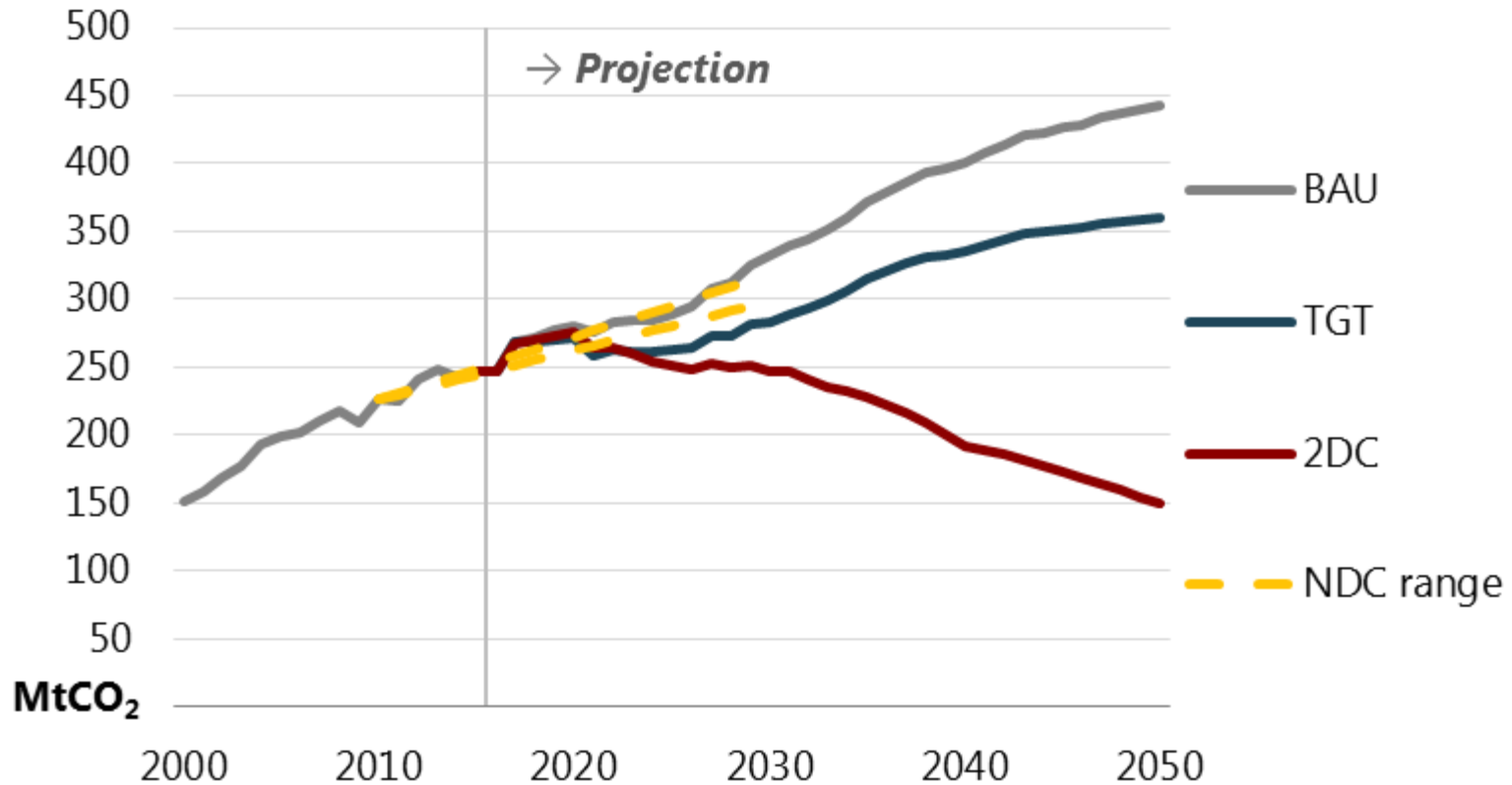
Sources: APERC Analysis and IEA (2018).

Coal almost singlehandedly shifts Thailand away from what looks like an achievable pathway. Oil also contributes to CO_2 increase in the BAU.

Growing demand, makes targets difficult

Title **Energy intensity target, 2000-2050**

→ *Projection*

Index (2005=100)

Legend: BAU — Target — 2DC — BAU_5 — BAU_6

Title **Renewable Doubling Goal Index, FED, 2000-2050**

→ *Projection*

Index (2010=100)

Legend: BAU, TGT, 2DC, BAU_5, BAU_6
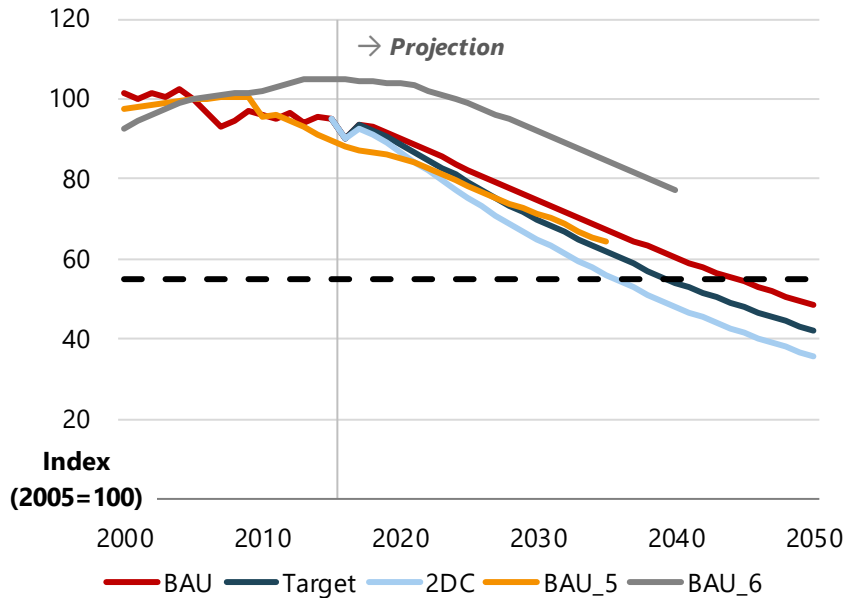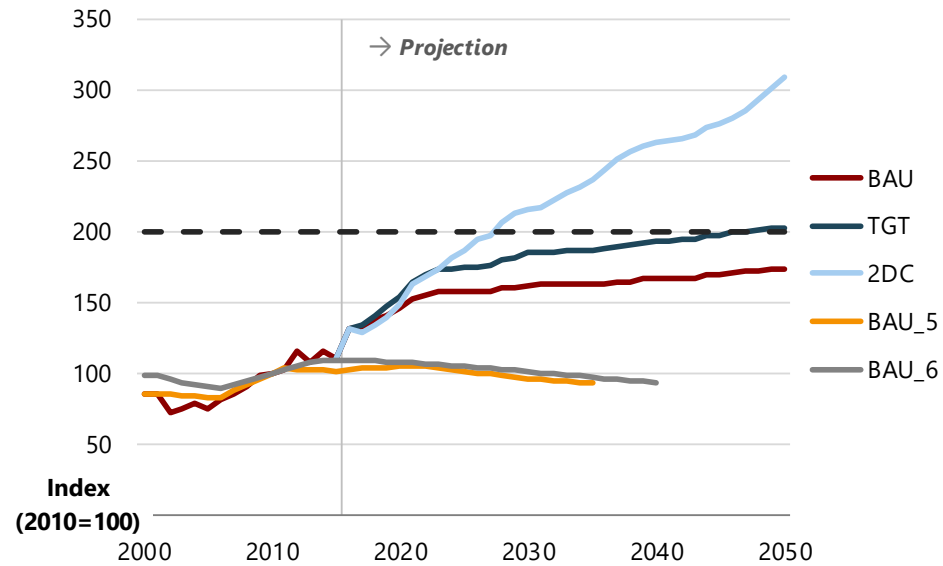
Final thoughts

- Monitoring and evaluation of the impacts of the 21st round bid (Erawan and Bongkot) and implementation of TPA should be exercised to benefit the future growth of natural gas and to ensure long-term energy supply security.

- Power development plan should be systematically revised on a regular basis rather than ad-hoc to clearly reflect necessary development for energy investors.

- PDP 2018 should be synchronised with other energy plans and Energy 4.0 to ensure that it not only reflects recent changes in power generation but will support and promote the modern energy technologies.

APERC
Asia Pacific Energy Research Centre

Thank you!

https://aperc.ieej.or.jp/

Our modelling

- Projections are demand-driven

- The model is a combination of sectoral models

- All sub-models use a consistent set of assumptions:
  - GDP
  - Population
  - Energy prices

Data Sources

- GDP: OECD, APERC projections

- Population: UNDESA

- Commodity prices: IEEJ

- Emissions pathways (2DC): *Energy Technology Perspectives*, IEA

- Technology costs and performance characteristics: many sources

  - Platts (power plants)

  - IRENA (renewables)

- Historic energy balances: *World Energy Statistics*, IEA

- More detail can be found in the 7th edition Methodology Annexes, which will be available online after Outlook is published

Mathematical formulation

- Mathematical formulation varies by sector

	Sector	Formulation	Software
Demand	Transport	Bottom-up accounting + econometric	Excel & GAMS
	Industry	Bottom-up accounting + econometric	Excel & GAMS
	Buildings	Bottom-up accounting + econometric	Excel & GAMS
Transformation	Electricity & Heat	LP (cost optimisation)	GAMS
	Refining	Accounting	Excel
Supply	Production	Accounting	Excel
	Trade	Accounting	Excel
Integration	All	None	GAMS

Model diagram (7th Edition)