

The Role of Renewables in Electric Power Systems in Achieving Carbon Neutrality in APEC

by

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1 Overview

The 21 economies that comprise the Asia Pacific Economic Cooperation (APEC) forum are home to almost three billion people and account for 60% of global GDP. APEC is reliant on immense levels of energy supply, with a significant trade component, required to enable continued strong economic growth in the region. The forum's purpose is to promote regional economic integration and trade. Understanding long-term energy market trends are fundamental to achieving this and has become increasingly important in the global push toward decarbonisation.

The APEC member economies, which include the world's largest energy producers and consumers, are pushing to increase the share of renewable energy in their economies. The 2014 APEC Summit and the 2015 APEC Energy Ministers' Meeting set goals to double the share of renewable energy in the total energy mix by 2030 from 2010 levels to achieve sustainable and resilient energy development in the Asia-Pacific region.

In recent years, most of the largest energy consumers, and consequently the largest emitters of CO₂, have stated their plans to achieve carbon neutrality in 2050-2060. In the 8th edition of APEC Energy Demand and Supply Outlook, one of two scenarios is the Carbon Neutrality scenario (CN). This hypothetical scenario includes plans and measures each economy could take to reduce emissions and capture opportunities to reduce carbon intensity further.

2 Methods

The 8th Outlook modelling involves decomposing the APEC energy system into multiple subcomponents spanning demand sectors (such as industry, transport, and buildings), transformation (power, heat, and refining), and supply (production and trade). Demand sector modelling relies on estimates of output, energy efficiency, fuel switching rates, activity rates, technology diffusion, and multiple other variables. Calibration occurs via knowledge-based iteration, particularly with economy-level experts. When demand is finalised, the power, heat, refining, and supply sector models deliver the required energy based on assumptions about fuel cost trajectories, and policy/market interventions. In the case of the power sector, a least cost model is deployed. However, cost-based decisions and assumptions are overridden if there is political backing for certain technologies or fuels that enhances their relative economic viability. There is frequent iteration of results, with extensive review and input from economy and energy experts to arrive at final energy demand, transformation, and supply results.

Characteristics that distinguish the Reference scenario results from the Carbon Neutrality scenario are energy efficiency rates that follow historic trends; gradual rates of fuel switching; and relatively slower diffusion of new technologies in demand and power sectors. The assumed level of macroeconomic output and activity are close to the same in both 8th Outlook scenarios.

3 Results

3 – 1 Introduction

The power sector, which accounted for 46% of APEC's CO₂ emissions in 2018 (EGEDA, 2021), should play a key role in decarbonisation. In CN, the power sector is expected to contribute half of the reduction in CO₂ emissions. This is achieved by reducing the production of electricity generated by fossil fuels by 40%. In CN, electricity produced from wind and solar in 2050 exceeds the total amount of electricity produced by all thermal power plants in 2018.

In the Carbon Neutrality scenario, electricity production in the APEC economies in 2050 is 60% higher than at 2018 levels. On the one hand, this growth is due to projected economic growth and, on the other hand, to accelerated electrification in all end-use sectors. Electrification is one of the primary measures to achieve the CO₂ emission reduction goals. These goals are achieved mainly using primary renewable energy from wind and solar on the power generation side.

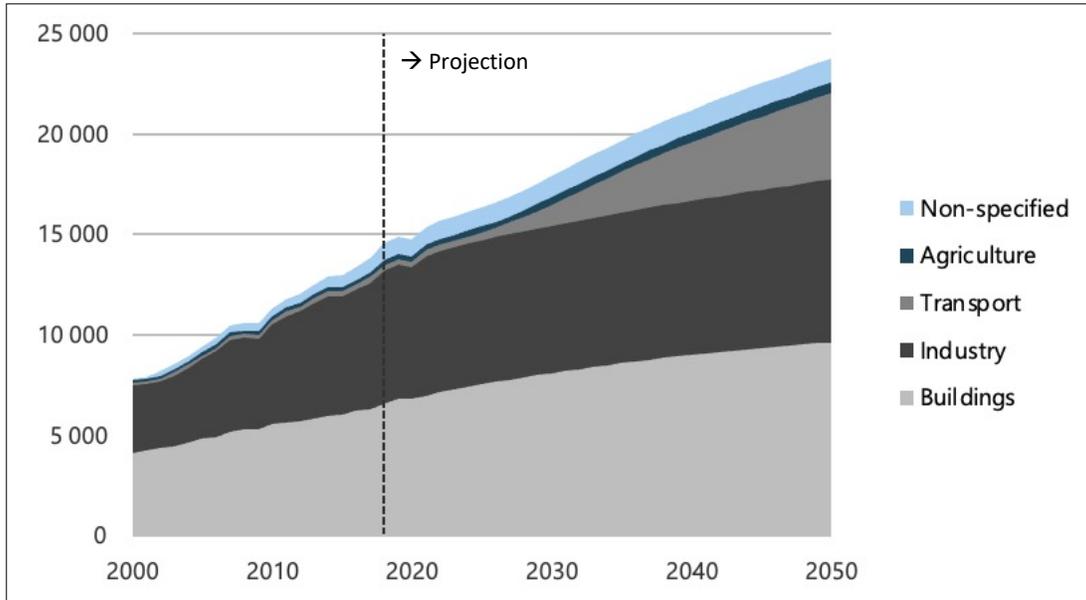
3 – 2 Demand for Electricity

The growth of electricity demand in APEC in the carbon-neutral scenario will continue to follow an almost linear trend. By 2050, electricity consumption could increase by 60% compared to 2018 levels. The contribution of different sectors to the increase in electricity consumption will vary. However, the share of electricity in the energy mix will increase substantially in all consumption sectors.

Transport will undergo fundamental changes in the structure of energy resources consumed. By 2050, the transport sector's share in the growth of electric power consumption will be nearly 40%. Buildings will account for 30% and industry for 15% of the increase in electricity consumption.

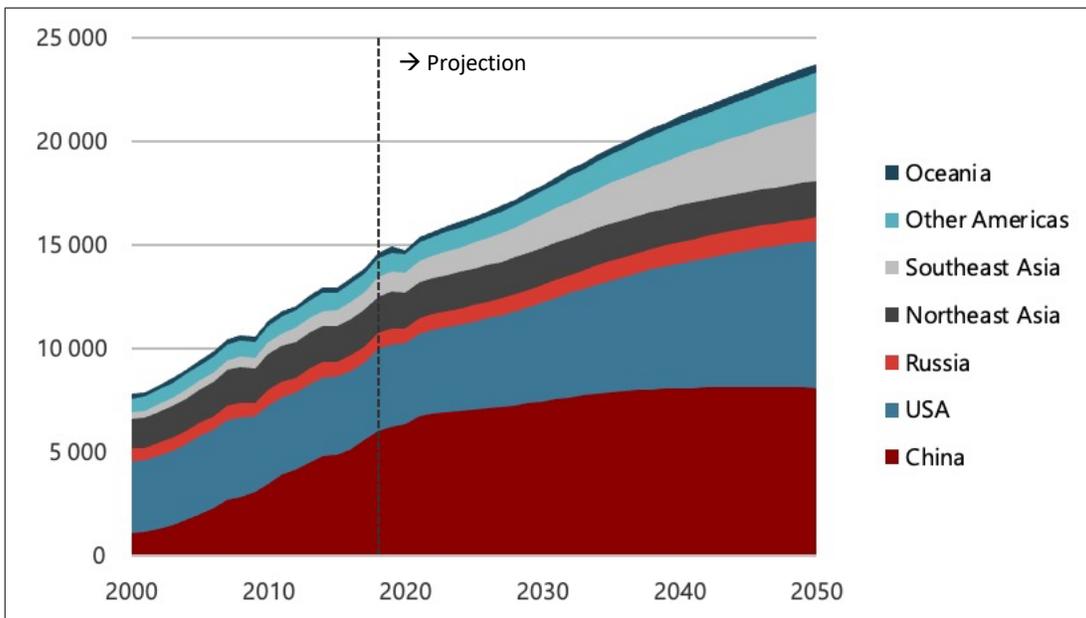
In CN, the increase in electricity consumption is expected to be distributed unevenly among APEC regions. Three regions will account for 84% of the increase in power consumption : the United States, China, and Southeast Asia. China and the United States will remain the largest electricity consumers in APEC. Electricity consumption in Southeast Asia is projected to increase by more than 2.5 times. Thus, Southeast Asian APEC member economies will become the 3rd largest consumers in APEC. The remaining APEC regions will account for no more than 15% of the increase in electricity consumption. In contrast, electricity consumption in the economies of Northeast Asia may remain at current levels or even decline.

Figure 3-1: APEC final electricity demand in the Carbon Neutrality scenario, by end-use sector, 2000–2050 (TWh)



Source: EGEDA, APERC analysis.

Figure 3-2: APEC final electricity demand in the Carbon Neutrality scenario, by region, 2000–2050 (TWh)



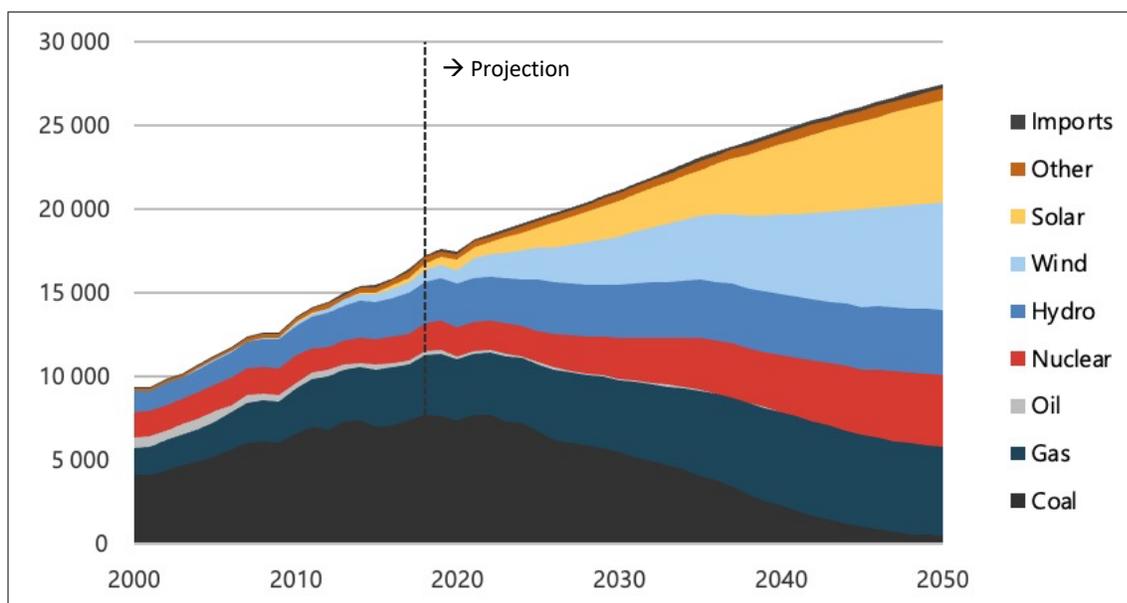
Source: EGEDA, APERC analysis.

3 – 3 Electricity generation

Electricity generation nearly doubled between 2000 and 2018. Two-thirds of the increase came from coal and gas-fired power plants. In the Carbon Neutrality scenario, electricity generation increases by 60% from 2018 to 2050. Significant changes in the generation structure are expected, with the share of thermal power plant generation decreasing from 67% in 2018 to 21% in 2050. Electricity production at coal-fired power plants will be reduced to an insignificant 2%.

By 2050, in CN, electricity generation by thermal power plants will be halved. Electricity generation at nuclear and hydropower plants will increase by 1.5 and 2.5 times, respectively. To meet expected growth in power demand and achieve a substantial emissions reduction, electricity generation from solar and wind power plants will need to increase by more than 10 times.

Figure 3-3: APEC electricity generation in the Carbon Neutrality scenario, by energy carrier, 2000–2050 (TWh)

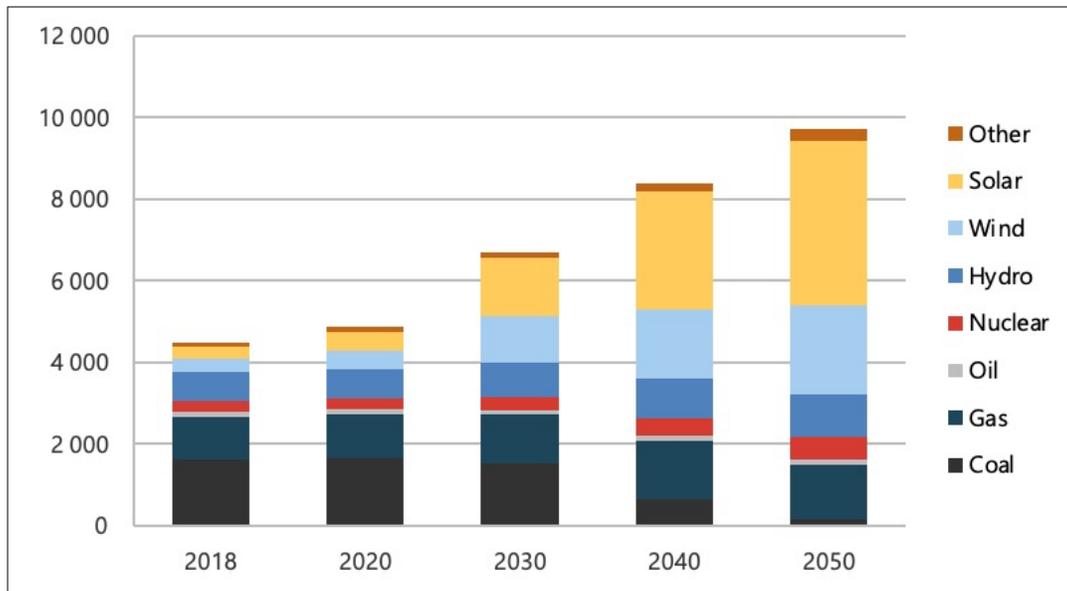


Source: EGEDA, APERC analysis.

3 – 4 Electricity generation capacity

Fossil fuel power plants account for more than 60% of APEC's current 4 500 GW installed capacity. The share of renewables, comprised mostly of hydro, solar, and wind, is 30%. In the Carbon Neutrality scenario, the structure of installed capacity undergoes significant changes through to 2050, with capacity increasing to almost 10 000 GW.

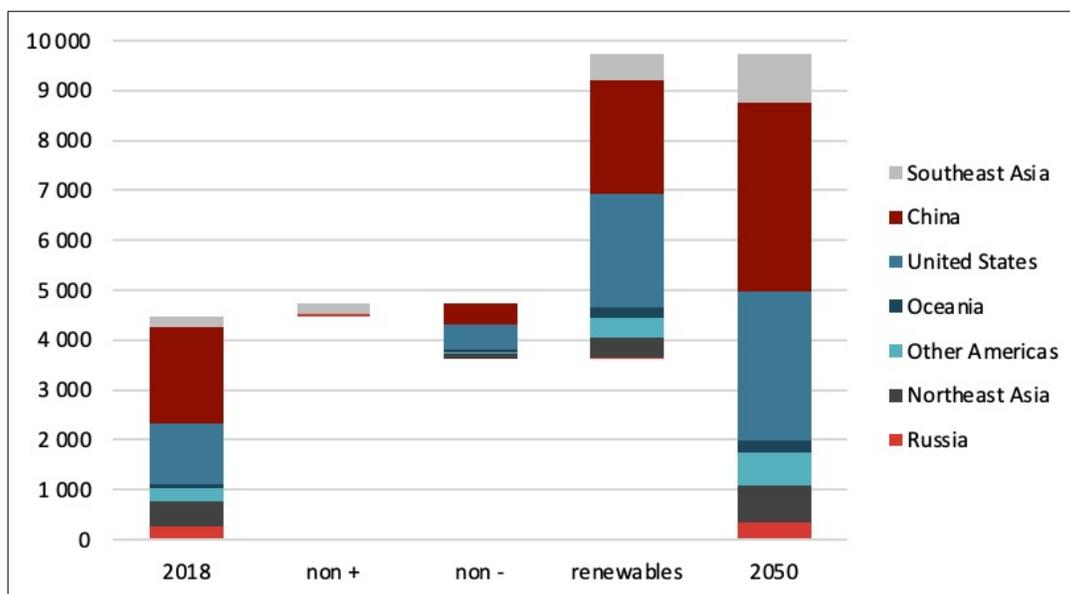
Figure 3-4: APEC generation capacity in the Carbon Neutrality scenario, 2018–2050 (GW)



Source: EGEDA, APERC analysis.

In CN China and the United States, in roughly equal shares, will account for almost 90% of the increase in new wind and solar generation capacity in APEC through 2050.

Figure 3-5: APEC generation capacity changes the Carbon Neutrality scenario, by region, 2018–2050 (GW)



Source: EGEDA, APERC analysis. “Non” refers to non-renewables. “+” and “-” refer to increases and decreases.

3 – 5 Transformation of the electricity generation

The Carbon Neutrality scenario envisions an unprecedented transformation of the power sector. Electricity production from wind and solar will increase more than 10-fold by 2050. At the same time, the share of such electricity will increase from 8% to 47%, and the share of electricity generated by fossil fuels will decrease from 67% in 2018 to 21% in 2050.

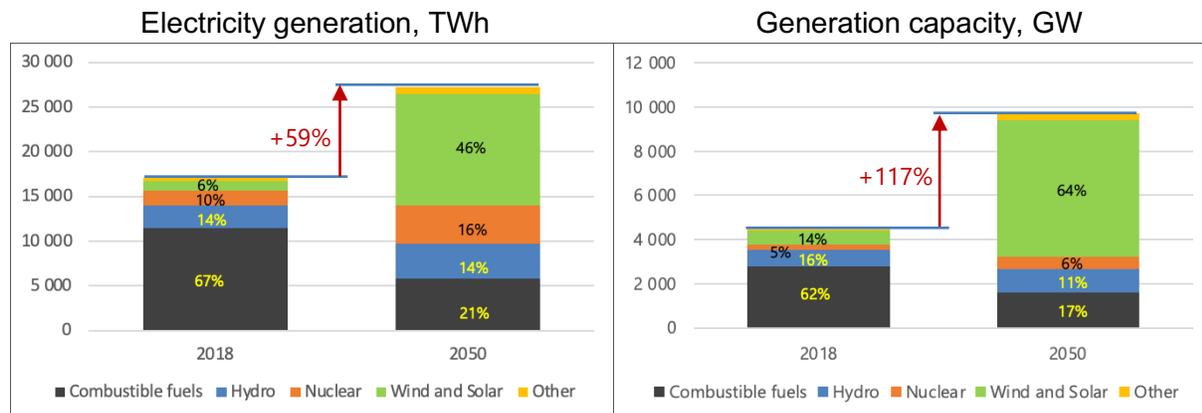
The share of thermal power plants decreases by about 45% due to the retirement of coal-fired thermal power plants and accelerated deployment of renewables. The share of hydropower plants declines from 16% in 2018 to 11% in 2050 (though absolute capacity increases through the projection). The share of nuclear power plants increases to 6%. The installed capacity of wind increases 7-fold while solar increases nearly 13-fold. The total installed capacity share of renewables, including hydro, reaches 75%.

Wind and solar have a significantly lower capacity factor than most other generation technologies. These two generation technologies' significant increase in capacity will cause the average APEC capacity factor to drop from 44% in 2018 to 32% in 2050.

To provide such an increase in electricity generation from renewables, a corresponding 10-fold increase in renewable generating capacity is required. The share of wind and solar generation capacity will increase from 14% to 64%. Thus, the shares of generating capacity of wind and solar and thermal power plants will become the opposite of the 2018 level.

This will require a significant transformation of the existing power systems to ensure consumers' sustainable and reliable power supply.

Figure 3-6: APEC electricity generation and generation capacity in the Carbon Neutrality scenario, 2018 and 2050



Source: EGEDA, APERC analysis.

4 Conclusions

There are two associated challenges in achieving carbon neutrality: decarbonising electricity generation and electrification in the end-use sectors. On the one hand, the reduction in electricity

generated using fossil fuels will directly reduce CO₂ emissions in the power industry. On the other hand, deepening electrification will replace fossil fuels with electricity in end-use sectors, thus reducing emissions on the demand side.

The transformation of electric power systems to significantly reduce CO₂ emissions requires a predominance of low-carbon energy sources. Due to the lower capacity factor of renewables, significant growth in electricity consumption will require more than a doubling of generating capacity by 2050. Generation from renewable energy sources is not dispatchable. Therefore, the predominance of renewable generating capacity will require a significant transformation of existing power systems to ensure a sustainable and reliable power supply to consumers. In the Carbon Neutrality scenario, measures to keep the reliability of electricity supply include maintaining existing fossil fuel-fired generating capacity as a backup source and using storage facilities to balance electricity output from renewables. Overall, this will significantly increase the reliance on critical minerals used in the construction of both wind and solar power plants and storage batteries.

The implementation of the Carbon Neutrality scenario assumes significant technical breakthroughs in electricity storage and cost reductions comparable to those already seen in photovoltaic panels and wind turbines over the past decade. It should be noted that the trend to maximise the use of renewable energy to prevent climate change is not in doubt. However, implementing the Carbon Neutrality scenario will require a significant acceleration of change. Rather, accelerating the development of technologies seems to be a challenging task. In such a case, it will be necessary to implement the required changes faster than now.

Implementing such a transformation will require significant investment and effort from regulators and governments. In addition, energy conservation and changes in consumer behaviour regarding energy use will become even more important.

Thus, the implementation of the Carbon Neutrality scenario assumes significant progress in technologies and accelerated performance of changes, reducing costs in addition to unprecedented investments in the generation, storage and transmission segments of the power sector.

5 References

Asia Pacific Energy Research Centre (2022), APEC Energy Demand and Supply Outlook 8th Edition [scheduled to be published in June 2022]