

Energy Security and Resilience in the APEC Region

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1 Introduction

The 21 economies that comprise the Asia Pacific Economic Cooperation (APEC) forum are home to almost three billion people and account for approximately 60% of global GDP and energy consumption. The region is also expected to account for a disproportionate share of future increases in global energy consumption. In several rapidly growing economies, increased energy demand causes increased dependence on energy imports, which raises the issue of energy security. All APEC economies are also expected to increase their reliance on variable renewable energy (VRE), such as solar and wind energy, which can reduce grid reliability. This paper utilizes the energy growth, import dependence, and energy mix projections from the 8th edition of the *APEC Energy Demand and Supply Outlook (8th Outlook)* to examine the energy security, resilience, and grid reliability risks facing the APEC economies over the next three decades.

Energy security, resilience, and grid reliability refer to the provision over time of uninterrupted energy supplies to consumers at a reasonable cost regardless of supply disruptions caused by natural and man-made disasters. Because modern economies demand substantial quantities of energy and that demand is relatively price inelastic, supply disruptions can impose substantial economic costs. Depending on the characteristics of an economy's energy system, changes in energy demand, import dependence, and the mix of energy types (fuels, electricity) can impair or enhance energy security, resilience, and grid reliability.

2 Methods

The 8th Outlook provides projections of future demand, import dependence, and energy mix for each of the 21 APEC member economies for two scenarios: a Reference scenario (REF) and a Carbon Neutrality scenario (CN). Each scenario is a hypothetical projection intended to provide analytic support for APEC economies as they implement energy programs and policies. REF is a pathway reflecting a continuation of existing trends in technology development and deployment, and current government programs and policies. CN illustrates a potential pathway where energy efficiency, fuel switching, and technology advance substantially along with ambitious government programs to reduce CO₂ emissions from fossil fuel combustion by 2050. The pathways are constructed based on the unique characteristics, policy objectives, and starting points of each economy. The CN scenario does not consider CO₂ emission sinks, such as land-use or technologies like direct air capture.

The 8th Outlook projections are developed using a computer model that decomposes 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 finalized, the power, heat, refining and supply, sector models deliver the required energy based on assumptions about fuel cost trajectories, and policy/market intervention. 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.

3 Results

3 – 1 Introduction

In general, economic growth and declining energy intensity are the primary drivers of energy demand in APEC. That said, the APEC region is comprised of a diverse group of economies. In aggregate, APEC's GDP is expected to double between now and 2050, but that growth masks a wide divergence of growth expected for individual economies. China, the largest APEC economy, will slow relative to its growth since 2000, but is still expected to grow by 135% between 2020 and 2050. Economic development is also assumed to continue at a rapid pace in APEC Southeast Asia and South America economies with GDP more than doubling out to 2050 for the entire APEC region. However, this rapid growth in economic output leads to energy demand that is only 12% higher in 2050 relative to just prior to the pandemic. China is expected to transition toward a more service-based economy, with energy demand slowly peaking by the early-2030s. Many other APEC economies continue to grow their economies without needing significantly more energy to do so. In fact, almost three-quarters of the growth in final energy demand out to 2050 is from the group of APEC economies in Southeast Asia. Energy demand from these economies almost doubles out to 2050, though for that same time period, their GDP more than triples.

Because modern economies demand substantial quantities of energy and that energy demand is relatively price inelastic, energy supply disruptions can impose substantial economic costs. The costs imposed by the interruption of a specific fuel is a function of the importance of that fuel in an economy's energy mix, the short-term, domestic demand and supply own-price elasticities, the share of the fuel provided by imports, the capacity to release strategic stocks of the fuel, and for internationally traded fuels, the short-term, international demand and supply own-price elasticities.

The 8th Outlook provides estimates of future energy consumption and import dependence for each major fuel for each of the 21 APEC economies. It also estimates the generation capacity and electricity generated from wind and solar energy. These estimates can be used to highlight energy security, resilience, and grid reliability risks for APEC economies as they pursue ambitious decarbonization programs.

3 – 2 Oil security

In REF, oil consumption in the APEC region peaks in 2035 and declines 5% from that peak by 2050. In CN, the decline in consumption is significantly larger; by 2050 oil consumption is down 50% from its 2019 peak. In aggregate, APEC oil import dependence also is expected to decline. APEC oil import dependence was 24% in REF and 23% in CN in 2020 and is expected to be 17% and 16% in REF and CN respectively.

Despite the declines in the volume and share of oil imports, oil security will remain a primary concern for three APEC regions: China, Japan, and Southeast Asia. In both REF and CN, each of these regions continues to import substantial volumes of oil, either as crude oil or petroleum products.

After rising rapidly from 2000 to 2019, oil consumption in China is expected to plateau and then decline through 2050 as the economy implements its decarbonization policies, primarily electrification of the transport sector. China's oil consumption is expected to peak in 2034 in REF and in 2025 in CN and decline by 11% and 50% from that peak by 2050 in REF and CN, respectively. As a result, China's net oil import dependence is expected to decline from 86% in REF and 83% in CN in 2020 to 69% in REF and CN. China will remain, however, the largest net oil importer in APEC throughout the projection period.

In Northeast Asia, oil consumption declines by 13% and 49% in REF and CN, but import dependence remains at 100%. Oil security continues to be a major concern in this region.

Despite decarbonization efforts, oil consumption in Southeast Asia is expected to increase due to rapid economic growth. The oil consumption growth is 36% in REF and declines by 17% in CN by 2050. As a result of the demand growth and declining indigenous oil production, SEA is the only APEC region where oil import dependence increases: from 58% in 2020 to 74% in REF and 70% in CN. Net oil imports in Southeast Asia increase by 52% in REF and decline by 5% in CN and account for 64% and 65% of APEC's total net oil imports by 2050 in REF and CN, respectively.

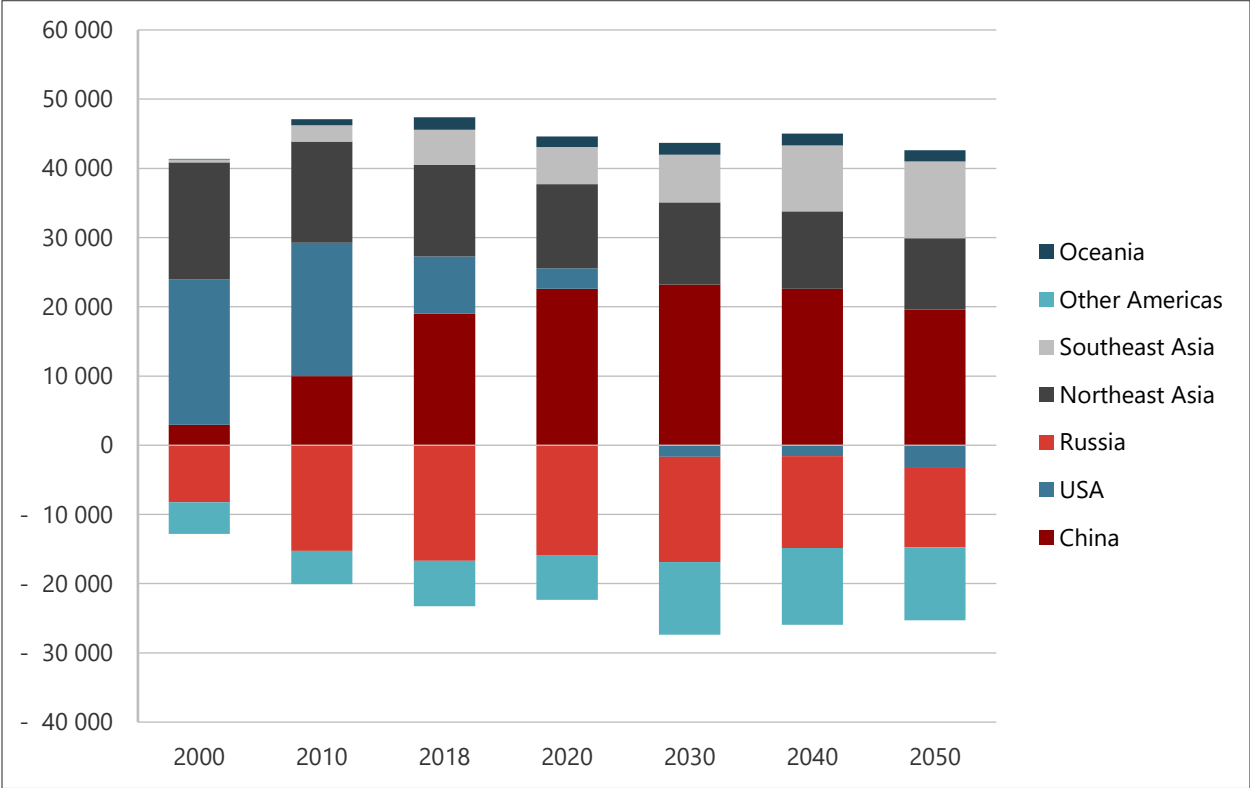
After relying strongly on oil imports in 2000, the USA dependence on oil imports has declined steadily over the succeeding 20 years and the economy's oil supply and demand is now roughly balanced. We expect that balance to shift slowly to increased oil exports over the coming years. In 2050, we expect USA to have a negative net oil import dependence of 11% and 14% in REF and CN, respectively.

In the 8th Outlook, both Russia and Other Americas remain major oil exporters through 2050. Russia remains the largest oil exporter in APEC, although that might change as a result of sanctions following the crisis in Ukraine that began in February 2022. In REF, the oil exports from Other Americas is comparable to those of Russia by 2050.

Oil security has been a major concern of oil importing economies since the early 1970s. Although APEC oil demand will decline significantly over the coming years, oil security will continue to be a major concern for oil importing economies, especially China and APEC economies in Northeast and Southeast Asia. The short-run, own-price elasticities of oil supply and oil demand are very low. When and if they occur, oil supply disruptions impose substantial costs on oil-importing economies. It is yet unclear how increased electrification and further improvements in energy efficiency will affect these short run elasticities. Until those changes are clear, oil-importing economies that depend on petroleum products for a significant portion of their energy needs will

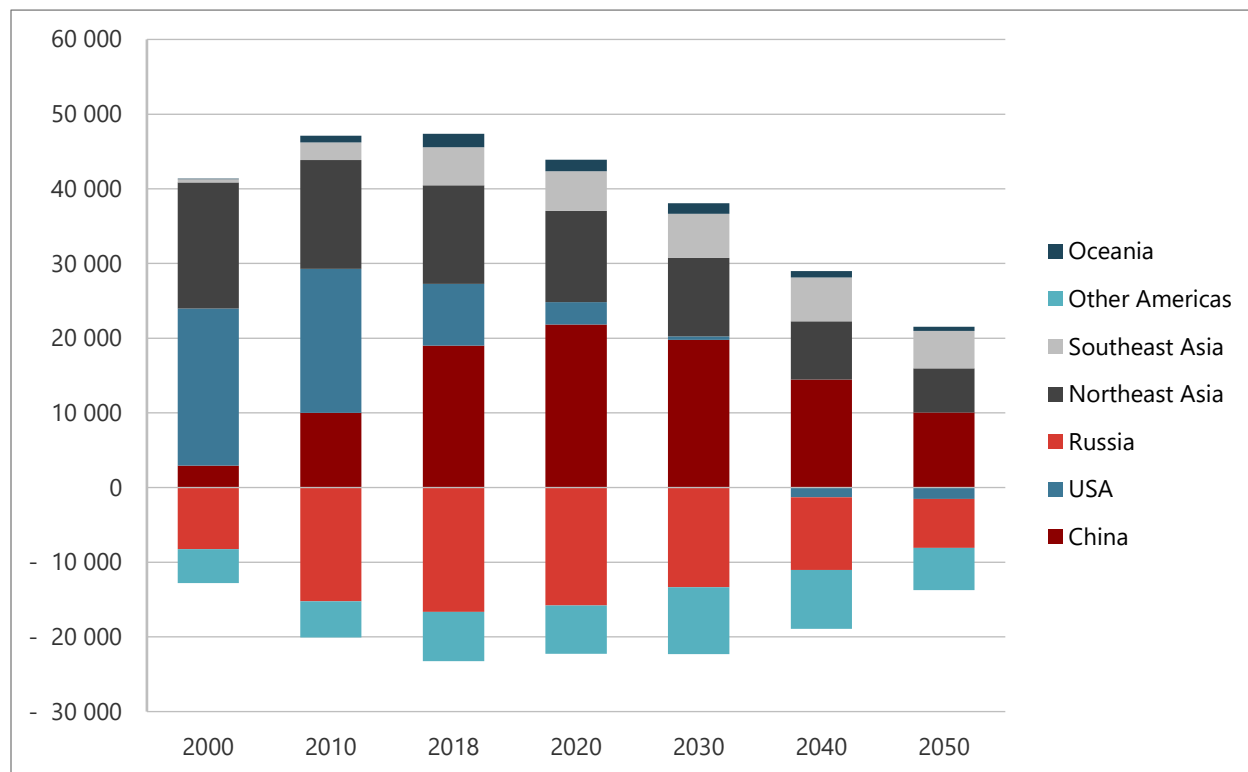
need to rely on traditional methods, such as strategic oil stockpiles, to reduce the economic losses associated with oil supply disruptions.

Figure 3-1: Net imports of crude oil and petroleum products in REF, 2000-2050 (PJ)



Source: EGEDA, APERC analysis. Exports appear as negative values.

Figure 3-2. Net imports of crude oil and petroleum products in CN, 2000-2050 (PJ).



Source: EGEDA, APERC analysis. Exports appear as negative values.

3 – 3 Natural gas security

For the last 20 years, the APEC economies in aggregate have been a net exporter of natural gas. From 2000 - 2010, gas exports from Russia, Other Americas, and Southeast Asia outweighed gas imports into Northeast Asia and the USA. China's gas imports grew rapidly after 2010 but increased gas production and exports from Oceania and the US transition from gas importer to gas exporter enabled APEC to retain its exporter position.

Looking forward, gas imports by China and Southeast Asia are expected to grow in both REF and CN. By 2050, gas imports into these two regions plus Northeast Asia are expected to exceed the exports of the other APEC economics. APEC's aggregate import dependence in 2050 is projected to reach 7% in REF and 11% in CN. For the next 30 years, gas security is likely to be an important concern for three APEC regions: China, Northeast Asia, and Southeast Asia.

In both REF and CN, China's gas net imports increase from 2020 through 2050, as a result of increased gas demand from fuel switching from coal and limited indigenous gas production due to challenging geologic conditions. Recent and future investments in new LNG and gas pipeline infrastructure increase import capacity substantially in China. In 2021, the economy became the largest LNG importer (Australia was the largest supplier) and the Power of Siberia pipeline from Russia started service with an initial capacity of 38 billion cubic meters per year. From 2020 to

2050, China's natural gas import dependence is expected to grow from 38% to 51% in both REF and CN.

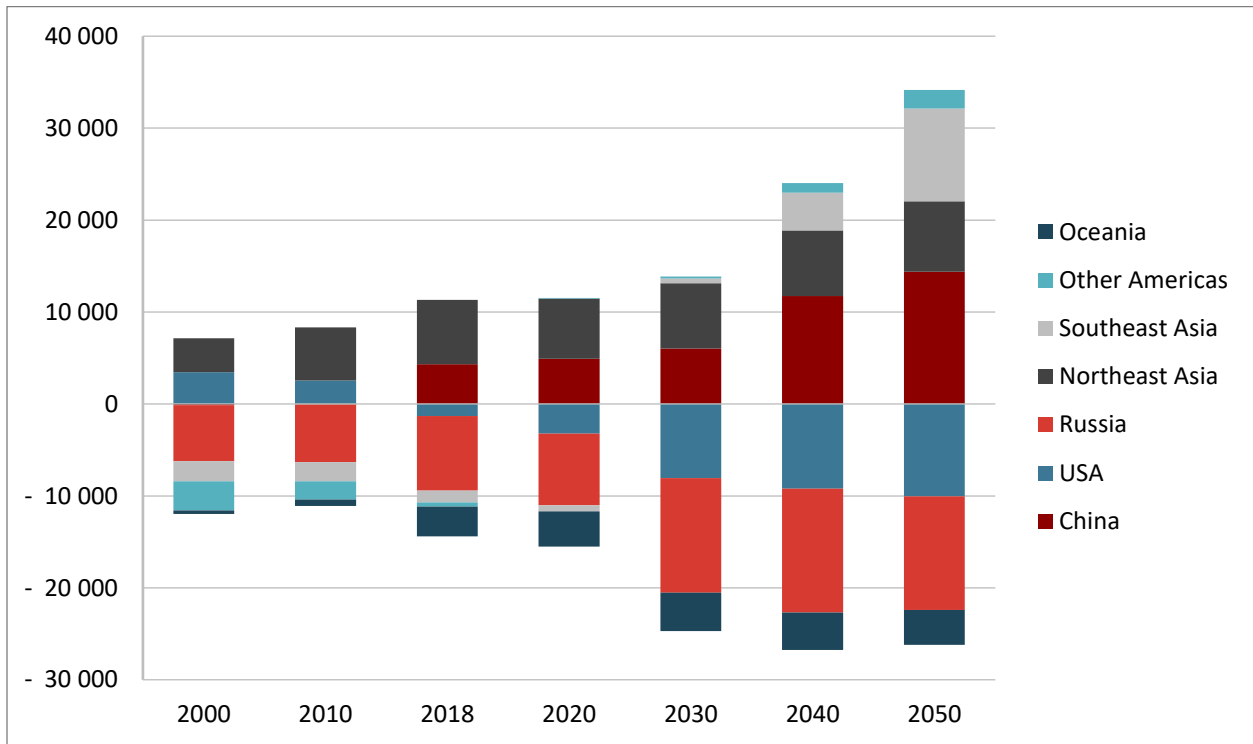
Starting in the mid-2020s, Southeast Asia's gas imports are expected to exceed its exports. The region goes from a net gas exporter to a gas importer with the associated energy security risks. Over the next 30 years, Southeast Asia accounts for the second largest regional increase in net natural gas imports due to a decline in domestic gas production and fuel switching from coal to gas. The region goes from exporting 638 PJ in 2020 to importing 515 PJ in 2030. By 2050, imports increase an additional 10 000 PJ. Even in CN, net gas imports in Southeast Asia follow an upward trajectory. In 2050, Southeast Asia natural gas import dependence is expected to be 61% and 55% in REF and CN, respectively.

Northeast Asia, which is wholly dependent on imports for its gas, has imported substantial volumes since 2000. In REF, NEA grows its net gas imports by 15% from 2020 to 2050, reaching a volume of more than 7 600 PJ (about half of China's imports). Oppositely, in CN, gas imports decline by 15% by 2050. Northeast Asia is expected to remain 100% dependent on gas imports in both REF and CN.

Due to its relatively low emissions and the high efficiency and relatively low capital costs of gas-fired power generation plants, natural gas is an attractive fuel for economies with rapidly growing demand for electricity. Gas can also support decarbonization efforts when used as a substitute for coal and as a dispatchable back-up fuel for variable renewable energy sources. Dependence on natural gas does create energy security risks. Because gas is more difficult to transport and store than coal and oil, the short-run, own-price supply elasticity of natural gas is low. It takes time to build new production and export/import facilities, and if appropriate geologic storage reservoirs are not available, storage is very expensive. When gas is used as one component of dispatchable power generation, demand elasticity can be high, but if other dispatchable sources of power (such as coal or oil) are not available, gas demand can also be very inelastic.

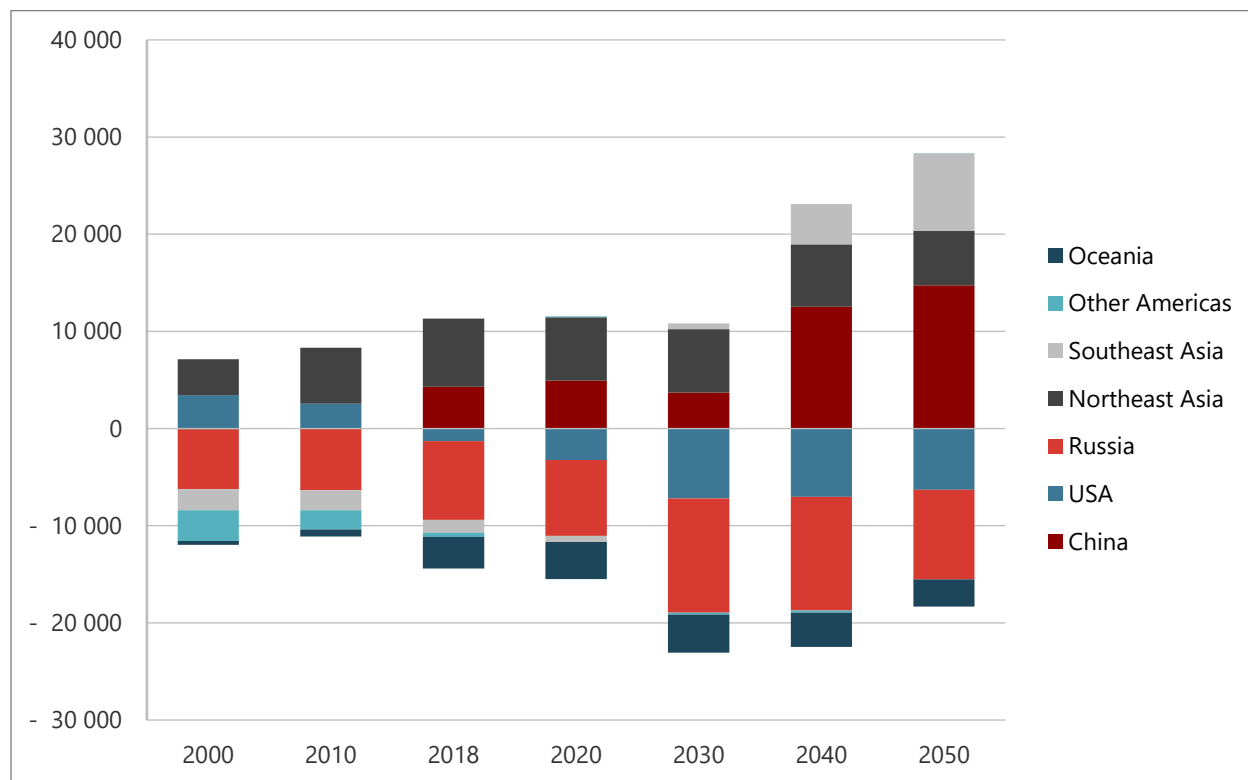
The results of the 8th Outlook indicate that China and Southeast and Northeast Asia need to pay continued attention to gas security issues.

Figure 3-3. Net natural gas imports in REF, 2000-2050 (PJ)



Source: EGEDA, APERC analysis. Exports appear as negative values.

Figure 3-4. Net natural gas imports in CN, 2000-2050 (PJ)



Source: EGEDA, APERC analysis. Exports appear as negative values.

3 – 4 Coal security

In aggregate, APEC economies currently export more coal than they import. In 2020, net coal import dependence was -6%. China and Northeast Asia are the only two APEC regions that import coal with a dependence fraction of 6% and 96%, respectively.

In 2050 in REF and CN, APEC net coal import dependence is expected to decline to -8% and increase to 1%, respectively, as APEC coal production declines more quickly than APEC coal consumption in CN. Between 2020 and 2050, China's coal consumption is expected to decline by 40% and 80% in REF and CN, respectively. The comparable figures in Northeast Asia are declines of 70% and 90%. China's coal import dependence is expected to remain flat at 6% in both REF and CN, and Northeast Asia's import dependence increases to 100% in both cases. Given the substantial drop in coal consumption these import dependence are less of a concern than they would be if consumption were higher.

As with natural gas, we expect Southeast Asia to transition from being a major coal exporter to a net coal importer by 2050, especially in CN. In 2020, Southeast Asia, had a negative coal import dependence of 70%. This changes significantly by 2050, in REF and CN, the region increases its dependence on coal imports to 3% and 42%, respectively. Even in CN, coal-fired power

generation expands to meet growing demand for electricity in Vietnam, Malaysia, the Philippines, and Thailand. Although 2050 coal consumption in Southeast Asia is 30% lower in CN than in REF, environmental policies and programs in some SEA economies cause coal production to decline more rapidly than consumption in the region, and thereby, increase dependence on coal imports.

Given its low storage cost, coal stockpiles are often an effective means of ensuring coal security. The declining use of coal throughout APEC over the next 30 years will also reduce coal security concerns. However, the growth of the international natural gas market over the last 20 years has increased and can be expected to continue to increase coal price volatility and create coal security risks. The ability of many electrical grids around the world to dispatch coal-fired power rather than gas-fired power when gas prices increase now causes international coal prices to rise when gas supply disruptions cause gas prices to rise. In some sense, the most effective means for increasing coal security in APEC may be measures designed to increase natural gas security.

Figure 3-5: Net coal imports in REF, 2000- 2050 (PJ)

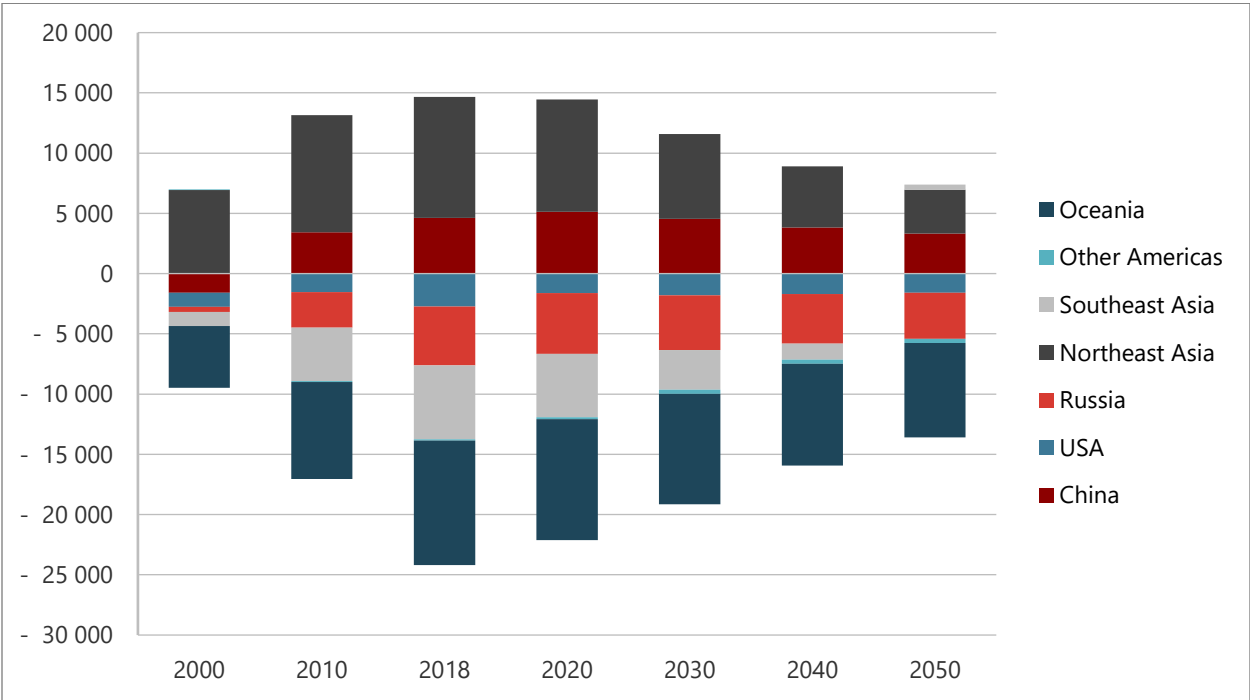
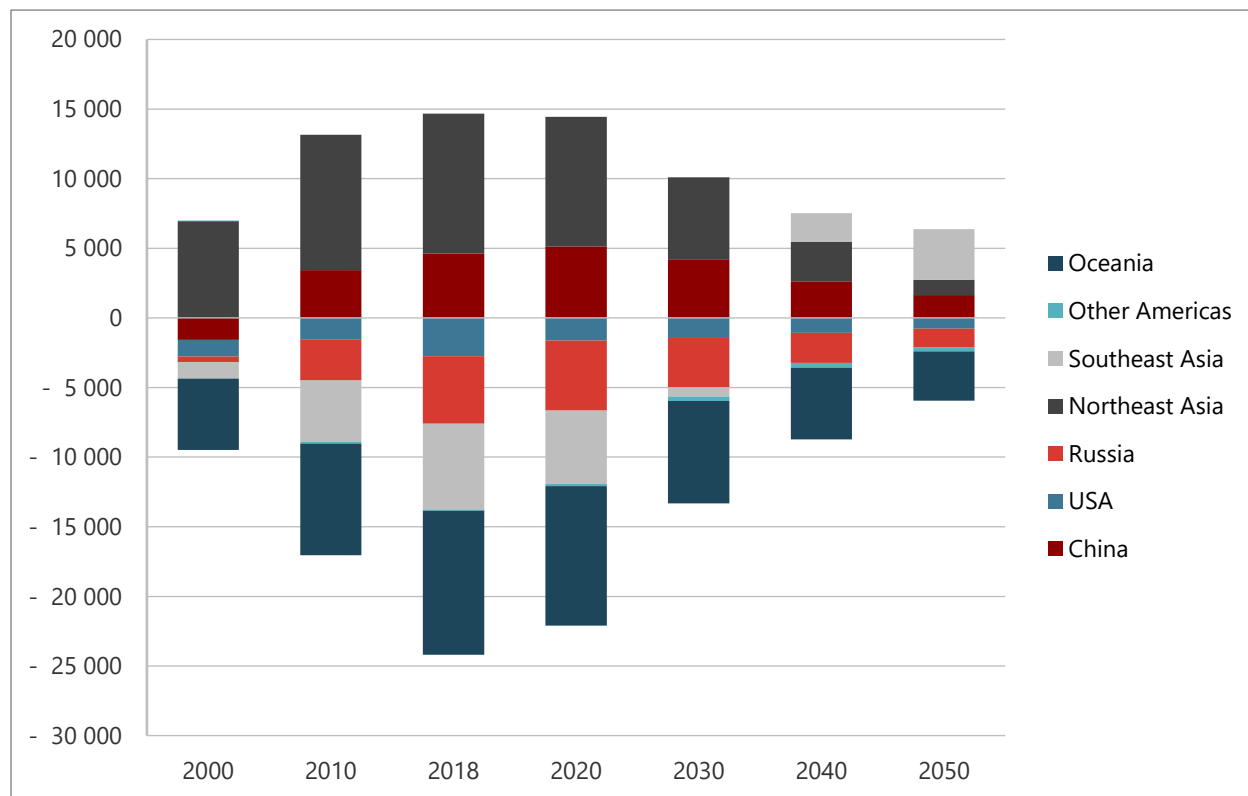


Figure 3-6: Net coal imports in CN, 2000- 2050 (PJ)



Source: EGEDA, APERC analysis. Exports appear as negative values.

3 – 5 Electric grid reliability

In 2018, wind and solar each represented 7% of total power generation capacity in APEC. In that year, wind energy generated 4% of all APEC electricity; solar energy generated 2%. The Outlook envisions large increases in solar plus wind capacities by 2050 in both REF (44% share of capacity) and CN (64% share of capacity). In REF, the share of generation increases to 14% for wind and 13% for solar by 2050. In CN, the generation share grows to 23% (wind) and 22% (solar).

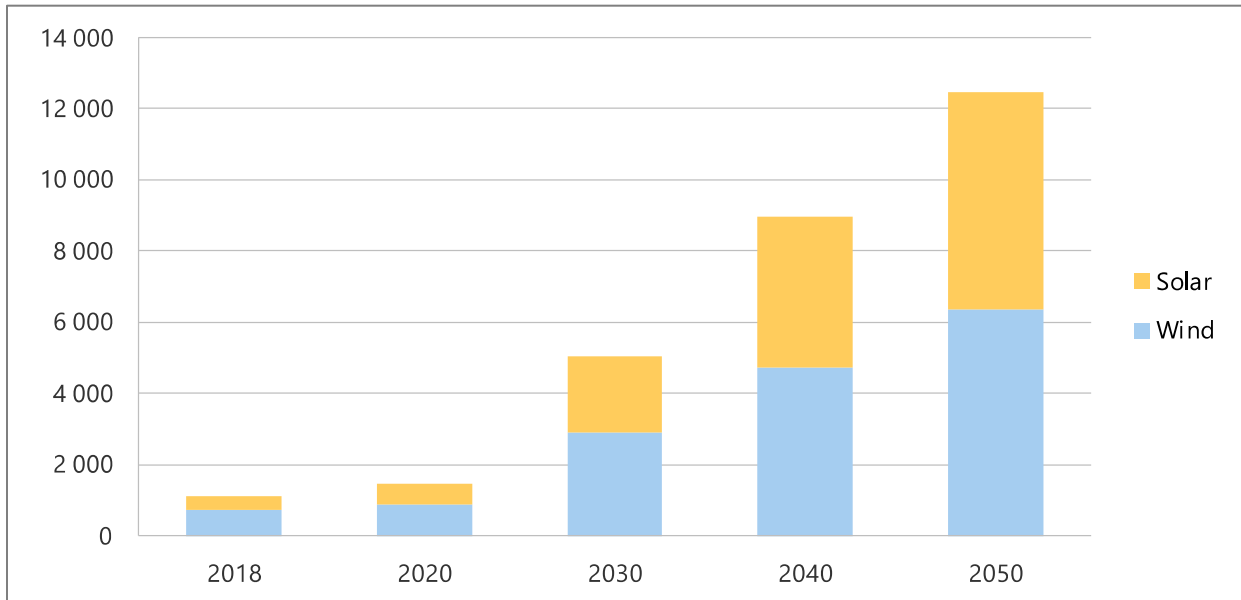
Electric grid stability requires continuous balancing of electricity supply and demand even as electric loads increase or decline and regardless of power plant and transmission facility failures. The task of balancing electric supply and demand is made more difficult as the share of VRE increases since wind and solar energy cannot always be relied on to meet changes in electric load. Grid scale batteries or other means of storing electricity are helpful in addressing the balancing challenge, but for a variety of reasons they have not yet been installed as rapidly as VRE sources have been.

Grid reliability appears to be declining and consumer costs increasing in regions where the reliance on non-dispatchable power sources, such as wind and solar, is increasing. In recent

years, APEC has experienced several notable grid outages in recent years in Australia (Sep 2016) and in the United States: California (Aug 2020) and Texas (Feb 2021). These outages impose substantial costs when they occur.

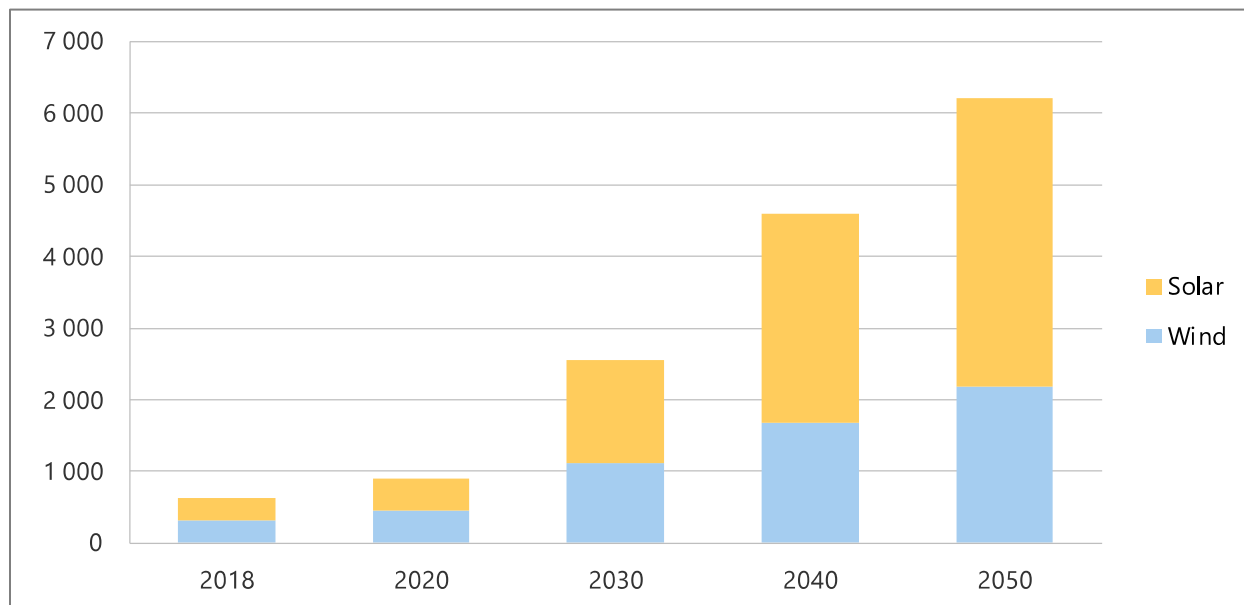
Solving the grid reliability issue, either through grid-scale electricity storage or back-up dispatchable power plants will be especially important for economies that plan to rely heavily on wind and solar energy as part of their decarbonization efforts. In the 8th Outlook, the CN pathway calls for the wind plus solar shares of generation to be high in the USA (71%), Oceania (70%), and Other Americas (56%).

Figure 3-7: Electricity generation in CN, 2018-2050 (TWh)



Source: EGEDA, APERC analysis

Figure 3-8: Generation capacity in CN, 2018-2050 (GW)



Source: EGEDA, APERC analysis.

4 Conclusions

The results of the 8th Outlook indicate that despite expected, substantial reductions in oil consumption, APEC economies in Asia that rely on high levels of imports for the oil they do consume will face continued oil security risks due to the low short-term demand and supply price elasticities both in their economies and internationally.

The growth of natural gas consumption and import dependence, especially in Southeast Asia, also creates energy security risks. The relative difficulty of transporting and storing natural gas, compared with oil and coal, increases the costs of gas supply disruptions when they occur.

The expected decline in coal consumption in APEC and the relatively low cost of storage should lower coal security risks but the increasingly tight correlation between international gas and coal prices means there is price risk for those economies that continue to rely on coal.

Finally, the 8th Outlook shows a large increase in dependence on wind and solar power generation, which to date has been correlated with higher consumer costs and reduced electric grid reliability. The USA, Oceania and Other Americas regions of APEC are expected to rely heavily on increased wind and solar power and will need to address the grid reliability issue in the future.

5 References

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