Asia-Pacific
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Oil and Gas Security During the Energy Transition

APEC Oil and Gas Security Studies
Series 19

APEC Energy Working Group

September 2023

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FOREWORD

After spending the much of the last decade focusing on committing to an energy transition to a low-carbon economy, higher energy prices and volatility over the past two years has put energy security back into the forefront of policy discussions. Governments are now reconsidering their long-term energy plans as an energy trilemma, wherein solutions must reconcile their energy transitions with affordability and energy security. With oil and gas demand to remain robust in APEC en route to carbon neutrality, it is worth highlighting how members are mitigating the current crisis, and examining what can be done to help achieve a balanced solution to the energy trilemma.

The analysis for this report began in mid-2022 to research the impacts of the energy transition on oil and gas security in the APEC region. The muted response to oil and gas supply in the face of rebounding demand is suggesting a potential return to the boom-bust oil market that governed energy markets prior to the advent of the Shale Revolution last decade. Amidst this, higher prices and volatility are prompting APEC policymakers to veer their energy policy plans and directly act to mitigate the impact on consumers, businesses, and the overall economy. It is important for members to understand the diversity of the policy approaches currently in use to balance the energy trilemma across the region, and the multitude of options available as APEC continues its journey towards carbon neutrality. This study examines the emerging trends to oil and gas markets brought on by this energy crisis, highlights the evolution in policy across APEC and provides recommendations to guide policymakers towards a secure, sustainable, and affordable energy future for the APEC region.

I very much hope our Oil and Gas Security Studies (OGSS) series will continue to provide useful information to help APEC economies better address oil and gas security issues. We will continue to work closely with governments and other stakeholders to support their efforts in ensure an affordable and secure energy future as we collectively embark on an energy transition.

Kazutomo Irie

Kazutomo IRIE

President

Asia Pacific Energy Research Centre

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EXECUTIVE SUMMARY

Energy security is now at the centre of energy policy discussions, together with decarbonisation and affordability.

Even before the Russian-Ukrainian conflict began in early 2022, the world was drifting towards a potential energy crisis. Balances of both oil and gas were tightening, as shifting investor preferences, an uncertain and uneven pandemic recovery, supply chain bottlenecks, and other factors limited the responsiveness of oil and gas supplies to price signals while demand crept back to pre-pandemic levels. The conflict exacerbated this tightness, resulting in higher price levels and volatility. World economies are now racing to reimagine their global energy supply chains to align with shifting geopolitical realities after spending several years focusing on enabling an energy transition to a low-carbon economy. Many APEC members are reconsidering their long-term energy plans in a way that reconciles the energy transition with both energy security and affordability. Viewing energy challenges as a trilemma will encourage switching away from oil and gas and towards alternatives, such as coal, hydrogen and renewables. For some members, this switching will be driven by government planning to diversify supply sources; for others, price signals will facilitate the switch.

Demand for oil and gas will likely remain robust this decade.

There is a push to strengthen energy security by transitioning to alternative fuel sources, diversifying the energy mix, and reducing energy demand (and waste), investing in energy efficiency and higher energy recovery. However, according to the Carbon Neutrality scenario in the 8th APEC Demand and Supply Outlook, even following a carbon-neutral pathway, demand, and subsequently net imports, for both oil and gas will increase in the APEC region this decade. Given the possibility of prolonged tightness in the oil and gas markets, APEC members will need to find short-term paths to balance this energy transition with affordability and energy security as their import dependence persists over the coming years.

APEC is increasingly turning towards the domestic prioritisation of energy supply chains

Amidst higher energy costs and a growing threat of supply disruptions, APEC members are increasingly turning to protectionist policies. While protectionism improves domestic energy security in the shorter term, it does so at the expense of security across the world and the APEC region. Furthermore, it is at odds with APEC's function of enabling and encouraging the free flow of goods throughout the region. Restricting trade not only risks exacerbating global market tightness now; it could also create supply disruptions in the future by fostering tit-for-tat protectionist policies over regional cooperation.

Governments are also striving to redefine their energy mix to mitigate the impact of oil and gas disruptions. Energy plans are shifting to leverage domestic endowments in economies blessed with large amounts of alternative resources, such as coal. In areas reliant on oil and gas imports, policy is turning towards energy diversification across multiple fuel alternatives, particularly coal and renewables, to reduce their long-term import dependence on oil and gas supplies. For example, during this turmoil, China has committed to developing its coal supply and relying on coal as a cornerstone of its energy security.

Governments are intervening in energy markets to improve affordability

The tumultuous reorganisation of the global energy supply chain is creating a dysfunctional energy market that is prompting governments to intervene to ensure that energy is available at affordable prices to mitigate the impact of volatile market conditions on their economy. Most APEC members are turning to subsidisation to improve energy affordability, be it through direct subsidies, lower taxation, or indirect transfers. Some governments are going further, participating in the direct procurement of energy and the infrastructure required to store and import it into their economy. While a necessary step to protect individual livelihoods and ensure that businesses remain solvent, such action could usher in a permanent inelasticity to market signals, which would reduce the ability to respond to future disruptions.

Short-term fuel switching is difficult

Fuel switching can occur through sophistication, redundancy, or replacement. Sophistication is the ability of a technology to use multiple fuels, for example, co-firing in boilers. Redundancy measures the excess capacity in a parallel technology that uses alternative fuels; for example, maintaining coal or oil-fired electrical capacity. Replacement involves investing in a substitute technology that runs on a different fuel; for example, installing an electric heat pump to replace a natural gas boiler to provide space heating. Most APEC members were fuel switching at the height of their capability by the end of 2021. Increased fuel switching requires additional investments in sophistication, redundancy or replacement technology. This cannot happen overnight. It could take residential consumers months to install a heat pump or backup generator and the lead time could be years for industrial users. The ability to switch is also limited by financial factors facing consumers and businesses. Increased switching potential ultimately involves additional cost, but this cost may be justifiable if energy disruptions are likely.

Short-term actions are improving energy security, but these actions have limits

Short-term actions implemented by APEC members are working to reduce the impact of the energy crisis on their economies. However, these actions are limited in their effectiveness, and are unlikely to be sustainable over the longer term. Some measures are already facing constraints – fuel switching is limited by the technology employed by end-users. Other limits are on the horizon. For example, subsidies will probably face fiscal constraints; eventually, storage mandates cannot stockpile above storage capacity; the supply of LNG carriers that can be chartered – or converted – into floating storage units is limited. Eventually, actors will need to invest in improving resiliency to supply shocks by adding more storage tanks and LNG carriers, and adopting technology that can enable a higher capacity of future fuel switching during oil and gas crises.

Long-term LNG contracts are insulating APEC importers from high spot prices

With spot prices hitting historical highs, there was much expectation that APEC LNG importers would respond promptly with gas-to-coal and other fuel switching to reduce their reliance on LNG imports. China conforms to this expectation – after becoming the world's top LNG importer in 2021, imports fell a fifth in 2022. In response to high spot prices and low domestic demand stemming from its stringent COVID-19 containment, China exploited the short-term flexibility of its contracting structure to reduce imports, which helped balance the global market. This contrasts with northeast Asia, where long-term contracts are providing lower-priced LNG, insulating importers from the spot price volatility, and muting the potential demand response. Going forward, APEC will rely on long-term LNG contracts to provide a buffer to gas market turmoil. Meanwhile, despite a rising commitment to long-term LNG contracting, China may be called on again to balance the global market. During its pandemic recovery, the success of being a balancer will depend on its ability to enable flexibility via diversification and fuel switching across its end-use sectors.

Current supply constraints suggest a return to the boom-and-bust oil cycle

After a decade of inexpensive oil and gas, the shale revolution is fading into a structural boom-and-bust cycle, where it takes long periods of high prices to manifest the investment necessary to balance out supply with growing demand. This could shift the marginal supplier of oil and gas out of the APEC region. Underinvestment in oil and gas will make these commodities more volatile and expensive, which will threaten the development of rapidly growing APEC members in China and southeast Asia.

Producing economies could incrementally expand supply by alleviating the bottlenecks facing the upstream services sector. For example, the elimination of certain tariffs and strategic investments in higher supply chain productive capacity could help alleviate the material and equipment constraints that are binding the oil and gas service sector in North America. However, in this era of capital discipline, it is uncertain to which extent profits will be invested in growing production or instead returned to shareholders. Furthermore, there may be a higher incentive to maximise shareholder returns now if an energy transition will deliver subpar returns on investment being made today. If the oil market is in an upcycle, it will take time for markets to alleviate this shortfall in investment.

Infrastructure constraints could limit APEC's role in alleviating the energy crisis

While APEC has the potential to reorganise global gas supply chains through higher LNG exports from the US, infrastructure bottlenecks due to permitting delays for key pipeline projects could constrain gas supply growth. In the face of such hurdles, actors across APEC could increase gas supply by frontloading current commitments to reduce the flaring, venting and fugitive releases of methane over the next few years. Cross-border pipeline trade, particularly from Canada, could also help meet the higher supply requirements for new LNG export capacity.

Severe weather is exacerbating APEC's energy security challenges

Severe weather and unexpected supply outages are challenging energy security and electrical reliability across APEC. Extreme temperatures can create higher-than-expected demand profiles due to higher requirements for heating or cooling. Inadequate sensitivity analyses by ISOs can cause electricity grids to be unprepared for these tail events. Droughts limit the water available for hydroelectricity and challenge the fuel availability for fossil fuel generators that rely on barge shipments for fuel supplies. Nuclear and fossil units can also experience capacity shortages if droughts limit their ability to cool their equipment. Storm surges resulting from typhoons, cyclones and hurricanes are causing outages at LNG export terminals, damaging refineries, and disrupting the just-in-time delivery of fuel supplies to vulnerable importers. These outages mean fossil fuels are facing their own challenges in ensuring grid reliability. In response to the turmoil, governments are intervening in their gas and electricity markets to ensure grid reliability and mitigate the impact of rising costs on both consumers and the economy.

Refinery product constraints create availability and affordability concerns

APEC refinery product supply is constrained by capacity reductions in North America, sanctions against Russia, and a decrease in the size of Chinese export tariffs. North American refinery capacity reductions can be attributed to closures and conversions to biorefineries, which typically result in a net product yield reduction from the original refinery. Closures are due to unexpected damage from operational failures and hurricanes, low profitability, and divestment to align structural assets with a potential lower carbon future. An extension of refinery lifetimes, and an examination of the merits of constructing newbuild refineries, should be considered throughout the APEC region. Furthermore, refinery conversions that tilt the product slate away from declining demand markets, like gasoline, and towards growth markets, like distillates, could increase their viability as profitable assets over the next decade.

Biofuel mandates alone are insufficient for improving energy security

While many in APEC turn to biofuel blending to reduce oil consumption and improve energy security, mandates alone are not enough to improve fuel security. Parallel policy that increases productive capacity to match the demand from blending mandates is necessary to prevent shifting concerns about oil security towards concerns about biofuel security.

SECTION 1. INTRODUCTION

1-1 Objective and scope of this study

In 2020, APEC launched the Putrajaya Vision 2040, which sets the goal of pursuing an open, dynamic, resilient, and peaceful Asia-Pacific community by 2040. APEC Economic Leaders have endorsed an action plan to implement the Putrajaya Vision 2040, which highlights the importance of “ensuring energy security, access, reliability and resilience through energy transition” (MFA, 2021). In this regard, APERC prepared this study on the impact of the energy transition on oil and gas supply security in the APEC region as one of the Oil and Gas Security Studies (OGSS).

In the last three years, many governments, both within and outside APEC, increased their commitment to transitioning away from fossil fuels, with several economies committing to carbon neutrality. During the same period, fossil fuel prices rose significantly. In 2021, annual average prices for Brent oil rose over two-thirds, and Asian LNG prices quadrupled. The geopolitical tensions following the Russo-Ukrainian conflict are creating a structural shift in commodity trade flows that is unravelling at an uncertain pace. This sent prices higher and increased volatility, and an acute availability crisis manifested itself in the natural gas, coal, and refined product market throughout 2022. The world is living through what many refer to as the first global energy crisis, and it could last for years or even the entire decade.

This study proposes to identify and evaluate potential actions that APEC members can take quickly to reduce the cost of oil and gas supply disruptions as they occur over the coming decade. It utilises a theoretical framework, outlined in Section 1-4, to anchor this discussion.

This report utilises results from the recently released 8th Edition of the APEC Energy Demand and Supply Outlook to highlight that the pace and trajectories of energy transitions are uncertain. But as the Putrajaya Vision 2040 highlights, it is imperative that APEC collectively ensures that energy access, security and reliability persist throughout the energy transition this decade, regardless of the form this transition takes. APERC believes that the findings of this report are conducive to fostering this part of the APEC Putrajaya Vision 2040.

While energy security more broadly includes other forms of energy and the critical minerals for producing renewable technologies, this study is focused only on oil and gas supply security because the mandate of the OGSS is limited to oil and gas. This study includes consideration of oil and gas supplies used to produce electricity, such as LNG or diesel consumed in the power sector but does not address electricity security and power grid reliability. For the remainder of this report the terms "energy security" and "oil and gas supply security" will be used interchangeably.

While the current energy crisis is a global event, this report will focus primarily on the energy security impacts on the APEC region. Because oil and gas markets are global in nature, and discussions of oil and gas security involve energy sources from economies outside the APEC region, this analysis could cover non-APEC economies. Nevertheless, the oil and gas developments in other regions will be discussed only to the extent that they affect APEC energy security.

1-2 Definition of energy security

Oil and gas supply disruptions can impose large economic and social costs on an economy. For this reason, governments adopt policies that reduce the likelihood of energy disruptions and/or mitigate their impacts if, and when, they occur. The APEC Energy Working Group endorsement of the APEC Oil and Gas Security Initiative (OGSI) in 2014 to aid APEC economies in addressing energy supply security and dealing with potential supply shortages and emergencies is consistent with this goal. The OGSS series is one of the three pillars of the OGSI. Its primary purpose is to encourage APEC economies to review their respective policies, plans, programs and measures on oil and gas security, which could help them in adopting appropriate approaches to handling possible supply shortages or supply emergencies in the future.

For the purposes of this series of the OGSS, as with OGSS18, APERC defines energy security as *providing reliable energy at reasonable cost*. This definition aligns with other definitions of energy security[1], although there are also many other definitions of energy security[2].

1-3 Framework for analysis

In the short-term, the framework for analysis assumes that the cost of an oil and gas supply disruption to an economy (cost of disruption) can be conceptualised as a function of that fuel's share of total primary energy supply (S_f), the fuel's own-use price elasticity of demand (ϵ_d), the fuel's own-use price elasticity of supply (ϵ_s), the import dependence of the fuel (I_f), and the number of stockpiles of the fuel (R_f):

$$cost\ of\ disruption_f = f(S_f, \epsilon_d, \epsilon_s, I_f.R_f)$$

[1] For example, the IEA currently defines energy security as "the uninterrupted availability of energy sources at an affordable price" (IEA, 2020).

[2] Please see APERC's Series 8 OGSS for an exploration on several definitions of energy security (2016).

This is a general, theoretical framework, and not meant to measure the exact cost of disruption, but rather to identify routes to reducing the cost of the current energy crisis on APEC member economies.

The short-term analysis will mostly focus on actions that either increase the elasticity of demand and supply or increase the use of oil and gas stockpiles. While this paper largely ignores the role of reducing import dependence through energy efficiency improvements, increasing the elasticity of demand will serve the goal of reducing oil and gas demand when prices rise, and in turn reduce import dependence. Beyond the initial cost of disruption, factors that shift demand and supply for oil and gas in the medium- to long-term (such as investment trends), will alter the short-term cost for future supply and demand disruptions.

1-4 Report outline

Following this Introduction, Section 2 provides an overview of the projection of oil and gas demand and supply in APEC over the next decade for two scenarios from the 8th Edition of the APEC Energy Demand and Supply Outlook. The Carbon Neutrality scenario particularly illustrates how fossil fuels will continue to fuel APEC even if the region starts transitioning to a carbon-neutral economy. Section 3 highlights various short-term strategies that APEC members are implementing – or could implement – to mitigate the impact of oil and gas supply disruptions. Section 4 emphasises how investment in a diverse array of energy types and sources is key for long-term energy security but identifies various actions that can help mitigate the impact of oil and gas supply disruptions in the longer term. Section 5 concludes with some key takeaways from the analysis.

SECTION 2. APEC OUTLOOK FOR OIL AND GAS: SUPPLY, DEMAND, AND IMPORT DEPENDENCE

Before detailing various short- and long-term strategies for mitigating the impact of oil and gas supply disruptions, it is worth highlighting why policymakers should focus on energy security this decade. This Section utilises a summary of results from the 8th Edition of the APEC Energy Demand and Supply Outlook to highlight that even if APEC embarks immediately on an energy transition towards carbon neutrality around mid-century, the region will continue to require significant amounts of oil and gas to fuel its economic activity. The discussion will showcase results from both the Reference scenario (REF) and the Carbon Neutrality scenario (CN). REF is a pathway where existing trends in technology development and deployment, and in policy frameworks continue in a similar manner. This provides a baseline to compare to CN, which outlines a potential pathway where energy efficiency, fuel switching, and technological advancement lead to a significant reduction in CO_2 emissions from fossil fuel combustion out to 2050. The discussion will first showcase the total primary energy supply (TPES)[3] for both natural gas and combined crude oil and oil products (oil) to illustrate that APEC will continue to

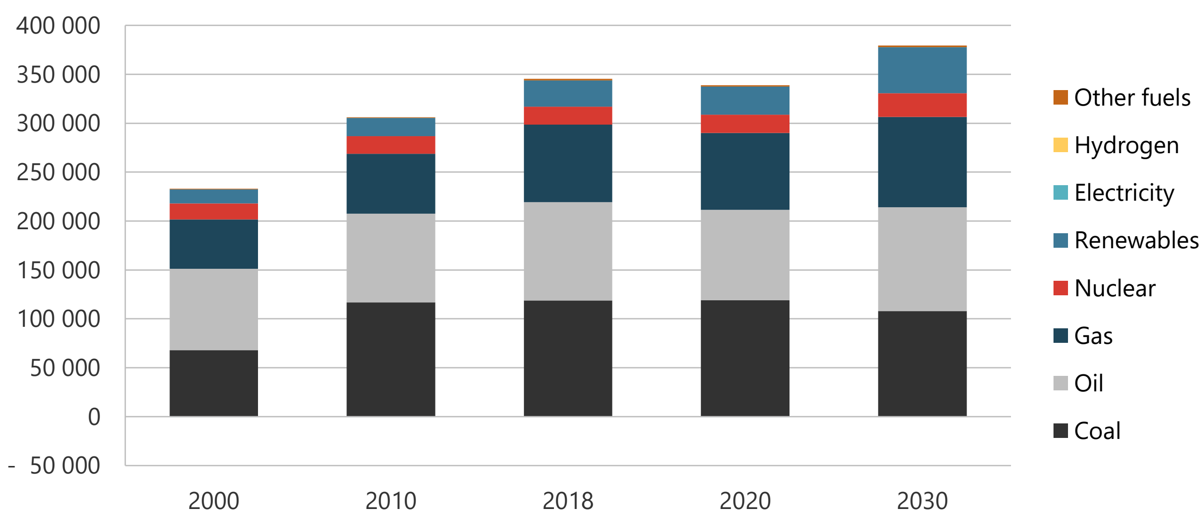
[3] TPES is reflective of the total energy requirements within an economy. It is equal to final energy demand for end-use sectors, plus the energy required for the transformation process, like generating electricity, producing oil and gas, refining crude oil and transforming fuels into hydrogen or other carriers. The text may also refer to TPES interchangeably as “total energy supply”.

require oil and gas this decade. It will then show import dependence to highlight how the region will continue to be vulnerable to oil and gas supply disruptions in either scenario.

2-1 Oil and gas TPES by region

TPES increases in both REF and CN, in response to a growth in demand from end-use sectors and transformation. From 2020 to 2030, TPES increases in REF and CN by 11% and 4.0%, respectively (see Figure 2-1 and 2-2 below). In 2030, the volume of TPES is 6.9% larger in REF than in CN, because of increased energy efficiency in CN.

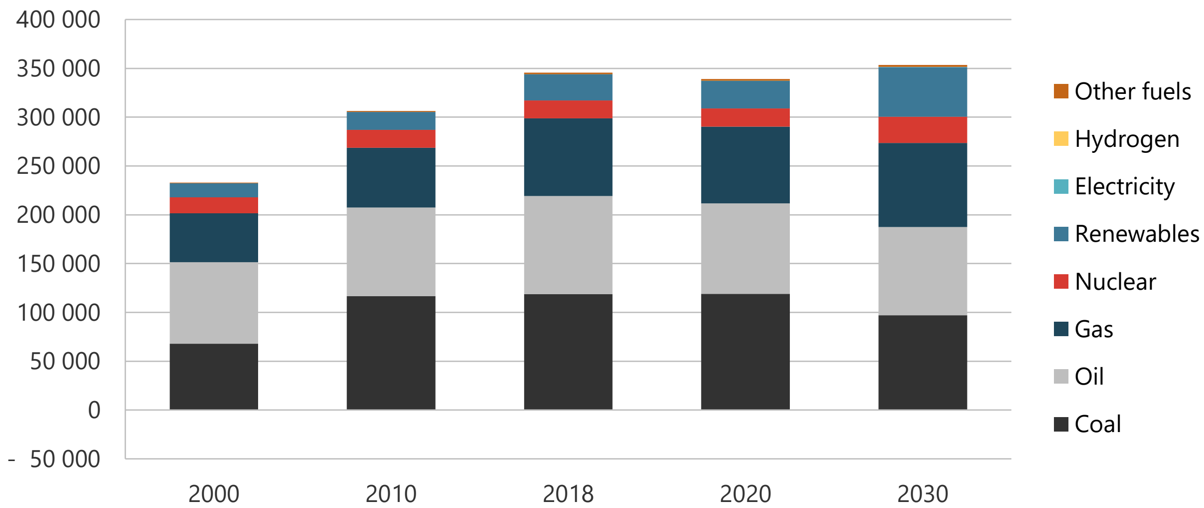
Figure 2-1: APEC total energy supply in REF, 2000-2030 (PJ)



Source: APERC (2022)

Fossil fuels dominate the energy mix in both scenarios. In CN, a phase-out of coal and a simultaneous increase in renewable energy occurs at a faster pace than in REF. In 2030, the share of fossil fuels in TPES accounts for 80% and 77%, in REF and CN, respectively. In CN, the total volume of fossil fuels is 11% less than in REF, while the use of renewable energy in CN is 7.7% larger than in REF. From 2020 to 2030, renewable energy from wind and solar PV increases by 43% in CN, which helps displace coal from the energy mix.

Figure 2-2: APEC total energy supply in CN, 2000-2030 (PJ)



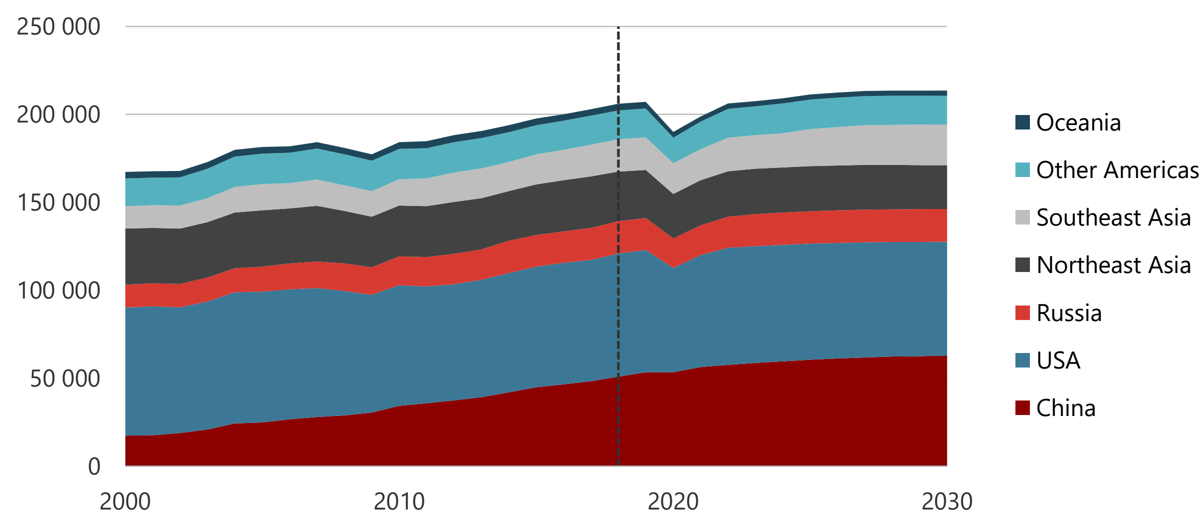
Source: APERC (2022)

Even en route to carbon neutrality, oil and gas supply requirements in APEC will remain robust this decade. Oil supply falls slightly (1.8%) due to higher electrification and gas supply increases by about a tenth.

2-2 Crude oil and petroleum products demand

In CN, increased energy efficiency reduces demand by 2.6% this decade (Figure 2-4). During the same period in REF, oil consumption in the APEC region increases by 11% (Figure 2-3).

Figure 2-3: APEC crude oil and petroleum products combined consumption in REF, 2000-2030 (PJ)

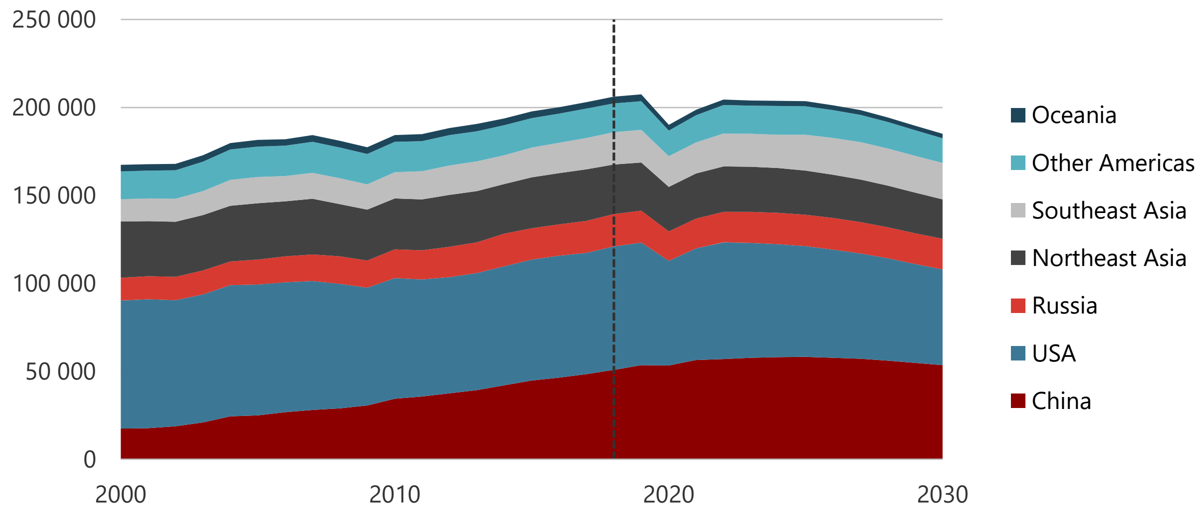


Source: APERC (2022)

China's oil consumption is expected to peak in 2025 in CN and decline by 8.0% from that peak by 2030. China's net oil import dependence is expected to decline from 86% in 2020 to 73% in 2030. China will remain the largest net oil importer in APEC throughout the projection period.

From 2020 to 2030, northeast Asia's oil consumption declines by 1.8% and 12% in REF and CN, respectively, but import dependence remains at 100% in both scenarios. As a result, oil security continues to be a major concern in this region.

Figure 2-4: APEC crude oil and petroleum products combined consumption in CN, 2000-2030 (PJ)



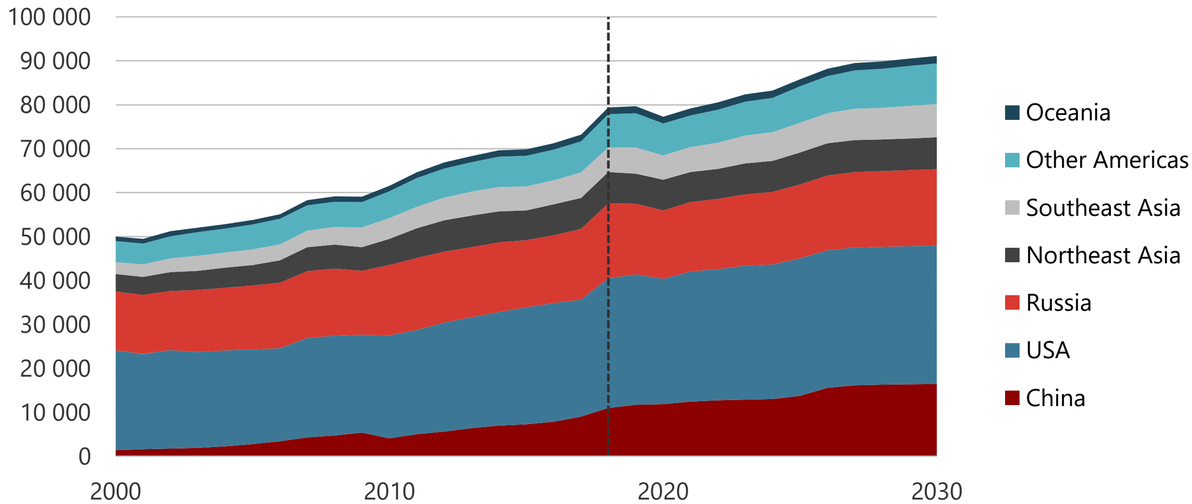
Source: APERC (2022)

Despite efforts to decouple oil demand from economic growth, oil consumption in southeast Asia is expected to increase in REF and CN due to rapid economic growth. From 2020-30, oil consumption growth in this region is 25% in REF and 16% in CN.

2-3 Natural gas demand

In 2030, total natural gas consumption is 6.6% larger in CN than in REF (see Figures 2.5, 2.6 below). The power sector is the largest natural gas-consuming sector in both scenarios. From 2020 to 2030, in REF, all regions see an increase in natural gas consumption, while in CN, northeast Asia and Oceania's gas consumption declines by 4.8% and 7.1%, respectively. In REF, from 2020 to 2030, the US is the largest natural gas consumer and has a consumption increase of 9.3%.

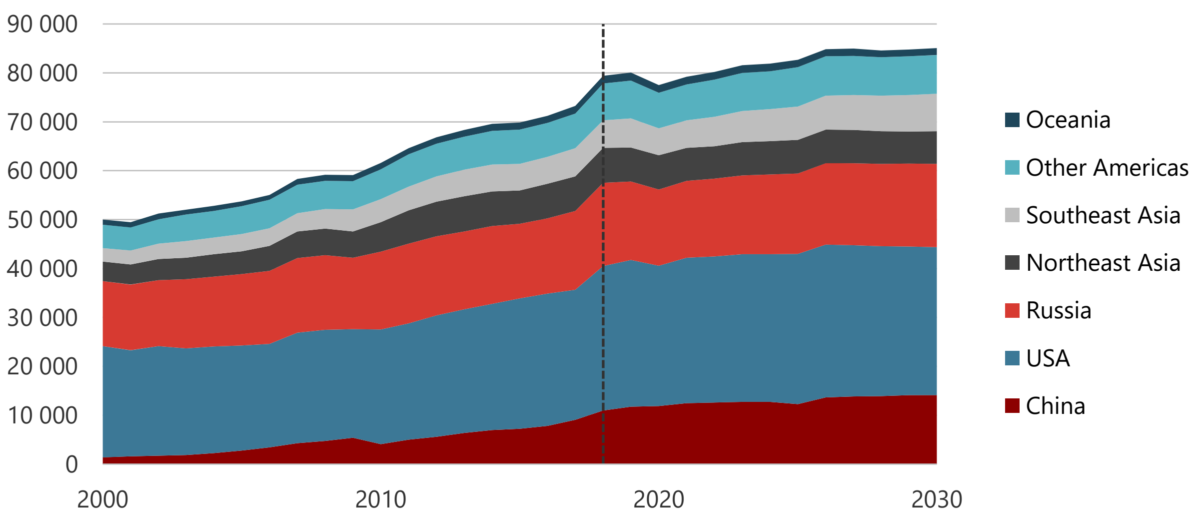
Figure 2-5: APEC gas consumption in REF, 2000-2030 (PJ)



Source: APERC (2022)

In southeast Asia, macroeconomic factors drive energy demand through 2030. Southeast Asia accounts for 20% of APEC's population and its gross domestic product (GDP) grows much faster than the APEC average. Southeast Asia and China see the largest consumption increases in both scenarios. In CN, southeast Asia and China's natural gas consumption increases by 28% and 16%, respectively. In REF, southeast Asia and China's natural gas consumption increases by 39% and 31%, respectively.

Figure 2-6: APEC gas consumption in CN, 2000-2030 (PJ)



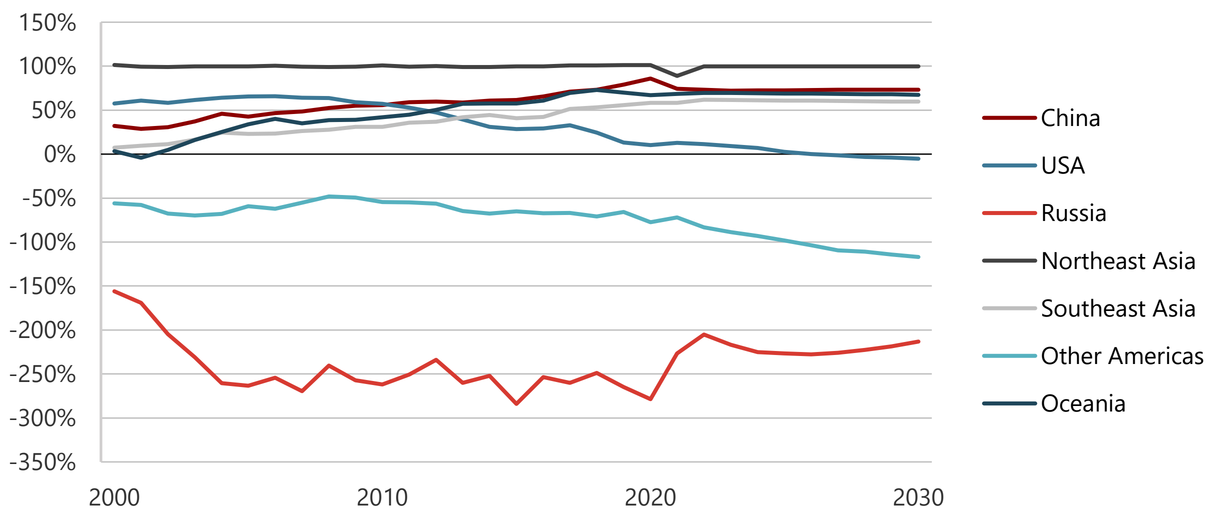
Source: APERC (2022)

2-4 Oil import dependence by region

On aggregate, APEC oil import dependence declines in both scenarios as the region demands reductions and higher production from APEC sources. APEC oil import dependence falls from around 24% in 2020 to 15% and 17% in REF and CN, respectively, by 2030. Despite the declines in the volume and share of oil imports, oil security will remain a primary concern for three APEC regions: China, northeast Asia, 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.

As a result of the demand growth and declining indigenous oil production, southeast Asia is the only APEC region where oil import dependence increases from 58% in 2020 to 60% in REF and remains unchanged in CN. From 2020-30, net oil imports in southeast Asia increase by 27% in REF and 14% in CN and account for 39% and 36% of APEC's total net oil imports by 2030 in REF and CN, respectively.

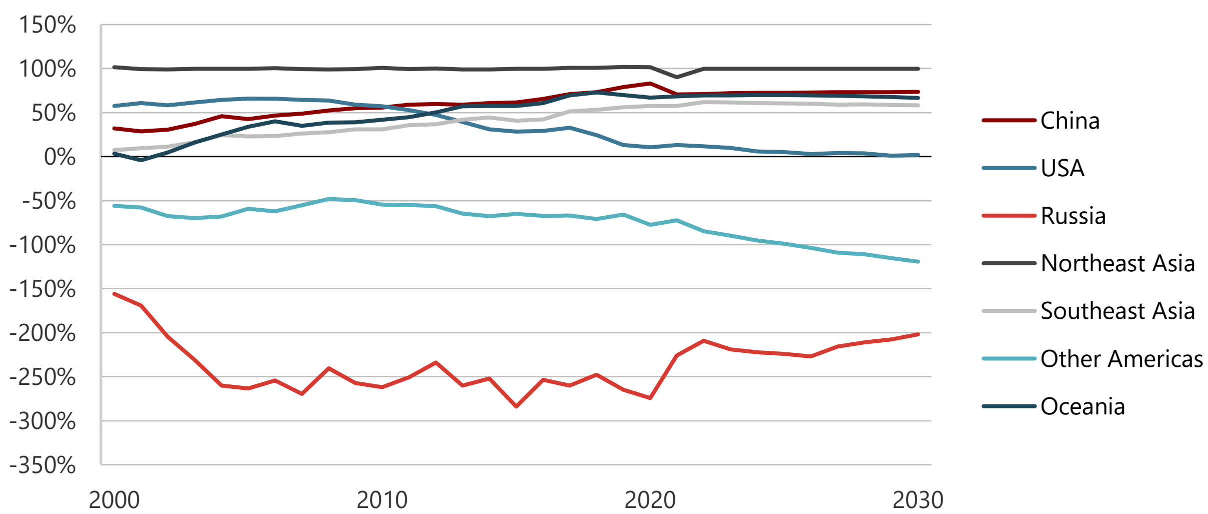
Figure 2-7: Oil import dependence by region in REF, 2000-2030



Source: APERC (2022)

After relying strongly on oil imports in 2000, the US's dependence on oil imports has declined steadily due to rising domestic production; US oil supply and demand are now roughly balanced. We expect that trend to continue slowly due to increased oil exports over the coming years. In REF, the US has a negative oil import dependence for the first time in 2027 because of abundant domestic supplies and exports but falls to around 5.0% by 2030. In CN, the US oil import dependence is 2.0% in 2030, as global demand declines pressure producers, resulting in domestic supply declines outpacing those in domestic oil consumption.

Figure 2-8: Oil import dependence by region in CN, 2000-2030

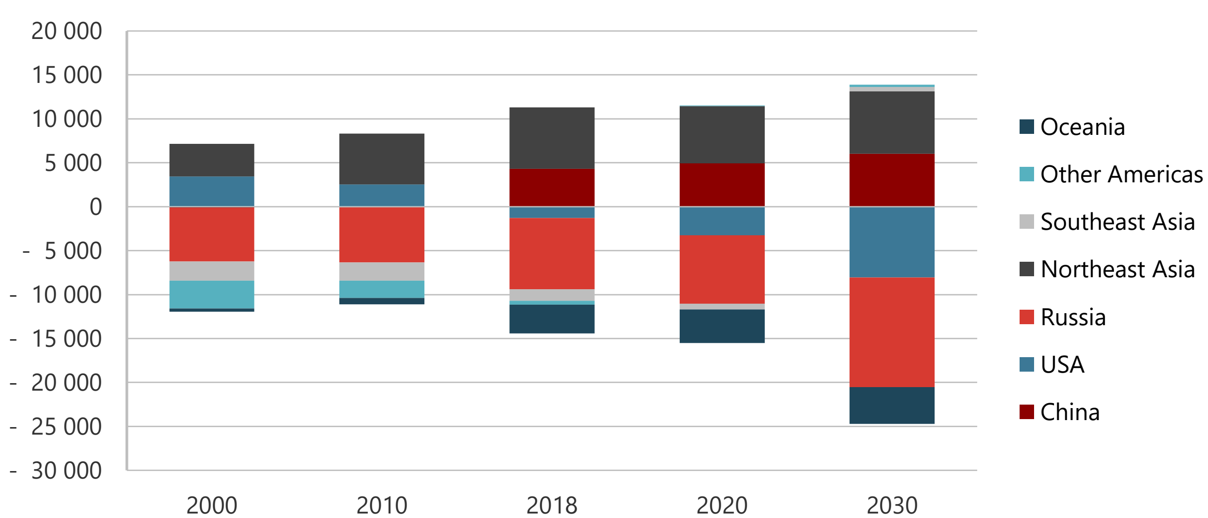


Source: APERC (2022)

2-5 Natural gas import dependence by region

For the last 20 years, the APEC economies on aggregate have been net exporters of natural gas. From 2000 - 2010, gas exports from Russia, other Americas, and southeast Asia outweighed gas imports into northeast Asia and the US. 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 (Figure 2-9).

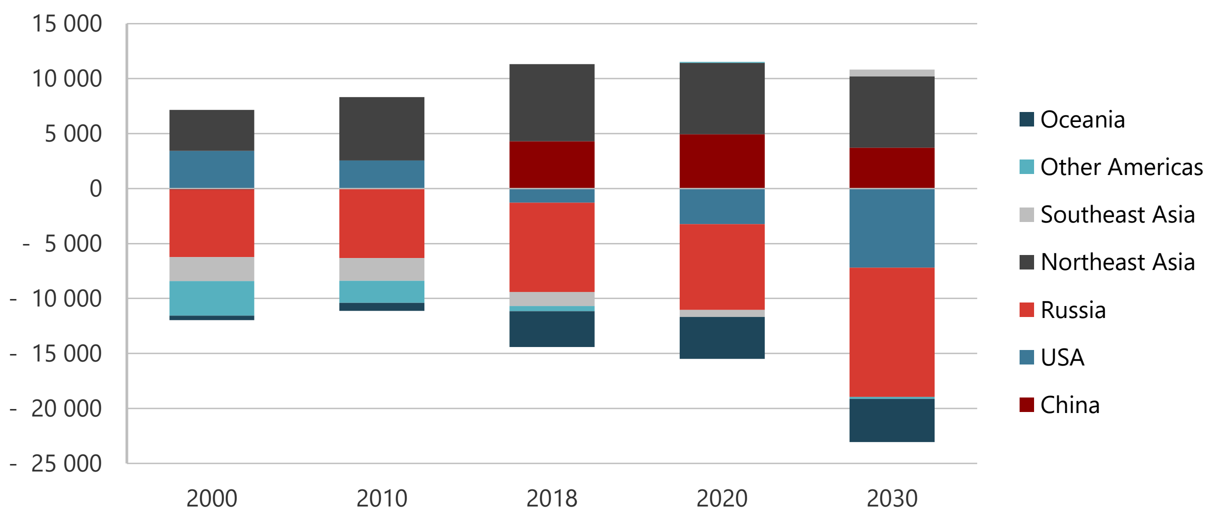
Figure 2-9: Net natural gas imports in REF, 2000-2030 (PJ)



Source: APERC (2022)

APEC's aggregate natural gas import dependence in 2030 is projected to reach negative 12% in REF and negative 14% in CN. However, gas imports by China and southeast Asia are expected to grow in REF, and southeast Asia's will continue to rise in CN (Figure 2-9 and Figure 2-10). This remaining reliance on gas imports for China, northeast Asia and southeast Asia will make all three regions vulnerable to gas supply disruptions this decade in either scenario.

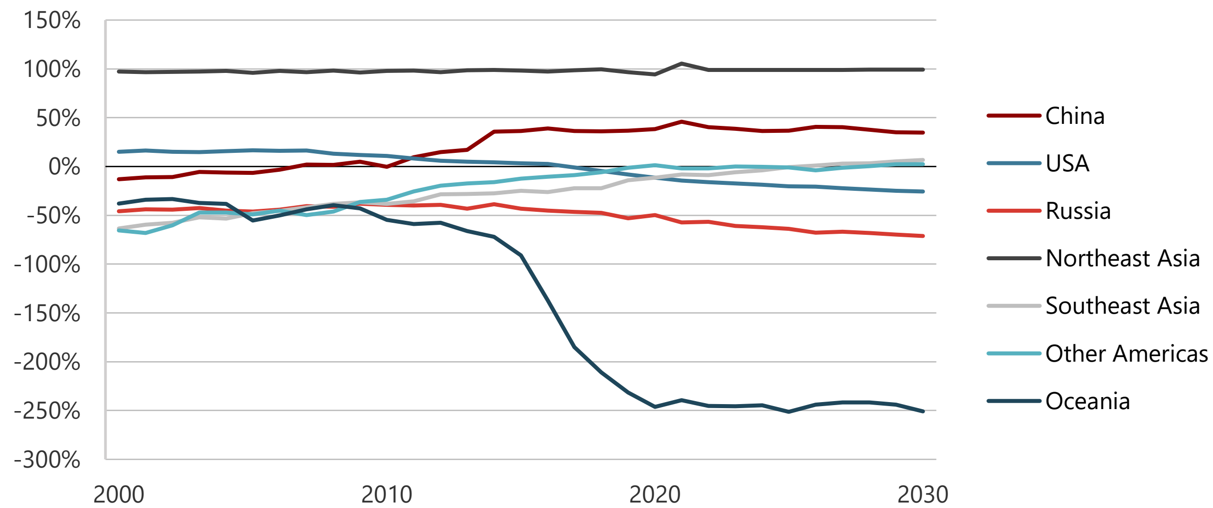
Figure 2-10: Net natural gas imports in CN, 2000-2030 (PJ)



Source: APERC (2022)

In both REF and CN, gas demand increases from fuel switching in the buildings, industry, and power sectors together outpace significant growth in domestic gas production. Recent and future investments in new LNG and gas pipeline infrastructure have increased China's ability to import substantial volumes of natural gas. In 2021, China became the largest LNG importer and the Power of Siberia pipeline from Russia started service with an initial capacity of 38 billion cubic metres (bcm) per year. From 2020 to 2030, China's natural gas import dependence is expected to fall from 38% to 35% in REF and from 38% to 25% in CN (Figure 2-11 and Figure 2-12).

Figure 2-11: Gas import dependence by region in REF, 2000-2030

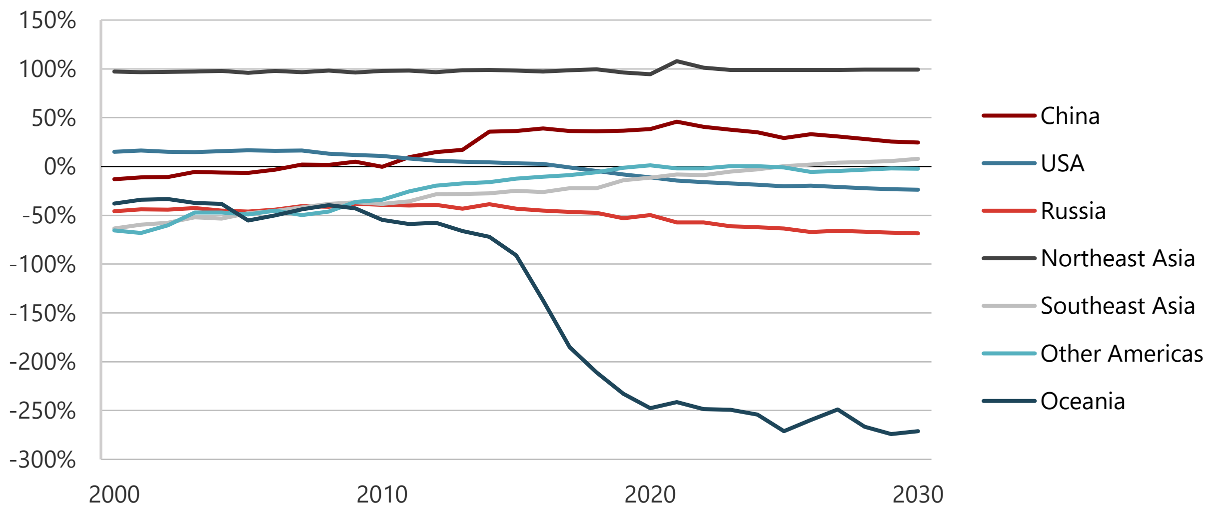


Source: APERC (2022)

Starting in the mid-2020s, southeast Asia's gas imports are expected to exceed its exports, transitioning the region 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 in the power sector. Russia remains the largest exporter of gas followed by the US. Even in CN, net gas imports in southeast Asia almost triple this decade. As a result, southeast Asia's natural gas import dependence flips from negative 11% in 2020 to 7.0% in 2030.

Northeast Asia, which is wholly dependent on imports for its gas, has imported substantial volumes since 2000. In REF, the region grows its net gas imports by 8.1% from 2020 to 2030 due to coal-to-gas switching policies in Korea and higher gas demand in Chinese Taipei following its nuclear phase-out. In CN, gas imports see a slight decline by 2030. Northeast Asia is expected to remain 100% dependent on gas imports in both REF and CN.

Figure 2-12: Gas import dependence by region in CN, 2000-2030



Source: APERC (2022)

2-6 Energy security concerns will remain during the energy transition

The results from the 8th Edition of the APEC Outlook illustrate that importing economies will need to rely on other actions to reduce the economic losses associated with oil supply disruptions during this energy transition. Since APEC oil demand will remain around or above today's levels through 2030, oil security will continue to be a major concern for oil-importing economies, especially China and APEC economies in northeast and southeast Asia. In the short run, if own-price elasticities of oil supply and oil demand remain low, oil supply disruptions will impose substantial costs on oil-importing economies.

It is yet unclear how increased electrification and further improvements in energy efficiency will affect these short-term elasticities. Due to its lower emission intensity than coal, the relatively low capital costs of gas-fired power generation plants, which provide ancillary and firming services to decarbonising electricity grids, natural gas is an attractive fuel for economies with rapidly growing demand for electricity. However, gas dependence does create energy security risks. Gas is more difficult to transport and store than coal and oil. 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.

With APEC oil and gas import dependence set to persist this decade, the following sections will highlight short-and long-term actions that APEC members are taking, or could take, to improve energy security during the initial stages of an uncertain energy transition.

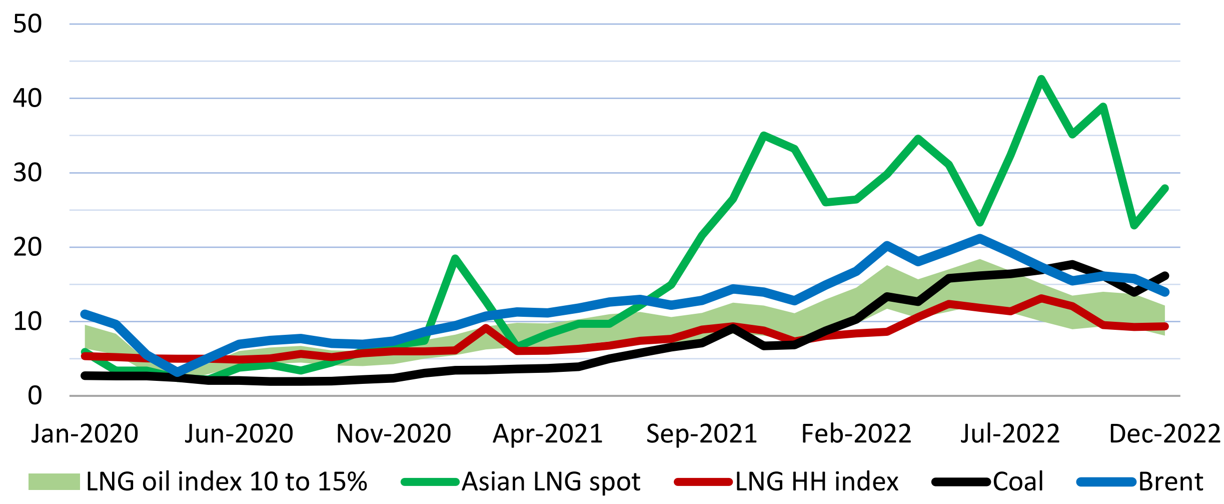
SECTION 3. SHORT-TERM ACTIONS TO IMPROVE ENERGY SECURITY

Threats to energy security are mostly a result of energy market shocks in the short term and constraints to investment in the longer term. End-users can reduce the impact of supply disruptions by engaging in fuel switching and conserving energy through lower activity. Governments can mitigate the impact of higher fuel prices on stakeholders by subsidising energy use, enabling short-term supply responses, accumulating fuel stockpiles, and diversifying fuel supply. However, in the short term, both end-users and governments will face constraints that limit this response. For example, technology endowments, fuel availability and budgets will limit the ability of end-users to switch to alternative fuels; while marginal energy conservation is sustainable, efforts that curtail economic output or reduce the utility of residential users are probably not; subsidies are limited by government fiscal capacities; infrastructure capacity limits stockpiling ability and fuel diversification ability; and long-term contracts, while effective at improving affordability, can reduce the price signal that incentivises demand responses. This section will highlight several short-term actions by APEC members that are mitigating the impact of the current energy crisis but will also touch on the factors constraining or hindering the short-term response.

3-1 How LNG contracts affect energy security and demand response

Several parts of this section attempt to examine the degree to which fuel switching can occur in the APEC region. With high spot prices of commodities dominating the headlines over the past year, it stands to reason that fuel and supply switching should already be visible. China is conforming to this expectation – after rising to the world's largest LNG importer in 2021, imports fell a fifth in 2022. However, this contrasts with northeast Asia, where natural gas demand and imports are proving to be relatively resilient. This can largely be explained by the difference in contract composition. While almost half of China's imports are tied to the spot market and short-term contracts, in northeast Asia the share is closer to a quarter (GIIGNL, 2022). The relative exposure of China's LNG supply to current high spot price signals is providing incentives to respond to the current crisis. In northeast Asia, the insulation of a lower pricing structure provided by longer contracts is muting the demand response (see below).

Figure 3-1: Monthly commodity prices facing LNG importers (USD per MMBtu)[4], 2020 to 2022



Source: JOGMEC (2023), IMF (2023), EIA (2023a, 2023b), APERC analysis

The chart above illustrates that LNG prices via a long-term contract are quite competitive with coal and oil products on an energy equivalent basis. The race to secure coal supply in the face of dwindling gas supplies is propelling spot coal prices to levels that are higher than most long-term LNG contracts signed before the current crisis. Furthermore, the destination clauses inherent to many APEC member LNG contracts prevent termination of delivery to capitalise on the arbitrage opportunity presented by European spot prices that floated around USD200 per MMBtu in September 2022.

For LNG importers, tilting LNG portfolios towards long-term contracts during an energy crisis provides the energy security advantages of both availability and relative affordability. This explains China's recent flurry of contracting activity; since the onset of recent LNG volatility in 2021, China has signed long-term agreements that equal its current spot market and short-term activity (GIIGNL, 2022). However, many of these contracts will not provide volumes until the second half of the decade. On the other hand, the stickiness of northeast Asian demand for natural gas illustrates how the insulation of longer contracting can blunt the responsiveness of economies to market signals in times of crisis. While APEC LNG importers should seek out longer contracts to secure affordable LNG supplies this decade, policy intervention will probably be required to facilitate fuel switching and energy savings before these contracts are available.

However, it is also worth noting that long-term contracts come at a cost. For one, the take-or-pay agreements and destination clauses inherent to many can limit flexibility for the consumer. Also, during

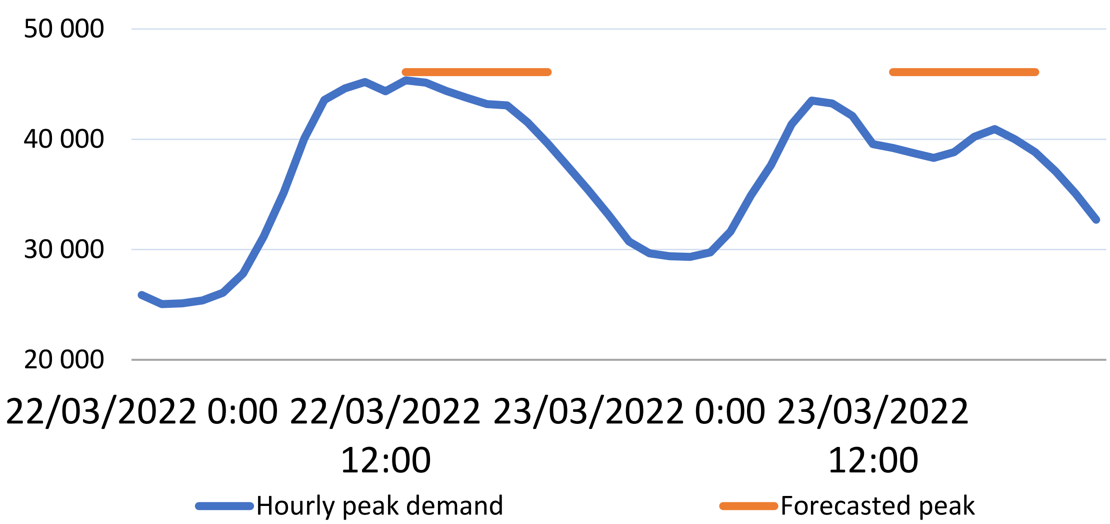
[4] Note: MMBtu stands for million British thermal units; the LNG oil index presents an estimate of the oil-index long-term contract price range between 10 to 15% of the Brent oil price; the Asian LNG spot bridges IMF and JOGMEC data to estimate the spot LNG prices facing Asian LNG importers; the LNG HH index estimates the Henry Hub-index long-term contract price as Henry Hub times 115% plus a USD3 per MMBtu liquefaction charge; coal is the FOB Newcastle price. All prices are converted to USD per MMBtu.

times of global oversupply, such as during the onset of the pandemic in 2020, spot prices can provide savings that could be unavailable to those tied to long-term prices. While not optimal during 2020 in hindsight, these contracts did provide ample cover for several APEC importers during the current crisis throughout 2021 and 2022.

3-2 A case study of conservation campaigns in Japan

A 7.4 magnitude earthquake off the coast of Fukushima, Japan in March 2022 prompted the temporary suspension of several thermal power plants during a period of unseasonably cold and cloudy weather that increased electricity demand while limiting solar output. On 22 March, the peak demand was forecast to exceed supply in the Tokyo region, prompting the government to issue a public warning that, without conservation efforts, millions of households could experience a blackout. The dimming of lights during live news broadcasts and at convenience and retail stores throughout this period stressed the severity of the situation. In response, end-users collectively reduced consumption enough to avoid a shortfall (Figure 3-2).

Figure 3-2: TEPCO forecast and peak demand, March 22 to 23 2022, (MW)



Source: TEPCO (2023), Grid Beyond (2022)

Japan's success at implementing emergency conversation campaigns stems not only from a recent history of necessity but a successful communication of policy to constituents and the resulting buy-in from those constituents. The aftermath of the Great East Japan Earthquake in March 2011 created a persistently tight electricity supply, particularly in areas serviced by the Tohoku and Tokyo electric power companies (Tohoku EPCO and TEPCO, respectively), due to the meltdown of the Fukushima Daiichi nuclear power plant, as well as damage to electricity infrastructure. A two-week rotational load shedding was carried out immediately after the quake in both Tohoku and Tokyo, and consumers were requested to reduce electricity usage. The government implemented an energy-saving strategy throughout the Northern Hemisphere's summer of 2011 in response to the tight electricity supply, enforcing a uniform 15% reduction in electricity demand across the affected areas. With strong support from various stakeholders and effective public information campaigns aimed at households through websites and other media, TEPCO surpassed the target reduction throughout the 2011 summer (18%). Analysis by Murakoshi et. al (2012, 2013) illustrates that this was not driven by less extreme weather and highlights the high level of household awareness of conserving campaigns during this period. This response built on the success of the Cool Biz campaign, initiated by the Ministry of Environment (MOEJ) in June 2005 in response to the Kyoto Protocol, which encouraged business employees to wear cool and comfortable clothes at work and set air conditioners to 28°C to reduce energy use and GHGs. A survey by Murakami et. al (2009) concluded that most respondents knew about the campaign, which suggests there had been an effective dissemination strategy by the government. Following the March 2011 disaster, the government upgraded the campaign into Super Cool Biz, encouraging the wearing of polo shirts and trainers at work.

The past year illustrates how Japan has built an effective channel, from the government to electricity consumers, for implementing emergency energy conservation measures during supply shortages. It may also be reducing aggregate consumption during non-emergency periods, reducing the economy's LNG import requirements (Yuki, Abe, 2023). Japan is aiming to implement similar gas conservation campaigns to reduce the likelihood and impact of LNG disruptions. Success will be contingent on replicating the successful behavioural response that Japan had to electricity demand. This energy-saving tool is essential for ensuring the economy's energy security and could serve as a blueprint for APEC net gas importers to mimic in order to reduce consumption and mitigate the impact of supply shocks over the coming decade.

3-3 The limits of fuel switching: a case study in APEC's power sector

The ability to switch from one energy source to another in the short-term is challenged in part because many activities and technologies, such as heating, cooling, vehicle drive trains, and motors, overwhelmingly rely on one fuel type or energy carrier. Switching from one source of energy to another requires one of the following:

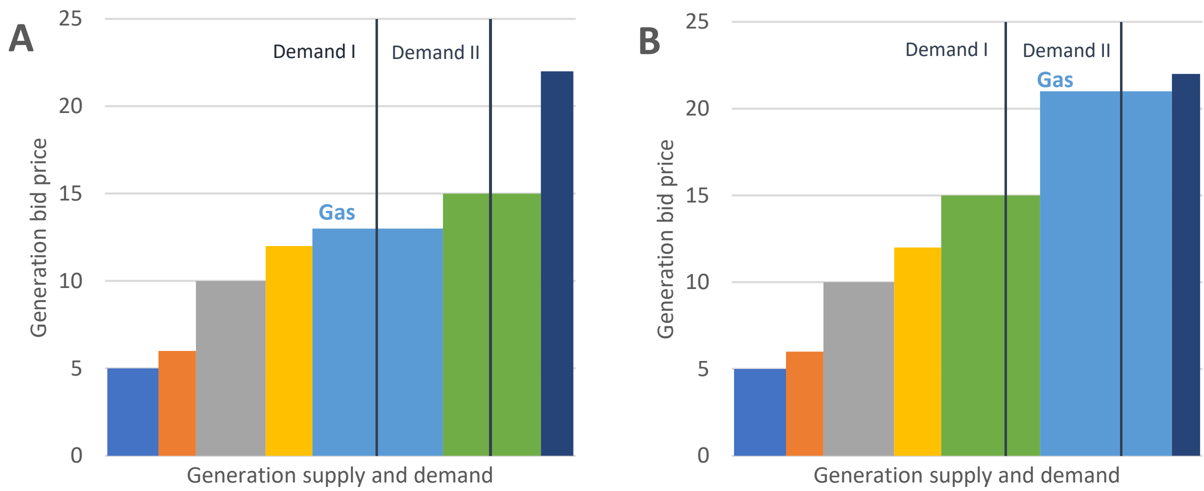
1. Replacement: investment in new equipment that uses a different energy source.
2. Sophistication: energy applications that can use multiple energy sources.
3. Redundancy: idle or working capacity that uses alternative energy sources.

And all three avenues for fuel switching involve additional cost. In an environment of stable energy markets, the additional cost will prove to be inefficient from a capital allocation perspective. However, if energy supply and demand are volatile, the additional cost to facilitate switching between energy sources may be justified.

The potential for short-term fuel switching is typically greatest in the power sector. This is mostly tied to the inherent redundancy built into the system, as installed capacity must be sufficient to meet infrequent periods of peak demand and to make up for unexpected losses. Power grids usually have a significant portion of assets idle during off-peak hours. Fuel switching also depends on the availability of resources. While variable renewables are useful at reducing the raw energy of base fuels over the course of a year, intermittency renders them a poor replacement for baseload generation during periods of higher fuel prices. Other baseload assets, such as thermal, nuclear, and hydro generators, are better at responding to external supply or price shocks.

In areas with competitive wholesale generation markets, switching will happen via the bid process. Figure 3-3 illustrates a hypothetical merit order. In both panels, surplus capacity exceeds demand but is lower during peak (Demand II) than off-peak (Demand I) hours. In panel B, higher natural gas prices move gas assets to a more expensive position in the merit order. During off-peak hours, switching (to the green bar alternative) reduces the impact of higher gas costs. However, peak periods (Demand II) still require gas assets, as there is no longer sufficient redundancy to bypass gas generation.

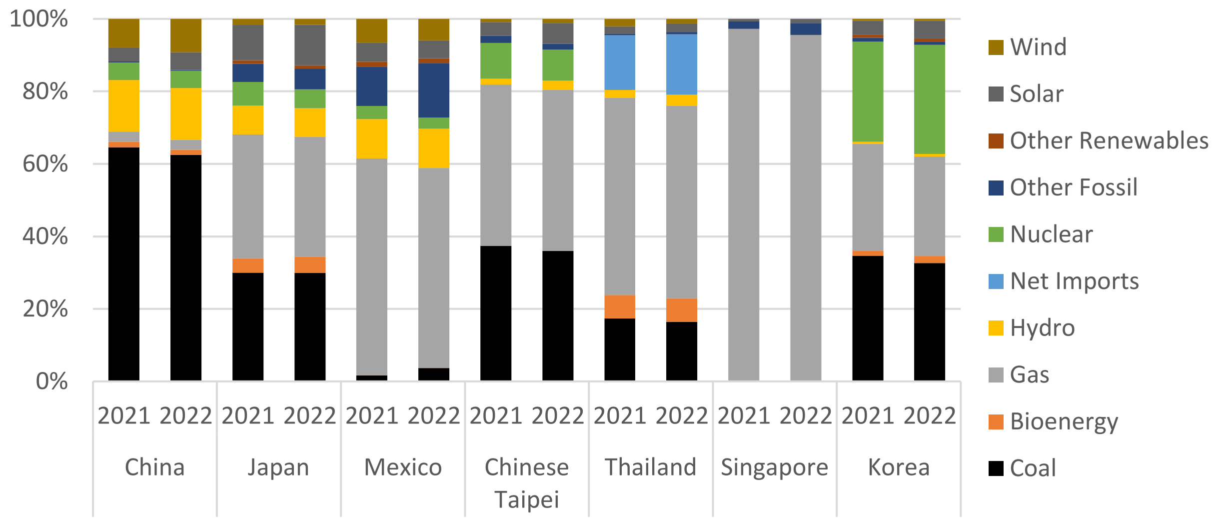
Figure 3-3: Hypothetical generation bidding curve and feasibility to switch away from gas following a change in bid price at different levels of demand



Source: APERC

Redundancy and LNG contracts (see Section 3-1) have limited fuel switching in power thus far. At the time of analysis, Ember data suggests that of APEC's net LNG importers, only China; Japan; Korea; Mexico; and Singapore are reducing gas generation (Ember, 2023). Both Japan and Mexico are switching towards oil- and coal-fired generation, Singapore is leveraging its oil-fired capacity, while Korea's reductions are mostly due to nuclear units returning to service. In China, a significant deployment of variable renewables is reducing the share of raw energy supply required from thermal fuels. While many of the reductions are marginal on aggregate, this could change as alternative capacity comes online. The restart of idled nuclear and damaged thermal units will provide much-needed capacity alternatives in Japan. A relaxation of a coal-to-gas switching policy in Korea will open higher coal capacity. However, the pursuit of a nuclear phase-out will force a higher gas share in Chinese Taipei. APEC members will need more baseload redundancy if they want to increase their fuel flexibility.

Figure 3-4: Electricity fuel mix in select APEC LNG importing economies, 2021 and 2022



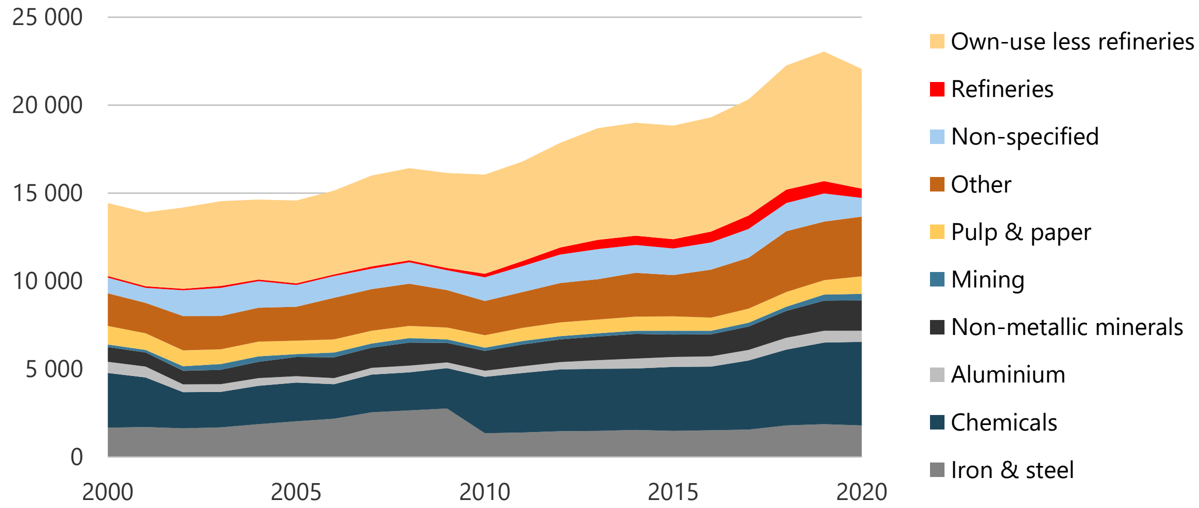
Source: Ember (2023)

3-4 The potential for fuel switching at the industrial level

Natural gas represented about 20% of APEC's industry energy demand in 2018, mainly in the form of process heat and non-energy use (EGEDA, 2022). With LNG spot prices hitting record highs in 2022, it stands to reason that large-scale users could help alleviate the gas crisis by embracing fuel switching. However, two things are limiting this in the APEC region: the competitiveness of long-term LNG contract pricing and the constraint of suitable substitutions for various end-uses. As argued in Section 3-3, fuel switching requires replacement, sophistication or redundancy. Industrial applications sometimes have sophisticated technology that can employ multiple fuel sources. However, it is rarely economical for businesses to invest in redundancy that uses alternative fuel sources, and replacement investments take time to materialise.

Section 3-10 highlights how the competitiveness of long-term LNG contracts is muting the price signal for industrial users, particularly since they are less likely to procure spot gas given the predictable and unseasonable nature of their production schedule compared to the power sector. For gas users exposed to spot pricing, investments in end-use technology and supply chains geared to natural gas can constrain fuel switching in the short term. High prices can be particularly devastating for highly gas-intensive industries, for example, those producing chemicals, fertilisers, steel, and aluminium, which have a low elasticity of substitution due to the limited substitutes available for their established technology (Chang et al, 2019). With substitution off the table, the only viable business strategy is output curtailment (WSJ, 2022). In 2013, a methanol plant in southern Chile was temporarily idled due to a low natural gas supply. More recently, in 2022, after an initial reduction of production capacity, some European smelters announced shutdowns due to the high price of natural gas.

Figure 3-5: Natural gas demand by APEC industrial subsectors in PJ, 2000 to 2020



Source: EGEDA (2022)

Oil refineries are uniquely suited to reduce gas demand due to the high substitutability of their natural gas use for process heat and their ability to produce intermediate substitutes in their production process. In 2022, Shell and Repsol reported that they were fully switching away from natural gas for process heat at their European refineries, and partially replacing it with oil products, either from other oil product inputs, like naphtha, or by combusting liquefied petroleum gases (LPGs) that are intermediate or final outputs of the refinery process (Reuters, 2022; YouTube, 2022). In the Netherlands, gas use by refineries was down over half in 2022 without affecting product throughput or output (CBS, 2022).

While oil refineries consume under one percent of APEC gas use, applying reductions in use like Europe would still provide significant relief to the global gas market. APEC refineries use between 500 and 700 PJ a year. Halving this is the equivalent of adding between 75 and 115 shipments of LNG to the global market. APEC members should investigate the potential for their refineries to switch away from gas and towards oil products, particularly LPGs. However, in the longer term, this could tighten oil product markets if an increase in oil demand in other sectors is observed (Bloomberg, 2022a, 2022b).

A key challenge could be the insulation of APEC members to spot price signals through long-term LNG contracts. Although this practice might be useful in volatile supply scenarios, if they are not sufficiently flexible, long-term LNG contracts can create problems if gas demand declines below contract levels. Furthermore, dedicating demand to satisfy long-term contract purchases could hinder the transition to potentially cleaner and more competitive alternative fuels. New LNG contracts will need to be designed considering the effect on potential environmental goals that industrial consumers might have.

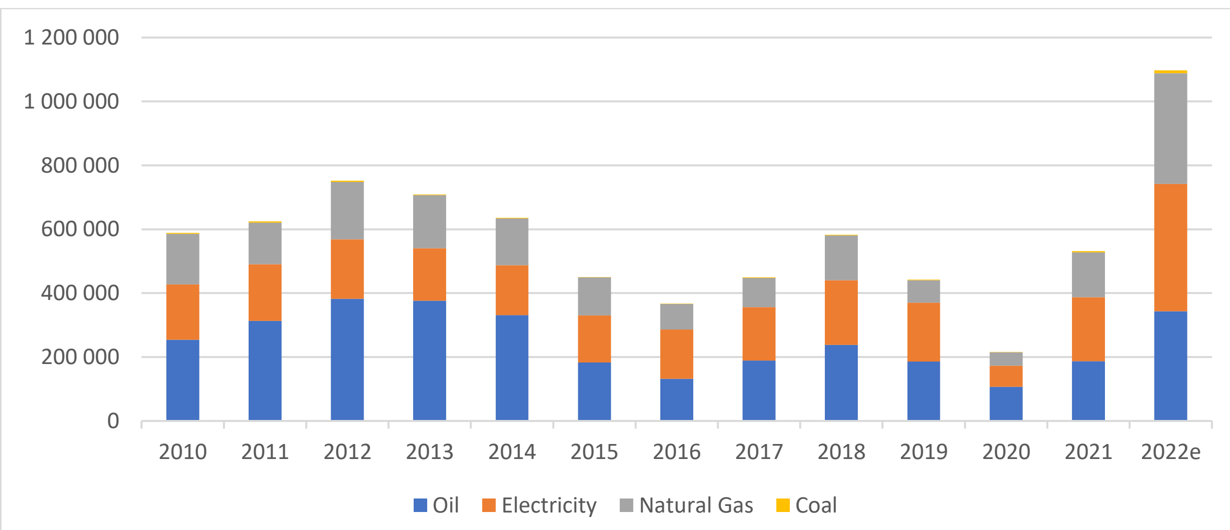
In the long run, members could further reduce their exposure to gas disruptions by promoting energy efficiency in highly gas-intensive industries. Accelerating the decarbonisation of industrial processes away from natural gas will improve the energy security of industry and APEC member economies (McKinsey, 2022).

3-5 Mitigating rising energy burdens with fossil fuels subsidies

Since energy end-use prices have a direct impact on industry and household activity, many economies tend to take policy measures to minimise the impact on domestic end-uses. However, such action can be at odds with other policy goals. For this reason, G20 and APEC leaders have promised since 2009 to phase out fossil fuel subsidies to help reduce emissions on the way to achieving carbon neutrality. However, the current energy crisis is introducing two competing priorities for policymakers: affordability and availability. Affordability concerns are pressuring governments to subsidise energy use to insulate the impact on consumers and ensure that businesses can last through the crisis. However, muting the price signal is preventing end-users from reducing demand sufficiently in response to the crisis. Experience within APEC suggest that issuing subsidies during high price periods can decrease the price elasticity of demand for oil and gas for prolonged periods, which in turn can exacerbate future supply shortages. In Thailand, heavy petrol price subsidies during 2003 - 2005 resulted in long-term adverse effects on consumers and the economy. Balancing affordability with the need to encourage lower consumption and the fiscal constraints of a more-indebted world after the pandemic is a difficult task for policymakers.

According to the IEA, total government support for fossil fuels nearly doubled in 2022 (IEA, 2023). This contrasts with 2020, when the value of fossil fuel consumption subsidies decreased by around 40% compared to 2019 due to COVID-19 unexpectedly reducing fossil fuel prices (Figures 3-6 below). This correlation between global fossil fuel prices and government fossil fuel subsidy expenditures will continue unless governments find a way to increase the own-price elasticity of demand for fossil fuels.

Figure 3-6: Fossil fuel consumption subsidies from select 42 economies, USD million, 2010-2022e



Source: IEA (2022, 2023)

APEC contains several examples of governments that are turning to subsidisation or providing tax incentives. In July 2022, Thailand overspent its subsidy in oil and cooking gas by USD4 billion. In addition, PTT Plc, the state-owned oil and gas conglomerate in Thailand, decided to allocate USD100 million to the

Oil Fuel Fund against a global oil price rise, following its months-long support of the diesel and LPG price subsidy (Bangkok Post, 2022).

The Korean government temporarily cut the fuel tax by 20% in November 2021 and reduced it to the maximum legal limit from July 2022. On 2 August 2022, the National Assembly passed a bill to increase the limit on the adjustment of the flexible tax rate on gasoline and diesel from the current 30% to 50% by the end of 2024. Additionally, the government is implementing a plan to expand subsidies for transport operators that use diesel to mitigate the rising cost of the fuel (S&P Global, 2022a).

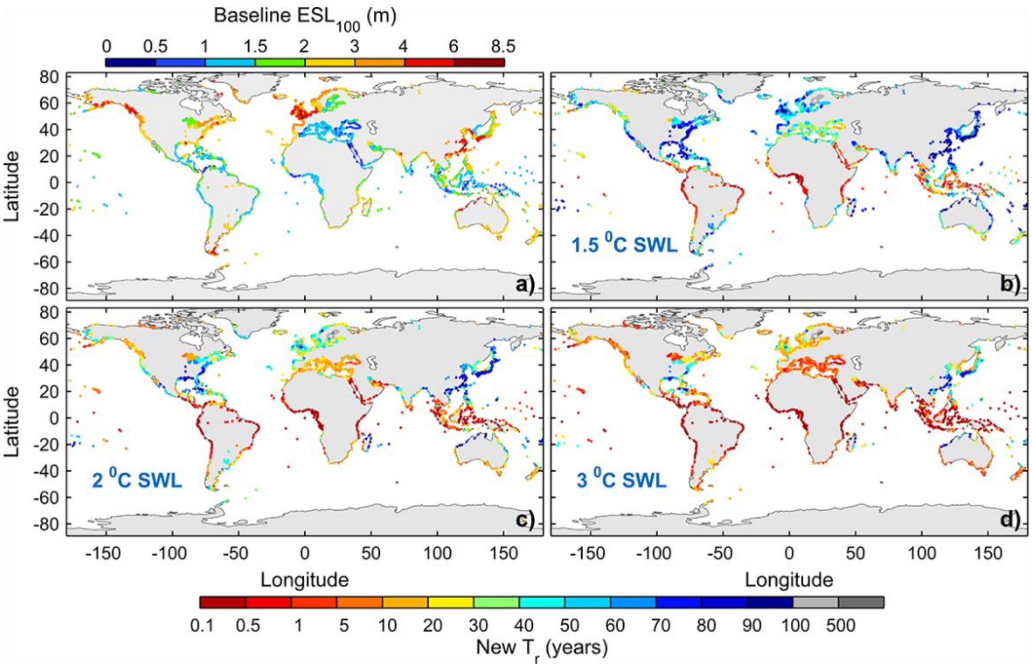
The situation in other economies is not much different. Some states in the US temporarily suspended fuel taxes in 2022 and President Biden asked Congress to waive federal fuel taxes for three months in June 2022. Japan will also provide subsidies to wholesalers of petroleum products from 27 January 2022 (METI, 2022a). Several Canadian provinces have reduced fuel taxes and introduced price caps to mitigate the impact of higher fuel costs on end-users.

Policymakers should exercise caution when implementing energy price subsidies because they weaken demand responses to higher prices and can negatively impact the fiscal health of an economy. A legal framework could be considered to set the limit of the price subsidy. In Thailand, the Oil Fund Act was recently amended with specific conditions stipulating that the fund can only be used to temporarily absorb price shocks with a specific ceiling of total spending. Price/tax subsidies that target specific groups of energy users, such as lower-income households, as opposed to a general price subsidy, could be considered to reduce government expenditure and increase the economy-wide demand response to higher price signals. Public understanding through effective communication from the government and cooperation to conserve energy is essential to ensure supply availability and induce a demand response elasticity to price volatility, which could be more common in the uncertain future.

3-6 Seaborne refined product supply reliability in a changing climate (a Peru study)

With most international trade, including energy goods, dependent on maritime transport, seaports are crucial components of economic and energy security. The economic losses arising from seaport operational disruption can be significant for the coastal-rich APEC region, particularly those members that rely on seaborne imports to fuel their oil supply requirements. Recently, the United Nations Conference for Trade and Development (UNCTAD) emphasised how climate change is increasing the frequency of extreme sea level (ESL) events across the globe (UNCTAD, 2021). During these events, seaports experience operational difficulties that can disrupt trade in oil and oil products for several days. The frequency of ESLs affecting Peru has increased by 16%, which risks creating supply disruptions to imported oil products (El Comercio, 2022). Media reports highlighting the potential for jet fuel and LPG shortages due to anomalous wave activity are increasing in frequency (DIHIDRONAV, 2022).

Figure 3-7: Estimated increase in the frequency of ESL events



Source: UNCTAD (2021)

Peruvian regulations require oil product producers and distributors to stockpile an equivalent to 15 days of consumption needs. In contrast, the International Energy Agency (IEA) members commit to keeping a cover of 90 days. In the case of LPG, which is used for cooking and transport, the storage capacity is approximately three days (RPP, 2022). Furthermore, having sufficient inventory cover may do little to prevent disruptions during an ESL event because the logistics of moving oil products from inventory to consumer delivery points often involve seaborne vessels. When Peru suffered LPG supply restrictions in 2022 due to anomalous waves, the Ministry of Energy and Mines responded by authorising the release of LPG stocks to maintain supply to the domestic market. If the frequency of ESLs continues to increase, Peru may find its storage insufficient and its oil product supply chain ill-equipped to cover domestic demand during a potential seaport disruption.

Climate change is likely to increase the frequency of ESL events over the coming decades (Vousdoukas et al., 2018; Kirezci et al, 2020), with the coastal zones that cover several APEC economies, including southeast Asia and the Pacific coast of South America, seeing several occurrences per year. Facing a higher operational risk to seaport operations, these APEC members must prepare for a higher frequency of oil product disruptions. Mitigation requires both investment in higher oil product storage capacity and a strengthening of the current seaport infrastructure to adapt to ESL events. It may also require investing in inventory redundancy, by moving a higher proportion of storage facilities closer to delivery points to ensure that ESLs do not render inventory coverage ineffective when it is most needed.

Additionally, some economies could pursue fuel diversification. For example, Peru could leverage its natural gas resources by extending access to residential and commercial users via an extension of its domestic natural gas pipeline network. These users could then switch from imported LPG to natural gas, thereby reducing exposure to supply disruptions from ESL events.

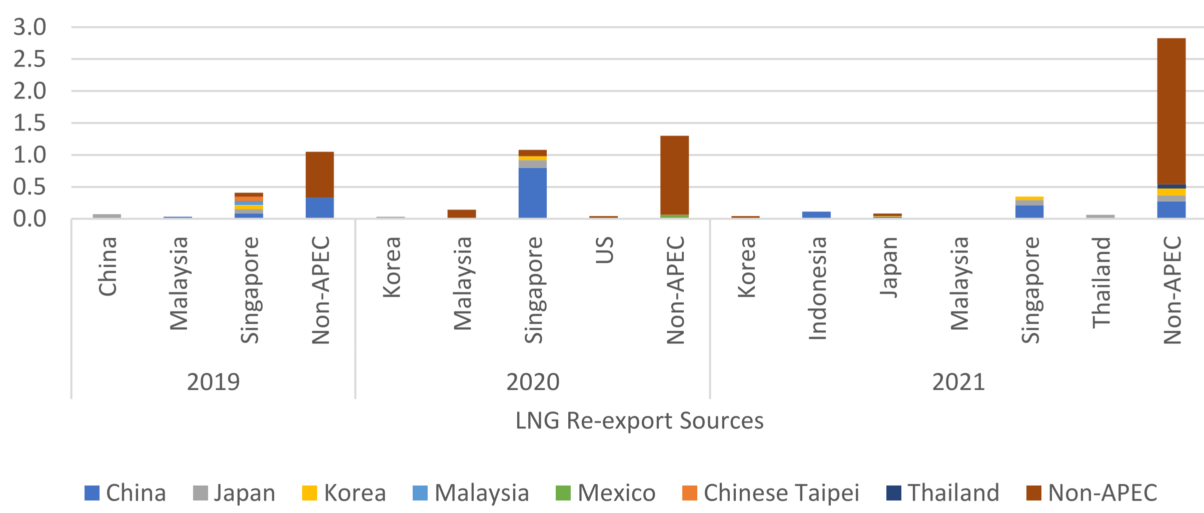
3-7 LNG re-export potential in southeast Asia and northeast Asia regions

LNG re-exports allow economies with surplus LNG to earn arbitrage profits and help alleviate shortages for other LNG importers. Although the share of LNG re-exports compared to net imports is quite small[5], the number of economies engaged in LNG re-export loading and receiving, and the amount of LNG re-exporting has increased steadily. In southeast Asia and northeast Asia regions, re-exporting LNG is quite common.

Southeast Asian economies tend to re-export to northeast economies in winter because the former economies are at seasonable low points and the latter are experiencing higher heating demand (Natural Gas World, 2021). For example, Thailand was able to sell surplus LNG to Japan during the unseasonably cold 2021 winter due to low domestic demand stemming from mild weather and lower activity during the pandemic (Nikkei Asia, 2022). Singapore, APEC's most active LNG re-exporter, sent cargoes to China; Japan; and Korea in 2021 (Figure 3-8), with most activity occurring during the Northern Hemisphere's winter (81%).

LNG re-export potential depends on various factors including LNG import and re-export capacity, LNG import dependency, the utilisation rate of LNG terminals, LNG demand seasonality, geographical location, and the distance from potential buyers with varying demand seasonality.

Figure 3-8: Annual LNG re-export flow destinations by source, 2019-2021, million tonnes



Source: GIIGNL (2022)

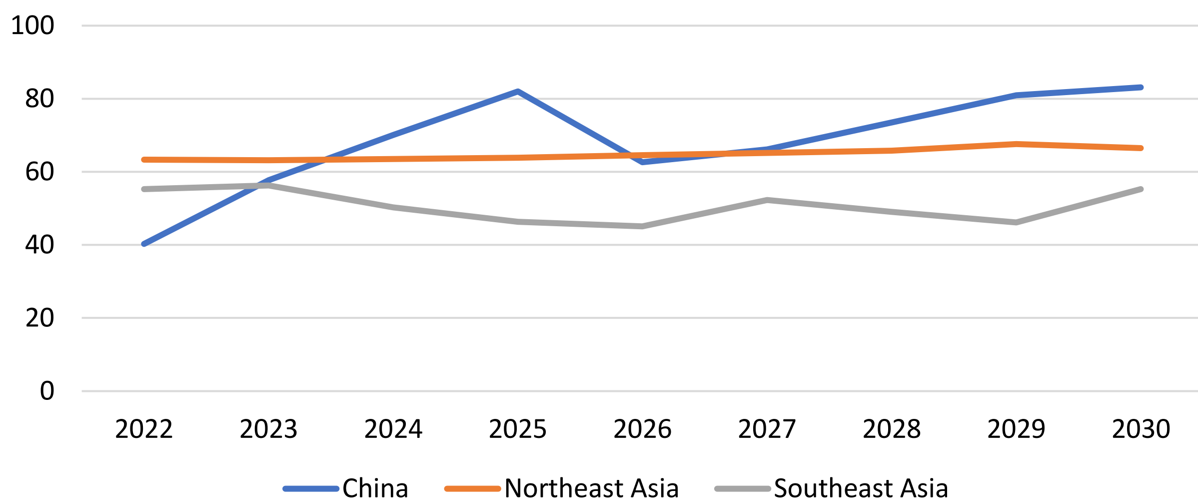
As illustrated in Section 2, rising demand for power generation is expected to increase net import dependence for both the southeast and northeast regions of APEC (see Figures 2-11 and 2-12). In

[5] In 2021, the share of LNG re-exports compared to net imports was 0.9%.

contrast, China's net import dependence will reduce to about 35% in 2030 with increased domestic natural gas production and increased import volume via pipeline. The increasing natural gas demand and depleted domestic natural gas production situation prompted the race among southeast and northeast Asian economies to expand and build new LNG-receiving terminals. An additional capacity of 28 million tonnes per annum (Mtpa) is expected to come into operation in stages by 2030 in northeast Asia, while 80 Mtpa will become available in southeast Asia.

As illustrated in Figure 3-9, rising LNG import capacity and the continued underutilisation of LNG import terminals will provide ample opportunity to increase LNG re-exports this decade. As most of the global demand growth is coming from Asia, distance will become the deciding factor for sourcing LNG during an emergency. This situation gives an advantage to the LNG re-export activities in northeast and southeast Asia.

Figure 3-9: Share of LNG import capacity unutilised, 2022-2030, CN of 8thAPEC Outlook, %



Source: APERC (2022)

While receiving terminals are common in northeast and southeast Asia economies, most of these do not yet possess reloading capability. In addition, provisions in the long-term contracts could prohibit LNG buyers from diverting cargoes during arbitrage situations, thereby restricting re-exports.

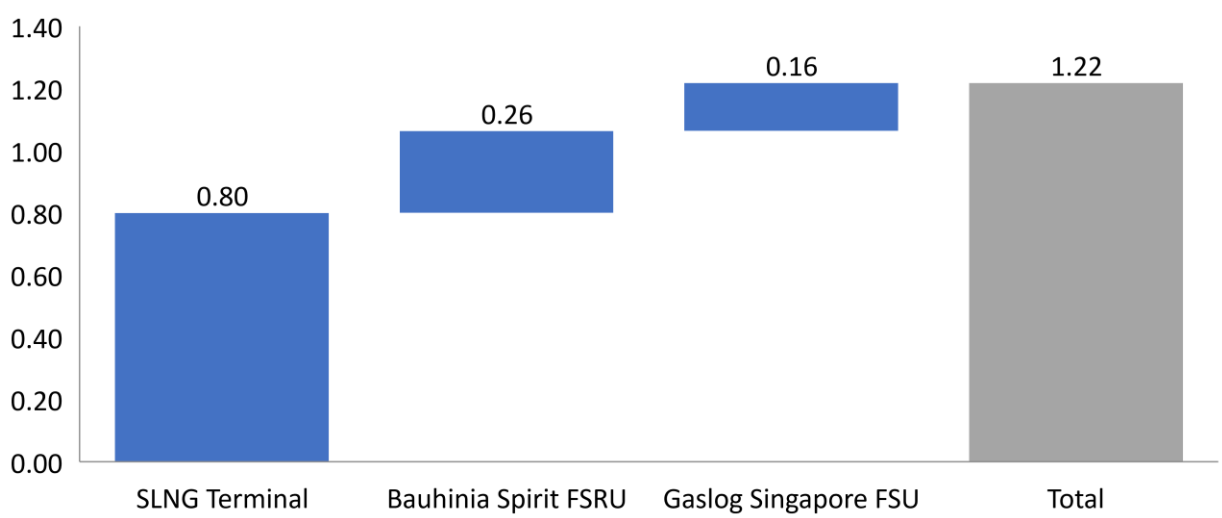
3-8 Chartering floating LNG carriers to improve gas security: a case study of Singapore

Singapore relies on imports to fulfil its natural gas supply, 95% of which is for electricity generation, with two-thirds of imports coming from Malaysia and Indonesia via pipeline, and a third from LNG vessels. Following an unexpected curtailment of pipeline imports from Indonesia's West Natuna region in September 2022, Singapore found itself facing a gas and electricity supply crisis. Wholesale electricity prices tripled in October, which sent several utilities into insolvency.

Singapore's Energy Market Authority (EMA) acted quickly. As a power system operator, industry regulator and developer, one of the main goals of the EMA is to ensure that the energy supply is reliable and secure. In October 2022, the EMA set up standby fuel facilities as a supply backstop, ordered gencos to acquire sufficient contracts to cover their retail commitments, and directed gencos to draw upon the inventories at standby facilities if they were short of fuel (EMA, 2021a). In December, the EMA revealed that one of these facilities was a standby LNG facility (SLF) (EMA, 2021b). In effect, the EMA procured LNG to ensure that sufficient supply existed to fuel power market activities. The actions helped Singapore endure the pipeline curtailment without a power outage and reduced the wholesale price of electricity to the cost of fuel, or about a third below its peak levels.

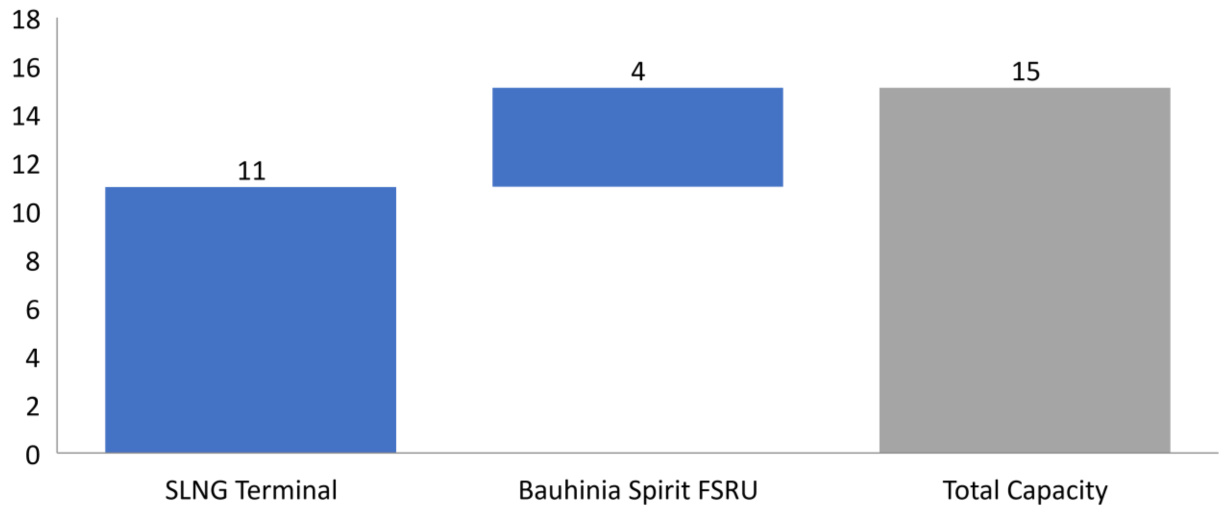
While the EMA did not publicly state how it secured more physical capacity for the SLF, Platts reports that Singapore chartered a floating storage unit (FSU) for 12 months and a floating storage and regasification unit (FSRU) for six months. Both have increased Singapore's on-site LNG storage to buffer against availability shocks, and the FSRU provides supply flexibility through higher regasification capability if Singapore continues to face pipeline disruptions. The two charts below illustrate how the actions have increased Singapore's LNG storage capacity by over 50% and its regasification capacity by 37%.

Figure 3-10: Singapore LNG storage capacity (million m3)



Source: GIIGNL (2022), S&P Global (2022b)

Figure 3-11: Singapore LNG regasification capacity (million tonnes per annum)



Source: GIIGNL (2022), Platts (2022)

Singapore's actions illustrate that it is possible to hedge against or mitigate an acute availability crisis in short order by chartering FSU and FSRU vessels. However, there are limitations. There are currently fewer than 50 FSRUs in operation on the planet and competition for the fleet is steep. For example, Germany is currently employing six FSRUs as it shifts supply away from piped Russian volumes. Both of Singapore's chartered vessels have other contractual commitments in Hong Kong, China (FSRU) and Panama (FSU) in 2023, which could limit the duration of this policy[6]. Singapore is planning to continue its pre-emptive measures to improve energy security until at least Q1 2023. It may then have to find alternative vessels or outbid the other contracts. APEC members could help increase the size of the global FSU and FSRU fleet by encouraging the conversion of outdated steam-driven vessels. With most of the world's LNG shipbuilding occurring in China; Japan; and Korea, APEC members are well-placed to shape the availability of these vessels going forward.

3-9 Repurposing aging LNG carriers to increase supply elasticity and storage capacity

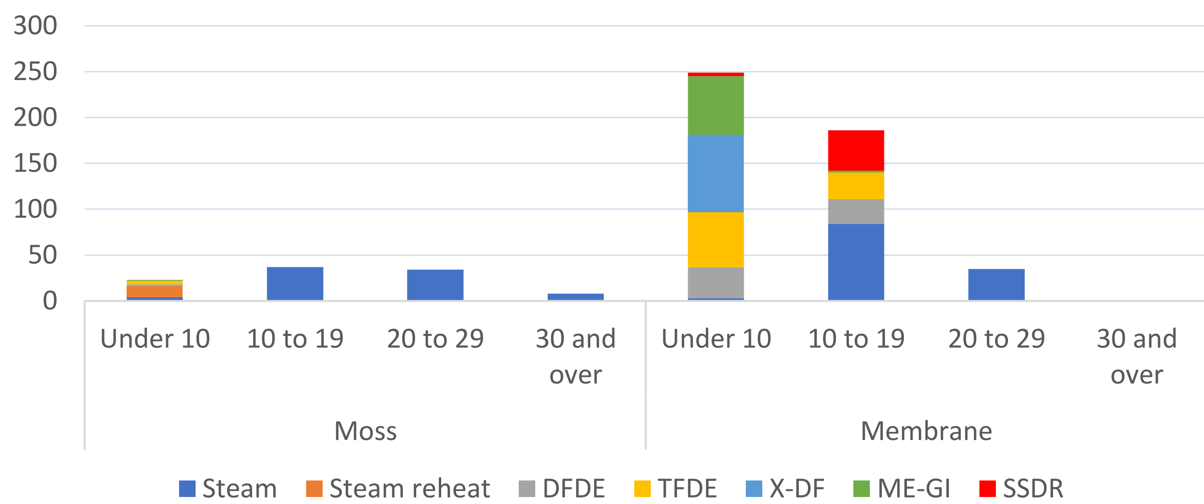
The emergence of the LNG portfolio player along with the increasing stringency of maritime emission regulations by the International Maritime Organization (IMO) continue to drive technology choice in LNG carriers[7]. Figure 3-12 illustrates this. In terms of containment, membrane systems are now the dominant technology, supplanting the spherical, protruding Moss tanks that dominated containment systems carriers in the early stages of the industry. Likewise, the tri-fuel diesel engines (TFDE) and the slow-speed, two-stroke ME-GI and X-DF engines are supplanting primordial steam-based propulsion

[6] As of publication, this vessel has since left Singapore and is in its commissioning stages in Hong Kong, China, and is expected to become the economy's first LNG import terminal later this year.

[7] Read more about how the LNG portfolio model and IMO environment regulations necessitate technological change in the containment and propulsion systems of LNG carriers in the third section of the OGSS 17 study: *Changing LNG market dynamics – implications for supply security in the APEC region* (APERC, 2020).

technologies due to their ability to operate flexibly and efficiently while maintaining compliance with IMO sulphur oxide and nitrous oxide regulations using boil-off gas from the LNG cargo. Of the 400 vessels built in the last 20 years, only 15% sport Moss containment systems and two-fifths have a steam-based propulsion system. While the current energy crisis should relax the pressure to improve cost and fuel-efficiency through the high charter rates that result during commodity shortages, emerging IMO regulations, particularly the Energy Efficiency eXisting ship Index (EEXI) and the Carbon Intensity Index (CII) will probably require a complete phase-out of steam-based propulsion (IGU, 2022).

Figure 3-12: Active global LNG carrier fleet, segmented by age, propulsion type and containment type[8]



Source: IGU (2022), GIIGL (2022), APERC analysis

Fortunately, this looming retirement of LNG carrier capacity brings with it an opportunity to bolster gas security through the repurposing of the existing LNG stock. Firstly, Moss containment systems can be repurposed into floating LNG (FLNG) units. While FLNG represents under two percent of global liquefaction capacity, the energy crisis is increasing interest in the technology due to its ability to produce and liquefy resources in remote, offshore gas fields without having to install significant infrastructure or incurring the permitting and environmental challenges associated with onshore developments. Also, repurposing a Moss carrier into an FLNG unit takes two-thirds the capital expenditure of constructing a newbuild FLNG vessel and a fraction of the four-to-six-year build time. Because the units could be deployed all over the world over a shorter time horizon, they would effectively increase global LNG supply elasticity in the short to medium term. With nearly 100 LNG carriers equipped with steam propulsion and Moss containment, there is an opportunity to generate almost 50 FLNG facilities (Nikkei Asia, 2022a; IGU, 2022; GIINGL, 2022).

[8] Note: steam refers to the steam turbine propulsion system; steam reheat refers to both the steam reheat engine system and the steam turbine and gas engine (STaGE) system; DFDE refers to dual-fuel diesel electric propulsion systems; TFDE refers to tri-fuel diesel; X-DF is a low-speed, two-stroke dual fuel engine; ME-GI, also a slow speed two-stroke model, is a high pressure mechanically operated and electronically controlled, gas injection engine; SSDR refers to slow speed diesel propulsion systems that are equipped with reliquefaction systems.

Secondly, existing steam-propelled membrane LNG carriers could be repurposed as FSRUs or FSUs. FSRUs can increase the supply elasticity via higher regasification capacity, and both FSRUs and FSUs mitigate the impact of LNG disruptions by increasing LNG storage capacity. Over 120 such vessels are currently in operation.

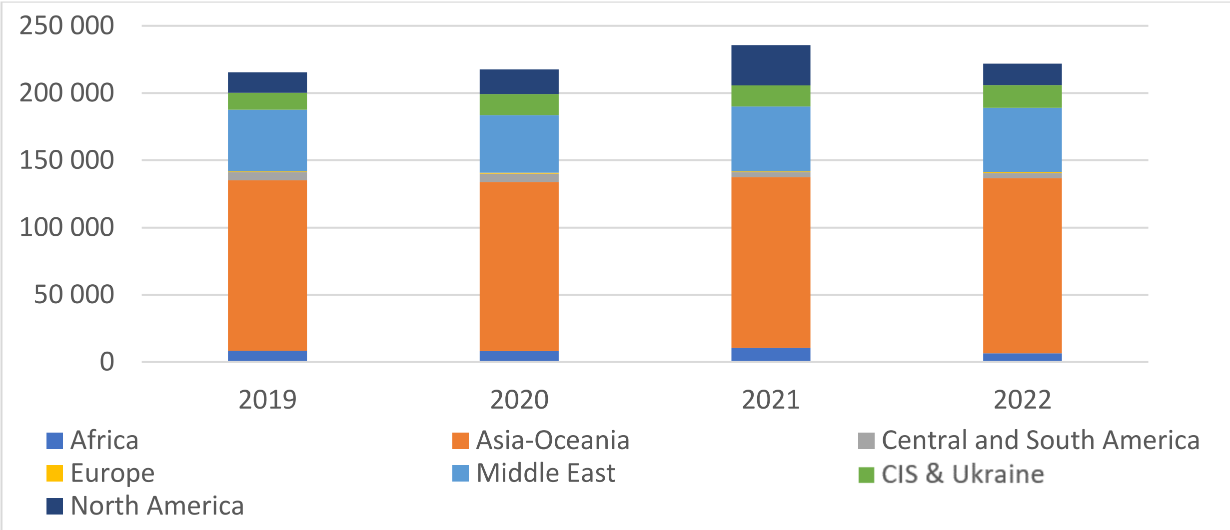
APEC members should consider encouraging shipbuilders to build new LNG carriers and converting older, less-efficient models into useful storage, regasification or producing assets. However, retiring the existing fleet too quickly could reduce LNG shipper flexibility, increase carrier rates and lead to less affordable, less available LNG. Shipbuilders in China; Japan; and Korea will need to make sure to ramp up their LNG carrier building to ensure that incremental shipping capacity offsets the decline from the rapid refurbishment. With about 200 vessels eligible for repurposing and about 200 on the current LNG carrier order book, shipbuilders should be able to avoid a shortage if they schedule appropriately.

3-10 Amassing LNG stockpiles in 2022 and beyond

APEC LNG importers have historically leveraged the flexibility inherent to Europe's natural gas market as a de facto storage facility. During periods of high Asian demand, rising LNG spot prices would signal Europe to shift supply – LNG cargo diversions towards Asia could be offset via a storage drawdown and higher pipeline imports, often from Russia (OIES, 2021). However, the fallout of the Russo-Ukrainian conflict is ending this dynamic. The REPowerEU initiative aims to eliminate Russian gas imports, with a third of the reduction coming from diversifying supply. It also sets annual storage targets of 90% by November and 80% by the end of the calendar year (EC, 2022). Furthermore, Russia is accelerating this substitution via significant export curtailments. The stage is set for Europe to emerge as a large LNG buyer that competes directly with Asia for cargoes.

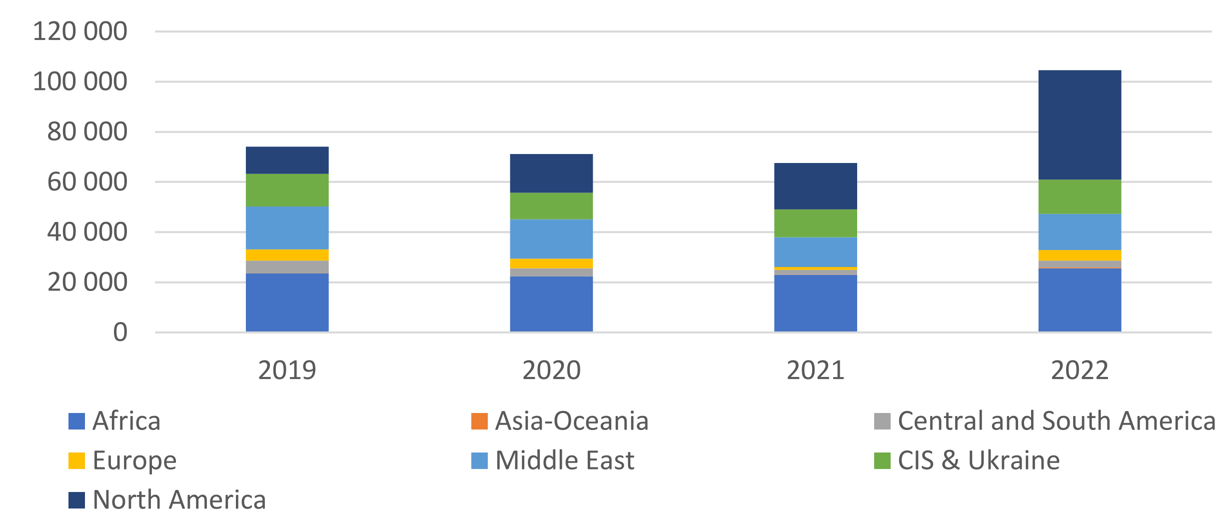
Record LNG spot prices and shifting LNG trade flows illustrate that this competition is already occurring. European imports of LNG are set to grow 48% in 2022, while APEC volumes are down 7.2% (Cedigaz, 2022). North America, the largest growing and most flexible LNG supplier, is providing Europe with 42% of its LNG imports, up from a quarter in 2021 (Figure 3-14). This is occurring at the expense of APEC, which saw North American imports fall from 13% to 7.2% (Figures 3-13 below).

Figure 3-13: APEC annual LNG imports by regional supply source, kilotonnes, 2019 to 2022, kilotonnes



Source: Cedigaz (2022)

Figure 3-14: Europe annual LNG imports by regional supply source, 2019 to 2022, kilotonnes



Source: Cedigaz (2022)

The considerations of three APEC members highlight how government intervention may be required to ensure that LNG storage is adequate to meet their demand requirements during this challenging period. Firstly, Korea is targeting a gas inventory level of 90% in its publicly owned company storage by November; as of August 2022, storage was only at 34% (KESIS, 2022; Bloomberg, 2022c). While LNG importers and wholesalers are required to have nine days of average daily domestic sales cover, utilities are under no such obligation. Thus, there is an argument that the government needs to encourage higher storage levels by imposing stockpiling requirements on all LNG users – not just importers and wholesalers. According to the government's position in February 2020, it has not yet considered the expansion of LNG stockpiling requirements to more companies. However, apart from this issue, the policy direction is towards expanding gas stockpiling for energy security.

In Singapore, the combination of a tight LNG market and pipeline disruptions from Indonesia made it necessary for the EMA to intervene in LNG procurement by setting up a SLF to ensure that gencos have adequate fuel cover. As articulated in Section 4-12, this involved the chartering of an FSRU and an FSU to increase LNG storage and LNG regasification capacity and directly purchasing LNG. Governments may need to engage in such activities to ensure supply in this competitive environment.

Lastly, the Japanese government is reviewing a framework to establish an LNG interchange coordination among utility companies across the economy (Nikkei, 2022b). This will effectively allow LNG storage surpluses in one area of the economy to offset potential deficits in other areas. Additionally, the METI decided to introduce a strategic surplus LNG (SBL) in December 2022 (METI, 2022b). This system is to help private companies secure surplus inventories from 2023 by establishing a fund in Japan Organization for Metals and Energy Security (JOGMEC) as an independent administrative agency.

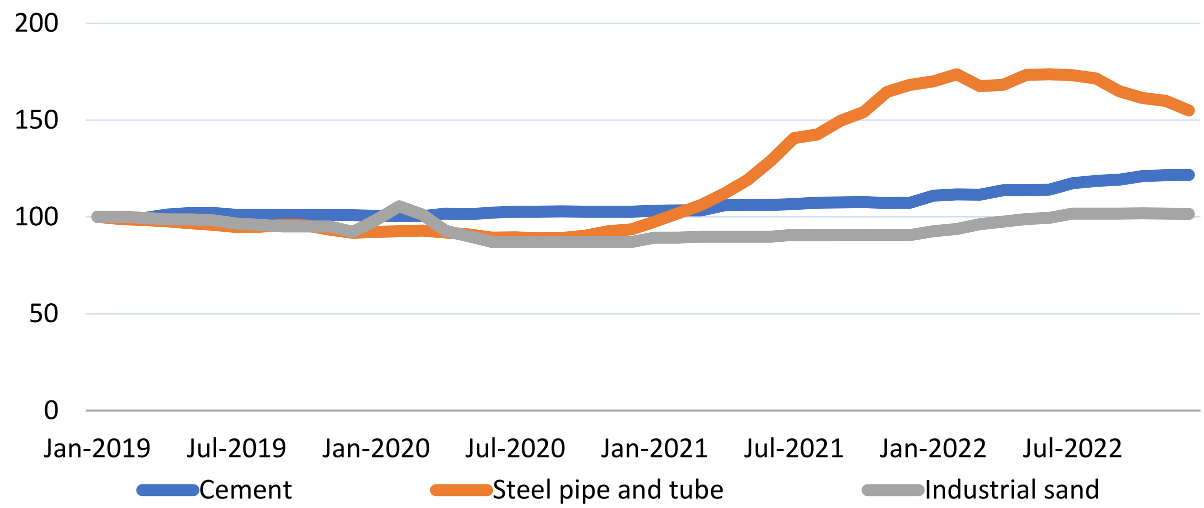
3-11 Alleviating input bottlenecks for the oil and gas service sector

After a decade of volatile and subpar financial performance, soaring hydrocarbon prices are generating record cash flows for oil and gas producers, which they are opting to return to investors via debt payments, dividends and share repurchases (Deloitte, 2022). While output is growing, producers are not responding to price signals as they did over the last decade. Less than half of cash flow is flowing into capital expenditures, down from 60% before the pandemic and about 75% mid-decade. The escalating energy crisis is increasing pressure on producers to divert more cash to growing supply. However, material and labour bottlenecks are impeding service providers from ramping up short-term production.

In the US, oil and gas executives surveyed cite labour shortages, inflation, and supply chain bottlenecks as the key drivers of uncertainty for their firms (Dallas Fed, 2022). Nearly all (94%) respondents blame supply chain issues for harming current operations. Specifically, 83% are experiencing equipment shortages, 89% steel tubular goods shortages, and 65% sand shortages, and almost two-thirds expect these issues to persist for over a year. Furthermore, according to Primary Vision, a tracker of the US frac spread count, both equipment and labour shortages are constraining hydraulic fracturing crews, with the current frac spread fleet[9] operating close to current capacity (MRT, 2022; AOGR, 2022). Production will continue to respond tepidly to market signals if these constraints keep impeding the scheduling of drilling and hydraulic fracturing activity.

[9] Frac spread fleets are the set of equipment and labor used to hydraulic fracture hydrocarbon wells to produce oil, gas and other products from shale, tight and coal-seam gas wells.

Figure 3-15: Monthly producer price index of oil and gas service inputs, 2019 to 2022, 100 = Jan 2019



Source: BLS (2023a, b, c)

Policy can help alleviate material bottlenecks in two ways. First, the US could utilise the Defense Production Act (DPA) to accelerate the production of the material inputs in low supply, such as oil country tubular goods (OCTGs), cement, frac sand and pressure pumps. However, the DPA is not a panacea – policymakers must learn from the recent shortcomings of the DPA and award contracts that are conditional on expanding production capacity for these inputs (PIIE, 2022). Second, it could reduce or eliminate both the steel and OCTG tariffs that are exacerbating the issues relating to both input cost and availability. While other sectors, including construction, are also competing for the low supply of some of these inputs during a pandemic rebound, this only stresses the importance of using targeted government policy to alleviate the bottlenecks.

On the labour side, recent oil price downturns and the pandemic have reduced labour participation in the industry. Brookings Institute credits 15% of the current US labour shortage to long COVID (Brookings, 2022). While the non-supervisor oil and gas extraction labour force is at its highest level since 2016, many oil and gas executives still cite labour shortages as an activity constraint (BLS, 2023d; Dallas Fed, 2022). Service companies are experiencing lower productivity, as new hires at pressure pumping companies learn the new skills of the trade (MRT, 2022). Labour constraints may simply take time to alleviate.

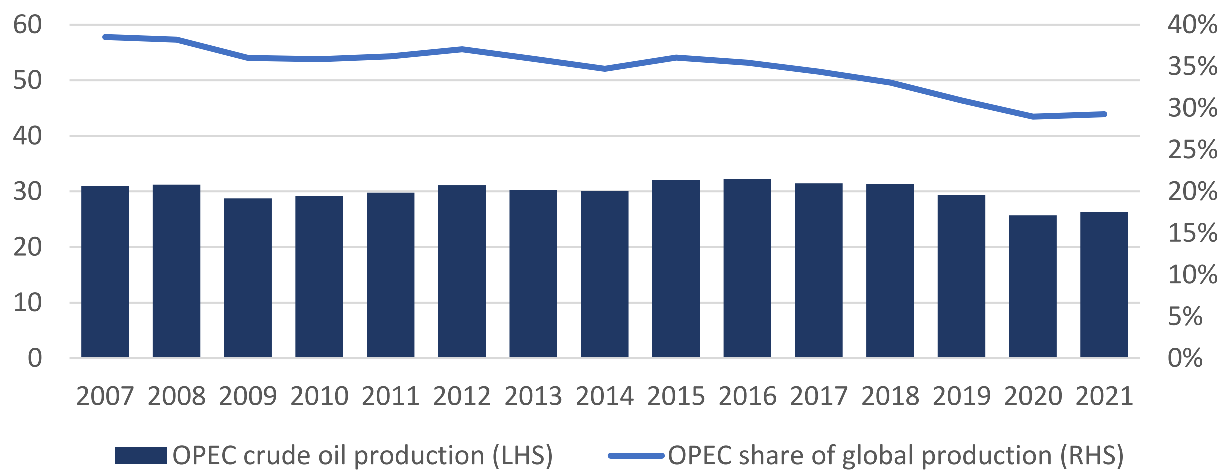
SECTION 4. LONGER-TERM ACTIONS TO IMPROVE ENERGY SECURITY

As argued in Section 3, short-term actions are effective but limited in their ability to address energy security over the longer term. This section highlights several long-term strategies that APEC members are employing or could employ to improve oil and gas security. These include: investments in technology by end-users to improve energy efficiency and incentivise electrification; a reconsideration of long-term energy plans; government intervention to increase availability and affordability; and investing in strategic storage capacity. Before all that, this section first starts with a discussion of the longer-term investment environment that is governing the oil and gas supply during the current crisis.

4-1 Constraints on investment – a case study of oil markets

Oil and gas producers generally fall into one of two categories: price-takers and price-makers. Price-takers generally choose to produce at a level where their marginal cost is equal to the prevailing oil (or gas) price. These producers are effectively free market participants, such as those located in economies like Canada and the US. Price-makers on the other hand, typically prefer to invest in some amount of excess productive capacity and belong to an influential consortium of producers that comprise the Organisation of Petroleum Exporting Countries (OPEC). OPEC uses its market power to maximise profits over and above what it would generate if its members operated as separate free market participants. Its market power derives from the large share of global production (Figure 4-1) and its flexibility to balance the market through its spare capacity (Figure 4-2).

Figure 4-1: OPEC annual crude oil production (million barrels per day; LHS) and share of global oil production (RHS), 2007 to 2021



Source: OPEC (2022)

Before the shale revolution, oil markets were traditionally governed by boom-and-bust commodity cycles; demand and supply would respond to prices dynamically with inherent lags. Typically, this cycle took years, upwards of a decade, to materialise, as it took years to explore and discover new sources of oil supply. Over the past few decades, the OPEC served as a potential wildcard to this dynamic – they utilised their market power (Figure 4-1) and excess production capacity (Figure 4-2) to mitigate or exacerbate the market swings to suit their strategic interests.

Figure 4-2: Middle East monthly surplus crude oil production capacity, including 2023 forecast (million barrels per day)

Source: EIA (2022a)

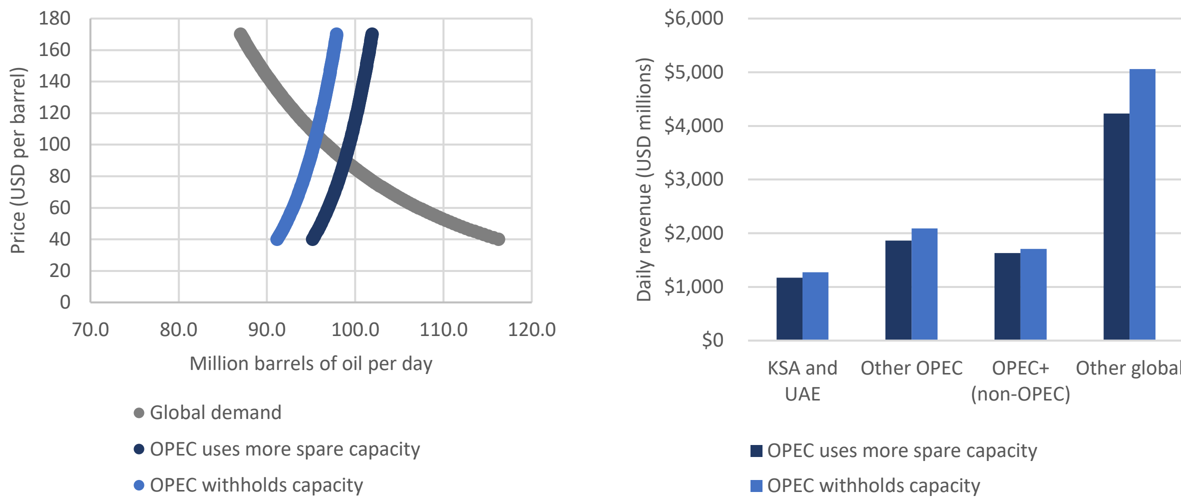
The shale revolution provided a temporary reprieve from this boom-bust dynamic, as producers took months to respond to price signals with barrels that traditionally took large-scale conventional, offshore or oil sand suppliers years to produce. This response lowered price volatility during the 2010s, prompting some to proclaim that the traditional boom-bust cycle had ended. However, the emergence of capital discipline by investors to make up for years of negative cash flow is constraining the supply response, as are input constraints to service providers and concerns about the long-term viability of oil suppliers if importers actively invest in reducing oil use[10].

The change in market dynamics means that OPEC could again become the marginal supplier of oil. This has important implications for how oil and gas markets will respond to shocks, particularly as the region has seen a reduction in its production capacity while demand rebounds from the COVID-19 pandemic. Already, OPEC has been reticent to tap its spare capacity (FT, 2022). This reluctance is partly due to geopolitical manoeuvring, and partly due to its newfound position as the marginal price setter. A simple model shows that it is in OPEC's best interests to withhold supply to maximise its profits, at the expense of global consumers (Figure 4-3)[11].

[10] Some industry participants cite the incorporation of environmental, social and governance (ESG) factors as a source of higher costs for financing capital (Dallas Fed, 2023), but APERC is unable to provide a material estimate of higher capital costs for shale producers from publicly available data.

[11] The model assumes a small amount of short-term responsiveness from non-OPEC producers, and a hypothetical withholding of OPEC spare capacity. Withholding capacity increases revenue for producers in the model.

Figure 4-3: Simple model showing OPEC's decision to withhold spare capacity and the impacts on revenue for oil and gas producers



Source: APERC analysis (2022), OPEC (2022)

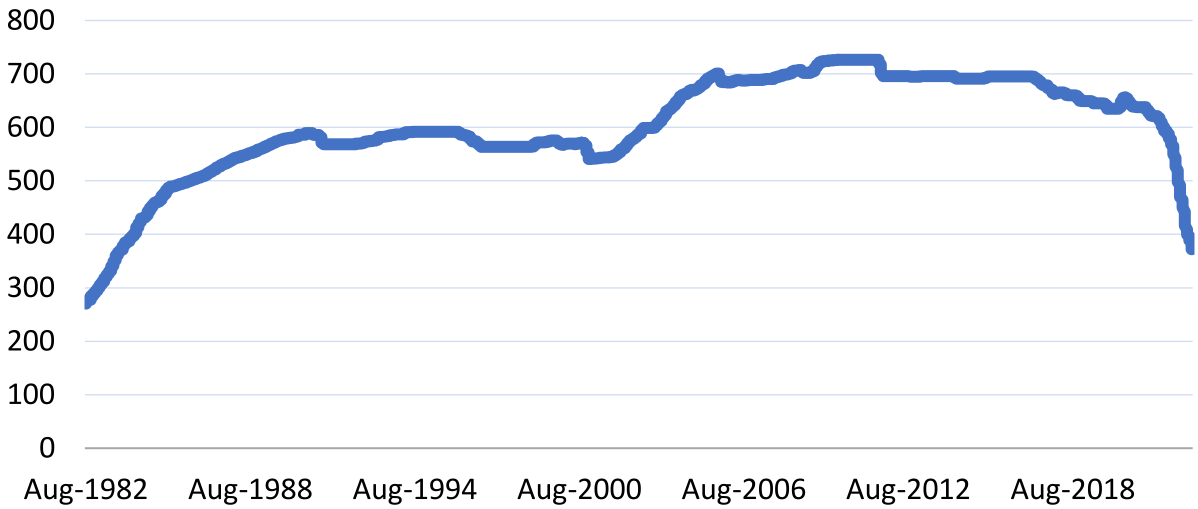
These conditions are favourable for the return of the boom-bust cycle that governed oil markets prior to the shale revolution. Under this environment, it is more likely that conventional supply growth, particularly from national oil companies (NOCs), including those in OPEC, will invest in incremental supply growth ahead of producers governed by capital markets given their fewer investment constraints. If OPEC does rise to the status of marginal supplier, it will have implications for energy security and the affordability of energy during the energy transition. If higher energy costs are the new reality, APEC will need to consider how to strategically mitigate the impacts of supply disruptions going forward.

4-2 Using strategic reserves to reduce the risk of investing in the current APEC oil supply

Uncertainty stemming from price volatility and the potential declining trajectory of demand this decade could be discouraging oil suppliers from diverting cash flows into higher productive capacity despite the high price signals lighting up the oil market. However, APEC members with strategic petroleum reserves (SPRs) could help by offering contractual price guarantees to producers to fill up storage in the future. As Employ America lays out in a recent proposal, the US SPR could utilise its exchange authority to propose exchanges of current crude releases with future purchases that are only sourced from newly drilled wells (Employ America, 2022). Price could also be locked down – to a fixed rate, or a fixed schedule such as the current forward curve.

Reducing future price volatility and guaranteeing a market for future barrels will reduce the risk of investing in projects that are characterised by volatile and uncertain cash flows, particularly in the face of a potential energy transition. The US Department of Energy has already proposed a framework to do something like this to refill the SPR (DOE, 2022a). Other APEC members with SPRs, namely Japan and Korea, could also perform similar actions.

Figure 4-4: US weekly ending stocks of crude oil in SPR stocks, million barrels, 1982 to 2022



Source: EIA (2023)

This strategy does present some challenges. Mainly, replenishing SPRs with light crude from shale and tight resources may be suboptimal due to the configuration of refineries to process sour barrels. This is certainly true of American refineries. In Japan, over 90% of imports come from sour crude assays (PAJ, 2022). The release composition from the SPR this year is predominantly sour, shifting the US SPR composition from a 60/40 sour/sweet split in 2021 to a 49/51 split in August 2022 (DOE, 2022b). Because of this, filling up the US SPR with lighter crude from shale and tight resources may not be strategically optimal. It may be wise to replace outflows with similarly sour barrels.

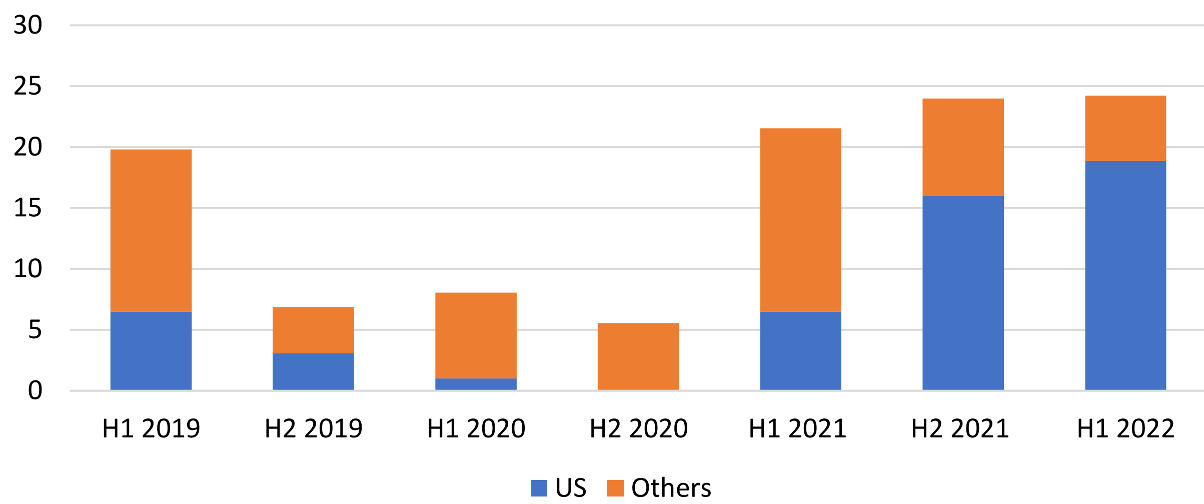
There may be some role for sour-producing APEC members, namely Canada and Mexico, to play in replenishing inventory. There is some history of the SPR storing such heavy, sour barrels. Prior to the latest release, 7% of the Bayo Choctaw storage site in Louisiana held Maya crude – a heavy-sour Mexican blend of similar quality to Canada's Western Canadian Select (WCS) benchmark. Since 2004, Mexico's oil production has been falling due to natural declines in its largest oilfields and a lack of investment in upstream activities. While it may be difficult to significantly increase Mexico's oil supplies in the current context, incremental gains in Canadian oil sand production could help replenish sour outflows. Leveraging such a heavy crude source may also allow for further blending of the light type of oil from the US.

The current and proposed usage of SPRs may be in conflict with their original purpose. This changed use may be justifiable, though it compromises the stockpile should an emergency arise that disrupts supply further.

4-3 Impacts of infrastructure constraints on short-term supply elasticity

As of 2022, the US has signed LNG supply agreements with various categories of consumers, amounting to almost 35 Mtpa from July 2021 to June 2022, a more than five-fold increase from the previous period (Figure 4-5). The LNG supply commitment will replace Russian gas to Europe as it looks to diversify supplies away from Russia and meet growing demand in Asia, especially from China, Korea and southeast Asia.

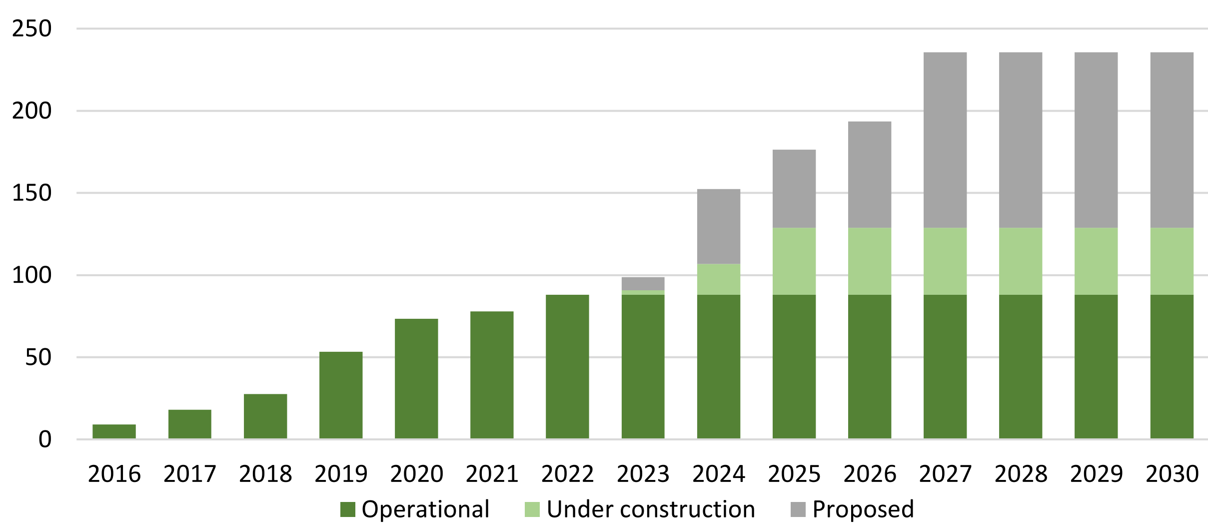
Figure 4-5: Global LNG Contract Activity, 2019 - H1 2022, million tonnes



Source: GIIGNL (2022)

The increase in liquefaction capacity will further support the US LNG supply commitment. High natural gas prices since mid-2021 have increased the appetite for upstream investment, especially in building new LNG export facilities or expanding existing LNG export facilities. If the projects currently under construction and approved by relevant permitting authorities are built on schedule, total US liquefaction capacity will increase by 168% to 236 Mtpa in 2030, compared to 88 Mtpa in 2022 (Figure 4-6).

Figure 4-6: LNG exports terminal capacity in the US, 2016-2030, million tonnes per annum

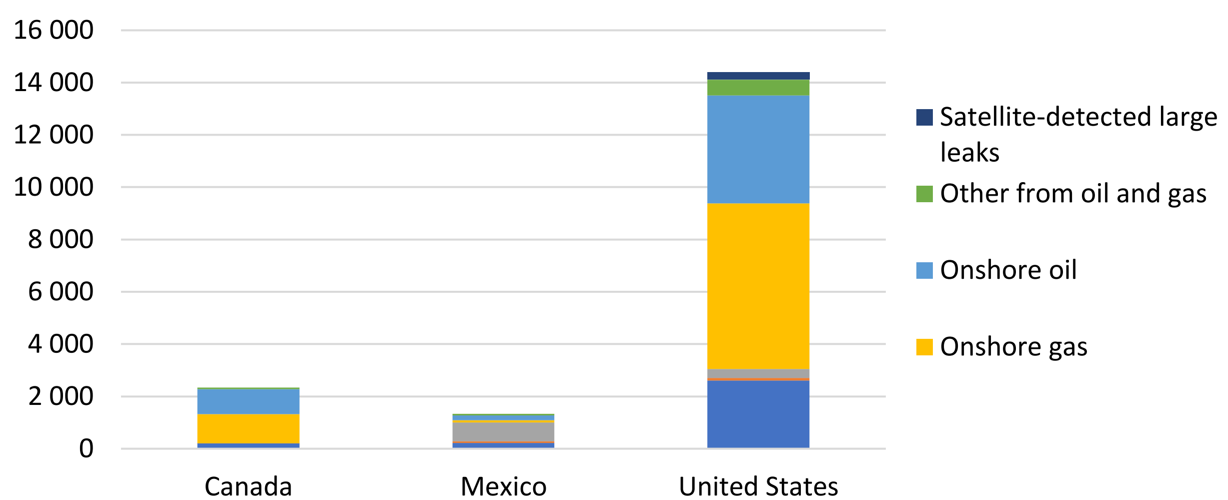


Source: EIA (2022b)

With domestic production surpassing 100 bcf/d this year, the US should have the upstream resources to meet its export commitments for the year. However, midstream constraints to the new build export facilities on the Gulf Coast may limit future supply. Of the nearly 20 bcf/d of projects approved by the Federal Energy Regulatory Commission (FERC), only 1.7 bcf/d of projects are under construction. Many of these projects are facing permission delays. A reduction in permit processing times is crucial to ensure the timely completion of natural gas pipeline projects to transport incremental gas to the US Gulf Coast. Other than FERC, project owners need to secure approvals or permits from various federal agencies or bureaus as required by Natural Gas Act and to comply with other laws, including the National Environmental Policy Act, the Clean Water Act and the Clean Air Act. These delays could disrupt short-term gas supplies, limiting the ability of the US to increase global LNG supply and to meet rising APEC and global LNG demand this decade.

There are other ways to increase gas supply. A concerted effort among policymakers and industry players will also improve the security of the natural gas supply in the short term. One of the measures that policymakers and industry players could take to boost gas supplies is reducing methane emissions across the gas supply chain. Canada; Mexico; and the US emitted about 18 billion tonnes of methane from gas and oil operations in 2021 (Figure 4-7), which translated to about 812 bcf of natural gas that could be available to the North American market. Capturing these emissions could increase the gas supply in short order and reduce the GHG impact of the North American upstream gas supply.

Figure 4-7: North America methane emission by oil and gas operations, 2021, million tonnes



Source: IEA (2022a)

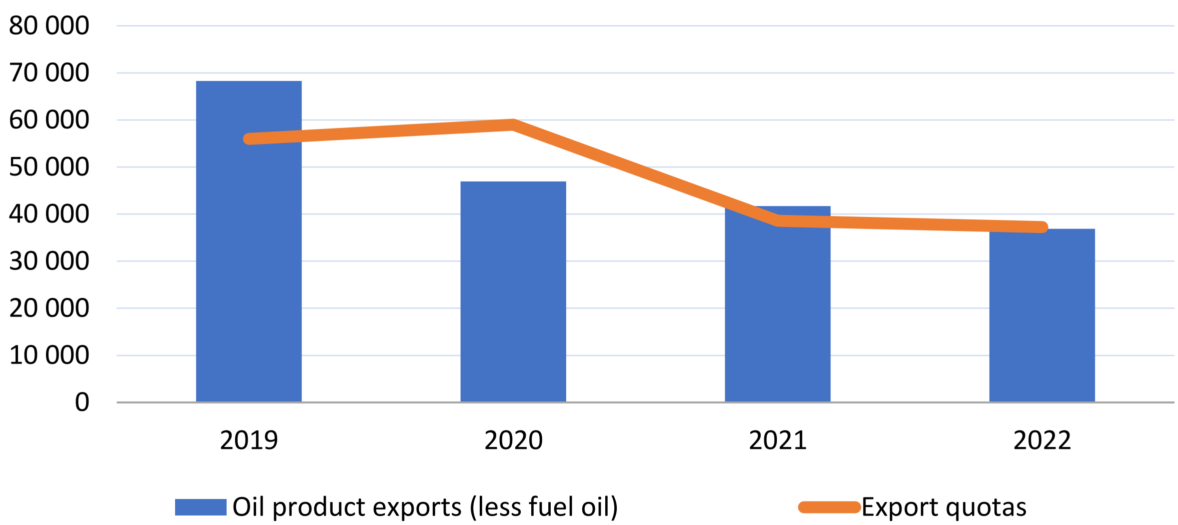
Another action that could fill the supply gap would be to increase Canadian natural gas exports to the US via existing pipelines. This would increase the utilisation of existing cross-border pipelines after the exports drop due to booming shale gas production in the US. Other measures to increase short-term supply elasticity in North America, especially in the US, were discussed in Sections 4-1 and 3-11.

4-4 The evolution of China's oil product export quotas

China is a major player in the global refining space. It possesses the world's second-largest refinery throughput and was responsible for over half the growth in refining capacity in the past decade and over three-quarters of the growth in oil product use. China's global export share of oil products doubled from 2.6% in 2011 to 5.3% in 2020 (BP, 2022).

However, a shift in its refinery export quotas policy has limited China's role as a supplier of oil products over the past two years. China reduced its export quotas for oil products[12] by over a third in 2021, and in 2022, the quotas were reduced by an additional 42% (Reuters, 2020a, 2022a; S&P Global, 2022). Excluding fuel oil, China's oil product exports fell 11% in 2021 and were down over half from 2020 volumes (EGEDA, 2022a). Lower refinery throughput, down 5.3% in 2021, only explains part of this fall in export quotas, suggesting that some output is being prioritised for domestic use – either for storage or immediate consumption. Whatever the reason, China's reduced exports could meet over two percent of global oil product supply at a time when global supply is tight.

Figure 4-8: China's annual product exports and quotas (thousand tonnes), 2019 to 2022



Source: EGEDA (2022a), Reuters (2020a, 2020b, 2022a), S&P Global (2022)

One rationale for the quotas is that China was attempting to bolster its energy security by prioritising domestic consumption. China's recent removal of pandemic restrictions has led to a rebound in the movement of people and goods and their associated demand for oil products. The rebound in China's exports at the end of 2022 suggests that this stockpiling was temporary and lower exports will not persist now that China is returning to normality.

But beyond surety of supply considerations, China may have enacted the low exports quota to align its refinery policies with its energy transition objectives (Carbon Brief, 2022a). Refining and petrochemicals are currently China's fourth highest-emitting sectors. With oil product consumption set to peak by 2035,

[12] This export quota excludes quotas for low sulfur fuel oil (LSFO), which have increased over the past two years.

a decade after refining capacity, weaning refineries off export markets ahead of schedule would curb emissions and help China achieve an emission peak before 2030 (Government of China, 2022). If this happens, the quota reduction could be a permanent strategy, and the recent rebound in exports at the end of 2022 may prove illusory.

Amidst this uncertainty, APEC members should take measures to increase domestic product supply and reduce their dependence on a tightening global product market. One way to do this is by extending the life of existing refineries that are set to retire. Members could make biorefinery conversions conditional on offsetting the entire product capacity lost in the conversion – currently, biorefineries are only replacing a sixth to a third of the refinery capacity they are retiring.

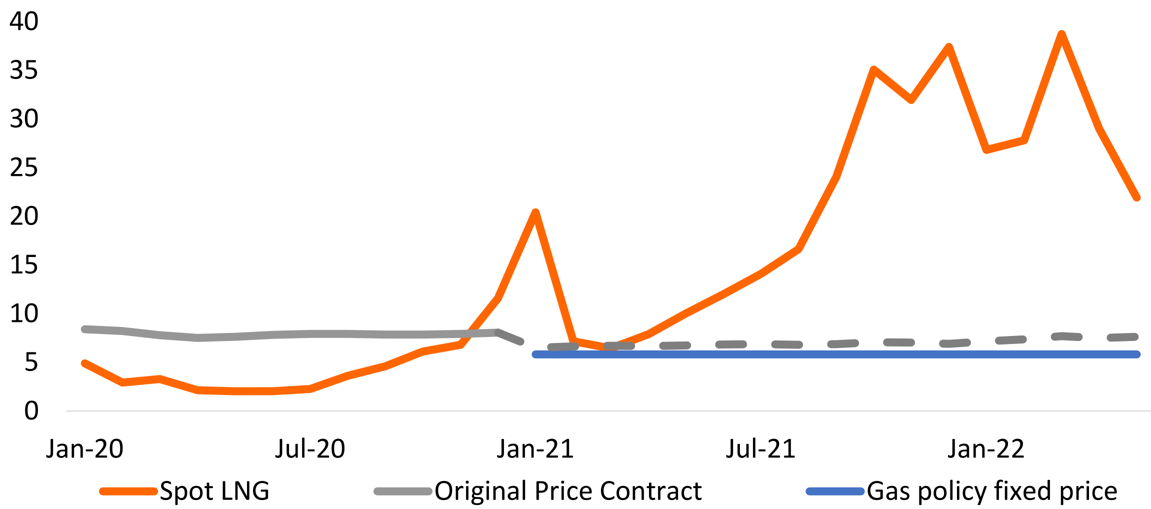
However, many refineries close for sound reasons. Several closures over the past two years were due to extraordinary events, such as irreparable damage from conflagrations and hurricanes. With product crack spreads flirting with record levels, it will be enticing for remaining refineries to capitalise on favourable export market conditions, and even extend their operating life, if feasible.

4-5 Domestic fixed gas pricing policy in Indonesia

In the face of high and volatile global gas prices, some energy producers are introducing policies to prioritise availability and affordability for the domestic market to ensure energy security and promote a robust recovery from the COVID-19 pandemic. This section examines Indonesian price controls to highlight the trade-offs of such policies.

Indonesia's domestic production fulfils almost all its domestic gas use, but half of it finds its way to the export market (MEMR, 2022a; EGEDA, 2022b). Implemented in 2020, the fixed gas price policy prioritises domestic users over export markets and sets a fixed price of about USD6 per MMBtu for select Indonesian industries and its power sector (blue line in Figure 4-9). Before the policy, domestic gas prices were generally indexed to crude oil via the Indonesia Crude Price (ICP; grey line in Figure 4-9). Consequently, gas prices and users in Indonesia are currently spared from the fluctuation of global energy prices; while the ICP has doubled over the past two years, gas prices have remained at the fixed rate (MEMR, 2001; 2021a; 2022b).

Figure 4-9: Indonesia domestic gas price and global spot LNG prices (USD per MMBtu)



Source: MEMR (2021a), IMF (2022), APERC Analysis

The government maintains the low fixed gas price for the domestic market by lowering government revenues under existing production-sharing contracts. Policymakers do this to insulate the domestic economy from the global shock of high gas prices. This has reduced the need for electricity subsidies and acts as a boon to industrial output, employment, and economic growth (MEMR, 2020a). Indonesia can do this because gas is predominantly from domestic sources. Contrast this to fuel oil, which is primarily sourced from imports. Government subsidies kept fuel oil prices low through August 2022. However, in September 2022, Indonesia increased the fuel price by an average of 30% due to the subsidy burden tripling to IDR502 trillion (USD34 billion) in 2022 (MEMR, 2022c; VOA, 2022).

Prior to its implementation, a cost-benefit analysis of the fixed gas policy estimated that the benefits of the energy subsidies – from higher industrial output and lower electricity subsidies – would outweigh forgone government revenues from 2020 to 2024 (MEMR, 2020b). However, current price levels are causing officials to revisit these calculations. SKK Migas reports that in 2021, the fixed price policy reduced government revenues by around USD1.2 billion; this number is likely to increase further (Bisnis, 2022a). On the other hand, the current gas price policy provides important support for the post-COVID recovery of the industry sector. The industry production utilisation has finally reached 75%, and increasing the gas price could set back the industrial output recovery, increase unemployment and reduce economic growth (Bisnis, 2022b).

As the government reviews the implementation of the domestic gas price policy, a careful evaluation of current economic post-COVID recovery conditions and the global energy price is crucial for balancing the possible decrease in the government revenue and expected multiplier effect on the economy and in energy security. While connecting the Indonesian gas supply to global markets would increase global LNG supply, and in turn, energy security for the highest bidder of LNG cargoes, it may make little sense to impose gas insecurity on Indonesia's own economy in return for higher government revenues.

4-6 Energy security in producer economies: The Australian experience

The energy market tumult brought on by the Russia-Ukraine conflict has been transmitted all the way to Australia's east coast, with meteoric price rises in both natural gas and electricity. But on the west coast of Australia, energy prices have remained relatively stable. This contrasting experience is largely due to divergent natural gas and energy policies.

As of 2021, Australia was the seventh largest global producer of natural gas, with almost three-quarters of its production exported via LNG. Expanding volumes of gas exports were enough for Australia to surpass Qatar as the largest global LNG exporter in 2021 (IEA, 2022b).

Almost two-thirds of Australia's natural gas production is in Western Australia. Exports are the driving force for Western Australian natural gas production, though to receive approval, natural gas export projects are required to make approximately 15% of their production available to domestic consumers. This certainty of supply delivers Western consumers a dependable quantity of natural gas that is little influenced by international market developments. On the east coast, where most Australians live, domestic supply certainty is not as assured.

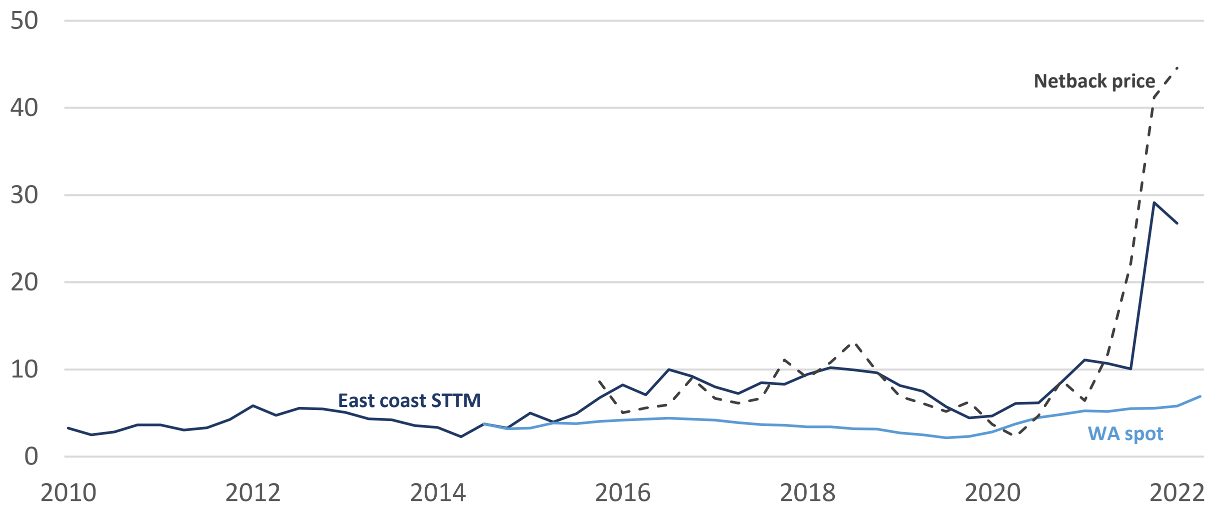
Rapidly expanding appetites for natural gas in Asia, particularly following the Fukushima nuclear reactor disaster in 2011, spurred the development of LNG-exporting facilities out of Gladstone, Queensland in the early 2010s. Gorgon LNG (GLNG), Asia-Pacific LNG (APLNG), and Queensland Curtis LNG (QCLNG) committed to building two LNG trains each, with their supply dependent on the development of unconventional coal seam gas out of Queensland's Surat and Bowen basins.

A quarter of a century after the first LNG cargo was shipped from Western Australia, the first east coast LNG cargo was shipped in late 2014. It represented the culmination of multiple years of project development and a combined investment of AUD60 billion. Before the development of this export capacity, east coast consumption of natural gas mostly flowed from conventional gas sources from southern Australia, with wholesale prices averaging AUD4 per gigajoule (GJ).

At the same time as the east coast LNG exporters began to ship their cargoes to Asia, production from conventional sources in the southern regions of Australia began to decline, which led to a tightening in the domestic market for natural gas.

Part of this tightening was due to multiple state-based moratoriums on natural gas exploration in the southern states of Australia. The tightness was exacerbated further because there was no requirement for the east coast LNG exporters to cordon off a portion of their production for domestic consumers, as is the case on the west coast. Additionally, production from the Surat and Bowen basins has been less than anticipated, leaving less gas available for LNG exporters to liquefy than was planned. Low production from these basins has turned LNG exporters into the marginal buyer of conventional gas supply from the domestic market, linking domestic east coast natural gas prices to prices in Asia. Wholesale domestic natural gas prices began to increase in 2016 due to this relationship, with average spot prices hitting historic levels, as shown in Figure 4-10.

Figure 4-10: Australian east coast short-term trading market for natural gas, JKM netback benchmark, and comparison to Western Australia spot prices, AUD per GJ



Source: AEMO (2023) and ACCC (2023)

Long-term contracts are shielding many domestic consumers from these large spot price movements. However, the price pressures have meant that newly signed contracts are now shorter and more expensive.

The Australian Domestic Gas Security Mechanism (ADGSM) was instituted as an initial response to the gas price spikes, though the mechanism does not provide the same amount of supply certainty as the domestic reservation requirement on the west coast. The federal government also instituted a Heads of Agreement with the east coast LNG exporters to attempt to ensure that domestic supply was prioritised ahead of international buyers, based on certain considerations.

This stabilised domestic prices at an average wholesale price of AUD8 per GJ from 2016 to 2019. However, the ADGSM and Heads of Agreement do not guarantee price stability for east coast consumers. As a result of the Russia-Ukraine conflict, natural gas prices have increased to unprecedented levels on the east coast, with wholesale spot prices increasing above AUD40 per GJ during the southern hemisphere winter, which is 10 times higher than the historic lows. Electricity prices have also moved higher due to the role that gas-fired generation plays as a marginal electricity supplier during peak demand periods. Higher-than-expected outages from coal-fired facilities have also increased reliance on gas generation.

In contrast, Australia's domestic west coast market was largely unaffected in 2022, with the domestic reservation policy providing more robust insulation than the measures implemented in the east. This shielding comes at the expense of international consumers, with less available international supply, and diminished revenue for the exporters.

Calls for domestic reservation have been strongly resisted by the east coast LNG exporters. However, the Australian Competition and Consumer Commission (ACCC), which monitors Australia's east coast gas market, has recently recommended a reservation policy. ACCC cites the fact that the east coast LNG exporters have extracted more gas from the east coast market than they have provided (via their Surat and Bowen basin coal-seam gas production) as a justification for the recommendation (ACCC, 2022).

For the end of July, and most of August 2022, one of APLNG's trains was offline for maintenance, which freed up gas from the Surat and Bowen basins for the domestic market. The worst of the price spikes (for gas and electricity) was effectively staved off during this maintenance.

In response to the international energy market turmoil, the Australian Government instituted a temporary wholesale price cap of AUD12 per GJ for the east coast in December 2022. The price cap will be in place for 12 months, and together with the Heads of Agreement, will ensure that sufficient gas supply is made available for east coast consumers at a price beneath international benchmarks. This action has served to provide some respite to Australia's current spiking levels of inflation.

The global energy market disruptions taking place in 2022 have created a tale of two Australias in terms of reliable and affordable energy. The west has been able to sail through the crisis with a sufficient supply of gas at prices that are largely disconnected from international movements. In contrast, consumers on the east coast are facing much higher energy costs and difficulty in securing supply. The wholesale price cap intervention is intended to be short-term. It aligns with other such interventions happening throughout the world, such as the imposition of a 25% windfall tax on British oil and gas producers by the UK government in response to the Russia-Ukraine conflict. The temporary nature of Australia's intervention means that east coast demand for natural gas is likely to continue to decline through the medium term and longer. Incentivising an appropriate amount of additional supply is a challenge in the context of falling demand and is made even more challenging with state-based exploration moratoriums still in place.

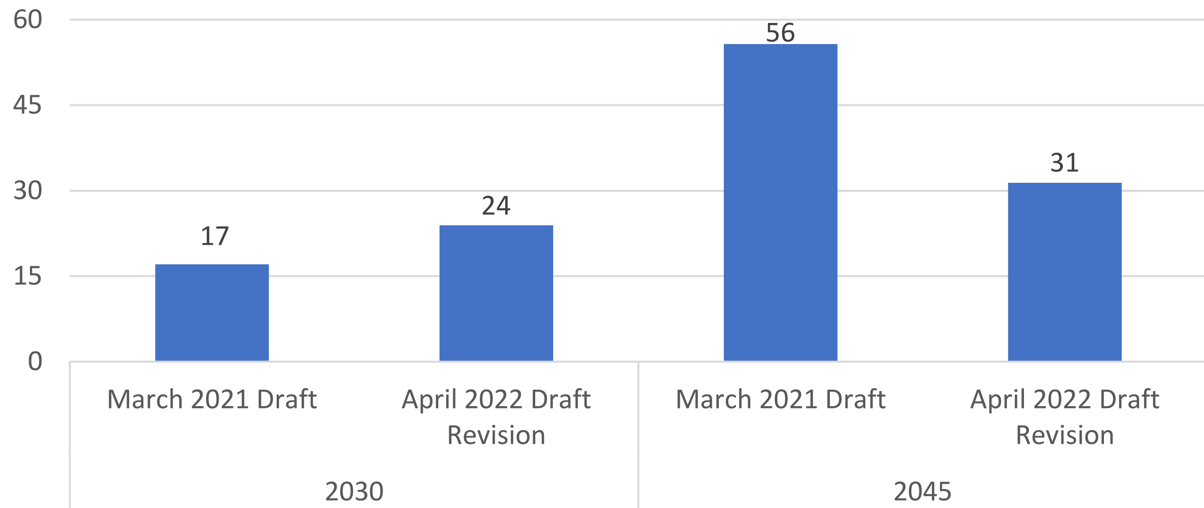
4-7 The long-term impact of high LNG prices on Viet Nam's power plan

Viet Nam will rely on a large volume of LNG imports to fuel its rapidly expanding economy and reduce the carbon intensity of its fuel mix over the coming decades. The government began this ambition with the adoption of Resolution 55 NQ-TW, which focuses on the rapid development of LNG-fired power plants. Viet Nam will require LNG imports of 8 bcm by 2030 and 15 bcm by 2045 to meet its future electricity generation requirements (Politburo, 2020).

The Hai Linh project is the first LNG import terminal in Viet Nam. The 1st stage of the project was completed in 2020. However, it still must undergo testing and commissioning. Meanwhile, the Thi Vai LNG port, with an annual capacity of one Mtpa, is expected to start operating in 2023. In addition, several LNG-fired power plants are scheduled for construction, such as the Nhon Trach 3 and Nhon Trach 4 projects (1.8 GW), the Son My 1 and 2 gas power projects (4.5 GW), and the Bac Lieu gas power project (3.2 GW). In addition, the revised Power Plan VII includes several approved LNG power projects, including the Long Son and Ca Na, which are currently selecting investors for implementation (The Diplomat, 2021; The Leader, 2022).

Viet Nam is reconsidering the draft Power Development Plan (PDP8) in compliance with the net-zero commitment at COP 26. Under the base-case scenario of the recent draft (Figure 4-11), the new LNG power capacity would approach 24 GW by 2030 and 31 GW by 2045 (Viet Nam Energy, 2022a). While the revision is opting for high LNG usage in the shorter term (2030), usage is significantly lower in the longer term (2045). This suggests that volatile and skyrocketing LNG prices are challenging Viet Nam's power plans as it balances its energy plans with its carbon-neutral ambitions (MOIT, 2022; Energy Intelligence, 2022).

Figure 4-11 Planned installed capacity from new LNG-fired power plants, GW



Source: Viet Nam Energy (2022a), APERC Analysis

Markets are challenging Viet Nam's power plans in several ways. Firstly, volatile prices are making it difficult to settle on long-term contracts between investors in the new LNG power plants and Electricity Vietnam (EVN), the electrical utility that will purchase the power from the LNG-fired plants. Because all approved LNG-fired power plants are independent power producers (IPP), investors must negotiate with state utilities for power purchase agreements (PPA). When calculating the electricity price in 2020, the imported LNG price was about USD12 per MMBtu. Prices more-than-doubled throughout 2021 to around USD25 per MMBtu and hit a high of USD32 per MMBtu in July 2022. LNG investors will incur significant losses at these prices. LNG cannot flow until the investors and EVN renegotiate a PPA that suits the new, volatile reality of the global LNG market (Viet Nam Energy, 2022b).

Secondly, the start-up of construction is conditional on the signing of PPAs. If PPA development between investors and authorities is delayed, the construction of the project infrastructure will also be delayed. In this case, the LNG development projects are forecast to take longer than expected (VN Express, 2022).

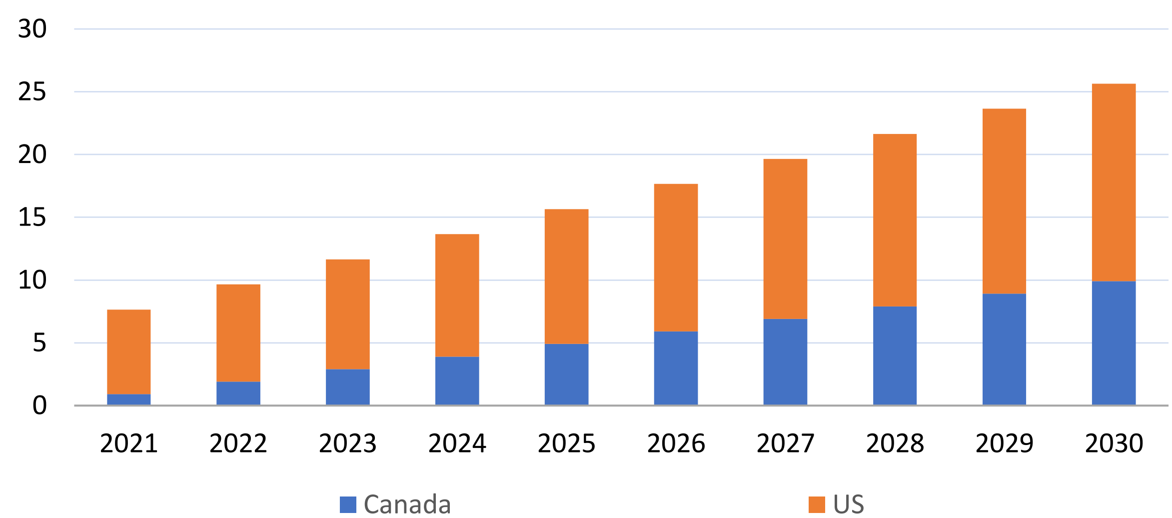
Finally, as a nascent LNG buyer in the international market, long-term LNG purchasing contracts are very challenging due to the competition between LNG customers in Asia and Europe, particularly in the context of price volatility. However, locking in low, stable LNG prices is a prerequisite to securing the PPAs necessary to support the power plan that Viet Nam wants to use to fuel its growing economy. This may require innovative methods of financing, like partnering with other APEC members to secure long-term contracts collectively. The longer that Viet Nam is unable to secure a contract, the more likely it is that it will have to reduce the role of LNG in its power mix.

4-8 The role of heat pump adoption in reducing gas demand

The installation of heat pumps is accelerating around the world, with several APEC members playing a leading part. Four of the top-six markets for air-sourced heat pump (ASHP) sales in the world are APEC members, namely Canada; China; Japan; and the US. Growth hit nearly 25% in Canada, 10% in China, and 15% in the US. While heat pumps remain a fraction of the total stock of heating systems, it is worth examining how their adoption can reduce demand during a gas supply crisis.

During the heating months, heat pumps use electricity to extract the energy from outside air and transfer it inside as heat. This principle of heat exchange goes the other way during cooling months, with the pump moving heat outside, like a refrigerator. However, this process is very efficient: heat pumps can generate around two to three units of heat for every unit of electricity they use. Put another way, they can be 190% to 300% efficient, which is much higher than natural gas boilers, which typically operate at an efficiency of around 85%. Even if the electricity sourcing the heat pump is generated completely from natural gas, replacing a gas-fired boiler with a heat pump can reduce the gas use by up to a third. The chart below illustrates that maintaining current ASHP rates in Canada and the US could reduce gas use by over 15 bcm by 2025 and by over 25 bcm by 2030. This is the equivalent of 100 typical LNG cargoes by 2025, and 160 by 2030.

Figure 4-12: Demand reduction via air-source heat pump adoption in Canada and the US (bcm)[13]



Source: OEE (2022a, 2022b, 2022c), Nature (2022), Carbon Brief (2022b), APERC analysis

This example shows how APEC members can increase gas supply by maintaining their current high pace of heat pump adoption. This will require sustaining policy support, via subsidies, and both newbuild and retrofit building standards and appliance standards that target both manufacturing and performance.

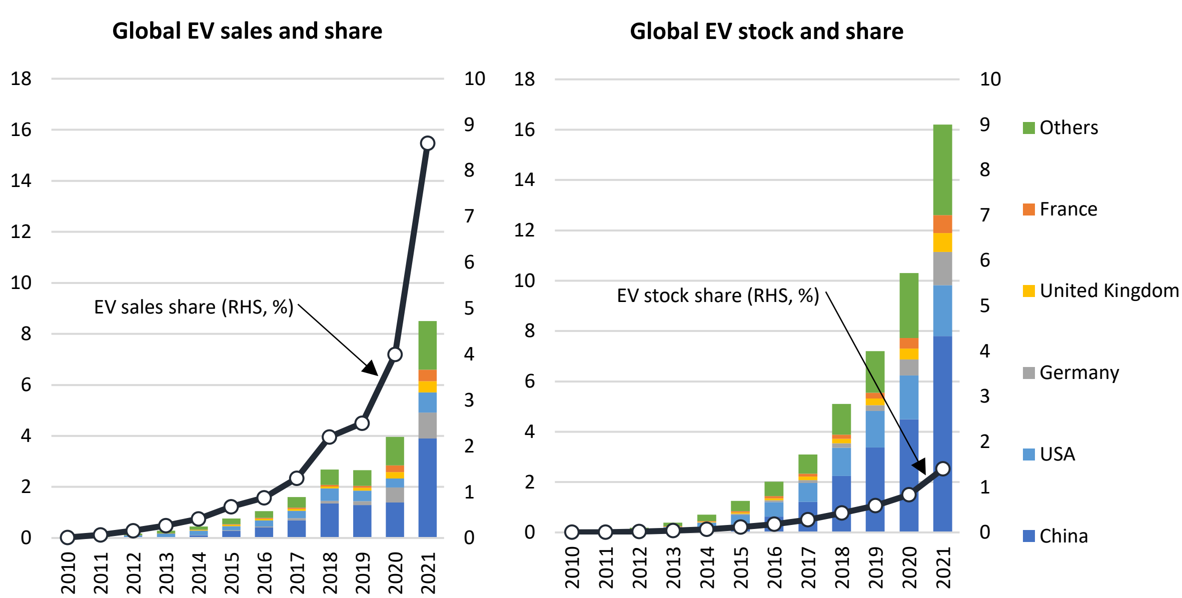
[13] This analysis assumes: that all air-sourced heat pump sales are installed into residential buildings during the year of sale; that each installation occurs in a building that demands an annual average amount of heating from a typical 85% natural gas boiler; that the heat pump performance yields an efficiency rate of 300%; that gas used for power generation is 15% in Canada and 37% in the US; and that line losses for electricity are 8%.

Banning fossil fuel appliance adoption, as several cities are doing in the US, will probably support adoption at higher rates than illustrated here. While electrification brings new concerns about grid reliability, the high efficiency of heat pumps will reduce the aggregate gas requirements across APEC, thereby improving gas security.

4-9 Adopting electric vehicles (EVs) to reduce oil demand

Targeting the electrification of transport through the adoption of EVs is seen as a way of addressing all three components of the energy trilemma. Firstly, on an immediate and lifecycle basis, EVs emit less than their internal combustion engine (ICE) counterparts (IEA, 2023). Secondly, electrifying transport improves oil security by reducing oil import dependence and diversifying the fuel requirements across the multiple fuel sources required to generate the power requirements for the vehicle fleet. Furthermore, with EVs being two to four times more efficient than ICE models, their adoption will result in an overall reduction in energy supply requirements (CER, 2021). Thirdly, due to the lower cost of power and the higher efficiency of EV models, adoption can improve affordability for those that can afford the higher capital outlay. However, it takes time for sales to replace the stock of existing vehicles. Even though the global sales share of EVs is increasing, the stock share is still below 2% (see Figure 4-13). Even China, with EV sales of 16% in 2021, only had an EV stock share of 3% in that year.

Figure 4-13: Global EV sales (left chart) and EV stock (right chart) by region, million vehicles (left axis) and global share of vehicle market (right axis, %)



Note: EV includes BEV (battery electric vehicles) and PHEV (plug-in hybrid electric vehicles)

Source: IEA (2022c, 2022d)

Sales shares are rising throughout APEC as many members use policy to encourage EV purchases and phase-out ICE vehicle sales. For example, China is promoting the development of charging infrastructure (China Daily, 2022; Government of China, 2020); Indonesia is exempting sales taxes on fuel cells and battery EVs with the goal of hitting a 100% share of electric sales for passenger vehicles and motorcycles by 2050 (MEMR, 2021b; Reuters 2021); Japan is providing both subsidies and tax incentives to support a phase-out of ICE vehicles sales by 2035 (METI, 2021, 2022; JAMA, 2023); Thailand is using promoting the development of charging infrastructure and domestic EV production capacity, and using various sales subsidies to hit a 30% sales target by 2030 for motorcycles and automobiles (Nikkei, 2022; Dezan Shira & Associates, 2022). Federally, the US is targeting a 50% sales share by 2030, and some states are aiming for a phase-out of ICE vehicles by 2035 (White House, 2021; Reuters, 2022b). This is not an exhaustive list. Many APEC members are conducting similar initiatives (IEA, 2022e).

However, an increasing stock share may require further support. For example, policies could reduce the ICE vehicle stock by paying consumers to scrap older, inefficient ICE models. Registration incentives – such as providing discounts to EVs and levies for ICE vehicles – could also incentivise scrappage. However, doing so could reduce the affordability of energy in general.

Going forward, automakers and battery suppliers must prepare to satisfy future EV demand. This will go beyond sales and manufacturing targets – such as Ford's goal of one-third of its production volume being EV in 2026, rising to half by 2030 – but towards the establishment of a stable and reliable supply of critical minerals and materials (Ford, 2022). The ability of EVs to address energy security during the energy transition will depend on this. Furthermore, APEC members will need to balance adoption with electricity planning to ensure that grid reliability is maintained without sacrificing energy affordability.

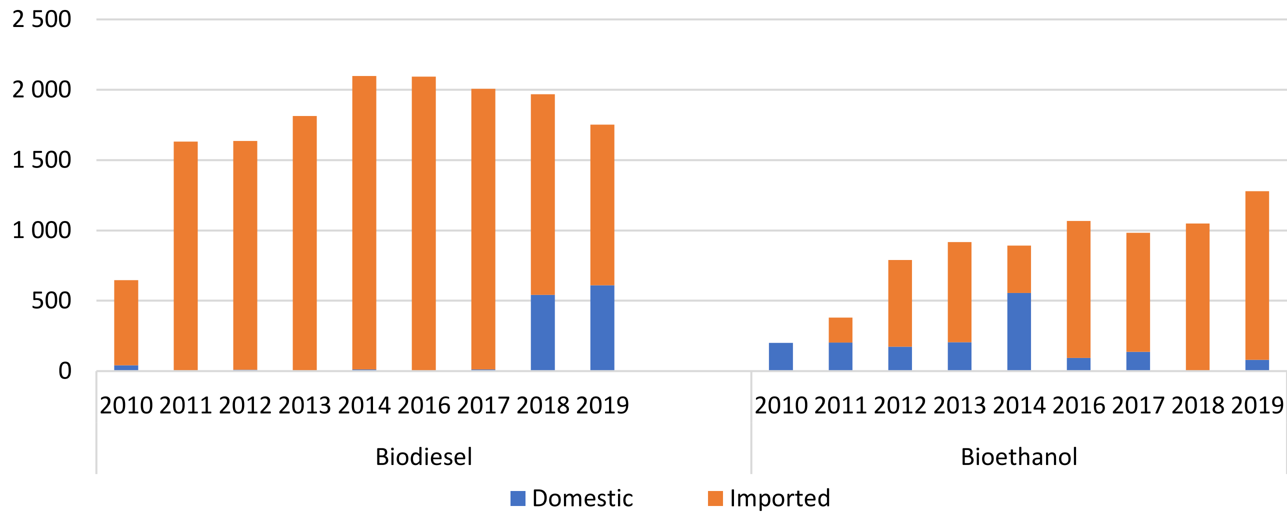
4-10 Do biofuel mandates increase energy security? A Peru case study

Biofuels are considered as alternative fuels for transportation that can reduce emissions and improve energy security by reducing an economy's dependence on oil imports. However, if policies are only able to foster demand growth and fail to generate domestic biofuel supply, the economy could simply be shifting its energy security risks from one liquid fuel to another.

In 2007, Peru approved laws that regulate the commercialisation of biofuels and established mandatory biofuel blends in gasoline and diesel that were to be sold in the main areas of Peru. Gasohol, a blend of gasoline with 7.8% bioethanol, and Diesel B5, a blend of diesel with 5% biodiesel, became the main fuels used in transport. The goal was to promote the development of a biofuel market with the intention of diversifying the fuel market and incentivising the growth of the agricultural and agro-industrial sectors.

Despite generating biofuel demand, the share of domestically produced biofuel failed to materialise (Figure 4-14). With little domestic supply available, the mandatory biofuel blend policy forced Peru to rely on imports from mainly the US (bioethanol and biodiesel) and Spain (biodiesel). Because most biofuels are imported, in this case, they do not contribute to energy independence.

Figure 4-14 Supply of biofuel in Peru by source, 2010 to 2019 (thousand barrels)



Source: MINEM (2021)

Peru's mandates did little to address the realities that constrain its biofuel supply. High feedstock costs and other factors make local biodiesel production an unattractive investment even when regulations ensure demand.

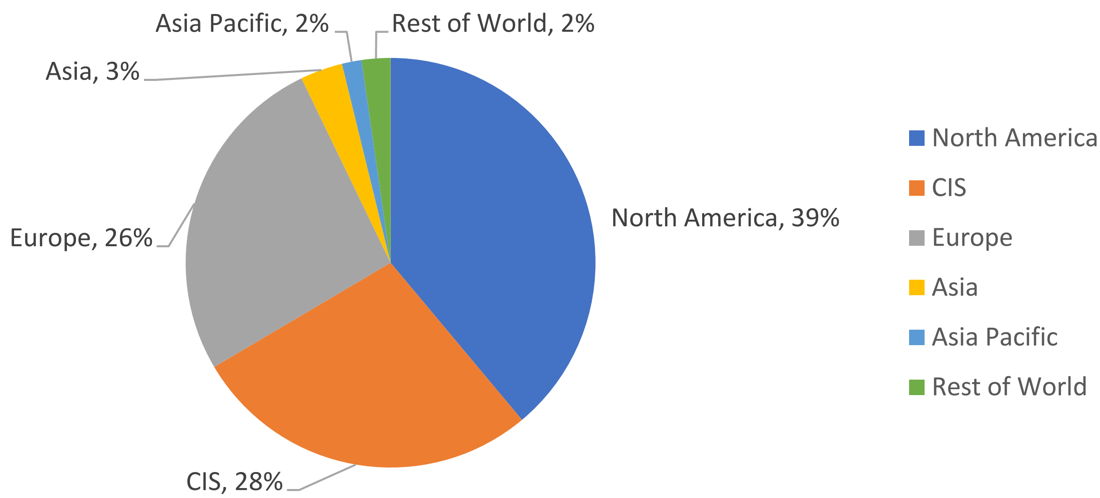
Biofuels are impacted by circumstances in the energy and agricultural sectors. Some potential advantages of biofuels such as the diversification of transport fuel mix and improvement of energy independence, among others, are only possible if the implications in both sectors are considered, and that type of holistic analysis is necessary in the development of policies. Regulations, like blending mandates, will only improve energy security if economies partake in parallel policy to foster the development of biofuel production domestically; otherwise, the mandate will trade oil security for ethanol security.

4-11 Underground gas storage: a China case study

In addition to storing natural gas in liquid form (liquefied natural gas, LNG), some economies with suitable topography (salt caverns, mines, depleted reservoirs, etc.) also developed underground gas storage (UGS) to store natural gas. UGS can help an economy to balance the seasonality of natural gas demand, reduce the amount of LNG imported in peak demand periods, lower the expenditure on pipeline infrastructure and LNG procurement, and ensure energy security.

The pioneers of UGS development include North America, the CIS (Commonwealth of Independent States), and Europe. In 2021, they had the top-three proportions of working gas volume (WGV) in the world, with shares of 39%, 28%, and 26%, respectively (Figure 4-15).

Figure 4-15: Share of global working gas in UGS by region, 2021



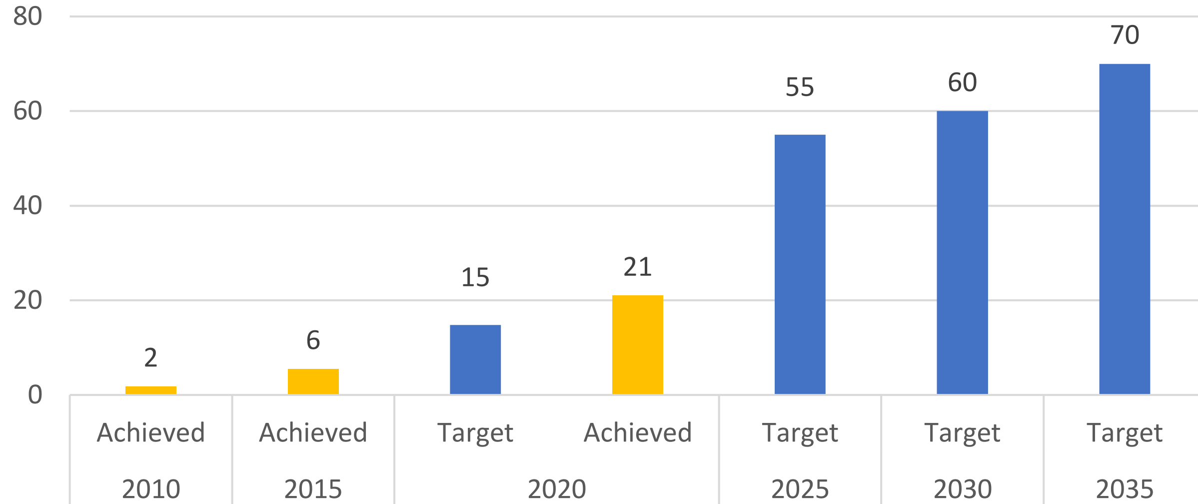
Source: IGU (2022)

China, the top net LNG gas importer in 2021, has been dedicated to developing UGS technology and infrastructure to balance the seasonal and geographical demand for natural gas. In 2021, China's share of WGV ranked fourth in the APEC region, and it accounted for 3% in the world.

Although the optimal proportion of UGS WGV to annual natural gas consumption varies by economies for different demand structures and LNG-related facilities, economies that reach or exceed 30% natural gas dependency often aim for at least 12%, which is a typical level of developed economies. China's proportion of UGS was far lower than this level in 2020.

To ensure the energy security and to balance the seasonal demand for natural gas, China has set several targets for UGS in its 12th, 13th, and 14th five-year plans (FYPs). The latest targets aim to increase the WGV to 55-60 bcm by 2025, 60-70 bcm by 2030, and 70-80 bcm by 2035 (Figure 4-16).

Figure 4-16: China's target for UGS WGV, bcm



Source: NEA (2012, 2022), Beijing Energy Magazine (2022)

As mentioned before, UGS can help an economy to balance the seasonality of natural gas demand. According to S&P Global, the expansion of UGS in China in 2030 is estimated to reduce by 0.65 million tonnes of LNG import per month in the Northern Hemisphere winter. In fact, the reduction can, to some extent, mitigate the tightness of the LNG market during the peak period.

China's UGS will be a very important measure to mitigate the impact of its reopening on global LNG markets. China's reduction in LNG imports, partially stemming from its zero-COVID policy, was instrumental in balancing global LNG markets during the tumultuous year of 2022. Following its reopening this year, the utilisation of UGS by China may be a key factor in reducing the severity of LNG price peaks over the coming decade. If other economies have suitable topography to build UGS, it would be a potential measure to ensure the domestic energy security and the economic LNG procurement. Furthermore, UGS also provides a positive external effect to mitigate the tightness of the LNG market during peak demand periods.

4-12 The importance of joint oil stockpiling – operationalising the ASEAN Petroleum Security Agreement

ASEAN launched the ASEAN Petroleum Security Agreement in 1986 (APSA), which stipulates regional cooperation to improve energy security in times of oversupply or undersupply of oil and/or petroleum products. Further modification of the Agreement was carried out in 2009 to include the adoption of individual and joint voluntary oil stockpiling under medium-and long-term measures. Stockpiling is important to ensure a stable supply of oil to support the growing economy in the southeast Asia region. Under the baseline REF of the 8th Edition, oil supply is expected to increase by about a fifth by 2050 from 2018 levels, and correspondingly, oil imports will rise by over two-thirds due to falling production (APERC, 2022). In CN, the electrification of transport and other end-uses will plateau southeast Asian oil supply this decade, but import requirements will still rise by over two-fifths by 2030. As shown in Figures

2-7 and 2-8, oil import dependence in the region is set to rise from around 50% currently to over 65% by 2050 in both REF and CN. Stockpiling will remain an important tool to mitigate oil supply disruptions.

The seven southeast Asian APEC economies, Brunei Darussalam; Indonesia; Malaysia; the Philippines; Singapore; Thailand; and Viet Nam, have entered the APSA. Under the revised Agreement, the Coordinated Emergency Response Mechanism (CERM) specifies that all members should strive to provide about 10% of their normal domestic requirements to distressed member for a continuous period of at least 30 days. Before requesting assistance under CERM, distressed member must implement short-term measures to reduce oil demand.

Stockpiling in southeast Asia is currently led by the private sector; governments do not lead interventions, nor do they own oil stocks. However, the extent of stockpiling by companies in the southeast Asia region in 2020 is well behind the IEA standard of 90 days equivalence, as shown by the Oil Stockpiling Index in the table below, apart from Singapore, which achieved the 90-day threshold. Given that five of the southeast Asian members are dependent on oil imports to fuel their economy (see the Oil Import Dependency Index column in the table below) and have low stockpiling levels, southeast Asian APEC members are highly susceptible to the impacts of oil disruptions.

Table 4-1: Stockpiling days, Stockpiling Index and Import Dependency Index for APEC southeast Asia

Southeast Asia Economy	Oil Stockpiling Days[14]	Oil Stockpiling Index[15]		Oil Import Dependency Index[16]	
		2015	2020	2015	2020
Brunei Darussalam	31 days for refineries	0.82	0.81	0.00	0.00
Indonesia	14 days (crude oil) and 23 days (oil products) by the NOC	0.92	0.74	0.42	0.31
Malaysia	30 days by the NOC	No information	0.82	0.00	0.00
The Philippines	30 days (crude oil) for refineries and 15 days (oil products) for importing companies	0.87	0.65	0.63	0.64
Singapore	90 days (oil products) for power companies	0.51	0.12	0.52	0.47
Thailand	22 days (oil crude) and 3.5 days (oil products) for refineries and traders	0.59	0.59	0.25	0.25

[14] Information as of May 2022

[15] The Oil Stockpiling Index was calculated based on domestic oil demand. The IEA's definition of stockholding equivalent to days of net imports was translated to days of domestic demand. Economies with oil stocks equivalent to 100 days and above will have an index of 0.00 (least vulnerable). However, economies with 15 days and below will have an index of 1.00 (most vulnerable).

[16] Oil import dependence index = net imports of crude oil and petroleum products / (crude oil production and petroleum products output + net imports of crude oil and petroleum products)

Viet Nam	10 days (oil crude) and 40 days (oil products) for oil companies	0.62	0.59	0.28	0.41

Source: APERC (2015), IEA (2022f), APERC calculations

Recognising this vulnerability, the Philippines announced its intention to establish an SPR. Its government-owned corporation oil company is mandated to conduct a feasibility study and accordingly, formulate an implementation plan for the establishment and operation of the SPR (PNOC, 2022). This development will increase the oil storage capacity of the Philippines, but it is not clear if it will help operationalise a joint stockpiling action in the southeast Asia region.

The 'voluntary' nature of oil stockpiling stipulated in the APSA 2009 is not stringent enough to mandate ASEAN members to hold oil stocks, let alone hold a minimum level. In addition, oil companies may be reluctant to accept a stockpiling obligation due to the lack of commercial returns. Including such a mandatory provision in a revision to the current APSA could result in legal challenges.

Southeast Asia could manifest joint stockpiling in practice through the development of an operationalisation roadmap. Such joint stockpiling could be based on multifaceted agreements, i.e., government-to-government or government-to-company agreements. Conducting an oil emergency exercise is also an important approach, especially in operationalising the procedural and institutional arrangements of the CERM. All in all, urgent actions are required by the southeast Asia economies to mitigate the potential supply disruptions in the long term, given the significant expected increase in southeast Asia's oil demand.

SECTION 5. POTENTIAL ACTIONS GOVERNMENTS CAN TAKE TO ENHANCE ENERGY SECURITY

Both Sections 3 and 4 illustrate that government intervention can improve energy security and mitigate the impact of oil and gas disruptions. Without government intervention, the impact on the households, businesses and overall economy of APEC would be much more severe. When energy security comes to the front of the policy agenda, policymakers can deliver meaningful action.

It is imperative that APEC retains this vigilance, even in the face of improving market conditions. Yes, energy prices are significantly lower than their crisis peaks: spot LNG prices are down 80%, while oil benchmarks are down around 40%. Inflation is slowing down, perhaps peaking. However, uncertainty continues to cloud the state of the oil and gas markets. While energy price levels are down, their movements are still volatile. The reorganisation of global energy supplies remains incomplete, and shifting geopolitical realities could lead to further restructuring. An unfolding banking crisis and the uncertain pace of China's reopening are slowing the pace of the global pandemic recovery. An energy transition is ongoing, but its pace, path and destination seem uncertain. Nevertheless, as Section 2 highlights, even amidst a transition towards carbon neutrality around mid-century, it remains likely that APEC demand for oil and gas will remain robust this decade. As governments continue catalysing an energy transition to a low-carbon economy, it remains imperative that energy security and affordability continue to sit at the forefront of policy discussions. Policy frameworks that ignore any aspect of the energy trilemma in favour of another will risk undermining the objectives of all three.

With that in mind, we close this report with several recommendations for APEC policymakers to improve oil and gas security during the energy transition.

5-1 Actions buyers can take to ensure a stable LNG Supply

Secure long-term LNG contracts with prospective LNG suppliers

Long-term LNG contracts provide certainty and access for prospective LNG suppliers while limiting the exposure of buyers to volatile and elevated spot LNG prices during market disruptions. Incumbent LNG importers should seek a diversity of contract types to limit their exposure to oil or gas indexation.

Engage in collective bidding to secure more favourable contracts

Cooperation across large-scale LNG importers to increase their demand base could lead to more favourable conditions for signing new LNG contracts. Less demand affords lower leverage in contract negotiation and makes it harder to obtain sufficient contract diversity. Emerging APEC importers in southeast Asia can mitigate this by engaging in collaborative bids for long-term LNG contracts. Incumbent importers in the region could also look at pooling their bids with emerging incumbents.

Invest in the upstream supply chain

APEC members should consider investing directly in LNG liquefaction projects. This crisis has illustrated that long-term LNG contracts are not enough. When spot prices rise high enough, the benefit to suppliers of breaking contract conditions can start to outweigh the costs. The only way to guarantee LNG supply during disruptive market conditions is to invest directly in the expansion of LNG facilities. This could also involve investing further upstream in the production of oil and gas supply, to guarantee that wells are drilled to fill the liquefaction requirements.

Enable LNG reloading at all LNG import terminals to increase the ability of LNG re-exports during crises

An APEC-wide assessment of the reloading potential at existing facilities would be useful. Expansion of reloading capability to increase the utilisation of APEC's LNG storage potential could mitigate the impact of future LNG disruptions. Such arbitrage opportunities will not be limited to the winter months. Demand for space cooling exists year-round in many southeast Asian economies and rises in northeast Asia during the summer months. The run-up on LNG benchmark prices in the summer months illustrates that supply disruptions may be an issue in future summers.

Invest in the resiliency of the LNG shipping supply chain

The European rush to replace Russian pipeline supplies with LNG is creating competition for services from LNG carriers, FSUs and FSRUs. This could increase shipping costs and limit the effectiveness of chartering carriers in alleviating gas disruptions by increasing short-term LNG storage and regasification capacity. Policymakers should incentivise the conversion of the around 200 inefficient, steam-propelled LNG carriers into FSUs, FSRUs or FLNG units to increase the short-term elasticity of LNG supply and invest in increasing LNG shipbuilding capacity to accelerate the turnover of these conversions into more efficient LNG carriers. With LNG shipbuilding concentrated in China; Japan; and Korea, APEC can play a central role in this transition by ensuring resiliency in the LNG shipbuilding supply chain. Shipyards have capacity limits and take years to build. Careful scheduling of conversions with newbuild vessel commissioning will be key to avoiding a decrease in LNG carrier capacity, which could push shipping costs higher. Members should also investigate the potential for shipbuilding constraints, both at the shipyard and in the material supply chain for LNG vessels. Improving resilience may also require investments in increasing LNG shipbuilding capacity.

5-2 Mitigating oil and gas disruptions with storage and stockpiles

Consider the expansion of LNG storage capacity at large-user endpoints

Actions to mandate utility-level LNG storage targets in places like Japan and Korea have mitigated the impact of LNG disruptions. However, capacity constraints will eventually limit the effectiveness of this strategy. Importers should investigate the suitability and potential for additional LNG storage tanks to expand capacity and provide higher cover over the next decade.

Investments in oil and product storage facilities and minimum storage requirements

Failure to develop adequate oil storage capacity and oil stockpiles is putting several APEC members at risk of bearing the brunt of supply disruptions. SPRs represent an important tool protecting economies from the economic impacts of just-in-time delivery disruptions and mitigating the impact of higher pricing that occurs during the structural booms of oil markets. Southeast Asian economies, which will be especially at risk as oil demand grows over the next decade, could buffer their region by developing an operationalisation roadmap for existing joint stockpiling agreements. This roadmap would incentivise higher investment in storage capacity by laying out multifaceted government-to-government and government-to-company agreements. Governments can also conduct exercises to develop procedural and institutional arrangements to effectively carry out emergency responses. In economies that depend on just-in-time deliveries of seaborne crude or product imports to fuel their oil requirements, investments in storage facilities could help mitigate the impact of a supply disruption – whether it is due to storm surges, other weather impacts, or other reasons.

Reduce the demand-side risk facing oil suppliers by committing to replenishing SPR storage volumes

Economies with SPRs could help reduce the demand uncertainty facing oil producers by committing to refill their SPR over the coming decade. Higher demand certainty will increase the returns from investing in short-term productive capacity, which could encourage investments in supply growth. Replenishing stockpiles at lower prices would also help provide a buffer against future oil and product supply disruptions.

5-3 Actions to increase the oil and gas supply

Alleviate service bottlenecks for the shale sector

Policymakers could increase APEC's oil and gas supply elasticity to commodity prices by increasing the productive capacity of the materials and equipment that are constraining the activity of service providers for shale and tight resources. A higher supply of frac sand, cement and OCTGs could put upward pressure on the rig count. Likewise, a higher supply of pressure pumps would increase the number of frac fleets available. Developing an inventory of the critical equipment constraints would enable policymakers to rapidly respond to future bottlenecks in the supply chain. APEC members should consider a broader, long-term view when implementing tariffs on important inputs for oil and gas production, such as steel and OCTGs.

Simplify the permitting process and frontload investments in methane emissions reductions

Newbuild LNG export terminals may face pipeline constraints due to permit approval delays. A simplification of this process would ensure that gas supply can grow to meet the rising global demand for LNG. Frontloading emissions reduction initiatives over the next couple of years will not only increase the gas supply for liquefaction but will also decarbonise the upstream chain, which will more closely align producers with decarbonisation ambitions and commitments.

Winterise the entire gas supply chain of APEC producer-exporters.

Oil and gas supply disruptions and refinery and power outages during extreme cold spells, particularly in the US, present a key vulnerability to the global energy system. While the US is now one of the largest producer-exporters of LNG and oil products in the world, its supply is not useful if it is susceptible to such a significant disruption when it is needed the most. Furthermore, gas and oil can do little to provide grid reliability if that reliability is contingent on the weather, particularly when the weather is yielding record demand peaks and the availability of energy is a life-or-death matter. Winterisation of the US energy supply chain is paramount to ensure reliability, affordability, and energy security at home and throughout APEC. The adoption of the Weather Emergency Preparedness Standards rule by the Texas Railroad Commission last summer is a welcome step, but the disruptions this winter illustrate that more work is needed to eliminate this vulnerability (RRC, 2022).

5-4 Demand-side actions: demand response, energy efficiency and fuel diversity

Consider investing in redundancy, sophistication, and replacement at large industrial and power facilities

The ability of large-scale industrial and power users to engage in fuel switching is limited by technological constraints. Investing in sophistication, such as dual-fire boilers, would increase demand elasticity during disruptive periods. A longer-term strategy is to invest in replacement technology that is not dependent on oil or gas. Redundancy also facilitates fuel switching, but at additional cost. Idle capacity needs to be weighed against the risk of supply disruptions. For the power sector, redundancy during periods of low demand can facilitate some level of fuel switching brought on by supply disruption. But the extent to which redundancy is required to meet the challenge of supply disruptions goes beyond considerations of seasonal or daily peak demand. To meet this challenge, markets need to be well designed to incentivise redundancy levels that sufficiently guard against supply-side disruption risks. APEC members can consider mothballing – rather than retiring – coal and oil-fired generation units to increase additional switching options for end-users.

Develop effective short-term demand response programs for electricity and natural gas consumers at the retail level

Many economies have demand response programs in place for large-scale industrial users, but establishing buy-in from smaller industrial, commercial, and retail users requires planning, communication, and incentives. Japan provides a useful model. Developing systems to effectively communicate potential supply shortfalls to consumers via the media can enable rapid responses and embed demand reductions during prolonged crises. Utility incentive schemes can further foster a culture of demand response and efficiency investment to reduce energy use. Providing consumers with granular demand data can empower them to find individual solutions to reduce demand without sacrificing their well-being.

Enable demand reductions by investing in electrification and technology adoption

Investing in efficient, demand-reduction technologies, like EVs and heat pumps, can reduce the exposure to oil and gas disruptions, reduce energy intensity, and open up more fuel supply on the global market. However, energy security will only improve if supply investments persist in the face of declining demand, which may be hard to guarantee in practice. Many producers are citing demand security as a reason not to invest in increasing upstream production capacity. Economies will also need to prioritise investments in transmission, distribution and storage infrastructure to ensure that higher electrification throughout the economy does not reduce grid reliability. Finally, ramping up the investment in low-carbon technologies, like heat pumps and EVs, will require strategic planning to ensure that technologies are secure and available. The increased use of low-carbon technologies, particularly batteries, will bring with it additional concerns surrounding material and mineral security. APEC hosts the bulk of the mining and processing of critical materials and minerals, as well as the manufacturing capacity necessary to build these technologies. Strategic cooperation will help ensure that investment rises enough to meet larger production requirements during the energy transition and that the trade frictions of the inputs that are critical to the transition are kept to a minimum.

Diversify long-term energy and power plans to reduce future vulnerabilities to supply shocks

The energy transition may require APEC members to think of their future energy plans as being additive to their current mix – and not simply a replacement of current, higher-emitting technologies – particularly when it comes to backup electrical capacity. Adjusting plans to leverage domestic endowments of all energy types can help reduce vulnerability to future oil and gas shocks. Investments in redundancy, while costly, could be a net benefit for large-scale users of oil and gas. In the power sector, redundancy will increase reserve margins, which will help avoid grid reliability challenges during higher-than-expected load peaks or oil and gas supply disruptions. Industrial investments in sophistication and redundancy could avoid curtailment of the output of essential economic drivers during periods of high oil and gas prices.

5-5 Measures to increase liquids supply

Consider extending refinery lifetimes via conversions to align more closely with evolving product demand

APEC members should work to maintain refinery capacity during the energy transition. Retiring refineries during this disruptive period in oil product markets could put undue economic hardship on consumers and businesses that rely on oil products to fuel their livelihoods and activity. In economies facing the prospect of plateauing and declining oil product demand, this may require investigating how to build new business models that do not rely on a high utilisation rate to keep the refinery a going concern. For example, this could involve converting refineries to produce more distillates and less gasoline, which will see demand decrease or plateau as higher EV penetration takes off this decade.

Ensure that bioconversions do not result in net capacity declines

Economies should make refinery bioconversions conditional on a guarantee that the plans will not result in a decline in net product capacity. Typically, bioconversions result in a net reduction in refinery capacity – conversions often only provide a fraction of the oil liquids capacity of the original refinery. During the energy transition, APEC should ensure that parallel expansions occur to make up for the lost capacity that has been partially responsible for the current tightness in product markets.

Make bioblending mandates conditional on domestic supply increases

Biofuel mandates will not improve energy security if they are not matched with equal increases in biofuel productive capacity. Shifting energy security concerns from one fuel to another would not lead to an overall improvement in energy security. APEC member biofuel mandates should be complemented with a policy that incentivises investment in biofuel production capacity.

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