What are the Energy Security Implications of Recent Declines in Both APEC and Global Spare Petroleum Refining Capacity?

Oil and Gas Security Study Series

Report 20

APEC Energy Working Group

April 2025

Asia-Pacific
Economic Cooperation

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FOREWORD

As the energy landscape continues to evolve, petroleum products remain pivotal in driving economic growth and sustaining industrial activities globally. However, recent disruptions — including trade restrictions due to geopolitical tensions on the supply side and changes in consumption patterns following COVID-19 on the demand side — have raised concerns about the adequacy of global petroleum refining capacity to meet future demand.

This report provides a comprehensive analysis of the challenges facing the petroleum refining sector, particularly within APEC. It examines historical trends, current dynamics, and future projections surrounding petroleum refinery capacity, consumption patterns, and supply security. A key observation is the narrowing gap between petroleum refinery capacity and petroleum product consumption, signaling a potential shortfall in the investment needed for petroleum refinery capacity expansion. Short-term projections within this decade indicate increased global petroleum product consumption driven by economic growth and industrial expansion across various regions. However, long-term scenarios of consumption diverge considerably, presenting complex challenges in decision-making on refinery capacity investments. Additionally, this report outlines diverse risk profiles across APEC sub-regions, ranging from economies heavily reliant on imports of petroleum products to those with robust domestic production capabilities. These differences highlight the necessity for proactive strategies and tailored policy measures by each economy to enhance the security of petroleum product supply in light of investment uncertainty.

It is my sincere hope that our Oil and Gas Security Study (OGSS) series will continue to provide valuable insights to APEC economies in effectively addressing oil and gas security concerns. Our commitment remains steadfast in collaborating closely with governments and other stakeholders within APEC to strengthen their efforts to ensure reliable and affordable energy while each economy navigates the energy transition.

Kazutomo IRIE

President
Asia Pacific Energy Research Centre
November 2024

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Disclaimers

The information and statements in this report reflect only the views of the authors and not necessarily APERC and might change in the future depending on unexpected external events of changes in the oil and gas policy agendas of particular economies.

EXECUTIVE SUMMARY

Global refineries appear to have fallen short of meeting the escalating demand for petroleum products.

Refinery capacity more than doubled from 1965, reaching almost 80 million barrels per day (mb/d) in 1980, with the US and Europe accounting for over half of global capacity. During this period, the OPEC oil embargo dampened demand, creating a significant quantity of spare refinery capacity. The US economic recession of 1980 caused a notable global downturn in petroleum product consumption. Despite a sluggish recovery from 1985 onwards, petroleum product consumption has been steadily growing at approximately 1.5% per annum, while refinery capacity has only expanded at about 1% annually. This trend has resulted in a gradual narrowing of the gap between refining capacity and consumption, with much of the capacity growth occurring outside of the US and Europe. The analysis reveals a declining ratio of global spare refinery capacity to consumption, from nearly 20% prior to 2001 down to 3% before the Covid-19 pandemic hit, highlighting the increasing vulnerability of global refineries to be unable to adequately and securely supply potential consumption growth without additional capacity expansions.

The recent Russia-Ukraine crisis and the subsequent ban of petroleum products from Russia together with other factors in global refining sector have caused supply disruptions, especially diesel, resulting in increased product prices.

The Russia-Ukraine crisis in early 2022 had a profound impact on global energy markets, particularly on petroleum product prices. The low level of spare refinery capacity both within APEC and globally as a result of recent refinery closures exacerbated this effect, contributing to substantial increases in gasoline and diesel crack spreads. Prior to the crisis, as the world transitioned out of the Covid-19 pandemic, the average US Gulf Coast gasoline crack spread surged nearly threefold, reaching 15.65 US dollar per barrel (USD/bbl). In early 2022, this upward trajectory intensified, with the gasoline crack spread nearly quadrupling to 23.06 USD/bbl. Similarly, the average diesel crack spread experienced a parallel trend at 40.82 USD/bbl, with a peak at a historic high of 116.37 USD/bbl on 28 April 2022. These dramatic spikes underscore the vulnerability of global petroleum markets to disruptions and highlight the critical importance of ensuring adequate refinery capacity.

The world and APEC look to rely on petroleum products consumption at least in the near term.

The challenge of ensuring supply security for petroleum products hinges on changes in consumption and refinery capacity. Projections from OPEC, IEA, and APERC offer varying perspectives, with consumption trajectories peaking at different points before diverging. While OPEC's outlook for global consumption indicates a consistent upward trajectory reaching 116 mb/d in 2050, the IEA anticipates a peak in global consumption of 106 mb/d by 2028, and a decline thereafter. In its 8th Energy Demand and Supply Outlook, APERC projected the peak of APEC region's oil consumption at just over 55 mb/d in 2037, with a decline thereafter. Addressing increased demand will require adequate investment in refinery capacity. Projections indicate that future investment requirements will range between US$90-140 billion from 2022 to 2028 to align with the IEA's projections, while a more substantial amount ranging from US$320-490 billion from 2022 to 2045 would be necessary to accommodate OPEC's longer-term forecast. The contrast between the increases of short-term demand and the uncertainty about long-term trends poses a challenge for investment decision-making within the refining sector. Furthermore, the expected shifts in the mix of

petroleum product consumption underscores the importance for infrastructure investment and the adaptation of production processes within the refining sector.

APEC economies pose diverse profiles in security of supply of petroleum products.

Analyzing historical trends in petroleum product consumption, refinery capacity, and net trade within each APEC sub-region provides valuable insights into supply security. Changes in oil production and refining economics since 2008 allowed APEC to become a net petroleum product exporter, with diesel emerging as a major product. Upon closer examination, however, each APEC sub-region presents a distinct refinery and net-trade landscape. For example, APEC Northeast Asia (NEA), despite its status as a net exporter of transport fuels, heavily depends on naphtha imports to satisfy its expanding petrochemical sector. As shown in the 8th Outlook, the APEC region's position may transition to net importer status, driven by burgeoning demand in China and Southeast Asia (SEA), surpassing the region's refinery capacity. Additionally, assessing refinery utilization rates in each sub-region provides insights into the ability to securely supply production in response to increased demand and to buffer against supply disruptions. Refinery utilization rates in many APEC sub-regions consistently surpass 80%, implying efficient resource usage. Yet, this high rate also signals potential challenges during periods of heightened demand. Two APEC sub-regions with notable refinery utilization rates are China, which has seen an increase from 65% in the mid-2010s to about 80% due to escalating consumption of petroleum products and efficiency improvements in oil refinery sector, and APEC Other Americas, where the rate has declined over the past two decades due to a more competitive import prices from the US, albeit with a slight uptick following the Covid-19. Conclusively, understanding these trends and their dynamics is essential for shaping future strategies and ensuring resilience in the APEC energy landscape.

Each APEC economy should make an assessment in its own policy regarding supply security of petroleum products.

Policy measures regarding petroleum product supply should be aligned with individual economy-specific decarbonization targets and their implementation strategies. APEC economies should conduct thorough assessments of their spare refining capacity as compared with importing option to safeguard supply security. This evaluation is particularly critical for import-dependent economies facing rapid growth in petroleum product consumption. While maintaining spare refining capacity is essential for longer-term disruptions and market fluctuation, strategic petroleum product reserves offer short-term mitigation during emergencies though incurring high maintaining costs. If needed, APEC governments should explore pathways to mitigate the financial risks associated with new refinery investments, possibly through incentives to promote the expansion and modernization of existing facilities. Government-owned oil companies may play a pivotal role in investing in additional refinery capacity, especially in economies with robust domestic crude oil production or integrated upstream-refining-petrochemical sectors. These recommendations underscore the importance of proactive measures to ensure the resilience and stability of petroleum product supply amidst evolving energy landscapes and geopolitical dynamics.

SECTION 1: INTRODUCTION

1-1 Background of this study

Oil and gas supply disruptions pose significant economic and societal risks, prompting governments to implement policies aimed at reducing the likelihood of such disruptions or mitigating their impacts. The endorsement of the APEC Oil and Gas Security Initiative (OGSI) by the APEC Energy Working Group (EWG) in 2014 aligns with this objective, providing support to APEC economies in addressing energy supply security challenges and preparing for potential supply shortages and emergencies. Among the three pillars of the OGSI, the Oil and Gas Security Studies (OGSS) plays a vital role in encouraging APEC economies to evaluate their policies, plans, programs, and measures related to oil and gas security, considering the important role of oil and gas even as APEC economies increasingly decarbonize. The OFSS program aims to assist economies in adopting suitable approaches to effectively prepare for potential supply shortages or emergencies in the future.

In the context of this series of OGSS, APERC defines energy security as *providing reliable energy at reasonable cost*. While this definition aligns with those provided by other institutes, there may be variations in the meaning and scope among different organizations.

1-2 Objective and scope of this study

Petroleum products security is crucial due to the essential role of those products in modern economies. While crude oil serves as the primary feedstock for petroleum products production, it is the refined products such as gasoline, diesel, and fuel oil that are essential in the transportation and industry sectors, just as naphtha is a key feedstock for petrochemical products and plastics. Any disruption in the supply of petroleum products can have far-reaching consequences. Moreover, petroleum products are integral to modern lifestyles, impacting everything from daily commutes to international trade, underscoring the critical need for robust security measures to ensure their adequate and timely availability at reasonable prices.

The primary objective of this study is to comprehensively inform APEC economies of the historical trends and future trajectories concerning global and APEC's downstream oil security, specifically focusing on petroleum products. To achieve this, we analyze spare refining capacity and petroleum product consumption, as well as their relationships to petroleum product crack spreads, which denote the price differences between petroleum product wholesale spot prices and crude oil spot prices. Additionally, we assess the potential energy supply and demand outlooks for petroleum products and provide insights into the current outlook for refinery capacity investment and divestment.

Furthermore, this study aims to evaluate challenges and propose individual and collective measures to ensure medium- and long-term security of petroleum products supply. We delve into petroleum product production, examining refinery capacity and utilization rates, the net trade of petroleum products, as well as consumption patterns on both global and APEC sub-region scales. Our global analysis is based on a literature review, while our assessment of APEC's energy landscape draws from the APEC Energy Demand and Supply Outlook, 8th Edition, and EGEDA’s data collection from APEC member economies.

1-3 Report outline

The analysis in Section 2 delves into the consumption trends of petroleum products and refinery capacity spanning from 1965 to 2022, capturing pivotal global events such as the Covid-19 pandemic. Furthermore, it examines the impact of recent trends in spare refinery capacity on petroleum product crack spreads. Section 3 highlights future challenges in the global and APEC contexts regarding petroleum products supply security, examining the investment needed in the oil refinery sector to meet growing demand across different outlook scenarios from different reputable institutes. This section also underscores the anticipated hurdles stemming from global shifting patterns of petroleum product consumption.

The subsequent sections focus on specific assessments of APEC sub-regions. Section 4 evaluates the supply security of petroleum products in APEC sub-regions, considering their varied net trade positions, by each key petroleum products. Session 5 delves into refinery utilization rates, providing insights into operational efficiencies and future supply capabilities. Finally, Section 6 concludes with recommended measures for APEC economies' governments to consider to enhance energy security, advocating for individual and collective efforts, including petroleum product stockpiling.

SECTION 2: HISTORICAL TRENDS

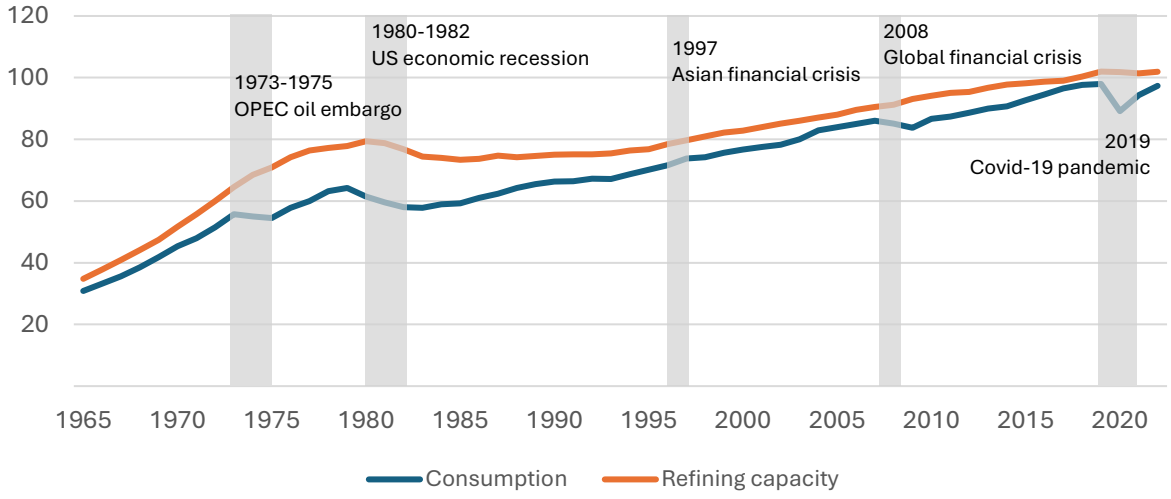
This section highlights the challenges of the slow pace of global petroleum refinery capacity additions in recent years, as compared to increases of global petroleum product consumption. It also highlights the risks of the tight situation of refinery capacity to the prices of petroleum products during the Russia-Ukraine crisis.

2-1 Global refinery capacity has not kept pace with growing petroleum products consumption.

From the mid-1960s, global refinery capacity more than doubled, increasing from less than 35 mb/d to a peak of 79 mb/d in 1980. This surge was primarily in response to the rapidly increasing consumption in the US and Europe. Specifically, refinery capacity in the US and Europe increased from 18 mb/d to 42 mb/d, representing more than half of global capacity. Concurrently, global consumption also more than doubled, rising from 31 mb/d to peak at 64 mb/d during the same period, before declining in 1980 due to the global recession. The recession led to a decrease in petroleum products consumption of 5 mb/d for five years, along with a similar reduction in refinery capacity for a span of about 10 years. Notably, it took global refineries 17 years, from 1980 to 1997, to regain the 1980 level of capacity of 79 mb/d. Concurrently, global consumption rebounded to 64 mb/d in just nine years following the crisis.

Since the sluggish recovery in 1985, the consumption of petroleum products has grown approximately 1.5% per annum until the beginning of Covid-19 pandemic in 2019. However, refinery capacity has grown only 1% per year, leading to a gradual narrowing of the gap between refining capacity and consumption, as shown in Figure 1. Specifically, over the past 30 years, much of the increase in global refining capacity has occurred outside of the US and Europe. Notably, refinery capacity in the US has never reached its peak of 19 mb/d, while in Europe, it has continuously decline from its peak at 23 mb/d in 1980 to reach 15 mb/d in 2019, as compared with a 14% increase in consumption in the US and a 3% decline in Europe during the period.

Figure 1: Global petroleum products consumption and refining capacity, 1965-2022 (mb/d)



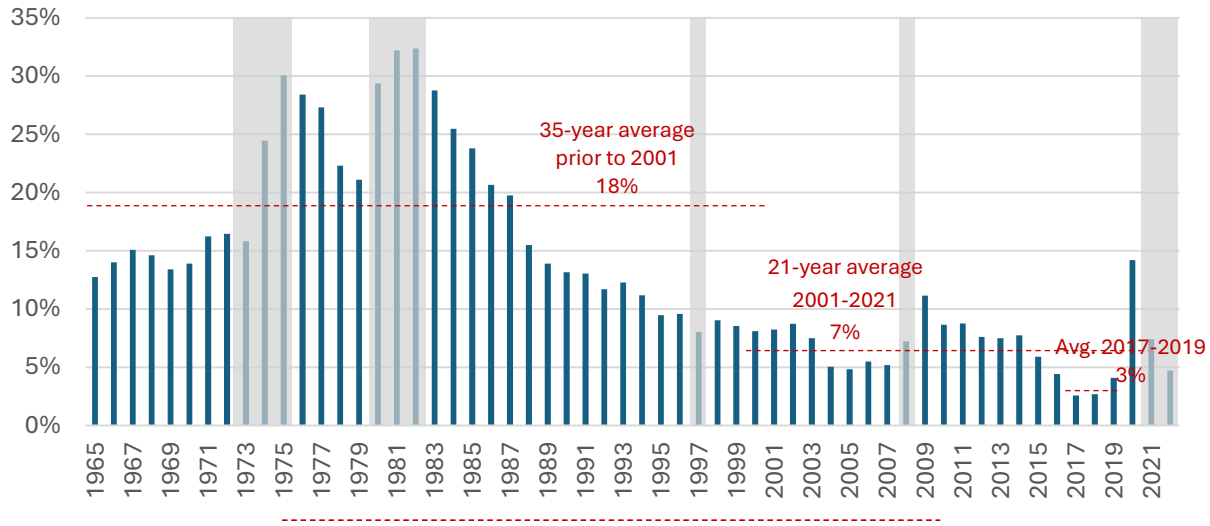
Source: Energy Institute (2023)

Another perspective on the issue is to investigate the capability of global refineries to ensure security of supply to meet future increases in consumption. This assumes that petroleum products

will maintain their important role in the energy transition, at least in the medium term. Figure 2 illustrates the historical trend of the ratio of global spare refinery capacity to consumption. Spare refinery capacity here refers to the total capacity of refinery to produce petroleum products, so-called crude distillation capacity, minus consumption of all petroleum products.

At the peak of consumption in 1981, the ratio of global spare refinery capacity to consumption reached 33%. Subsequently, the ratio steadily declined in response to the slow addition of global refinery capacity compared to the rapid increase in consumption. Notably, the period from 2017 to 2019, prior to the Covid-19 pandemic, saw the ratio plummet to just 3%, in contrast to the 7% observed over the last 21 years. This underscores the diminishing security of global refineries to adequately supply potential consumption increases without new refinery capacity additions.

Figure 2: Percentage of global spare refinery capacity[1] to consumption



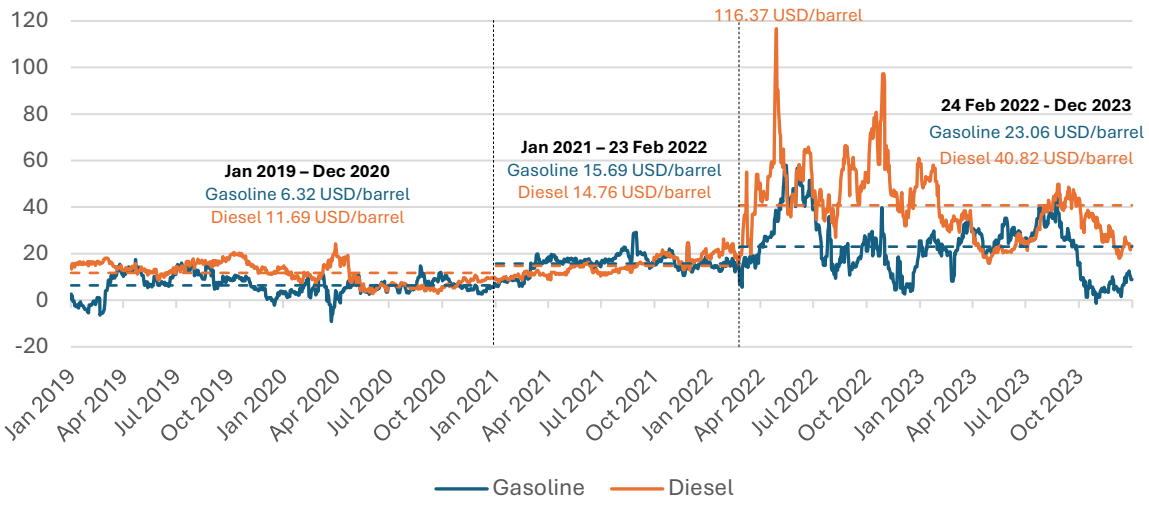
[1] Atmospheric distillation capacity less petroleum products consumption
Source: Energy Institute (2023) and APERC analysis

2-2 Low level of spare refinery capacity in APEC and the world likely contributed to increases in gasoline and diesel crack spreads.

The tightness in global refinery capacity, as indicated by the low ratio of global spare refinery capacity to consumption discussed earlier, contributed to the increased gasoline and diesel prices stemming from supply disruptions during the Russia-Ukraine crisis. Figure 3 examines the margins between spot prices of gasoline and diesel at the US Gulf Coast compared with prices of crude oil, known as product crack spreads. For instance, the crack spread of gasoline averaged 6.32 US dollars per barrel (USD/bbl) between 2019 and 2020. In the two years leading up to the Russia-Ukraine crisis, the gasoline crack spread in US Gulf Coast nearly tripled to 15.69 USD/bbl due to tight gasoline supply. Immediately after the crisis began, it surged to about 60 USD/bbl. Until December of last year, the average gasoline spread at US Gulf Coast was 23 USD/bbl, almost four times higher than the average of 2019-2020. The diesel crack spread exhibited greater volatilities during the same period, peaking at 116 USD/bbl in June 2022, which was ten times higher than its historical average. A similar examination at gasoline and diesel crack spreads at Singapore spot market revealed a similar impact where the spreads of gasoline and diesel were significantly increased to almost double and triple, respectively, in respond to the supply disruptions and tight in global refinery capacity during the same period as in Figure 4.

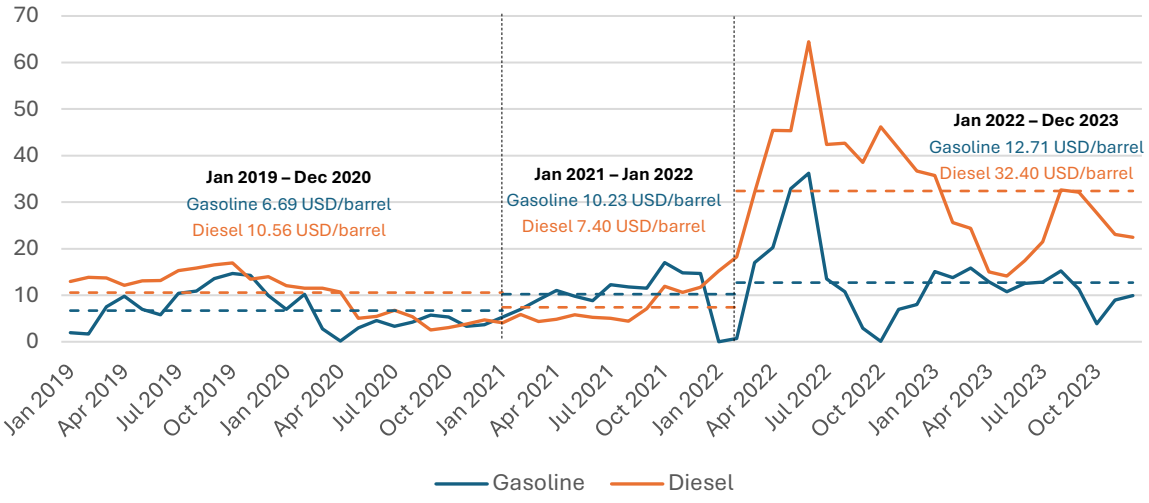
However, it is important to note that recent developments during the time of this report indicate a situation where refining capacity growth could exceed growth in demand for refined products. These developments indicate the necessity for APEC economies to monitor and evaluate their refining capacity, as highlighted in chapter 6.

Figure 3: US Gulf Coast crack spread, Jan 2019 – Dec 2023 (USD/barrel)



Source: EIA

Figure 4: Singapore crack spread, Jan 2019 - Dec 2023 (USD/barrel)



Source: IEA

SECTION 3: FUTURE CHALLENGES ON PETROLEUM PRODUCTS SUPPLY SECURITY

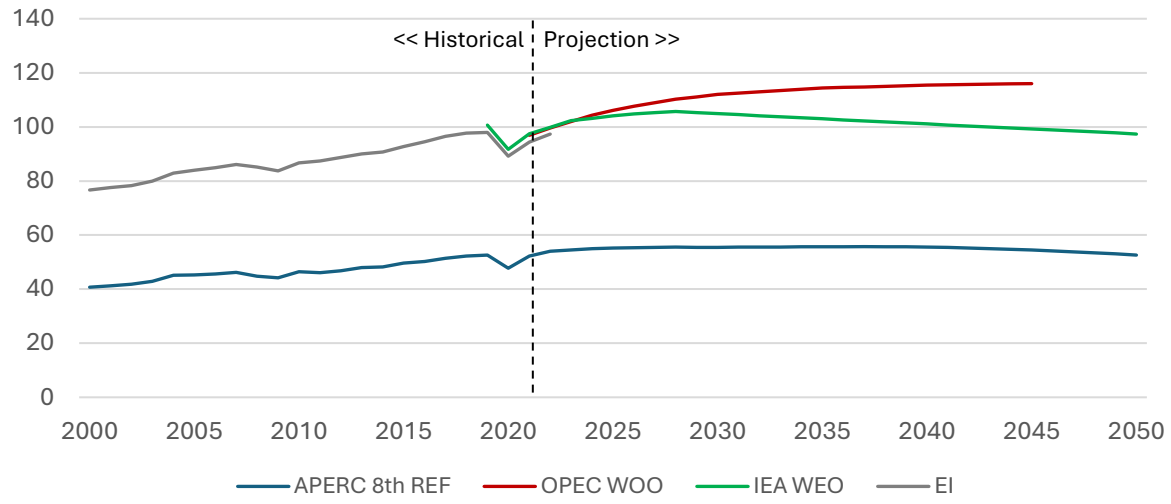
Section 3 examines future outlooks for petroleum product consumption and refinery capacity to highlight the challenges of apparent inadequate refinery capacity in the short term, as well as the level of investment in oil refinery capacity needed to meet targets of different consumption outlooks.

3-1 Diverse perspectives exist across various institutions on future global petroleum products consumption.

The challenges and risks of supply security of petroleum products largely depend on two factors, the outlook of petroleum product consumption and refinery capacity. We will first examine the outlook of consumption, followed by refinery capacity.

Figure 5 summarizes the three projections of petroleum product consumption from OPEC Reference Scenario, IEA Stated Policies Scenario, and APERC Outlook 8th Reference Scenario. OPEC's projection (2023) indicates an optimistic growth trajectory reaching 116 mb/d in 2045, albeit exhibiting a diminishing trend over time. Conversely, IEA (2023) anticipates a more conservative growth based on global decarbonization efforts, with consumption peaking at 105.7 mb/d in 2028 before declining to 98 mb/d in 2050. APERC's 8th Edition Outlook (2022) projects a slight decline in consumption in the long term, with growth modestly tapering off after reaching a peak of 55.7 mb/d in 2037.

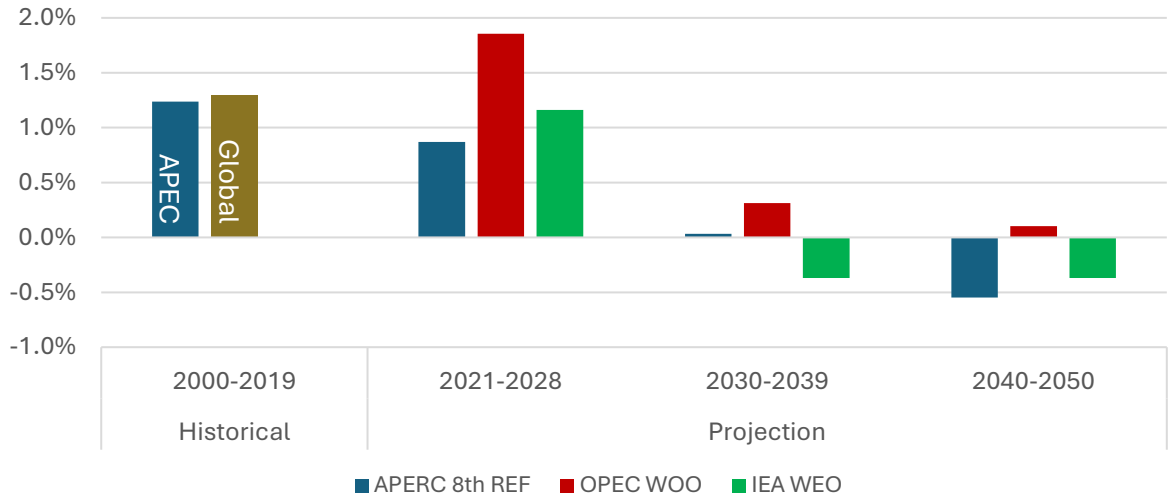
Figure 5: Global and APEC petroleum products consumption, 2000-2050 (mb/d)



Source: APERC, IEA, OPEC

When comparing these projections with historical consumption growth rates over the last 20 years, which have averaged around 1.2% annually globally and within APEC, APEC anticipates the most conservative short-term growth until 2028 at less than 1%. IEA follows with a growth estimate of 1.1%, and OPEC presents the most optimistic outlook at 1.8%. However, beyond 2028, only OPEC forecasts continued growth, albeit at diminished rates, while APERC and IEA foresee declines, as illustrated in Figure 6.

Figure 6: Annual growth rate in petroleum products consumption

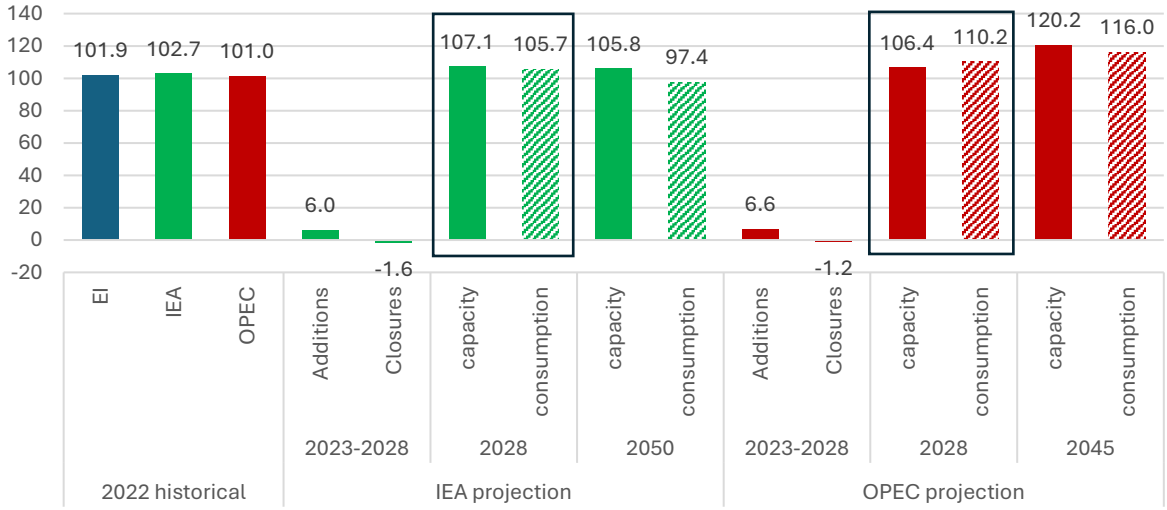


Source: APERC, IEA, OPEC

3-2 Different views on refinery capacity pose challenges to future product supply security.

Historical data from Energy Institute (EI), IEA, and OPEC exhibit a slight variance in global refinery capacity in 2022, estimated at approximately 102 mb/d, as depicted in Figure 7. Alongside its projection of petroleum products consumption of 105.7 mb/d in 2028, IEA anticipates refinery capacity to increase marginally from 102 mb/d to 107 mb/d, slightly surpassing projected consumption levels. However, IEA projects a decline in both refinery capacity and consumption through 2050, reaching 105 mb/d and 97 mb/d, respectively. In contrast, OPEC projects a lower global refinery capacity of 106 mb/d by 2028, compared to a consumption projection of 110 mb/d for the same period. OPEC's projection suggests an increase in global refinery capacity to 120 mb/d by 2045, slightly exceeding the anticipated continued consumption of 116 mb/d. The marginal disparity between refinery capacity and consumption, particularly evident in the near term in 2028 according to IEA, presents a challenge to supply security, given that refineries typically operate at less than full capacity. Conversely, OPEC's projection poses a different near-term challenge, indicating a potential shortfall in refinery capacity relative to consumption. Overall, the marginal discrepancies between refining capacity and petroleum products consumption from both institutions underscore the imperative for additional capacity expansion.

Figure 7: Capacity and consumption projections (mb/d)



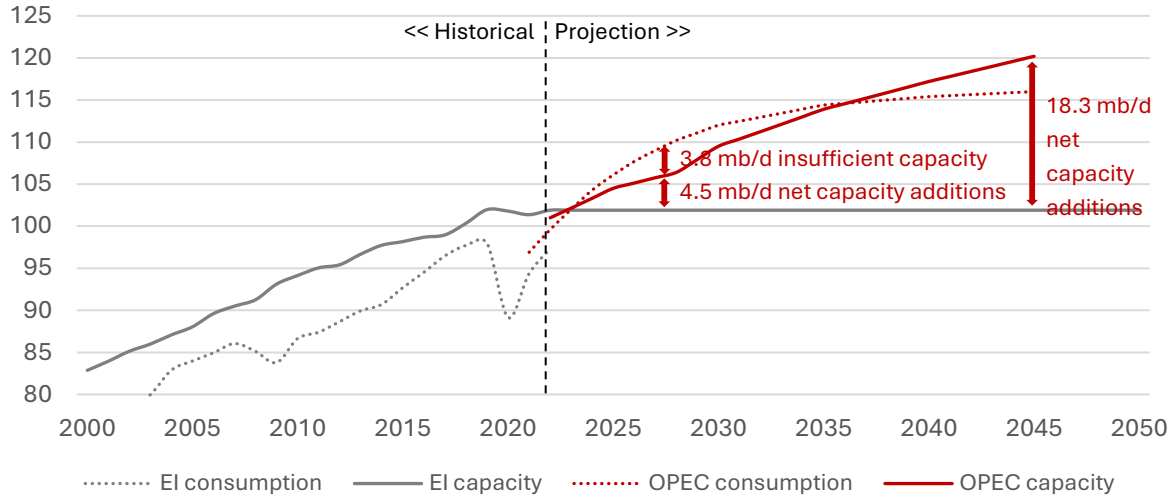
Source: EI, IEA, OPEC

3-3 Significant investment in global refinery capacity additions is required to meet near-term and medium-term demand.

To highlight the necessity of global refinery sector to maintain adequate level of refinery capacity, this section estimates the requisite future investments in refinery capacity necessary to meet anticipated consumption levels as projected by OPEC and IEA.

Figure 8 illustrates OPEC's projection of a sustained increase in refinery capacity, shown in solid line. However, when comparing this projection with its consumption estimates, it becomes evident that near-term refinery capacity, which considers announced projects, falls short of meeting anticipated consumption levels, as indicated by the dotted line. Assuming that global refinery capacity remains constant at 2022 levels, an additional 8.3 mb/d of net capacity must be added by 2028 to align with projected consumption rates. Even with a successful implementation of 4.5 mb/d net capacity addition projected by OPEC, global refinery capacity will still lag behind consumption by 3.8 mb/d. In essence, the global refining sector faces a shortfall in capacity to satisfy near-term consumption demands. Looking further ahead to 2045, OPEC anticipates a cumulative net addition of 18.3 mb/d from 2022 levels, equaling the total capacity of all the refineries in the US today, to adequately meet projected consumption requirements.

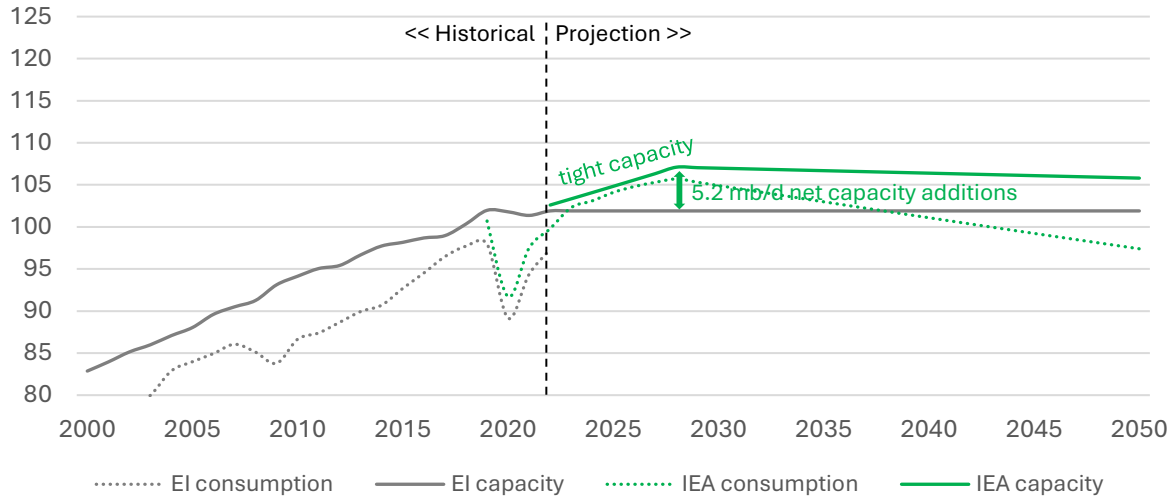
Figure 8: Global petroleum products consumption and refining capacity, OPEC projection (mb/d)



Source: EI and OPEC

Comparing with projections from the IEA, in Figure 9, the IEA anticipates a net addition in refinery capacity of approximately 5.2 mb/d by 2028. It is noteworthy that from 2022 to 2028, a tightening of the global refinery capacity appears evident based on capacity and consumption projections. This tightening stems from the sustained rapid increase in petroleum product consumption in the near term relative to the growth in refinery capacity. In the longer term, however, the IEA expects a more rapid decline in consumption compared to refinery capacity. Projections suggest that by 2050, refinery capacity will still surpass current levels, while consumption will trend downward to meet current levels.

Figure 9: Global petroleum products consumption and refining capacity, IEA projection (mb/d)

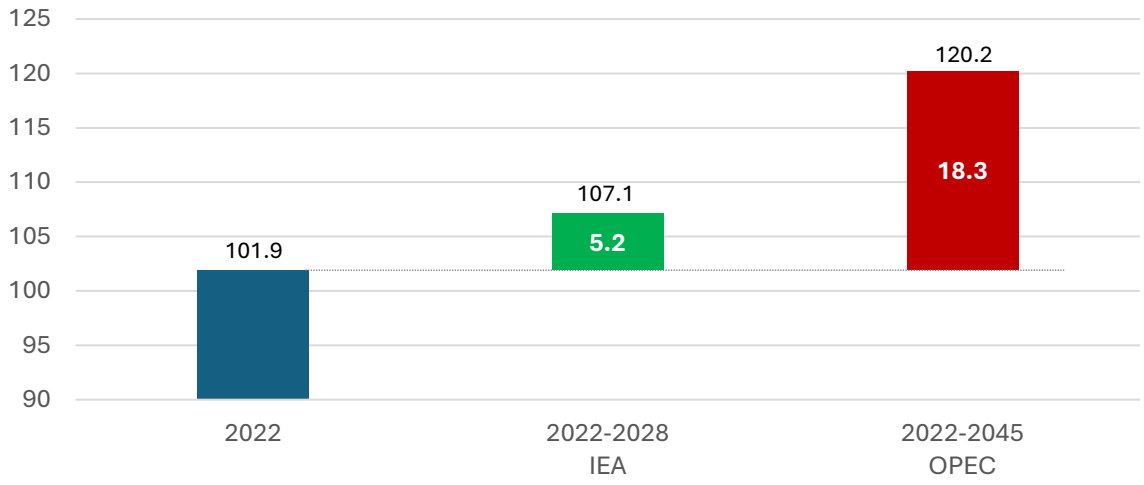


Source: EI and IEA

To estimate the magnitude of investment required, the highest levels of refinery capacity addition projections provided by IEA and OPEC are considered. In the near term, the IEA forecasts a net increase of 5.2 mb/d in capacity additions, while over the longer term, OPEC projects a net increase of 18.3 mb/d. These incremental capacity enhancements are poised to increase global

refining capacity from 102 mb/d in 2022 to 107 mb/d by 2028 and further to 120 mb/d by 2045, as shown in Figure 10.

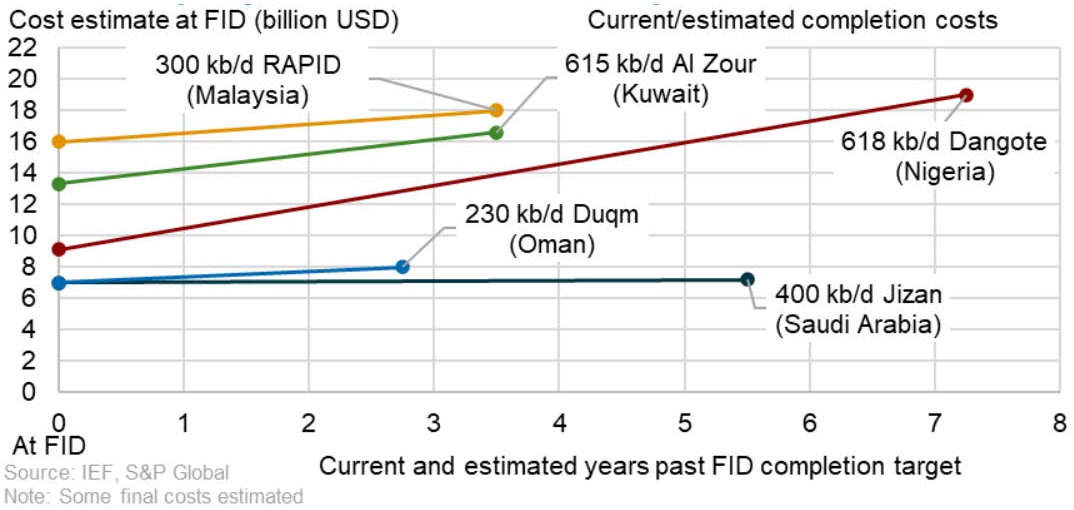
Figure 10: Peak required refinery capacity (mb/d)



Source: APERC analysis based on data from EI, IEA, and OPEC

The level of investment is estimated based on the project costs of new refineries as quoted by the International Energy Forum (IEF) and S&P Global, as depicted in Figure 11. Our assumptions regarding cost estimates fall within the range of the final investment decision (FID) and current or estimated completion costs. The low-cost estimate pertains to the 400 thousand barrels per day (kb/d) Jizan Refinery project in Saudi Arabia, with costs standing at 7 billion USD. Conversely, the high-cost estimate is associated with the 615 kb/d Al Zour Refinery project in Kuwait, totaling 16.5 billion USD. Under these parameters, we derive cumulative investment estimates ranging from US$90 to US$140 billion based on IEA's refinery capacity projections near-term by 2028, and cumulative investment projections ranging from US$320 to US$490 billion between 2022 and 2045 in the long-term forecasts provided by OPEC, as shown in Table 1. Most investment is expected to be front-loaded, driven by high demand for refined products in the near term, particularly before 2028. However, looking towards the longer term, there exists a higher degree of uncertainty regarding demand dynamics. This juxtaposition of strong, near-term demand growth against uncertain longer-term demand outlooks underscores the complexities, or even a reluctance, in decision-making required in investment planning within the refining sector.

Figure 11: Escalating costs and project delay in new refinery projects



Source: IEF and S&P Global

Table 1: Estimated levels of cumulative investment in the refining sector

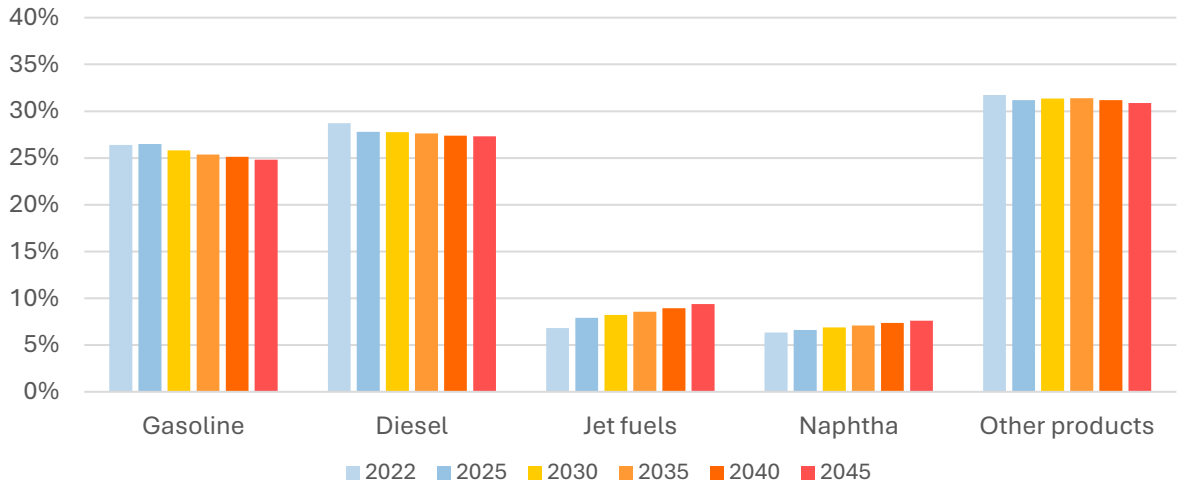
Estimated investment (cumulative)	Net refinery capacity additions (mb/d)	Low-cost estimate (billion USD)	High-cost estimate (billion USD)
2022-2045 OPEC	18.3	320	490
2022-2028 IEA	5.2	90	140

Source: APERC analysis based on data from IEF and S&P Global

3-4 Changing shares of petroleum products consumption can pose another challenge to flexibility of refineries.

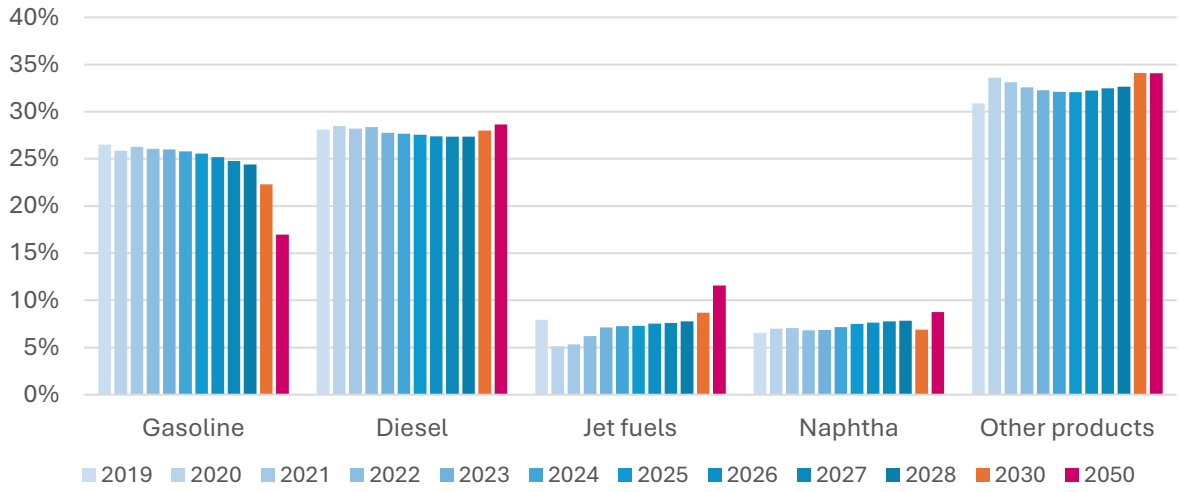
In addition to the discussed requirements for oil refinery capacity additions, the oil refining sector has to proactively anticipate the evolving pattern of petroleum products consumption, driven by various factors including the paces of electric vehicle penetration. Figure 12 to Figure 14 highlight the projected trends in petroleum products consumption up to 2045 and 2050. OPEC in Figure 12 expects the share of gasoline consumption to marginally decrease from 26% to 25%, while diesel's share to slightly drop from 29% to 27%. Conversely, IEA in Figure 13 anticipated a more substantial decline in gasoline share, plummeting from 26% to 18%, while jet fuel's share to double from 6% to 12% by 2050. Meanwhile, APERC in Figure 14 sees a significant decrease in the share of gasoline consumption from 36% to 27%, with that of diesel increasing from 28% to 31%, respectively. It is crucial to recognize that these shifts in the mix of petroleum product consumption may vary significantly from region to region. As such, regional refineries may necessitate additional investments to upgrade their refinery processes, adjust crude oil slates, as well as enhance infrastructures and logistics for different petroleum products to align with these evolving trends. Furthermore, these transformations may present greater challenges for smaller refineries with limited flexibility to adapt to such changes.

Figure 12: Share of petroleum products consumption by OPEC



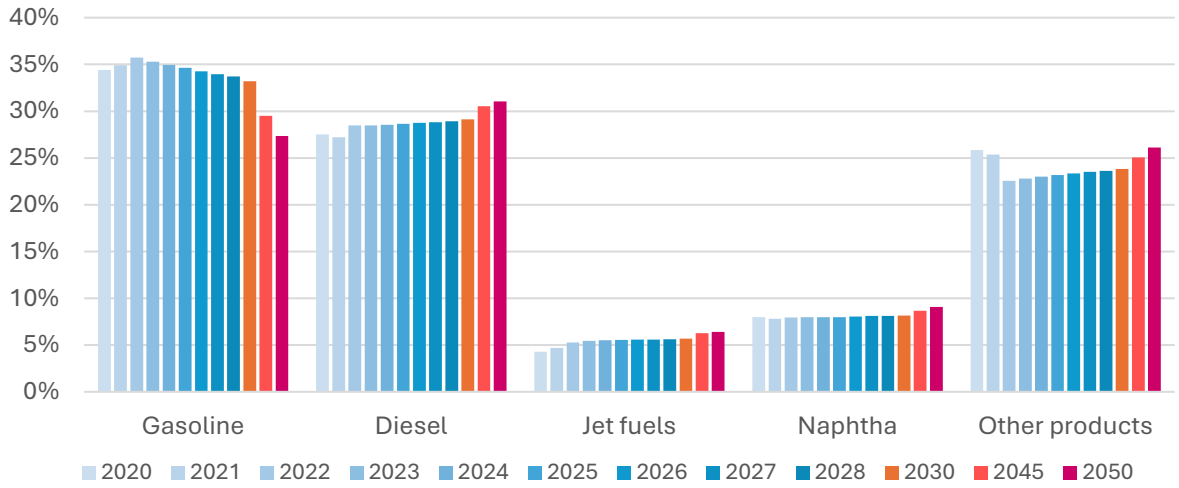
Source: OPEC

Figure 13: Share of petroleum products consumption by IEA



Source: IEA

Figure 14: Share of petroleum products consumption by APERC (Outlook 8th)



Source: EGEDA and APERC

3-5 Other challenges that can impact petroleum products supply security and refinery capacity investment.

In addition to the challenging issues surrounding adequate refinery capacity and the evolving consumption patterns of petroleum products, several critical factors also demand attention. First, it is imperative to recognize that the output of petroleum products from a refinery is typically less than its installed capacity, so called nameplate capacity. Consequently, maintaining spare refinery capacity in comparison to consumption levels becomes essential, allowing for flexibility in responding to unexpected disruption and ensuring the security of petroleum product supply. Second, the investment and construction processes involved in establishing a greenfield refinery or expanding existing capacities entail lengthy lead times exceeding five years. Furthermore, they necessitate a stable margin environment for a period of at least 15-20 years to justify investment. As an illustration, decisions regarding investment in oil refinery projects to avoid a global capacity shortage by 2030 must be taken now at this time. Hence, the significance of making timely decisions regarding refinery capacity investments cannot be overstated. Early investment decisions are crucial not only for meeting future demand but also for mitigating the risk of supply shortages and price volatility in the long term. Lastly, it is crucial to acknowledge that these multi-billion-dollar refinery projects face significant challenges in justifying their viability amidst prevailing unfavorable investment conditions and uncertain future scenarios.

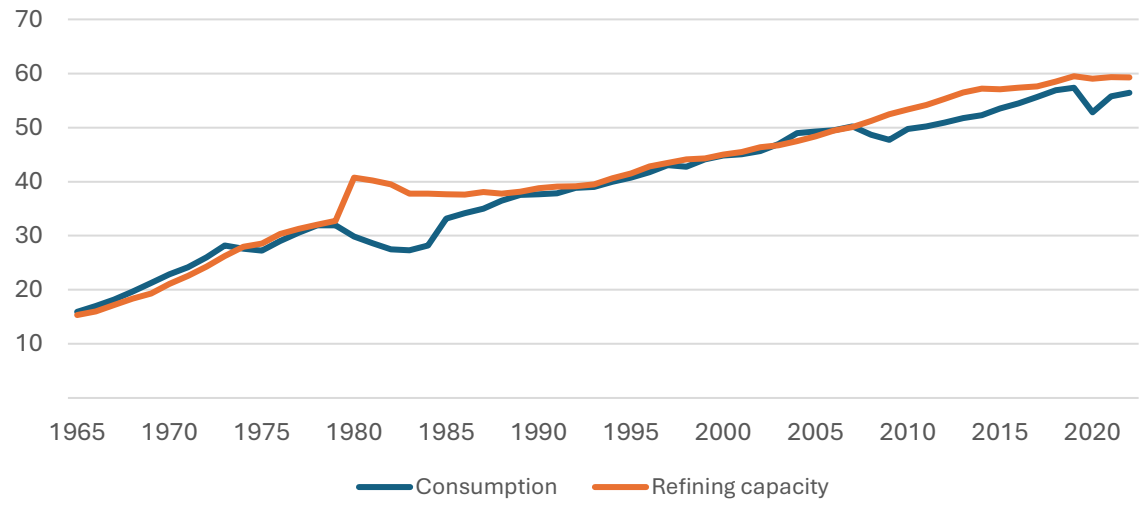
SECTION 4: ASSESSMENT OF PETROLEUM PRODUCTS SUPPLY SECURITY IN APEC SUB-REGIONS

This section delves into supply security issues of petroleum products within APEC and its sub-regions. An examination of historical trends of net petroleum products imports and exports in each sub-region is conducted to pinpoint any potential supply security risks or challenges, particularly in heightened dependency on product imports.

4-1 APEC oil market tightened prior to 2008, preceding a downward shift in consumption that enable it to become a net exporter.

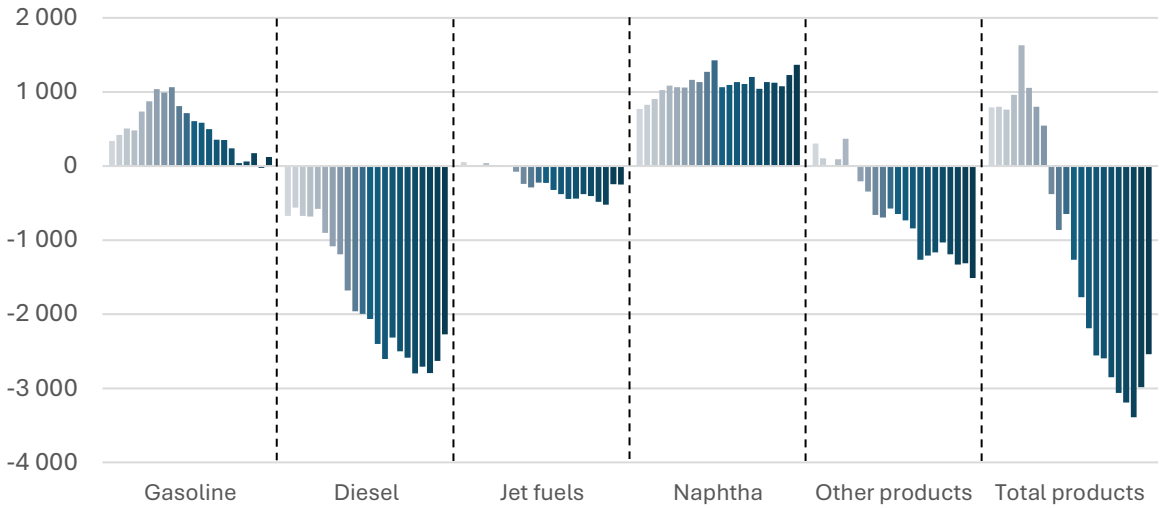
Historical trends of refining capacity and petroleum product consumption of APEC are shown in Figure 15, whereas Figure 16 plots historical net import (+) or net export (-) of each petroleum product from 2000 to 2021, each bar represents a single year. Notably, APEC transitioned from the net importer to being a net exporter of total petroleum products in 2008 after the global financial crisis. However, an examination of individual products reveals diverse trends within the APEC region. For instance, there has been a notable decline in gasoline imports post-2008, indicating a reduced reliance on external sources for this product. Conversely, diesel has emerged as a key export product, with net export quantities exceeding 2,000 kb/d over the past decade. This trend has been predominantly driven by diesel exports from the United States, Russia, and China, despite temporary declines during the COVID-19 pandemic. Of particular interest is APEC's continued dependence on naphtha imports, consistently above 1,000 kb/d, over the past two decades, alongside an increasing trend in the net export of other petroleum products such as fuel oil, petroleum coke, and bitumen. However, a more granular analysis of APEC sub-regions reveals varying degrees of petroleum product supply security.

Figure 15: APEC petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



Excluding Brunei and Papua New Guinea
Source: EI

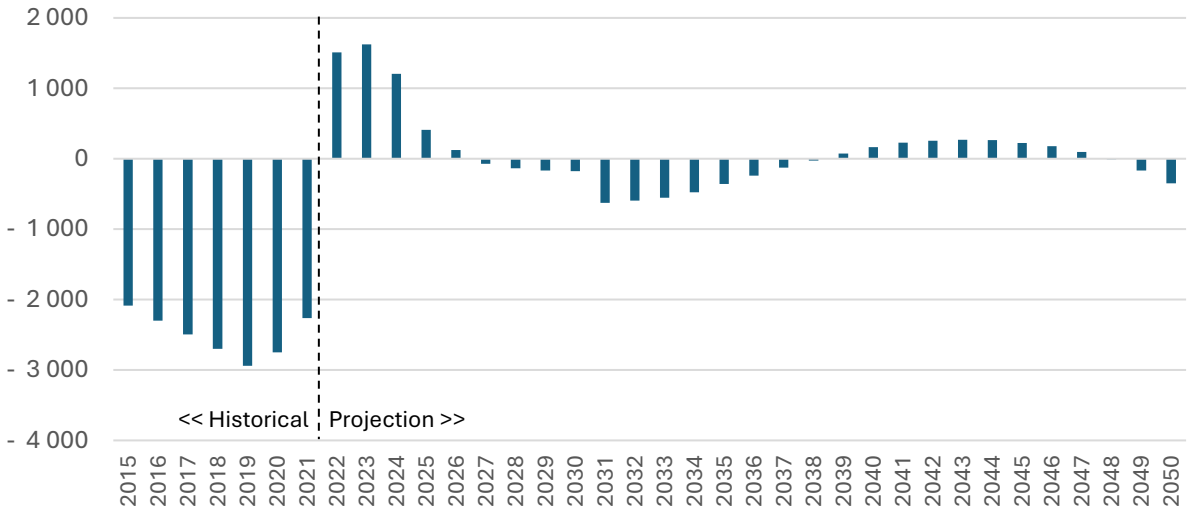
Figure 16: APEC net imports of petroleum products, 2000-2021 (kb/d)



Other products include fuel oil, petroleum coke, bitumen, etc. (excluding LPG)
Source: EGEDA

Looking ahead, it is anticipated that the APEC region's decade-long status as a net exporter of petroleum products will undergo a change. Findings from the Outlook 8th Edition (REF) reveal a decline in net petroleum products exports, primarily driven by escalating demand in China and APEC Southeast Asia sub-region, which outpaces refinery output. Consequently, this trend prompts a surge in imports, as illustrated in Figure 17.

Figure 17: APEC net imports of petroleum products, 2015-2050 (kb/d)



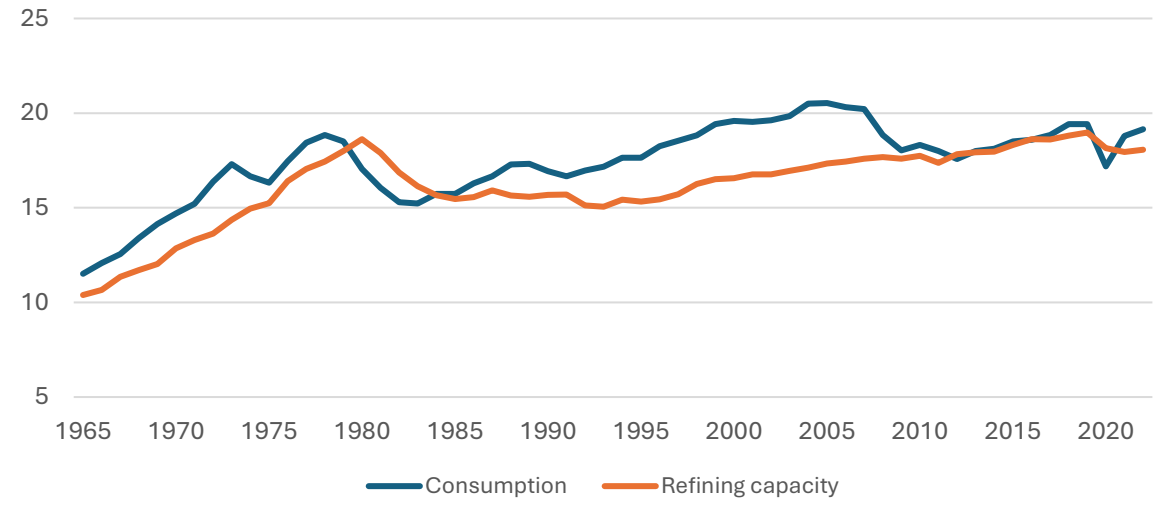
Source: EGEDA and APERC

4-2 The US emerged as a major net product exporter in 2009 due to low energy prices and efficient refineries.

Historically, from 1985 to 2009, the refinery capacity in the US consistently fell short of meeting its consumption, prompting significant reliance on imports. However, the repercussions of the 2007-2008 financial crisis significantly impacted consumption levels, resulting in a marked decrease to a level nearly equal to refinery capacity. At the same time, the US witnessed a consistent

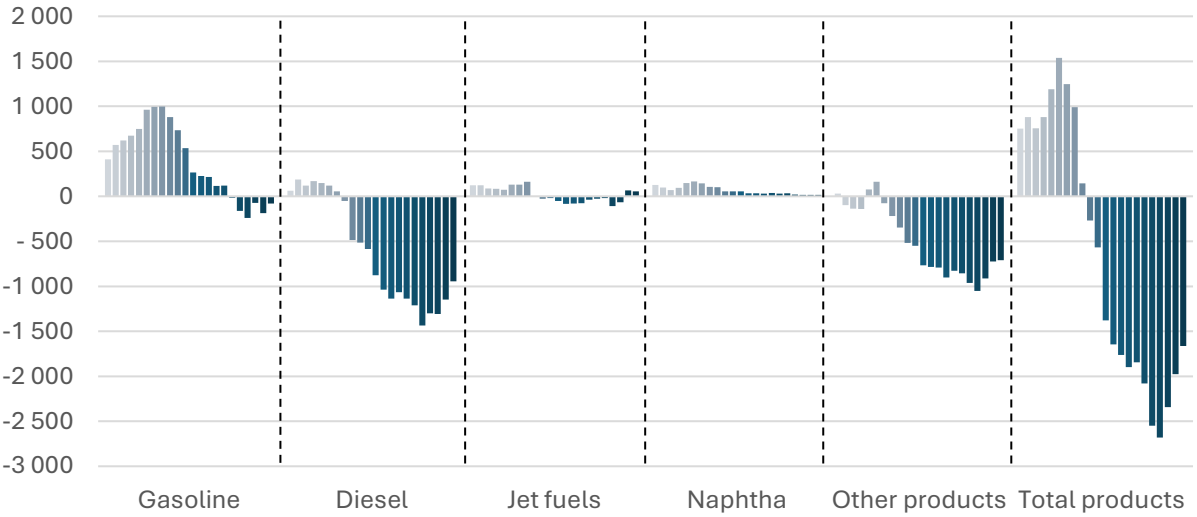
increase in refinery capacity from early 2000 to 2019, moving up from 17 mb/d to 19 mb/d. Decline in consumption and refinery capacity expansion, coupled with robust throughput, markedly bolstered diesel exports. Concurrently, US refineries increased their diesel product yield ratio from 20% to 35%, strategically positioning themselves to capitalize on export opportunities in Europe and other developing economies. This strategic approach enabled substantial growth in diesel and other product exports. Looking ahead, the United States stands poised to maintain its competitive edge as a leading exporter of petroleum products globally, supported by the low production costs of crude oil and natural gas, alongside the efficiency of its refinery sector. As of 2022, the US boasted a refinery capacity of 18.1 mb/d, the largest amongst APEC economies (EI (Energy Institute) 2023). Projection indicates a marginal reduction in US refinery capacity to 17.6 mb/d (IEA (International Energy Agency) 2023). Overall, the US is in a more secure position on future petroleum product supply.

Figure 18: US petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



Source: EI

Figure 19: US net imports of petroleum products, 2000-2021 (kb/d)

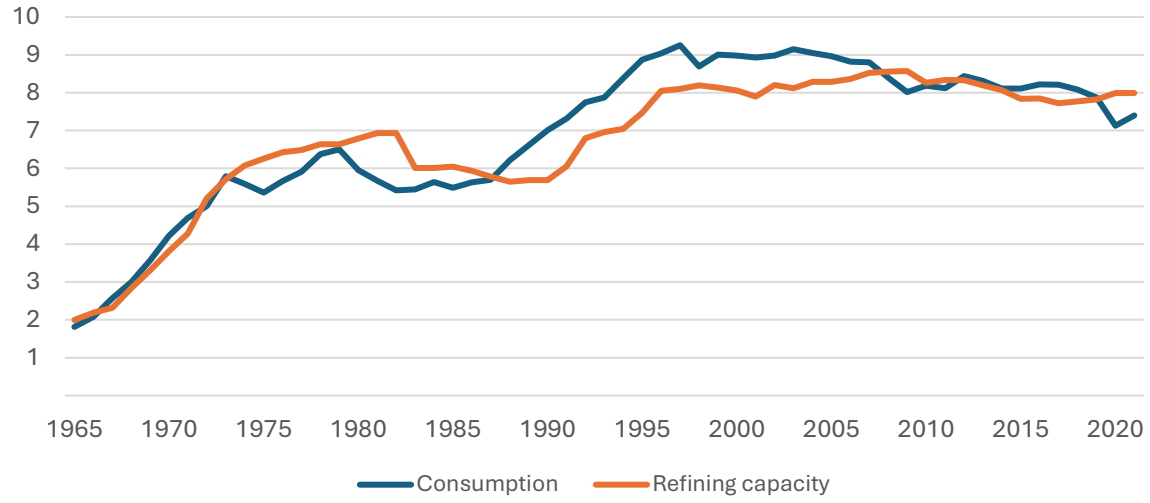


Source: EGEDA

4-3 APEC Northeast Asia and Southeast Asia face different circumstances

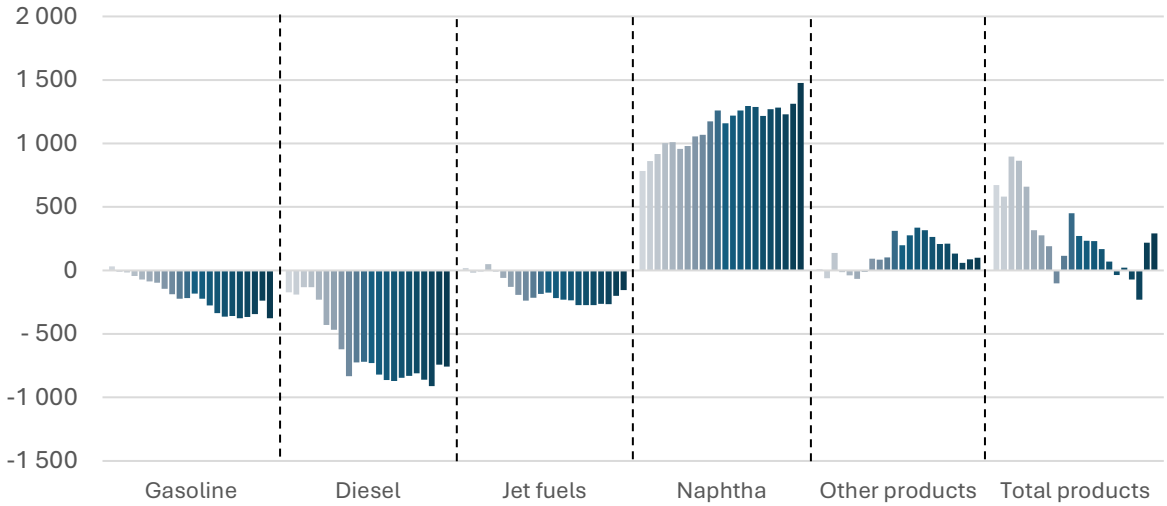
APEC Northeast Asia with a focus on energy efficiency measures has exhibited declining petroleum product consumption starting in 2000, as shown in Figure 20. As the region's refinery capacity has hovered around 8 mb/d since 1995, this has led to an upward trend in gasoline and diesel exports. Nevertheless, APEC Northeast Asia persists in its significant reliance on naphtha imports of more than 1,000 kb/d to supply the petrochemical sector, as shown in Figure 21. In the short term, the net reduction in refinery capacity in APEC Northeast Asia, particularly Japan, may present heightened challenges in ensuring a steady supply of naphtha.

Figure 20: APEC Northeast Asia petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



APEC Northeast Asia includes Hong Kong, China; Japan; Korea; and Chinese Taipei.
Source: EI

Figure 21: APEC Northeast Asia net imports of petroleum products, 2000-2021 (kb/d)

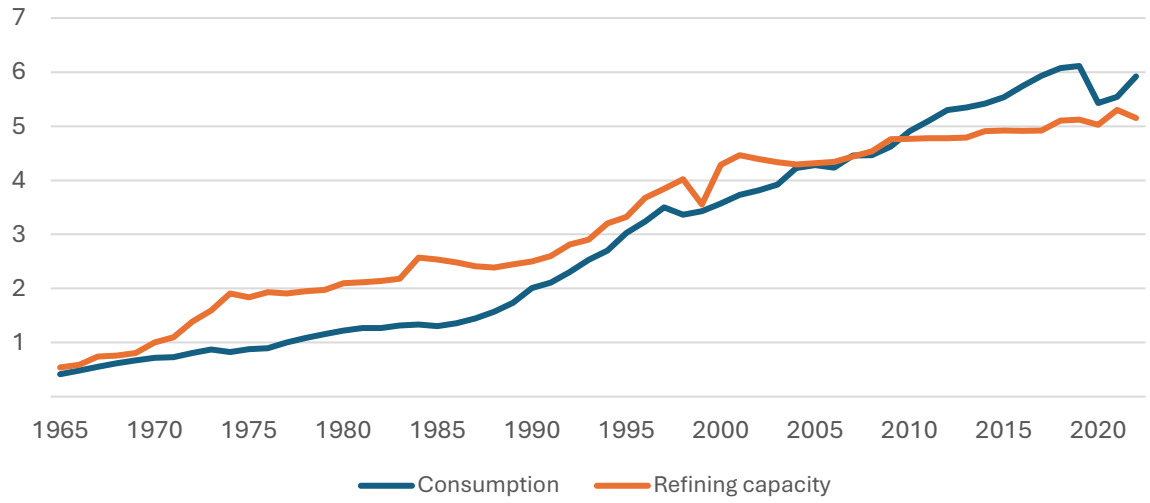


Source: EGEDA

APEC Southeast Asia is heavily dependent on net imports for all petroleum products, except for jet fuel, as seen in Figure 23, owing to a gap between oil consumption and refining capacity growth rates (2.5% versus 0.8% annually from 2010 to 2019), as seen in Figure 22. As consumption began

outpacing refinery capacity around 2010, APEC Southeast Asia's refineries have consistently operated at high utilization rates, coupled with heightened levels of petroleum product imports. With sustained GDP growth projections extending to 2060, APEC Southeast Asia anticipates higher reliance on imports, thereby exacerbating challenges in ensuring petroleum product supply security, unless strategic plans for additional refinery capacity are enacted. Looking ahead to 2025, Thailand stands as the sole economy in APEC Southeast Asia to have announced capacity expansions of 125 kb/d, posing challenges to meeting the region's surging demand with domestic refining capacity in the near term.

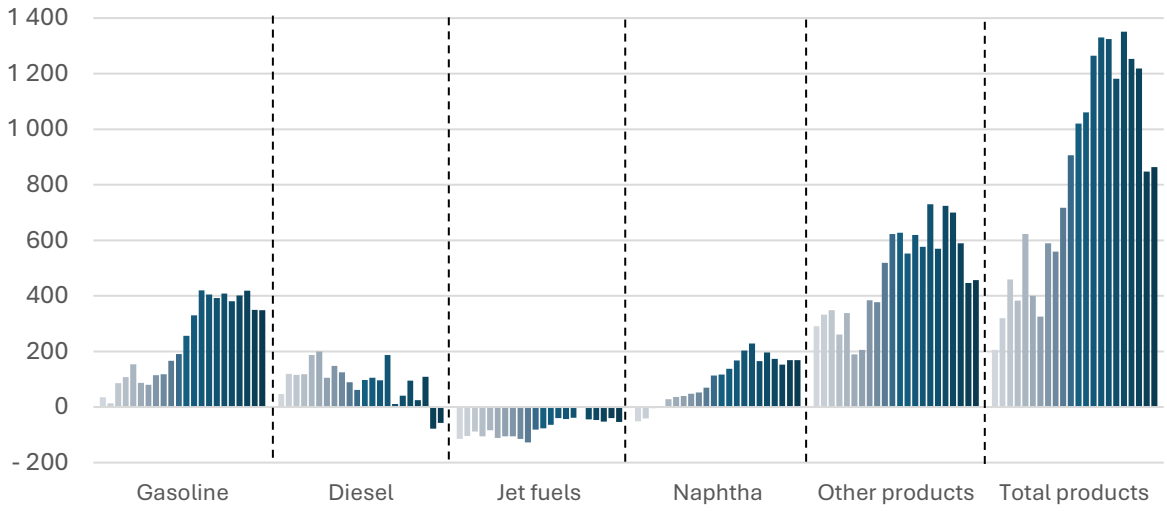
Figure 22: APEC Southeast Asia petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



APEC Southeast Asia includes Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam. In this figure, data for Brunei Darussalam is not included.

Source: EI

Figure 23: APEC Southeast Asia net imports of petroleum products, 2000-2021 (kb/d)



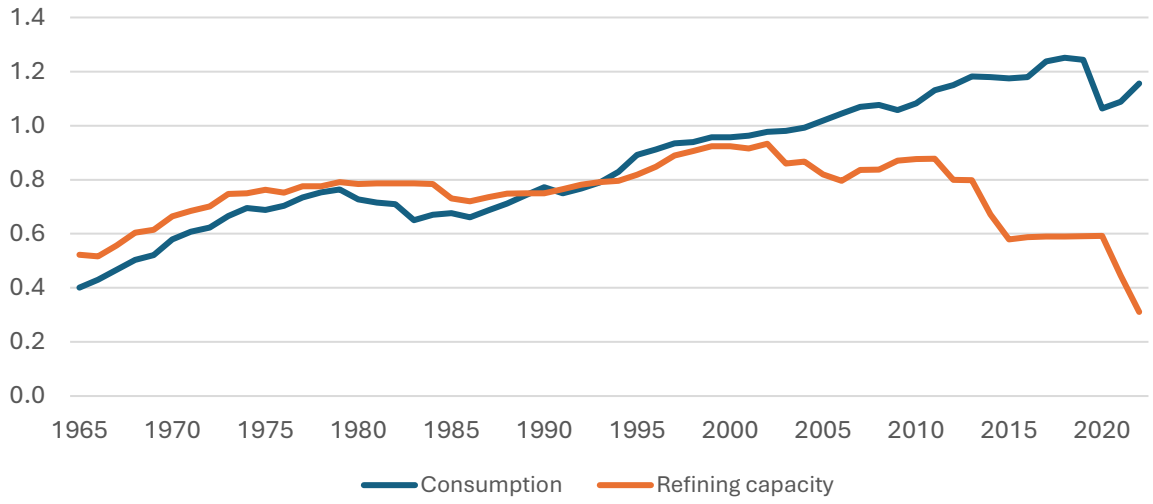
Source: EGEDA

4-4 APEC Oceania and APEC Other Americas are becoming more reliant on imports of petroleum products.

APEC Oceania and APEC Other Americas exhibit notable similarities in petroleum supply security. Firstly, the consumption of petroleum products in both sub-regions has steadily increased over the past 40 years. Secondly, consumption growth has consistently outpaced refining capacity additions since 1990, necessitating a growing reliance on imports for nearly all petroleum products.

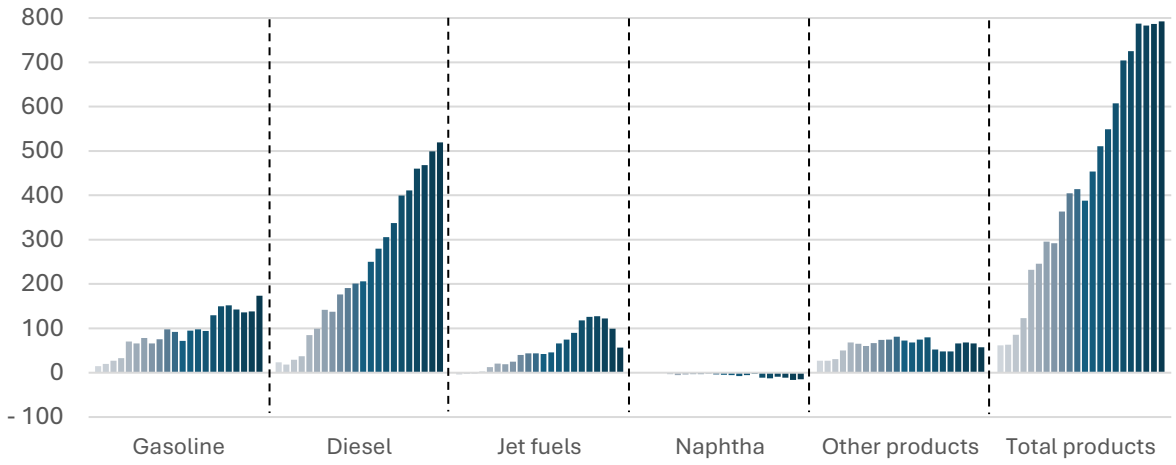
Specifically, Oceania, as depicted in Figure 24 and Figure 25, is experiencing a heightened dependency on imported petroleum products, particularly diesel. Refinery capacity in Oceania has declined by more than half since 2000, reaching just above 300 kb/d (0.3 mb/d) in 2022, while consumption continues to rise to reach more than 1,200 kb/d (1.2 mb/d) prior to the pandemic. Recent closures of refineries in Australia and New Zealand, partly due to the flexibility and cost-effectiveness of importing finished products as opposed to refining crude oil domestically, have further compounded this challenge. Prior to the Covid-19 pandemic, the utilization rate of refineries in the APEC Oceania sub-region consistently exceeded 95%, indicating a significant strain on domestic refining capacity and supply. On the import side, APEC Oceania's total net imports averaged 800 kb/d during the period of 2019-2021, with net diesel imports accounting for 60% of total imports, as shown in Figure 25.

Figure 24: APEC Oceania petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



APEC Oceania includes Australia, New Zealand, and Papua New Guinea
Source: EI

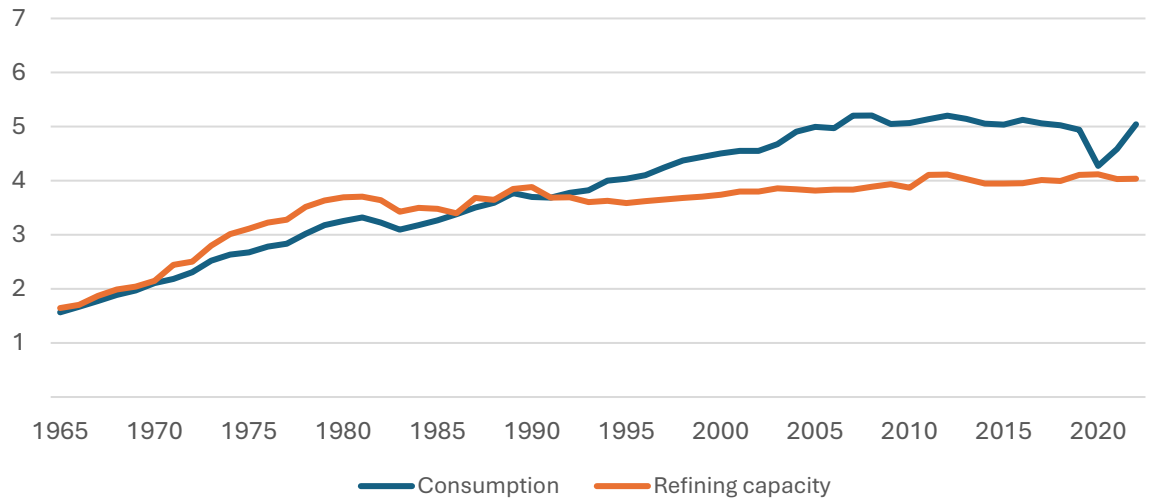
Figure 25: APEC Oceania net imports of petroleum products, 2000-2021 (kb/d)



Source: EGEDA

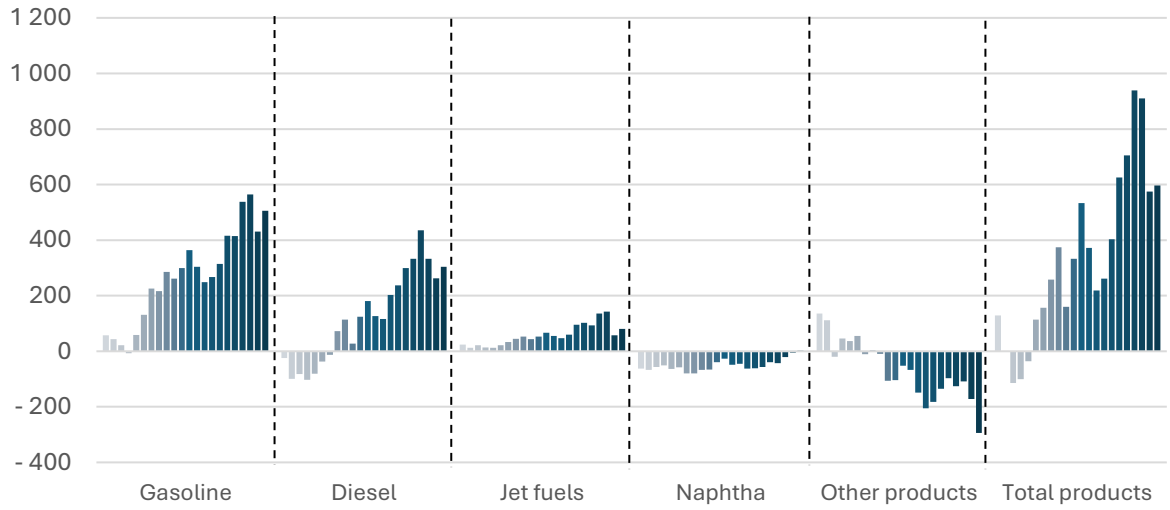
Similarly, in Figure 26, APEC Other Americas are increasingly reliant on gasoline and diesel imports due to limited refinery capacity, which stood at 4 mb/d in 2022, coupled with a low utilization rate averaging 70% across the region. Much like the APEC Oceania sub-region, APEC Other Americas relies significantly on imports of both gasoline and diesel. Gasoline net imports peaked at nearly 600 kb/d in 2019, while diesel reached a peak of 400 kb/d before experiencing a decline during the Covid-19 pandemic. The total net product imports of Other Americas approached nearly 1,000 kb/d in 2018.

Figure 26: Other Americas petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



APEC Other Americas includes Canada, Chile, Mexico, and Peru
Source: EI

Figure 27: Other Americas net imports of petroleum products, 2000-2021 (kb/d)

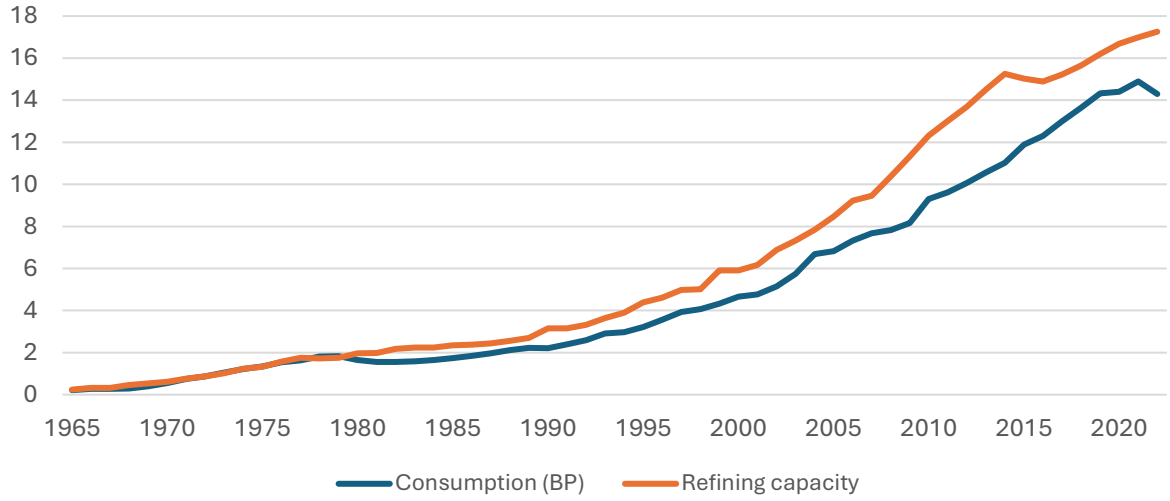


Source: EGEDA

4-5 China is a net exporter of transport fuels but a net importer of naphtha.

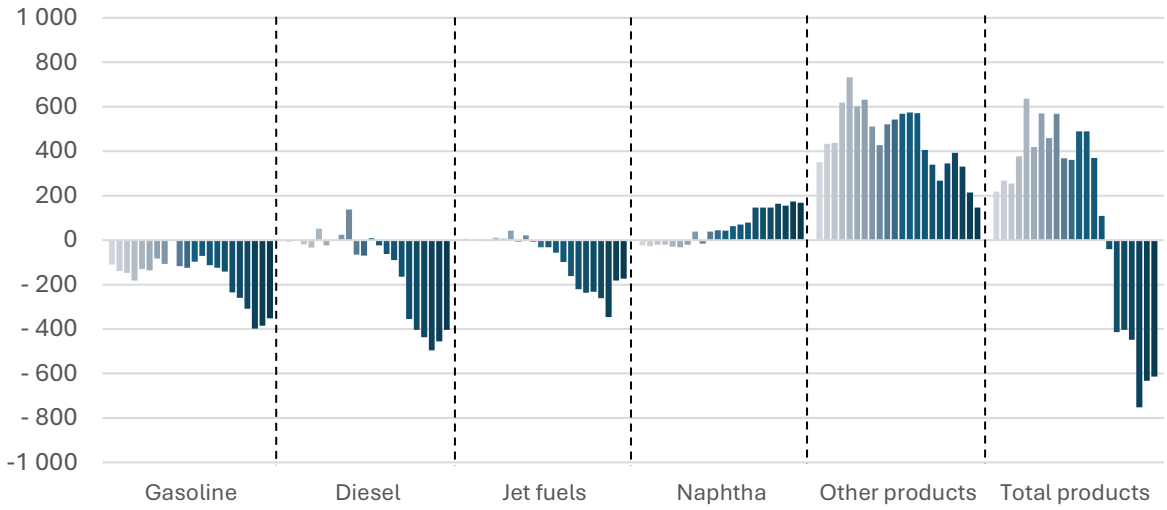
China demonstrates distinctive characteristics in its energy circumstances. Over the past decade, it has emerged as a significant net exporter of petroleum products, notably gasoline, diesel, and jet fuel, in Figure 29. Concurrently, China has emphasized policy measures to become less dependent on imports in Other Products category, notable imports of fuel oil (Figure 29). On the refining front, China's capacity has expanded markedly over the last 20 years, nearly tripling from nearly 6 mb/d in 2000 to 17.3 mb/d by 2022 (Figure 28), second only to the US's 18.1 mb/d. The significant capacity expansions have driven the growth in net exports of transport fuels since 2017, albeit with a temporary decline in 2020-2021. Projections indicate that China's refinery capacity is poised to reach 19.7 mb/d by 2028, surpassing that of any other sub-region within APEC (IEA (International Energy Agency) 2023). Consequently, similar to the United States and Russia, China's current export position and planned refinery capacity expansions position it with relatively lower exposure to petroleum product supply security concerns.

Figure 28: China petroleum products consumption and refinery capacity, 1965-2022 (mb/d)



Source: EI

Figure 29: China net imports of petroleum products, 2000-2021 (kb/d)

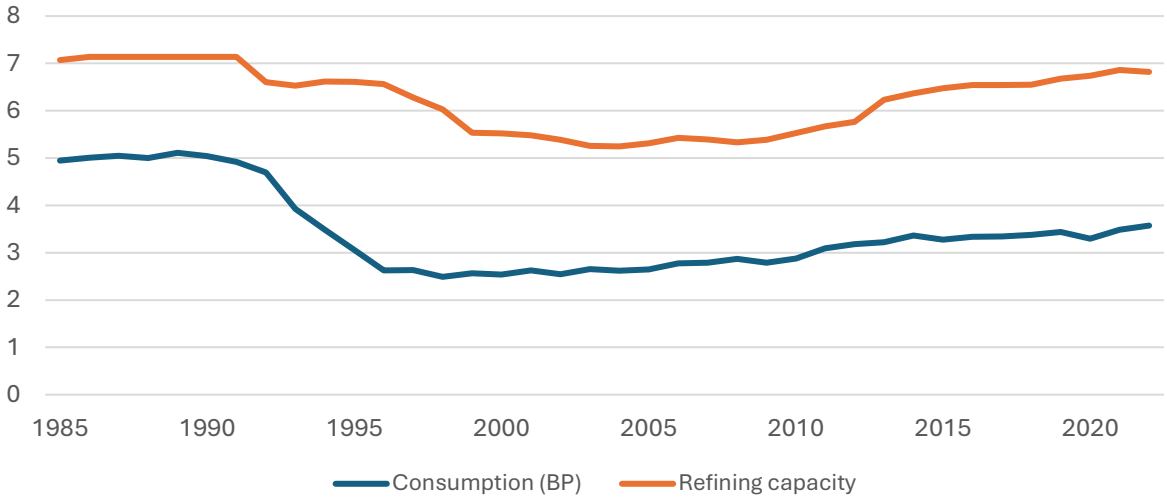


Source: EGEDA

4-6 Russia is a leading exporter of petroleum products.

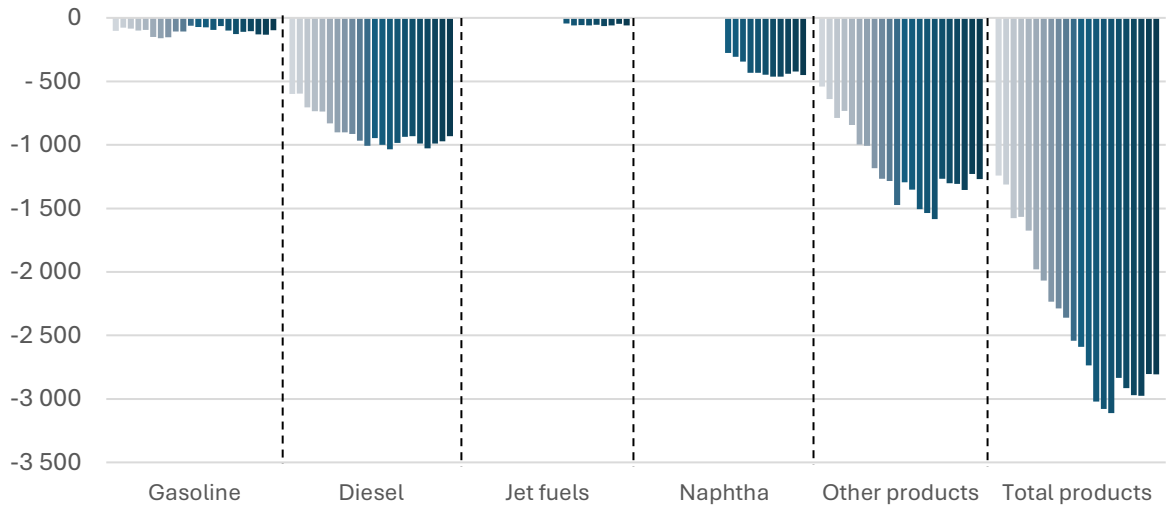
Throughout history, Russia has strengthened its standing as a leading global exporter of petroleum products. Over the past decade, Russia has consistently boasted the highest net total product exports within APEC. Specifically, Russian petroleum product exports surged from 1.2 mb/d in 2000 to almost tripling to 3.1 mb/d by 2015, maintaining a robust level of over 2.5 mb/d over the past decade, highest among APEC sub-regions, as shown in Figure 31. The total refinery capacity in Russia has significantly exceeded domestic consumption. With an extensive refinery capacity of nearly 7 mb/d, coupled with a high yield ratio of diesel, reaching 30% in 2021, and utilizing URALS heavy crude oil, Russia has strategically positioned itself to emphasize diesel exports. This capacity surpasses the domestic consumption of 3.5 mb/d, as seen in Figure 30. Based on announced refinery projects, Russia's refinery capacity is anticipated to remain stable through 2028. Since Russia's current refinery capacity is almost twice its consumption, the future energy security risks for Russia are minimal.

Figure 30: Russia petroleum products consumption and refinery capacity, 1985-2022 (mb/d)



Source: EI

Figure 31: Russia net imports of petroleum products, 2000-2021 (kb/d)

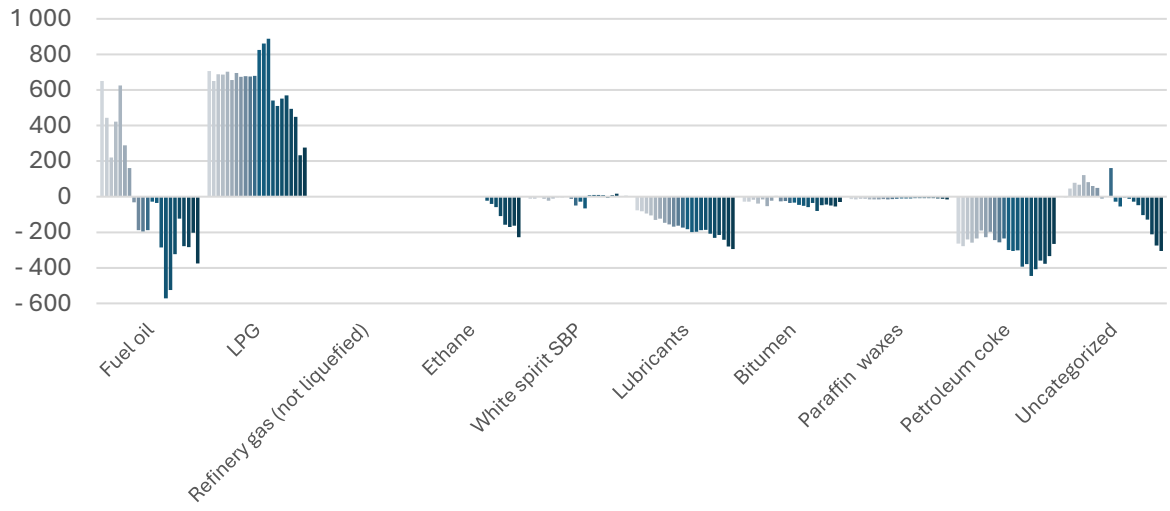


Source: EGEDA

4-7 The importance of net trade of other petroleum products.

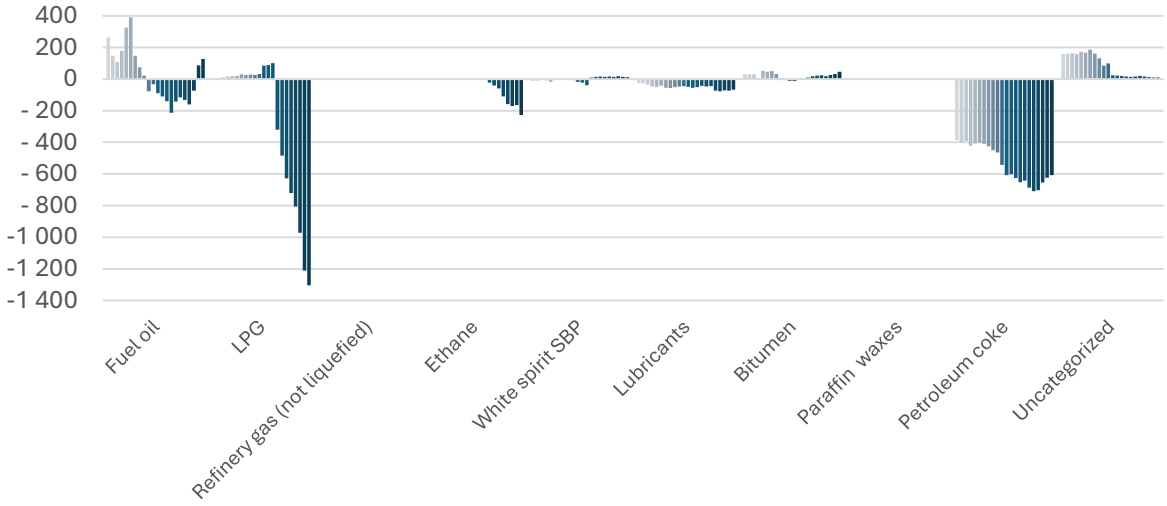
The examination of the *other products* category is imperative for considering the security of supply for specific petroleum products. Figure 32 to Figure 39 provide distinct profiles of net import and export of other products by aggregated APEC and APEC sub-regions, categorized into ten subcategories: fuel oil, LPG, refinery gas, ethane, white spirit, lubricants, bitumen, paraffin waxes, petroleum coke, and uncategorized. In the preceding subsection, LPG is omitted from the other products classification due to its production origin, with 60% from oil refineries and the remaining output sourced from gas processing plants. Furthermore, LPG output represents less than 5% of total refinery output. Thus, we did not consider the supply security of LPG to be solely determined by the operations of oil refineries. In this subsection, APEC member economies are encouraged to scrutinize specific products exhibiting an increasing reliance on imports, such as the case of growing LPG imports in China, APEC Northeast Asia, and APEC Other Americas.

Figure 32: APEC net imports of other products, 2000-2021 (kb/d)



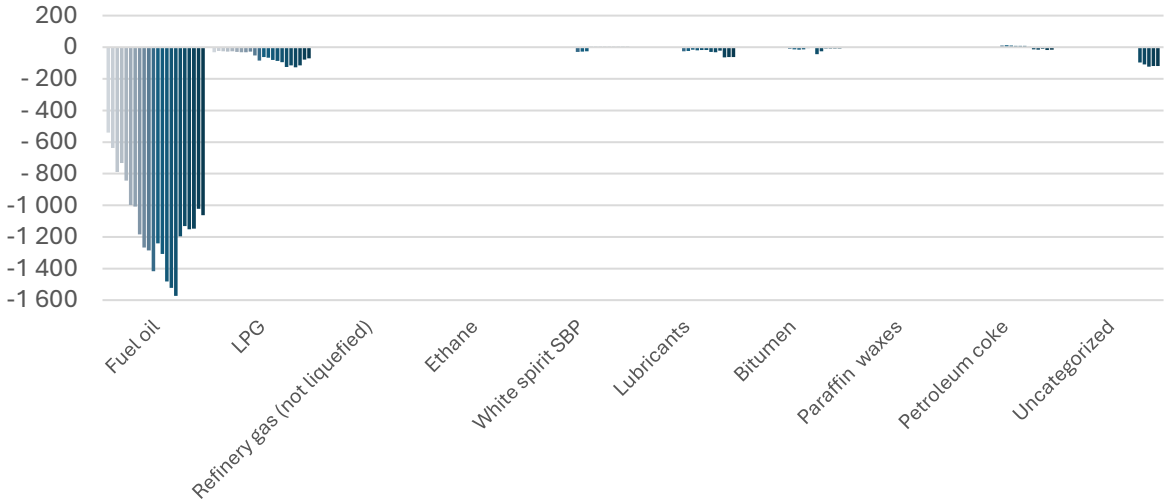
Source: EGEDA

Figure 33: US net imports of other products, 2000-2021 (kb/d)



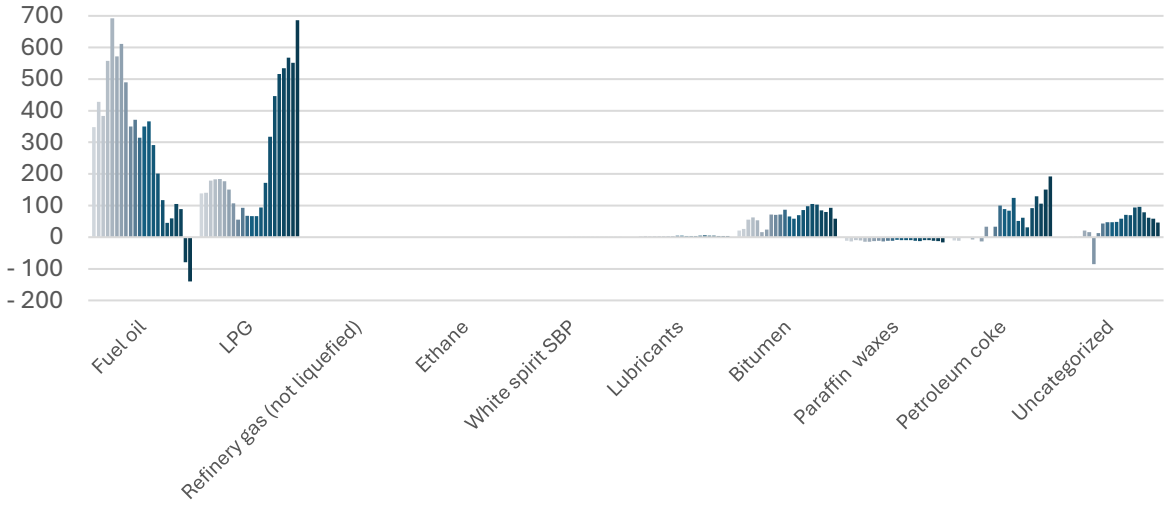
Source: EGEDA

Figure 34: Russia net imports of other products, 2000-2021 (kb/d)



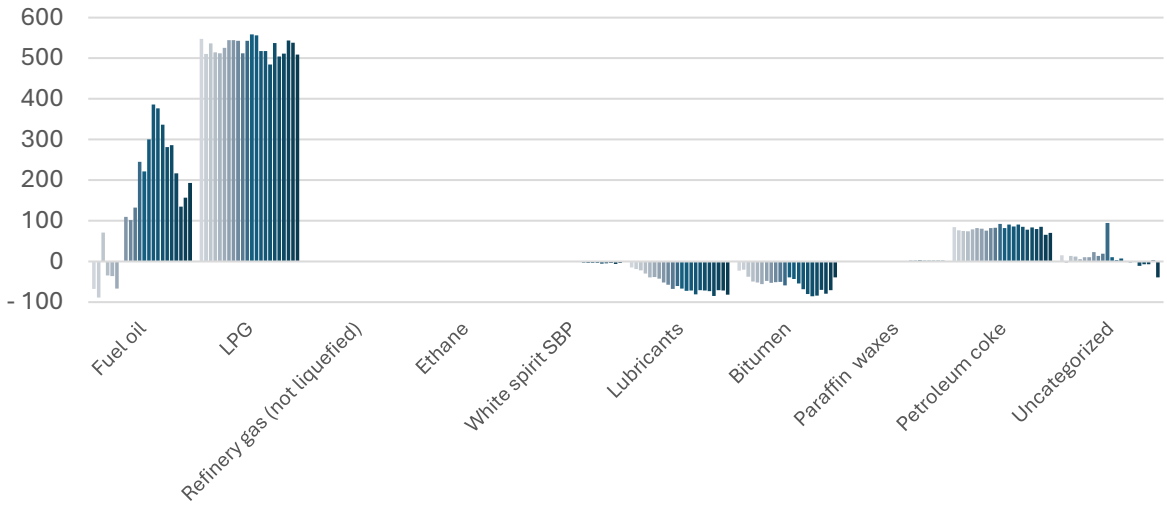
Source: EGEDA

Figure 35: China net imports of other products, 2000-2021 (kb/d)



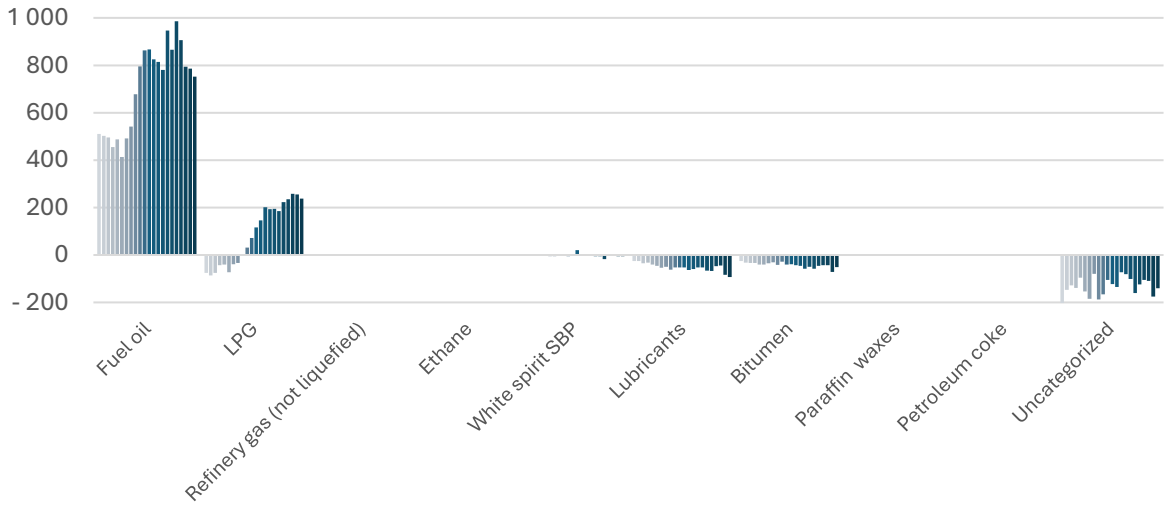
Source: EGEDA

Figure 36: APEC Northeast Asia net imports of other products, 2000-2021 (kb/d)



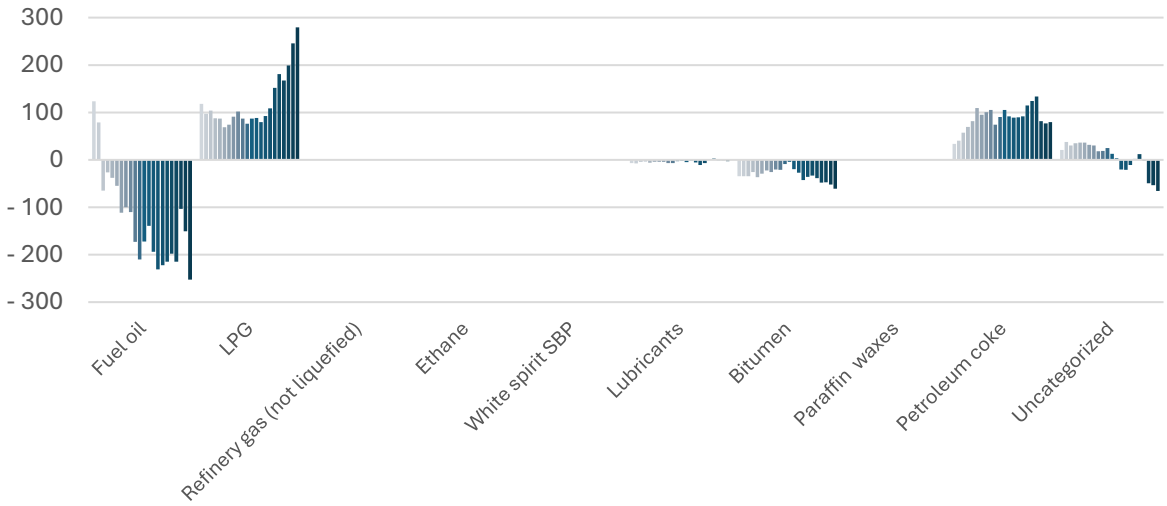
Source: EGEDA

Figure 37: APEC Southeast Asia net imports of other products, 2000-2021 (kb/d)



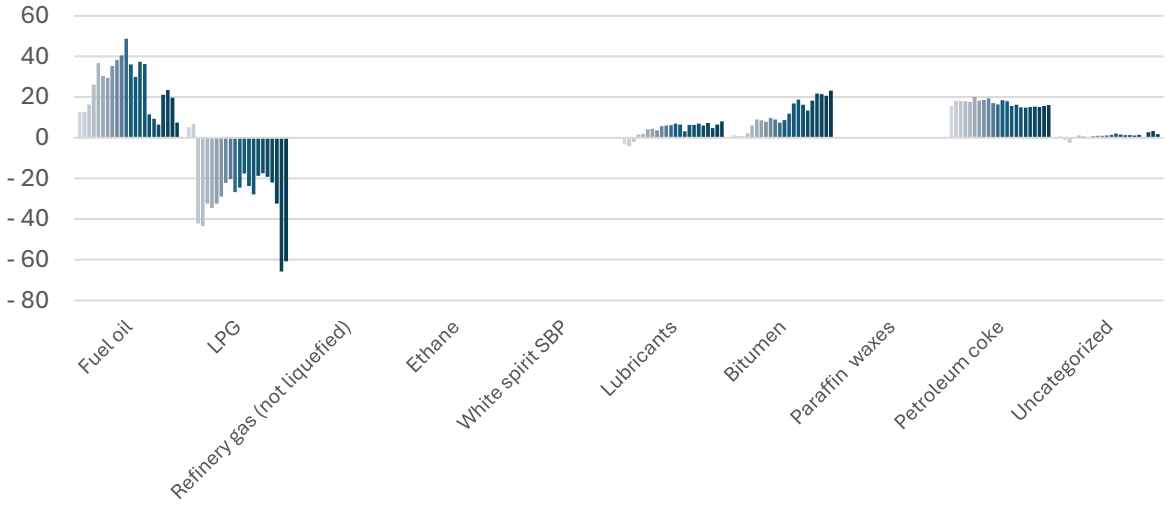
Source: EGEDA

Figure 38: APEC Other Americas net imports of other products, 2000-2021 (kb/d)



Source: EGEDA

Figure 39: APEC Oceania net imports of other products, 2000-2021 (kb/d)



Source: EGEDA

SECTION 5: ASSESSMENT OF PETROLEUM REFINERY UTILIZATION IN APEC SUB-REGIONS

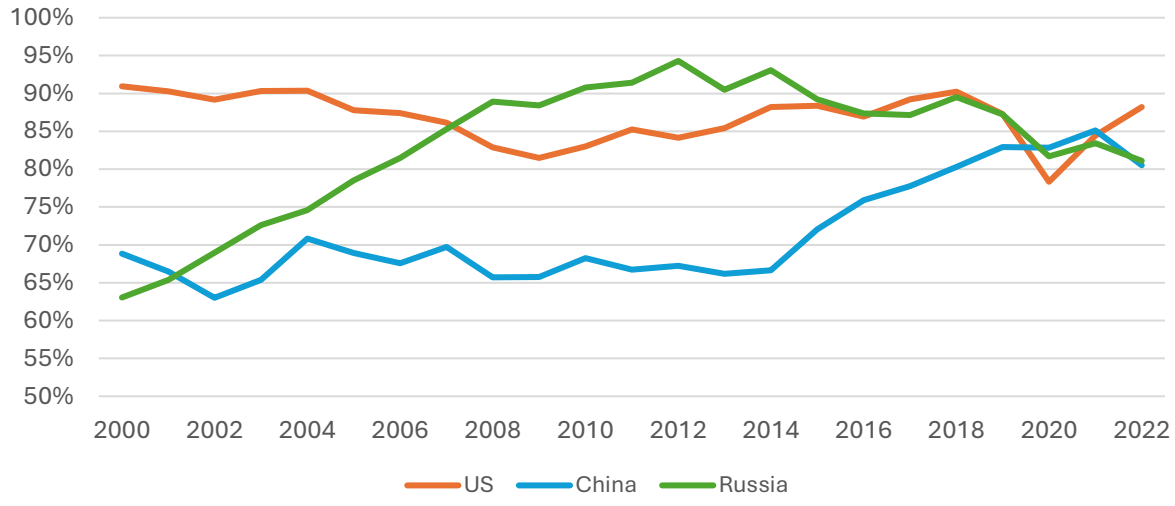
This section examines the current positions regarding the utilization ratio of refineries within the APEC region and its sub-regions. The utilization ratio denotes the proportion of crude oil input to a refinery in relation to its crude oil distillation capacity. This ratio holds significant implications as it reflects the additional capabilities of a refinery to meet future rising demand for petroleum products. A refining sector is considered under strain when the utilization ratio exceeds 80%-90%. In such instances, even minor disruptions in petroleum product supply, such as an emergency shutdown of a major refinery, or even a major unit of a refinery, have the potential to bring about substantial price hikes and product supply risks.

5-1 Refineries in larger APEC sub-regions are already running at high utilization rates.

Total combined refinery capacity of the three largest APEC sub-regions, namely the US, China, and Russia, stood at 42 mb/d, representing over 70% of total APEC refinery capacity and 40% of total global refinery capacity in 2022. Therefore, the present status of refinery utilization rates in these three sub-regions serves as a crucial indicator of both global and APEC-wide petroleum product supply security.

The utilization ratio in the United States, Russia, and China is illustrated in Figure 40. In 2022, refineries in these three sub-regions demonstrated a robust utilization ratio exceeding 80%. Particularly, both the US and Russia have consistently maintained refinery utilization rates above 80% for the past decade. In contrast, China experienced a significant increase in its utilization rate from approximately 65% to 80% between 2014 and 2022. This surge was driven by the need to meet rising demand and capitalize on export opportunities for petroleum products, particularly within the APEC Southeast Asia and APEC Oceania regions. While these high utilization rates are generally required for profitability, they also pose risks for meeting future demands for domestic consumption and exports, especially in the event of an unplanned outage at a major refinery.

Figure 40: US, China, and Russia refinery utilization rates, 2000-2022



Source: APERC analysis based on data from EI

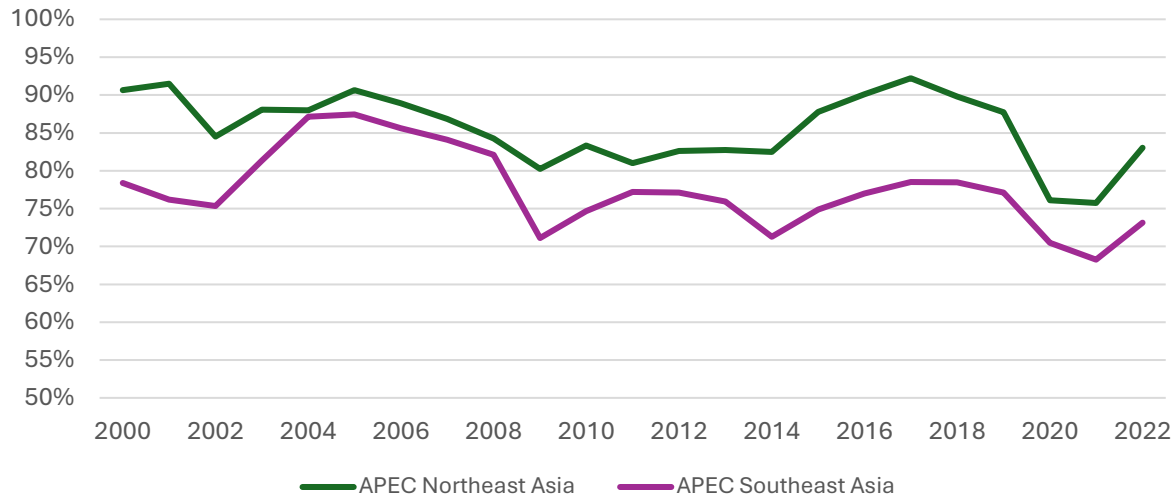
5-2 Divergence of refinery utilization between APEC Northeast Asia and APEC Southeast Asia.

APEC Northeast Asia's refineries have consistently maintained a utilization rate of over 80% for the past two decades, except during the COVID-19. These refineries are highly integrated with petrochemical sectors, particularly naphtha as a petrochemical feedstock. This integration and some refinery closures contributed to sustained high utilization rates, despite declines in consumption. Conversely, the region's refineries present unique challenges due to varying characteristics. The smaller-scale refineries in Japan and Chinese Taipei, in particular, face difficulties in adapting to the anticipated near-term decline in demand for transport fuels. Meanwhile, the larger and more complex refineries in Korea encounter challenges in maintaining competitiveness in exporting petroleum products, given their reliance on crude oil imports and declines in global consumption of transport fuels.

On the other hand, APEC Southeast Asia's refineries operate at a lower utilization rate, standing at 73% in 2022, despite increasing demand and limited capacity additions. As discussed in Section 4, the region is increasingly dependent on imports for all petroleum products except jet fuel. Consequently, the existing low utilization ratio may theoretically offer a degree of supply security in the near term, though this is subject to diminish as the utilization ratio increases.

Conclusively, the contrasting situations in these two sub-regions present challenges amidst future uncertainties in both supply and demand dynamics.

Figure 41: APEC Northeast Asia and APEC Southeast Asia refinery utilization rates, 2000-2022



Source: APERC analysis based on data from EI

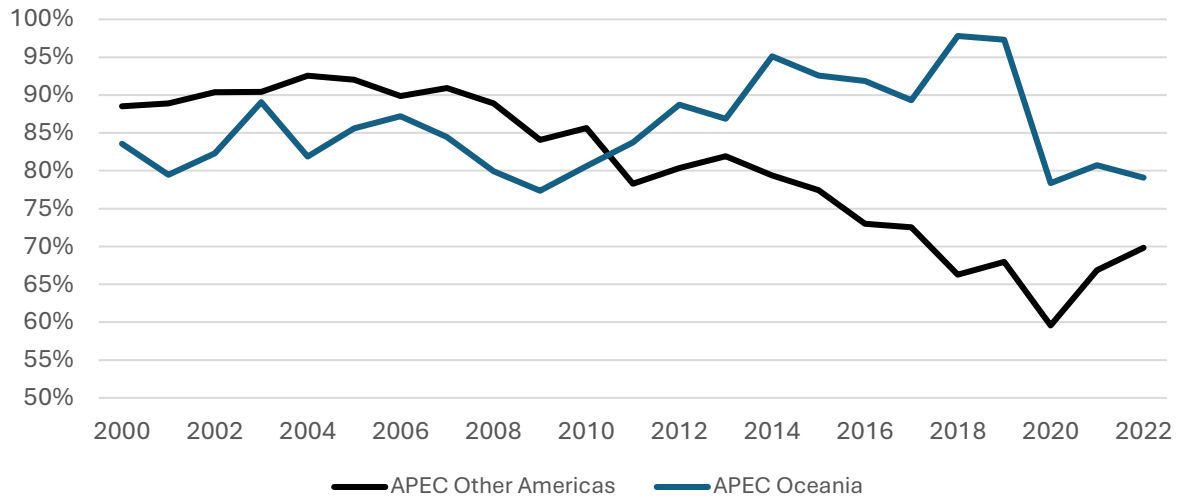
5-3 Different views of refinery sectors in Other America and Oceania.

Unlike other APEC sub-regions, the utilization ratio of the refinery sector in APEC Other Americas has experienced a substantial decline over the past 18 years. This ratio plummeted from 93% in 2004 to below 60% in 2020, despite witnessing relatively constant consumption levels. It then rebounded to 70% post-pandemic (refer to Figure 42). Throughout this period, APEC Other Americas became increasingly dependent on imports of gasoline and diesel, due to competitive pricing offered by US refineries. Despite this trend, refinery capacity remained unchanged, leading to declining output and lower utilization ratios.

Meanwhile, the utilization ratio of refineries in APEC Oceania has consistently remained in the high range, exceeding 80% since 2000. However, the significant closure of refineries within this region emerges as a primary contributing factor to its elevated utilization levels. Notably, petroleum products consumption in Oceania surged by 20% while refinery capacity experienced a drop of almost 70% between 2000 and 2022. Consequently, the utilization ratio of the remaining refining capacity increased to over 95% before the onset of the Covid-19.

In summary, these two APEC sub-regions illustrate a common challenge concerning the security of petroleum product supply, characterized by heavy reliance on product imports. However, they exhibit distinct profiles in terms of their respective domestic refining sectors.

Figure 42: APEC Other Americas and APEC Oceania refinery utilization rates, 2000-2022



Source: APERC analysis based on data from EI

SECTION 6: CONCLUSIONS AND RECOMMENDATIONS

6-1 Conclusions

1) Spare refining capacity has been declining in APEC and the rest of the world for 40 years.

As petroleum products maintain their pivotal roles in the global energy transition, it becomes increasingly evident that recent global refinery capacity has failed to match the rising consumption levels. This discrepancy is underscored by the declining global refining capacity relative to consumption, raising concerns regarding supply security. This situation is examined in Section 2-1.

2) Low spare refining capacity increases petroleum product price volatility and degrades energy security.

The impacts of the global refinery capacity constraints preceding and during the Ukraine crisis are underscored in Section 2-2. Notably, the average 'crack spreads'—the differentials between spot product prices and crude oil prices—of diesel and gasoline in the US Gulf Coast during 2022-2023 surged nearly fourfold compared to historical averages. A parallel trend was observed in the Singapore market, where crack spreads for diesel and gasoline similarly reflected the influence of constrained global refinery capacity during this timeframe.

3) Uncertainty about long term petroleum product demand increases the riskiness of additional refinery investments.

OPEC, IEA, and APERC 8th Outlook-REF anticipated growth in petroleum product consumption, at least in the near term. Specifically, OPEC expects continued growth extending to 2045, whereas projections from IEA show a rapid decline and APERC anticipates a moderate decline. These different outlooks, as examined in Section 3-1, reflect uncertainty and risk to ongoing and anticipated investment in oil refinery infrastructure which typically requires substantial upfront capital requirements and long lead time of secured and stable returns to justify their viability.

4) If petroleum product demand increases in the near term, creating spare refining capacity will require substantial capital investments.

To increase global refinery capacity in accordance with both the near-term projection from IEA and longer term from OPEC, net additional capacity of 5.2 mb/d and 18.3 mb/d need to be built and in operation by 2028 and 2045, respectively. This required investment is challenging given current uncertainties regarding future consumption trajectories, compounded by high interest rates and other investment hurdles. Section 3-2 provides a comprehensive analysis of these requisite investments in refinery capacity.

5) Changes in the relative consumption shares of different petroleum products exacerbate those security risks.

Economic growth and recent decarbonization initiatives have resulted in changes in consumption shares of petroleum products. Section 3-3 provides an in-dept assessment of these changes. Consumption of gasoline, for example, is declining in many economies relative to diesel use as a result of increased electrical vehicles. Conversely, consumption of jet fuel is expected to increase due to growing GDP and increased air transportation activity. These changes underscore potential petroleum product supply risks, as refineries are often constrained to specific product lines.

Addressing these shifts may necessitate significant investments to adapt production processes, a decision that is difficult given the uncertain outlook for petroleum product demand.

6-2 Recommendations

The following are recommended measures that APEC economies could consider to enhance their security of petroleum products supply during the energy transition. These measures should be viewed in conjunction with policy directives and implementation plans aimed at achieving decarbonization targets specific to each economy, while considering the diverse pathways to decarbonization.

1) APEC economies should evaluate how low spare refining capacity affects their energy security.

Depending on specific circumstances and business environments, each economy should evaluate its spare refining capacity to safeguard its supply security. For example, an economy experiencing rapid GDP growth and projecting increased petroleum products consumption may require higher spare domestic refining capacity compared to a more developed economy with robust energy efficiency measures and less dependence on petroleum products.

2) The evaluation is especially important for import dependent economies.

The importance of having spare refining capacity is more pronounced in import-dependent economies, especially those experiencing rapid growth. Increasing global demand of petroleum products, coupling with tight refining capacity in the near term, amplify the risks of supply security, especially for economies dependent on crude oil and petroleum product imports.

3) Strategic petroleum product reserves can help with localized and/or short-term supply emergencies but are expensive to maintain.

Strategic petroleum product reserves can provide supply security and alleviate supply disruptions, but for a limited period when contrasted with spare refining capacity. Moreover, the maintenance of strategic petroleum reserves entails significant costs, especially in the current price volatilities.

4) Spare refining capacity is better for longer term disruptions and/or market changes.

Ensuring an adequate level of spare refinery capacity, ideally with capability and flexibility to adapt to future changes in consumption patterns, can enhance supply security and minimize risk exposures for long term disruptions and market fluctuation. An example includes a spare refining capacity that is equipped to transition towards the production of more promising products, such as petrochemical feedstocks or biofuels, while simultaneously ensuring supply security of conventional products in the near term.

5) APEC governments should explore ways to reduce the financial risks of new refinery investments.

APEC governments possess numerous avenues through which they can encourage or incentivize the expansion of their oil refining sector to provide more security of supply. As evidenced by some economies of APEC, such incentives may include the promotion of petrochemical industries to retain and invest in upgrading of existing refineries, thereby enabling them to provide security of supply and ensuring the sustained viability of these facilities over the long term. Other financial

incentives such as a special tax-exemption on upgrading of existing with promising potential could also be considered.

6) Government-owned oil companies may be better positioned than private companies to create spare refining capacity.

Government-owned oil companies may help investing in additional refinery capacity with lower required hurdle rates with a justification based on energy supply security. This consideration gains significance, especially within economies boasting robust domestic crude oil production, underpinned by efficient price-transfer mechanisms or seamless integration between upstream and refining sectors. Moreover, it holds relevance in economies marked by relationships between state-owned or public-private-owned refining entities and the petrochemical sectors.

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