Oil Refining Industry Insights

Stretched Sector Fuels Market Volatility

A Report by the International Energy Forum
and S&P Global

September 2022

IEF S&P Global

INTERNATIONAL ENERGY FORUM

S&P Global

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The International Energy Forum (IEF) is the world's largest international organization of energy ministers from 71 countries and includes both producing and consuming nations. The IEF has a broad mandate to examine all energy issues including oil and gas, clean and renewable energy, sustainability, energy transitions and new technologies, data transparency, and energy access. Through the Forum and its associated events, officials, industry executives, and other experts engage in a dialogue of increasing importance to global energy security and sustainability.

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Executive Summary

Short-term dynamics

- Global refining capacity declined for the first time in 20 years in 2020, and again in 2021 as the pandemic weakened margins, accelerated refinery closures, and motivated conversions to biofuels or distribution terminals. A record 3.8 million barrels per day (mb/d) of gross atmospheric crude distillation capacity closed between 2020 and mid-2022.
- Constricted crude distillation capacity and reduced petroleum product exports from Russia and China have driven refinery margins to record levels. Product markets are currently fraught as refinery utilization across most regions are at maximum, inventories are low, and new capacity is months or years away. Refining margins for key products ballooned in the summer of 2022 to a record $35-50/bbl compared to the normal $10/bbl – underscoring the severe bottlenecks in the sector.
- Russia and China are the primary two countries that have available refining capacity, but sanctions limit Russia's exports and domestic policies limit China's. Russia was the world's largest exporter of fuel oil and heavy feedstocks, but sanctions and embargos have displaced nearly 3 mb/d of products that are not easily rerouted. Chinese product exports are down 30% from 2019 levels as the government has strategically shifted to prioritizing domestic markets.
- Product markets will likely remain very tight until mid-decade. More than 2 mb/d in net capacity is scheduled to come online by end-2023, but history shows delays and operational challenges could stall progress. These are likely the last major, greenfield, fuel-oriented, refineries to be built as the energy transition will limit the need for conventional refinery capacity in the future.
- In both the short-term and medium-term, the balance for fuel markets will be fragile. Any unexpected, prolonged refinery outage could cause high and volatile prices. There will not be significant extra capacity, nor any significant projects coming online. This underscores the need to maintain robust inventories and contingency plans for supplies.

Medium-term outlook

- High refining margins in the past led to more investment, but that is not occurring now. The expectation that the energy transition could make refineries stranded assets has deterred investment. The last major greenfield fuel refineries are likely FID'd and will come onstream in the next few years.
- Downstream refining capital expenditures will need to reach $190 bn through 2030 for upgrades to refining capacity, petrochemical feedstock buildouts, and sustaining existing assets. This is down nearly 50% from pre-COVID levels and will likely be met. Meanwhile, investments in petrochemical complexes and downstream decarbonization efforts are set to rise.

- Only 2.3 mb/d of net CDU capacity will come online between 2022-2027. The added capacity will be concentrated east of Suez. Capacity will shift geographically to better reflect global consumption patterns.
- The energy transitions and decarbonization policies will mean the downstream sector will need to reduce yields of traditional hydrocarbon transportation fuels and increase petrochemicals.
- Passenger EV sales are forecast to rise sharply in the upcoming years as policy support continues, the cost of EV manufacturing declines, and more EV models come to market. Plug-in vehicle sales are forecast to grow from 6.6 million in 2021, to 35.7 million in 2030. This is expected to replace 4 mb/d of gasoline and diesel demand by the end of the decade, and cause hydrocarbon fuels' share of transportation fuel consumption to plateau by 2028.
- Refineries have become larger in size, more efficient, complex, and competitive. More than 65% of the capacity additions over the next decade will add at least 300 thousand barrels per day (kb/d) in capacity. Mega, integrated refining-and-petrochemical plants have been the most resilient in recent years, due to their flexibility and scale.
- The last standing refineries will be efficient and highly integrated complexes that leverage decarbonization technologies and digitalization. Investors will look beyond the current asset use for how it can be repurposed for the transition. Downstream assets will be valued for the potential for hydrogen, green fuels, and CCUS, even if, in some cases, they do not achieve strong profit or performance in traditional fuel markets.

Introduction: Turbulent Energy Markets

Energy demand and supply have been rocked on a global scale over the past two years. COVID-19 created a global demand shock that sank crude and petroleum product prices to new lows. Then as pandemic lockdown policies waned, demand recovered strongly and was immediately met with a supply-side shock; initially as producers scrambled to ramp capacity back up, then as sanctions and embargos impacted Russian energy production following Moscow's invasion of Ukraine.

Crude oil and downstream markets are often influenced by global factors. Today, geopolitical, economic, and policy outcomes are highly uncertain and are complicating and delaying energy markets from finding balance. Energy security has made a sudden comeback to the forefront of policy concerns. The current crises accentuate the need for governments to strike a delicate balance between accelerating the energy transition for tomorrow and ensuring adequate energy supplies needed today.

The energy transition has and will continue to restructure the landscape and business model for the oil and gas upstream and downstream sectors. Demand growth will shift from hydrocarbon-based transportation fuels toward petrochemicals and biofuels along new trade routes. Investments adapting to these future changes need to be strategic and cater to evolving demand trends.

This report focuses on the position of the downstream refining sector in today's disrupted energy environment and how fundamentals will evolve in the short- and medium-term. We also examine the hurdles for investment through 2030 and how the energy transition is reshaping the downstream business model.

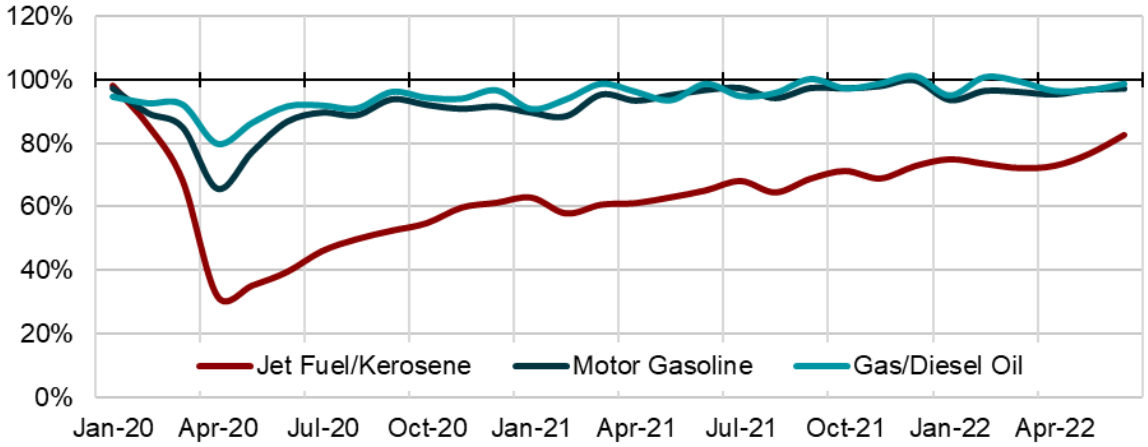
Current State of Play: Refineries Running at Full-Tilt

Demand has recovered from COVID-19

Global oil demand has largely rebounded from the COVID-induced drop. However, the recovery has been asynchronous across regions and fuel types. China's COVID-zero policy has resulted in significant lockdowns off and on in 2022 while many other countries have removed barriers to travel. Global jet fuel demand remains ~15% below pre-COVID levels while gasoline, diesel, and LPG demand are at or above pre-pandemic quantities.

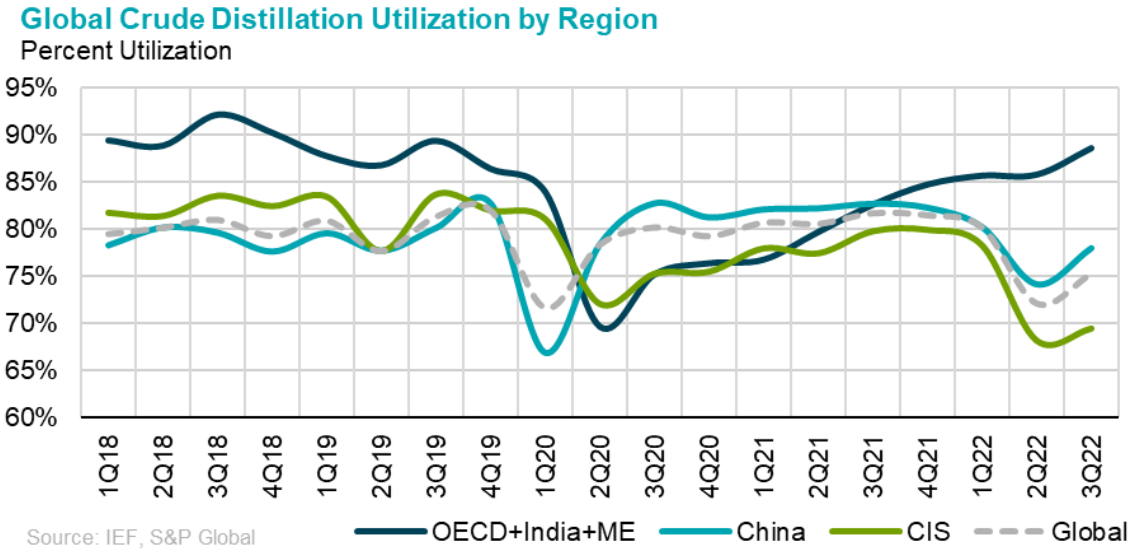
Global Product Demand vs. 2019 Levels

Percent of 2019 demand



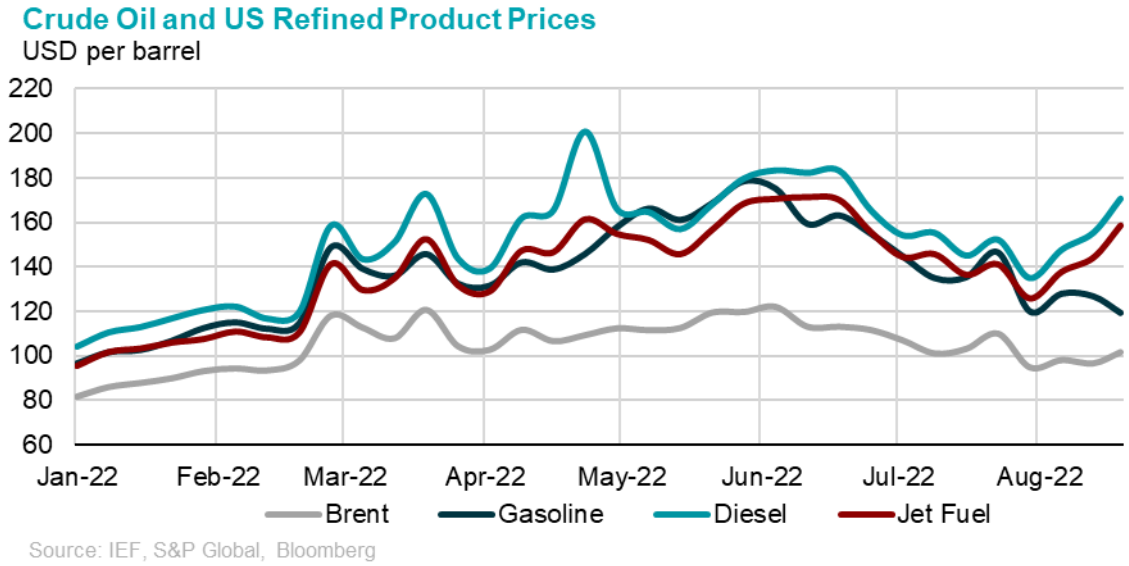
Source: IEF, S&P Global

The global refining system was relatively well utilized in 2018-19 before the pandemic. Since March 2020, global refining capacity has fallen by 3.8 mb/d, while global demand has grown by 5.6 mb/d. This puts pressure on all available refining capacity to run at high utilization levels to keep up with demand.

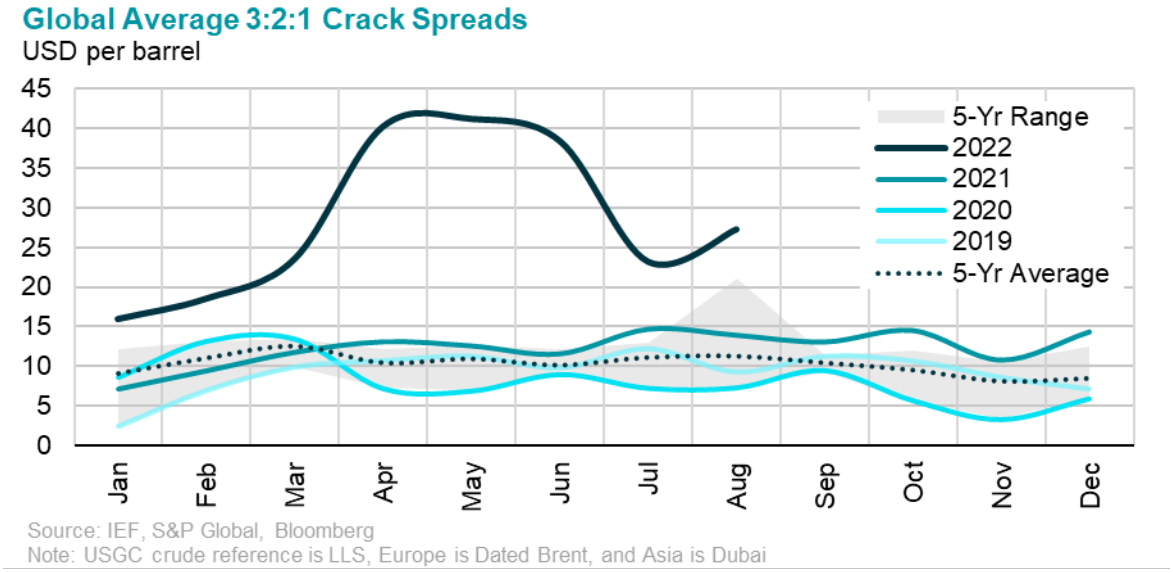


Product prices are rising faster than crude prices

Tightness in global refining capacity, low inventories, and continued strong demand are pushing petroleum product prices higher relative to crude oil prices.



As a result, refining margins (commonly associated with product “crack” spreads) ballooned to record levels in 2Q2022 and were three to five times higher than the five-year average. Margins have partially retreated since early-July on deteriorating economic outlooks but remain two to three times above the five-year average. There is every economic incentive to produce more product, but there simply is little available refining capacity to do so.



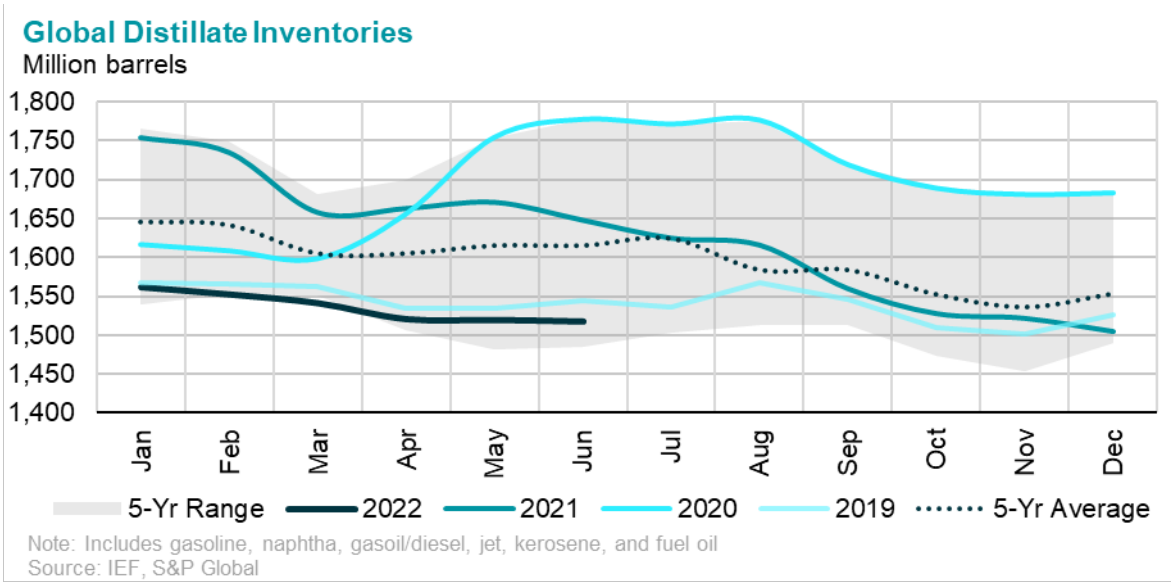
Source: IEF, S&P Global, Bloomberg
Note: USGC crude reference is LLS, Europe is Dated Brent, and Asia is Dubai

No quick or easy fixes

There are no immediate or easy remedies to reduce product prices or bring more refining capacity online quickly. Building new capacity requires significant capital and long lead-times.

Strategic crude oil inventories have been tapped multiple times to relieve markets since the beginning of the year, demonstrating the sense of urgency to supply markets. The US and IEA coordinated releases have, or are scheduled, to provide more than 212 million barrels to the market (about 1.0-1.2 mb/d for most of the year), but only 8% of the amount scheduled to draw are petroleum products and 92% crude oil – blunting the releases' effectiveness given tight markets for refining capacity. In the OECD, products account for only 20% of government-controlled stocks and are predominately located in Europe.

Global commercial and strategic product inventories remain near the bottom of the five-year range, providing little buffer to the market.



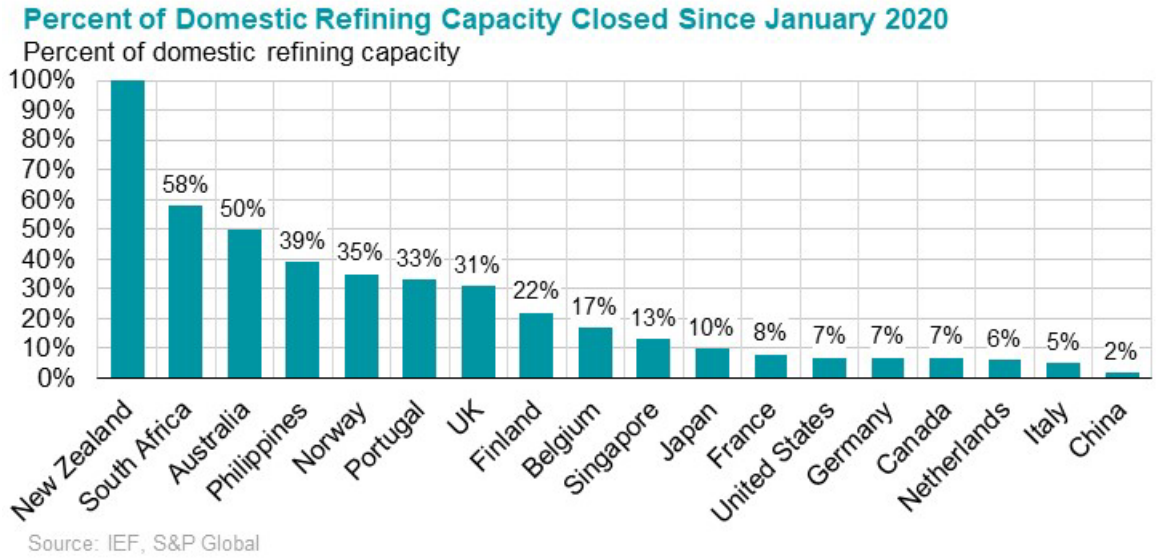
Some governments have reduced fuel taxes or provided subsidies to shield consumers from high prices. While this may provide some relief to consumers, it prolongs tightness in the market by removing the chance for rebalancing via reduced demand spurred by high prices. With few options to increase supply, it appears increasingly likely that demand destruction is the only path to rebalancing the market until new capacity comes online.

How We Got Here: A Perfect Storm

Climate policies and COVID-19 accelerated refinery closures and green conversions

Since January 1, 2020, nine countries have closed at least 15% of their national refining capacity, including seven that have closed more than 30%. Around 80% of the closures and conversions since COVID began have occurred in OECD countries where, in general, environmental regulations are more mature. These closures were for the most part predicted to happen absent COVID, but over the course of five or more years, not all at once.

While the pandemic slowed consumption of petroleum products, progress on climate policy accelerated. Most of the net zero commitments made by national governments, companies and financial institutions were declared in 2020 and 2021. While longer-term in nature, these targets have reinforced the expectation that oil demand will decline long-term and less refining capacity will be needed.



Since early-2020, refineries have closed for a variety of reasons:

- Poor margins and prohibitive costs meant it was not profitable to fix some damaged refineries.
- Other refineries closed because they were unprofitable, ill-equipped for coming changes, or because of pressures from other more “competitive” refineries.
- Other refineries converted to produce green fuels.

These closures/conversions include refineries across nearly 20 countries and range in size from 16 kb/d to 270 kb/d of CDU capacity.

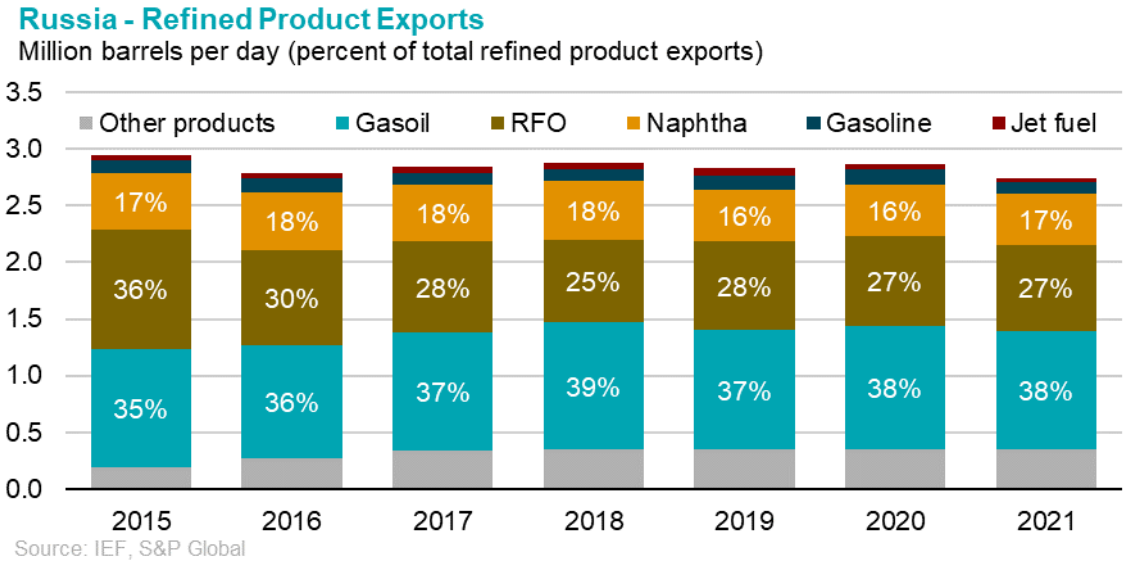
Additionally, new refinery start-ups were delayed by issues related to supply chains, labor, and capital (e.g. 615 kb/d Al Zour refinery in Kuwait and 618 kb/d Dangote refinery in Nigeria).

Markets roiled by Russia’s invasion of Ukraine

Russia’s invasion of Ukraine is spurring an unprecedented reshuffling of global refined product trade and more obstacles are on the horizon. Sanctions and embargos now mean Russian product exports are struggling to find buyers and significant amounts are ending up in foreign and limited domestic inventories, forcing domestic refinery runs lower.

Rerouting traditional flows of Russia’s petroleum product exports is more complicated than for crude oil. Term tenders and existing supply contracts for products often have specifications tailored to a specific market (octane, sulfur, ethanol etc.), and the scarcity of alternative supplies for importers is causing prices to rise. Rerouting of product flows is also resulting in longer distance trips for clean tankers (tankers that carry refined products rather than crude oil). Longer distance trips translate into fewer available ships for booking and higher tanker rates in general.

Russia is the largest global exporter of heavy feedstocks and fuel oil, exporting a total of ~2.9 mb/d of products pre-invasion, of which the EU imported 2.2 mb/d while the US imported 0.4 mb/d.



Because of very limited alternative supplies, Europe and the US have struggled the most with replacing Russian heavy feedstock imports. For diesel, exports from the US, India, and the Middle East is beginning to fill gaps in Europe, but not without higher prices and lower inventories. Naphtha is also commonly exported to Europe from Russia; however, lower East-of-Suez demand is currently easing availability and prices. Once the Asian cracker demand returns later in 2022, the market is projected to tighten.

If Russia cannot find buyers for its diesel and semi-processed feedstocks, refinery runs will have to fall further once inventory options are exhausted. This could result in a very tight or negative domestic gasoline balance. Russia typically produces most of the gasoline it consumes, but it could be forced to import gasoline because of cuts in domestic refinery runs. This will put more strain on the already tight global product market.

The most likely alternative markets for Russian products, particularly diesel, are Africa and Latin America. However, the transit time for product deliveries from Russia to West Africa and Latin America is 25-30 days, compared to 8 days to Europe. Already high freight rates, and a looming insurance ban means these trades may be uneconomic for both buyer and seller.

An EU embargo on importing Russian crude via pipeline comes into effect on 5th December 2022, and a ban on importing refined products of Russian origin from 5th February 2023. There are several exemptions to the embargo, but it will broadly cut 90% of Russian crude imports and nearly all product imports.

An EU-led ban on insuring cargoes of Russian oil or products will take effect alongside the pipeline embargo. Without insurance, many shipowners/operators will be unable to transport Russian cargoes, drastically limiting the number of vessels available to Russian exporters. Alternatives to the traditional EU and London-dominated shipping insurance system are very limited and may not be accepted by some market participants. The Russian Sovkomflot fleet is now insured by domestic insurers, however, the fleet size is relatively small compared to total Russian crude oil trade. EU and participating insurers have until the end of 2022 to enact the ban.

A price cap on Russian-origin shipments is also under discussion and would allow exemption from the insurance ban for purchases below a certain price. However, the full impact of a price cap is uncertain, as it will require unwavering cooperation from importing countries and will depend on Russia's willingness to sell at steep discount.

Finally, trade finance is a further complication to displacing Russian oil from traditional western markets to alternative markets. Once the EU-ban is in place, Russian and non-sanctioned country banks may step in to provide this vital service but at an added cost and level of uncertainty. Most large international trading houses have stated they will not trade Russian oil and it is these companies that have key contracts with African and Latin nations to supply products.

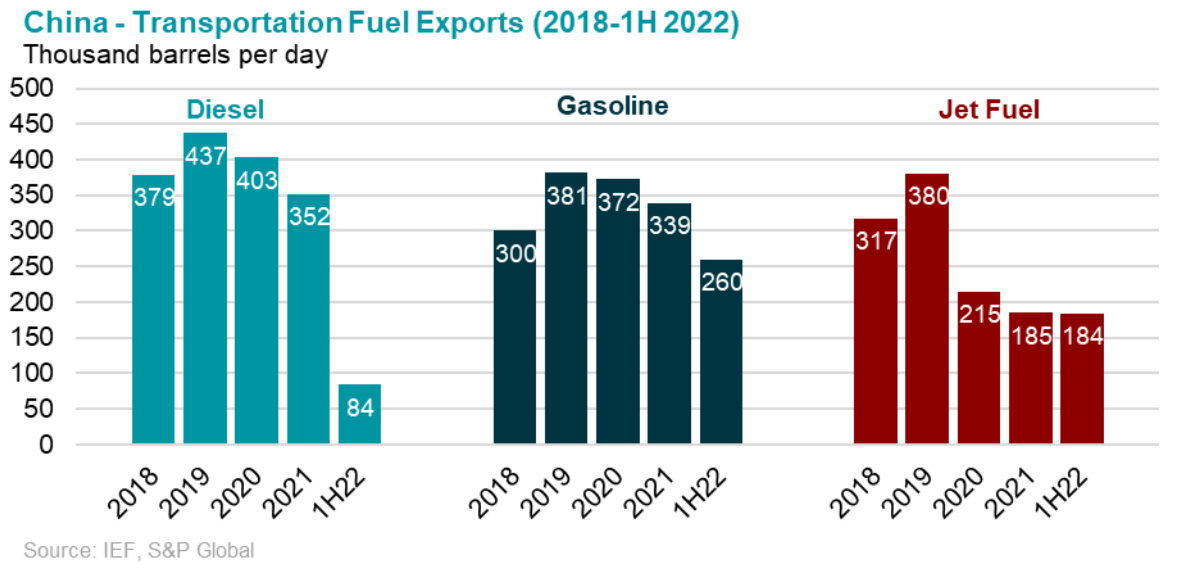
China's underutilized refining capacity unlikely to save the day

Outside of Russia, China is one of the few places where there is underutilized refining capacity. However, this capacity is unlikely to help ease global markets.

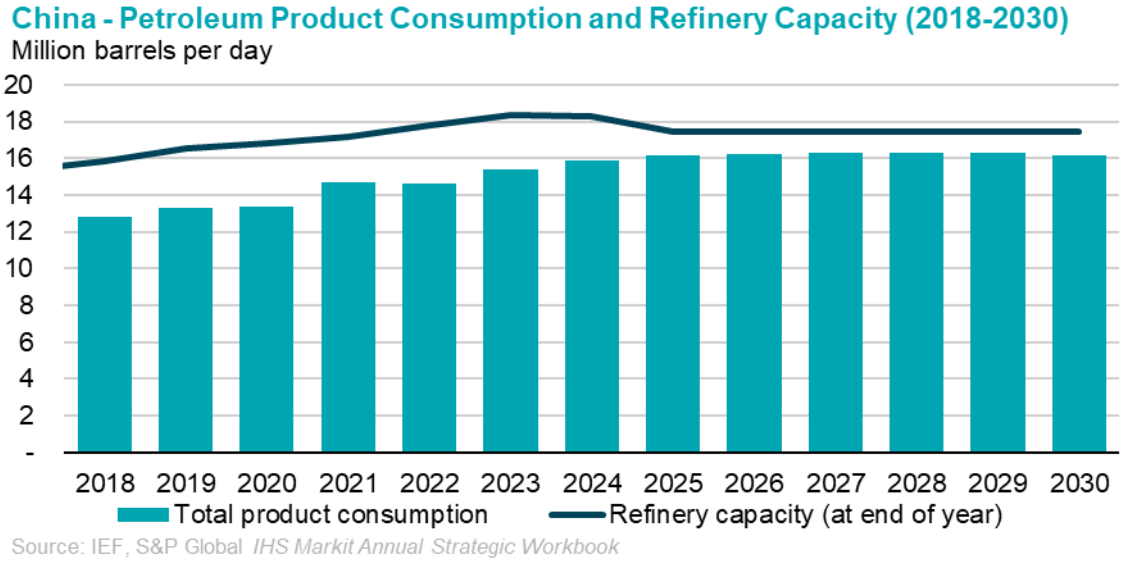
China's refineries are running at below 75% utilization compared with the historical normal of ~80% (China's max utilization rate is typically lower than the US or Europe due to a group of smaller, less utilized independent refineries). However, refineries cannot unilaterally decide to increase exports, China's government provides refinery-specific export quota limits on transportation fuels and has been reigning in these quotas for more than a year.

The total export quota allocation for 2022, thus far, is on-par with 2021 but down ~30% from 2019 levels. The reduction in export allocations from 2019-20 levels is a strategic shift to consolidate and prioritize the domestic market. China's government is keen to cut oil product exports to ensure domestic supplies and meet decarbonization targets (although the decarbonization target has been relaxed this year to balance economic growth and ensure energy security).

China increased total product exports from ~600 kb/d in 2013 to 1.4 mb/d in 2019. So far in 2022, and despite continued refinery capacity additions and record crack spreads, exports have averaged only 950 kb/d, including only 530 kb/d of primary transport fuels.



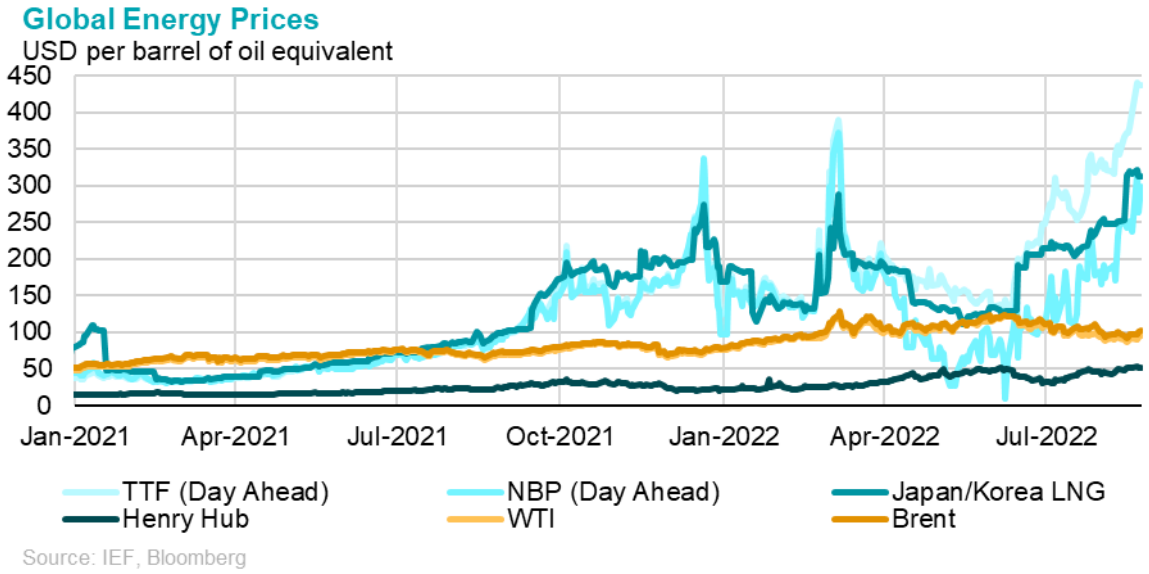
China's government climate policies aim to reduce inefficient refining capacity. CDU capacity will contract mid-decade while domestic demand will continue to grow. China's domestic markets for refined products will tighten through the medium-term increasing the likelihood that reduced product exports are the new norm as China's government focuses on security of supply.



High natural gas prices' feedback loop: Higher refining costs and increased oil demand

Soaring natural gas prices may not have had as much of an impact on product markets as the three issues raised above, but it has been a contributing and complicating factor.

Refineries use significant amounts of natural gas, primarily for heat needed in distillation and chemical processes, as well as an input to make hydrogen. Natural gas prices are at a record high in Europe and Asia, nearing $300-450 per barrel equivalent (at the time of writing), significantly increasing the operating costs for regional refineries. The increase in refinery costs then gets passed through to consumers via larger spreads between petroleum products and crude oil.



Refineries use natural gas to make hydrogen that is in turn used to remove sulfur from petroleum products so that they can meet quality and environmental standards. Higher natural gas prices mean this desulfurization process becomes more costly, and therefore further driving up prices for very low-sulfur petroleum products. The production of diesel from hydrocracking units, which consumes large quantities of hydrogen per barrel of product, are particularly costly and resulting in high diesel and jet fuel crack spreads.

Refineries also use significant amounts of electricity to operate equipment, which is sometimes generated onsite using natural gas, or purchased from the local grid. Depending on the refinery's location, the cost of electricity can be tied to natural gas prices, resulting in yet another increase in costs transferred on to petroleum product prices.

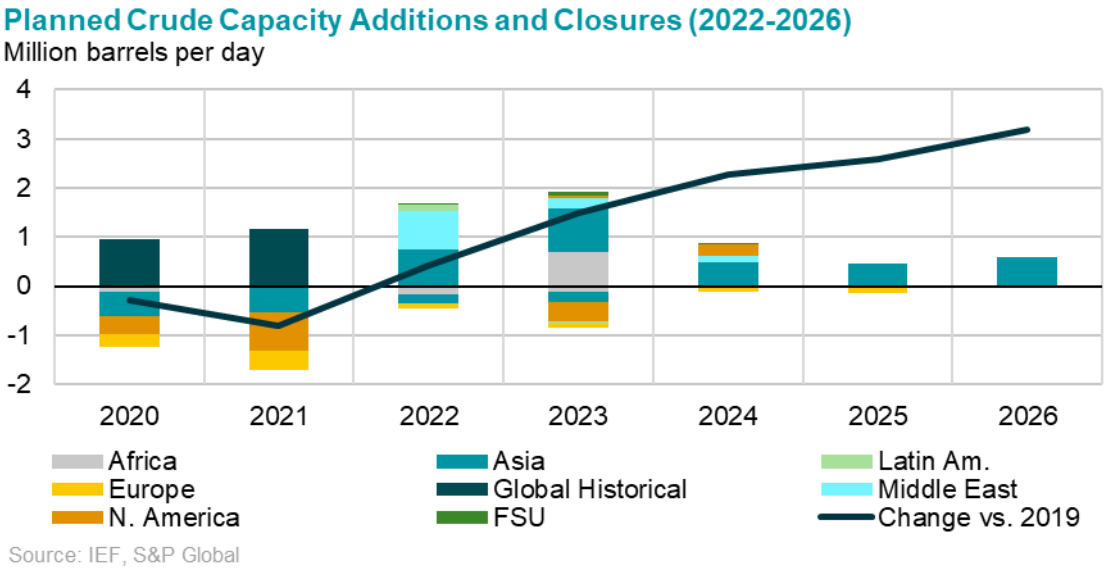
High natural gas prices are also leading to fuel switching in certain sectors and locations. Certain industrial or power sectors that typically use natural gas have some limited ability to burn crude oil, fuel oil, or even diesel instead. There is often some environmental limit to this switching in addition to the limited equipment capacity for these fuels. Still, anecdotal evidence shows German manufacturers are switching from natural gas to fuel oil where possible, while oil-fired power plants have been brought back to replace natural gas. During high natural gas prices last winter (2021-2022), northern Europe, Northeast US, Pakistan, and other locations turned to more direct burn of crude oil and petroleum products for power generation.

Thus, a price feedback loop develops between high natural gas prices leading to increased refinery costs, leading to higher petroleum product prices, while demand for fuel increases as some industrial consumers switch from natural gas to petroleum products because of high natural gas prices.

What's Next: Relief on the Horizon?

Two million barrels per day of net capacity is planned to come online by end-2023

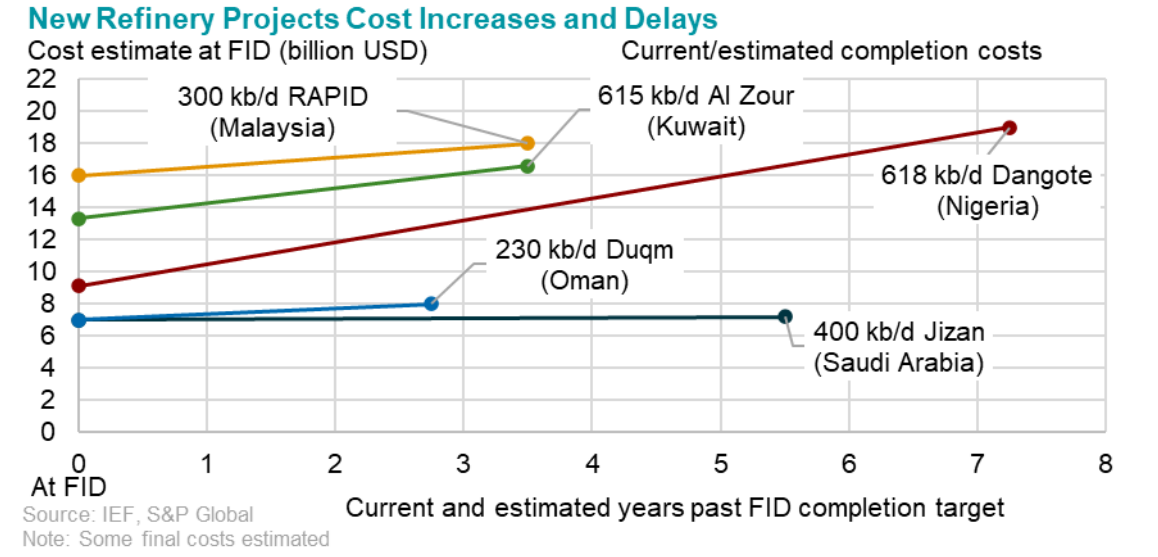
Absent an increasingly likely negative demand shock, the best hope to re-balance the market and lower product prices are the ramp-up of large new refineries in the Middle East, Africa, and Asia. By the end of 2023 global refining capacity is expected to be 1.5 mb/d above 2019 levels. However, this assumes refineries are completed on time and can ramp-up operations quickly—both far from guaranteed.



Source: IEF, S&P Global

History shows ramp-ups could take a year or more

History shows there could be delays or challenges in ramp-up operations of new refineries. Large refineries often take more than a year to reach maximum product exports and can sometimes take more than two years. Ramp-up of large-scale refineries (+150 kb/d) are often riddled with delays and variability. Each large-scale plant faces unique challenges, as attested by delays in Jizan (KSA—aboveground risks), Ruwais (UAE—fire), and RAPID (Malaysia—fire).



Balances likely to remain tight for several years

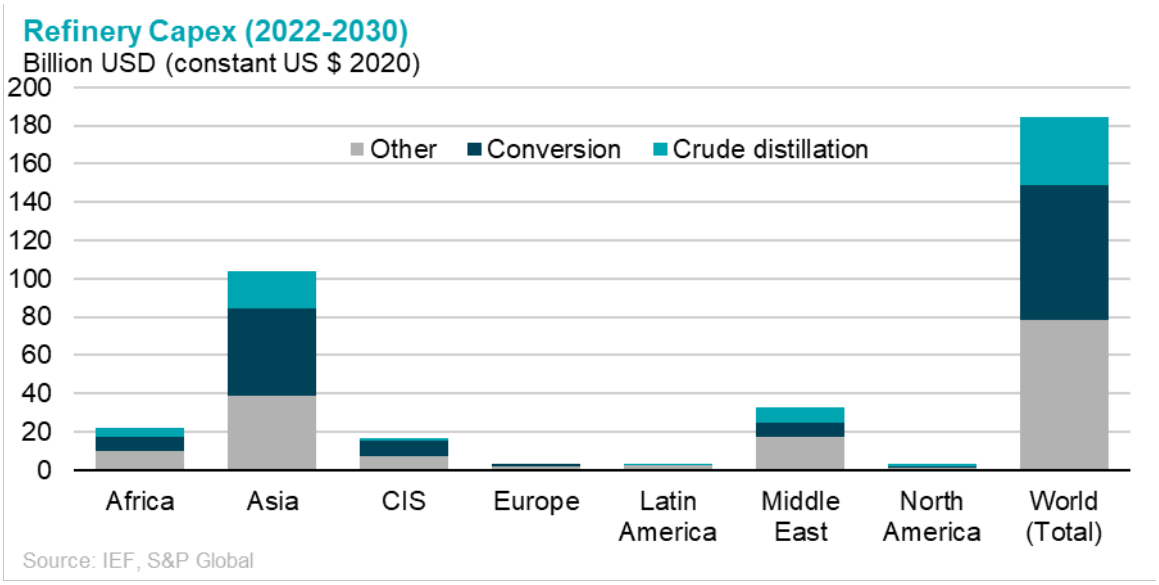
Gradual ramp-ups and unexpected challenges will likely delay market balancing to the middle of the decade. Any unexpected, prolonged outages at operating refineries—which happen with some regularity—will further tighten the market and lengthen the rebalancing timeline.

In the past, high refining margins led to more investment and expanded refining capacity, but the expectations this time are different. The energy transition, shifting consumer preferences, and government policies, have resulted in concerns that the refinery investments today could become the stranded assets of tomorrow, a major deterrent to new project development. As a result, the last group of major greenfield fuel-only-oriented refineries have likely received final investment decisions and will come onstream in the next few years.

Medium-Term Investment Trends

Capex investment needs to reach $190 bn through 2030

Downstream capital expenditures will need to reach $190 bn through 2030 for upgrades to atmospheric crude distillation unit (ACDU) capacity and conversion/secondary capacity, and for sustaining existing assets. This is down nearly 50% from pre-COVID levels and will likely be met.



Fuel balances will loosen slightly in 2025-2026 as new capacity is ramped up, but then tighten again through 2030 until the energy mix transitions to lower carbon alternatives. The lack of investment for CDU capacity post-2025 means tight markets will only be relieved by reductions to demand, either from higher prices or from EV and biofuel substitutions, as new supply will be limited. Any new ACDU capacity post-2026 will likely be from upgrades and not greenfield projects.

Downstream decarbonization spending on the rise

Alongside investments in transportation fuels and petrochemical capacity, refineries are also expected to invest in cleantech, aimed at decarbonizing refinery outputs and operations. The main categories include carbon-related efficiency improvements, low-carbon hydrogen production, and carbon capture and storage. Biofuels and petrochemical integration are excluded from this category (discussed in more detail below). The majority of these clean (low-carbon) refinery-focused investments are concentrated in Europe and North America, supported by emissions-reduction targets. However, China and parts of Asia will quickly catch up after 2040.

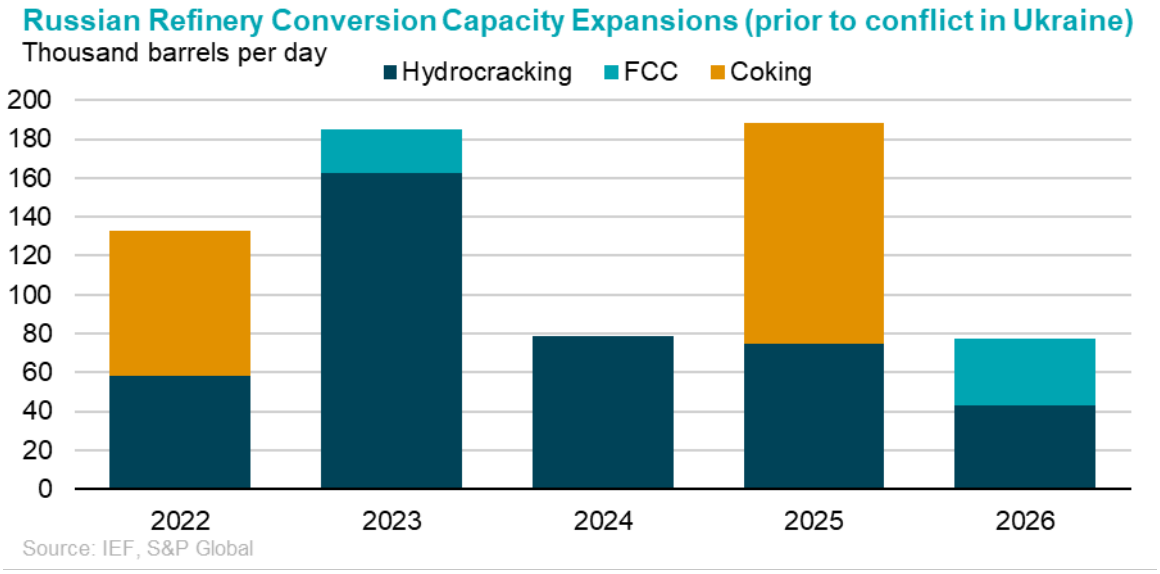
The timing and approach to cleantech investment will vary strongly between regions, with political support and company ESG goals key in influencing capital flows. Globally, the refining industry is projected to spend approximately $25 billion by 2030, and an additional $75 billion from 2031-2040 on clean technology, which is in addition to the traditional categories of capex (ACDU capacity, conversion capacity, and sustaining assets).

Russian capacity upgrades (+650 kb/d) will be stalled

The ongoing Russian invasion of Ukraine will exacerbate oil and downstream market uncertainty and complexity not just in the short-term, but durably.

For years Russia's government has been supportive of refinery modernization efforts and has provided subsidies that support these projects. In 2020-2021, 14 refineries signed investment agreements with the government that envisaged a collective RUB 800 billion ($13 bn) investment in conversion capacity projects. This was expected to help stream about 662 kb/d of conversion

capacity over 2022-26, mainly hydrocracking to upgrade ample fuel oil supplies into more valuable products like diesel.



As a result of Russia's invasion of Ukraine, Western governments imposed several rounds of sanctions, including a ban on the export of Western refining technology and equipment to Russia. Despite some domestic alternatives, Russia has been extensively relying on Western refining technology and catalysts.

Sanctions will also make it difficult for Russia to source replacement parts if there are any accidents/damages to domestic refineries. This could ultimately lead to Russia needing to import products that it currently produces domestically.

Even if Russia can source refining technology from alternative providers (potentially China), it is still highly uncertain if there will be funding for these projects and an outlet for Russian diesel exports by the time projects are streamed. Thus only around half of these projects are now expected to be realized, mostly those that are already close to completion.

An Evolving Downstream Model

Refineries are stuck between the hammer and the anvil

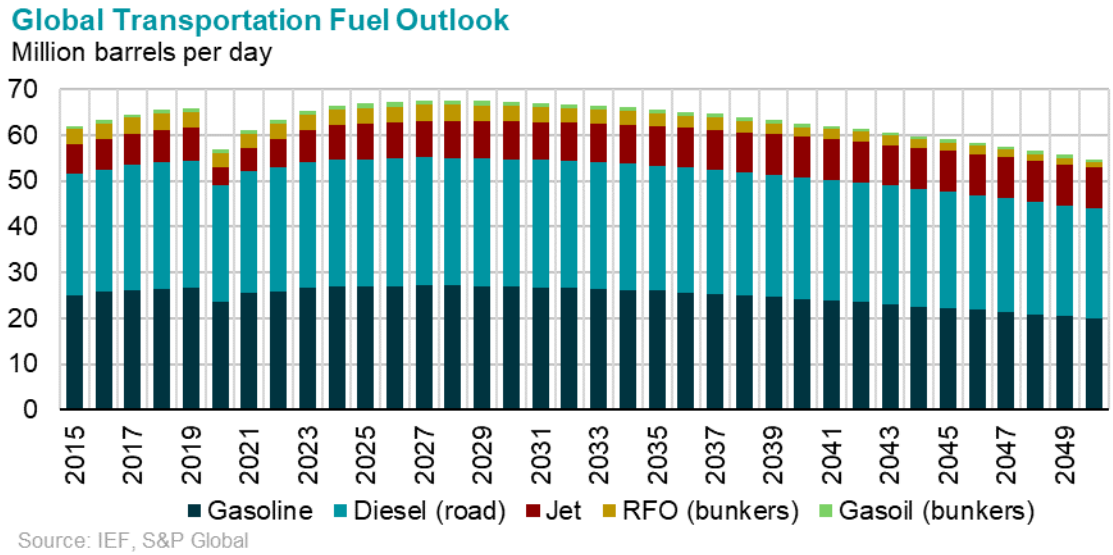
Even in less complicated times, refining was a challenging sector in which to make investment decisions. Regulations simultaneously push for lower demand for petroleum products through fuel efficiency improvements and the use of biofuels, while also requiring refineries to invest to meet increasing environmental standards. Additionally, refinery investment decisions need to consider fluctuations in both the supply and characteristics of crude oil, as well as shifting patterns in petroleum product demand.

The energy transition now further complicates the refining investment calculus, through structural changes to the energy demand mix, especially in the transportation sector where the pace of change is highly uncertain.

Investment decisions—influenced by government regulations and societal pressure—are expected to be increasingly directed to lower-carbon alternative fuels and energy sources. With these shifts, there will be a heightened focus on carbon reduction and management throughout the value chain.

Traditional transportation fuels will remain an integral part of the energy mix for decades to come; however, higher fuel economy standards, biofuels and electrification will together cause hydrocarbon's contribution to these transportation fuels to plateau by 2028.

Waning demand *growth* will cap the investment needed for new refining capacity. As complex industrial facilities, refineries have a long life and are quite capital intensive, forcing investment decisions to be driven by the expected demand and returns over the long term—more than just a decade.



Source: IEF, S&P Global

Fuel standards continue to tighten globally

Most major markets are now at ultra-low sulfur levels (e.g. 10 parts per millions) for on-road fuels. Beginning in April 2020, India adopted Euro 6 equivalent fuel standards, while Indonesia, Brazil and Saudi Arabia are heading for lower sulfur standards in the medium-term. Other emerging economies will likely follow suit, resulting in greater global convergence on fuel quality standards.

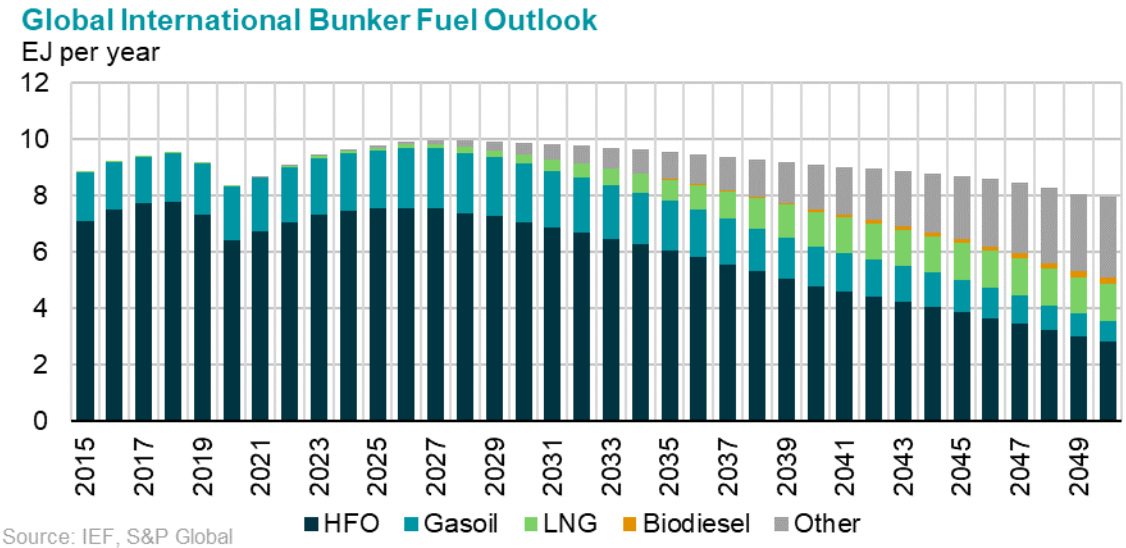
These new standards will require some older or less complex refineries to invest to comply or compete. This is not a new trend in the global market but a continuing pressure on refinery owners.

Evolving shipping regulations

The International Maritime Organization (IMO) is expected to turn its attention from sulfur emissions to the carbon intensity of maritime transportation. Marine bunker fuels were one of the least regulated from a quality perspective and an important market for refineries until IMO 2020. IMO 2020 reshaped the marine fuel market by lowering the sulfur content limit of bunker fuels from 3.5% to 0.5% at the beginning of 2020 and created major repercussions for some refineries.

New IMO regulations targeting vessel efficiency and carbon intensity are expected in 2023. Emissions will be lowered by penetration of LNG into the marine fleet, and lower carbon

alternatives, particularly low-carbon sources of hydrogen and ammonia, will erode the contribution of fossil-based fuels. Non-traditional bunkers will account for almost half of bunker fuel demand by 2050, while low carbon alternatives will offset around 0.2 mb/d of demand by 2030 and around 1.3 mb/d by 2050.



Source: IEF, S&P Global
Note: "Other" includes hydrogen, ammonia, and other alternatives

Changing markets for aviation fuels

Aviation is considered the hardest-to-abate major transportation sector. The continued use of a high energy-density liquid fuel is required for the foreseeable future for most applications. Sustainable aviation fuel (SAF) penetration is beginning to appear in the form of renewable jet fuel (biobased and hydroprocessed).

In October 2021, members of the International Air Transport Association (IATA) committed to reaching net-zero carbon emissions by 2050. The US has set a goal of replacing all traditional jet fuel with SAF by 2050. The EU and UK have also set mandates on fuel producers or airlines.

High ambitions in Europe and the US contribute to global SAF reaching 2% of jet fuel demand in 2030 and 18% in 2050. Alternatives to bio-based liquid fuels are also possible (such as hydrogen-based liquid fuels), if currently expensive, and early developments are underway for these fuels too.

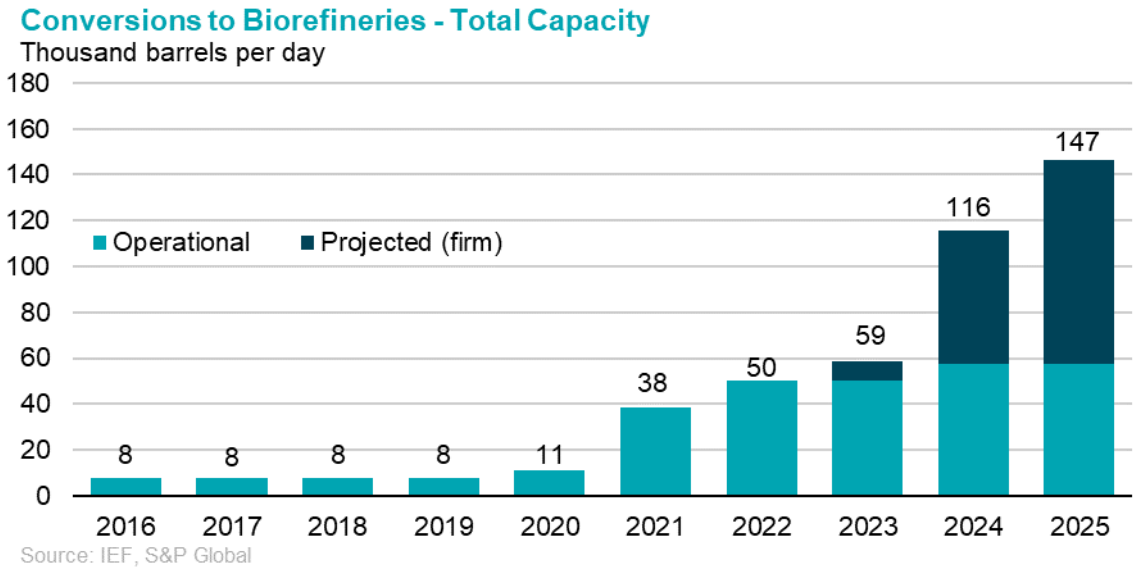
Biofuel demand to double by 2050

Global biofuels and alternative liquids demand to grow by 50% by 2030 on 2021 levels and more than double by 2050 in the base case, displacing petroleum-derived fuels produced by refineries. Advanced and lower-carbon biofuels integration will be increasingly needed to meet decarbonization targets, but feedstock challenges and costs still tend to limit these options, particularly in the near-term as the Ukraine crisis tightens agricultural feedstock markets.

Prompted by renewable fuel policies, some refineries, particularly in the US and Europe, are opting to become biofuel producers (using hydrotreater units to produce renewable diesel and other means) rather than completely shutting down.

Importantly, the volumetric output of a converted refinery is typically much lower compared with when the facility processed crude oil into transportation fuels. For example, a refinery in Rodeo, California now produces 50 kb/d of renewable fuels compared to its pre-conversion production of an estimated 57 kb/d of motor gasoline, 13 kb/d of diesel, and 2 kb/d of jet fuel.

Based on announced projects that are considered as "firm", conversions will accelerate from 2023-24. Conversion capacity will nearly triple by 2025, expanding to 147 kb/d in 2025 from 50 kb/d in 2022.

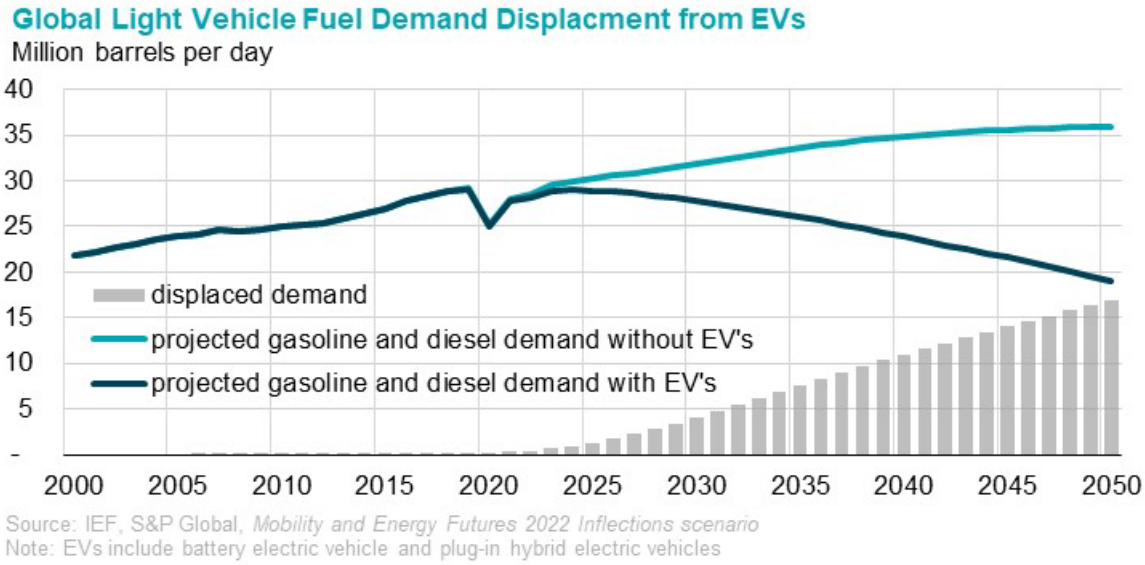


EV penetration accelerating and offsetting 4 mb/d of demand by 2030

Passenger EV sales are forecast to rise sharply in the upcoming years as policy support continues, the cost of lithium-ion batteries decline, and more EV models come to showroom floors.

Today, 20-25% of cars sold in China and in western Europe are a plug-in vehicle (either a battery vehicle or plug-in hybrid). Plug-in vehicle sales are forecast to grow from 6.6 million in 2021 to 35.7 million in 2030 driven by China, Europe and to a lesser extent the US. This is forecast to displace 4 mb/d of gasoline and diesel demand by 2030 and 17 mb/d by 2050.

(Note: This analysis was undertaken prior to the U.S. Inflation Reduction Act's passage, which altered incentives for EVs and biofuels in the United States.)



Source: IEF, S&P Global, *Mobility and Energy Futures 2022 Inflections scenario*
Note: EVs include battery electric vehicle and plug-in hybrid electric vehicles

Demand growth for petrochemicals

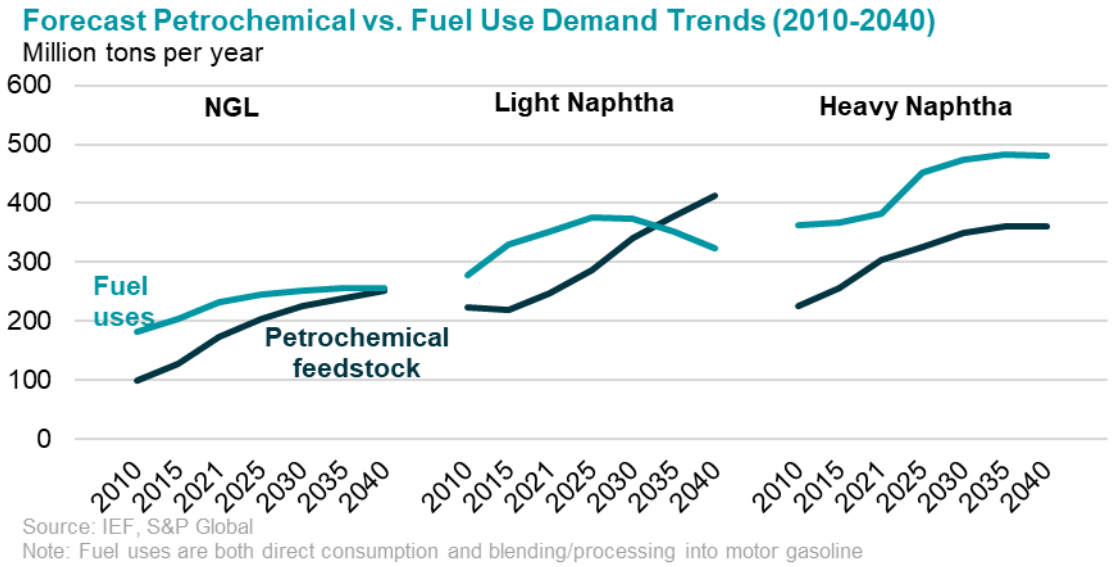
As global petroleum-derived fuel demand plateaus, some refineries are shifting focus away from producing transportation fuels towards more petrochemical outputs. While producing petrochemicals from integrated refining/petrochemical complexes has long been a strategy for certain companies, expanding and deepening integrated petrochemical production with transportation fuels production is becoming an important hedge for more refineries.

Although refinery-sourced transportation fuels demand will plateau and eventually fall, petrochemical demand, for which there are few alternatives, will increase. This is expected even as the level of petrochemical product recycling increases to meet circular economy targets.

Petrochemicals are produced from a range of feedstocks, including crude oil (e.g. naphtha from refining to produce olefins and aromatics-based products), natural gas (e.g. for methanol production) and natural gas liquids (e.g. propane from gas processing and refining to produce olefins-based products).

The demand for petrochemical feedstocks (ethane, LPG, and naphtha) from refineries and gas processing has increased about 23% from 2010 to 2021 and is projected to grow by another 19% by 2030.

Demand in Asia will account for about 70% of the petrochemicals demand increase, although a good portion of the plastics and fibers produced from this feedstock consumption will be contained in manufactured products that are exported to global markets outside of Asia.



Naphtha forms the basis for most oil-sourced feedstocks and is relied on heavily in the growing Asian market. The markets that have access to cost advantaged NGL supplies, notably the US and certain Middle Eastern countries, utilize ethane, propane and to a lesser extent butane.

To supply future feedstock growth, refineries will need to try to increase naphtha yields through new conversion investments and incremental operational changes. To the degree NGL supplies are available, they provide an advantaged feedstock selection but much more naphtha (and some heavier) feedstocks will be needed from crude-derived refining sources.

As fuels demand slows, the refinery output of petrochemicals and petrochemicals feedstocks will grow at the expense of fuels output. There is a range of technology options to make this production yield shift at both newbuild and existing refining/integrated facilities.

Newly built Chinese refineries are producing yields of over half petrochemicals using established oil conversion technologies. Innovative technologies to further shift yields are being evaluated.

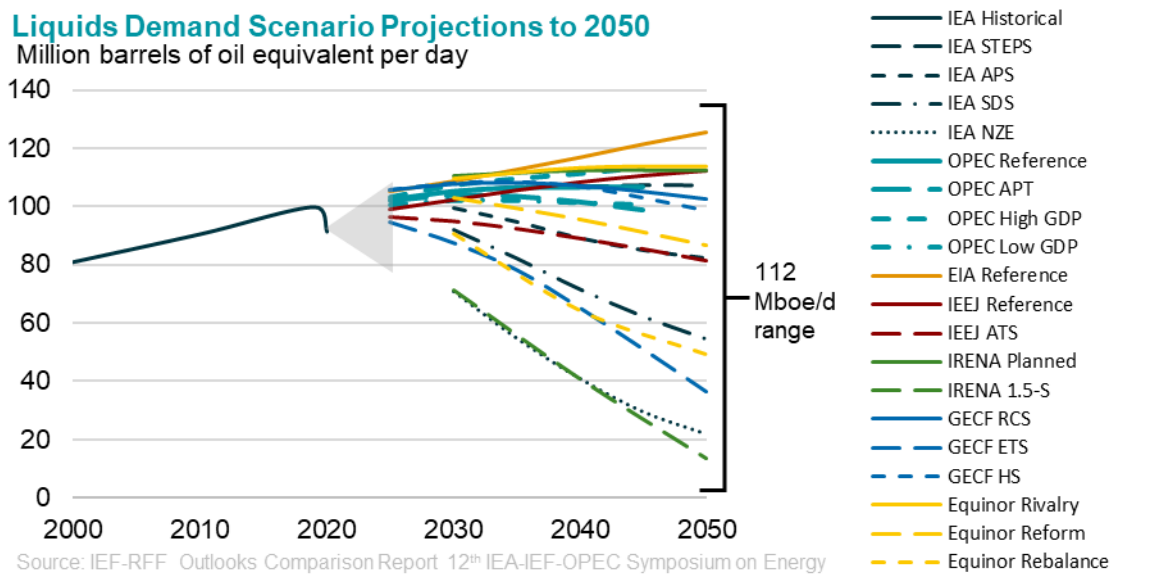
Beyond the few newbuilt plants expected, moderate shifts are anticipated within many of the world's large and complex refineries that today produce smaller yields of petrochemicals.

Challenging Investment Environment: Who Survives?

Paramount uncertainty

While policymakers' climate ambitions are high, legally binding targets lag. Many proposals could directly impact demand, such as Internal Combustion Engine (ICE) bans, or impact refineries on an operational level.

This high level of policy uncertainty is easily apparent in the various long-term forecasts and their varying scenarios. The difference between petroleum liquids demand in the highest and lowest case for the following 28 years is 112 mb/d, or more than the size of today's market.



Although, the current energy crisis has brought energy security and affordability back to the forefront for policymakers, investors require certainty of returns.

The refining sector, and the energy industry in general, needs more certainty from policymakers over penalties and incentives for future investments to ensure sufficient capital, for all technologies, is mobilized to meet the climate challenge.

Survival of the fittest and lucky

Refineries will need to become larger in size, more efficient, complex, and competitive. Mega, integrated refining-and-petrochemical plants have been the most resilient in recent years, due to their flexibility and scale. These facilities are able to adjust outputs to better match changing demand. As transportation fuel demand plateaus and declines, these types of facilities will be able to cater to growing petrochemical demand, however, these are the most expensive and difficult types of facilities to build.

Other downstream assets will be valued for their potential manufacturing base for low-carbon hydrogen, green fuels, CCUS, and access to logistics, even if they had weak profits/performance in petroleum-derived fuel markets. Investors will look beyond the current asset use, in favor of how refining assets can be repurposed for the transition.

However, oil and gas companies remain under continued pressure from investors to focus not only on financial returns but also to commit and, ultimately, deliver on ESG standards. Emissions and environmental impacts from refinery operations are increasingly under regulatory pressure and scrutiny, with more refinery specific-solutions and investment still needed.

Survival is not limited to the fittest however, it will also require some luck. Refineries that become damaged in accidents, adverse weather, or face other operational challenges will face a merciless cost-benefit analysis. More weight will be placed on the cost of repairs and restoration due to the looming prospect of declining demand and more stringent environmental policies.

Conclusion

The global downstream industry faces significant near-, medium-, and long-term challenges. On the one hand, current markets are facing upheaval and unprecedented restructuring following record refinery closures in 2020-2021, sanctions on one of the world's largest fossil fuel exporters, and a strategic shift in China to reduce petroleum product exports. On the other hand, investors are looking ahead to an uncertain future for refining as the world transitions to low-carbon energy sources. These varied challenges – that can at times be opposing – create a challenging decision-making context for refiners as they seek to make consistent operational and investment choices.

The downstream industry is innovative and resilient. Past experience (e.g. IMO 2020, COVID-19, sanctions on Russia) has demonstrated that the industry can react quickly to calm the turbulence of volatile markets. There is no reason to expect that it will not continue to meet new challenges.

The downstream sector will emerge from the current disruptions leaner, more efficient, and better adapted to the evolving markets. Refining capacity will have shifted geographically and technically to reflect global consumption patterns more accurately and to be better prepared for the energy transition.

The final greenfield fuel refineries have received FIDs and are scheduled to come online this decade. Unlike in the past, high refining margins are less likely to attract investment and new capacity. As a result, downstream markets will likely remain tight for much of the decade, until demand growth for traditional fuels begins to plateau.

Product supply/demand balance will be more delicate this decade and any unforeseen operational challenges could have an outsized impact on prices and volatility. Policymakers can prepare by increasing strategic product inventories and diversifying supplies.

In the long-run, the refining industry is on a pathway to a less carbon-intensive future. However, that pathway is set to be uneven because of an evolving and fractured decarbonization policy landscape.

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