



Medium Term Outlook for Oil and Refined Products?

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Energy Industry Report

The Abdullah Bin Hamad Al-Attiyah International Foundation for
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INTRODUCTION

MEDIUM TERM OUTLOOK FOR OIL AND REFINED PRODUCTS?

The global refining industry faces a shifting terrain. Demand and refining capacity are moving to the Middle East and Asia, while product specifications are tightening, especially in 2020 for marine fuels.

A wave of new refining investment confronts relatively subdued demand growth, and both the feedstock slate and required output are gradually changing. What is the medium-term outlook for the global oil refining industry? How are refiners ensuring future competitiveness? What are the different challenges for independent refiners, international oil companies, and national oil firms from exporting and importing countries?



Energy Industry Report

This research paper is part of a 12-month series published by the Al-Attiyah Foundation every year. Each in-depth research paper focuses on a prevalent energy topic that is of interest to the Foundation's members and partners. The 12 technical papers are distributed in hard copy to members, partners and universities, as well as made available online to all Foundation members.



EXECUTIVE SUMMARY

- The geography of demand, and hence of refining capacity and ownership, is shifting towards the Middle East and Asia.
- Strong investment in new and expanded refineries in 2019–20 and 2022 will exceed demand growth, put margins under pressure and lead to refinery closures in some mature markets, particularly Europe.
- 'Peak refining' will be reached before 'peak oil demand', because of growing product supply from natural gas liquids (NGLs), condensate and biofuels.
- The structure of demand will continue to shift away from fuel oil and towards petrochemical feedstocks and jet kerosene.
- New, large and sophisticated Middle Eastern National Oil Company joint-venture refineries in Asia are increasingly important. They reflect the strategic goal of securing demand in key markets.
- Refineries remain under continuing and intensifying pressure to improve environmental performance. This includes producing new-specification fuels, such as low-sulphur fuel oil to meet the IMO 2020 shipping fuel regulationsⁱ. Greenhouse gas emissions will come under increasing pressure, especially in Europe.



IMPLICATIONS FOR LEADING OIL AND GAS PRODUCERS

- Market conditions are likely to be challenging for refiners over the next few years.
- Petrochemical integration is increasingly crucial for new refinery economics. Investors in new refineries have to consider their economic competitiveness, as well as the strategic rationale for joint-venture refineries in key demand centres.
- Refineries will come under increasing environmental pressure, and future plans have to consider how to lower greenhouse gas emissions at a reasonable cost.
- Integrated company strategies have to incorporate this new reality. International oil companies (IOCs) could divest or close their refineries, exporting-country NOCs could strive for competitiveness and market access, and importing-country NOCs target supply security. But all of these approaches have problems.

REFINING CAPACITY IS SET FOR STRONG NEAR-TERM GROWTH

Refineries have enjoyed good recent margins, because of lower crude prices, and the stocks of pure refiners have outperformed those of upstream companiesⁱⁱ. Companies have invested in more complex capacity, even though light sweet crude has been abundant and even trading at a discount to medium-heavy crudes that have been reduced by OPEC cuts.

Projects already under construction or committed will add nearly 7 million bbl/day of distillation capacity by 2023-24, mostly in the Middle East, former Soviet Union and Asiaⁱⁱⁱ. Russian projects are typically expansions rather than new greenfield facilities.

Key projects are shown in TABLE 1. It can be seen that there are major waves of new capacity in 2019-20 and 2022 (some of the 2020 projects will probably slip into 2021). Addition from major projects of 1.8 Mbbl/day in 2019 and 1.96 Mbbl/day in 2020 greatly exceeds demand growth in those years.

Some of the projects further out, such as the projects in Algeria, Mexico and Uzbekistan, are less likely to be completed on time or at all. A few of numerous other speculative refineries, including in Angola, Kenya, South Africa^{iv}, Sudan, Uganda, Zambia, Algeria, Iran, Iraq and Pakistan could also advance. Some concepts, such as Sinopec's 0.4 Mbbl/day Caojing plant in Shanghai^v, slowed down?

This outpaces the likely growth in demand for refining, so medium-term utilisation specifically expected to fall. This is in regions where oil demand is falling, notably Europe, but parts of Asia too will be affected. US refinery utilisation will remain higher, though, because of its sophistication and access to cheap natural gas fuel.

Some 75% of the capacity addition is in mega-refineries, modern, complex, integrated with petrochemicals, often with cheap energy supplies, and long-term crude supply from Middle Eastern national oil companies (NOCs). These refineries will be highly competitive against older plants.

After 2024, low utilisation will reduce the growth rate in overall capacity to around 0.4% annually (mostly expansions at existing plants). However, countries such as China and India are likely to construct new plants to remain self-sufficient. This will put pressure on some refineries in Europe, especially, to close. European refineries will

TABLE 1 MAJOR NEW WORLD REFINING PROJECTS (+ FOR EXPANSIONS)^{vi}

Project	Country	Distillation capacity (Mbbl/day)	Onstream year
Sidi Rezine	Algeria	+0.02	March 2019
STAR (Aliaga)	Turkey	0.214	2019
Zhoushan / Zhejiang	China	0.4	2019
Hengli (Dalian)	China	0.4	2019
Slavyansky	Russia	+0.01	2019
Jebel Ali (ENOC)	Dubai, UAE	+0.07	Q4 2019
PRefChem	Malaysia	0.3	End-2019
Jazan	Saudi Arabia	0.4	End-2019
Persian Gulf Star	Iran	+0.25	March 2020
Brooge, Fujairah	UAE	+0.024	1Q 2020
Clean Fuels	Kuwait	+0.1	April 2020
Mari El	Russia	+0.115	2020
Taneco	Russia	+0.05	2020
Moscow	Russia	+0.131	2020
SATORP Jubail	Saudi Arabia	+0.02	2020
Al Zour	Kuwait	0.615	2H 2020
Dangote	Nigeria	0.65	End-2020
Baku	Azerbaijan	+0.03	2021
Zarqa	Jordan	+0.06	2021
Sitra	Bahrain	+0.093	2022
Ilsky	Russia	+0.078	2022
MIDOR, Alexandria	Egypt	+0.06	2022
Dos Bocas	Mexico	0.34	2022 ^{vii}
Karbala	Iraq	0.15	2022
Duqm	Oman	0.23	2022
Beaumont	Texas, US	+0.25	2022
Jizzakh	Uzbekistan	0.1	2022
Nayara	India	0.52	2022-24
Jieyang	China	0.4	2023
Ruwais (ADNOC)	Abu Dhabi, UAE	0.663	2024
Tuban	Indonesia	0.3	2024
Raigad	India	1.2	2025
Mangistau	Kazakhstan	0.2	2025

REFINING CAPACITY IS SET FOR STRONG NEAR-TERM GROWTH

also be affected by the continuing tightening of environmental regulations. Even in China, many refineries are small – the average size is only 87 kbbbl/day, half the global average – and many will have to consolidate or expand to survive^{viii}.

In early 2020, the introduction of the IMO 2020 regulation restricting the sulphur content of ship bunker fuels will have a significant effect on refining. Marine diesel will be in high demand, widening its premium to gasoline. Low-sulphur fuel oil (LSFO) will be popular, for those refineries able to produce it; high-sulphur fuel oil (HSFO) will have to be dumped at low prices, widening the differential between sweet and sour (typically heavy) crudes. Uniper and Brooge have constructed small refineries at the bunkering port of Fujairah in the UAE specifically to produce LSFO. Refiners in China, South Korea, Japan, south-east Asia, India, Rotterdam and Texas have made upgrades to produce LSFO and very-low sulphur fuel oil (VLSFO)^{ix}.

However, by 2022, the refinery and shipping system will probably have adjusted, with less heavy high-sulphur fuel oil being produced, and ships making more use of LNG and scrubbers. Improved shipping efficiency and growing use of LNG means that overall marine oil use (marine diesel, LSFO and HSFO) will gradually fall after 2021.

'PEAK REFINING' WILL BECOME BEFORE 'PEAK OIL DEMAND'

The date of peak oil demand has been much-debated in recent years, with estimates ranging from the early 2020s to after 2050^x. Peak oil demand would be caused by the rise of non-oil technologies, particularly electric vehicles, and growing efficiency of internal combustion engines and other oil-using equipment. Whenever the date, though, the peak in refining demand will come earlier.

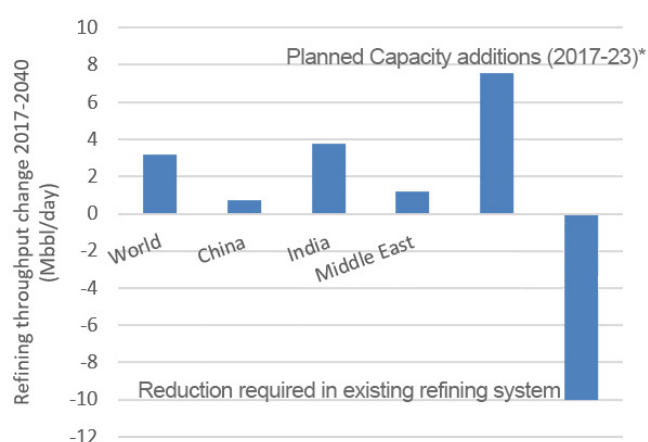
Much 'oil' currently being produced is actually condensate and natural gas liquids (NGLs), requiring no or minimal refining. The rise of US 'light tight oil' ('shale oil') has meant the crude slate has become increasingly light. World NGL output has grown 4.8% annually during 2008-18, while combined crude and condensate production has risen only 0.9% annually^{xi}.

This trend is intensified by the start-up of associated liquids from new natural gas projects, with gas demand growth likely to continue outpacing oil's in the coming decades. For instance, Qatar's planned LNG expansion around 2024 may bring another 385 kbbbl/day of condensate and 180 kbbbl/day of LPG to the market^{xii}.

In addition, biofuels are increasingly blended into motor gasoline and diesel, and are likely to take a larger role in aviation. They have grown at a compound average growth rate (CAGR) of 6.8% over the past decade, to reach 1.8 Mbbbl/day. Biomaterials may also make up a growing share of petrochemical feedstocks. Coal-to-liquids, gas-to-liquids, methanol to olefins and coal-to-chemicals are other competing processes, particularly in China.

The addition of major capacity in the near-term and the shifting geography towards India, China and the Middle East means that capacity elsewhere will have to shut down (FIGURE 1). 10 Mbbbl/day of refining output could close by 2040, probably mostly in Europe and Japan.

FIGURE 1 REFINING CAPACITY CHANGES BY GEOGRAPHY, 2017-40^{xiii}

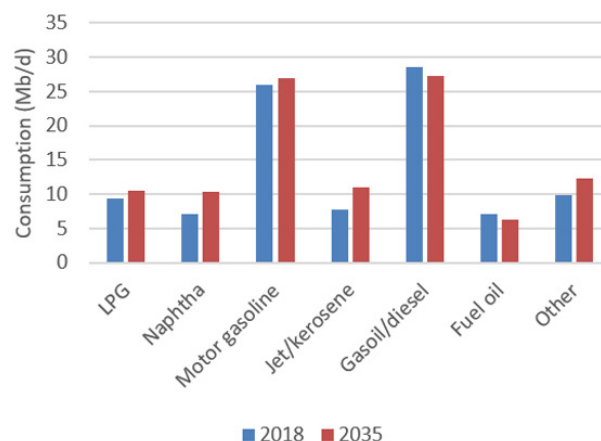


PRODUCT DEMAND WILL SHIFT MODERATELY

Demand will shift between refined products, but only slowly and moderately. The biggest percentage rise will come in the petrochemical feedstocks – LPG and naphtha – and in jet kerosene for air travel. Diesel will fall due to competition from electric vehicles, falling use of oil in power, and Europe's turn away from light diesel cars because of pollution. Fuel oil will drop as it is phased out of power and loses share in shipping.

Overall these changes are relatively modest over a lengthy period, and should be readily accommodated by shifting feedstocks (which are anyway getting lighter, allowing output of more LPG and naphtha and less fuel oil),

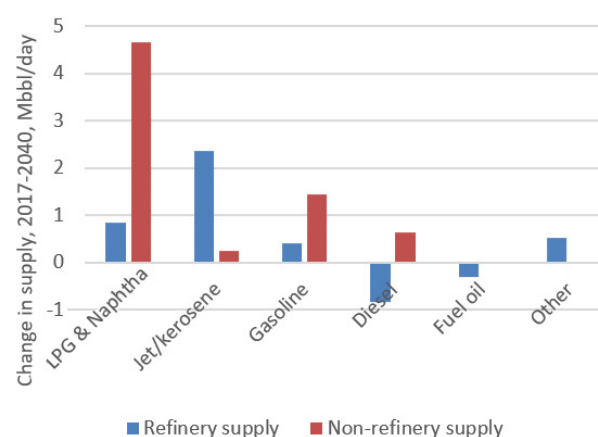
FIGURE 2 OIL PRODUCTION DEMAND CHANGE, 2018-35^{xiv}



refinery upgrades, and shifting of runs between plants. However, unsophisticated refineries with high fuel oil slates, still common in countries such as Iraq, will suffer.

The two factors of changing product supply and increasing non-refined supply interact (FIGURE 2). The increase in LPG, gasoline and diesel will mainly come from non-refining sources (NGLs), while higher levels of jet kerosene and other products will be supplied from refineries.

FIGURE 3 CHANGE IN OIL PRODUCT SUPPLY FROM REFINERY AND NON-REFINERY, 2017-2040^{xv}



JOINT-VENTURE REFINERIES WITH MIDDLE EASTERN NOCs ARE A KEY PART OF THE LANDSCAPE

Middle Eastern national oil companies (NOCs) have increasingly sought in recent years to 'secure' demand by constructing large, modern joint-venture refineries in Asian countries. According to the IEA, the Middle Eastern and developing Asia share of refining runs will rise from 37% in 2018 to 48% in 2040, while Europe's share drops from 16% to 13%^{xvi}.

Saudi Aramco, Abu Dhabi National Oil Company (ADNOC), and Kuwait Petroleum Corporation (KPC) have been the leaders in this process. Aramco has strengthened its position in Japan, South Korea and the US, but the key focus has been on developing Asia, particularly China and now India. Investments have also been made or sought in Malaysia, Indonesia, Vietnam and Pakistan. Meanwhile, Russia's Rosneft bought 49.13% of Nayara (previously Essar Oil) in India in

2017, in partnership with trader Trafigura. The intention of the NOCs is to 'secure' demand by locking in market access. Meanwhile, the host countries hope to get guaranteed access to crude for security of supply, and possibly some preferential terms.

Meanwhile, Algeria's Sonatrach bought the Augusta refinery in Sicily from ExxonMobil in May 2018, but this was to provide product supply for the domestic market.

The strategy of building major new refinery capacity has risks for the NOCs. Chinese demand will not grow forever. More generally, it places large capital assets in consuming countries, vulnerable to changes in political relations, taxation and environmental rules. And, if and when world oil demand begins to decline, NOCs may find they have doubled-down on heavy expenditure on the oil sector instead of diversifying.



NOCs have also built refineries at home to meet domestic demand growth, which has been very fast in the Middle East. This applies particularly to Saudi Arabia and Kuwait, and also to the UAE, Iran and Iraq. However, further expansion may be less required, as demand growth slows because of fuel subsidy reductions, and as the power sector moves away from oil in favour of gas and renewables.

Outside the US, pure-play refineries, both private and state-owned, have relatively underperformed in recent years. Investment in midstream assets, such as transport and storage, and in trading, may add additional value.

PETROCHEMICAL INTEGRATION IS INCREASINGLY KEY FOR NEW REFINERY ECONOMICS

Petrochemicals are seen as a more 'future-proof' output than fuels, given that most forecasts show continuing growth in Asian petrochemical demand in particular. The average world refinery yields 8-10% chemicals; global demand is 15-16% feedstocks, increasing to 20.4% by 2040. Integrated refineries yield about 20% chemicals. The 'crude-to-chemicals' plant planned by Saudi Aramco at Yanbu' targets 45%, and further technology advances could raise this to 70-80%^{xvii}.

Integrated plants have additional advantages^{xviii}:

- Output of higher-value products by transferring low-value byproducts from refinery to petrochemical units or vice-versa;
- Reduced margin volatility due to a more varied output slate;
- Value addition from the ability to vary inputs and outputs depending on market conditions;
- Environmental/efficiency gains from waste heat integration and use of petrochemical by-product methane as refinery fuel;
- Shared utilities and other common facilities (water, power, fire-fighting, control room, marine terminal, storage, waste disposal);
- Reduction of overheads by sharing (HR, management, security, administration);
- Smaller economic size, since petrochemicals margins are higher than for fuels.



As with upstream oil and gas, digitalisation and other advanced technologies are improving refining competitiveness. Key areas for the 'Refinery of the Future^{xix}' include:

- 'Digital twin', to model the refinery and its operations, speed up construction and commissioning, and test improvements without the risk of operating the physical plant;
- Drones for remote inspection and leak detection;
- Sensors and machinery data, to improve performance;
- Predictive maintenance via sensors and 'machine learning';
- Advanced analytics, to optimise crude slates and product output. This is particularly value-adding for integrated petrochemical complexes with a wider range of outputs;
- Automation, to support less-experienced operators;
- 3D printing, to replace components and limit the requirement for inventory of spares.

Tightening environmental standards continue, both on refining operations and product output. Refineries produced 10% of total industrial CO₂, about 0.74 Gt/year, in 2008, a figure that is expected rise to 0.98 Gt/year (6% of total industrial emissions) by 2050^{xx}. The EU is considering imposing greenhouse-gas (GHG) footprint standards for imported and domestically-produced oil and gas. This could well extend to refined oil products, or even perhaps plastics and other petrochemical goods.



To some extent, refining's GHG footprint can be addressed by efficiency improvements, waste heat re-use and integration, and changing feedstocks to low carbon-footprint crudes.

Deeper decarbonisation may require:

- importing low-carbon electricity;
- diversifying feedstocks to include 'green' or 'blue' hydrogen (respectively, hydrogen made from zero-carbon electricity or from fossil fuels with carbon capture and storage (CCS), biomaterials and recycled inputs;
- incorporating CCS, most applicable initially to the fluid catalytic cracker (FCC) (20-50% of a typical refinery's total emissions) and hydrogen plant (5-20% of total emissions).

Shell's Quest heavy oil upgrader in Alberta, Canada, captures about 1 Mt of CO₂ annually^{xxi}. Various other refineries, including in Sweden and the Netherlands, have assessed CCS possibilities.



CONCLUSIONS

The global refining outlook is challenging because of the strong growth from 2019-24 in modern, sophisticated capacity. This will put pressure on smaller, less advanced and geographically less favoured refineries, mostly in Europe and Japan, but also the smaller plants in China. In the longer term, global required refining capacity will peak before overall oil demand does.

The shift in anticipated product demand is relatively slow and modest, and the refining system should be able to adapt.

Refineries can safeguard their economic viability by technological sophistication, scale, combination with midstream and trading, and petrochemical integration. IMO 2020 offers a short-term profit opportunity for refineries able to produce low-sulphur bunker fuels. However, environmental regulations will require continuing investment, particularly when attention turns to refining's carbon footprint.

Integrated company strategies have to adapt to these new realities. IOCs could close their uncompetitive refineries, but would retain heavy liabilities and clean-up costs, or sell

them but only at distressed prices. Exporting-country NOCs can bet on market access and enhanced competitiveness, but risk deepening over-exposure to the oil sector.

Importing-country NOCs can strike a good bargain with partners, but have to ask whether supply security is still so important in a world of abundant supply and, at some point, declining demand.



APPENDIX

ⁱ See the Al-Attiah Foundation Research Series Issue 18 (February 2018) 'Clearing the decks: Marine fuel specifications'

ⁱⁱ https://www2.deloitte.com/content/dam/insights/us/articles/5051_Oil-and-Gas-series-Refining-and-marketing/DI_Refining-and-marketing.pdf

ⁱⁱⁱ <https://www.mckinsey.com/industries/oil-and-gas/our-insights/~media/64ECC6D-805354081B82433E06258D375.ashx?>

^{iv} <https://www.heraldlive.co.za/news/politics/2019-02-13-new-shot-at-coega-refinery/>

^v <https://www.reuters.com/article/us-sinopec-refinery-relocation/sinopec-gets-initial-approval-for-10-billion-shanghai-refinery-sources-idUSBRE9A00CW20131101>

^{vi} Qamar Energy research; media and company reports; <https://stratasadvisors.com/Insights/2019/032619-Downstream-Russian-CIS-Refinery-Project-Update-2019>; <https://www.euro-petrole.com/rosneft-and-pertamina-jv-sign-tuban-refinery-design-contract-n-i-19625>

^{vii} Likely to be delayed

^{viii} <https://www.ief.org/resources/files/events/ief-sinopec-lecture---25-march-2019/china-refining-industry-outlook-and-oil-demand-peak.pdf>

^{ix} <https://www.reuters.com/article/us-global-oil-imo-factbox/factbox-global-refiners-raise-cleaner-shipping-fuel-output-ahead-of-imo-2020-idUSKBN1XU0RK?feedType=RSS&feedName=businessNews>

^x See the Al-Attiah Foundation Research Series Issue 19 (March 2018) 'Peak Oil and Gas Demand'

^{xi} BP Statistical Review of World Energy 2019

^{xii} Middle East Economic Survey Volume 26, Number 48 (29th November 2019)

^{xiii} BP Energy Outlook 2019

^{xiv} Data from <https://www.mckinsey.com/industries/oil-and-gas/our-insights/~media/64ECC6D-805354081B82433E06258D375.ashx?>

^{xv} BP Energy Outlook 2019

^{xvi} <https://www.spglobal.com/platts/en/market-insights/latest-news/oil/111319-iea-says-refining-sector-to-transform-by-2040-asia-to-dominate>

^{xvii} See the Al-Attiah Foundation Research Series Issue 34 (June 2019) 'Petrochemicals: Changing Trends in Refineries'

^{xviii} <https://cen.acs.org/business/petrochemicals/future-oil-chemicals-fuels/97/i8>

^{xix} <https://www.uop.com/wp-content/uploads/2019/05/UOP-Introducing-the-Refinery-of-the-Future-John-Gugel1.pdf>

^{xx} <https://ieaghg.org/conferences/ghgt/2-un-categorised/523-ccs-in-process-industries-state-of-the-art-and-future-opportunities>

^{xxi} https://www.shell.ca/en_ca/about-us/projects-and-sites/quest-carbon-capture-and-storage-project.html

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