The International Maritime Organisation (IMO) rules on sulphur in fuel oil for shipping and the effect on Africa

pwc

Energex Partners

DOWNSTREAM | ADVISORS

Preface

Many times, the events that shape the world seem inconsequential at the beginning, but their effects end up being far-reaching. While maritime fuels account for only about 4% of global oil demand, the new International Maritime Organisation (IMO) regulations that are changing the quality of shipping fuel will have a global effect on oil prices. The driver of this change is to reduce the air pollution created in the shipping industry by reducing the sulphur content of the fuels that ships use. Two hundred of the biggest ships produce more sulphur and nitrous oxide emissions each day than the global car fleet combined.

The new rules potentially add billions of dollars of cost to Africa. The rising price of fuel for shipping will raise the delivered cost of imports and depress those of exports. As Africa is a significant importer of Automotive Gas Oil (AGO), and gasoline, it has exposure to rising prices resulting from the change in refining activity needed to meet the new regulations.

The impact of the new regulations on the African oil sector will be profound given the mix of lower and higher sulphur in oil production in some places. Compared to the global average, there are generally less complex refineries in Africa; there are government subsidies for road-fuel; there is a higher dependence on imported fuels (which are expected to increase in price); and a higher proportion of power generation fed by high sulphur fuels. The challenges posed by the new regulations must be understood and prepared for by all those affected.

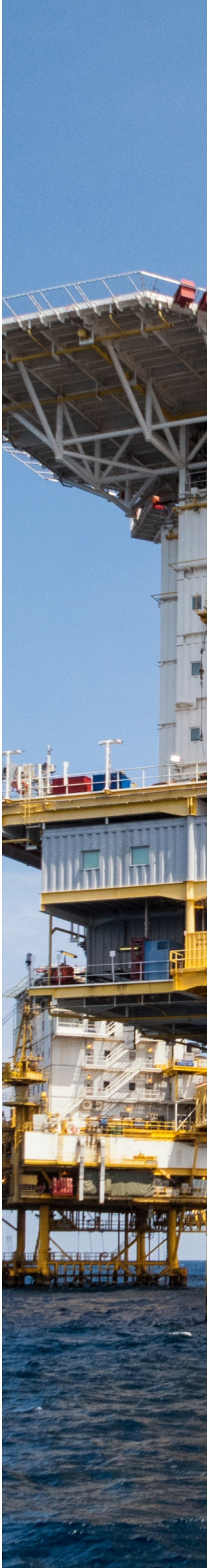
Many industry experts and researchers have written on the impact of the regulations from various perspectives with very little detail on the impact on Africa. PwC Nigeria in partnership with Energex Partners and Downstream Advisors Inc. has developed this report examining the impact of the regulation on Africa in detail considering key actors in the African market viz producers, refiners, consumers, governments, industries among others.

The report contains rigorous in-depth analyses of the wins and possible losses Africa stands to make as a result of the regulation. It also discusses the challenges, key considerations and strategic imperatives for each player in the African oil and gas industry.

While it is intended that the report will be read by a wide range of audiences interested in the subject matter, we have divided it into two parts for easy comprehension - the main report which is suited for technical and non-technical readers and the appendix with detailed technical analysis. We have also included a glossary of key terms that explains some of the technical terms in the report.

Pedro Omontuemhen
Partner,
Oil & Gas and Power Leader
pedro.omontuemhen@pwc.com

Andrew S. Nevin
Partner,
Chief Economist
andrew.x.nevin@pwc.com



The new International Maritime Organisation (IMO) regulations changing the quality of shipping fuel will have a global effect on oil prices. The new rules potentially add billions of dollars of cost to Africa. The rising price of fuel for shipping will raise the delivered cost of imports and depress those of exports. As Africa is a significant importer of Automotive Gas Oil (AGO) / Diesel, and Gasoline, it has exposure to rising prices resulting from the change in refining activity needed to meet the new regulations.

The impact of the new regulations on the African oil sector will be profound given the mix of lower and higher sulphur in oil production in some places. Compared to the global average, there are generally less complex refineries in Africa; there are government subsidies for road-fuel; there is a higher dependence on imported fuels (which are expected to increase in price); and a higher proportion of power generation fed by high sulphur fuels. The challenges posed by the new regulations must be understood and prepared for by all those affected.

Content

1

African winners and losers from IMO 2020

Sector	Most Disadvantaged	Opportunity/Risk	Most Advantaged
Governments	Subsidies for road fuels	Higher/lower state revenue depending on crude field qualities	State power generation using High Sulphur Fuel Oil
Refiners	Simple refiners using high sulphur crude/oil exporting fuel	Refiner switching /using local low sulphur crude	Complex refiners using high sulphur crude but with a low fuel oil yield
Crude Producers	High sulphur crude producers	Crude producers with limited access to optimum market	Low sulphur crude producers with full export capability
Bunker Companies	Bunker suppliers with access to high sulphur fuel oil only	Logistics to supply either MGO, VLSFO or HSFO	Bunker suppliers of VLSFO able to include this in a multi HSFO/MGO bunker fuels offer
Industry Consumers	Energy-intensive industries/consumers of long haul freight	Distillate consumers (Airlines/Haulage)	Consumer of high sulphur fuel oil e.g. bitumen producers
Storage	Refinery storage operations	Crude export terminal logistics	Fuel oil and VLSFO blend & storage facilities
Power Generation/ Others	Power generation companies using diesel/low sulphur fuels	Scrubber manufacturers	Power generation companies using High Sulphur fuel oil

Particularly exposed African sectors

Note that South Africa and Egypt's profile will look different from the above diagram, given their production of higher sulphur crudes and more complex refineries

2

The new regulations: a price shock for the market

200 of the biggest ships produce more sulphur and nitrous oxide emissions each day than the global car fleet combined. This is largely a function of the very high-sulphur fuel that vessels use, compared to other modes of transport.

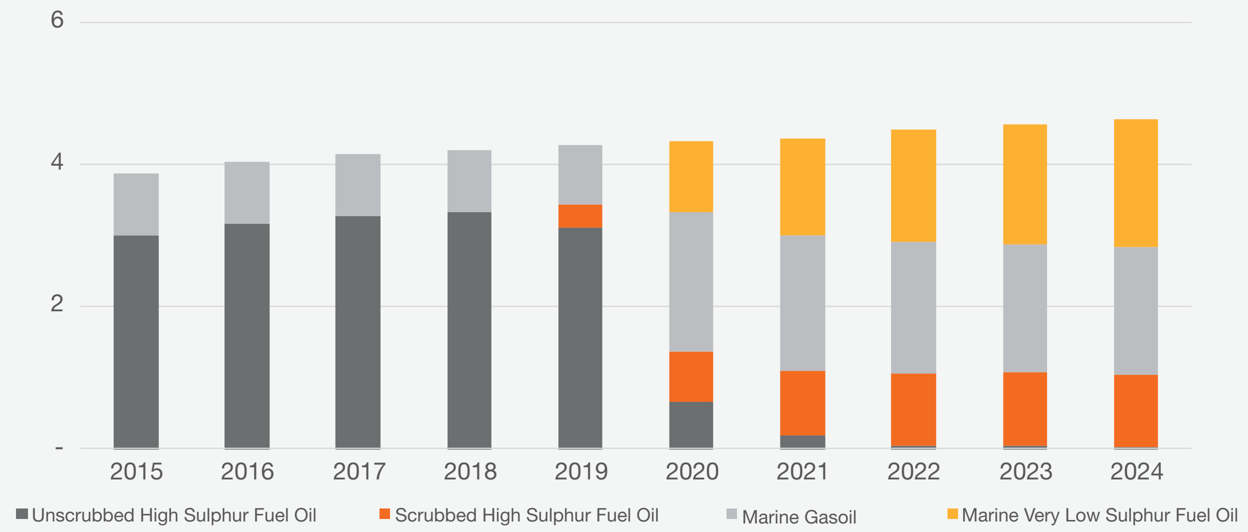
On 1 January 2020, a new global cap by the IMO on sulphur content in marine fuels will come into effect. The new regulations, known as IMO 2020, mandate a maximum sulphur content of 0.5% in marine fuels globally. The current sulphur cap is 3.5% and has enabled the use of some 3.5 million barrels per day (bbl/d) of high sulphur marine fuel, of around 100 million barrels per day of global oil demand. Shipping is currently the biggest market for the world's high sulphur fuel oil (HSFO) production, with some analysts predicting more than 70% drop in global demand for HSFO.

The IMO 2020 regulations, which will see high sulphur fuel oil largely replaced by more expensive very low sulphur fuel oils (VLSFO) or cleaner but even more expensive marine diesel, will cause the biggest upheaval in oil prices since the financial crisis as all industries either supplying or using oil will be affected.

The IEA global analysis of this adjustment in demand by the shipping industry is portrayed in the following bar chart. It shows the changing components of the marine fuels in the years 2020-2024 and implies that:

- The initial competition for lower sulphur distillate products (Marine Gasoil/Diesel(MGO)) is expected to be significant
- In addition to this, other distillate products will be used to help create compliant new low sulphur marine fuels through mixing ("blending") with different fuel oils
- This is expected to continue for a period before a greater proportion of VLSFO is produced by refineries and distributed to where it is needed.

Figure 1: Marine Bunker Product Demand mb/d



Source: IEA 2019. All rights reserved

Due to IMO 2020, the increase in total demand for distillate is expected to lead to increased prices for distillate products, including automotive diesel and jet fuel. As distillates (specifically Vacuum Gasoil - VGO) are also used in the refining process to produce lighter products such as gasoline and naphtha, these sectors (including the petrochemicals industry) will be affected. Some commentators also see high sulphur fuel oil prices collapsing, which will lead to a competition with coal, as power generation will become its largest remaining market outlet.

Refiners, suppliers, traders, and consumers, will be forced to adapt to the potential increase in costs because of IMO 2020

The shift in the demand between low sulphur (LS) and high sulphur (HS) will be sudden and unprecedented. This has made it difficult for analysts to predict the likely impact on the various high sulphur-low sulphur product price differentials, product-to-crude price differentials, and HS-LS crude oil price differentials. The latter two will be impacted as different crude oils around the world have different sulphur content and hence their values will change as a result of IMO 2020. Consequently, we are seeing a wide range of price forecasts materialising, some of which are very extreme.

There is an extensive ongoing debate concerning the severity and the duration of this upheaval with some very aggressive predictions seen on price and therefore economic impact:

- **Some analysts sees the global cost of the new regulations as $1 trillion over 5 years, whereas others have calculated the global cost of the new regulations as $240bn**
- **One consultancy has even suggested a possible reduction in the US GDP as high as 7%**
- **Bullish analysts see price moves comparable to the 2008 period when crude surged to $140 usd/bbl and distillate cracks (price premium to crude oil) were at record highs.**

The oil industry has a long history of finding solutions to problems caused by the adoption of new fuel standards, for example, the phase out of lead in petrol or an increased requirement for renewable content. After periods of high volatility, the operations and price eventually settle into a new normal.

However, these previous changes have tended to be much more modest and gradual, compared to the relatively seismic product specification shift that is represented by IMO 2020.

Our analysis suggests that the more extreme forecasts of different product prices scenarios are overstated, at least in the longer term. There is sufficient refining capacity and low sulphur crude oil available to produce the new fuels required by IMO 2020. However, there is great uncertainty on how long it will take the global refining system to find this new equilibrium, which means an initial period of increased volatility.

In the short to medium term, there might be supply and demand disruption and volatility in prices of the impacted fuel grades. Oil producers, refiners and consumers will have to review their activities and take action to mitigate the business impact from these impending changes in demand and prices.

For industry and governments in Africa, this event will create a significant challenge for many; either in how to make the most of the opportunity or in how to mitigate the likely cost impact. African governments and industries need to consider the following:

1. What could be the risk impact to your business in the years ahead, and
2. How might that be managed through operational adjustments and appropriate risk management.

Each Individual Company requires an individual solution. PWC/DAI/Energex together can provide the analysis and the advice needed to adapt to the new regulations

3

IMO in context

A variety of analysts from banks and consultancies, have suggested that the new IMO regulations will reduce the global demand for HSFO from 3.5 million to 1 million bbl/day. Concerns that the new low sulphur grade is difficult to supply therefore suggests that the resulting shortage of bunker fuel will be made up by usage of marine diesel (distillates).

The more bullish analysts believe that the only way to meet this demand for distillate is a sharp increase in global crude runs. This increase in gasoil demand would drive the price of crude oil higher.

Our analysis shows that this view does not fully consider the capacity of the global refining system and the product yields it can produce. The supply and demand of oil cannot balance if the world increases crude supply rates (increase oil supplies) without a corresponding increase in demand for the whole barrel.

This report explains how the global refining system could meet the product demand using the same crude supply rate and composition, with or without IMO 2020, by processing differently.

1. Segregation of low sulphur crudes and low sulphur fuel oil will be key as they will be more valuable in a world that needs fuels to be <0.5% sulphur post IMO
2. The higher price of "finished" 0.5% sulphur diesel (500ppm Automotive Gasoil "AGO") versus the refinery feedstock diesel (Vacuum Gasoil "VGO") used for processing, should drive the world to consume VGO instead of diesel as a bunker fuel.

Some of the supply challenges that the refiners face in producing and delivering the VLSFO include:

- Efficient sourcing/distribution of low-sulphur feedstocks and blendstocks to where they are most needed
- New supply/marketing relationships need to be formed as traditional suppliers/offtakers may no longer be optimum
- Many refiners may struggle to compete for low sulphur crudes and blend stocks in a period where price uncertainty and high volatility will necessitate thorough and agile analysis and decision making
- Many refiners may not be ready with appropriate reconfiguration of refinery units, storage tanks and other infrastructure that will be required to segregate the high and low sulphur feedstock and blendstock streams
- Refiners may need time to get their new VLSFO specs approved and accepted by the shipping industry.

Consequently, there will likely be a **period of transition** where the shipping industry will need to consume more of the less-economic (and readily available) Marine Gasoil ("MGO") while the refining and bunkering supply chains gradually increase their ability to supply VLSFO to where it is needed.

This increased demand for distillate products could then have a meaningfully adverse price impact for other consumers of diesel and other road fuels.

The report considers how these changes will affect Africa's oil industry and energy-intensive industries.

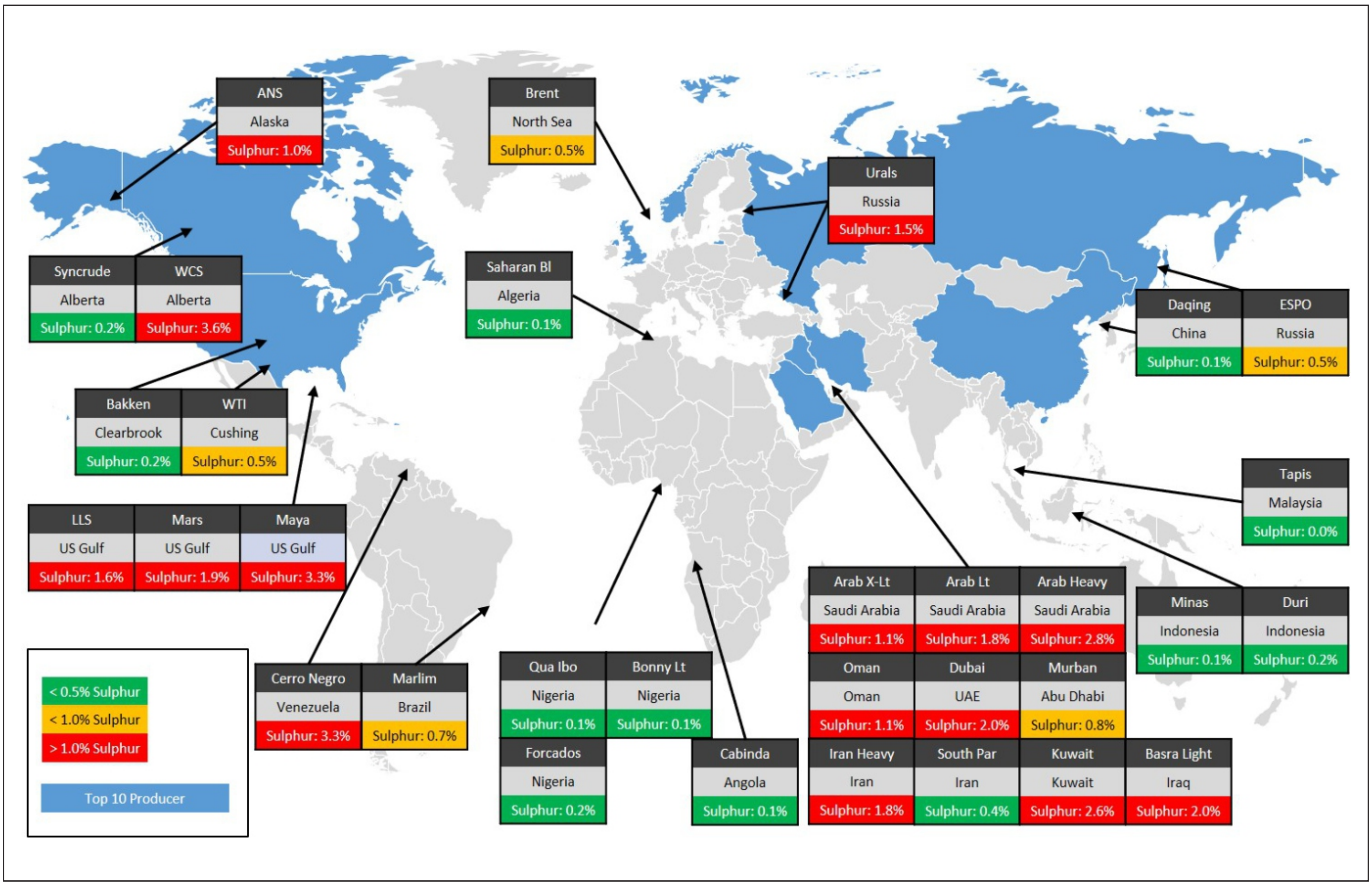
The reader should be aware that some analysts forecast that the HSFO price will go to a coal-price parity, a view that we do not feel is supported by the available information. This view is based upon there being insufficient demand for high sulfur residual fuel oil. We are of the opinion that both HSFO and LSFO prices will remain closer to Brent (one of the most traded crude oils globally). Even without significant on-board exhaust treatment (scrubber) additions on ships, enough residual fuel conversion capacity exists in the global refinery system to eventually consume the high sulfur vacuum residual fuel which is not blended to fuel oil post IMO 2020.

For a detailed discussion of this issue see the appendix.

4

Production and refining: the segregation of low sulphur crude

Each of the world's 250+ crude oils can be identified and defined by its hydrocarbon content. The two principal characteristics are density and sulphur. These vary from light and sweet to heavy and sour; low density and low sulphur (sweet) to high density with high sulphur (sour).



The composition of the crude has a significant effect on the quality of the products derived from its processing. The lower the sulphur content of the crude oil going into the refinery, the lower the sulphur content of the fuel oil produced from the distillation process. It is important to realise that the sulphur content of the residual fuel oil is usually higher than that of the whole crude and that is where the sulphur is concentrated after refining.

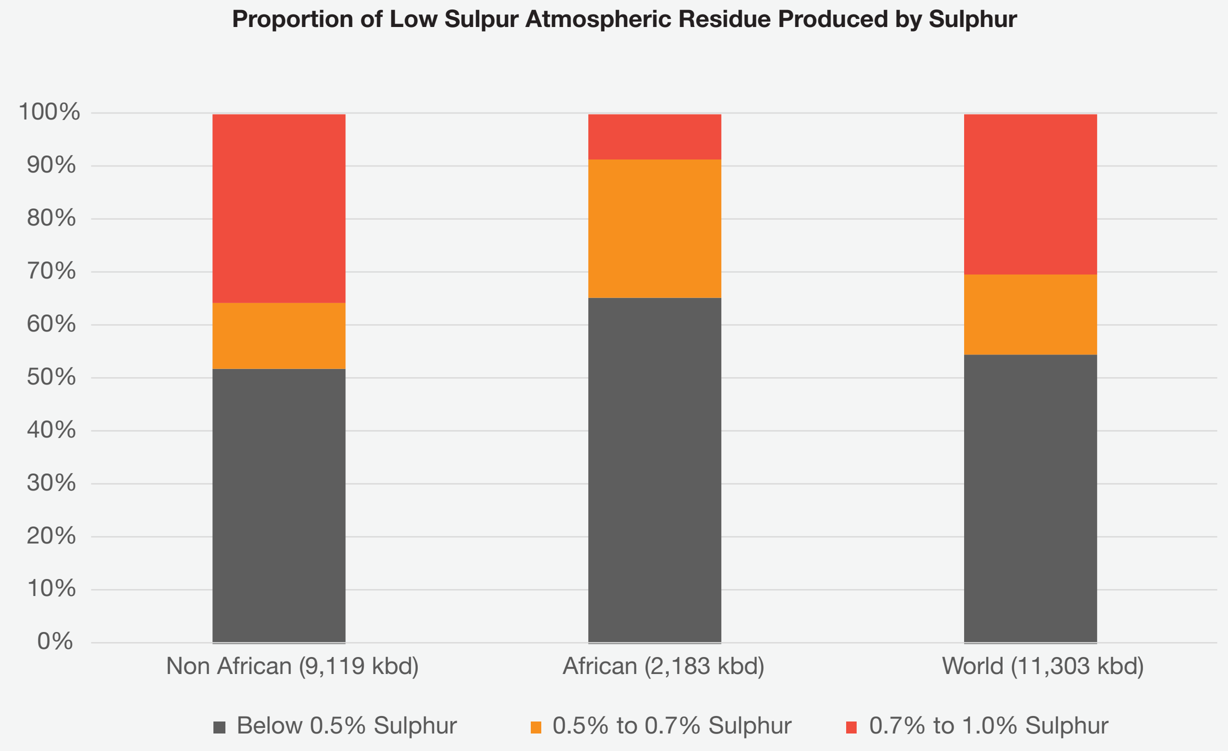
Globally there is sufficient low sulphur crude of the required quality to meet the demand for the new low sulphur fuel oil for bunkers. The key challenge for refiners will be to source and then segregate the low sulphur crude streams more efficiently to ensure the required processing results.

Many refiners can produce VLSFO without investment by switching to lower sulphur crudes as their feedstock. Enough straight run atmospheric residual fuel of less than 0.5% sulphur will be available just through segregation of crudes. While some of this low sulphur straight-run atmospheric residual fuel supply is land-locked or has alternate markets, our analysis suggests that enough VLSFO can be supplied as marine bunker fuel through crude segregation. The price premiums of crudes yielding VLSFO will increase as refiners switch their production to VLSFO.

Some refiners may even partially shut down their vacuum units to produce straight run atmospheric residual fuel instead of VGO and vacuum residual fuel (see below: Refining A Change Of Operations).

Refiners will segregate crude oils to produce LSFO. As shown in the figure 3 (that breaks down the 11.3 mb/d of the low sulphur atmospheric residual fuel production meaning atmospheric residue containing 1% or less sulphur), over six mb/d of atmospheric residual fuel (55% of the total low sulphur production) is produced today with a sulphur content of 0.5% or less. Over eight mb/d of atmospheric residual fuel (70% of the total low Sulphur production) has a sulphur content of 0.7% or less and therefore will have a value being blended into the marine fuels pool. Comparing this for Africa, we can see that 65% of the low Sulphur atmospheric residual fuel has a sulphur content of 0.5% or less, while 91% has a sulphur content of 0.7% or less.

Figure 3: Proportion of low sulphur atmospheric residue produced by sulphur



Source: DAI

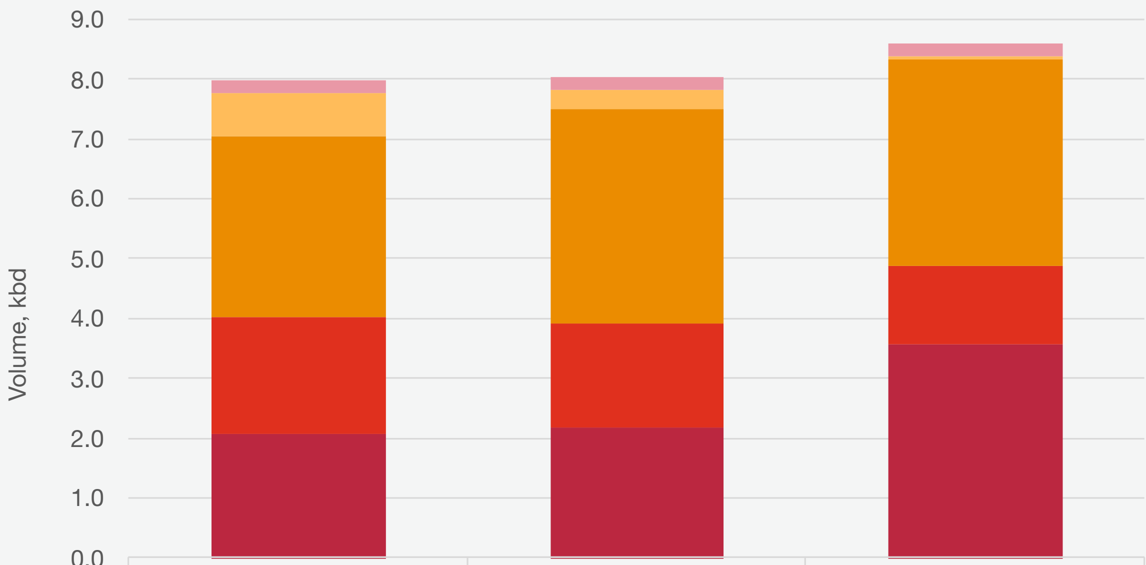
The segregation of low sulphur crude: the challenge for Africa

For much of Africa the crude production is already low sulphur and so is the resulting fuel oil from processing so the demand for exports will remain strong. The challenge will be in maximizing the value from those exports.

Crude oil consumption in Africa is consistently lower compared to its production, and the excess crude is exported, as shown in figure 4. Other growing markets like Asia will take advantage and import more low sulphur crude oil from Africa to meet demand and the new quality standards.

Figure 4: Consumption Breakdown of African Crude Production

Forecast Consumption Breakdown of African Crude Production



	2017	2020	2030
S. America exports	0.2	0.2	0.2
N. America exports	0.7	0.3	0.1
Asia exports	3.0	3.6	3.4
Europe exports	1.9	1.7	1.3
African consumption	2.1	2.2	3.6

Source: DAI

The above graph represents the actual (2017) and projected (2020, 2030) African crude oil production, consumption, export and import, together with the forecast destination (data in thousand b/d).

The forecasted African crude oil supply and demand balance will be affected by strong internal demand growth, especially in the 2020-2030 period. This increase in consumption (+1.5 M b/d) will be partially offset by the higher crude production (+0.6 M b/d). The remaining demand will be compensated by decreasing crude exports to regions such as North America and Europe:

- North America will continue the trend of the recent years in cutting the crude imports from West Africa. Light and sweet African crudes will be replaced by higher domestic tight/shale oil production that has very similar quality.
- European refinery throughput is forecast to steadily decrease (older, less competitive refineries) which will lower the need of crude imports. Crude flow to the Far East is projected to increase from 2017 level peaking in 2020 close to 3.6 M b/d.

Can African refiners segregate the low sulphur residual fuel oils needed to meet the new specification?

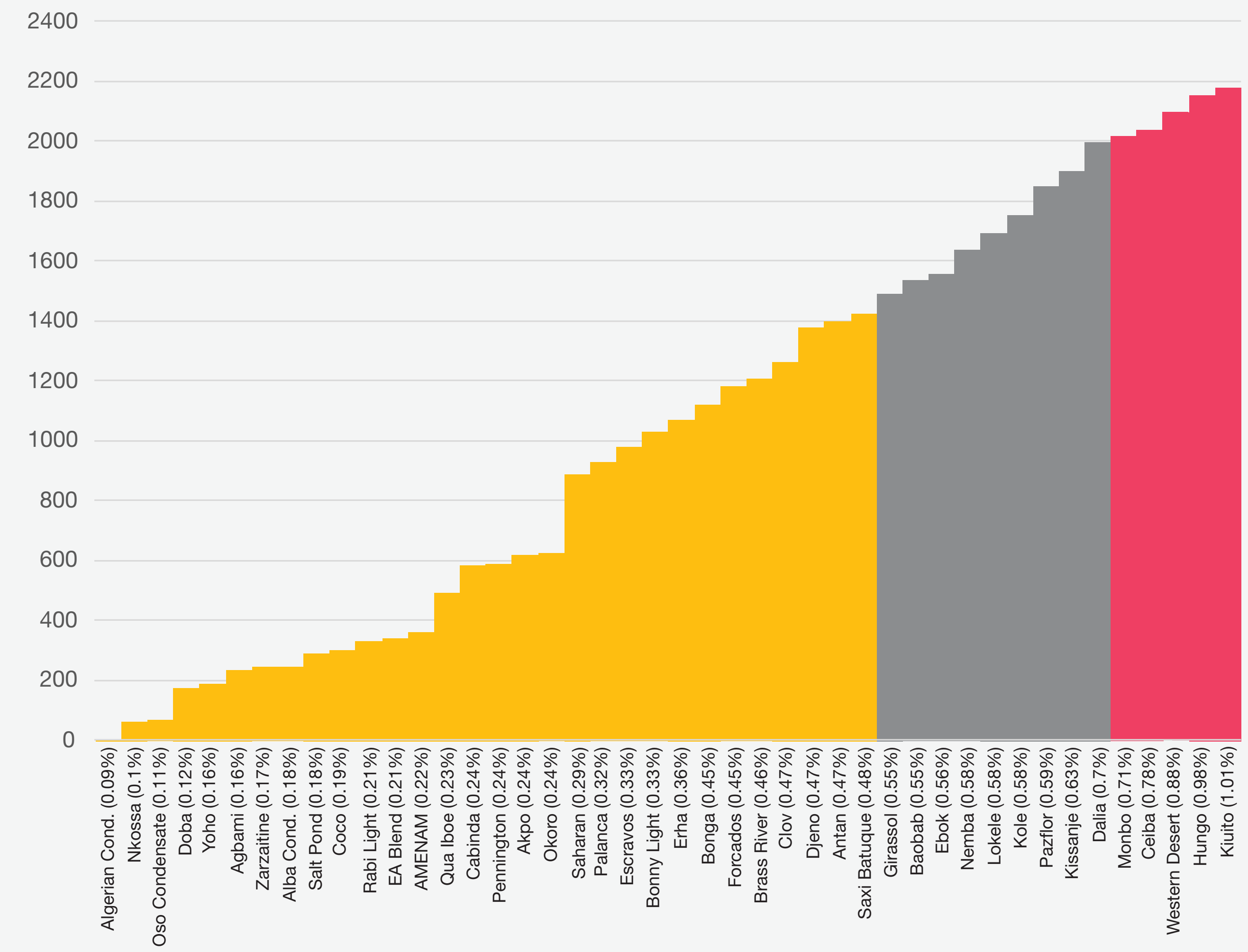
Is there sufficient infrastructure to export low sulphur residual fuel rather than use it in domestic high sulphur markets?

Close to 90% of Africa's crude oil production is sweet. Africa contains roughly 50 crude oils containing low sulfur vacuum residue capable of blending directly to meet a vlsfo specification. To put this into context, there are slightly more than 200 of such marketable crude oils worldwide.

Figure 5 shows that 65% of the total low sulphur vacuum residue produced from African crudes (or 1426 kbd - shaded amber of the total 2183 kbd) is below 0.5% sulphur. 30 out of the 44 crudes named here yield less than 0.5% sulphur vacuum residue.

Note also that the vacuum residue below 0.7% sulphur is expected to have a good value (shaded amber and grey) as blend components for compliant marine fuels; representing 93% of the African crudes.

Figure 5: Cumulative Available African Atmospheric Residues (kbd)



Source: DAI

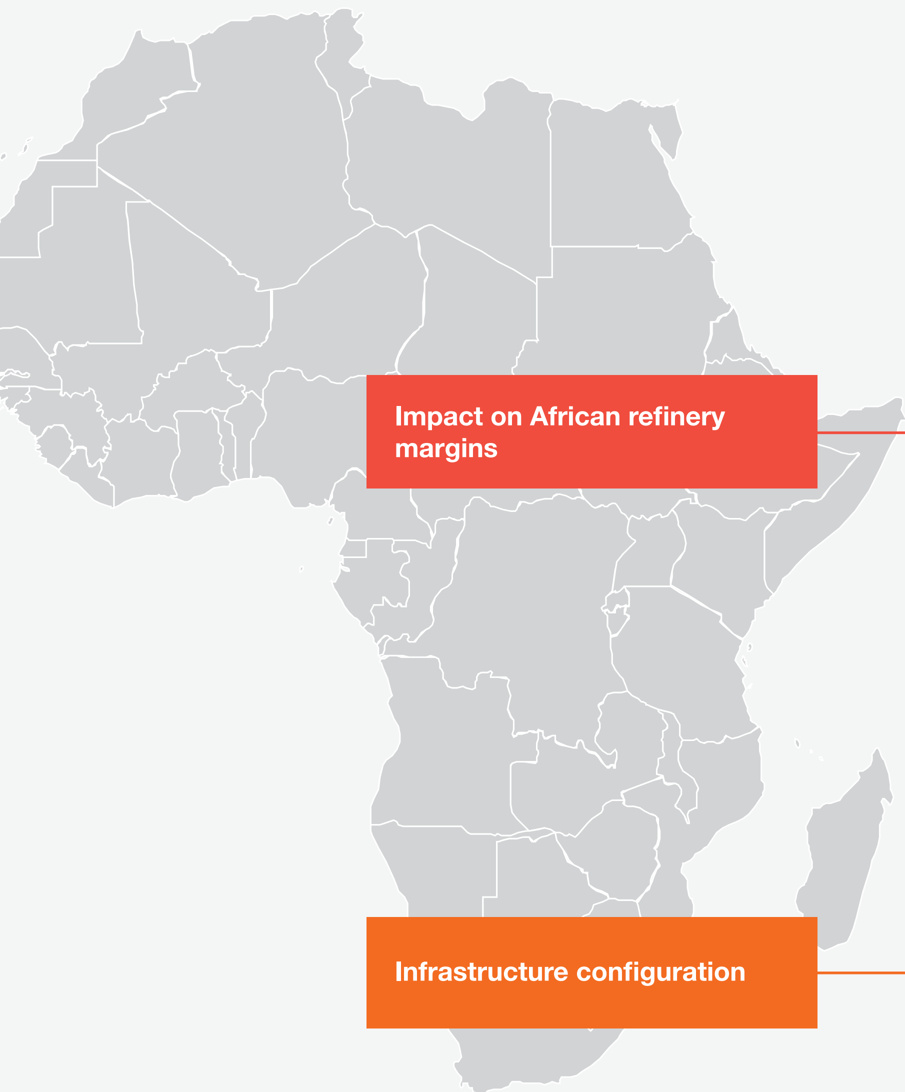
These graphs suggest a possible bonanza for African refiners 'naturally' producing low sulphur fuel oil, using local crudes as feedstocks. Even with relatively less sophisticated refineries it should be feasible to meet the new regulations and achieve the higher prices they bring.

The ability to supply the fuel to market is dependent on a variety of factors beyond simple crude choice. For example, there may be limitations of insufficient tankage, pipelines, or access to export terminals.

With refineries competing on a global basis, African refineries hold a competitive advantage due to their location in a feed-surplus, product-short market. These advantages, along with lower-cost natural gas and less stringent fuel standards, enable several African refineries with low complexities and desulfurization capacities to perform profitably in the world market. African hydroskimming refineries are expected to continue to compete through 2030 due to their access to a significant volume of low sulfur crudes. Such refineries would generally be at risk in other markets where low sulpur contents crudes are not available.

Where low sulphur fuel is being used in a potential high sulphur market (e.g. power generation) is there sufficient infrastructure to allow not just the export of the IMO suitable fuel, but the import of a replacement high sulphur barrel?

The challenges and considerations for African producers and National Oil Companies (NOCs)



Challenges

Export Programmes

Impact on African refinery margins

Infrastructure configuration

Considerations

How do African producers adjust their export programmes to maximise the value of their low sulphur crudes?

- Is the increased value of the low sulphur crude understood and achievable?
- Do FOB exports still provide the best access to the best markets?
- Does supplying local/inland refiners provide better economics as freight rates rise?

Is the analysis in place to identify the maximum return for the new refinery margins?

- Does the refinery planning team have access to the required pricing data/values for the new grades?
- Should low sulphur crude be exported and high sulphur products be imported, or local refinery runs increased?

Is the storage configuration and infrastructure sufficient for the necessary segregation of the low-sulphur and high-sulphur crude oils?

- Is there sufficient access to tankage/pipes/jetties for the export of more crude and/or fuel?
- Is there sufficient tankage/pipes jetties for export of crude/resid/products to be replaced by high sulphur imports?

5

Refining: a change of operation to optimise margins?

The relative value of vacuum gasoil (VGO) versus gasoline and diesel/automotive gasoil (AGO) will create an incentive to change refinery operations

New IMO 2020 sulphur rules will transform the global bunker fuel market from a low cost, low price segment to a medium-high value, high-quality product market that must be price-competitive with low sulphur refinery feedstock. That is at least the case during the first couple of years following 2020 during which the production of 0.5% bunker fuel will change refinery operations.

The conversion, or upgrading of the crude, is determined in each refinery by the complexity of the refinery. At simple plants with only crude distillation units, the fuel oil yield will be some 40%. Very complex refineries produce little or no fuel oil as it is all upgraded. The majority of refineries will lie in between, but they still have considerable flexibility in how to run those units.

Medium complex refineries upgrade their residual fuel oil, producing Vacuum Gasoil (VGO) which is used as a feedstock for further processing in a Catalytic Cracker to produce gasoline, a type of marine diesel (called light cycle oil) and naphtha. Historically, refineries have been motivated to convert as much of their crude into higher value transportation fuels (diesel, jet, and gasoline) and, consequently, fuel oil (which due to the processes tends to have the concentration of the sulphur) has been priced at a discount to crude to dispose of it.

0.5% sulphur VGO currently sells at significant discounts ($4-8/bbl) versus automotive diesel. This would be enough to motivate shippers to purchase low sulfur VGO for bunker fuel. In turn, refiners will process less VGO in their catalytic cracker units. This could reduce the world's production of gasoline

Thus, the calculation for any medium complex refinery will be, at what price is it economic to use VGO as a marine fuel or as a feedstock into the production of gasoline, light cycle oil and naphthas?

This course of action will be confined to the medium complex refineries. Using all of the VGO to make the new 0.5% sulphur bunker fuel actually means less of a finished diesel fraction is required. **Therefore, this alteration of processing operation meets the demand without the need for any increase in total crude runs**

Simple refineries can only reduce their sulphur through crude choice (this has the impact of increasing the value of many African lower sulphur crudes).

For a fully complex refinery the incentive to reduce their upgrading to make fuel oil rather than clean products will have to be substantially higher

Refiners investing in new residue conversion will face a new risk that the investment will not be economic.

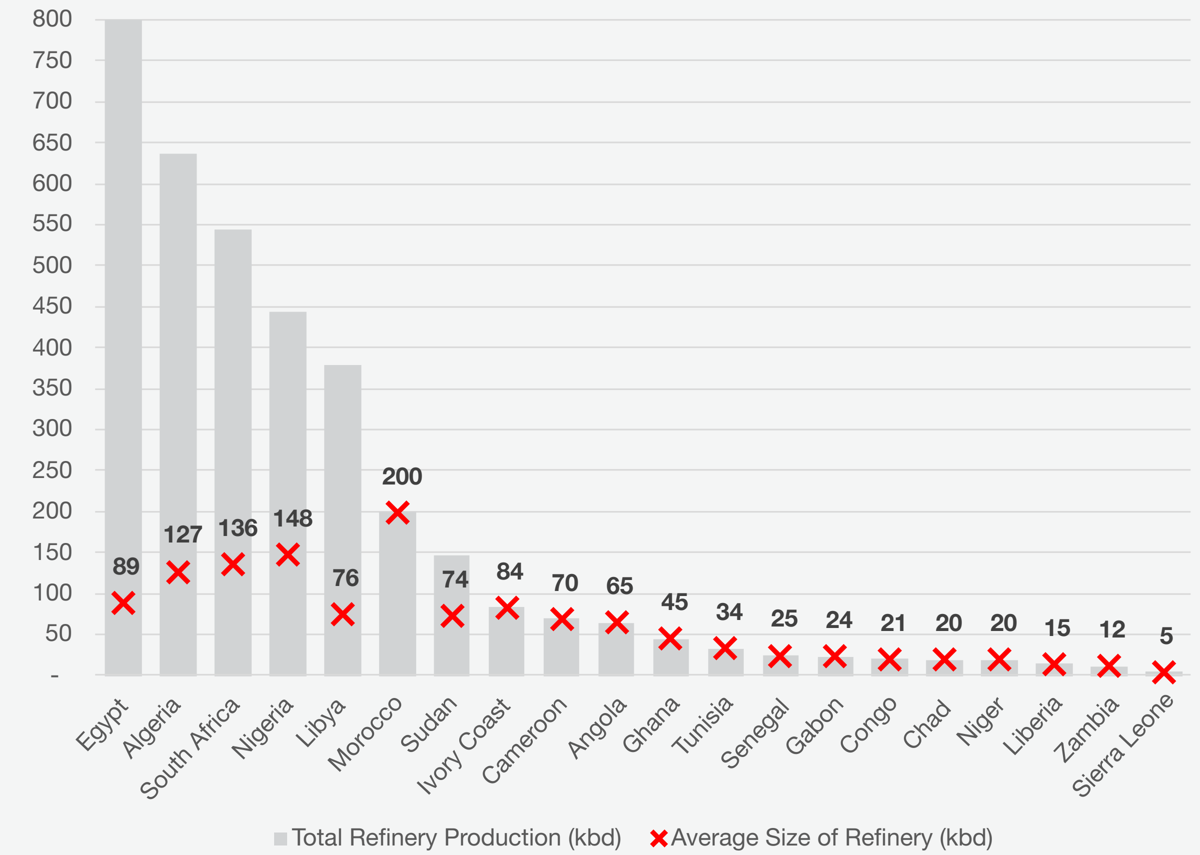
For a detailed analysis of the refining processes see the appendix

The incentive to change refinery operations: the challenges for Africa:

Figure 6 shows a breakdown of nameplate refinery capacity by country in Africa. It is important to note however:

- Many of the refineries such as those in Nigeria, Libya and Morocco are running at low utilisations and hence output of refined products is below 50% of the nameplate and will require investment to improve
- Most refineries in Africa are simple “hydroskimming” refineries with only a handful of exceptions being more complex mainly in the North and South such as Skikda (Algeria), Mostorod (Egypt), Chevron and SAPREF (South Africa) and Ndajamena (Chad)

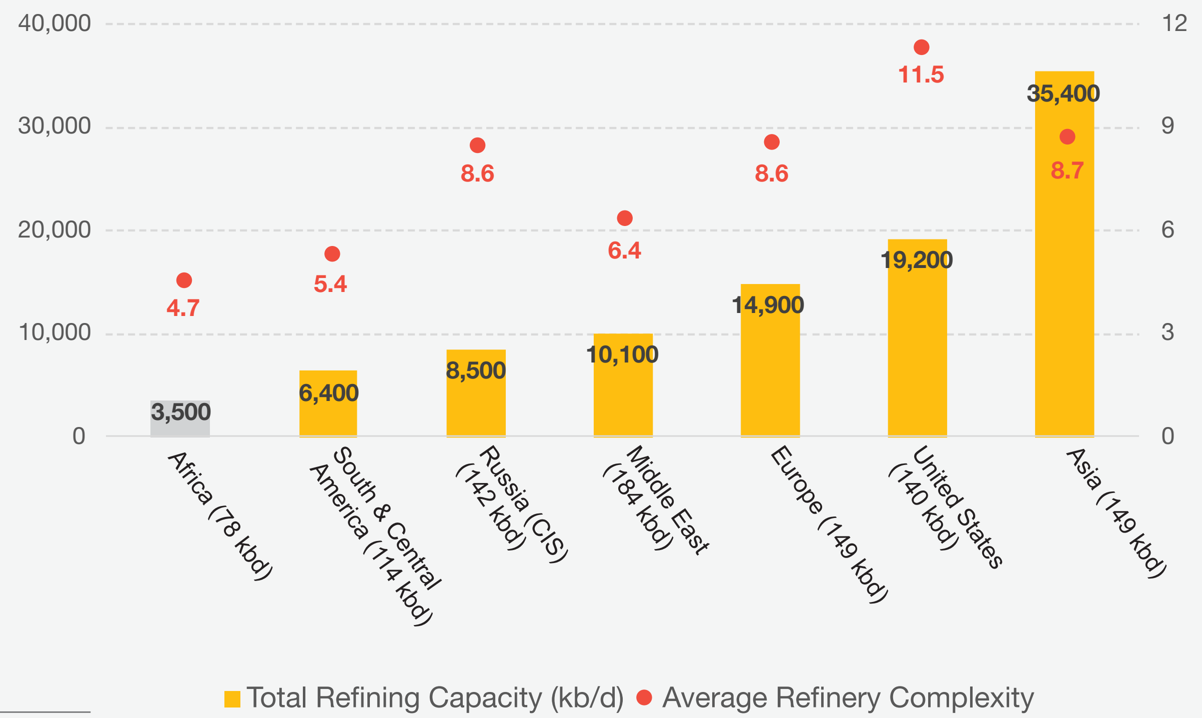
Figure 6: African "nameplate" refinery capacity by country



Source: Industry data

To put this in the global context, on average African oil refineries are roughly one-half of both capacity and complexity of refineries in Europe and United States (note that figure7 below shows the average refinery capacity for each region in brackets).

Figure 7: Regional Refinery Capacity and Average Complexity



Source: DAI

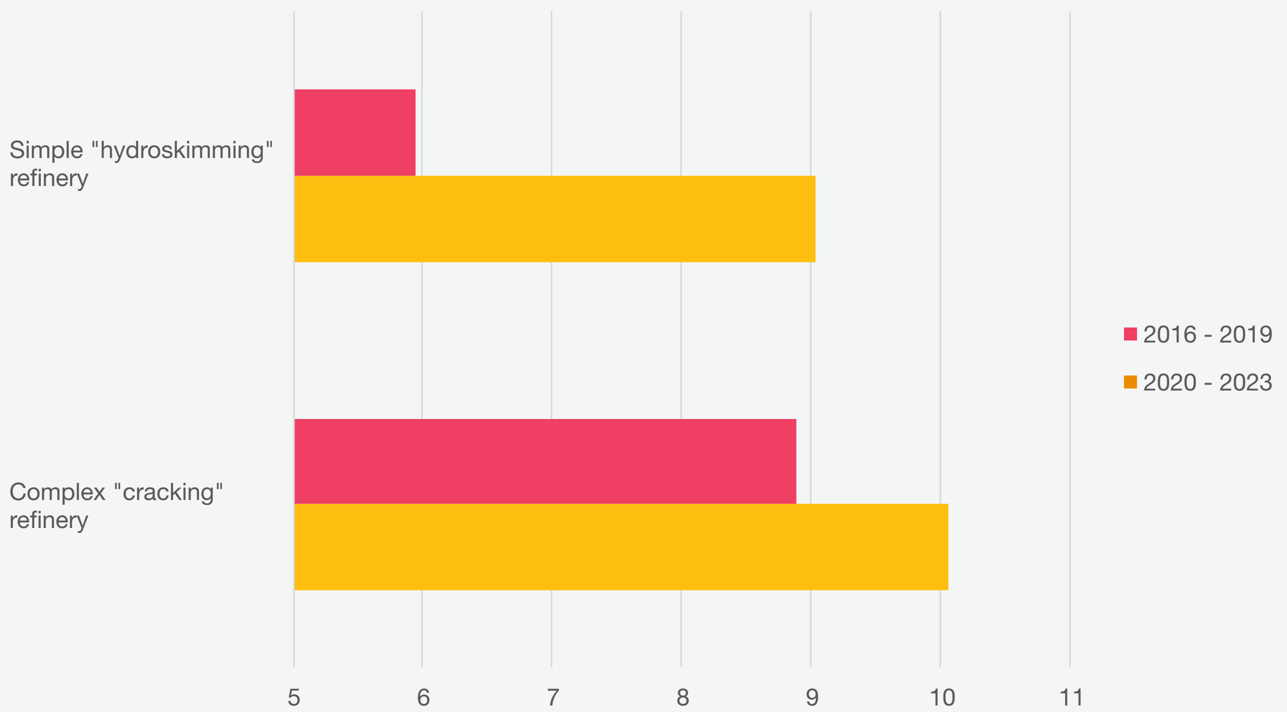
Nevertheless, West African oil refineries generally benefit from having access to lower cost crude and high prices for products. IMO 2020 increases the ability of African refineries to profit from these location advantages by providing a higher price for (low sulphur) straight run atmospheric residue. Given the availability of low sulphur African crude oil, African hydroskimming refineries producing 0.5% sulphur fuel oil will be strongly profitable and should maximise their throughputs accordingly.

Furthermore, the higher price of low sulphur straight-run fuel oil suggests that a less sophisticated refinery producing the required fuel oil will be nearly as profitable as refineries with residual fuel conversion.

This is illustrated in figure 8 below which compares the refinery margins of two hypothetical refineries – a simple “hydro skimming” refinery and a more complex “cracking” refinery. As shown, a hydroskimming refinery located in Africa can achieve nearly the same cash margin as a residual fuel cracking refinery of the same size.

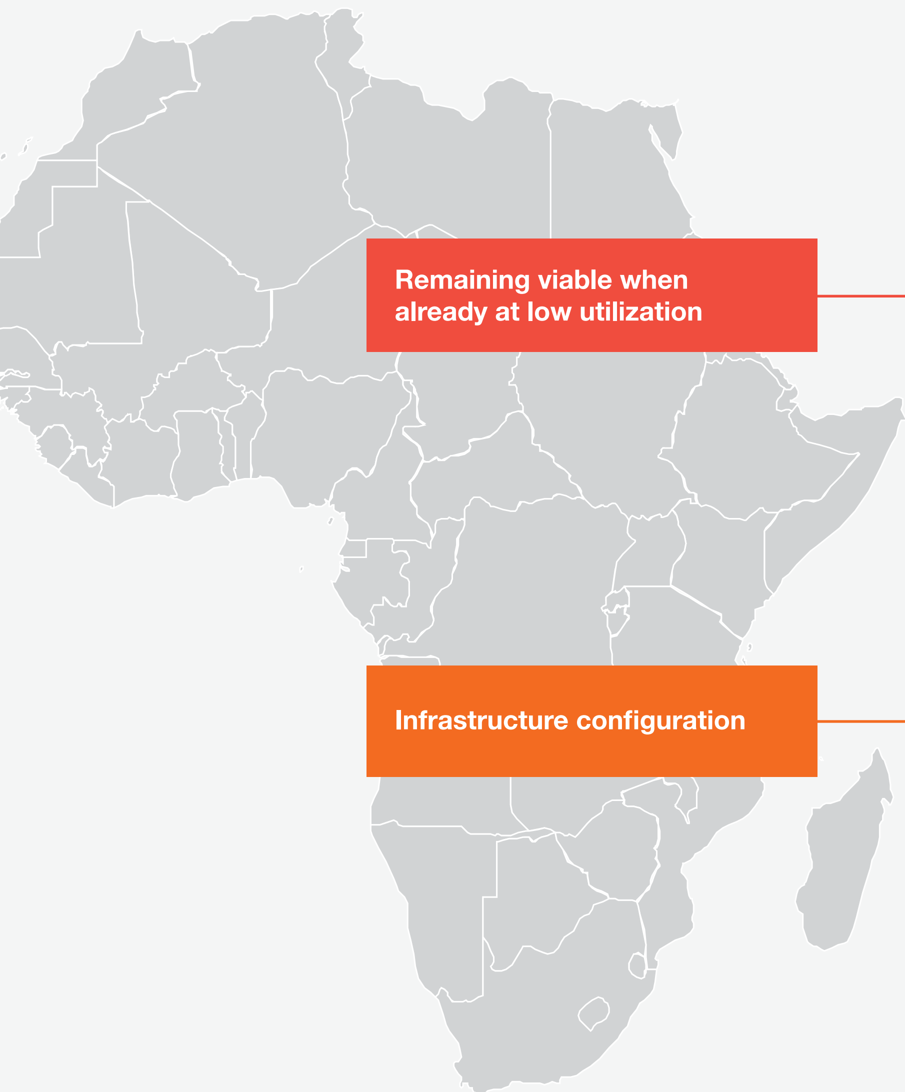
The Dangote refinery, being built in Lagos, is to start up in 2021. When finished the refinery is expected to have a capacity of 650,000 b/d (460,000 b/d Crude Distillation Unit) and an approximate complexity of 8.9 due to these “upgrading units”. We can see from the chart below that it could be advantageous to bring the core distillation units up and running as soon as possible to benefit from the IMO 2020 uplift expected in simple refinery margins.

Figure 8: Refinery Margins Before and After Implementation of IMO 2020 ($/bbl)



Source: DAI

The challenges and considerations for African refiners



Challenges

Planning for the change in terms of feedstocks and refinery production

Considerations

Have the lower-complexity African refiners done sufficient planning and modelling to ensure they can continue to be viable?

- How can the sourcing of appropriate feedstock (low sulphur crudes) and more dynamic segregation of feedstock and blend components benefit a refinery?
- What will margins look like?
- How can refineries optimize their processing?
- Does the refinery planning have access to the needed pricing data/values for the new grades?
- Is there full understanding of the effects on the whole oil barrel of the new sulphur regulations?

Challenges

Remaining viable when already at low utilization

Considerations

A number of refineries in Africa operate below capacity or are part mothballed. The future economics of these refineries, and potential investment cases, should be reassessed in light of the IMO 2020 changes:

- Are governments and NOCs seeking appropriate advice and analysis to reconsider the investment case for upgrading their refineries?

Challenges

Infrastructure configuration

Considerations

Are the refinery units and storage configuration and infrastructure sufficient for the necessary segregation of low sulphur and high sulphur crudes and blend stock?

- Is there sufficient access to tankage/pipes/jetties for the export of more crude and/or fuel?
- Is there sufficient tankage/pipes jetties for export of crude/resid/products to be replaced by high sulphur imports?

Challenges

Widening of clean products vs high sulphur products prices

Considerations

The new regulation suggest a widening in value of low sulphur clean products relative to high sulphur products

- Is it economically viable to import high sulphur diesel\gasoline and export low sulphur?
- Is it viable to maximise returns through product blending?


LUFKIN

6

The wider Africa impact of IMO 2020

Bunkers and shipping

The industry most affected by IMO 2020 is the shipping industry. Ships will have to pay more for their bunker fuel as the price of the new grade is much higher than the previous quality

The new regulations have created practical concerns for shippers and the bunker companies who supply their fuel. Quality and accessibility of the new fuel is a major consideration. Shippers are concerned that if they cannot access the already more expensive VLSFO in a particular port, they will be forced to buy even more expensive marine diesel (MGO). These uncertainties will add to the upward pressure on prices.

Many of the traditional bunkering ports (Singapore, Fujairah and Rotterdam being the biggest) need to reconsider their supply sources. In Africa, for example Durban a high sulphur port, must seek new supplies, perhaps in co-ordination with the local refiners considering their mode of operation. In West Africa, easier access to low sulphur fuel provides an opportunity to expand bunker business.

Fuel can be responsible for up to half of shipping costs. Seabury Maritime, a consultancy, estimates that the cost of shipping a standard container from the US to China will rise by 35% as result of the IMO changes.

Maersk, quoted by Forbes, determined that IMO 2020 will cause its yearly fuel costs to increase by up to $2 billion (approximately $100-175 per TEU, depending on length of journey). This is in addition to the $5 billion of fuels costs incurred in 2018 on 11.9 million tonnes, according to their 2018 annual report, and they have announced plans to shift those increased fuel costs onto its customers before the regulations take effect.

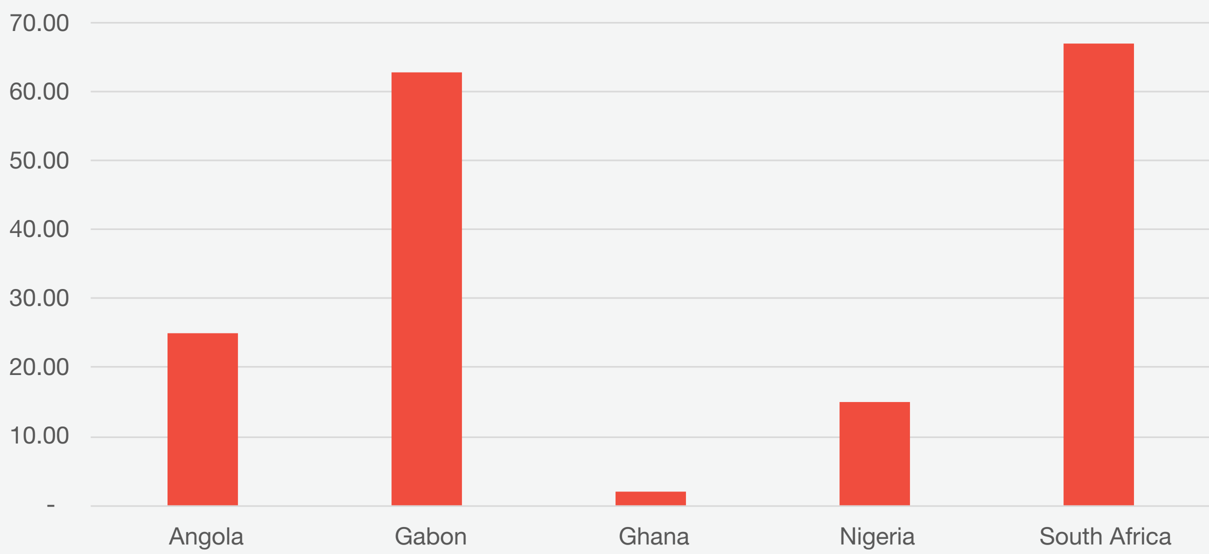
Some ships are fitting 'scrubbers' (onboard exhaust systems) that allow them to continue to use the (potentially much) cheaper high sulphur fuel oil. However only a small proportion of ships have taken this approach given the cost of refit and limited availability of ship yards to complete all refits on time. This uptake will increase in time and some analysts show around 3500 vessels with scrubbers (equivalent to circa 900 kbd fuel demand) by mid 2020 rising to around 5300 (equivalent to 1400 kbd fuel demand by end 2022). This is not at a sufficient enough scale to have a material impact on the IMO conclusions we described in this document.

The new regulations add costs to the world supply chain and ultimately those costs will be borne by the end consumer.

Governments

- For African governments that subsidise fuel costs there will be an added burden to their budget
- According to figures from the IEA in 2015 the amount of fossil fuel subsidies distributed by sub-Saharan African countries was $26 billion (Angola, Cote d'Ivoire, Mozambique, Nigeria, South Africa, Tanzania, Zambia and Zimbabwe all had subsidies in excess of $1billion. In N Africa in 2016 Libyan and Egyptian subsidies were $2.5 billion and $11.1 billion respectively.
- In countries such as Ghana and Gabon the total subsidy was less, but per capita was still high.

Figure 9: Normalised Fossil Fuel Subsidies of Select Sub-Saharan African Countries (2016)



Source: DAI

Cost of operating public transport will rise.
Even if the governments are not subsidizing fuel directly, they will see an increased cost burden for the running of public transport, buses and trains (and even police and military vehicles) will be more expensive to use.

Many economists will tell you that an oil price increase acts like a brake on the economy as consumers are forced to spend a greater proportion of their disposable income on transport (both private and public) and delivered goods (with higher freight/distribution costs). Price elasticity for fuel/transport tends to be lower (a priority spend) so demand for other goods and services will then suffer. In economic terms, the "multiplier" effect of a drop in spending on non-fuel goods and services can be very detrimental for an economy if the fuel price increase is meaningful and sustained, as eventually jobs are affected and incomes reduce.

Direct consumers

- Drivers will see the pump prices rise.
- The price of kerosene for home cooking and heating will be affected by the general rise in distillate prices.
- In Africa, there is a larger proportion of households reliant on oil for fuel and power generation.
- Spending on public transport will rise.

Indirect consumers

- Road Transport costs will rise
- Diesel prices are a significant part of the logistic costs of on-land transportation, affecting the distribution of goods, from factory, mines and farms to their buyers
- These costs will be passed onto the end consumer.

Asphalt

- The new regulations will reduce cost of feedstocks for asphalt manufacturing
- Can governments take the opportunity to build road/housing infrastructure more cheaply?

The challenges and considerations for African governments and consumers

Challenges / **Considerations**

Macro economics and policies

Have governments analysed the effect of the regulations on their GDP?

- Analysis is needed of the whole picture; the increased costs of energy direct and indirectly.
- Are any policy changes required to offset the burden/impact?
- Is there any price hedging to consider?

Fuels subsidies

Has a decision been made regarding the financial support to mitigate rising costs of fuel

- Africa has enormous subsidies of road fuel prices. What is effect of a 10-20% rise?
- How is the extra cost to run public transport managed?

Fiscal revenues

Is the correct regime in place to take advantages of the opportunities?

- Will the government reap the benefit of higher prices for low sulphur crude exports?
- Are incentives in place to maximise government returns from crude rather than product export value increasing?

Direct consumer impacts

Are governments prepared for:

- The rise in direct costs of heating/cooking?
- Considering the promotion of switching to LPG from kerosene use?

Creating opportunities

Can governments promote any IMO 2020 driven opportunities?

- Switching electricity generation to high sulphur (cheaper) fuel – purchasing mobile generators for remote areas?
- Consider duel fuel economics and options
- Promote infrastructure build on the back of lower asphalt costs?

Case Study of Nigeria

Impact of the IMO regulation on Nigeria

Budget

The effect of the IMO regulation on Nigeria's budget is transmitted through the potential shift in oil prices and relative value changes between crude oil and refined products (road fuels). The IMO regulation could raise relative values of road fuels as the change would cause greater global demand for distillate products (AGO) and lower global production of gasoline (PMS) as well as increasing shipping / import costs. At the same time, if oil prices increase, there will be higher oil revenue on crude production compared to the budgeted oil revenue.

To assess the overall impact on Nigerian national budgets, we need to break it down by sector to assess the impact on crude revenues and then the impact on road fuels subsidies and public transport costs. At a high level this could look along the lines of the following:

Nigeria could gain a crude production related revenue surplus amounting to USD3.08 billion.

If oil prices rise by:	Oil price will be ($)	Budgeted oil revenue ($'b)	Actual monthly revenue ($'b)	Revenue surplus ($'b)
5%	$63	12.3	12.92	0.62
10%	$66	12.3	13.53	1.20
20%	$72	12.3	14.76	2.43
25%	$75	12.3	15.38	3.08

Source: Budget office, PwC analysis

Expenditure and borrowing

Nigeria can record as much as USD3.08 billion additional revenue if oil price rises because of IMO regulation. These can be utilized in reducing the budget deficit of USD6.4billion in the 2019 budget and consequently, borrowings. At a high level this could look along the lines of the following:

2019 borrowings to finance USD6.4billion deficits could drop by 57.6% from USD5.4billion to USD2.3billion if oil price rises by 25%

If oil prices rise by:	Revenue surplus ($'b)	USD6.4billion budget deficits would reduce to:	USD5.4billion budgeted borrowing will reduce to:
5%	0.62	5.8	4.7
10%	1.23	5.2	4.1
20%	2.46	3.9	2.9
25%	3.10	3.3	2.3

Source: PwC analysis

Subsidy payments

Nigeria budgeted the sum of USD1 billion in the 2019 budget to cater for subsidy payments. If oil price rises, cost of subsidy will rise. PwC estimates that a 1% increase in oil price will increase subsidy cost by 4.67%.

Case Study of Nigeria

Subsidy cost could increase to a figure between USD1.2 billion and USD2.2 billion. This can be financed by the revenue surplus from oil. Albeit, this comes at the expense of reducing borrowings

If oil prices rise by:	Subsidy rises by:	And subsidy cost will be (USD'b):	The difference between the higher subsidy cost and budgeted subsidy cost will be (USD'b)	Revenue surplus from oil price increase (USD'b)	revenue surplus remaining after financing subsidy payment (USD'b)
5%	23%	1.2	0.23	0.6	0.37
10%	47%	1.5	0.46	1.21	0.74
20%	93%	1.9	0.93	2.42	1.5
25%	117%	2.2	1.16	3.02	1.86

Source: PwC analysis

Removal of subsidy
If the federal government decides to remove subsidy in the event of that the IMO regulation leads to increase in the price of distillate products, there are reinforced effects

- Provided that landing cost of petroleum products import rises due to implementation of the IMO, PMS prices would rise
- The higher prices will escalate further due to removal of subsidy

PMS price could rise to between USD0.62 and USD1.24 if subsidy is removed when the IMO 2020 regulation is on course.

Increase in PMS price due to IMO	PMS price will be	Removal of subsidy will further increase PMS prices by	PMS price will be
5%	0.48	23%	0.59
10%	0.50	47%	0.74
20%	0.55	93%	1.07
25%	0.57	117%	1.24

Source: PwC analysis

Since changes in the price of PMS is tied to changes in the price of transport, food, housing and other essentials of life, subsidy removal will increase inflation rate and cost of living and reduce the standard of living, worsening poverty level.
Further analysis would be required to forecast and model these factors and sensitivities including the public transport and power sectors.

7

Regional African analysis of IMO 2020

African strategies should consider for:

- Governments on how to optimise revenues vs. subsidies depending on crude, ground fuels and power generation mix
- Crude producers on maximising revenues and getting low sulphur crudes to the best market post IMO 2020
- Refiners on the best way to configure production and logistics to minimise downsides and maximise opportunity
- Bunker companies on their offer and logistical requirements
- Consumers on likely impact to their businesses and risk mitigation strategies
- Storage companies on how to create flexibility to offer the best service for IMO 2020
- Power generation companies exposed to high diesel prices or able to use the cheaper high sulphur fuel oil post IMO 2020

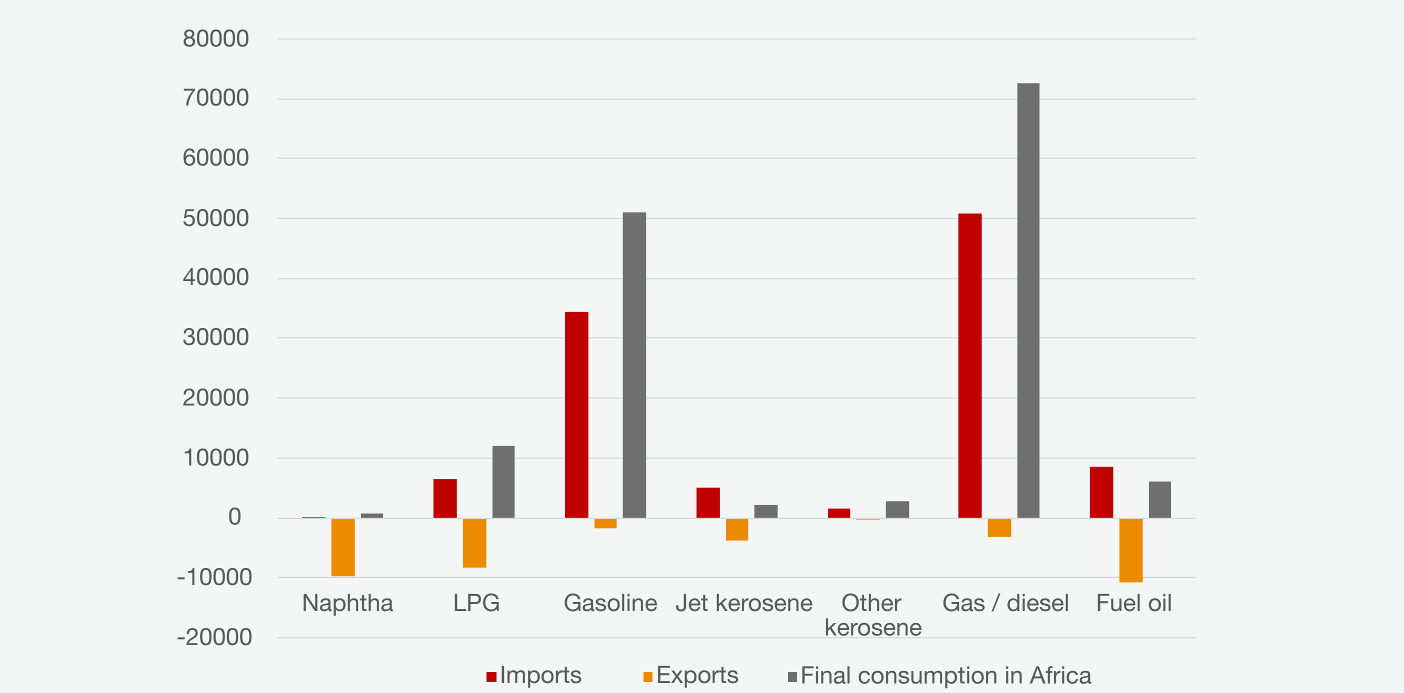
Sector	Typical Energy Cost as Proportion of Total for Africa
Financial Services	10%
Manufacturing	30%
Cement	31%
Agriculture	14%
Transportation/Logistics	34%
Household	15%

Sectors impacted by region

Sector	Topic	North	South	East	West	Central
Governments	High fuel subsidies on clean products, e.g. South Africa $3.5 bn, Egypt $11bn, Mozambique, Tanzania, Zambia, Zimbabwe > $1 bn, Libya $2.5bn, Nigeria $5bn	X	X	X	X	X
Oil Producers	Low sulphur producers advantaged	X		X	X	
	Exposure to higher freight costs	X	X	X	X	X
Simple Refiners	Simple refineries present	X	X	X	X	X
	Access to low sulphur crudes	X			X	
	Infrastructure requirements to maximise exports of low sulphur residual fuels	X	X	X	X	X
Complex Refiners	Complex refineries present (South Africa, Egypt and Chad)	X	X			X
Bunkering	Major bunkering ports present (South Africa, Egypt and Nigeria)		X	X	X	
	Challenges around access to low sulphur fuel		X	X	X	
	Higher blending infrastructure requirements		X	X	X	
Storage	Need to further segregate sulphur streams		X	X	X	
Power Generation	Exposed to higher cost of power from gasoil and low sulphur fuel oil	X	X	X	X	X
	Beneficiary of lower high sulphur fuel oil prices		X			
Mining	High exposure to fuel costs (particularly in remote locations) for utilities and logistics	X	X	X	X	X

The scale of the issue for oil products

2016 Africa Refined Products Movements ('000s metric tonnes)



Source: IEA data, Energex analysis

Summing up: the challenges and considerations for Africa

Each industry will face its own challenge in dealing with the new regulations. This document is not intended to be an exhaustive list of the challenges, nor to provide all the answers. As outlined before, it is important to consider how the significant price uncertainty around IMO 2020 impacts the cost and revenue of individual states or businesses, both directly and indirectly.

What could be the risk impact on your business in the years ahead and how might this be best managed through analysis and then optimised by adopting the appropriate operational adjustments and risk management.

PWC/Downstream Advisors/Energex can provide the analysis and the support needed to evaluate the effect of the IMO 2020 regulations on your situation

We can provide advice on how best to mitigate costs and take advantage of the opportunities that are available.

Glossary

AGO – Automotive Gasoil: a fuel with a maximum content of 0.5% (or 500 parts per million / ppm) sulphur used in heavy goods vehicles and diesel cars

ECA (SECA) zone – (Sulphur) Emissions Control Area comprising of the Baltic Sea, the North Sea, the North American ECA, including most of US and Canadian coast and the US Caribbean ECA. After 1st January 2015, the ECA zone has been subject to a 0.1% sulphur limit for marine fuels

FCC – Fluid Catalytic Cracker is a refinery unit that used vacuum gasoil (see VGO) as a raw material (feedstock) to produce gasolines, naphthas and LPG

HSFO – High Sulphur Fuel Oil used (until 1st January 2020) to supply the shipping industry that was subject to a 3.5% maximum sulphur limit, as a fuel for power generation and as a raw material (feedstock) for refinery processes producing products such as diesel

IEA – the International Energy Agency

IMO – International Maritime Organisation: the United Nations specialized agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. http://www.imo.org

IMO 2020 – the new rules that apply in MARPOL Annex VI of from the 1st January 2020 to put a maximum 0.5% sulphur cap on the fuels that ships can use

MARPOL – short for Marine Pollution. In 1997 the regulations regarding air pollution from ships as described in Annex VI of the MARPOL Convention (concerning air pollution from ships) were adopted by the IMO

MGO – Marine Gasoil is a marine fuel that meets the current 0.1% sulphur limit for the ECA zone. This fuel is more expensive than VLSFO

PMS – Premium Motor Spirit the standard name for gasoline in Nigeria

Scrubber – a unit that can be fitted to the exhaust of a ship to remove its atmospheric sulphur emissions. There are two types – open (where sulphur recovered is disposed of at sea) and closed (where sulphur is stored and taken to port for disposal). There is some ongoing debate on whether open loop scrubbers has an adverse impact on the environment

Straight-run atmospheric residual fuel – is the oil present as fuel in the bottom of the crude distillation column that is produced under normal atmospheric pressure. The temperatures used are not high enough to “crack” the fuel oil and hence this is a process possible in most simple refineries

VGO – Vacuum Gasoil which is a feedstock for refinery processes (see FCC) and also can be blended with other products to make VLSFO

VLSFO – Very Low Sulphur Fuel Oil that complies with the IMO 2020 0.5% sulphur limit

Contacts

PwC contact persons/authors

Pedro Omontuemhen
Partner,
Oil & Gas and Power Leader
pedro.omontuemhen@pwc.com

Andrew S. Nevin
Partner,
Chief Economist
andrew.x.nevin@pwc.com

Oluseyi Agbedana
Senior Manager
oluseyi.agbedana@pwc.com

Akolawole Odunlami
Senior Associate
akolawole.d.odunlami@pwc.com

Energex contact persons/authors

Steve Jones
Director
imo2020@energex.partners

Jason Rajah
Midstream Asset Specialist
imo2020@energex.partners

Jonathan Martland
Oil products and petchems Specialist
imo2020@energex.partners

Downstream Advisors contact persons/authors

Steve Graybill
President
sgraybill@downstreamadvisors.com

Alain de Plaen
Vice President
adeplaen@downstreamadvisors.com

Jana Verberg
Consultant
jverberg@downstreamadvisors.com

Hameed Alaba
Consultant
halaba@downstreamadvisors.com

Acknowledgment

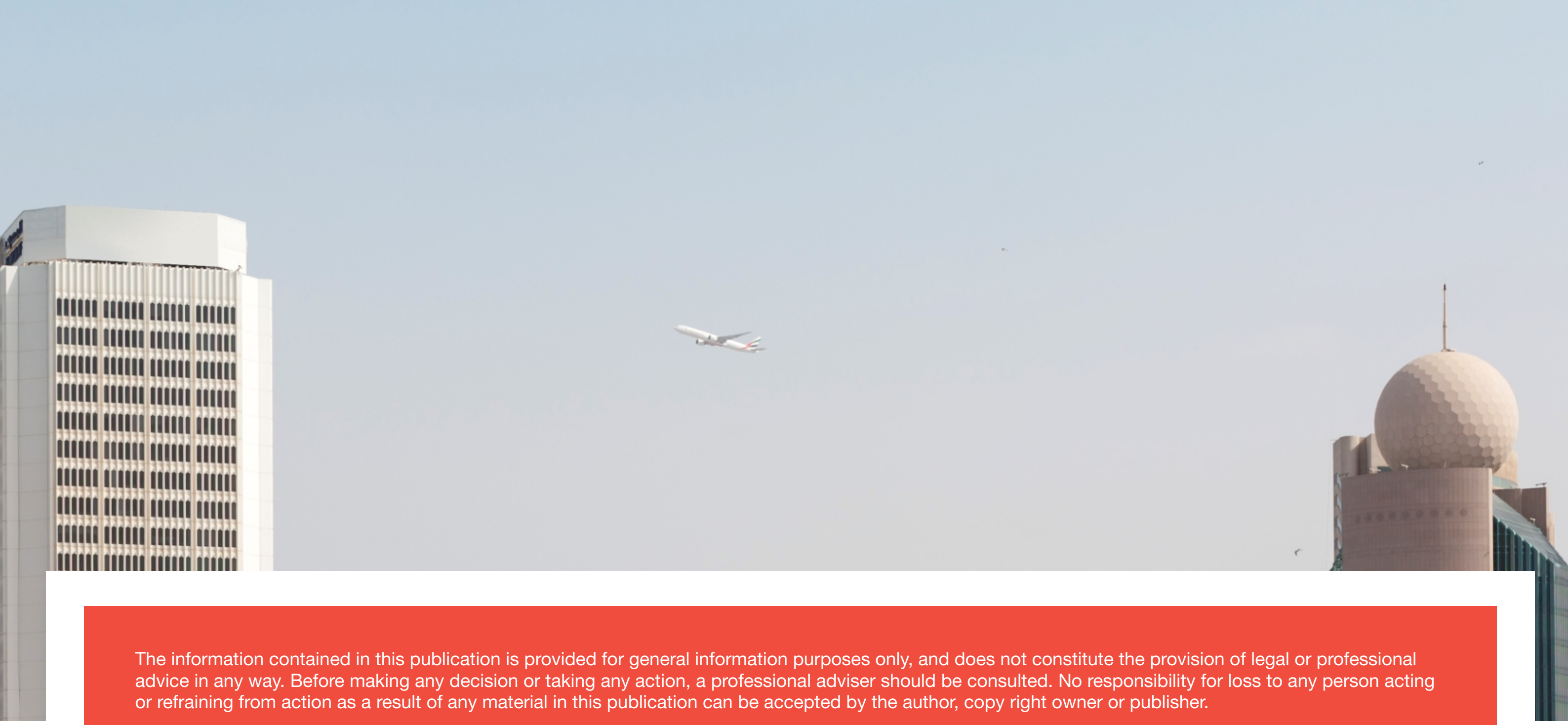
We would like to thank Olumide Adeosun, Awwal Bello, Delia Asuzu, Omomia Omosomi, Yemi Akoyi and David Meres for their contributions to the development of this report.

IMO Africa services to customers

Sector	Customer type	Challenge / opportunity	Joint services of PwC / EPL / DAI (Specific to customer type)
Governments	Subsidiser of road fuels	Budgeting and managing increased draw on state funds	• Hedging, policy scenarios and sourcing strategies
	Utilities and road construction	Cheaper fuel and asphalt	
	Crude production revenues	Higher / lower state revenues depending on qualities	• Detailed advice on opportunities / challenges with advice on how to optimise revenues / find best customers
Crude producers	Low sulphur producer	Higher value versus other global crudes	
	High sulphur producer	Lower demand in global refining system	
Refiners	Simple refiners	Optimising value of production and local low sulphur crude supply	• Optimal configuration of production units, cut points and associated logistics infrastructure • Prioritisation of investments to maximise revenues • Commercial model and negotiation advice in terms of feedstock sourcing and products sales • Start-up planning • Hedging and exposure management strategies
	Complex refiners	Maximising value through crude selections and flexibility	
	New refiner	Maximising value	
Industrials	Power generators using fuel oil	Improved margins as HSFO prices drop	• Hedging and sourcing strategies • Supply chain management to understand how to manage quality, when/if to commit to fuel switching, what the implications are on assets/ storage, etc.
	Companies using diesel / gasoline	Pressure on margins due to increase in clean fuels prices	
	Construction and mining companies	Cheaper asphalt offset by increased diesel prices	
Consumers	Long haul freight users	Increased clean fuels prices	
Bunker companies	Suppliers to shipping industry	Multiple types of fuels required by shipping industry	• Hedging and sourcing strategies • Commercial strategies to consider three marine fuels grades • Impact on the bunkering business model and supply chain
Storage	Refinery storage operations	Reconfiguration potentially required	• Optimal configuration of midstream storage, import and export capabilities to debottleneck and create flexibility

IMO Africa services to customers (General Joint services of PwC / EPL / DAI)

1	Bespoke advice as a first phase led by PwC to assess the sensitivity to different price moves and changes in product / grade availability
2	Price and exposure risk management advice and solutions beyond hedging through identifying / understanding key risks and opportunities in the more volatile and uncertain environment
3	Financial forecasting and budgeting
4	Policy and operating principles advice
5	Organisation change solutions and implementation



The information contained in this publication is provided for general information purposes only, and does not constitute the provision of legal or professional advice in any way. Before making any decision or taking any action, a professional adviser should be consulted. No responsibility for loss to any person acting or refraining from action as a result of any material in this publication can be accepted by the author, copy right owner or publisher.

This publication has been prepared for general guidance on matters of interest only, and does not constitute professional advice. You should not act upon the information contained in this publication without obtaining specific professional advice. No representation or warranty (express or implied) is given as to the accuracy or completeness of the information contained in this publication, and, to the extent permitted by law, PricewaterhouseCoopers Inc, its subsidiary and associated companies and entities and their respective directors, employees agents and subcontractors do not accept or assume any liability, responsibility or duty of care for any consequences of you or anyone else acting, or refraining to act, in reliance on the information contained in this publication or for any decision based on it.

Energex Partners

Energex Partners

Energex Partners is a boutique advisory practice consisting of senior energy industry experts from the oil and gas majors and other leading players in the energy sector with decades of proven, practical operational experience across the value chain. Our practitioner experience from the front-line of the industry means that we offer intelligent judgement and partnership in execution to help our clients achieve strategic or investment objectives. This hands-on experience spans trading, midstream storage and terminals, shipping and transportation, refinery performance optimisation, downstream fuels distribution, as well as risk management, credit and financing solutions.

We help our clients to understand and improve commercial performance; to retain and monetise the full value of the flexibility that is inherent throughout the value chain and the associated assets and contracts. We also help our clients to grow their own direct customer activity through broader and more commercial offerings.

Email: imo2020@energex.partners
Website: www.energex.partners

Downstream Advisors Incorporated

DOWNSTREAM | ADVISORS

Downstream Advisors, Inc. (DAI) is an international consulting firm specializing in the technical and economic aspects of the downstream petroleum industries – refining, marketing, transportation, petrochemicals, and power. Our services include valuations, transactional due diligence, economic modeling, market analysis, and project development.

Clients rely on DAI's technical and economic expertise in valuing existing oil refineries, oil storage terminals, service stations, oil tankers, and pipelines as well as in conducting market supply and demand analysis, competitive studies, crude valuations, and price forecasts. DAI consultants have conducted due diligence for the buyer, seller, or competing bidder for over 20 percent of the actual oil refinery transactions occurring in Europe, North America, and South America for the past 20 years. We have valued over 100 petroleum terminals in more than 30 countries.

DAI is currently developing an integrated world supply and demand pricing model which models multiple regions of the world in a unified fashion to determine regional prices and margins based upon the marginal costs. We have assisted in the design and development of refineries located in Colombia, the Netherlands, Russia, and the United States and are currently serving as the owner's engineer in the design, construction, and start-up of refineries in the Bahamas, Germany, and Uganda.

Email: info@downstreamadvisors.com
Website: www.downstreamadvisors.com

pwc

About PwC
At PwC, our purpose is to build trust in society and solve important problems. We're a network of firms in 157 countries with more than 276,000 people who are committed to delivering quality in assurance, advisory and tax services. Find out more by visiting us at www.pwc.com/ng

Appendix A – DAI Detailed Informational Report

I. IMO 2020 Introduction

On January 1, 2020, a new global cap on sulphur content in bunker fuels will come into effect. The new regulation by the International Maritime Organization ("IMO") will mandate a maximum sulphur content of 0.5% in bunker fuels globally ("IMO 2020").

The current sulphur cap has been maintained at 3.5% since 2012 (the cap was 4.5% prior to 2012), and the new regulation is expected to herald an era of significant change in the maritime industry. Changes will mostly affect vessels that operate outside the designated Emission Control Areas ("ECAs"), as the current sulphur cap for ECAs is even lower, at 0.1%. The changes will also impact crude oil producers and refiners as well as shippers.

This detailed informational report has been prepared by Downstream Advisors, Inc. ("DAI") as an Appendix to the IMO 2020 Thought Piece presented jointly by PWC, Energex, and DAI. The analysis and projections provided in this Appendix are those of DAI.

II. General Oil Market Overview

This section discusses other key dynamics of the world oil market before discussing IMO 2020.

The global oil refining and petrochemicals industries continue to progress towards greater economies of scale to competitively meet a growing global demand for petroleum-based fuels and chemicals. The economic driving force behind investments stems not only from the growth in oil demand but also from rebalancing of the demand for oil products and the refining capacity supplying that demand.

Economic Growth

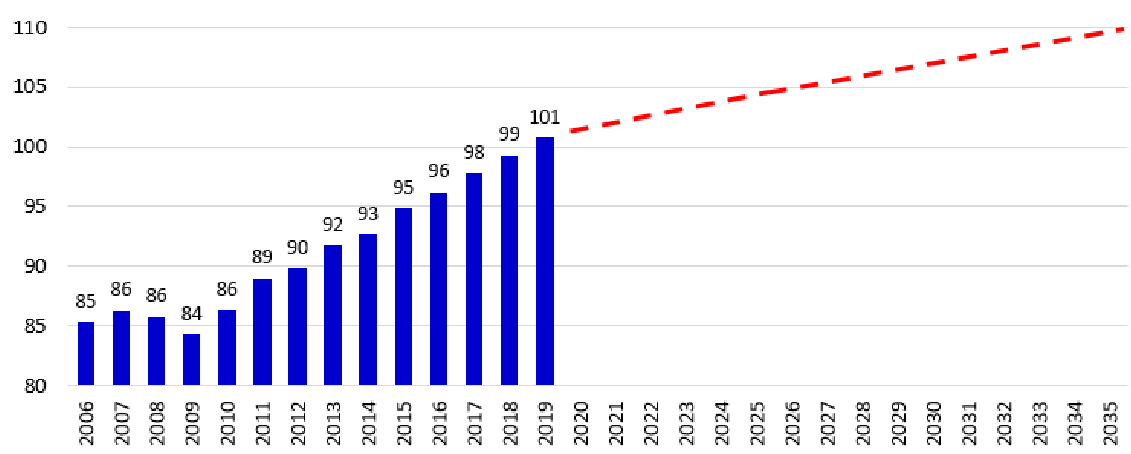
In June 2019, the World Bank call for global economic growth rate projections have been downgraded from 2.9% to 2.6% for 2019, followed by a projection to gradually rise to 2.8% by 2021. The United States' growth is projected to be 2.5% in 2019, 1.7% in 2020, and 1.6% in 2021.

Elsewhere, China's growth is projected to be in the 6.1% to 6.2% range in the medium term, and India has a growth projection of +7.5% in the 2019 to 2020 period. In Russia, the projection for 2019 has been downgraded to 1.2%. The Brazilian economy recovered in 2017 after two years of recession, now showing a positive growth rate of 1.5% in 2019. Both countries are forecast to accelerate in the coming years, advancing by 1.8% and 2.5% annually over the 2020 to 2021 period.

World Oil Demand

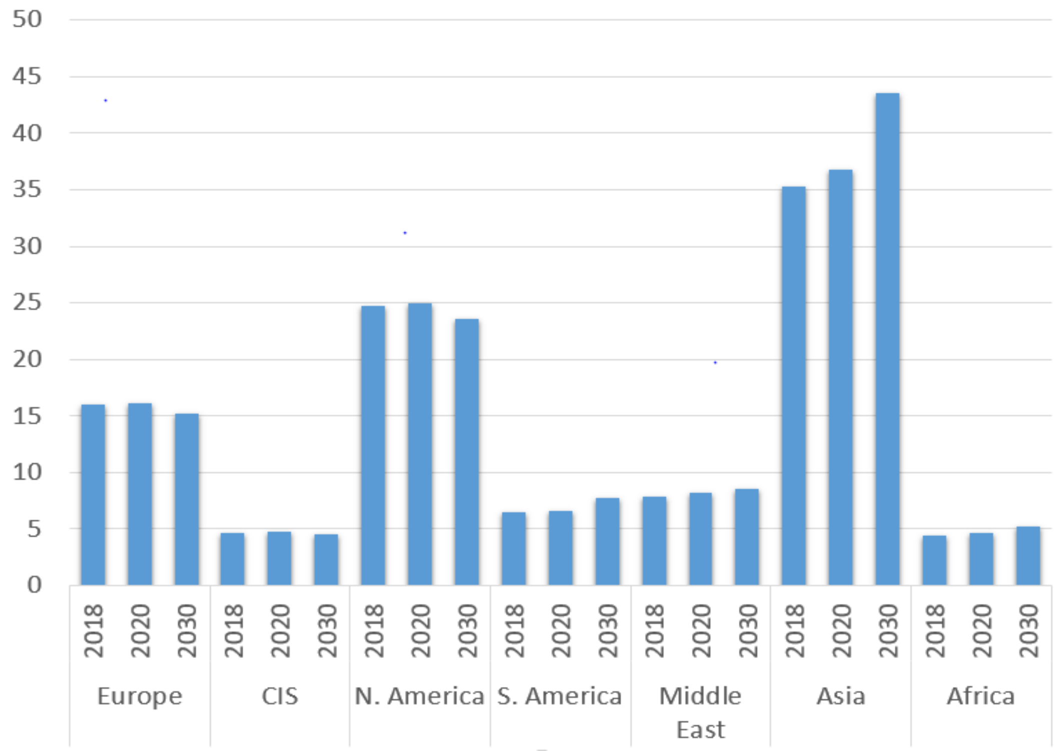
As shown in Figure II-1, global demand for petroleum products continues to grow with the growth in GDP supporting investments in new refineries and profits for competitive refineries. Global oil demand is projected to grow from 101 mb/d in 2019 to 104.5 mb/d by 2025 and 110 mb/d by 2035.

Figure II-1: Worldwide Oil Demand [Million b/d]



Source: IEA, DAI (Projection)

Figure II-2: Petroleum Products Demand by Region [Million b/d]



Source: DAI Analysis

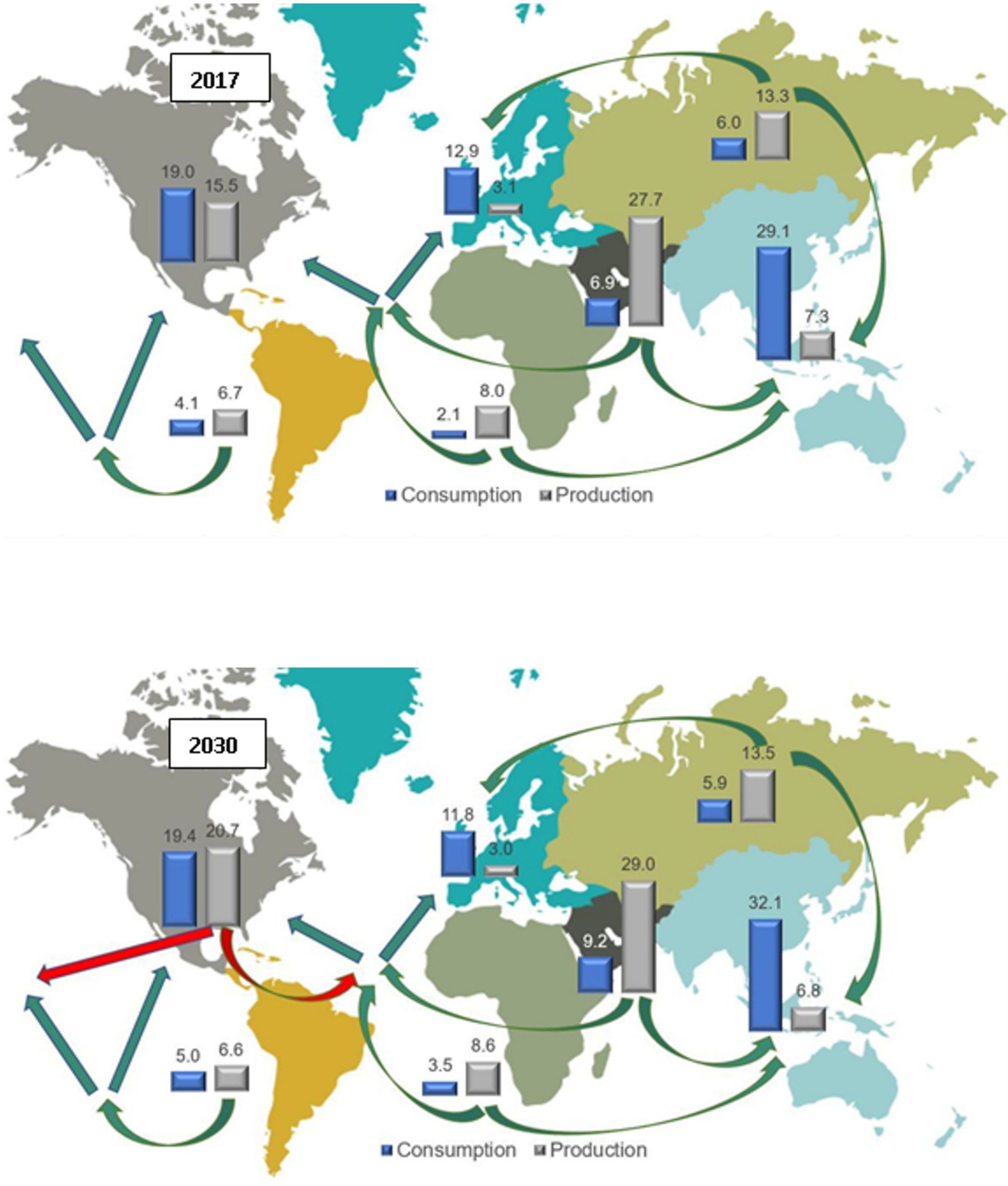
Changing Crude Supplies

During 2017 the demand for crude oil surpassed the supply, boosting the global price per barrel to over $70 at the beginning of 2018. The oil price peaked at $80 before it settled back around $65 in the first half of 2019.

The price increase in 2017 and 2018 led to more production. The price forecast provided in this outlook projects crude oil prices to remain in the range of $60 to $70 per barrel, which is consistent with growing economy and pro-active responses by producers to manage another oversupply situation.

As shown in Figure II-3, imbalances between consumption and production call for crude movements from Africa, the Middle East, Russia, and South America to the U.S., Europe, and Asia. This trend is not static and between 2017 and 2030; it will evolve differently for each region. The growth in U.S. crude production is leading to new balances with crude oil exports emerging from the U.S. Gulf Coast. U.S. exports are only for excess of light crude that American refineries cannot process, while heavy crude import from South America and the Middle East is projected to continue to feed several conversion units. Primary destinations for American tight oil will be Europe and the Far East, while major cuts on U.S. imports are mainly for crudes coming from West Africa.

Figure II-3: Crude Oil Balances by region for 2017 & 2030 [Million b/d]



Source: DAI Analysis

Significant growth in U.S. crude oil and gas liquids production (Figures II-4 and II-5) will lead to new balances with crude oil exports emerging from the U.S. Gulf Coast.

Figure II-4: U.S. Crude Oil Production (Million b/d)

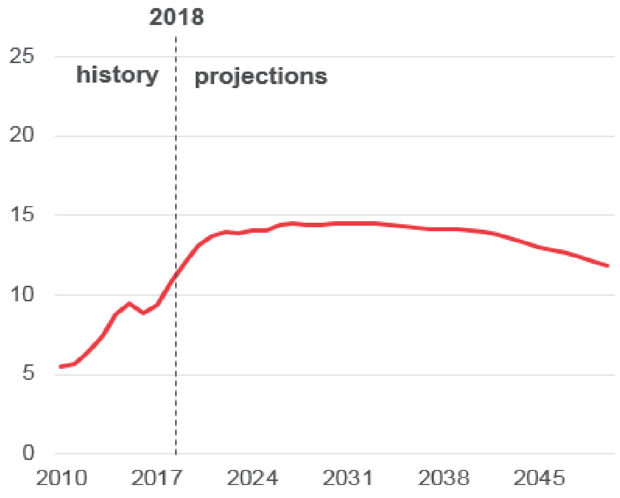
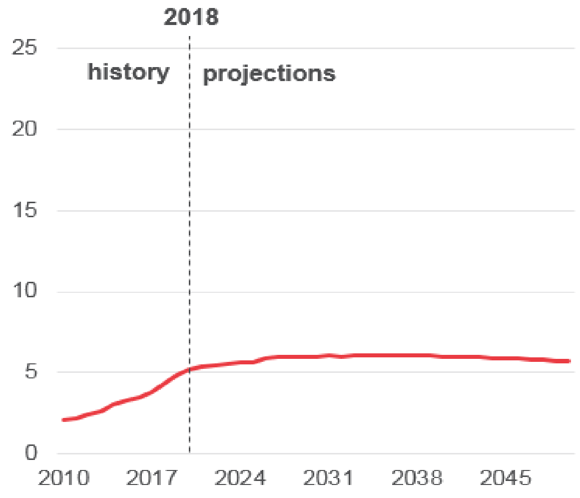


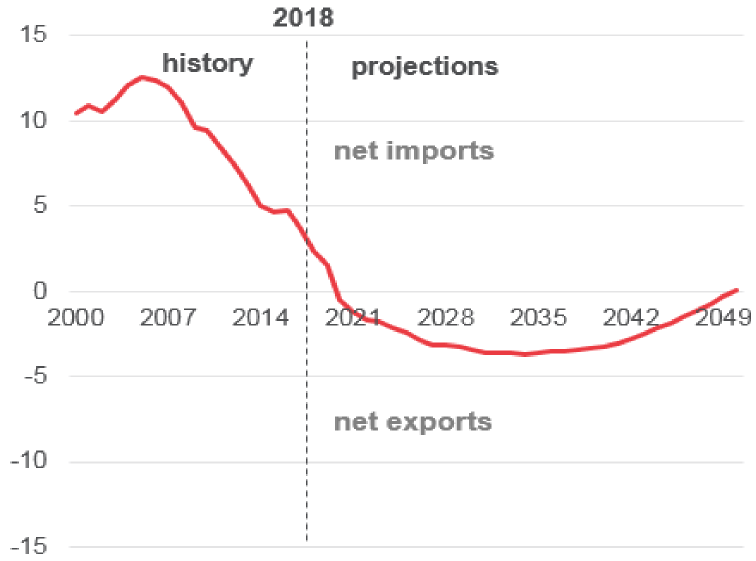
Figure II-5: U.S. Crude Oil Production (Million b/d)



Source: DAI Analysis

As shown in Figure II-6, the U.S. Energy Information Administration predicts that the United States will become a net exporter of crude oil and gas liquids by 2021.

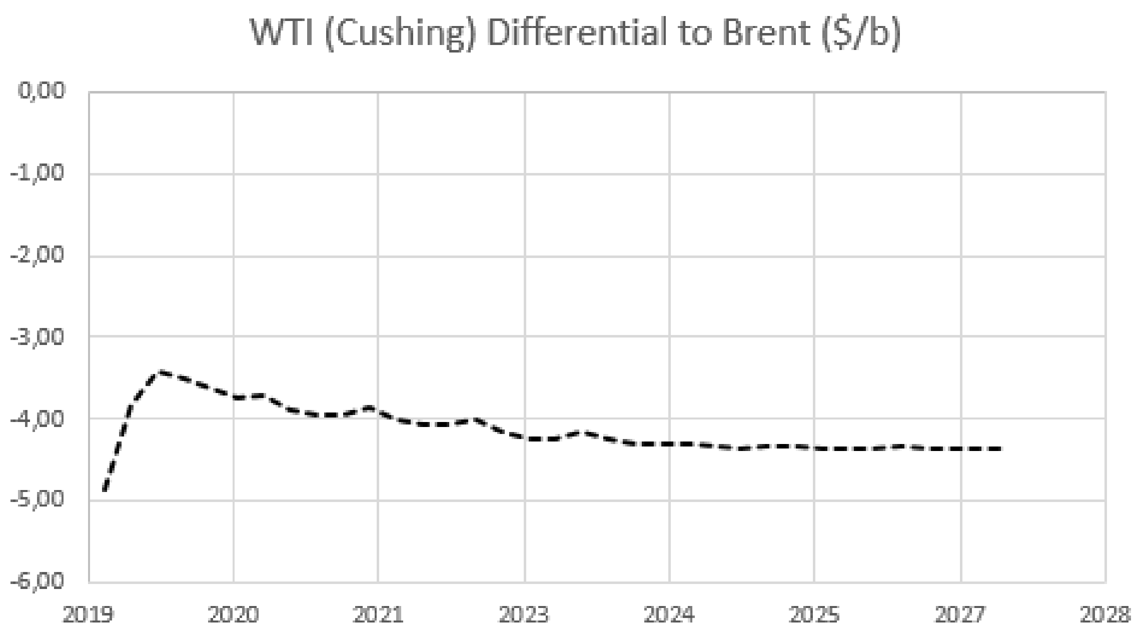
Figure II-6: U.S. Petroleum and Other Liquids Net Imports/Exports (Million b/d)



Source: DAI Analysis

As shown in Figure II-7, the Chicago Mercantile Exchange ("CME") forward curve reflects a long-term supply advantage for refineries with access to low-cost USGC crude.

Figure II-7: Implied Differential between WTI (Houston) and Dated Brent (1) [$/b]

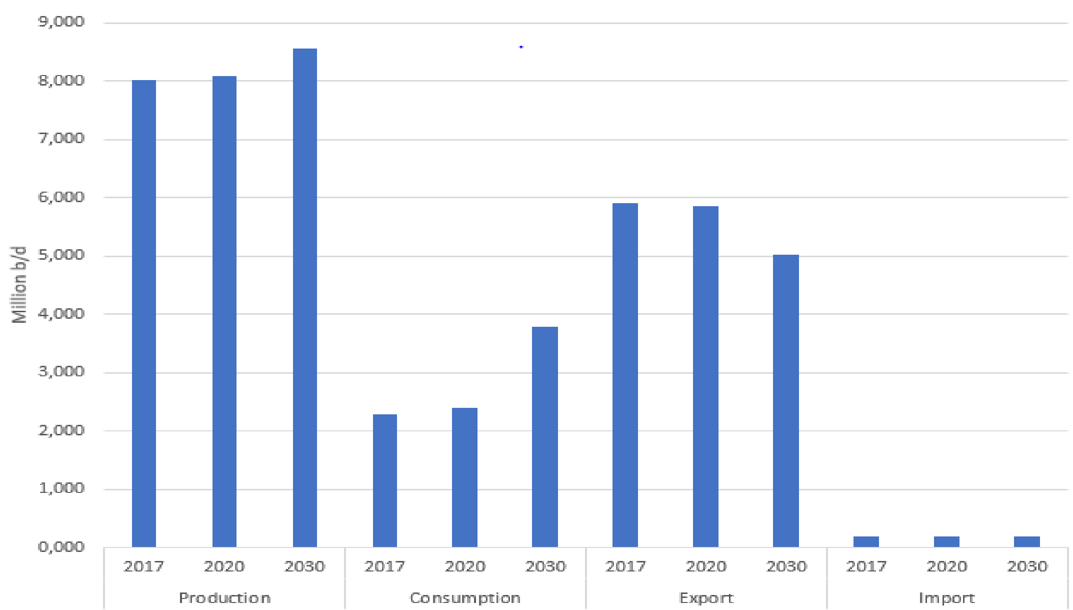


Source: Based upon CME forward curve and a 3 $/b cost for Cushing to Houston

African Crude Flows

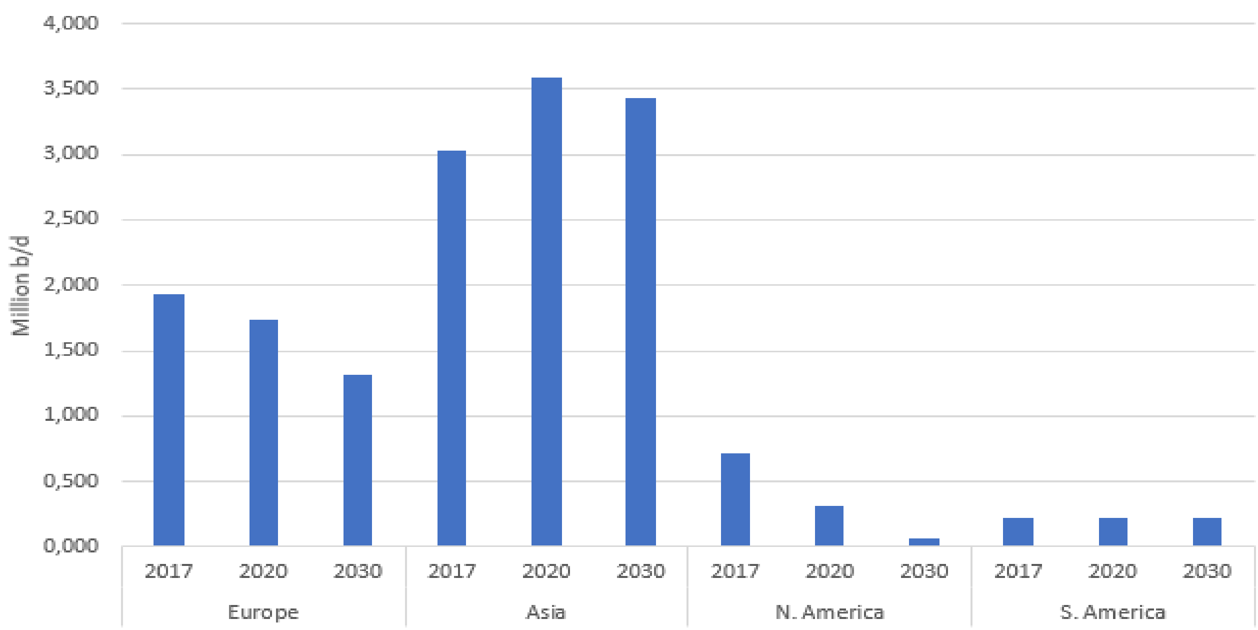
Figure 11-8a on the following page presents historical and projected balances on West African crude flows, and Figure 11-8b shows where the West African crude exports go.

Figure II-8a: Projected West African crude flows



Source: DAI Analysis

Figure II-8b: Projected West African crude exports

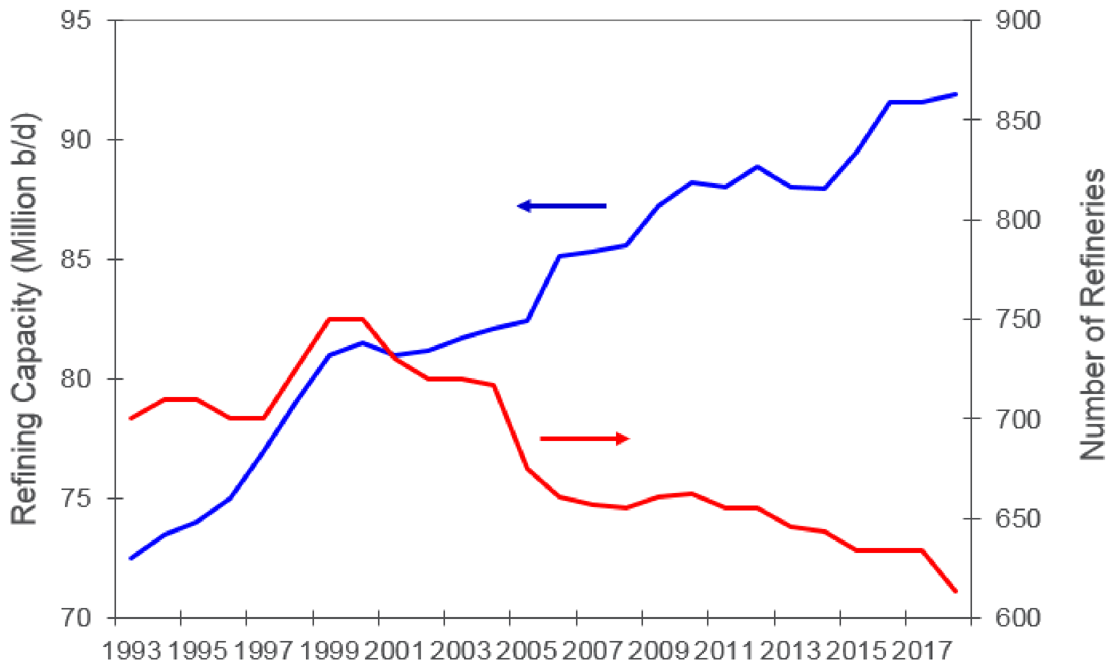


Source: DAI Analysis

Refining Capacity

As shown in Figure II-9, the world's refining capacity continues to grow with more capacity from fewer refineries.

Figure II-9: Worldwide Crude Oil Refining Capacity and Number of Refineries

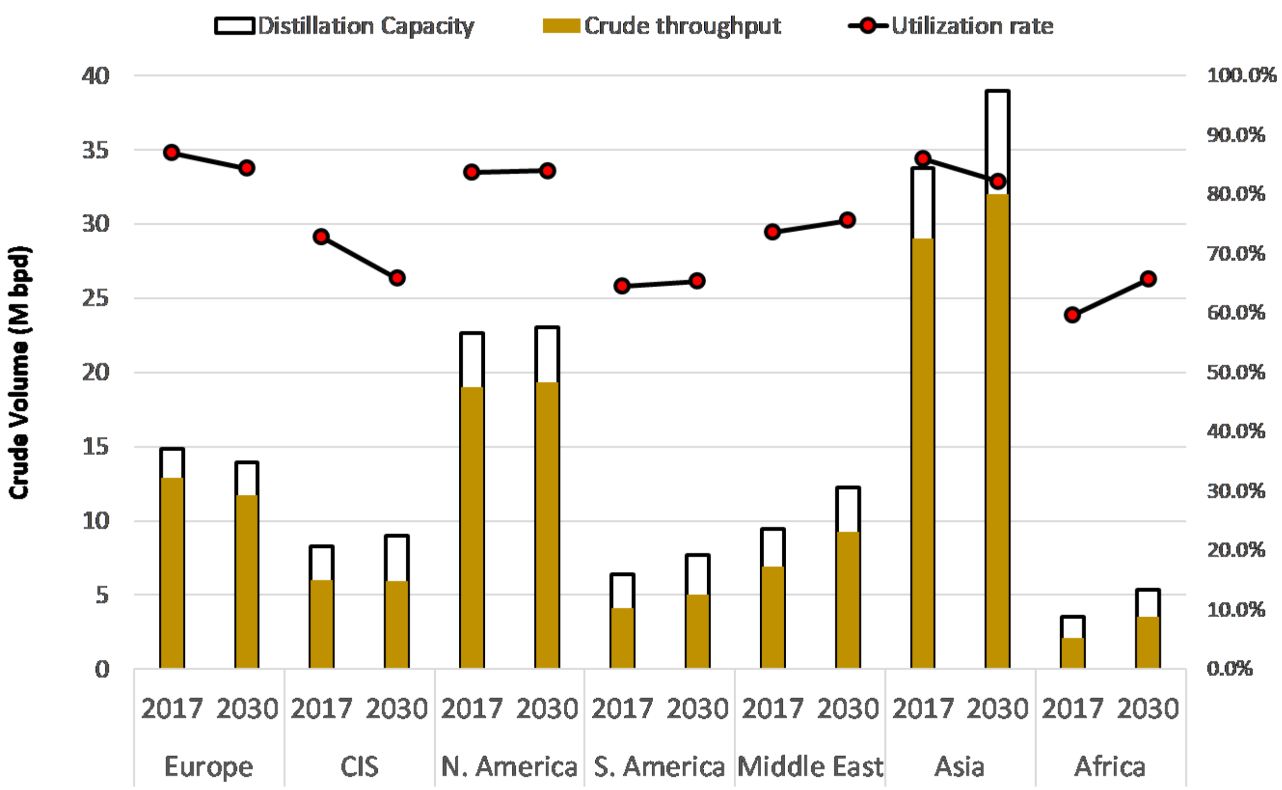


Source: Oil & Gas Journal

The industry consensus is that refining capacity will be added in blocks at a rate necessary to meet future product demand. Additionally, the ongoing trend in capacity re-distribution away from mature markets such as Europe and Japan and into growing economies including Asia and the Middle East is expected to continue. Lower performing, often old and small, refineries in Europe will not be able to compete in the long term with the larger and more complex refineries being added in the Middle East, India, and China.

Consequently, European refining capacity is expected to fall by 0.9 million b/d between 2017 and 2030. Distillation capacity is projected to increase over the next ten years by 5.2 million b/d in Asia with another 2.8 million b/d coming on stream in the Middle East and 1.8 million b/d in Africa. Latin American capacity will rise by 1.3 million b/d, while North America and CIS will add around half a million b/d of capacity in each region. In total, global distillation capacity is expected to reflect a net increase of 11.3 million b/d over the 2017 to 2030 period.

Figure II-10: Refinery Capacity and Utilization by region



Source: DAI analysis

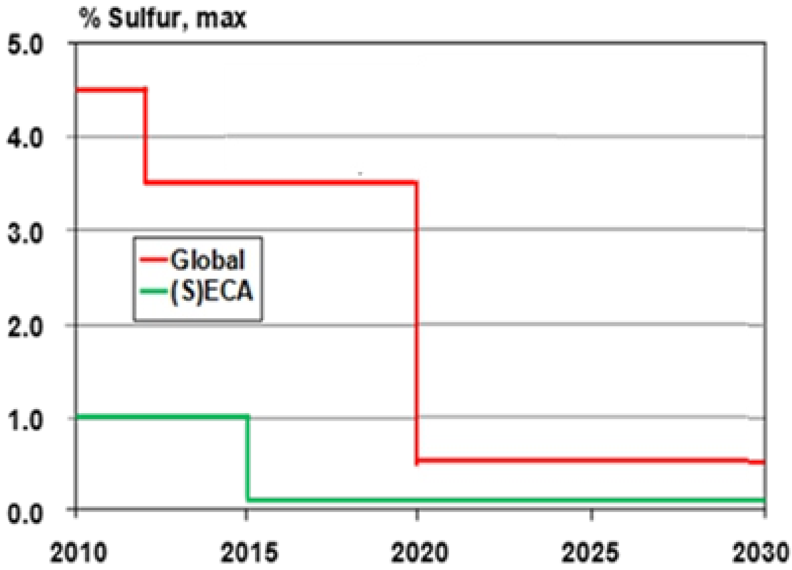
III. IMO 2020 Background

IMO 2020 follows a series of prior marine fuel sulphur reductions. As illustrated in Figure III-1, the global sulphur-in-fuel limit for international marine fuels was reduced from 4.5 Wt.% to 3.5 Wt.% in 2012. Stricter restrictions have also been enacted in navigational waters designated as ECAs around Europe, North America, and Central America. Since January 1, 2015, vessels operating in an ECA market are required to use fuels with a maximum sulphur content of 0.1 Wt.% or employ an on-board exhaust gas scrubber ("EGS") system.

IMO issued further mandatory regulation in October 2018, announcing a carriage ban on all non-compliant fuels, effective from March 2020, two months after the new cap becomes effective. This additional ban is a reinforcement of the new cap and prevents the carriage and transport of non-compliant fuels for combustion purposes. An exemption is made for vessels with installed 'scrubbers': devices that eliminate most of the of sulphur content in marine fuels.

By water washing the exhaust gas stream prior to discharge to the atmosphere, the EGS systems provide an exception to the sulphur-in-fuel limits. Today and in 2020, vessels having approved EGS systems will have no constraint on the sulphur content of their bunker fuel other than the given system's certification.

Figure III-1: IMO Bunker Specification Changes

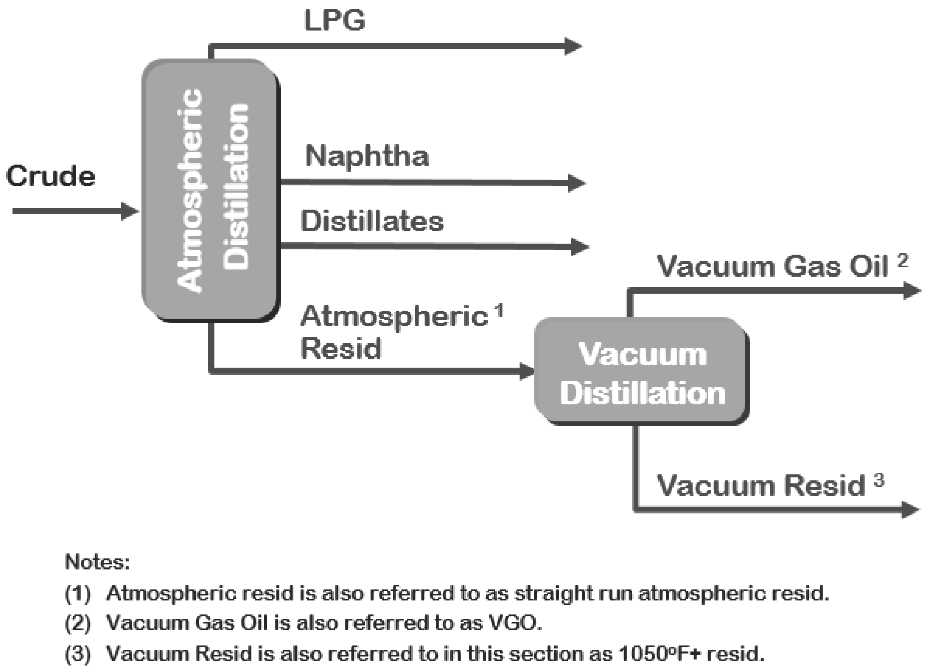


Before we go further into explaining IMO 2020, we present an overview of the different intermediate product types referred to in this section.

As shown in Figure III-2, vacuum resid is the heaviest of the intermediate products from a refinery's distillation process (where crude is separated into its basic components) and is essentially the bottom of the barrel. Vacuum resid in this analysis is defined as all crude oil product boiling above 1050°F. If vacuum resid is not upgraded to other, lighter, products through other refinery conversion units, vacuum resid is blended into heavy fuel oil or bitumen ("asphalt"). Heavy fuel oil is sometimes referred to as "residual fuel oil" and is often categorized as high sulphur fuel oil ("HSFO") or low sulphur fuel oil ("LSFO"). Heavy fuel oil is used as a furnace fuel in power plants and is also the primary fuel used in ships. When supplied to ships, heavy fuel oil is referred to as marine bunker fuel.

Vacuum gas oil ("VGO") is the next heaviest boiling intermediate product from the crude distillation process. VGO is normally converted to gasoline and distillate in what are referred to as cracking units (either an FCC unit or a hydrocracking unit). However, VGO can also be used as marine bunker fuel.

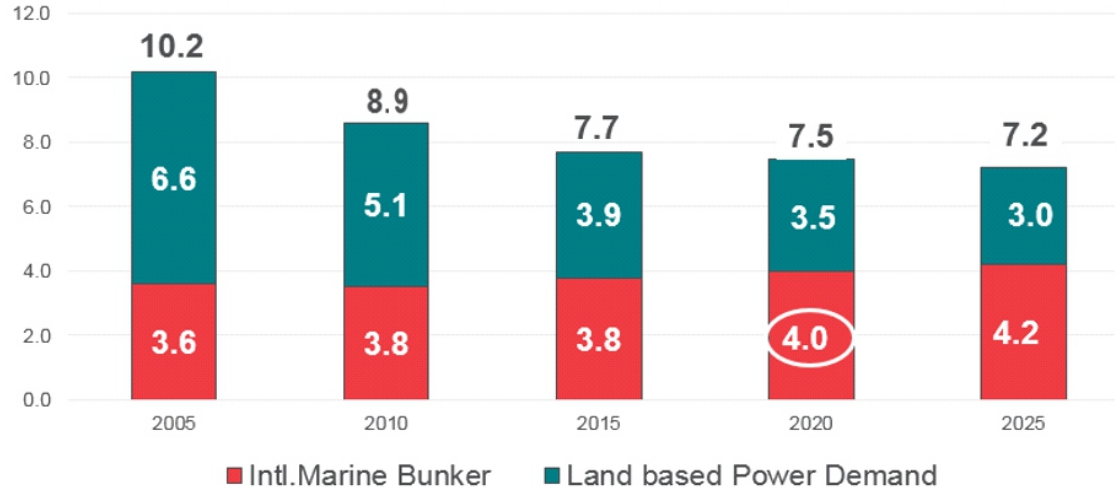
Figure III-2: Refinery Crude Distillation Products



Bunker Fuel Supply Options

Figure III-3 below presents the world's past and projected heavy fuel oil. The graph includes demand from the international marine bunker market and from the land-based power market and covers all grades of sulphur content (LSFO and HSFO). While demand for land-based fuel will continue to decline, growth in international marine bunker fuel is driven by greater world commerce. As shown, 4.0 million b/d of marine bunker fuel will be affected by the IMO 2020 specification change. Four fuels are candidates for meeting this marine bunker fuel demand. These fuels are listed in order from least expensive to most expensive.

Figure III-3: Global Heavy Fuel Oil Demand[1] [Millions b/d)



Note: (1) Includes heavy fuel oil for both international marine bunker market and land-based power market.

Source: DAI analysis

3.5% Sulphur Heavy Fuel Oil (HSFO)	HSFO will continue to be allowed for ships having an approved EGS system (or having a waiver in some circumstances). This is typically a blend of approximately 60 percent residue produced from high sulphur crudes and the balance distillate.
0.5% Sulphur Heavy Fuel Oil (0.5% S FO)	This is typically a blend of residue from low sulphur crudes along with low sulphur distillates and other de - sulphurized refinery products.
0.5% Sulphur Vacuum Gas Oil (VGO)	As noted above, VGO is normally converted to gasoline and distillate in cracking units but can also be used as marine bunker fuel. Note that ExxonMobil, BP, and Shell are marketing VGO - type material as 0.5% sulphur fuel oil.
0.5% Sulphur Marine Diesel	Marine diesel is like automotive diesel or home heating oil and is by far the most expensive option.

Key Price Differentials

The impact of IMO 2020 will be realized through the change in price relationships between these four fuels as well as crude oil. The important price differentials specifically impacted by IMO 2020 are listed below:

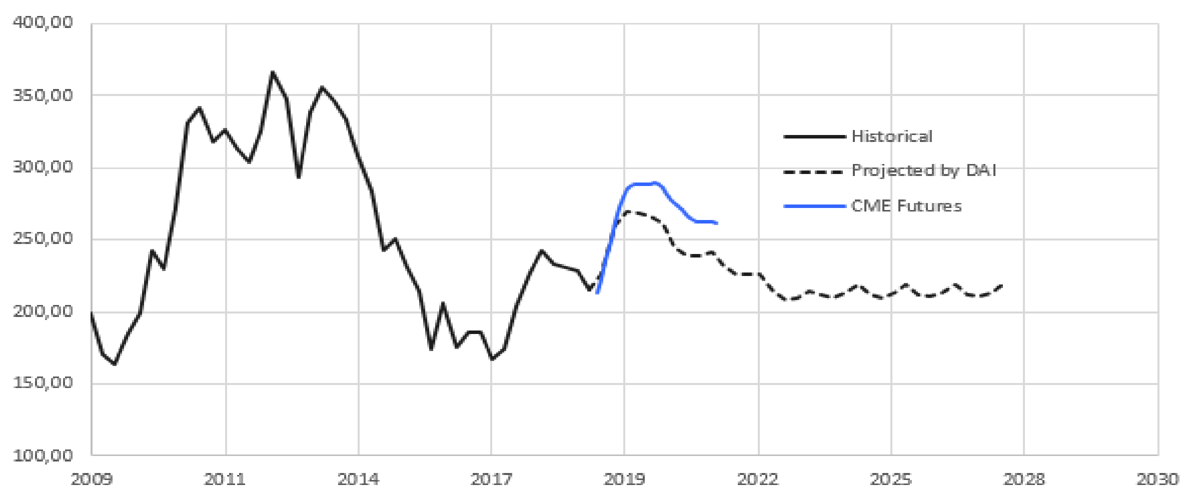
- 3.5% sulphur fuel oil (HSFO) to Brent
- 0.5% sulphur fuel oil (0.5% FO) to Brent
- Discount to Brent for high sulphur crudes producing HSFO
- Premium to Brent for low sulphur crudes producing 0.5% FO

For refineries looking to convert resid into LSFO, VGO, and gasoil, the key price differentials are:

- HSFO to 0.5% LSFO (and 0.5% S VGO)
- HSFO to gasoil

Figure III-4 presents the historical and projected price spread between HSFO and gasoil. The CME futures price projection shown in the figure is from June 2019. The gasoil spread has historically priced between 200 and 400 $/t. Looking forward, the CME futures curve reaches $288/t before dropping to approximately $260/t.

Figure III-4: Price Spread between NWE HSFO & NWE Gasoil [$/t]



IMO 2020 Market View is Changing

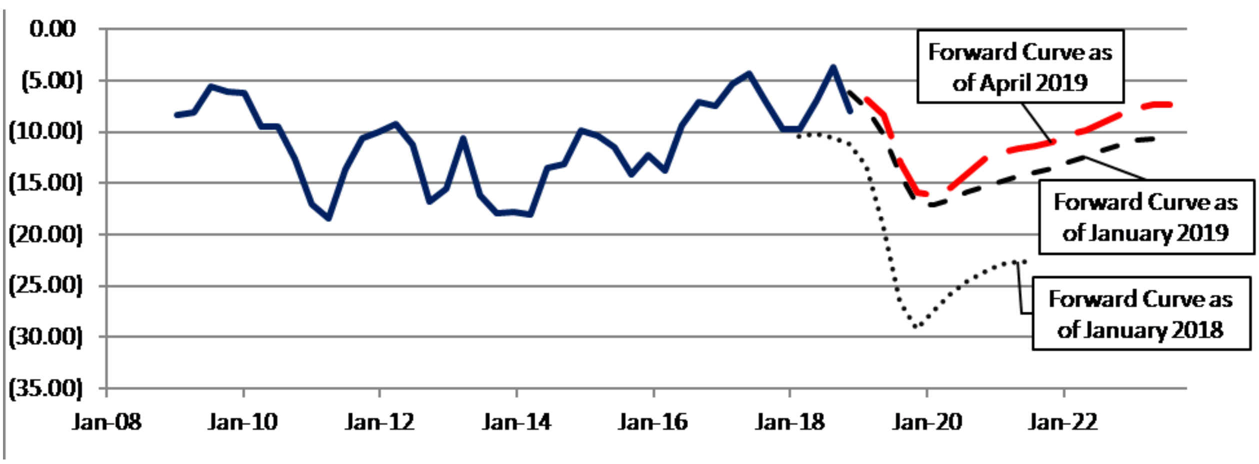
The market view of the above price relationships is changing.

One misconception is that an increased distillate demand will drive the world's refineries to increase crude charge rates. First, the higher price of 0.5% S diesel versus VGO will drive the world to consume 0.5% S VGO instead of diesel. Secondly, it is not possible for the world oil supply and demand to balance if the world increases crude rates (increase oil supplies) without a corresponding increase in demand. The discussions in this report explain how the world will meet the product demand using the same crude charge rate and composition with or without IMO 2020 by processing differently. VGO and segregation of low sulphur crudes will be key.

Another prior misconception was the projection that HSFO price would go to a coal price parity based upon there being insufficient demand for high sulphur resid. DAI is of the opinion that both HSFO and LSFO prices will remain closer to Brent than others have previously projected based on the resid balances. As shown in this report, DAI's analysis indicates that, even without significant scrubber additions, enough resid conversion capacity exists to consume the high sulphur vacuum resid which is not blended to fuel oil.

Possibly as the result of similar resid balances, the futures market on the projected HSFO price discount has changed from a year ago. As shown in Figure III-5, the futures market in January 2018 projected HSFO to drop to $30/b below Brent in 2020. In January 2019, the forward curve projected the HSFO price would drop to less than $20/b below Brent in 2020 and then rise over time to a discount of less than $15/b below Brent. In April 2019, the forward curve projected the HSFO price would recover to less than $10/b below Brent.

Figure III-5: Change in Forward Curve for 3.5% S FO Price 3.5% Fuel Oil Barges FOB Rotterdam (Platts) Crack ($/b)



Source: DAI analysis, CME Futures Settlements

The timing for the HSFO price recovery will depend upon the level of scrubber additions and resid conversion capacity additions in the next three to five years.

There does appear to be market consensus that the price relationships of 0.5% S VGO and of 0.5% S marine diesel to ultra-low sulphur diesel will continue in line with today's relationships. Consensus also exists that blending 10 ppm S diesel ("ULSD") to fuel oil will provide a floor for determining the price relationship of 0.5% S FO relative to ULSD.

Projecting where the heavy fuel oil price differentials will end up is best done by understanding the future supply and demand balance for vacuum resid. This vacuum resid balance is the following topic.

Global Resid Supply and Demand Balance

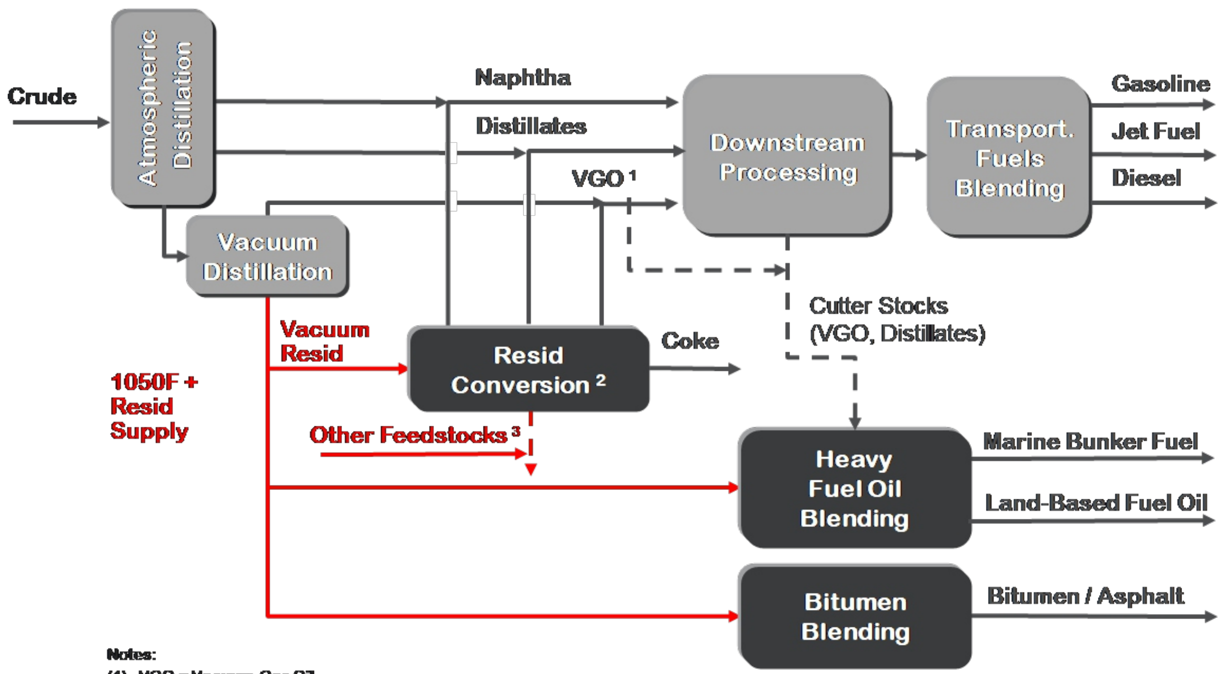
The demand for vacuum resid has been growing and is expected to continue to grow for the uses mentioned previously (more conversion to lighter products given increasing conversion capacity around the world, asphalt demand for roads, and marine bunker fuel for ships). This demand increase has helped drive the narrowing of the price differential between gasoil and HSFO (which as mentioned is one of several marine bunker fuels derived from vacuum resid) from around $300/t differential prior to 2015 to approximately $200/t since 2015. The increase in demand for vacuum resid (e.g. through the use of HSFO) and the narrowing of the price differential would be projected to continue were it not for the impact of IMO.

In 2020, IMO will cause a significant decrease in demand for HSFO as shippers move to 0.5% S FO, VGO, and marine diesel to satisfy their fuel needs. This will widen the HSFO price differential to gasoil and increase the HSFO discount to Brent. After 2020, HSFO demand and prices will rebound as shippers install scrubbers and continue using HSFO.

The following analysis focuses on the global supply and demand balance for 1050°F+ resid, meaning all oil in the world boiling above 1050°F (“1050°F+ resid” or “vacuum resid”). On the supply side of 1050°F+ resid, over 95 percent of the 1050°F+ material is generated from fractionating crude oil with additional volume generated from steam cracking and other thermal cracking. The percentage 1050°F+ resid content in the world's crude will not vary much over the next ten years. Therefore, the key considerations are the world oil's demand and crude processing rate, which are very predictable. In 2015, the world produced 13.4 million barrels per day (mb/d) of 1050°F+ resid based on processing 80 mb/d of crude oil. In 2020, the world will produce 13.9 million barrels per day (mb/d) of 1050°F+ resid.

Considering the demand side, Figure III-6 diagrams the disposition of vacuum residue defined in this analysis as all product in the world boiling above 1050oF (1050oF+ resid).

Figure III-6: Diagram of 1050oF+ Resid Supply and Disposition



Notes:
(1) VGO = Vacuum Gas Oil.
(2) Resid conversion includes resid coking, solvent de-asphalting, hydrocracking, hydrotreating, fluid catalytic cracking, and visbreaking.
(3) Other Feedstocks include visbreaker resid, thermal cracker tar, pytar, hydrotreated resid, pitch, and FCC slurry oil.

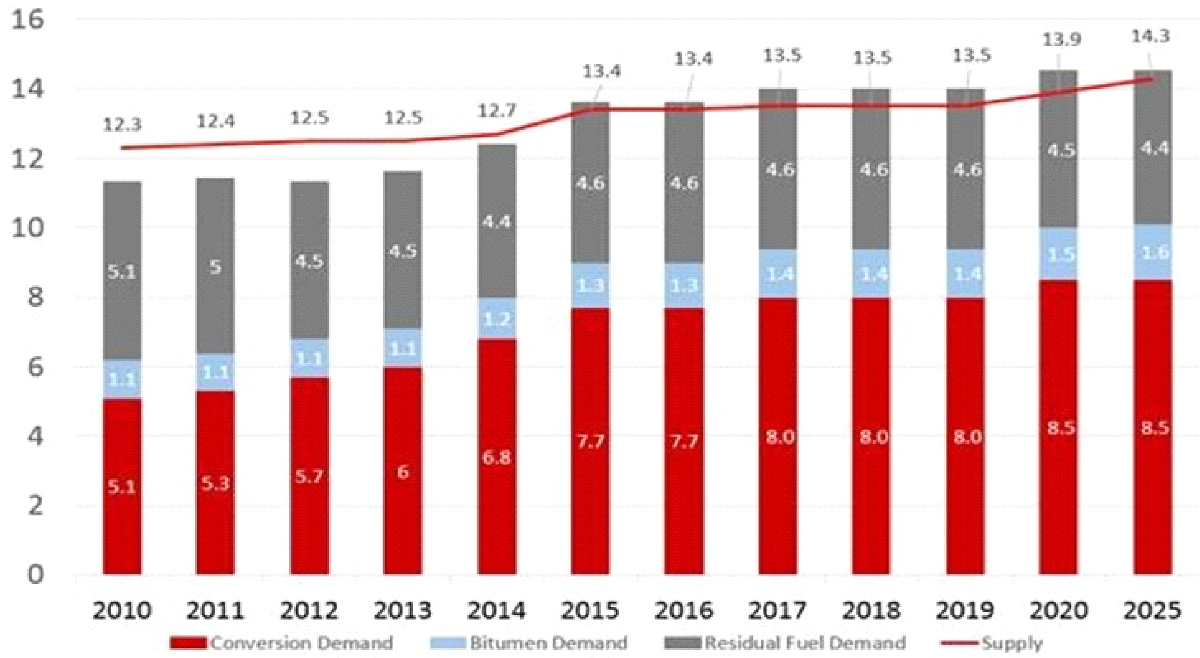
Source: DAI

The 1050°F+ resid has four primary dispositions:
1) as a feed to resid conversion processes
2) to the marine bunker market
3) to the land-based power market
4) to the bitumen/asphalt market

Vacuum resid is fed pure to conversion units but is blended with lighter hydrocarbons in producing heavy fuel oil and bitumen. Specifically, heavy fuel oil as bunker fuel is comprised of two components which includes the 1050°F+ resid and hydrocarbons boiling below 1050°F+ such as distillates, VGO, or slurry oil (cutter stocks).1 Bitumen is fractionated in such a way that a portion of hydrocarbon boiling below 1050°F (VGO) remains with the vacuum resid to produce on-specification product.

Figure III-7 shows the global vacuum resid supply/demand outlook for the 1050°F+ boiling material only. The conversion demand in this graph is based on 70% of the world's resid conversion capacity. The 1050°F+ resid content in bitumen is estimated to be 75%, and the 1050°F+ resid content in heavy fuel oil is estimated to be 60%. Both percentages2 are typical.

Figure III-7: 1050°F+ Vacuum Resid Supply/Demand Outlook [Million b/d]



Source: DAI analysis

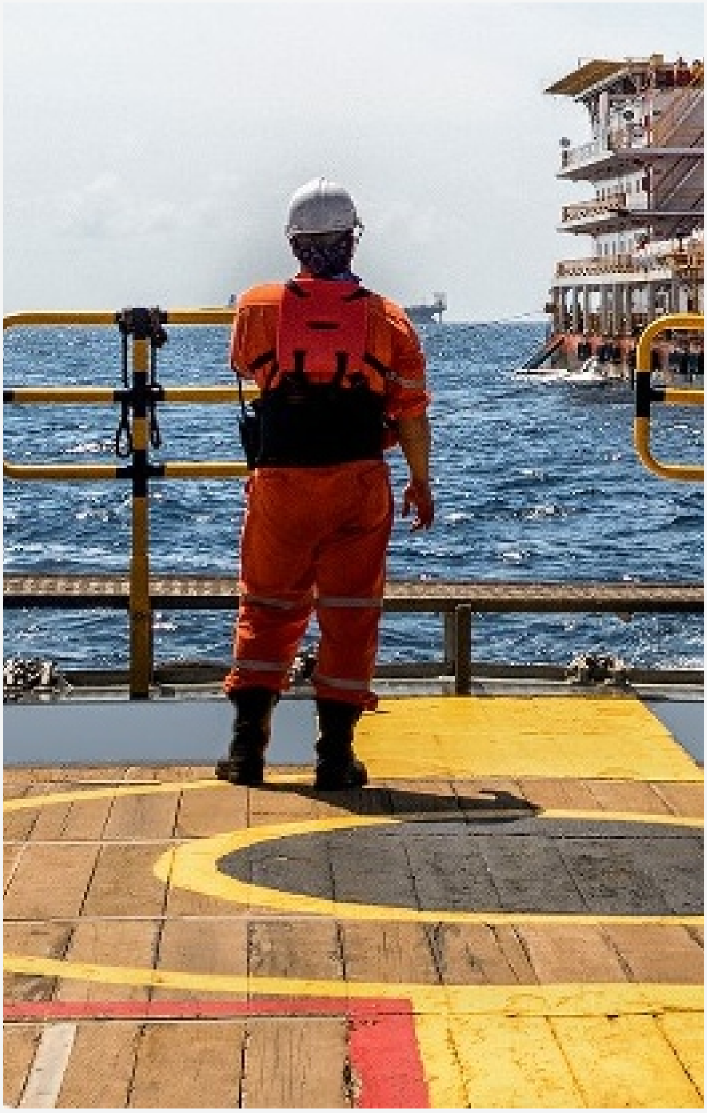
As shown in the graph, a structural change occurred in 2015 in which the demand exceeded the supply. This shift in 2015 coincides with the 2015 shift in price differential between HSFO and gasoil shown in Figure III-4. Given the expected continued demand growth, the vacuum resid supply/demand balance will be tight going forward.

Notes:

(1) Cutter stocks are heavy fuel oil blend stocks such as VGO, slurry oil, and distillates which cut the viscosity of the residual fuel to meet flow specifications.

(2) For example, the 1050oF+ resid demand of 4.6 million b/d in 2015 = 60% x 7.7 million b/d heavy fuel oil demand in 2015 (shown in Figure III-3).

Based on this analysis, one can conclude that bunker fuel oil should remain at a historically high price relative to Brent and gasoil.



Based on this analysis, one can conclude that bunker fuel oil should remain at a historically high price relative to Brent and gasoil.

The following summarizes further insights based on DAI's analysis.

Crude Segregation	• Refiners can produce 0.5% S FO without investment by switching to a lower sulphur crude slate. • Segregation and blending of low sulphur residues will be an important activity post-2020. • Considering all straight run atmospheric resid produced in the world, ovr 6 million b/d is 0.5% sulphur or lower. This means abundant 0.5% S FO will be available just through segregation of crudes. • Whereas some of this low sulphur straight run atmospheric resid supply is land-locked and competing outlets do exist for anode-grade coke production and for low sulphur fuel to the land-based power market, DAI projects that 1.5 million b/d of 0.5% S FO can be supplied as marine bunker fuel through crude segregation. 3 • Production of low sulphur straight run atmospheric resid will be cost-effective for select refineries with access to low sulphur crude such as Nigerian refineries. • The price premiums of crudes producing 0.5% S FO will increase as refiners switch their production to 0.5% S FO.
Vacuum Gas Oil (VGO)	Generally used as an FCC feedstock, VGO at its current price is significantly less expensive than diesel for meeting the 0.5% S FO demand. The price of 0.5% S VGO will increase as shippers seek a lower price for 0.5% S bunker fuel. Refiners will likely back out their most marginal FCC feedstocks to sell low sulphur VGO at a $/tonne price that is equal to or greater than the net product value of the gasoline and diesel (referred to as light cycle oil) produced from the FCC. Backing out these marginal FCC feedstocks will allow refiners to produce more low sulphur bunker fuel blend stocks. As noted above, some refiners may even partially shut down their vacuum unit to produce straight run atmospheric resid instead of VGO and vacuum resid.
Shipper Concerns	Many shippers plan to use marine diesel or are installing scrubbers considering fuel compatibility and logistical concerns. The possibility of incompatible fuels precipitating asphaltenes in a ship's fuel tanks is a significant concern for shippers. In addition to the fuel compatibility concern, existing bunkering facilities are limited on storing and segregating multiple grades of fuels.
Timing	Whereas several have forecast a significant shift from heavy fuel oil to marine diesel oil (“MDO”), this shift will not last. Announcements of shipper decisions to install scrubbers continues. For companies not installing scrubbers, facilities and procedures will eventually be adapted for use 0.5% S FO oil and/or 0.5% S VGO instead of the more expensive marine diesel.
Resid Conversion Capacity	The world has enough residue conversion capacity today to accommodate the excess supply of high sulphur residue resulting from IMO 2020.
Scrubber Additions	The addition of scrubbers is gaining ground. Current projections on scrubber additions suggest an HSFO demand after January 1, 2020 equal to 20 percent of the pre-2020 HSFO demand (“20% EGS Scenario”) with additional scrubbers being added thereafter. Projections for 2025 predict HSFO demand to be as much as 60 percent of the pre-2020 HSFO demand (“60% EGS Scenario”).
ULSD/HSFO Blending	Blending of one part of HSFO with three to seven parts of 10 ppm diesel (ULSD) will produce 0.5% S FO. As the market transitions to more economic means of supply, this type of blending will provide a floor for determining the price relationship of 0.5% S FO relative to ULSD.
Changing Expectations	The spread between 0.5% S FO, VGO, HSFO, and Brent will change as more conversion and more scrubbers are added. The changing expectations are reflected in the futures market. In January 2018, the futures market priced Rotterdam HSFO in 2020 at $30/b below Brent. In December 2018, the futures market priced Rotterdam HSFO in 2020 to be $18/b below Brent and narrowing to $15/b below Brent eighteen months later.

Tables III-8 and III-9 present DAI's supply and disposition projection of the world's 1050°F+ resid considering two scenarios of HSFO demand recovery.The 20% EGS Scenario reflects a balance in which the HSFO bunker fuel demand equals 20 percent of the total marine bunker fuel demand. DAI considers this scenario to be a reasonable projection for the HSFO demand in 2020. The 60% EGS Scenario reflects a scenario of continued scrubber additions such that the HSFO bunker demand equals 60% of the total marine bunker fuel demand.

20% EGS Scenario

Table III-8 on the following page presents the overall supply and disposition of the world's 1050°F+ resid considering the 20% EGS Scenario.

As shown, 13.9 million b/d of the world's crude oil will be 1050°F+ resid. Approximately 2.4 million b/d of the 1050°F+ resid supply will be directed to the marine bunker market prior to the 2020 switch. After IMO 2020, DAI projects that 0.9 million b/d of 1050°F+ resid will be segregated to supply the low sulphur residual bunker market. Another 0.5 million b/d of high sulphur resid is projected to go to ships with EGS or waivers (i.e. non-compliance). The balance of the 1050°F+ resid will feed conversion processes.

Table III-8: World 1050°F+ Resid Supply / Disposition with 20% EGS[(1)] [Million b/d]

	Before IMO 2020 Switch	Flow	After IMO 2020 Switch
World Supply	13.9		13.9
Bitumen	1.5		1.5
Marine Bunker High S (>0.5 %S)	2.4	0.5	0.5 (1)
Marine Bunker Low S (<0.5 %S)		0.9	0.9 (2)
Land Based Power	2.1	1.0	2.1
Conversion (Coking/HC/HDS)	7.9		8.9

Notes: (1) Balances reflect 20% EGS/non-compliance
(2) Low sulphur bunker fuel demand will be met by replacing 1 mb/d of high sulphur 1050oF+ with low sulphur VGO.

Source: DAI analysis

60% EGS Scenario

Table III-9 presents the overall supply and disposition of the world's 1050°F+ resid considering the 60% EGS scenario.

In this case, 1.5 million b/d of high sulphur resid will go to ships with EGS. Another 0.9 million b/d of 1050°F+ resid will be segregated to supply the 0.5% S FO demand. Despite the capacity additions, no additional resid will be left for additional resid conversion.

Table III-9: World 1050oF+ Resid Supply / Disposition with 60% EGS[(1)] [Million b/d]

	Before IMO 2020 Switch	Flow	After IMO 2020 Switch
World Supply	13.9		13.9
Bitumen	1.5		1.5
Marine Bunker High S (>0.5 %S)	2.4	1.5	1.5 (1)
Marine Bunker Low S (<0.5 %S)		0.9	0.9 (2)
Land Based Power	2.1	0.0	2.1
Conversion (Coking/HC/HDS)	7.9		7.9

Notes: (1) Balances reflect 60% EGS/non-compliance
(2)) Low sulphur bunker fuel demand will be met by low sulphur resid supply from existing low sulphur crude oils.

Source: DAI analysis

In summary, refiners investing in residue conversion to remove market risk will face a new risk that a tightened resid balance will drive prices for the resid conversion feedstocks higher than anticipated. Shippers investing in EGS are likely to find higher prices for HSFO than originally used to justify their EGS investment.

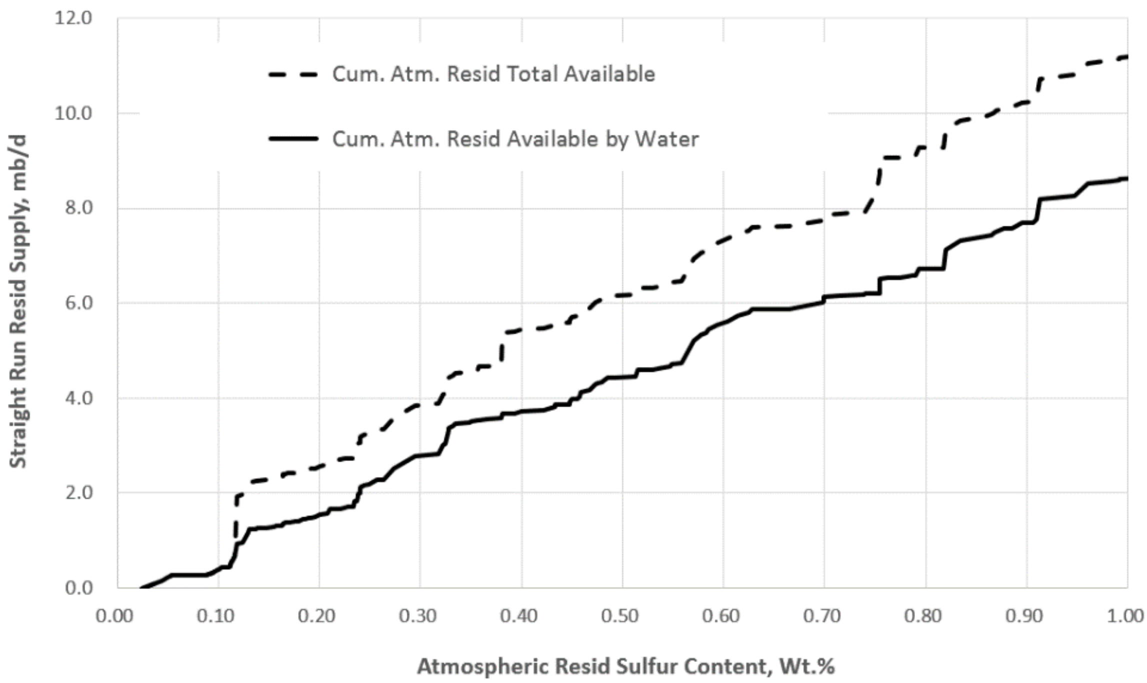
IV. Key Responses: Segregation of Crude Oils and Use of VGO

To dispel a well published misconception, there is no need to use diesel-boiling material to meet the bunker fuel specifications.

As noted in the above summary, Refiners will segregate crude oils to produce LSFO. As shown in Figure IV-1, over six mb/d of atmospheric resid is produced today with a sulphur content of 0.5% or less. Over eight mb/d of atmospheric resid has a sulphur content of 1.0% or less.

As further noted, 0.5% S VGO sells at significant discounts ($4-8/b) versus diesel. This spread is enough to motivate shippers to purchase low sulphur VGO for bunker fuel instead of diesel. In turn, Refiners will process less VGO in the FCC unit. Whereas backing out the VGO from FCC feed will reduce the world's production of FCC gasoline and FCC light cycle oil (marine diesel), this reduction will be mitigated by additional products created from increased production from resid conversion units.

Figure IV-1: World Supply Curve for Low Sulphur Atmospheric Resid versus Atmospheric Resid Sulphur Content



Source: DAI analysis

V. Impact on African Crude Producers

While impacting African crude oil producers, IMO 2020 will not require investment or modifications to crude oil production facilities. Instead, IMO 2020 will impact the price at which producers can sell their specific crude oil relative to reference crudes. The key for African low sulphur crude producers is to ensure they are receiving an appropriate premium for the higher value LSFO which will be produced from their crude oil relative to others. Crude price assessments should be conducted which entail valuing the fractional components of the producer's crude relative to the fractional components of the reference crude considering the specific time period and location.

Figure V-1: African Crudes Atmospheric Residue Sulphur Contents

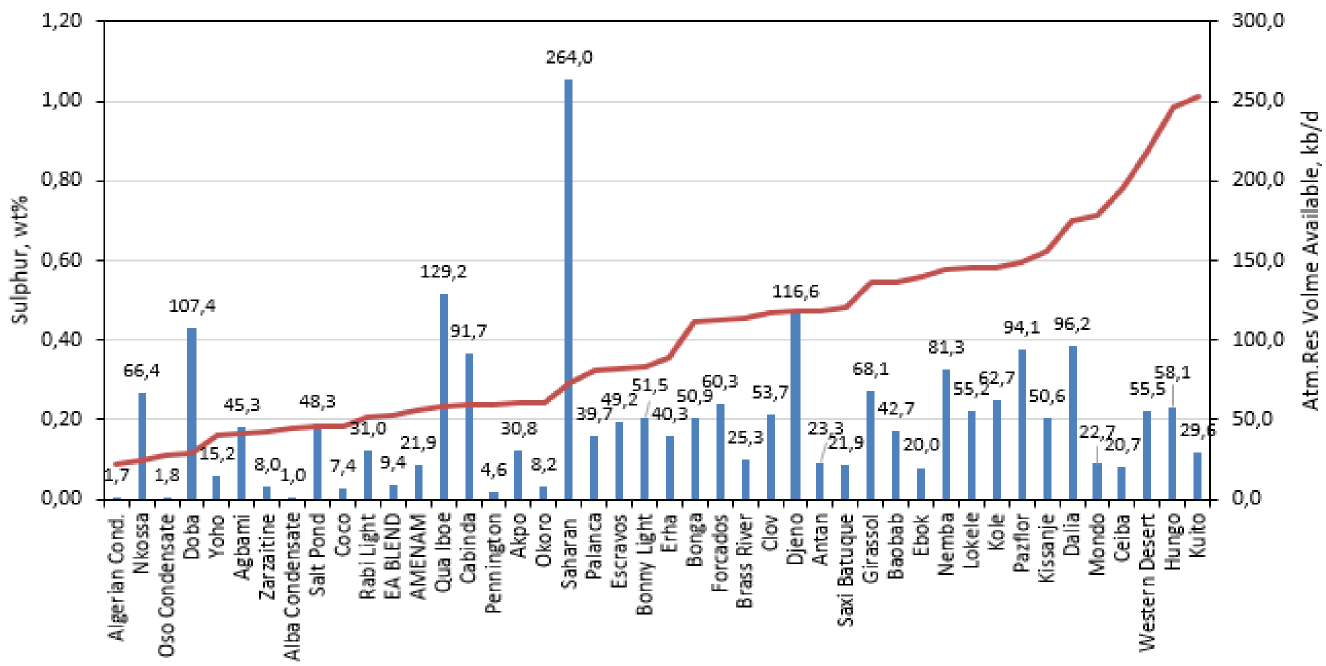
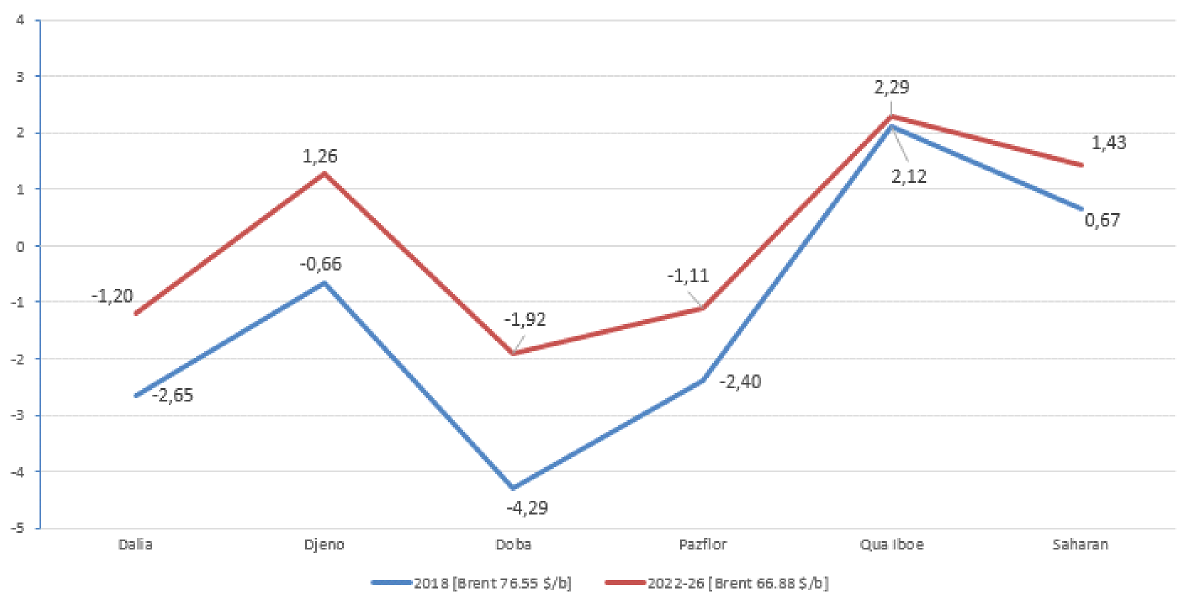


Figure V-2 below shows the relative value of African crudes and dated Brent. The actual differentials of African crude oil versus dated Brent will depend on the relative product values at the region where the crude oil is supplied. For the values shown by the graph, a location differential for NW Europe vs. Africa needs to be subtracted.

Figure V-1: African Crudes Atmospheric Residue Sulphur Contents

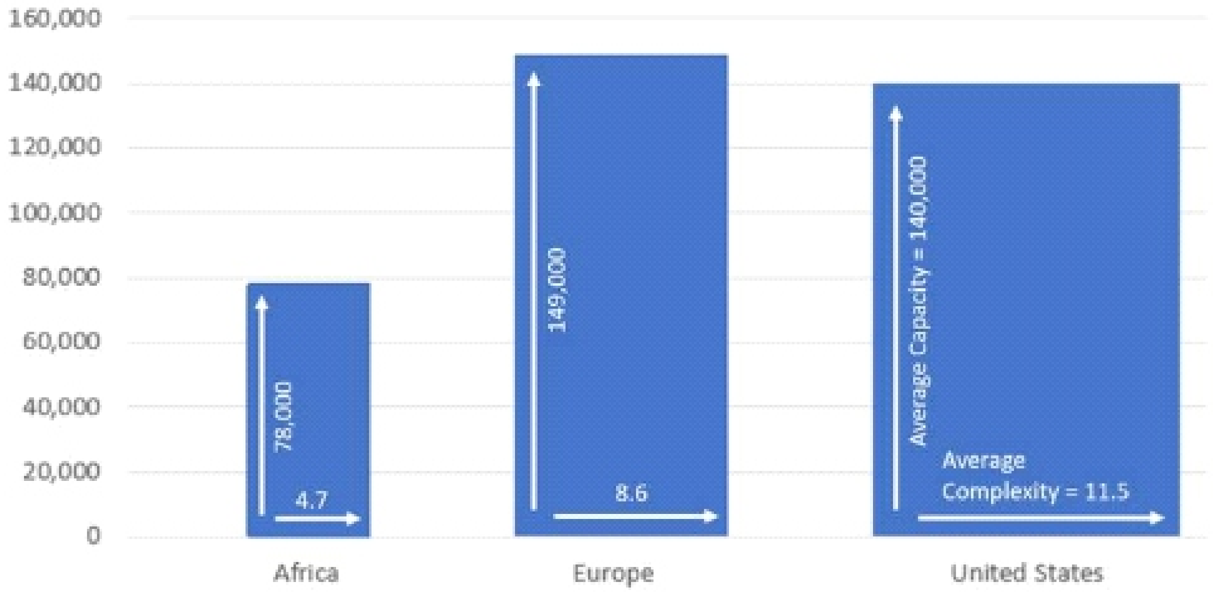


Source: DAI analysis

VI. Impact on Oil Refiners

As shown in the back-up table of Figure VI-1 below, African oil refineries are roughly one-half of the capacity and complexity of refineries in Europe and the United States. The Dangote refinery being built in Lagos, Nigeria reduces that size difference. The refinery is to start up in 2020 or 2021. When completed, the refinery will include a resid catalytic cracking unit as well as have a crude capacity of 650,000 b/d and an approximate complexity of 8.9.

Figure VI-1: Comparison of Average Refinery Capacity (b/d) and Complexity – Africa, Europe, and United States



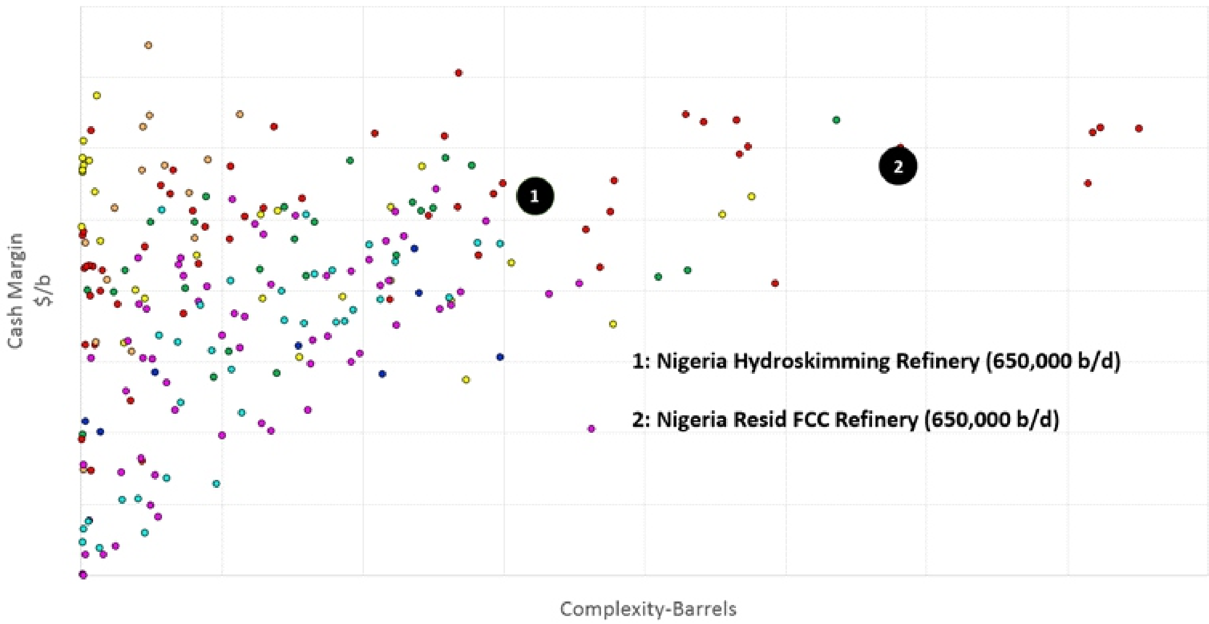
Values:

	Total Refining Capacity (barrels/day)	Average Refining Capacity (barrels/day)	Average Complexity
Africa	3,500,000	78,000	4.7
Europe	14,900,000	149,000	8.6
United States	19,200,000	140,000	11.5

Source: DAI analysis

West African oil refineries generally benefit from having access to lower cost crude and higher prices for products. IMO 2020 eases the ability for African refineries to profit from these location advantages by providing a high price for straight run atmospheric residue. Given the availability of low sulphur African crude oil, African hydroskimming refineries producing 0.5% sulphur fuel oil will be nearly as profitable as refineries with resid conversion. This is illustrated in Figure VI-2 which compares the projected cash margins of two hypothetical refineries in Nigeria with the projected cash margins refineries competing in Europe and the United States. In Figure VI-2, the cash margin is plotted against each refinery's size reflected by the refinery's crude charge capacity times the refinery's complexity index. As shown, a hydroskimming refinery located in Nigeria is able to achieve nearly the same cash margin as a resid cracking refinery of the same size. Implications from this analysis suggest that the Dangote refinery may benefit from beginning hydroskimming operations earlier with cracking operations coming on at a later phase.

Figure VI-2: Comparison of Refinery Per-Barrel Cash Margins versus Size (Complexity x Capacity Barrels)



Source: DAI analysis

VII. Impact on Shippers

Shipping is currently the largest market for HSFO production. IMO 2020 regulations will cause HSFO to be largely replaced by more expensive LSFO or marine diesel, which will cause a significant increase in oil prices. Initial competition for distillate products in the shipping industry may be significant for a period until a greater proportion of LSFO is able to be produced and distributed.

VIII. Impact on Other Transportation Fuels

IMO 2020 is expected to cause price volatility in the first one to three years following its implementation. The prices of distillate products such as gasoline, jet fuel, and diesel are expected to increase along with LSFO prices.