Centre for Energy, Petroleum
and Mineral Law and Policy
University of Dundee

# Petroleum Refineries in Nigeria: why do they perform so poorly?

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Research Paper

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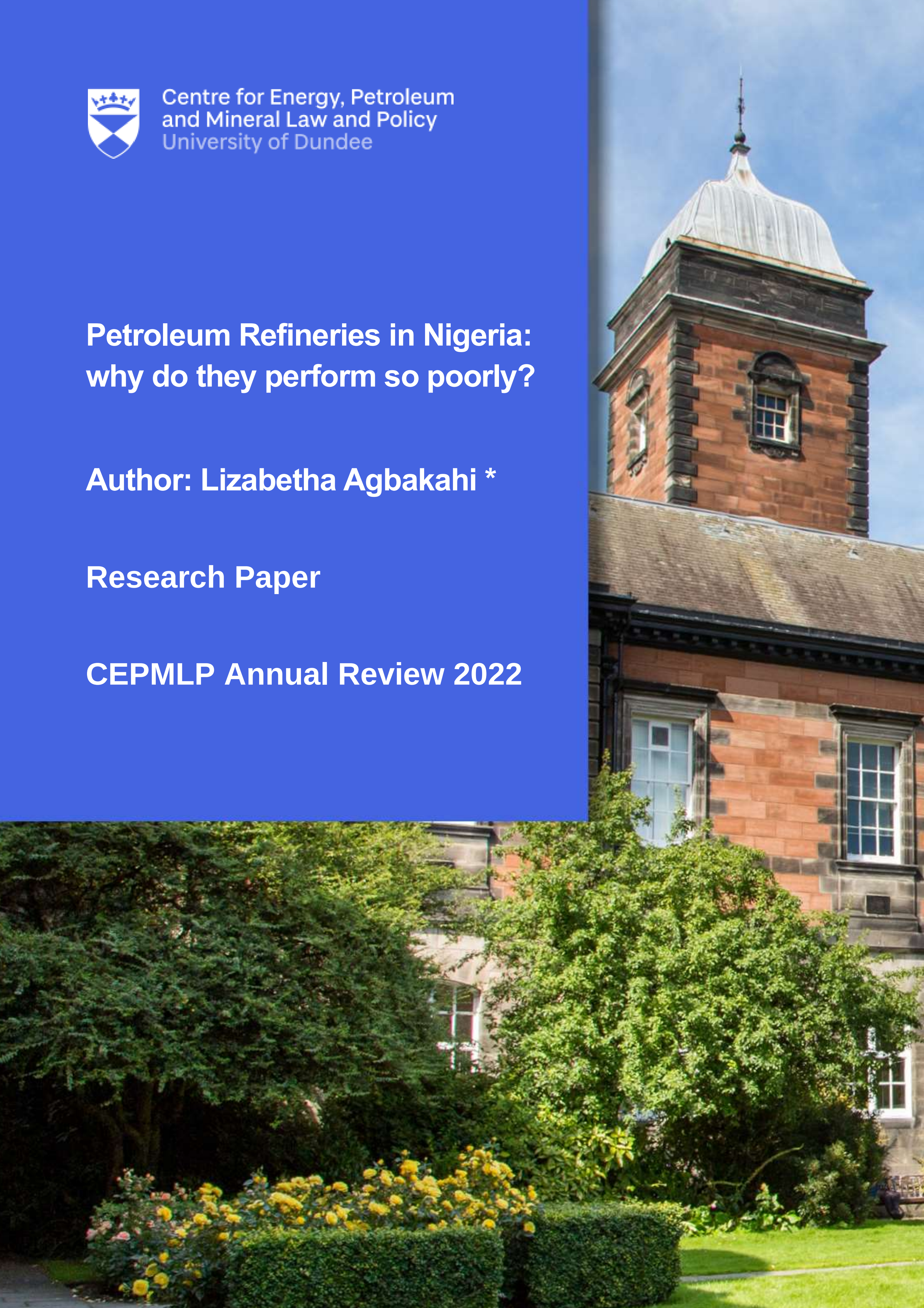

# Abstract

*In common with other countries around the world, the productivity and performance of refineries in Nigeria over time has been far from spectacular. Different explanations have been given for this phenomenon, including government intrusion in product pricing regime leading to under-recovery, lack/delay in turnaround maintenance (TAM), and pipeline vandalization. This research paper analyzes the root causes of the persistent low performance of this government refineries and indicates that the underperformance of these refineries in Nigeria was largely attributed political interference in the price of Premium Motor Spirit (PMS) via subsidy and the average capacity utilization of these refineries of just 15%, a figure that is critically low. In the context of the above, this paper argues in favour of remedial policy solutions centred on the recapitalization of these refineries via their complete or partial privatization.*

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# 1. Introduction

In many nations, refineries play a vital role in the economy. The role of a refinery in a nation varies from the supply of petroleum products to job creation and revenue generation. Crude oil exploitation in Nigeria commenced in 1937 when sole concessionary rights were granted to Shell D'Arcy over Nigeria (Ogbuigwe, A., 2018). Shell D'Arcy is now known as Shell-BP Petroleum Development Company of Nigeria Limited. The company achieved Nigeria's first oil commercial discovery in 1956, this achievement taking place in Oloibiri, Bayelsa State (Ogbuigwe Akpezi, 2018). Upstream development continued apace, such that just two years later, in 1958, Nigeria exported its first cargo of cruel oil.

Subsequently, as the economy and population of Nigeria increased so did the demand for petroleum products which was met by importation. Just after Independence in 1960, the Shell-BP Petroleum Development Company maximized an opportunity to build a refinery to meet the product demand of the country (Onwuegbuchunam *et al.*, 2020a). In total, there are four Federal Government of Nigeria (FGN)-owned refineries, all controlled and managed by the country's National Oil Company (NOC), namely the Nigerian National Petroleum Corporation (NNPC).

The four FGN-owned refineries have a combined plate capacity of 445,000 bpsd (barrel per stream day), namely the: Warri Refinery and Petrochemical Company (WRPC); Old Port Harcourt Refinery; New Port Harcourt Refinery and Petrochemical Company (PHRC); and Kaduna Refinery and Petrochemical Company (KRPC). Table 1 below shows the capacity of the crude oil refineries in Nigeria.

*Table 1:Crude oil refineries in Nigeria and their capacities*

| Plant | Capacity (bpsd) | Date of commissioning |
|---|---|---|
| Warri Refinery | 125,000 | 1978 |
| New Port Harcourt Refinery | 150,000 | 1989 |
| Kaduna Refinery | 110,000 | 1980 |
| Old Port Harcourt Refinery | 60,000 | 1965 |

Source: Author & DPR.

However, the performance of Nigerian refineries has been very abysmal. Many motives have been assigned to this poor performance including the government intrusion in product pricing regime, lack/delay in TAM, and pipeline vandalization (Nwozor *et al.*, 2020).

In the quest to generate an immediate solution, the Nigerian government has subsequently invited private companies into investing in modular refineries to sufficiently satisfy local demand. This has not provided a permanent solution, however, as these modular refineries do not have the capacity and refinery technology to produce the needed petroleum products like Premium Motor Spirit (PMS) and gasoline diesel (Ogbon, Otanocha and Rim-Rukeh, 2018).

Despite the immense magnitude of this challenge, relatively little, if any, has been published about it in mainstream literature. This paper, therefore, sets out to examine the primary reasons of the prolonged poor performance of this government-owned refinery. The discovery, development, and exploration of oil in the country also offer an additional incentive for the pursuit of the aforementioned challenge. In this regard, it would be fascinating to discover how Nigerian refineries could strategically exploit their potential to better their fortunes.

The rest of the paper proceeds as follows: the second section examines the issues affecting the global refinery industry while section three examines the impact of the existing market dynamics on Nigerian refineries' performance; section three provides an analysis of the market dynamics of Nigerian petroleum refineries; section four discourses the technical and operational efficiencies of these refineries; and conclusions are provided in section five.

# 2. An Overview of Petroleum Refining

Petroleum refineries transform crude oil into various petroleum products, this is mainly achieved through a distillation process which split up the crude oil into diverse fractions depending on the boiling point ranges (Walls, 2010). The process ends in the selective reconfiguration of new products such as gasoline, kerosene, diesel, fuel oil, and so on. However, these petroleum products are essential inputs to an economy's production process, whether directly or indirectly, and thus their presence is essential to the development of an economy.

Generally, refineries are categorized into four types: topping, hydro skimming, conversion, and deep conversion refinery (IEA, 2014; Jing *et al.*, 2020). Figure 1 below illustrates the basic refinery processing units and products.

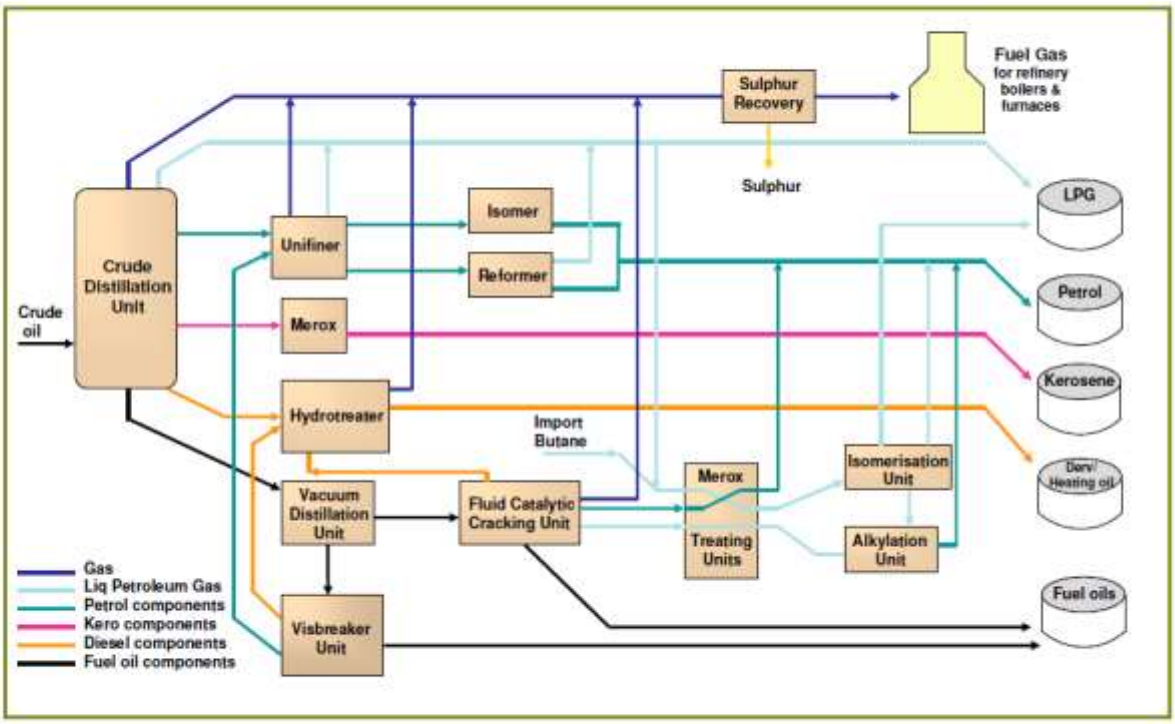



*Figure 1:Refinery Processing Units and Products (UKPIA, 2011)*

Topping refineries are considered as the simplest category which consists of crude distillation and basic support plant. Their capacity to alter the natural yield pattern of the feedstock they process is very restricted and they end up simply extricating crude oil into light gas and refinery fuel, naphtha, distillates, and residual or heavy fuel oil.

The hydro skimming refinery is a more advanced than the topping refinery; designed and constructed to include catalytic reforming, different hydro-treating units, and product combination. The catalytic reforming permits for the upgrade of naphtha gasoline and nitrogen are produced as a by-product for hydrotreating units. The hydro-treating unit allows the removal of impurities such as sulphur among others and this class of refinery is common in counties with low gasoline demand.

Conversion or cracking refinery is the next stage in a complex overall process, including, variously, visual distillation, catalytic cracking or hydrocracking, and the use of alkylation units. It has the capacity to improve the natural product patterns of the crudes they process but they unavoidably still produce some heavy, low-priced products, like asphalt and residual fuel.

Even more complex is the deep conversion or coking refineries. The deep conversion units have the capacity to transform the heaviest and least valuable crude oil fractions by converting them into lighter streams of more valuable light products (EIA, 2020). Deep conversion plants often prove the most profitable form of refinery(McKinsey, 2020).

The physical features define the unique operating features and economics of refineries which will be looked into later. Normally, the configuration level adopted by a refinery is set on by its location, crude slate features, and product quality specifications (MU, 2020). The configuration of a refinery is influenced by environmental regulations and standards. The dynamic interplay and evolution of these factors has caused the unceasing development of refineries over time (James H. Gary, Glenn E. Handwerk, 2004).

According to BP’s Statistical Review (2020), the world refinery capacity rose at 1.5million barrels per day (mbd) barrels per day in 2020, the largest recorded annual increase since 2009. This growth was a result of additional refining capacity in China, the Middle East region, and the USA. Lately, the refinery business has been characterized by high capital requirements business and yet relatively low margins (EIA, 2020). Refinery utilization in the world fell sharply, by 1.2% (to 82.5%) the largest annual decline since 2009. The average refinery margins for these three regions US Gulf Coast, Northwest Europe, and Singapore slightly lowered falling from $5.4/ barrel of oil equivalent (bbl) in 2018 to $[1]4.7/bbl in 2020 (BP, 2020).

The economic performance of refineries is affected by many factors, including: refinery configurations; the cost of crude oil purchases; the product price and demand; operational cost; and levels of capacity utilization.

[1] All $ figures quotes are United States Dollars.

# 3. Analysis of Market Dynamics of Nigerian Refineries

## 3.1 Product Demand Analysis

The successful outcome of any economic unit in a country depends on the availability of a market for its product. Figure 2 below shows the (refined) petroleum product consumption trajectory in Nigeria. It indicates that the market has a steady growth with motor gasoline and gas/diesel being the two most vital products in demand. These two products have shown an average growth rate of 6.7% and 5.9% respectively for the period 2010-2018. Overall, the total product demand revealed an average growth rate of 11.45% which interprets into an increase in demand from 9,399.0 kilotonnes (kt) of oil in 2010 to 21,272.0kt in 2018 (IEA, 2020).

Petroleum refining operates in a dynamic market, and therefore, to thrive and compete favorably, there is a need to adapt with agility to changing market conditions.
Indicative of change over time, the configuration of the refineries in Nigeria reflects growing high levels of demand for refined petrol products domestically.

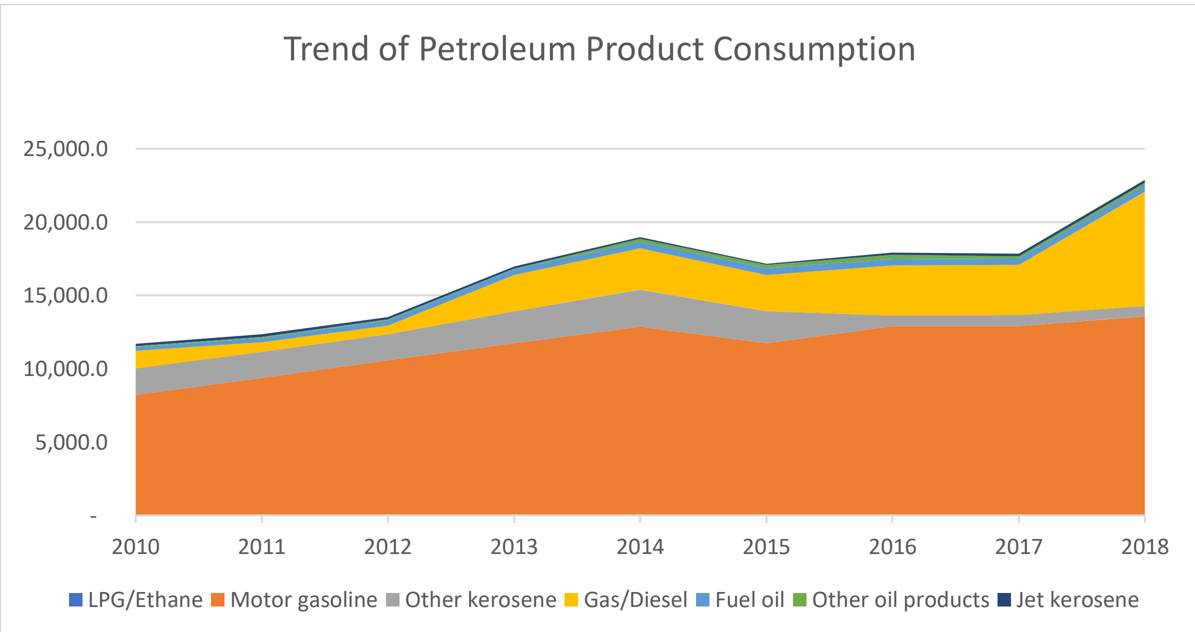



*Figure 2:Trend of Petroleum Product Consumption in Nigeria (2010-2018) (IEA, 2020)*

Data available indicates that domestic production is incapable of satisfying local demand, leading to the high importation of products from external sources. According to EIA (2020), 442,00 b/d (barrels/ day) of petroleum products were imported into the country which worth $9.95 billion (bn). In 2019, the domestic refinery was only able to serve less than 10% of the domestic market demand, implying a gap of more than 90% to be met by imports – and representing lost potential revenue to the FGN.

## 3.2 Capacity Utilization Analysis

Refinery capacity utilization is one of the indicators pertinent to the efficient operation of refineries, as is the concept of bpsd (see above): namely the maximum input capacity in b/d that any particular distillation facility can process. Refineries are capital intensive and rely economics of scale to keep unit costs of production low, hence high bpsd and levels of utilization are both important drivers of profitability.

Hence, for a refinery to be profitable it requires to operate at a high-capacity utilization rate and amongst the reasons for the poor performance of refineries is that capacity utilization is less than optimal. The capacity utilization margin in Nigeria has been low since the 1990s, it has hardly achieved a utilization level of 25% or 30% of its capacity. This can be seen in table 2 below.

*Table 2:Refinery Performance (% Capacity Utilization)*

| Year | KRPC | PHRC | WRPC | NDPC | Total |
|---|---|---|---|---|---|
| 2010 | 19.99% | 12.90% | 42.68% | NAP | 21.23% |
| 2011 | 19.00% | 21.24% | 39.79% | 22.20% | 23.03% |
| 2012 | 29.07% | 16.35% | 27.89% | 55.75% | 20.61% |
| 2013 | 29.50% | 29.96% | 16.74% | 18.52% | 22.09% |
| 2014 | 11.05% | 15.70% | 19.24% | 50.37% | 13.51% |
| 2015 | 3.00% | 6.18% | 6.67% | 71.47% | 4.85% |
| 2016 | 9.37% | 21.78% | 11.80% | 60.54% | 13.08% |
| 2017 | 15.09% | 4.67% | 11.82% | 69.69% | 8.76% |
| 2018 | 0.41% | 15.10% | 2.31% | 70.40% | 5.98% |

Source: DPR (2019)

## 3.3 Product Pricing Analysis

The process of setting prices for petroleum products has certain implications for the profitability or otherwise of the refineries. Since 2010, Nigeria started using swap agreements to refine its crude oil to meet domestic needs, which is in two forms the crude oil for refined product exchange agreement (RPEA) and an offshore processing agreement (OPA)(*NNPC*, 2015). However, these facts make it difficult to determine ex-refinery prices.

Nigeria's downstream petroleum sector is heavily regulated, with two pricing mechanisms in place for petroleum products. Firstly, diesel pricing is deregulated and marketers are free to fix its price while PMS and others are determined by the government from time to time. The prices of the products are always set below the market price and value, a subsidy scheme is set aside to cover the under-recovery associated with the below market price. The Expected Open Market Price (EOMP) is administratively determined by the Petroleum Products Pricing Regulatory Agency (PPPRA) created through a template agreed on by the stakeholders in the framework of the agency's decision-making board (Ozo-Eson, 2013). The pricing process is computed in two ways by the PPPRA and they are as follows:

i. **Landing Cost** = The cost of product as quoted on Platts (reference spot market is that of Free On Board Rotterdam Barge) + Insurance & Freight + Trader's Margin + Lightering Expenses (SVH) + NPA + Financing (SVH) + Jetty Depot Throughput Charge + Storage Charge;
ii. **Expected Open Market Price** = Landing Cost + marketing and distribution margins + taxes;
iii. **Approved Retail Price/ Ex-depot Price** = EOMP – subsidy; and
iv. **Pump Price** = ex-depot + marketing and distribution margins.

First, international market prices and exchange rate volatility are directly integrated into the local system, and refiners' have no control over the mitigation of their effects (Ozo-Eson, 2013). This is because the refiners used are faced with a price ceiling and are therefore at the mercy of the government or the regulatory authority and the landed cost is determined by the exchange rate. Hence, this is highly salient to profitability of the refineries.

Besides, recognizing that some level of regulation would be essential even in a fully deregulated environment, the research paper considers that such a system is far more likely to reflect the cost elements set out above (as the focus of the regulation would be different) and would ensure that economic costs are pass-through than the current arrangement. It can be noted that the issue is not in the Petroleum Products Pricing Regulatory Agency framework but the policy environment at set up by the FGN (Ogbuigwe, 2018). For example, subsidies, it has become a huge issue of debate and affect refineries in Nigeria. The difference between the EOMP given by the PPPRA and the approved retail price (ARP) is the subsidy per litre (SPL) paid by the FGN Currently, the EOMP is 183 Naira/per litre ($0.48) and the ARP is 160 naira/per litre ($0.42) having that domestic consumption daily is approximately 55 million litre per day, the government has to pay a subsidy of about 1.1 billion naira ($2,887,139) daily. The exchange rate is based on the Central Bank of Nigeria rate of 30/11/2020 of 381 Naira to $1 (*The Guardian Nigeria News*, 2021).

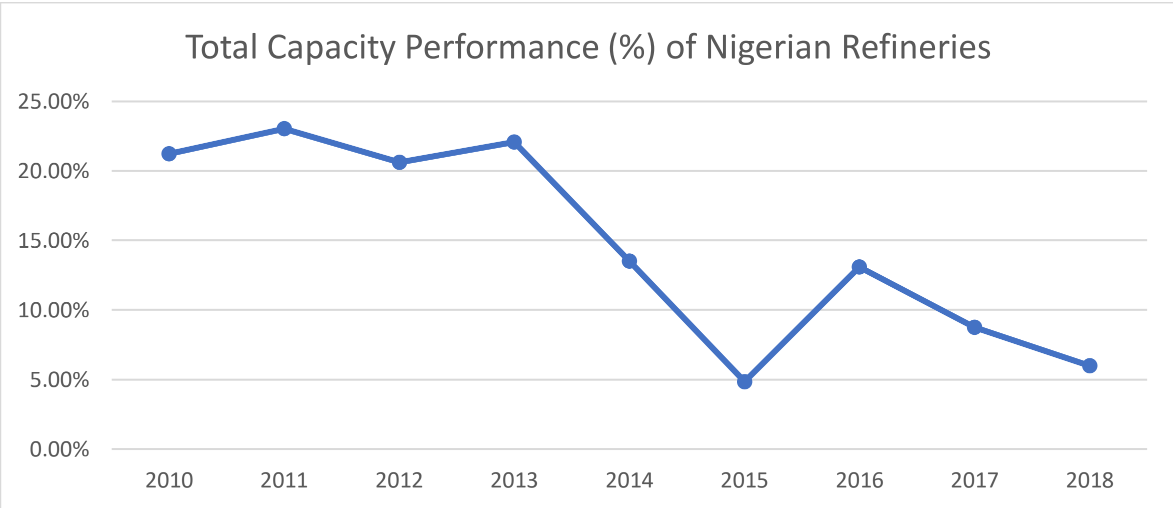



Figure 3:Trend of Nigeria Refinery Capacity Utilization (DPR,2019)

For the period 2010-2018, figure 3 above shows the trend of Nigeria refinery capacity utilization.

Given an overall distillation capacity of 445,000bpsd (see above), the refineries' theoretical maximum annual production in sum would be in excess of 162.4million (m) barrels per annum (p.a.) if all refineries operate at full capacity, experience no downtimes nor (implausibly) any conversion losses (fuel lost in the system while processing crude oil to petroleum products). In practice, 100% capacity utilization is infeasible, the question is what level of utilization can be sustainably and profitably achieved.

Indeed, Nigerian refineries perform well below not just these maximum theoretical figures, but also more realistic levels of overall production given real world conditions. At best, their highest rate of recorded level of production being 102,703.25 barrels p.a. achieved in 2011, indicating an average of just 281,38 b/d (DPR, 2019). At this level of production, the utilization rate was only 23.03%, and that for the best annual set of figures recorded; far worse (lower), a figure of just 4.85% utilization was recorded in 2015 (DPR, 2019). Evidently, these rates of capacity utilization by Nigerian refineries are sub-optimal and NNPC is incapable of making maximum economic returns. At the current utilization rate, Nigerian crude oil refineries would be unable to take advantage of economies of scale afforded to them by merit of their design and construction.

# 4. Analysis of the Efficiency of Nigerian Refineries

## 4.1 Refinery Configuration Analysis

The technological effectiveness of the refinery is determined by the refinery complexity and the configurations implemented in the refinery. One salient variable, amongst others, is the various characteristics of the feedstock (crude). The more advanced refineries are in a position to change the normal yield trends of the various crude slates to improve the profitability of the refinery. The defining characteristics of the medium, sweet and heavy, sour crudes have an inherent economic gain that can be beneficial to complex refining plants (Ibrahim, 2012).

Heavy, sour crude has less value and is sold at a large discount relative to the more valuable and costly light, sweet crude. Since conversion and deep conversion refineries are capable of turning these crude slates into a light, high-priced/expensive product slates, they grab the rent arising from their price spread. However, it should be noted that the volume of rent received in this process is constrained by the comparatively high production costs of the "disadvantaged" crudes. The net margin of a deep conversion refinery could be four times higher that of a simple topping refinery (James H. Gary, Glenn E. Handwerk, 2004).

Nigerian refineries tend to be complex, e.g., one uses a naphtha catalytic reforming unit (CRU), another a Fluid Catalytic Conversion unit (FCCU) for gasoline(Ogbuigwe, 2018). The refineries are capable of achieving high-level technical efficiency. Although, the degree to which these refineries can vary crude slates tends to affect its margins.

Table 3 below show the design, capacity, configuration and yield of refineries in Nigeria.

*Table 3:Nigerian Refineries Design, Capacities, Configuration and Yields*

| | Port Harcourt | Warri | Kaduna | Total |
|---|---|---|---|---|
| Capacity MTA | 10.5 | 6.0 | 5.5 | 22 |
| Commissioning date | 1988 | 1978 | 1980 | |
| Refinery configuration | CDU/CCR/ FCC | CDU/CRU/ FCC/PP | CDU/CRU/FCC/ lubes/wax | |
| Additional processes/ petrochemicals | Dimersol/alky | Carbon black (18)/PP(35) | Asphalt(3O0) /LAB(30) benzene(15) | |
| Crude supply | P/L from Bonny | P/L from Escravos | P/L from Escravos via Warri | |
| Design PMS | 3.0 | 2.1 | 1.3 | 6.4 |
| Design DPK | 1.4 | 0.5 | 0.6 | 2.5 |
| Design AGO | 2.4 | 1.7 | 1.0 | 5.1 |

Source: (Ogbuigwe, 2018) MTA IS Metric ton per annum P/L means pipeline

The product refined by these refineries is of high market value. Therefore, to maximize the gains generated from the existing market opportunity requires achieving higher level of utilization, e.g., via capital investment.

The difference between the sales prices of the refined petroleum products (PMS, AGO, HHK) and the price of crude oil is termed the “crack spread”, and it considered a simple method to ascertain the profitability of a refinery (MU, 2020). A 3:2:1 crack spread is used in US where most of Nigeria crude oil is exported and imported (EIA, 2013). The 3:2:1 means that at the margin, 3 bbls of crude oil will produce 2 bbls of PMS and 1 bbl of Automotive Gas Oil (AGO) or Household Kerosene (HHK) which are the main petroleum products used in Nigeria.

Currently, a barrel of Nigerian oil cost about $56, the PPPRA pricing template put the cost of PMS at $0.433 per litre and one barrel of PMS at $68.873 likewise diesel is at $0.587 a litre and $93.260 per barrel at a CBN exchange rate of N381/$1. Therefore, the gross cracking margin of an average refinery in Nigeria is ((2*68.873) + 93.260 – (3*56)) or $231.006 or $77.002 per bbl. In sum, assuming these refineries' capacity utilization was above 70% or more the refineries will be profitable based on the crack spread calculation above to determine the margin.

## 4.2 Operational Efficiency Analysis

Another key unit that determines the profitability of an economic unit is operational efficiency. For the refinery industry, this has often got to do with tactically changing crude inputs to take advantage of the spread between low and high sulphur crudes, different product slates to match changing demand patterns, and maximizing capacity to profit from the reducing fixed cost and other cost-cutting related benefits (Onwuegbuchunam *et al.*, 2020b). Indeed, refiners embraces all the other strategic decisions that seek to optimize the performance and product outcome of the refinery. Unlike branded consumer goods, petroleum products are standardized commodities therefore refiner cannot maximize their returns based on product differentiation.

Notwithstanding the refineries in Nigeria are complex conversion plants, and as such can benefit from the “disadvantaged” crude (Nwosu, 2018). The major challenge is the refineries lack maintenance and as such this limits the operational performance of the refineries. The petroleum refinery is designed and installed in order to manufacture specified quantities and specifications (quality) of each petroleum products. This plant or unit operate continuously for 24–36 months on the basis of a appropriate maintenance culture, before being shut down for a period of time to be serviced which is called TAM (Igboanugo, Garba and Okafor, 2015). In a situation, where TAM is excessively overdue the capacity utilization of the refinery which shows its performance starts to decline.

Figure 4 below indicates what the Port Harcourt Refinery would have been expected to produce in a scenario of timely TAM and 90% capacity utilization.

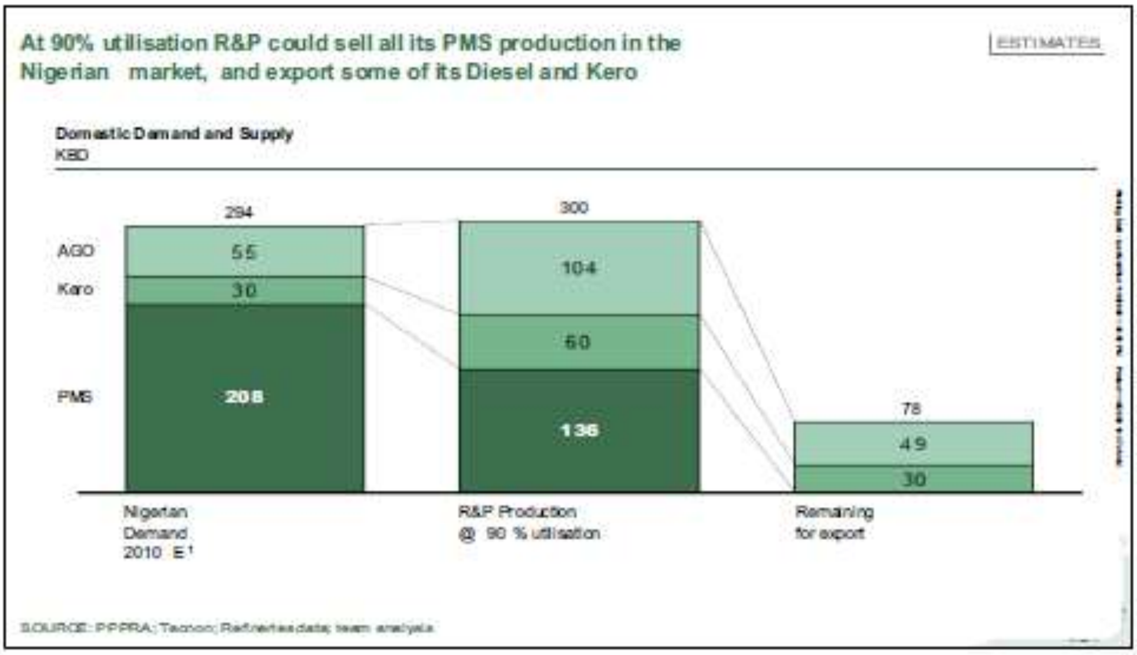
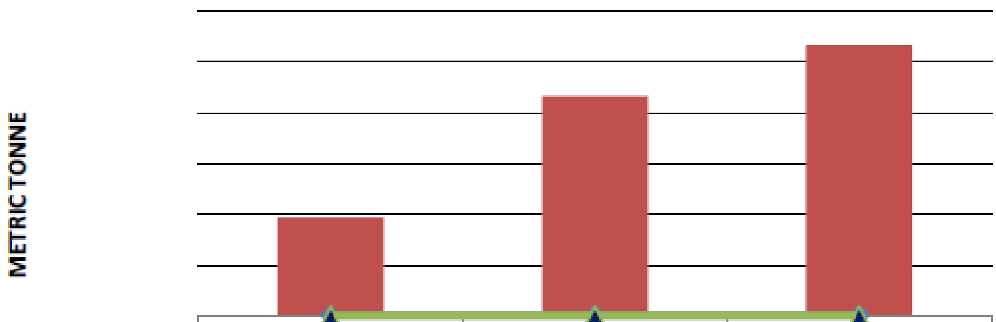



Figure 4:Port Harcourt Refinery (PPPRA,2018)

Figure 5 below shows the outcome of the Port Harcourt refinery due to default in TAM, and inconsistent supply of crude oil feedstock.




| | UP TO Q2, 2012 ACTUAL | UP TO Q2, 2013 ACTUAL | UP TO Q2, 2013 PLAN |
|---|---|---|---|
| CRUDE PROCESSED (MT) | 387,294 | 865,033 | 1,067,230 |
| EFFECTIVE CAPACITY UTILISATION % | 7.50 | 16.84 | 20.78 |
| ON-STREAM EFFICIENCY % | 17.83 | 37.58 | 31.42 |

*Figure 5:Port Harcourt Refinery Operational Performance between 2012-2013(Ogbuigwe ,2018).*

From figure 4 above the Port Harcourt refinery with 90% capacity utilization and timely TAM will be able to balance the domestic demand and have excess supply which the country can export to generate revenue. Figure 5 then shows the operational performance of the Port

Harcourt refinery. As of the end of June 2013, had a capacity utilisation and on-stream efficiency of 23.46 percent and 37.58 percent, respectively. The plant's performance was hampered mostly by a scarcity of bonny light crude oil.  Port Harcourt Refinery’s average capacity utilisation and onstream efficiency were 3.92 percent and 6.12 percent, respectively, in Q2 2012. This poor performance was largely attributable to a scarcity of feedstock during the quarter in question. When crude oil supplies improved marginally in Q2 2013, this improved to 12.48 percent and 20.43 percent, respectively.

It is clear that low-capacity utilization is due to the default in the maintenance of plants/units used in the refineries. Machinery and other support facilities in the refineries are prone to corrosion due to their use and proximity to operation and environmental conditions. This corrosion needs careful consideration to be given to through the various repair interventions, strategies and at some fixed times, so that the necessary usage of the services can be maintained and the service life prolonged to a point where maintenance costs become prohibitive and replacement actions become unavoidable (Ogbuigwe, 2018).

According to the American Petroleum Institute (API), turnaround maintenance is a periodic stoppage (total or partial) of a refining process unit for servicing and repair procedures and for the inspection, testing and replacement of process materials and equipment. Moreover, it is important for the health/lifespan of a refinery and are considered the most costly aspect of a plant or process unit maintenance budget (Angela *et al.*, 2018). But in Nigeria, refineries often fail to get this operational attention on-time.

Also, the low-capacity utilisation can also be linked to inefficient management practices and pipeline vandalization. These above-mentioned issues have been a struggle for the refineries in Nigeria. Due to the constant vandalization of pipelines, NNPC resorted in transportation of the crude oil and as such this increases the operation cost of the refinery. The impact of this has made it difficult for investment in the refineries as investors find it unattractive. Recently, NNPC audit recorded a loss of 1.6trillion (tn) in the operative and administrative maintenance of the refineries for the past five years (Premium Times, 2021).

In sum, the poor performance of Nigerian refineries can be attributed to the lack of TAM, poor utilization of refinery capacity, poor product pricing. Existing refineries should be restored and put back into service at a rate of at least 80–90% capacity utilisation. When compared to the cost of establishing Greenfield refineries of similar capacity, this is the most cost-effective choice. This can be accomplished in one of two ways: through a private-sector-led financing and rehabilitation effort, such as the one being pursued by NNPC, or through outright divestiture of majority equity holdings to the private sector from the government's existing 100% ownership.

# 5. Conclusion

Following the above, it is obvious that the performance of the four FGN-owned refineries in Nigeria has been poor. First, the average capacity utilization level of these refineries is barely above 15% which is woefully uneconomical. Also, the prices of its products are being seriously manipulated by the government and under-priced, resulting to serious under recovery for the NNPC. It is also considered bloated labor force and major operational inefficiencies. The most significant challenge to the economic performance of the refineries lies with political intrusion in the application of the petroleum product pricing formula through subsidy. This has usually been motivated by reasons of subsidizing consumers or gaining political advantage. From the analysis there exists a vast market opportunity for the refineries, yet to be exploited, and growing demand for the petroleum products, this cannot be linked to the under-performance of the refineries. Looking at the blend of factors analysed above, it is advisable that the government revamp the refineries thereby carry out proper maintenance, expansion, and upgrade if possible or another logical policy alternative will be to recapitalize it either through complete or partial privatization.

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