# European Refinery Margin Index: Methodology

## Abstract

The current available refinery margins for reference need updating. Many have been in place for numerous years and therefore are subject to legacy methodology that is not relevant for the current refinery economic climate. With the Onyx European Refinery Benchmark, we aim to provide an index that more accurately reflects the current output of European refiners. In addition, we have provided an index which is a gross refinery margin calculation constructed entirely from market prices. This in turn allows for the Onyx European Refinery Benchmark to be used directly as a hedging solution or a speculative instrument.

## Introduction

The refinery business in Europe, whilst having struggled in recent times, is still a large business and there is a constant push for infrastructure investment as well as operational optimisation to accommodate demand shift across the product complex. In addition, refinery yields, especially in Europe, are still very much susceptible to the chemical make-up of the feedstock used in the CDU. Therefore, changes in crude flows into and out of Europe are particularly important for determining the benchmark crude quality used by European refiners. Additionally alternate refinery margin references are calculated as an estimated net margin, with associated operational costs and freight a component of the calculation. Whilst this might provide interest for economic health or lack thereof, it means the margin cannot be both referenced and hedged, or indeed traded on a speculative basis with exposures to each product being clearly defined.

## Proposal

Onyx calculates the price using the following product weightings:

| Product | Weightings (%) |
|---|---|
| **LPG** | 6 |
| **Naphtha** | 10.5 |
| **Gasoline** | 31 |
| **Jet** | 4 |

| | |
|---|---|
| **Gasoil** | 28 |
| **0.5%FO** | 4 |
| **1%FO** | 4 |
| **3.5%FO** | 12.5 |

## Justification

In order to logically convey our argument, we will be starting with a verified base case and make adjustments in proportion to our reasoning. The base case will be product weighting estimations from a study by the EU commission in 2000. These product weightings are largely representative of the refinery margin estimates still used today, whilst being sourced from a governing body suggests a reasonable level of reliability.

In order to have a more representative number for current refinery margins we must consider how structural physical oil flows have developed as well as refinery infrastructure. On studying the changes, we can evaluate the consequent impact on the product weightings from the base case and adjust accordingly.

The European Commission estimated in 2000 that European refiners yielded the below NWE and MED yields. Given an approximate 65/35 split calculated in crude throughput per day between NWE and MED refiners, the European Average yields can be considered as follows:

| Product | **NWE** | **MED** | **European Average (65/35 Weighting)** |
|---|---|---|---|
| LPG | 2.5 | 2.5 | 2.5 |
| Naphtha | 7 | 6 | 6.65 |
| Gasoline | 27 | 26 | 26.65 |
| Jet | 9 | 6 | 7.95 |

| | | | |
|---|---|---|---|
| Gasoil | 33 | 28 | 31.25 |
| 1% FO | 5 | 0 | 3.25 |
| 3.5% FO | 7 | 14 | 9.45 |
| Heavy FO | 12 | 14 | 12.7 |

## What we see as the major differences in refinery yields since 2000:

### 1. Infrastructure Development Improving Complexity

Although the majority of NWE refiners are less complex than global counterparts, with no refineries making Stratas' list of most complex refineries worldwide, the complexity of refineries has grown greatly since 2000. Hydrocracking, hydrotreating, and coking units appear to be the drivers of this increase. In 2012, the average complexity index of EU refineries was 9.0, having grown significantly from 7.3 in 1998.

A report commissioned by the EU Commission and published by Purvin and Gertz confirms the increased Gasoline and Naphtha fraction of hydrocracking and hydrotreating refineries, suggesting 7% higher yields on North Sea crude when compared to hydroskimming refineries. Moreover, Varo writes that hydroskimming refineries yield approximately 32% Gasoline and Naphtha, 32% Middle Distillates, and 32% Heavy Distillates. In comparison, catalytic cracking refineries produce 45% Gasoline and Naphtha, 31% Middle Distillates, and 20% Heavy Distillates, and coking refineries 50% Gasoline and Naphtha, 36% Middle Distillates, and 15% Heavy Distillates.

Given that European refineries have increased their complexity, it is logical that the distillate yield would have moved more away from residual fuels and a greater propensity of lighter products. Looking at European product flows between 2000 and 2017, European gasoline exports increased by 41.41MM tonnes, whilst Naphtha imports increased by 5.4MM tonnes. In turn gasoil imports rose by 16.1MM tonnes and whilst both distillate and gasoline demand have risen, it is again logical that the improved complexity has mostly benefited gasoline production.

## 2. Evolving Crude Flows Have Led to a Lighter Feedstock Slate

Going back to the base case of 2000, crude and feedstock flow into Europe has developed such that the average crude slate is now markedly different. The key changes to structural crude inflow to European refiners have been the following:

### *i) US Crude Increases*

Once the ban on US exports was lifted in 2015, Europe very quickly became a reliable and consistent output for this new flow of crude. Over the last four years, exporters have been steadily increasing volume to Europe as export capacity grows, whilst import facilities have been built to accommodate consistent arrivals. The oil exported has been priced competitively given the disparity between WTI priced crudes and European, opening an arbitrage for crude traders to exploit. Despite a relative narrowing of the arbitrage margin in the last year, exports to Europe have nevertheless increased at a considerable rate, gaining a foothold in the market as a reliable source of light sweet oil. Approximately 850,000 b/d of US crude has moved across the Atlantic in H1-2019, huge volumes compared with 550,000 b/d for the whole of 2018 and 300,000 b/d in 2017. Most US crude exports are delivered as the grade WTI Midland, meeting a high-quality specification from shale oil fields. Given the shale oil production has moved away from independent producers to established oil companies, more and more of the new oil production is managed by companies that have ownership of the logistical chain, hence the export economics remain such that the grade can continue to be competitive with European substitutes produced locally. This is evidenced by trades in the Platts MOC e-window which have seen physical trades of WTI Midland deliverable on a DAP basis at discounts to Forties and Ekofisk despite superior quality.

### *ii) CPC Production Increase*

The CPC pipeline opened in 2001, transporting crude from multiple injection points across Kazakhstan, Russia and Ukraine to supply the European market. CPC blend is light sweet crude which has grown to become a structural flow into Europe in the last two decades. The CPC pipeline has been a conduit for supply growth in the region which is now supplying oil from the Giant Kashagan field which came online in 2016. Alongside the new oil field and expansion of the pipeline, there has been an increase in capacity to 1.45mbpd from 960kbpd in 2016*.

The API is light sweet and low sulphur, which therefore lends itself commonly as a blending crude for heavy crudes coming into the region such as Basrah Light.

*https://www.spglobal.com/platts/en/market-insights/videos/market-movers-europe/093019-saudi-oil-production-restored-europe-gas
https://www.azernews.az/region/125389.html

### *iii) Nigerian pointing Europe*

Over the past decade, Nigerian crude has shifted from facing US, Indian and Chinese refiners to face European refiners.

The US is a textbook example of a country that has lowered Nigerian imports, leaving more for European refiners. US shale oil and Nigerian crude slates are similar in nature. With the shale boom, a lot of US refineries have displaced Nigerian grades for local shale slates, cutting out logistical costs and time. This has caused a Nigerian crude oil imports to steadily decrease from 2017 to 2019. Additionally, the closure of the PES refinery, a large consumer of WAF, has left a hole in demand.

As exports into the US have been cut, the next outlets for Nigerian crude oils are India, China and Europe.

India has traditionally been a very important country for Nigeria. India became the largest export destination for Nigerian crude oil in 2013 when the US began using this own domestic shale supply. In the first quarter of 2019, India accounted for 16.43% of Nigeria's total export. Specifically, Nigeria exported crude oil worth N684 billion to the country in just one quarter. However, India have been moving away from Nigerian crude for cheaper Iraqi Basra crude. Hence, Europe will become ever more important for Nigerian crude outlets.

Nigeria exports approximately 700,000 b/d of crude to Europe. Nigerian crudes are not only light by API, but also by distillate yields; 'Bonny Light (one of the Nigerian crudes getting backed out of the Gulf Coast by rising domestic production) has kerosene (360–500°F cut) and diesel (500–650°F) yields at 20.8 per cent and 24.8 per cent respectively'. Spain is the second largest importer of Nigeria's crude oil, with The Netherlands and France in third and fifth place.

***iv) Libyan production***

Libya has the largest proven reserves of oil in Africa, and has been a key light, sweet crude supplier. Libya's oil production has normalised around 1.3mbpd although last year NOC outlined plans to raise production to 2.2mbpd, close to their 3mbpd production back in 1970. Their production is more consistent with fewer geopolitical tensions, as there were in 2011, surrounding their production. Although, as experienced in 2018, there are still supply disruptions, NOC's ability to bring production online quickly is to note.

**Distillation Yields**

Distillation yields of the crudes entering or being redirected to the European market are weighted to the lighter yielding products as shown by the straight run yields.

| | **Straight Run Weightings (%)** | | | | |
|---|---|---|---|---|---|
| **Product** | **WTI Midland (US Export Benchmark)** | **CPC** | **Es Sider (Libya)** | **Agbami (Nigerian Benchmark)** | **Urals (Heavy crude for reference)** |
| **C1 to C4** | | 4 | 2 | 5 | 3 |
| **Naphtha** | | 41 | 21 | 39 | 10 |
| **Kerosene** | | 11 | 9 | 11 | 8 |
| **Gasoil** | | 15 | 27 | 30 | 25 |
| **Atmospheric Residue** | | 29 | 41 | 15 | 47 |

The straight run yields do not reflect the estimated output as refineries even of relatively low complexity do more than run feedstock through a CDU. What they do show is the impact of the carbon chain being "lighter" or in other words shorter than the heavier counterparts.

As the above shows, the grades that have come into the Europe feedstock pool produce a lot of more lighter yielding products with the use of the distillation columns alone relative to the standard heavy feedstock (referenced to Urals as a benchmark heavy crude). In addition, it is not that the standard cut is proportionately higher of all products, rather weighted more to the extreme end of the barrel. This gives us justification to proportion product weightings towards gasoline, Naphtha and LPG rather than increasing the weighting on Kerosene and Gasoil.

## Conclusion

Marrying the increased complexity of European refiners alongside empirical data on product exports out of European refiners, it is clear there has been a shift in the benchmark European refiner to produce a lighter spectrum of products. In addition, all new production of crude that has entered the Europe and fed the European refinery market has been an undeniably light slate with an emphasis on gasoline, Naphtha and LPG production.

**Adjustments**

With the purpose of the Onyx Refinery Benchmark to accurately reflect current refinery output, it is logical to proportionately adjust the weightings to reflect the findings. In addition, as stated in the introduction, we want the Index to be a true reflection of what can be hedged using the oil derivative market. We there have considered basis risk (accuracy of hedge vs physical price) and liquidity constraints on execution.

1. ***Removal and Redistribution of Heavy Fuel Product Weighting***

In the EU Commission base case there is an average weighting of 13%. The improved complexity and lighter slate would suggest considerably less of heavy fuel produced and sold into the open market, whilst Europe remains a key exporter of residual fuel to Eastern markets. In addition, heavy fuels such as bitumen have no associated derivative and therefore retaining this in the calculation leaves a proportion of the Index that is not able to manage using the financial market.

50% of the Heavy fuel weighting will be redistributed to 3.5% and 0.5%. Given that the light crudes entering the market are also low sulphur, we have allocated 2/3 of the heavy fuel weighting to 0.5% & 1/3 to 3.5% fuel oil. The other 50% will be allocated up the distillation column evenly to Gasoline, Naphtha and LPG.

### 2. *Shift Distillate vs Gasoline Yield*

Given the light slate increase it is logical that the base case is underestimating yields of Gasoline. This is backed up by the import and export statistics of the two products as improved refinery structures shift yields lighter. Therefore, 20% of middle distillate yields (Gasoil and Jet) will be moved up the carbon chain into Gasoline, LPG, and Naphtha. This addition is distributed according to a rounded volume weighted average of the original European yields.

### 3. *Weighting of Swap Contracts for Final Price*

The aim of the index is firstly to reflect the output of refinery products which we have expressed through product weightings. The second aim is to ensure that the index can be hedged effectively, and the reference price is as close to an execution price as possible.

With the latter aim in mind, we have weighted the swaps contracts in order to best reflect hedge accuracy, which as well as assessing location must also have a factor of liquidity. The NWE Europe market is by far more liquid to the Med contract equivalent. E.g. NWE Naphtha has liquidity sourced from E/W, Naphtha cracks and Naphtha flat price whereas the Mediterranean price is typically implied from the NWE price plus a differential for Med vs. NWE known as the "Med-North". This differential is typically valued on a net back basis using a freight assessment for the physical route. Another important point is given Med contracts are less liquid than the NWE contracts, when evaluating basis (the value between a hedge at the settled physical price) the value given away by paying the Med bid/offer outweighs the hedge accuracy that embeds the freight differential. This being typical across the spectrum of the European swaps market, we will apply the same adjustment across the products

Factoring in the above, the price solution will be using NWE prices vs Med prices on a 65/35 weighting.

**Onyx Refinery Benchmark- Europe Final Yield**

| Product | Contract Name (ICE) | Contract Name (CME) | Yield | Conversion Ratio to barrel |
|---|---|---|---|---|
| LPG | Propane, Argus CIF ARA Future | European Propane CIF ARA (Argus) Futures | 6.00% | 12.4 |
| Naphtha | Naphtha CIF NWE Cargoes Future | European Naphtha Cargoes CIF NWE (Platts) Futures | 10.50% | 8.9 |
| Gasoline | Argus Eurobob Oxy FOB Rotterdam Barges Future | Gasoline Euro-bob Oxy NWE Barges (Argus) Futures | 31.00% | 8.33 |

| | | | | |
|---|---|---|---|---|
| Jet Fuel | Jet CIF NWE Cargoes Future | Jet Fuel Cargoes CIF NWE (Platts) BALMO Futures | 4.00% | 7.88 |
| Gasoil | ULSD 10ppm CIF NWE Cargoes Future | ULSD 10ppm Cargoes CIF NWE (Platts) Futures | 28.00% | 7.45 |
| HSFO | Fuel Oil 3.5% FOB Rotterdam Barges Future | European 3.5% Fuel Oil Barges FOB Rdam (Platts) Futures | 12.50% | 6.35 |
| LSFO | Fuel Oil 1% FOB NWE Cargoes Swap | European 1% Fuel Oil Cargoes FOB NWE (Platts) Futures | 4.00% | 6.35 |
| VLSFO | Marine Fuel 0.5% FOB Rotterdam Barges (Platts) Future | European FOB Rdam Marine Fuel 0.5% Barges (Platts) Futures | 4.00% | 6.35 |

These yields have been calculated using the above methodology and rounded to allow for effective trading and hedging.

# References:

AzerNews.az. (2019). CPC records growth in oil exports in 2017. [online] Available at: https://www.azernews.az/region/125389.html [Accessed 29 Oct. 2019].

Ejiofor Alike, "Nigeria's Oil Revenue Threatened As India Shifts To Alternative Market - THISDAYLIVE", *THISDAYLIVE*, 2019 <https://www.thisdaylive.com/index.php/2019/09/30/nigerias-oil-revenue-threatened-as-india-shifts-to-alternative-market/> [Accessed 21 October 2019].

Ejiofor Alike, "Nigeria Set For Highest Oil Exports To Europe", *Thisday*, 2019 <https://www.pressreader.com/> [Accessed 21 October 2019].

"First Delivered WTI Midland Crude Oil Cargo Trades In Platts Assessment Process | S&P Global Platts", Spglobal.Com, 2019 <https://www.spglobal.com/platts/en/market-insights/latest-news/oil/070219-first-delivered-wti-midland-crude-oil-cargo-trades-in-platts-assessment-process> [Accessed 21 October 2019].

"How Unstable Is Libya's Oil Production?", Reuters.Com, 2019 <https://www.reuters.com/article/us-libya-oil-explainer-idUSKBN1K61Y6> [Accessed 21 October 2019].

"Libya's Oil Corporation Warns Of Possible Fall In Oil Output Amid Disagreements With Gov't", *Globalsecurity.Org*, 2019 <https://www.globalsecurity.org/wmd/library/news/libya/2019/libya-191003-sputnik01.htm> [Accessed 21 October 2019].

Ruslan Lukach and others, *EU Petroleum Refining Fitness Check: Impact of EU Legislation on Sectoral Economic Performance*, JRC Science for Policy Report (European Commission, 2015) <https://core.ac.uk/download/pdf/38631408.pdf> [Accessed 21 October 2019].

"Net Imports Of Selected Petroleum Products, EU-28, In Selected Years, 1990-2017.Png - Statistics Explained", *Ec.Europa.Eu*, 2019 <https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:Net_imports_of_selected_petroleum_products,_EU-28,_in_selected_years,_1990-2017.png> [Accessed 21 October 2019].

Purvis and Gertz, *AN INTRODUCTION TO THE COMPLEXITY OF REFINERY BUSINESS INTERRUPTION*, 2009 <http://www.oilpera.com/download/i/mark_dl/u/4008959274/4545337892/> [Accessed 21 October 2019].

"Refinery Rankings | Stratas Advisors", *Stratasadvisors.Com*, 2019 <https://stratasadvisors.com/Insights/042617-Refinery-Rankings> [Accessed 21 October 2019].

Amrita Sen, *US Tight Oils: Prospects And Implications* (Oxford: The Oxford Institute for Energy Studies, 2019) <https://www.oxfordenergy.org/wpcms/wp-content/uploads/2013/10/WPM-51.pdf?v=7516fd43adaa> [Accessed 21 October 2019].

Spglobal.com. (2019). Market Movers Europe, Sep 30-Oct 4: Saudi oil production fully restored as Europe is awash with gas | S&P Global Platts. [online] Available at: https://www.spglobal.com/platts/en/market-insights/videos/market-movers-europe/093019-saudi-oil-production-restored-europe-gas [Accessed 29 Oct. 2019].

"Top Trading Partners For Nigeria's Exports And Imports In 2019 |", *Nairametrics*, 2019 <https://nairametrics.com/2019/08/12/top-trading-partners-for-nigerias-exports-and-imports-in-2019/> [Accessed 21 October 2019].

Valero, *Basics of Refining and Optimization* (Valero, 2015) <https://www.valero.com/en-us/Documents/Operations/2015+Barclays+Teach-In+FINAL+2-3-2015.pdf> [Accessed 21 October 2019].

"WTI to Play Increasing Role in European Benchmarking", *Argusmedia.Com*, 2019 <https://www.argusmedia.com/en/news/1965000-wti-to-play-increasing-role-in-european-benchmarking> [Accessed 21 October 2019].

# Disclaimer