International Energy Agency

Oil Market Report

Methodology Notes

Oil Industry and Markets Division

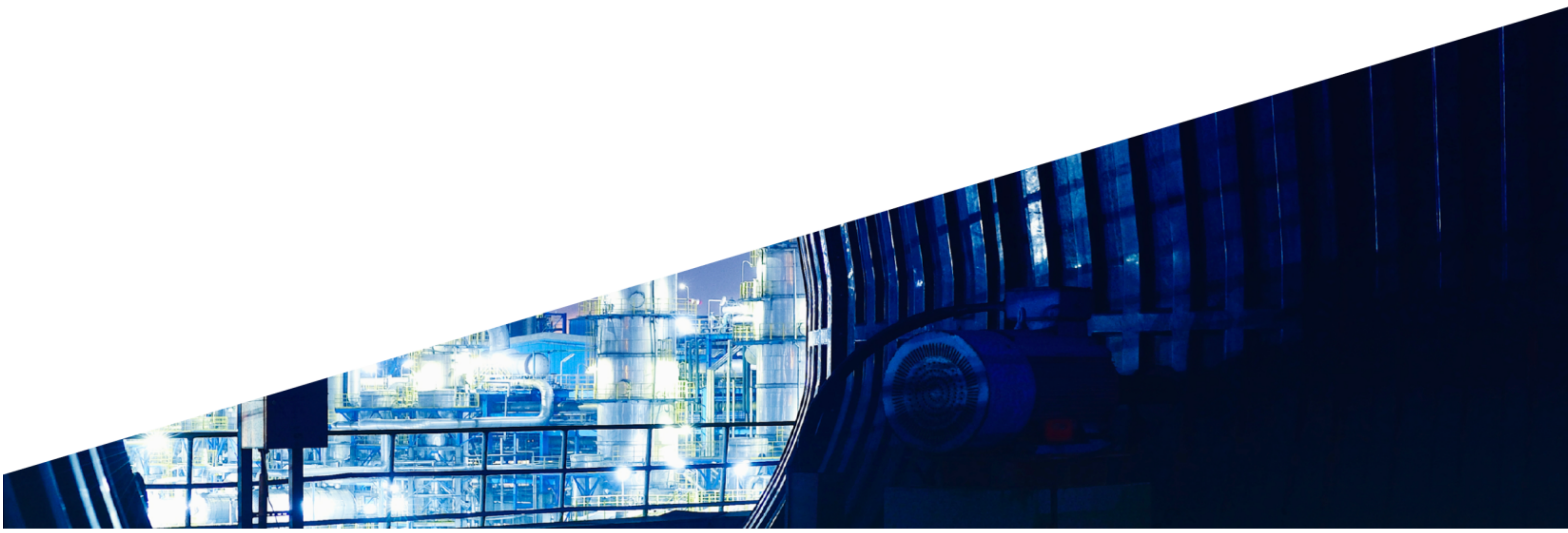
July 2022

The Oil Industry and Markets Division of the International Energy Agency has published refinery margins since June 1992 in its monthly *Oil Market Report*. This note details our new methodology for calculating refinery margins starting from July 2022.

Historical margins are available to subscribers on http://www.oilmarketreport.org/refinerysp.asp

Comments and suggestions are welcome and will be considered. Please contact http://www.oilmarketreport.org/contacts.asp

In the event of significant changes to our assumptions and methodology this note will be updated and replaced by a new document.



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Introduction

The Oil Industry and Markets Division of the International Energy Agency has published refinery margins since June 1992 in its monthly Oil Market Report. This note details our new methodology that aims to better reflect the evolution of refinery crude diet, yields and crude oil and product pricing observed in recent years. In addition, hydrogen and emission allowance costs are included, where applicable, as well as integrated petrochemical margins for two hubs.

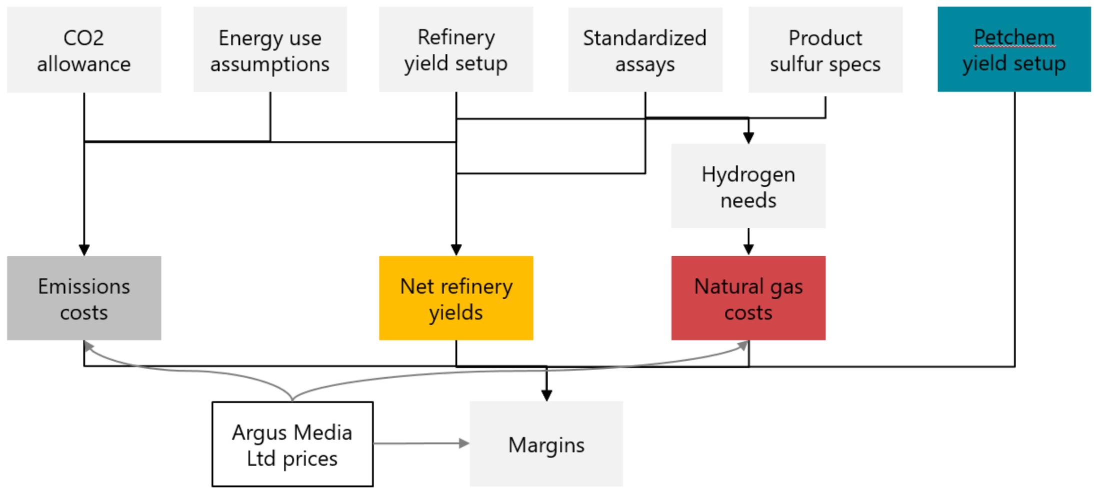
IEA refinery margins remain strictly indicative, however, and do not include the full spectrum of energy costs (purchased steam, electricity, etc) as well as other non-energy variable costs (such as chemicals or catalysts) or capital expenditures.

Main changes:

- Using observed as opposed to simulated refinery yields to calculate refinery margins.
- Introduction of petrochemical component for NW Europe and Singapore cracking margins.
- Inclusion of emission allowance costs for NW Europe and Mediterranean refining hubs.
- Inclusion of hydrogen costs.
- Changes to product and crude oil price quotes.

These margins should be referenced as IEA Global Indicator Refinery Margins. On the charts and tables, referenced in IEA publications, the source should be identified as IEA/Argus Media Ltd prices.

Figure 1. IEA refinery margins calculation workflow



Refining hubs

Since the publication of the previous update to the IEA refinery margins methodology in 2011, there have been major geographical changes to the global refining system. Between 2011 and 2022, crude throughputs in the Atlantic Basin have fallen by 1.4 mb/d while for East of Suez they have increased by 7 mb/d. Throughputs in the Atlantic Basin are still 1.5 mb/d higher than in the East of Suez, but this gap has shrunk from 11 mb/d in 2011.

Nevertheless, the most liquid product trading hubs and well-established price assessments continue to be limited mostly to the Atlantic Basin, in addition to having no or only minimal regulatory constraints such as import and export quotas and taxes. For now, the IEA will continue assessing refinery margins for five regions, including only Singapore from East of Suez refining hubs.

- Northwest Europe
- Mediterranean Europe
- US Gulf Coast
- US Midcontinent
- Singapore

Refinery configuration and product yields

Two to three types of refinery configurations are selected per region, based on the characteristics of existing refinery capacity. For example, coking facilities are not very common in Northwest Europe, while hydroskimming refineries are rare in the US.

Refinery configuration by region

	Hydroskimming	Cracking/ Hydrocracking	Coking	Petrochemical component
NW Europe	X	X		X
Mediterranean	X	X		
US Gulf Coast		X	X	
US Midcontinent		X	X	
Singapore		X		X

The new methodology is diverting from software-simulated refinery yields where the specified configuration and crude grade drive the outputs. The primary purpose of these models is in crude trading or refinery operations planning. Our main purpose is to track a hypothetical average refinery, based on prevailing crude diets and typical product outputs in each refining centre. Yields take into account both long-term structural changes and the impact on demand and refinery operations/product configurations and will be reassessed on an annual basis.

In addition to long-term structural changes, the Covid-19 pandemic has had a major impact on various sectors of oil consumption and affected refinery throughputs and product configuration. Fixed refinery yields are less fit to capture margins developments since the start of the Covid-19 pandemic. However, while we can observe refinery yield changes on a monthly basis, it is not practical to change yield sets frequently. We will reassess refinery yields once a year until jet and diesel yields stabilise.

Hydroskimming yields are based on publicly available crude oil assays. Northwest Europe and Mediterranean cracking/hydrocracking refinery yields are based on refinery input and output data from the IEA's Monthly Oil Statistics, with adjustments for sweet and sour crude grades. Singapore refinery margins are based on average yield statistics for several Asian countries, where reliable datasets are available. US hubs refinery yields are based on *EIA* data for the following refining districts:

- Texas Inland
- Louisiana Gulf Coast

- Texas Gulf Coast
- Oklahoma/Kansas/Missouri
- Indiana, Illinois, Kentucky.

Observed product yields are simplified to inlcude only major traded products.

Refining crude oil usually results in a volumetric expansion as products coming out of the process, and in general, products used in various sectors, tend to be lighter than crude oil. It also results in losses as sulphur, hydrogen, and other non-hydrocarbon gases, water, and various impurities are removed in the refining process. We use the difference in densities of a standard product basket and the given crude oil type to calculate the volumetric expansion. Calculated values of sulphur removed are used to estimate processing losses.

For US refineries, we assume a neutral standing with regards to the renewable fuel obligations. This means that an average US refinery is assumed netither to have a deficit nor excess of Renewable Identification Numbers.

The yield table is available below.

Crude grades

Instead of tying refinery margin calculations to a specific grade, our new methodology is based on types of crude. We consider light sweet, medium sour and heavy sour grades, which may be a chronological composite of several crude grades that reflect evolving crude oil supply and trade dynamics. For example, Singapore light sweet grade is composed of Tapis quotes until mid-2019 and then replaced by WTI quotes on a cost and freight (CFR) Singapore basis. We have similar developments in product prices where, for example, different diesel or gasoil quotes are concatenated to form a continuous time series of diesel prices. Our crude oil, refined products, freight and natural gas composite price series have been developed in consultation with leading energy and commodity price reporting agency Argus, our market data provider.

Crude types with respective grades	
NWE light sweet	North Sea Dated
NWE medium sour	Urals
MED light sweet*	Saharan Blend
MED medium sour*	Basrah Medium
USGC light sweet	WTI
USGC medium sour	Mars
USGC heavy sour*	WCS
USMC light sweet	WTI
USMC heavy sour*	WCS
Singapore light sweet*	WTI
Singapore medium sour	Dubai
Singapore heavy sour*	Basrah Heavy

*Composite types, preceded by one or more other crude quotes

Energy use

A significant change compared to our previous methodology is the treatment of energy costs. Now they are explicitly calculated from refinery fuel use whereas previously they were assumed in processing losses. Assumptions for energy use are based on average refinery own use, derived from the IEA's *World Energy Balances*, and adjusted for different configurations and crude types. Energy use only includes oil products used as fuel and does not include losses. Furthermore, it does not emulate costs of purchased energy such as electricity, heat, steam or natural gas for energy use.

Margin type	Energy use*
NW Europe light sweet hydroskimming	3.00%
NW Europe light sweet cracking	4.00%
NW Europe medium sour cracking	4.25%
Mediterranean light sweet hydroskimming	3.00%
Mediterranean light sweet cracking	4.00%
Mediterranean medium sour cracking	4.25%
USGC light sweet cracking	4.00%
USGC medium sour cracking	4.25%
USGC heavy sour coking	6.00%
USMC light sweet cracking	4.00%
USMC heavy sour coking	6.00%
Singapore light sweet cracking	4.00%
Singapore medium sour cracking	4.25%

*% in energy terms

Hydrogen costs

We model hydrogen requirements by crude type and refinery configuration. By-product hydrogen from reformer and naphtha cracker units is taken into account as "free" hydrogen supply. The residual hydrogen needs are modelled as production from steam methane reformers, using natural gas as a feedstock. The hydrogen cost used in the refinery margin calculations includes only the natural gas feedstock costs. Our light sweet hydroskimming and cracking margin models show no need for on-purpose hydrogen production, with the by-product hydrogen sufficient to cover the relatively modest requirements (compared to medium-sour cracking).

Figure 2. Hydrogen cost modelling (per barrel of crude oil processed)

Margin type	Total H_2 demand (kg)	H_2 supply reformer (kg)	H_2 supply petchem (kg)	Remaining H_2 demand (kg)	Natural gas demand (mmbtu)
NW Europe light sweet hydroskimming	0.1	0.4	-	0.0	0.00
NW Europe light sweet cracking	0.3	0.3	-	0.0	0.00
NW Europe light sweet cracking + Petchem	0.3	0.3	0.2	0.0	0.00
NW Europe medium sour cracking	1.1	0.1	-	1.0	0.15
NW Europe medium sour cracking + Petchem	1.1	0.1	0.2	0.9	0.12
Mediterranean light sweet hydroskimming	0.1	0.3	-	0.0	0.00
Mediterranean light sweet cracking	0.3	0.3	-	0.0	0.00
Mediterranean medium sour cracking	1.1	0.2	-	1.0	0.14
USGC light sweet cracking	0.1	0.6	-	0.0	0.00
USGC medium sour cracking	1.7	0.3	-	1.4	0.20
USGC heavy sour coking	3.0	0.2	-	2.8	0.40
USMC light sweet cracking	0.1	0.6	-	0.0	0.00
USMC heavy sour coking	2.7	0.2	-	2.5	0.36
Singapore light sweet cracking	0.1	0.4	-	0.0	0.00
Singapore light sweet cracking + Petchem	0.1	0.4	0.2	0.0	0.00
Singapore medium sour cracking	1.0	0.2	-	0.9	0.12
Singapore medium sour cracking + Petchem	1.0	0.2	0.2	0.7	0.10

Emission costs

Carbon dioxide emissions from hydrogen production are aggregated with the emissions from refinery energy consumption and used as the basis for calculating refinery emission allowance costs for the Northwest Europe and Mediterranean refining hubs. The European Environment Agency's (EEA) emissions trading data are used for historical calculations. We model 2022 emissions and free allocations based on our throughput forecast and 2021 emissions intensity. This will be updated for 2022 after the EEA publishes the data in 2Q23.

Margin type	CO2 emissions (kg/bbl)
NW Europe light sweet hydroskimming	7
NW Europe light sweet cracking	14
NW Europe medium sour cracking	26
Mediterranean light sweet hydroskimming	7
Mediterranean light sweet cracking	15
Mediterranean medium sour cracking	25
USGC light sweet cracking	16
USGC medium sour cracking	27
USGC heavy sour coking	56
USMC light sweet cracking	14
USMC heavy sour coking	53
Singapore light sweet cracking	14
Singapore medium sour cracking	25

The following table summarises final yields used for margin calculations and natural gas and emission cost parameters.

IEA Global Indicator Refinery Margin Yields and Cost Parameters 2022

	LPG	Naphtha	Gasoline	Jet/Kero	Diesel	Heat Oil	LSFO	HSFO	Petcoke	Total*	Natural gas**	CO_2 emissions***
NW Europe												
Light sweet hydroskimming	3.0%	10.0%	20.5%	12.0%	20.0%	5.0%	28.5%	0.0%	0.0%	99.3%	0.00	2.13
Light sweet cracking	4.9%	14.0%	21.5%	8.5%	28.5%	12.2%	10.0%	0.0%	0.0%	99.6%	0.00	4.27
Medium sour cracking	5.7%	13.6%	21.3%	7.3%	32.3%	14.0%	0.0%	9.8%	0.0%	104.1%	0.15	7.88
Mediterranean												
Light sweet hydroskimming	3.6%	6.1%	14.8%	10.1%	30.7%	0.1%	34.3%	0.0%	0.0%	99.8%	0.00	2.14
Light sweet cracking	4.2%	8.5%	20.7%	11.7%	27.2%	16.4%	12.4%	0.0%	0.0%	101.2%	0.00	4.51
Medium sour cracking	4.8%	9.5%	21.3%	9.3%	29.3%	17.2%	0.0%	12.8%	0.0%	104.3%	0.14	7.65
US Gulf Coast												
Light sweet cracking	3.5%	1.2%	54.2%	7.2%	25.2%	5.2%	0.0%	0.0%	0.0%	96.7%	0.00	-
Medium sour cracking	5.8%	4.0%	45.2%	11.6%	28.2%	4.2%	0.0%	5.4%	0.0%	104.4%	0.20	-
Heavy sour coking	7.0%	6.0%	46.2%	11.0%	28.6%	6.6%	0.0%	0.0%	3.0%	108.6%	0.40	-
US Midwest												
Light sweet cracking	2.7%	0.2%	51.2%	3.7%	34.7%	5.2%	0.0%	0.0%	0.0%	97.7%	0.00	-
Heavy sour coking	5.7%	3.2%	54.9%	10.3%	23.9%	5.9%	0.0%	2.5%	3.1%	109.5%	0.36	-
Singapore												
Light sweet cracking	5.2%	13.4%	24.1%	11.1%	18.1%	14.3%	11.3%	0.0%	0.0%	97.7%	0.00	-
Medium sour cracking	6.3%	13.3%	23.2%	12.2%	21.2%	15.2%	0.0%	12.1%	0.0%	103.5%	0.12	-
Heavy sour coking	6.7%	8.7%	28.0%	12.0%	25.0%	14.4%	0.0%	5.4%	4.3%	104.5%	-0.35	-

*Net yields after processing gains and losses of oil used for energy. ** Natural gas used for hydrogen production, in mmbtu. *** CO_2 missing allowances in kg, applicable only to European margins

Petrochemical margins

To quantify the contribution from integrated petrochemical operations, we have introduced a simplified petrochemical margin component for Northwest Europe and Singapore. It assumes that naphtha produced in the refinery is used as feedstock in an integrated cracker (except for volumes diverted to gasoline production). By-product hydrogen is accounted for as "free" hydrogen supply for refinery uses and is reflected in savings on natural gas purchases for petrochemically-integrated refineries.

Figure 3. Petrochemical margin components