International Energy Agency

Oil Market Report

Methodology Notes

Oil Industry and Markets Division

August 2024

Contents

Introduction (updated)

The Oil Industry and Markets Division of the International Energy Agency has published refinery margins since June 1992 in its monthly Oil Market Report. In 2022, the IEA refining margins calculation was revised (Methodology 2022) to provide an indicative site average margin based on three criteria:

- Geography, namely: Mediterranean, North West Europe, Singapore, the US Gulf Coast, and the US Midcontinent

- Crude processed: selection based on typical regional crude slate, accessibility, API and sulphur composition

- Refinery complexity profile: Hydroskimming, catalytic cracking, coking and petrochemicals integration

This note details the new August 2024 methodology (Figure 1) that integrates:

- the utility costs on top of the existing calculation such as natural gas, refinery fuel gas, LPG, fuel oil, electricity, petroleum coke, imported steam
- a new yield structure based on empirical data
- some prices adjustments

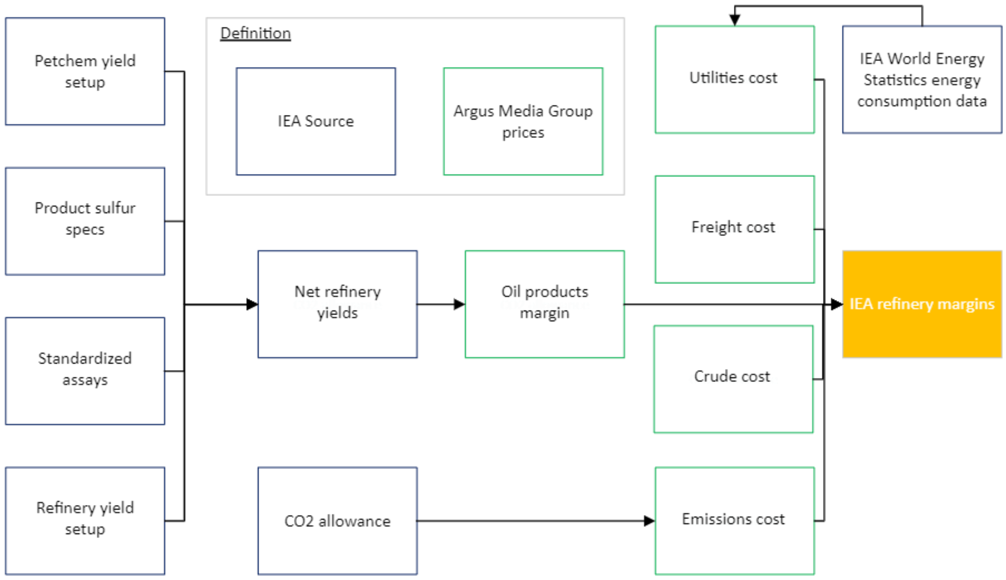
To avoid double counting, initial energy use assumptions and hydrogen needs calculations have been removed from the new process. The objective is to provide a more realistic refining margin driven by the commodity market.

In order to get the utilities data, the source that has been chosen is the IEA World Energy Statistics. This country-level dataset is calculated from the annual submission by the OECD members. It contains the throughput and the consumption of all types of energy quoted above on a country level.

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

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 Group prices.

Figure 1: IEA refinery margins calculation workflow



Refining hubs

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 (updated)

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

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.

Initially, the methodology was diverting from software-simulated refinery yields where the specified configuration and crude grade drive the outputs. The methodology now implements some empirical features to calculate the yields. For some regions, the yields are now adjusted depending on the available data. For instance, USGC and USMC yields are obtained from U.S. Energy Information Administration (EIA) publications. 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.

Observed product yields are simplified to include 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 neither to have a deficit nor excess of Renewable Identification Numbers.

The yield table is available below.

Crude grades (updated)

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	Argus Brent Sour
MED light sweet*	Saharan Blend
MED medium sour*	Basrah Medium
USGC light sweet	WTI
USGC medium sour	Mars
USGC heavy sour*	WCS

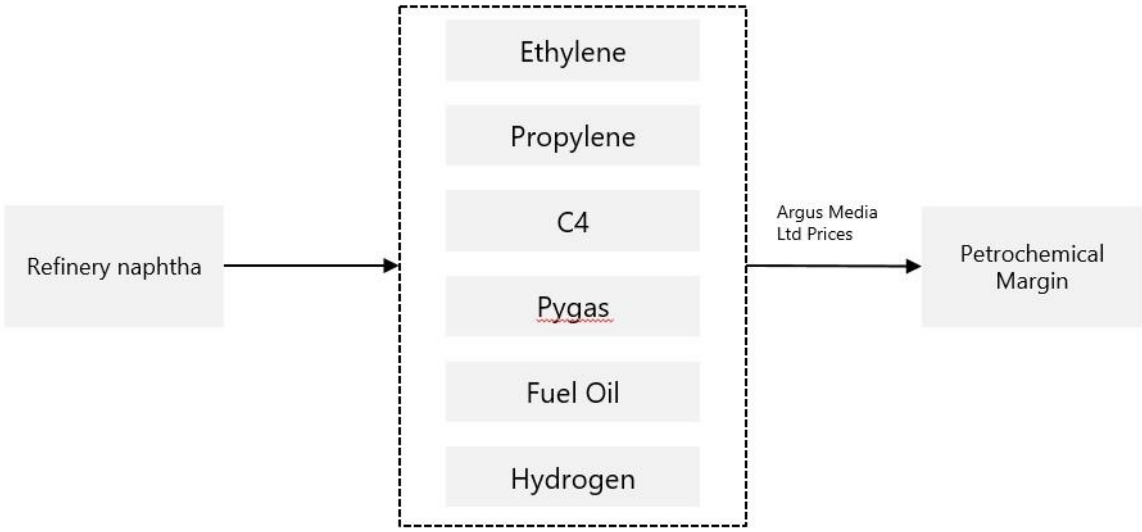
USMC light sweet	WTI
USMC heavy sour*	WCS
Singapore light sweet*	WTI
Singapore medium sour	Dubai
Singapore heavy sour*	Basrah Heavy

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

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



Emission costs (updated)

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

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

IEA Global Indicator Refinery Margin Yields and Cost Parameters 2023

	LPG	Naphtha	Gasoline	Jet/Kero	Diesel	Heat Oil	LSFO	HSFO	Petcoke	Total
NW Europe										
Light sweet hydroskimming	6.0%	7.0%	20.0%	12.0%	20.0%	7.0%	28.0%	0.0%	0.0%	100.0%
Light sweet cracking	7.0%	6.0%	28.0%	12.0%	28.0%	7.0%	14.0%	0.0%	0.0%	102.0%
Medium sour cracking	7.0%	8.0%	23.0%	7.7%	25.0%	14.3%	0.0%	17.0%	0.0%	102.0%
Mediterranean										
Light sweet hydroskimming	3.6%	6.1%	14.8%	10.1%	30.7%	0.1%	34.5%	0.0%	0.0%	100.0%
Light sweet cracking	4.2%	8.5%	20.7%	11.7%	27.2%	16.4%	12.4%	0.0%	0.0%	101.2%
Medium sour cracking	7.0%	8.0%	21.3%	8.0%	26.3%	14.3%	0.0%	17.0%	0.0%	101.9%
US Gulf Coast										
Light sweet cracking	7.0%	4.0%	44.0%	10.0%	25.2%	5.2%	4.5%	2.0%	0.0%	102.0%
Medium sour cracking	7.0%	3.9%	41.7%	7.0%	27.3%	6.3%	0.0%	7.4%	0.0%	100.7%
Heavy sour coking	10.0%	0.0%	43.0%	10.0%	30.0%	3.0%	0.0%	0.0%	8.0%	104.0%
US Midwest										
Light sweet cracking	10.0%	1.0%	47.6%	6.0%	25.7%	3.7%	8.0%	0.0%	0.0%	102.0%
Heavy sour coking	7.0%	0.0%	50.0%	7.0%	24.9%	4.6%	0.0%	0.0%	10.0%	103.5%
Singapore										
Light sweet cracking	5.6%	15.4%	26.1%	11.1%	18.1%	14.3%	11.3%	0.0%	0.0%	102.0%
Medium sour cracking	6.3%	13.3%	23.2%	12.2%	19.2%	13.2%	0.0%	14.1%	0.0%	101.5%
Heavy sour coking	7.0%	8.7%	28.0%	12.0%	27.0%	14.4%	0.0%	0.0%	7.0%	104.1%

Energy consumption costs (updated)

In the new methodology, the utility consumption costs are now included in the refinery margin calculation.

The marginal impact of energy costs over the refinery's gross margin is driven by:

- The average energy consumption by barrel of crude processed
- The regional daily price by utility

Given that the World Energy Statistics granularity is based on a country level, a list of selected representative countries (figure below) has been chosen to get the Marginal Energy Consumption (MJ/bl of crude processed) by region.

National data used as the basis for modelling refinery energy costs					
	Northwest Europe	Mediterranean	Singapore	US Gulf Coast	US Midcontinent
Hydroskimming	Ireland	Ireland	Korea	N/A	N/A
Catalytic Cracking	France/Germany/ Belgium/Netherlands/ Finland	Italy/Greece/ Turkiye/Hungary/ Spain	Korea	US	US
Coking	N/A	Hungary	Korea	US	US

Source: IEA World Energy Statistics.

The selection by country is based on the number of available refineries, their configuration and their location. For example, Ireland is one of the only European countries in the OECD that possesses one refinery that is configured as hydroskimming (HSK). This is why it is used for NWE HSK and MED HSK utility costs calculation. In the meantime, Hungary is also a particular case where the only operational refinery uses a Delayed Coker.

Once the countries are selected by region, a weighted average is calculated to get the marginal consumption by energy in MJ by barrel of crude processed (table below).

Marginal Energy Consumption by region (MJ/bl of crude processed)				
Energy \ Region	NWE	MED	SING	US
NATGAS	56.6	92.0	62.0	187.9
FUEL GAS	206.9	247.2	179.7	114.9
ETHANE	0.0	0.0	0.0	0.0
LPG	11.1	12.7	3.5	1.1
FUEL OIL	14.3	16.4	3.0	0.0
ELECTRICITY	28.2	31.9	49.0	32.5
PETCOKE	27.6	29.3	9.7	60.1
IMPORTED STEAM	11.0	4.0	1.2	9.2
TOTAL	**355.8**	**433.5**	**308.1**	**405.8**

Source: IEA World Energy Statistics 2022 data

The first step is to get the marginal consumption by energy, the second step is to choose an adequate price for each utility (table below). Most of the prices come from Argus Media Group, the few exceptions that are provided by Bloomberg concern prices that are not available from 2010 to 2020.

Mapping between energy type and selected price					
Energy type	Price type	NWE	MED	SING	US
Natural Gas	Natural Gas	TTF	PVB	LNG Northeast Asia	Nymex
Fuel Gas	LPG	Propane coaster NWE	Propane coaster MED	Propane Argus far east	Propane Mt Belvieu LST
LPG	LPG	Propane coaster NWE	Propane coaster MED	Propane Argus far east	Propane Mt Belvieu LST
Fuel Oil	HSFO	3.5%S 380cst cargo NWE	3.5%S 380cst cargo W MED	Fuel oil 3.5%S 380cst cargo SING	3.0%S barge USGC
Petcoke	Petcoke	x	PetCoke Turkey 5.5%S	PetCoke India 4.5%S	PetCoke USGC 6.5%S
Electricity	Electricity	French OTC	Spanish OTC	JEPX	Power PJM West
Imported Steam	Natural Gas	TTF	PVB	LNG Northeast Asia	Nymex

Source: Argus Media Group, Bloomberg

Once the marginal consumption by energy and the prices are obtained, the Total Marginal Energy Cost by country is calculated following the mathematical relationship:

$$Total\ Marginal\ Energy\ Cost_x\ (US\$/bl) = \frac{\sum(Energy\ consumption_{i,x}(MJ) \times Energy\ Price_{i,x}\ (US\$/MJ))}{Throughput_x(bl)}$$

With x country, i the type of energy.

The main advantage of this methodology resides in the quality of the dataset. The IEA spends a lot of time and resources on the data consolidation in order to provide the World Energy Statistics. Also, the dataset is based on data provided by the OECD members which makes this approach empirical and not theoretical anymore.

However, a few downsides remain in this methodology:

- The granularity is by year and the last data available is often two years before publication
- There are approximative assumptions as it is based on a country level. The pool by country implies that many refineries with different configurations, crude assays, locations and markets are in the same bucket. Which means that two different refinery configurations can have the same marginal energy cost despite the different operational conditions, crude processed or market shared. It can result in an energy cost overestimation
- The lack of information regarding the natural gas required for hydrogen production via steam methane reforming for some countries. This part will be improved with the IEA's Energy Data Centre in order to clarify what is behind the natural gas energy flow

Refinery margin calculation (updated)

Once the yields, the prices and all the costs related obtained (Figure 1), the refinery margin is calculated as followed:

$$\begin{aligned} Refinery\ margin_{x,\ y,\ z} &= \sum (Yield_{\ i,x,y,z} \times Price_{\ i,x,y,z}) - Crude\ Price_{x,y} - Freight\ Cost_{\ x,y} \\ &- CO2tax_{x,y,z} - Total\ Marginal\ Energy\ Cost_x \end{aligned}$$

With x geography, y crude, z profile and i product.

Changes compared to July 2022 model (updated)

What changed compared to July 2022 model is the:

- Addition of the marginal energy cost
- Revision of the yields structure based on an empirical approach
- Substitution of some prices that were considered outdated or not adapted to the market

Each region's sensitivity responded differently to the three main changes.
The energy assessment underlines the disparities between the different region of the globe (see table below). Northwest Europe, Mediterranean basin and Singapore see the largest impact to margins, given that energy costs are higher here. Furthermore, this change in the methodology underscores the significant cost advantage that the USA enjoys over the rest of the regions, given that natural gas and LPG are significantly cheaper.

Marginal Energy Cost of a Medium Sour FCC profile by region ($/bl of crude processed)				
Energy \ Region	**NWE**	**MED**	**SING**	**US**
NATGAS	0.51	0.81	0.59	0.35
FUEL GAS	1.88	2.37	1.84	0.69
ETHANE	0.00	0.00	0.00	0.00
LPG	0.10	0.12	0.04	0.01
FUEL OIL	0.11	0.12	0.02	0.00
ELECTRICITY	0.85	0.73	1.04	0.19
PETCOKE	0.09	0.09	0.03	0.13
IMPORTED STEAM	0.10	0.04	0.01	0.02
TOTAL	**3.63**	**4.29**	**3.57**	**1.39**

Source: IEA Monthly Oil Statistics, IEA World Energy Statistics, EIA, Argus Media Group

The next table shows the difference of margins between the former methodology and the new one. For NWE, MED and SING most of the difference is explained by the marginal energy cost subtraction.

Regarding the US, the revision of the yields has a substantial impact on the USGC and USMC margins. The yields are now aligned with EIA publications which pulls the margins down. The biggest contributor is the Gasoline yield that was higher than the US Gulf Coast and Mid Continent yearly average.

IEA Margins New VS Old differential (Left) and New Margin (Right)														
$/bbl	**2021**		**2022**		**2023**		**4Q23**		**1Q24**		**2Q24**		**Jul 24**	
NW Europe	**Diff**	**New**	**Diff**	**New**	**Diff**	**New**	**Diff**	**New**	**Diff**	**New**	**Diff**	**New**	**Diff**	**New**
Light sweet hydroskimming	-2.32	0.21	-2.80	7.26	-2.25	5.57	-2.17	4.14	-2.25	4.63	-2.25	1.83	-2.45	0.57
Light sweet cracking	-3.61	-0.10	-6.91	9.32	-2.62	9.19	-2.91	7.50	-2.29	8.71	-1.41	5.79	-2.01	3.87
Light sweet cracking + Petchem	-2.03	4.52	-7.61	10.83	-2.96	8.90	-3.27	7.41	-2.31	8.92	-1.41	6.17	-1.66	3.98
Medium sour cracking	-6.49	-0.38	-9.13	30.00	-9.91	7.65	-10.20	6.84	-10.02	8.44	-8.55	4.31	-8.71	2.95
Mediumsour cracking + Petchem	-1.47	7.60	-3.48	37.80	-4.85	12.76	-5.21	12.10	-4.77	13.93	-3.31	9.92	-3.36	8.07
Mediterranean														
Light sweet hydroskimming	-2.26	0.64	-3.18	5.91	-2.49	5.68	-2.38	4.03	-2.30	4.60	-1.95	2.71	-2.33	1.05
Light sweet cracking	-7.40	-2.44	-9.46	7.35	-5.84	8.12	-5.68	6.07	-4.93	7.33	-4.34	5.17	-4.88	2.75
Medium sour cracking	-8.34	-2.66	-11.58	10.08	-10.69	6.64	-10.15	4.55	-10.59	7.79	-8.81	3.43	-8.62	2.39
US Gulf Coast														
Light sweet cracking	-2.89	8.15	-4.56	22.08	-3.65	16.82	-1.28	10.16	-1.29	15.41	-1.55	10.86	-1.33	11.08
Medium sour cracking	-8.13	7.66	-12.38	23.31	-10.30	16.18	-8.61	9.67	-8.68	14.59	-7.89	9.38	-7.58	10.65
Heavy sour coking	-9.68	10.30	-14.50	31.42	-11.87	22.74	-10.57	15.78	-10.96	20.26	-10.56	14.93	-11.67	15.76
US Midwest														
Light sweet cracking	-0.39	11.94	-4.34	25.56	-2.77	16.75	-2.22	8.20	-3.37	14.68	-5.26	14.27	-6.23	16.75
Heavy sour coking	-11.98	14.03	-16.50	34.11	-14.42	22.18	-14.03	13.05	-17.19	17.95	-18.59	18.28	-19.72	22.65
Singapore														
Light sweet cracking	-2.89	0.21	-2.48	8.99	-1.29	5.97	-1.52	5.21	-0.52	6.90	-0.56	1.79	-1.16	1.78
Light sweet cracking + Petchem	-2.67	2.14	-2.07	10.87	-0.92	7.15	-1.13	6.22	-0.26	7.63	-0.32	2.28	-0.92	2.08
Medium sour cracking	-5.60	-1.68	-6.16	6.65	-5.88	3.14	-5.94	1.85	-5.67	4.35	-5.15	-0.33	-5.52	0.73
Medium sour cracking + Petchem	-3.33	2.29	-1.97	12.30	-2.68	7.14	-2.73	5.66	-2.52	7.95	-2.36	2.71	-2.76	3.55

Source: IEA analysis based on price assessments from Argus Media Group.

Another contributor to the US margins reduction is the revision of some prices. The prices have been changed to better reflect the biggest amount of sells among USGC and USMC markets. Here is the list of what changed:

- Gasoline 87 conventional Colonial M pipe to Gasoline 87 conventional USGC Waterborne
- Diesel ULSD Colonial 61 pipe to Diesel ULSD 62 USGC Waterborne
- Gasoline 89 premium to Gasoline 87 conventional USMC

On the other side of the Atlantic, as showed in the Table 15 MED Medium Sour FCC is the refinery profile that has been the most impacted among MED, NWE and SING regions. This significant difference is explained by the changing of crude and consequently the freight:

- Argus Brent Sour to Basrah Medium for MED Medium Sour
- Basrah Medium to Basrah Heavy for MED Heavy sour