



# Crude oil refining

**How is crude oil turned into a commercially viable fuel for the world's industries?**



### What is crude oil refining?

Crude oil is a mixture of various hydrocarbons and elements such as nitrogen, oxygen or sulphur,

depending on its source.

Refineries work by taking crude, filtering out contaminants and separating the crude into light and heavy compounds. The lightest fuels have two to four carbon atoms in their hydrocarbon chains, the heaviest have over 20.

Refining also alters the oil's chemical properties, often by shortening hydrocarbon chains to create lighter oils.

### Why do we refine crude oil?

Refining the oil removes traces of volatile materials that are harmful to machinery, such as salt and dissolved gases, or those that are damaging to the environment, such as sulphur. Sulphur content will become increasingly important as the International Maritime Organization sulphur fuel cap comes into effect in 2020.

Fuel requirements also differ between industries. For example, aviation prefers lighter fuels, as it requires fuels with higher specific energy, whereas deep sea cargo ships typically burn heavier bunker fuel. Refining can tailor crude output to supply such industries.

### What kind of products can a barrel of crude provide?

The products of crude oil range from light gaseous fuels, such as propane and butane, to heavy by-products such as asphalt and coke.

Between these extremes, bunker oil, lubricants and diesel sit on the heavier side of the spectrum. Kerosene, jet fuel and gasoline are lighter.

The proportion of fuels extracted from a single barrel of crude is highly reliant on where the crude comes from.

That said, the US Energy Information Administration estimated in 2017 that, after refining, the average 42 gallon barrel of US crude produces was 42% gasoline,

28% distillate fuel, mostly diesel fuel, 10% kerosene-type jet fuel, 4% gas liquids and 4% still gas. The remaining 12% is made up of many other products in small amounts, such as fuel oil, coke, asphalt oil, waxes and lubricants.

### What is the first stage of crude oil refining?

Most refining techniques start with crude distillation unit (CDU) refining, whereby crude is heated to separate it into its different component substances.

The crude is initially heated to 100–137°C then passed through a desalter to remove salt crystals that can damage sensitive machinery. Following desalination, the crude is heated to over 350°C and separated into heavier and lighter material. The process commonly produces gas vapours, diesel, naphtha, kerosene, gas oils and residuum.

The gas vapours are used to produce liquefied petroleum gases such as butane and propane. The residuum is used to produce industrial oils, or oil solids such as asphalt.

For its part, the naphtha is passed through a reformer and turned into gasoline, while gas oils are cracked down to produce lighter oils.

### How are naphtha and gas oil further refined after CDU?

After initial refining, some products have to be further refined. Naphtha, one of the by-products of CDU refining, is commonly passed through a catalytic reformer after the CDU, to create gasoline. The reformer breaks some of the naphtha's molecules into smaller variants and reforms hydrocarbons to create a gasoline base.

The chemical nature of gas oils must also be altered to create lighter fuel. Catalytic cracking is the most common refining process used to convert gas oils and uses heat between 450–500°C, along with pressure and the presence of a catalyst, often silica, aluminium or magnesium, to crack hydrocarbon chains.

#### Analyst comment:

'Tighter controls of sulphur in vessel exhaust gases in the shipping sector effective from 2020 are likely to provide a boost to complex, distillate-weighted refineries. Quantifying the margin impact of increased global distillate demand remains challenging, with analysts forecasting a \$0.5–1.5/bbl increase.'  
Carlos Gomes, oil and gas analyst

Hydrocracking adds hydrogen to the mix and produces only light oils. The hydrogen also combines with contaminants, like sulphur, helping in their removal.

### **What is Brent crude and West Texas Intermediate?**

Some crude oils are used to benchmark prices for a wide spectrum of oils. The most commonly quoted benchmarks are Brent crude and West Texas Intermediate (WTI).

Brent crude refers to a variety of crude extracted from the North Sea, and is commonly used to benchmark African, European and Middle Eastern prices. Brent is a sweet crude, meaning it contains a low sulphur content.

WTI is the main benchmark for US domestic consumption. Although they are the most commonly used benchmarks, WTI and Brent are not alone; there are 161 crude oil benchmarks.

Among the 161 benchmarks, Dubai crude is often referenced. A heavier oil with a high sulphur content extracted out of Oman, Dubai and Abu Dhabi, it is the main reference for Persian Gulf oil delivered to Asia. The Organization of the Petroleum Exporting Countries (OPEC) Reference Basket is the other commonly used average, taken from a mixture of crudes extracted by OPEC.