Crude oil and petroleum product flows and related important statistics

Stève Gervais
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Presentation overview

Key oil trends

Key concepts

Key points for reporting monthly oil
Key oil trends
Key oil trends - Supply

Largest source of primary energy in 2016

A changing production landscape...

2016

<table>
<thead>
<tr>
<th>Producers</th>
<th>Mt</th>
<th>% of world total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>583</td>
<td>13.5</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>546</td>
<td>12.6</td>
</tr>
<tr>
<td>United States</td>
<td>537</td>
<td>12.4</td>
</tr>
<tr>
<td>Canada</td>
<td>220</td>
<td>5.1</td>
</tr>
<tr>
<td>Islamic Rep. of Iran</td>
<td>200</td>
<td>4.6</td>
</tr>
<tr>
<td>People’s Rep. of China</td>
<td>200</td>
<td>4.6</td>
</tr>
<tr>
<td>Iraq</td>
<td>191</td>
<td>4.4</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>182</td>
<td>4.2</td>
</tr>
<tr>
<td>Kuwait</td>
<td>159</td>
<td>3.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>135</td>
<td>3.1</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>1,368</td>
<td>31.8</td>
</tr>
<tr>
<td>World</td>
<td>4,321</td>
<td>100.0</td>
</tr>
</tbody>
</table>

2017

<table>
<thead>
<tr>
<th>Producers</th>
<th>Mt</th>
<th>% of world total</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>583</td>
<td>12.9</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>590</td>
<td>12.8</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>548</td>
<td>12.6</td>
</tr>
<tr>
<td>Canada</td>
<td>237</td>
<td>5.4</td>
</tr>
<tr>
<td>Islamic Rep. of Iran</td>
<td>229</td>
<td>5.2</td>
</tr>
<tr>
<td>Iraq</td>
<td>225</td>
<td>5.2</td>
</tr>
<tr>
<td>People’s Rep. of China</td>
<td>192</td>
<td>4.4</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>178</td>
<td>4.1</td>
</tr>
<tr>
<td>Kuwait</td>
<td>149</td>
<td>3.4</td>
</tr>
<tr>
<td>Brazil</td>
<td>137</td>
<td>3.1</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>1,347</td>
<td>30.9</td>
</tr>
<tr>
<td>World</td>
<td>4,365</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Key oil trends - Refining

Most of the growth in refining has taken place in the Middle East and Asia Oceania.

Output of fuel oil and diesel is declining…

Source: Oil Market Reports Maps and Key world energy statistics 2018, IEA
Key oil trends – Demand

Growth in oil demand is driven by non-OECD countries

Oil product demand by geographical region

Key demand trends

Source: Oil Information 2018 and Key world energy statistics, IEA
By the end of 2019 it is expected that 13 MT/y of petrochemical capacity will come online.

- This will impact demand for petrochemical feedstocks of oil origin, traditionally: **naphtha, LPG, ethane** and **other oil products**.

Source: Oil Information 2018, IEA
Key concepts
### Oil classification – Primary and secondary oil products

<table>
<thead>
<tr>
<th>Primary oil products</th>
<th>Finished secondary oil products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil</td>
<td>Refinery gas</td>
</tr>
<tr>
<td>Condensates</td>
<td>Ethane</td>
</tr>
<tr>
<td>Natural gas liquids</td>
<td>LPG</td>
</tr>
<tr>
<td>Synthetic crude oil, shale oil...</td>
<td>Naphtha</td>
</tr>
<tr>
<td><strong>Secondary products inputs to refinery</strong></td>
<td>Aviation gasoline</td>
</tr>
<tr>
<td>Additives/blending components</td>
<td>Gasoline type jet fuel</td>
</tr>
<tr>
<td>Refinery feedstocks</td>
<td>Motor gasoline</td>
</tr>
<tr>
<td></td>
<td>Kerosene type jet fuel</td>
</tr>
<tr>
<td></td>
<td>Other kerosene</td>
</tr>
<tr>
<td></td>
<td>Other products</td>
</tr>
</tbody>
</table>

- Gas/diesel oil
- Fuel oil
- White spirit + SBP
- Lubricants
- Bitumen
- Paraffin waxes
- Petroleum coke
- Other products

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**Oil classification – Density**

- Most oil is lighter than water, but extra heavy oils have higher density than water.

- The specific gravity or density of the liquid is needed to convert from mass to volume and vice versa.
  - The API gravity is commonly used to express the specific gravity of petroleum.

Source: Oil Industry and Markets Division analysis, IEA
Oil classification - Condensates

- **Condensate** is a *high-quality light oil* recovered from associated or non-associated gas reservoirs.

- In comparison to normal crude oil, condensate needs to undergo *fewer refining* processes and is therefore *versatile* and in *high demand*.
  - Condensate used directly (petrochemicals) or further processed to produce secondary oil products.

**Field condensate**

Recovered from associated and non-associated gas *fields* and is normally intermixed with the crude oil stream.

**Plant condensate**

Recovered in natural gas processing plants or separation facilities.
Oil classification – Sulphur content

- Sulphur content is another key characteristic of oil that serves to differentiate between products.

- From an average crude oil barrel, 70-80% of Sulphur has to be removed to meet product specifications.

Source: Oil Industry and Markets Division analysis, IEA

Sulphur pyramids in Alberta, Canada
Oil classification – Energy content

- Because oil products can vary greatly in their characteristics it is key to collect net calorific values information.
  - Production
  - Imports
  - Exports

- This information is essential to compile the energy balance and to derive CO2 emissions.

**Example net calorific values of United States crude oil.**

<table>
<thead>
<tr>
<th>Flow</th>
<th>kj/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCV Production</td>
<td>42 679</td>
</tr>
<tr>
<td>NCV Imports</td>
<td>43 604</td>
</tr>
<tr>
<td>NCV Exports</td>
<td>42 694</td>
</tr>
<tr>
<td>Average NCV</td>
<td>42 871</td>
</tr>
</tbody>
</table>
Oil classification – Density, Sulphur and refinery yields

• Crude oils have a wide range of physical and chemical properties.

• Refinery specifications determine the type of input and output (refinery yield)
  - Reconfiguring a refinery is expensive, so refinery yields tend to remain stable over time

As a result refinery yields are consistent over time…
Oil balance – Supply of primary oil products

Refinery intake is mostly crude oil but they also process other primary and unfinished secondary oil products.
Oil balance – Indigenous production

- Production should include both onshore and offshore production and exclude amounts returned to formation.

- It is important to determine the point of measurement of production.
Oil balance – Receipts from other sources

- As well as oil products, receipts from other fuel sources can enter the refinery process.

**Solid fuels**

*For example liquids produced from coal liquefaction plants.*

**Natural gas**

*Natural gas can be used to:*
- upgrade synthetic crude oil and petroleum products.
- manufacture of synthetic gasoline in the petrochemical sector.

**Biofuels**

*Amounts of biofuels for blending with transport fuels (bio gasoline, bio diesel, bio jet kerosene)*
Oil balance - Stocks

- Stocks are held for three main reasons: logistics, security and business.

- Stocks can be divided into three categories:

<table>
<thead>
<tr>
<th>Primary stocks</th>
<th>Secondary stocks</th>
<th>Tertiary stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Held in the supply chain (producers, importers, refiners, etc.) and for strategic purposes by government or stock holding organizations.</td>
<td>Held in small bulk plants (marketing facilities below a certain capacity) and retail establishments.</td>
<td>Held by final end-consumers (power plants, industrial entities, or consumers in the residential/commercial sector)</td>
</tr>
</tbody>
</table>

- They can be further divided based on the stockholding structure: industry stocks, government stocks and agency stocks.
Oil balance – Transformation

Oil

Crude oil
Natural gas liquids
Other Hydrocarbons
Additives/Blending components
Refinery feedstocks

Refinery intake

Refinery

Refinery fuel

Oil products

Refinery gas
Ethane
LPG
Naphtha
Aviation gasoline
Gasoline type jet fuel
Motor gasoline
Kerosene type jet fuel
Other kerosene
Gas/diesel oil
Fuel oil
White spirit + SBP
Lubricants
Bitumen
Paraffin waxes
Petroleum coke
Other products

Refinery gross output

Lightest

Heaviest
Oil balance – Transformation efficiencies

Losses can occur during the refining process due to evaporation.

When refinery intake > refinery gross output = **refinery losses**.
When refinery intake < refinery gross output = **refinery gains**.

**Refinery Yield** = \( \frac{\text{Refinery Output of Total Secondary Products}}{\text{Refinery Intake of Total Primary Products}} \times 100 \)

- **Mass units** – small losses with no gains.
- **Volume units** – gains are likely because lighter products are produced.
- **Energy units** – small losses with no gains.
Reclassification of products within a refinery is common.
- Change in specification
- Blended into other products.

We refer to these as **inter-product transfers**, this does not involve further processing.

The *density* and *value* of the oil products will impact the reclassifications.

When products are *reprocessed* in a refinery we consider these “**products transferred**”, these products are not delivered to the market.

<table>
<thead>
<tr>
<th>Possible</th>
<th>Possible but not very likely</th>
<th>Not likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerosene to gasoil</td>
<td>Naphtha to gasoline</td>
<td>Gasoline to naphtha</td>
</tr>
<tr>
<td>Jet kerosene to</td>
<td>Diesel to fuel oil</td>
<td>Diesel to jet kerosene</td>
</tr>
<tr>
<td>diesel</td>
<td></td>
<td>LPG to fuel oil</td>
</tr>
</tbody>
</table>

**More generally heavy to light products**
Oil balance – Supply of secondary oil products

Refinery

Refinery gross output

Primary product receipts

Interproduct transfers

Exports

Stock build

International Marine Bunkers

Refinery fuel

Products transferred

Stock draw

Recycled products

Gross inland deliveries

Transformation

Final Consumption

<table>
<thead>
<tr>
<th>Finished secondary oil products</th>
<th>Refinery gas</th>
<th>Gas/diesel oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethane</td>
<td></td>
<td>Fuel oil</td>
</tr>
<tr>
<td>LPG</td>
<td></td>
<td>White spirit + SBP</td>
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<td>Naphtha</td>
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<td>Lubricants</td>
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<td>Bitumen</td>
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<td>Paraffin waxes</td>
</tr>
<tr>
<td>Motor gasoline</td>
<td></td>
<td>Petroleum coke</td>
</tr>
<tr>
<td>Kerosene type jet fuel</td>
<td></td>
<td>Other products</td>
</tr>
<tr>
<td>Other kerosene</td>
<td></td>
<td>Primary products used directly</td>
</tr>
</tbody>
</table>

Refinery primary product receipts

Refinery fuel

Exports

Stock build

Interproduct transfers

Final Consumption

Gross inland deliveries

Transformation
Oil balance – International marine bunkers

• This flow covers the deliveries of oil to:
  - Ships of all flags undertaking an international voyages.

• Domestic navigation and consumption by fishing vessels are covered elsewhere in the balance.

Why it matters:

• Important outlet for the refining industry.
• Important part of demand for oil in a country.
• 80% of global trade in physical goods is done by sea – key to track policy impact.
• The distinction between national and international navigation matters for emissions calculations (they are excluded from national inventories).
Due to their specific properties, different oil products have specific uses.

*Examples of the types of oil products one can expect to find in different consumption sectors*

<table>
<thead>
<tr>
<th>Electricity plants</th>
<th>Chemical and Petrochemical</th>
<th>Aviation</th>
<th>Road transport</th>
<th>Navigation</th>
<th>Residential</th>
<th>Non-energy use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil Diesel</td>
<td>Naphtha Diesel</td>
<td>Jet kerosene</td>
<td>Gasoline Diesel</td>
<td>Heating oil*</td>
<td>Naphtha Kerosene</td>
<td>Bitumen Paraffin waxes</td>
</tr>
<tr>
<td></td>
<td>LPG Ethane Kerosene Other products</td>
<td></td>
<td></td>
<td>Fuel oil</td>
<td>Heating oil</td>
<td></td>
</tr>
</tbody>
</table>

*The category Heating oil includes marine diesel and diesel used in rail traffic.*
The petrochemical industry is a special case as it is not only a large consumer of oil but also a producer of oil products. As such it is an integral part of the oil balance.

**Oil Balance**

- **Include:**
  - All oil inputs (for energy and non-energy use)
  - Energy use output

- **Not include:**
  - Non-energy use output

**Energy output**
- Oil products e.g. pyrolysis gasoline

**Non-energy output**
- Fertilizers
- Plastics
- Synthetic fibers ...
Oil data sources – Where does it all come from?

Supply Data

Producers, oil terminals, importers/exporters or customs data, refiners.
Surveys, company reports, etc.

Demand Data

Energy Consumers, wholesalers.
End-use survey for households and enterprises, sales data, etc.

Integrated Approach

Using existing surveys, direct measurement, estimation and modelling
Oil data sources – Types of data collection

**Surveys**
- Enterprise
- Household

**Administration data**
- Energy regulator, custom office, excise tax records etc.
- Industry associations, chamber of commerce etc.

**Estimation/modelling**
- e.g. NGL production-> LPG exports/refinery output
Beyond data collection

Annual and quarterly Publications
Fuel Information books, World energy statistics & balances, CO₂ emissions…

Data support
Oil Market Report, World energy outlook…

IEA website
Atlas, Sankey flows…

Booklet
Key World Energy Statistics

Mobile App
Android, apple and windows

Electronic data files
Online data service
Key points for reporting monthly oil
Why collect monthly oil data?

- Transparency in the oil market
- Improved analysis and policies
- Energy security

Alberta wildfires prompt oil firms to suspend production and evacuate staff

At least 233,000 barrels per day of oil sands production have been halted as government of Canadian province says 66 forest fires are burning.

Oil rises as Kuwaiti strike cuts output for third day

Fire halts operations at Pemex’s Salina Cruz refinery

Hurricane Harvey Forces Even More Texas Oil Refineries To Close

Shell Nigeria Declares Force Majeure On Nigerian Light Oil Exports
Why collect monthly oil data?

- **Transparency in the oil market**
  - Short-term/Trend indications
  - Seasonality
  - Impact of events (planned or unplanned)
  - Data validation

- **Improved analysis and policies**
  - Preliminary source of information
  - Basis for comparison with annual data

- **Energy security purposes**
  - Recent/quick assessment of markets
  - Size of a supply disruption
  - Ad-hoc assessment
  - Monitoring of a country’s ability to face a disruption
Why collect monthly oil data – Transparency in the oil market

*Short term – Trend indicators*

- **OECD - Total Product Demand**
  - [Graph showing production demand with data points from 2014 to 2018.]

- **OECD - Total Oil Stocks**
  - [Graph showing oil stocks with data points from 2014 to 2018.]

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Why collect monthly oil data – Transparency in the oil market

**Seasonality**

**Greece – Jet Kerosene Demand**

**UK – Other Kerosene Demand**
Why collect monthly oil data – Transparency in the oil market

**Impact of events - Scheduled maintenance**

**Austria – Crude, NGL + Feedstocks**
Refinery Intake

**Austria – Total Products**
Refinery Gross Output
Why collect monthly oil data – Transparency in the oil market

Impact of events - Detailed visualization of the effects of unplanned events

- Example: France 2016 - Impact of strike on oil markets / oil industry

Source: IEA, Monthly oil data service
Why collect monthly oil data – Transparency in the oil market

Data validation - Detailed visualization of possible data issues

% - Refinery losses as a percentage of refinery intake

A negative refinery loss implies a refinery gain

Source: IEA, Monthly oil data service, Oil Information 2017
Why collect monthly oil data – Improved analysis and policies

Preliminary source of information

Why collect monthly oil data – Improved analysis and policies

Basis for comparison with annual data

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**South Africa - Total Gasoline - Demand**

<table>
<thead>
<tr>
<th>Year</th>
<th>JODI</th>
<th>AOS</th>
<th>BEs</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>8946</td>
<td>8473</td>
<td>8708</td>
<td>8353</td>
</tr>
<tr>
<td>2007</td>
<td>8107</td>
<td>8380</td>
<td>8030</td>
<td>8138</td>
</tr>
</tbody>
</table>

**Notes:**
- JODI-AOS as % JODI
- **No AOS**
- **No AOS**
- **No AOS**
- **No AOS**
- **No AOS**
- **No AOS**
- **No AOS**
- **No AOS**
- **No AOS**

*1. Number of months per year in which JODI MoU data are present*
Why collect monthly oil data – Improved analysis and policies

Basis for comparison with annual data
Why collect monthly oil data – Improved analysis and policies

Basis for comparison with annual data
Challenges in collecting monthly data

• Timeliness can be a factor

• The data collection system of a country also matters (voluntary v. mandatory)

• Confidentiality issues

In this example, monthly deliveries data does not cover private operators.