# OVERVIEW OF THE EUROPEAN DOWNSTREAM OIL INDUSTRY

europia european petroleum industry association

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## INTRODUCTION

- **This report has been compiled by Purvin & Gertz at the request of EUROPIA to provide an independent view of the oil refining, distribution and marketing industry in Europe.**
- **The report covers the following areas**
  - A global overview of the petroleum industry
  - An introduction to refineries and the refining process
  - An introduction to the crude oil market
  - An overview of the markets for refined products
  - The economics of refining and the factors that affect its profitability
  - The future challenges that face the European refining industry

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# Index

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## SECTION I

# OVERVIEW OF THE PETROLEUM INDUSTRY

## Introduction to this section

- This section provides a high level overview of the petroleum industry and introduces important topics about its structure and operations that are discussed in more detail later in the report.
- The industry is composed of three main segments, the exploration and production of crude oil, the refining of crude oil into finished products and the distribution/sale of those products to end consumers.
- The section illustrates how products are distributed to market, by showing the typical options for logistics and the typical channels through which products are sold
- At the end of the section we have provided a review of the downstream oil industry structure for the United Kingdom and Switzerland. This illustrates the wide range of structures that are seen across Europe.

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## The petroleum industry has three key business segments

**Crude Oil Exploration & Production**

**Refining**

**Product Distribution & Sales**

**Upstream**

**Downstream**

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- The petroleum industry can be divided into three broad segments: crude oil exploration and production, refining and product distribution and sales.
- Crude oil exploration and production is commonly referred to as the "Upstream". Refining and product sales are generally referred to as the "Downstream", although it is necessary to distinguish between refining and distribution/sales as they are generally operated as separate business areas.
- Some of the earliest companies active in the oil industry have evolved to become what is known nowadays as "The Majors", or "The Major International Oil Companies (Major IOCs)". Throughout this report, this term is applied to the following six companies: BP, Chevron, ConocoPhillips, ExxonMobil, Shell and Total.
- As the industry is globalising new major companies are being formed, particularly in Russia, China, India and Brazil. These companies are exhibiting global ambition both in the upstream and downstream. In these countries the major companies have a strong domestic base from which to grow, with generally supportive government policies.

## Each segment has different characteristics

| | Upstream | Refining | Distribution & Sales |
|---|---|---|---|
| Key Characteristic | Resource extraction | Manufacturing | Marketing |
| Key Drivers | • Revenue depends on absolute price<br>• Access to resources<br>• Technical skills | • Revenue depends on margin<br>• Location<br>• Configuration<br>• Technical skills<br>• Economy of scale | • Revenue depends on margin<br>• Competitive supply cost<br>• Location<br>• Marketing skills<br>• Economy of scale |
| Financial Resources to participate | Highly capital intensive | Highly capital intensive | Low capital relative to other segments |
| Government take | Often highly taxed | Subject to corporate taxes | Subject to corporate taxes. Products highly taxed in Europe |

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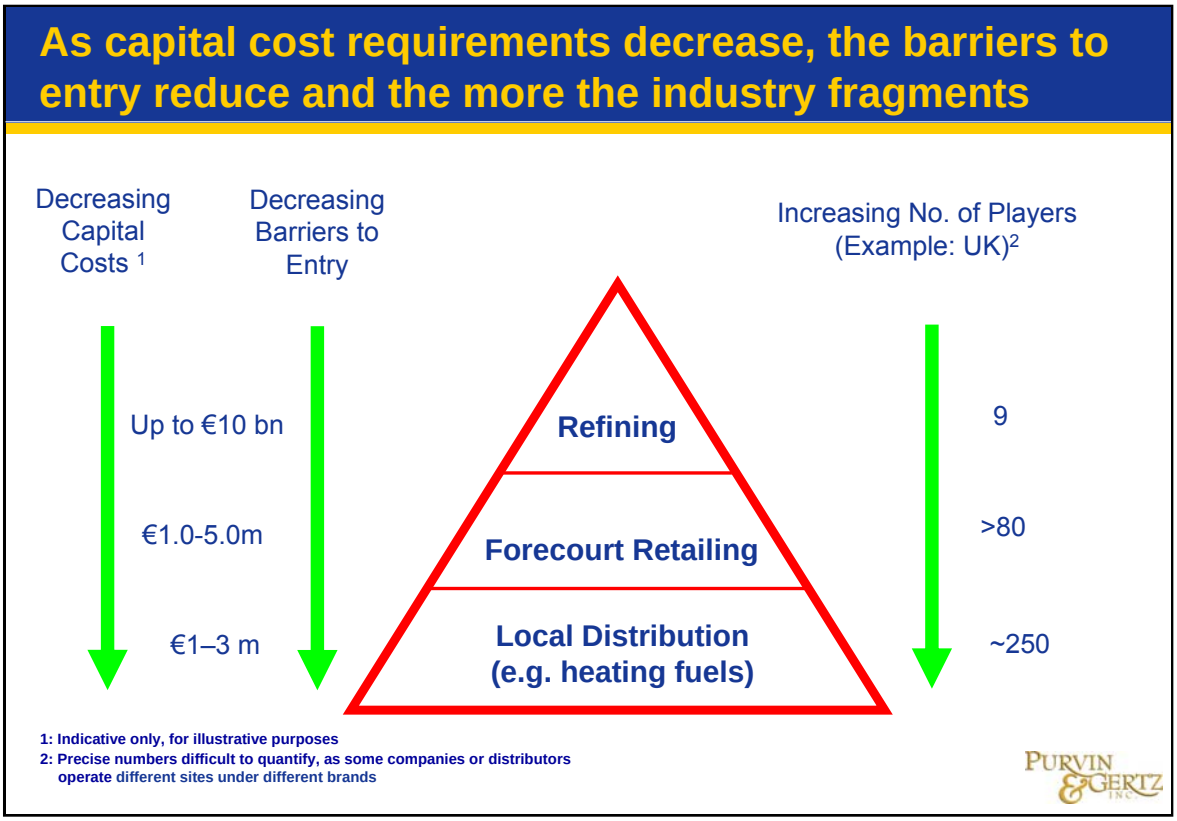
- The three different segments of the petroleum industry have distinct characteristics reflecting the nature of their operations, degrees of capital intensity and economics.
- The profitability of the upstream depends on the absolute price of crude. Higher oil prices encourage more exploration activity and higher levels of recovery from existing fields. The converse is true when prices fall.
- The profitability of the refining sector depends on the relative values of crude oil and different refined products. As each refinery is configured – and located – differently, so the profitability of each refinery differs, according both to the refinery yield and the crude supply and product distribution logistics.
- Distribution and sales is the segment of the petroleum industry that is the most widely visible to the public. Profitability is driven by the margin between acquisition costs and sales prices. Marketing skills are important as are good sales locations and competitive costs.
- End products (motor gasoline, diesel) are essentially commodities which are sold into a highly competitive marketplace, with often a small profit margin on sales. Retailers therefore use marketing strategies and skills to maximise their profitability. In many countries fuel retailers rely on sales of non oil items in their forecourt shops to supplement their income from oil sales.
- Barriers to entry into distribution and sales are relatively low compared to the other segments and many substantial new entrants have been seen in recent years, most notably the supermarkets.
- In general the refining and marketing sectors are taxed in line with normal corporate taxes. The upstream is often taxed at higher rates, with special production taxes. This varies considerably between countries.




- Although not shown above, the range of investments made by upstream companies varies enormously. Large and complex projects such as a giant oil or gas field can cost more than $50 billion to develop and can only be undertaken by a group of large companies. Easier to exploit and smaller fields can be developed by smaller companies.
- The refining sector is also very capital-intensive. As an example, to build a large, internationally-competitive refinery could cost up to €10 billion today. Even an existing and fully depreciated refinery could hold several hundred million Euros worth of oil stocks.
- By contrast, a high-throughput, modern service station would cost between €1-5 million. Approximately €1-3 million for a small fuels depot and road tankers would be sufficient to conduct heating oil distribution activities at a local level. The cost of a small petrol station would also be of this order of magnitude, or even lower.
- The Major IOCs have traditionally been active in all segments, as they are amongst the few companies that can raise the necessary capital.
- Smaller, independent organisations are relatively few in large capital-intensive segments such as refining (see later), but the further down the supply chain towards the consumer level the number of independent players increases significantly as barriers to entry diminish.
- There is a constant evolution in the retail sector, with some companies withdrawing from the market and others taking their place. Over the last several years the most significant new entrants have been the supermarkets which sell motor fuels at competitive prices in order to encourage consumers to their stores. In some countries they have captured a large market share. The impact of the entry of supermarkets is for the remainder of the network to shrink as volumes fall.

## Companies can be active in any or all of the industry segments

**Upstream**

**Refining**

**Product Distribution & Sales**

- Companies can be involved in either one, two or all three industry segments.
- Companies can also own and operate separate brands for retailing.
- Activity in more than one segment is sometimes referred to as "vertical integration".
- True vertical integration is quite uncommon in Europe.
- By true vertical integration we mean supplying your own crude to your own refinery and sell the products through your own distribution channels.

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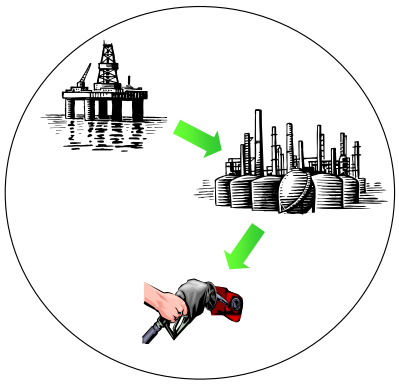
- Companies involved in the oil industry can be active in one, two or all three of these segments. All of the IOCs and most of the other large oil companies are active in all three, whereas smaller companies that tend to focus on one or two segments only are referred to as "independents".
- Involvement in more than one segment, for example in crude oil production and petroleum refining, is often referred to as "vertical integration"; however, this commonly accepted term no longer reflects modern commercial realities.
- Most companies that are active in more than one segment are not truly vertically integrated as they process purchased crude in their refineries and buy products to supply their networks, while some of the product obtained from their refineries is sold to others. There are very few exceptions to this.
- The theoretical benefits of vertical integration are the secure supply of crude to the refinery and secure outlets for products from the refinery. However in each segment there is generally a number of competitors and the market will determine the prices that can be charged. Competition law in Europe prevents a dominant share that could give price control to any one participant.

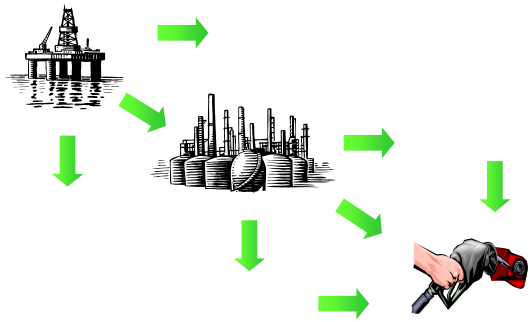
## The petroleum industry has evolved from the vertical integration model to separate business segments

### 19th and Early 20th Centuries: The Vertically Integrated Company



- Own crude flows mostly to own refineries and products are distributed through own channels.

### Modern Business Operations: Separate Business Segments



- Evolution of petroleum markets has allowed each segment to operate independently
- Markets provide basis for full industry transparency – essential for taxation and the business implications of modern cross-border operations and trade

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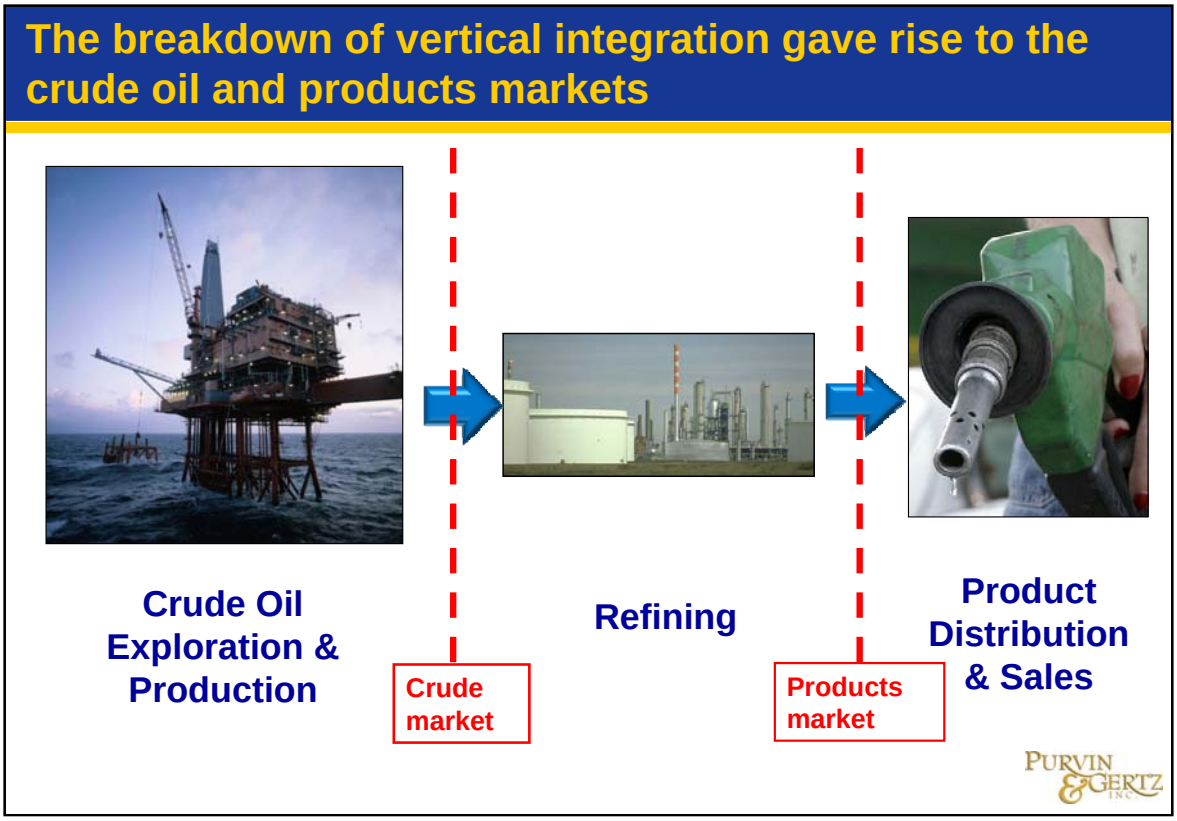
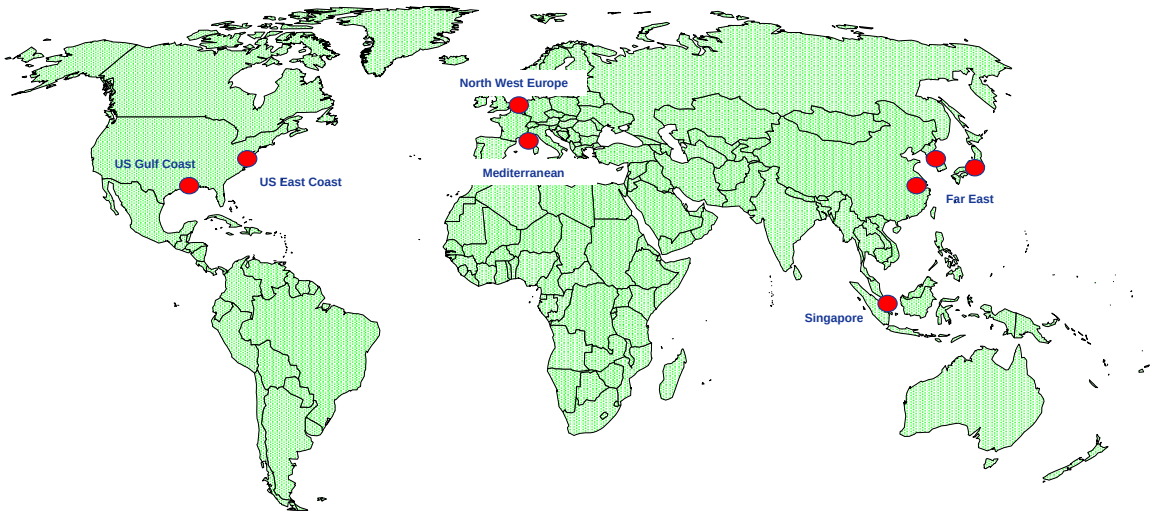
- Early in the industry's evolution, petroleum companies were integrated all the way from the oil well to the end consumer, via their own refineries. This was the era of vertical integration.
- At this time the world crude production was concentrated in the hands of a relatively small number of oil companies. These companies were present in several major crude producing regions and product consuming regions. They jointly had a large share of global oil markets in all segments and could afford a true vertical integration with strong ties between individual segments.
- This model broke down in the 1970s with the nationalisation of oil and gas resources in several countries (see **Section III**) to create National Oil Companies (NOCs). This resulted in the loss of upstream capacity by the IOCs and the new NOCs having crude and no downstream in which to process it.
- The focus of the IOCs at this time switched to finding new reserves to replace those that were lost. The discovery of the North Sea and other new oil provinces, coupled with the crude sales being made by the NOCs gave rise to large volumes of traded crude.
- The vertically integrated business model broke down as markets for crude oil and refined products developed, allowing many more companies to participate in each segment of the business.



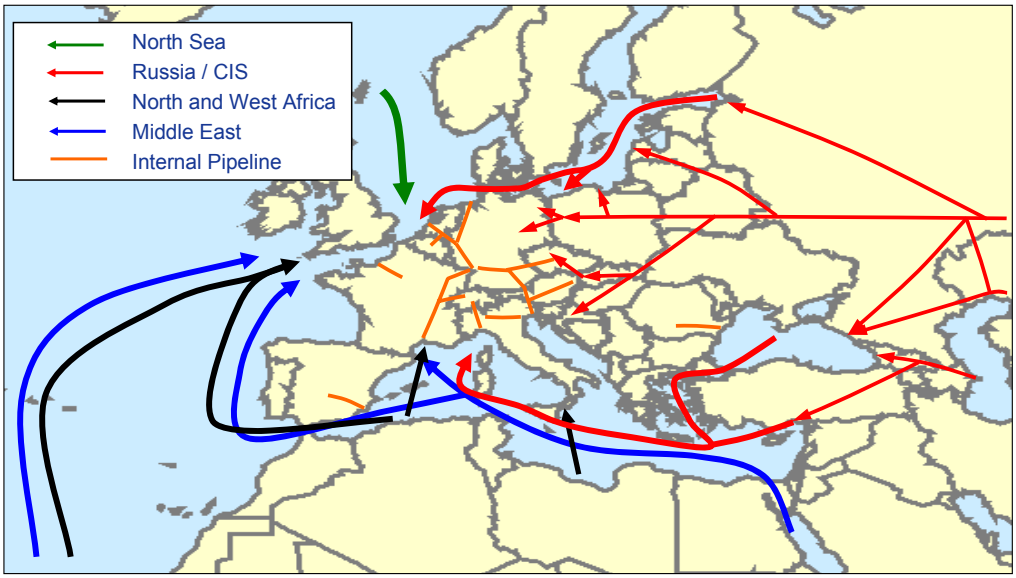

- A free market for crude oil developed and grew rapidly following the nationalisation of production by several countries. The evolution and current activities in the world crude oil markets is discussed in **Section III** of this report.
- The free availability of traded crude opened up the opportunity for independent refiners to establish. In Europe these included ERG, Saras, Motor Oil (Hellas) and more recently Petroplus. Most grew during the 1980s and 1990s.
- The development of independent refiners, and the construction of export refineries in the oil producing and exporting countries, resulted in the increasing availability of refined products for sale. A market for refined products developed as a result of this. The refined products market is discussed in **Section IV**.
- The development of markets in which crude oil and refined products could be freely traded allowed each business segment to operate independently. Companies that participated in only one of the three industry segments were able to operate on a commercial basis.
- Operating as separate business segments is now a necessity. Crude oil producers sell their crudes to those who can pay the highest price, typically those refineries that are in the best position to process the crude. Crude oil production is heavily taxed in some countries and in order to set a price against which the tax is levied, the fiscal authorities will look at the market price for the oil. This alone prevents an oil producer integrated with a refinery from transferring crude to his refinery at below market price
- Refiners will seek optimum sources of crude depending on their particular situation (**Sections III and V**). Distributors will seek the lowest cost of supply.
- With a number of independent operators in each segment, transparent markets for crude and products easily expose any instances of cross subsidy between segments.

## Crude oil is bought by refineries. The most important crude markets have developed at refining centres




- Large refining centres have developed at locations that were well positioned to take advantage of crude supply, access to refined product markets or both. As a result there was a large trade and markets developed that related to these specific locations. Some of these locations now serve as reference points for the pricing of crudes and refined products.
- The most important such locations are the US Gulf Coast, Rotterdam in North West Europe (often referred to as ARA, Amsterdam-Rotterdam-Antwerp) and the Far East (Singapore). At a European level, the Mediterranean is also regarded as an important market.
- **North West Europe** is Europe's largest refining centre. Terminals located in Rotterdam also function as gateway to supply Germany and Switzerland. In this region a crude oil market developed around the trading of North Sea crude
- **The US Gulf Coast** is the primary US refining centre. Refining capacity developed around the supply of crude from Texas, Venezuela and the Gulf of Mexico. The East Coast has less refining capacity and is partly served by excess production at the Gulf Coast refineries. A crude oil market developed around the sale of Texas and Louisiana crude.
- The largest concentrations of refining capacity in the **Far East** are in Singapore, Korea, China and Japan. Singapore has historically had a more liberalized market and a more favourable investment climate. The export refinery capacity and storage capacity in Singapore provided the opportunity for a market centre to develop.
- The evolution and operation of the world crude market is discussed in detail in **Section III.** In **Section IV** the development of the products markets is discussed.

## The majority of European crude oil is supplied by North Sea, Russia/CIS, Africa and Middle East




- European refineries receive crude oil from a wide range of sources, which include the North Sea (32%), the Russia/CIS region (35%), the Middle East (18%) and North and West Africa (15%), as these are the most economical for EU refineries to process. Some North Sea crude oil production is exported to North America, but quantities are reducing as production declines.
- The majority of European refineries are located on the coast, so that the general method of delivering crude oil is by tanker. For inland refineries, located to be nearer markets, crude oil is delivered by pipeline to the refinery from coastal terminals.
- In Central and Eastern Europe, Russian crude delivered through the Druzhba pipeline system is the main source of supply. This is a legacy of the oil infrastructure built during the Cold War era. The Druzhba system (Druzhba means "Friendship") reaches all of the countries of the old Warsaw Pact.
- Other inland refineries, such as those in Germany and France receive crude oil from pipelines running from coastal terminals. In some countries there is some crude produced at inland oil fields but volumes are generally declining.

## The participants in the market also include traders who buy and sell crude and products

- **The emergence of separate markets for crude oil and refined products presented an opportunity for companies to participate solely in trading**
- **Volumes handled by the major traders are now a significant part of the market**
- **The traders fulfil a valuable role by quickly identifying arbitrage opportunities between markets and correcting imbalances**
- **Some are also investors in infrastructure to support their activities, mainly storage, terminals and shipping, but in some cases also refineries and oil fields**
- **In addition to physical traders there are companies that just trade oil contracts or "paper" in the futures markets**

- With the development of the oil markets the opportunity for companies to trade between buyers and sellers arose. There are two classes of company active as intermediaries, brokers and traders.
- Brokers match the needs of a seller with a buyer and vice versa, taking a commission if a transaction is completed, rather like an estate agent in a housing transaction.
- Traders buy and sell crude and products, taking market risk in the process. They will often charter ships or rent storage to move or store the crude oil and the refined products they own.
- Most oil companies have trading groups that provide trading services internally, i.e. they participate in the crude and products markets to buy and sell according to the needs of the parent company. Some of the larger companies will also engage in some additional trading for profit above their physical requirements.
- There are also some very large independent traders, the largest of which deal in very large volumes. Vitol and Glencore, two of the largest commodity traders, together account for over 4% of the world oil market. This is about one third of the total production of the six Major IOCs.
- Vitol and Glencore have invested in refineries, terminals and tankers. Both own shares in some oil producing companies. Besides these specific examples, other physical traders own or rent oil storage capacity to support their activities.
- Some financial companies such as the major banks also trade in "derivatives" (See **Section III and IV**) such as oil futures. Morgan Stanley and Goldman Sachs are known to be an active participants in both the physical oil market and the paper markets. Some banks and other participate solely in the paper markets.

## Oil refineries provide the essential link between crude oil and the products that consumers require

- **Crude oil needs to be refined in order to provide the products consumers need**
- **Refining separates crude into various products**
- **Refineries also convert low value products into more valuable products**
- **They treat the raw products to remove impurities**
- **As markets have evolved and quality requirements tightened, refining has become more complex**

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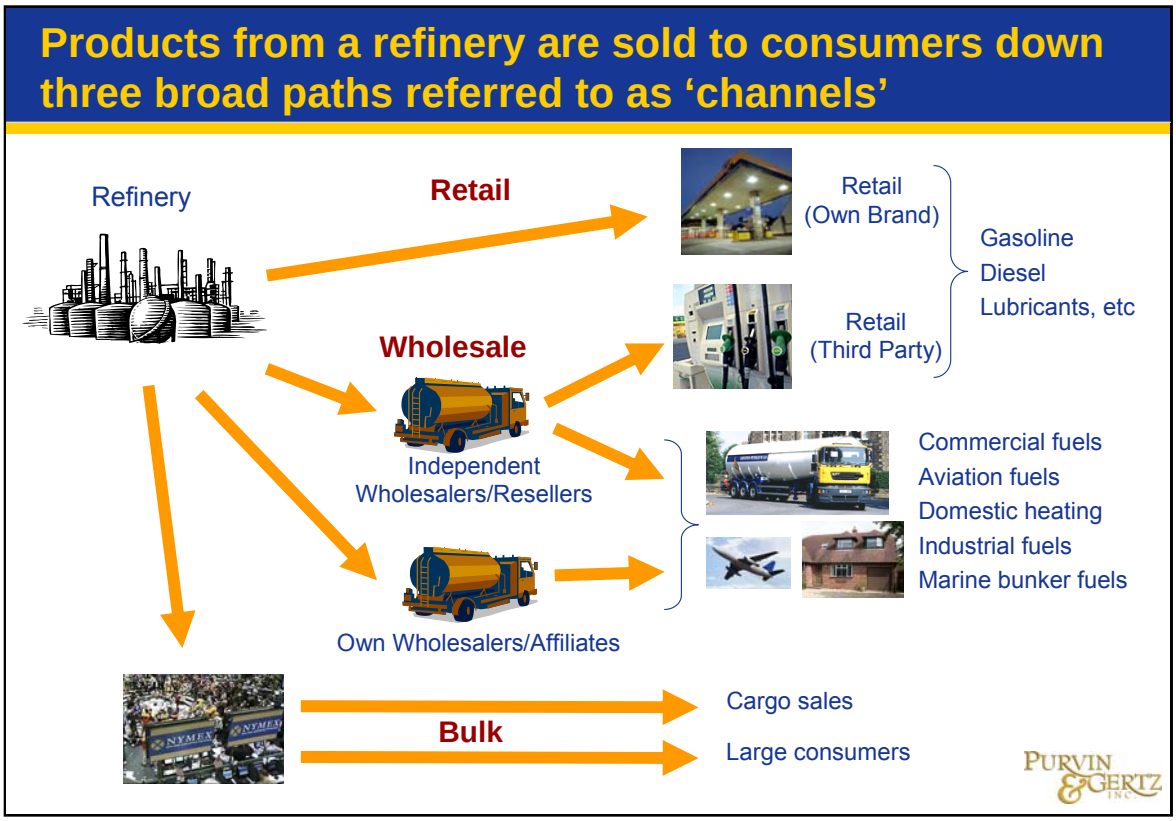
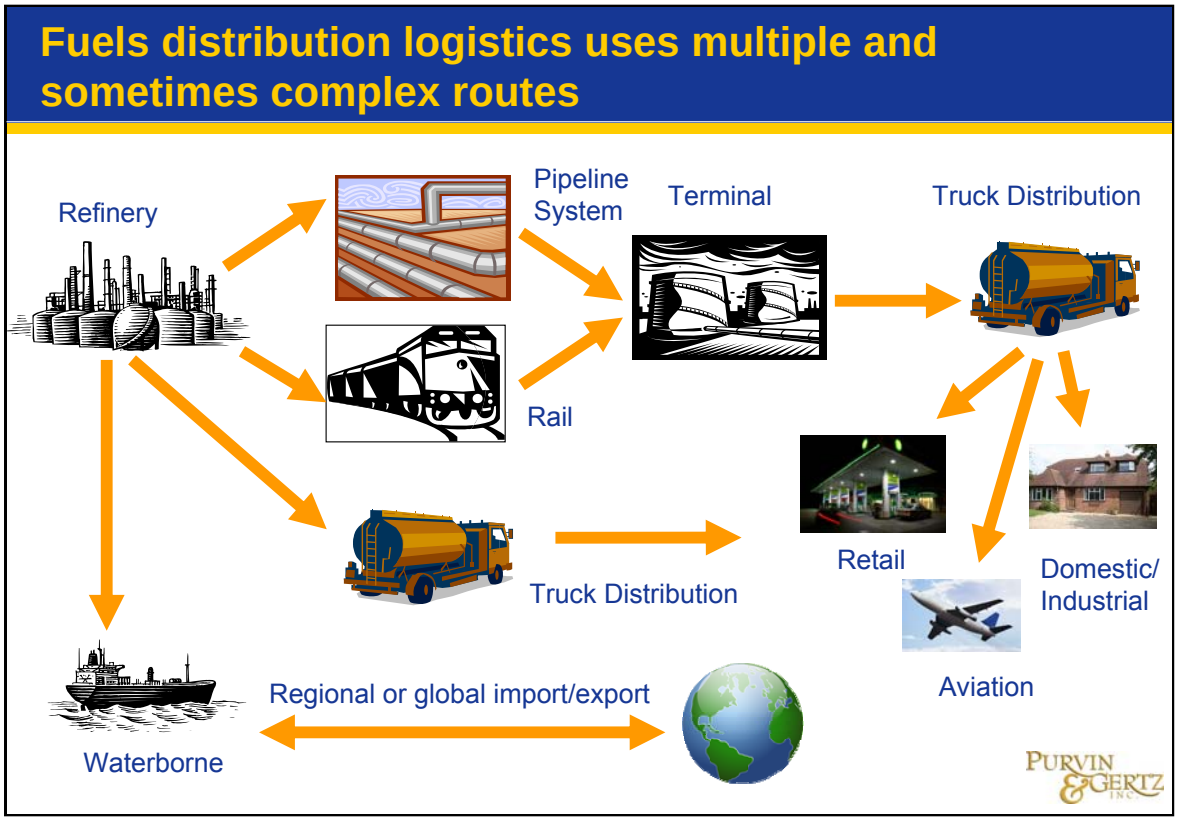
- Refineries buy crude oil from producers in the crude market. The types of crude they buy will depend on a number of factors which include their product needs, the capacities and types of process units they have and their supply logistics.
- Crude oil contains a mixture of hydrocarbon types, the proportions of which vary between different types of crude. The refinery separates these products by distillation into fractions that correspond to the types of products that consumers need.
- For example there is a fraction that is used to make gasoline, another that makes fuel for aircraft and another, heavier fraction that is used to make diesel fuel.
- The products from the distillation will not meet the required specifications and so have to be treated in other units. For example the diesel fuel from distilling crude can contain a lot of sulphur that has to be removed by further processing.
- There are limits to the proportion of any product that a refinery can make which are dictated by the processing equipment it has. Every refinery will produce a mix or 'slate' of different products which can vary between limits, but most refineries produce at least five different products.
- The types and operation of refinery processes are discussed in detail in **Section II**
- The development of the crude oil and refined products markets has allowed independent refineries to operate. The amount of profit that a refinery can make will depend on the cost of crude and the value of the products that it sells. Each will be dictated by the market. The difference between the value of the products and cost of crude is called the 'refining margin'. This is discussed in **Section V.**
- Each refinery has a different slate of products and the price of each product can vary depending on its balance of supply and demand. Refinery margins can be very volatile because of this.




- There are three main channels of sale for products from a refinery to the consumer; Retail, Wholesale and Bulk. Companies that own refineries may participate in some or all of these channels.
- The most visible example is the retail petrol station, where automotive fuels and lubricants are sold. A refinery can supply its own company network or the network of a third party via a wholesaler.
- The wholesale (or distributor) sector supplies to customers in small loads either directly from a refinery by truck or from a distribution terminal that is fed from a refinery or imports. This sector supplies a wide range of products including motor fuels either to retailers or to individual large consumers, home heating oil direct to customers, aviation fuels and some speciality products. Wholesalers may be independent companies or owned or partly owned by refiners.
- Large commercial users such as the operator of a truck fleet, an airline, a ship owner or a power plant will typically receive direct delivery of large parcels (e.g. a few thousand tonnes) to the point of use. These end users will be served with commercial contracts. Companies that own refineries often have their own aviation and marine sales divisions to sell directly to large customers.
- Another example of wholesale activity is the sale of products by public tender. This is a form of procurement often used by public administrations. Again, companies that own refineries may participate in the tender through their own affiliates or, alternatively, an independent wholesaler would be awarded the contract. Either way, the winner of the tender would then secure wholesale supplies from a suitable local refinery or import.
- Bulk sales are large volume sales that are generally made directly by the refiner or by a large trading company. Typical customers would be a petrochemicals plant or nearby power station. For example the Lavera refinery supplies feedstock to the adjacent petrochemicals plant. For convenience this category also includes cargo sales from the refinery to export, although this is often handled by the company's supply and trading group.




- Most refineries serve the market immediately surrounding them by truck. The typical capacity of a fuels refinery can far exceed the consumption in the immediate market and consequently products have to be moved to more distant locations by alternative means of transport.
- More distant markets are reached either by rail, by sea or by pipeline. In some countries the pipelines are required to offer capacity to any legitimate user (common carrier provisions) and in others they are owned by one or more companies and reserved for the use of the owners.
- Large points of consumption such as a large airport or a power plant can be served with direct delivery from refineries by pipeline. As an example, airports such as London Heathrow and Gatwick, Paris CDG, Amsterdam, Frankfurt and Madrid are all served by pipeline.
- Exchanges are used widely in the industry to minimise distribution costs. Two companies, A and B, each own a refinery in different parts of the country and each is a national marketer. Company A will supply product to Company B in the area around its refinery and Company B will reciprocate for Company A around its refinery.
- Exchanges are possible as refined products are commodities with the same quality specification applicable to all sales. The distribution cost reductions allowed by exchanges are passed to the consumer through competition. Moreover, avoiding transportation reduces carbon emissions.


- The majority of companies in the oil industry are active in both upstream and downstream. The majority of companies that are active only in the downstream, have both refining and distribution activities.
- For many years, the European refining industry was defined not only by the presence of most of the major IOCs in most countries, but also by many national or regional companies (formerly government owned, then privatised) operating predominantly in one country only or in a particular region. Examples of the latter include DEA and Veba in Germany, Petrofina in Belgium, Agip in Italy, Repsol in Spain, OMV in Austria, MOL in Hungary, etc.
- Other companies that have entered the European refining industry are the upstream-based national oil companies (NOCs) of oil producing countries, such as OPEC members and Russia. OPEC countries were initially interested in acquiring assets to secure outlets for their crude (the traditional form of vertical integration) but never secured sufficient capacity to develop strong positions. Recently some have decided to leave the European downstream. In the last few years, Saudi Aramco has sold its share of Motor Oil (Hellas), and Tamoil, owned by the Libyan National Oil Corporation, has attempted to sell its three refineries. Russian oil companies have entered the European refining sector more recently (Lukoil).
- An increasing share of retail sales, especially in France and the UK, has been gained by large supermarket chains such as Carrefour, Leclerc, Auchan, Morrisons, Tesco, and Sainsbury's. By operating high-throughput service stations at their store sites, selling at very competitive prices, they have reached market shares of nearly 50% by volume in France and 39% by volume in the UK. Their strategy is partly driven by competitive pricing of fuel sales to attract customers for sales of groceries, which remains their core business. The ability of these players to obtain products is a testimony to market openness.

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# OWNERSHIP OF EUROPEAN REFINERIES AND SPECIFIC COUNTRY EXAMPLES

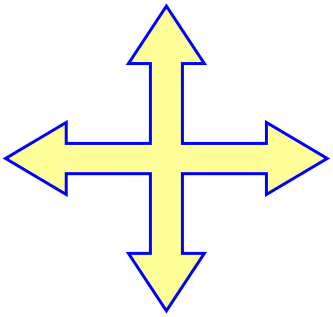
## European refining can be classified into four classes of ownership

MAJOR IOCs

- Operations in upstream, refining and distribution

GOVERNMENT / REGIONAL COMPANIES

- Historically state-owned, but may now be part or fully privatised
- Operations centred around either one particular country or regional area
- Have evolved the most in the past 20 years: some have been absorbed by mergers with IOCs, while some have enlarged their area of operations



NATIONAL OIL COMPANIES

- Downstream operating divisions of state-owned, crude oil-producing countries
- Have made some downstream acquisitions abroad

INDEPENDENTS

- Smaller companies, either privately or publicly owned.
- Operate mostly as refining-only company, although some are active also in distribution/sales
- Can also be active in other industries, e.g. petrochemicals

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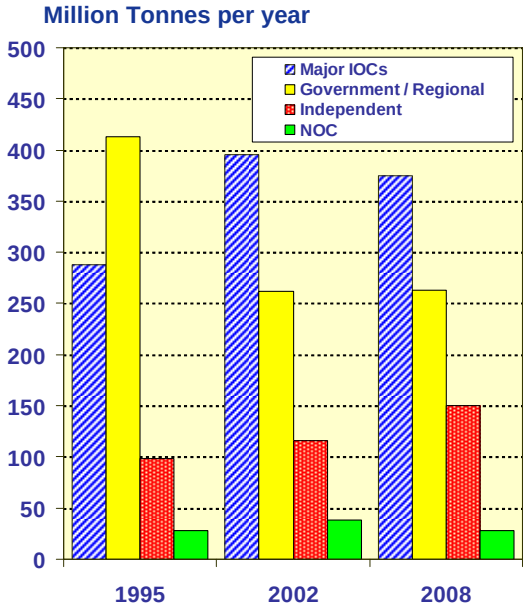
- There are four broad categories of refinery ownership in Europe: Major IOCs, Government/ Regional companies, Independents and National Oil Companies (NOCs).
- Government/Regional companies comprise those companies that either originated as a state-owned interest, and may have been privatised subsequently, or have historically concentrated operations in a certain regional area, sometimes in one country only. They often own both refining and distribution activities. Current examples include Repsol (Spain), Eni (Italy), OMV (Austria), MOL (Hungary), PKN Orlen (Poland), Preem (Sweden), Neste Oil (Finland), Hellenic Petroleum (Greece), etc.
- Independent companies include refiners, such as Petroplus, Saras, ERG and Motor Oil (Hellas), as well as petrochemical companies that have diversified into refining such as Ineos and LyondellBasell.
- NOCs are the downstream operating arms of major upstream producing countries, such as those from Venezuela, Kuwait and Saudi Arabia. More recently, Russian companies such as Lukoil have entered the European refining industry.

## The refinery ownership profile in Europe has changed with a growth in independent ownership




- Up until the mid/late-1990s, 50% of capacity was operated by national or regional companies, with few independents
- Significant consolidation from 1999 resulted in several national companies being taken over by the Majors, or merging to form larger organisations
  - *Exit/mergers of Elf, DEA, Petrofina and Veba*
- Former gov't-owned national companies have evolved into regional players
  - *Eg: MOL, OMV, PKN, Eni*
- The European industry has also seen a notable increase in the number of independent players, to 18% of capacity
  - *Established players such as Saras, ERG and Petroplus, as well as recent entries such as Ineos*

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- From the late 1990s, there have been several industry mergers that have resulted in company consolidation and new joint-ventures. For example, Elf and Petrofina, which had both operated principally as regional players, were acquired by Total, their assets thus becoming part of the refining system of one of the Major IOCs. Prior to this BP took over the European downstream operations of Mobil.
- This trend was reinforced in the early-2000s following the takeovers in Germany of Veba by BP and of DEA by Shell. By this period, the share of the regional players reduced sharply to 32%, and the share of European refineries owned by the Major IOCs reached its peak at 49%.
- The most recent trend has been the increase in the capacity owned by independent refinery operators, mainly as a result of the majors divesting some of their assets. The most visible has been Petroplus, which has made a total of eight refinery acquisitions since 1998. Ineos and LyondellBasell have also entered the industry recently, acquiring refineries from BP and Shell respectively. In these cases it was through the acquisition of associated petrochemicals operations. These have been in addition to more established independent companies such as Saras and ERG, in Italy. There are now 13 Independent companies, representing over 18% of capacity
- The presence of overseas divisions of the NOCs has been relatively small, with less than 5% of total capacity.
- The amount of capacity owned by the Majors has reduced by 20 million tonnes since 2002, to only 46% of European capacity. The one exception to this trend has been the acquisition of the Wilhelmshaven refinery in Germany by ConocoPhillips from Beta, a private company.

## The UK and Switzerland are both good examples of different market structures and logistics

- In the following slides we use the UK and Switzerland as examples of different types of downstream ownership and participation in distribution and sales.
- These countries represent two ends of the spectrum of market structure in Europe and exhibit features found in all European markets.
- The UK has many refineries owned both by IOCs and independents. All of the refineries are on the coast and there is an extensive pipeline system used to reach the main inland demand centres. The supermarkets have a large share in the retail sector.
- Switzerland by contrast is located inland and has only two refineries, now owned by independents. The market is short of product which is imported from both the North and South of Europe. The retail sector is dominated by independent companies with a limited presence of the supermarkets.

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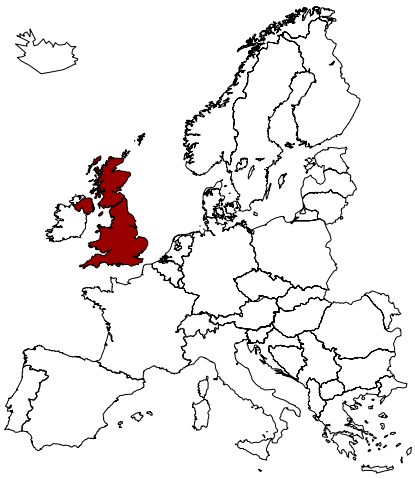
## Industry structure – UK: large refining base, Major IOCs active, increasing industry fragmentation

- Offshore crude oil production
- Crude supplied by tanker, from Baltic Sea, West Africa, Mediterranean or Middle East
- Large refining base of 1.9m B/D: 11 refineries, owned by ten companies, all on coastal locations
- Major oil companies very active, with 63% of refining capacity and 53% of retail stations (by brand)
- Refinery sales by pipeline, tanker and local truck distribution. Extensive logistics network
- Supermarkets operate about 12% of retail sites, but account for around 40% of retail sales
- Evidence of increasing industry fragmentation, as a result of sales of refineries and retail sites by Majors to independents



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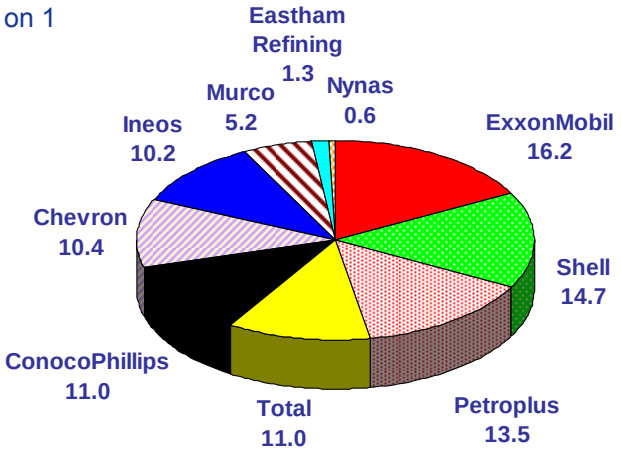
- The UK has a large offshore oil-producing region, the majority of which is within the North Sea. Crude is loaded to tankers offshore or transferred to land terminals by pipeline. The refineries at Grangemouth and Teesside receive North Sea crude oil directly from crude export terminals by pipeline. The other refineries receive crude oil at their jetties by ship, sourcing it from a wide variety of locations.
- According to location, refined products are distributed either by pipeline to inland terminals, by coastal shipping to other terminals, or direct truck sales for inland distribution. Refineries and coastal terminals also serve as the central point for product imports and exports by long-distance shipping from/to overseas sources/destinations.
- Many of the Major IOCs are active in the UK downstream, with refining and distribution / sales presence of Shell, ExxonMobil, Chevron, ConocoPhillips and Total. BP has now sold its refineries to Ineos (the Grangemouth refinery) and Petroplus (the Coryton refinery) and is present only in the distribution sector. There is also an independent refining presence by Ineos and Petroplus, as well as independent retail-only operations by small, private companies as well as the supermarkets (see below).

## UK refining capacity is evenly spread across eight companies, plus two small asphalt refiners

Refining Capacity on 1 Jan 2008: Million Tonnes / Year




- **Five refineries are owned by the Major IOCs (with Shell also having a part-share in Eastham)**
- **Independent companies are represented by Petroplus (with two refineries) and Ineos**

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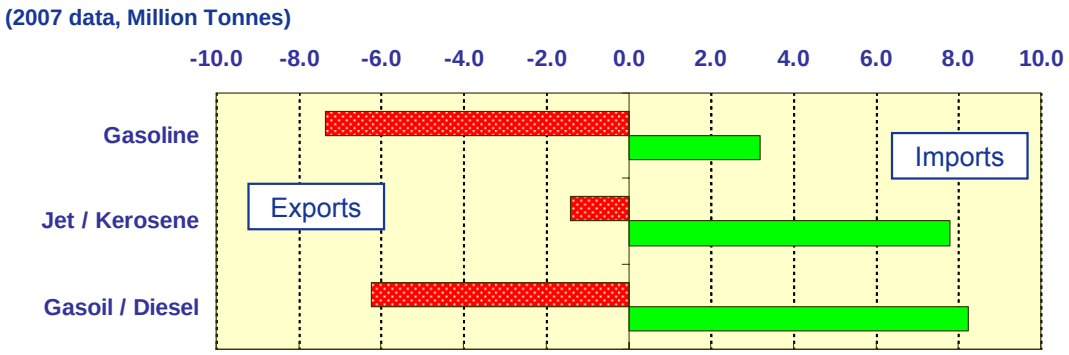
- Most of the Major IOCs are present in the UK refining sector, the exception being BP which sold its two refineries to Ineos and Petroplus.
- As a result of these transactions, independently-operated refineries account for 26% of UK refining capacity. This includes the specialist refiner AB Nynas, which in addition to its own plant in Scotland also owns a 50% share of the Eastham Refining Company with Shell.
- The largest share of refining capacity by any one company in the UK is owned by ExxonMobil, with 16% of total UK capacity. This capacity is at a single, very large site located at Fawley, near Southampton.
- The refining base is also distributed across the country. As the majors generally have just one refinery location but national retail coverage, the majority of fuel supplies are by exchange agreements and swaps, where refiners supply product to retailers at market-related prices in one part of the country in exchange for a reciprocal arrangement with another refiner in another location.

## Light products are actively traded in the UK




- Although the UK has a production surplus of gasoline, some distribution companies import gasoline because of supply and logistics advantages
- The UK has a sizeable jet/kerosene deficit, mostly sourced from the Middle East
- There is considerable trade in gasoil/diesel, with the UK predominantly exporting heating oil but importing diesel

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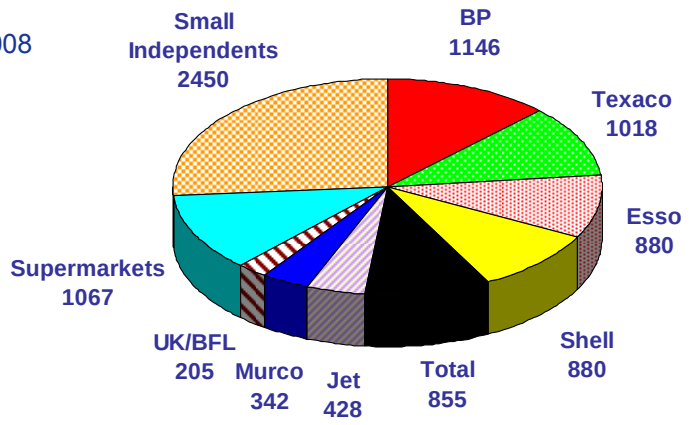
- Owing to its large refining base the UK is a substantial manufacturer of refined products. However, there is of active trade in the major light products.
- As gasoline demand is in decline, by about 3%-4% per year, the UK has an increasing surplus which it exports, mainly to North America. However, despite the large surplus there are still imports of gasoline, especially in the southeast of the country.
- As a result of the growth of jet fuel demand, the UK is a net importer of jet /kerosene by about 6.4 million tonnes, with demand concentrated in the southeast of the country. The imports represented nearly 40% of consumption in 2007.
- The rise in the number of diesel-powered cars, as well as increasing commercial use of diesel (e.g. by trucks for freight), has resulted in the UK becoming a small net importer of gasoil/diesel of about 2.0 million tonnes.
- Although supply and demand of gasoil/diesel are almost in balance, trade in and out of the UK is substantial. This trade is the result of market players seeking overall optimization of their activities. Some refiners may find it optimal to supply locations outside of the UK, while some UK marketers may be able to import products on more favourable terms.
- The large trade flows are also a result of the location of UK refineries relative to product demand. The populous Southeast of England can be served comparatively well from refineries in Belgium, the Netherlands and the North of France. By contrast, the refineries in Wales produce more products than is consumed locally but are well located to export to Ireland.

## The UK fuels sales sector is highly fragmented

Number of Service Stations on 1 Jan 2008




- **Major IOCs account for 52% of service stations**
- **Supermarkets operate only 12% of all retail sites, but account for 39% of fuel sales**
- **Independent retailers operate 28% of sites, although average site throughput is less than the national average**

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- Of the approximately 9,000 service stations, the largest single market share by any one company by number of sites is 13% (held by BP).
- The brands of all the major IOCs are present in fuels distribution and retailing in the UK. However, in some cases, such as Texaco and ConocoPhillips, the sites have been sold to third-party operators. These stations retain the IOC's brand and are supplied exclusively by that IOC under a contract. At the end of the contract period the operator can change supplier, in which case the new supplier would re-brand the station and would be its exclusive supplier for the duration of the new contract. The typical duration of these contracts is 5-6 years.
- The major supermarket chains such as Tesco, Sainsbury's and Morrisons account for about 12% of the service stations. However, their sites, which are typically at the supermarket, are all high-volume operations, with average throughputs of up to 10 million litres/year. As a result, their share of fuels retailing by volume is much greater at 39%. Their product is supplied either directly by refineries or by trading organisations.
- In addition to the supermarkets, there is also a large share of smaller independent retailers, who make up 28% of UK service stations. However, these are generally small sites with an average throughput of below 2 million litres/year, considerably lower than the national average of about 4 million litres/year.
- Retailing, like refining, has high fixed costs and so with high site throughputs, supermarkets are able to price keenly, putting pressure on the local, lower throughput sites. The loss of sales forced many of the smaller sites to close.
- Rationalisation of numbers of service stations has also been a continuous feature of the retail market for several years, with the closure of small, low-throughput sites and development of larger, high-volume stations located along the main highways
- Fuels retailers rely heavily on income from other activities such as shops and car washes to provide adequate income.

## Industry structure – Switzerland: inland market, limited infrastructure and selective presence of Major IOCs

- No local crude oil production
- Crude supplied by pipeline from ports in the Mediterranean
- Only two refineries with total of 120,000 B/D. Limited logistics network, owing to geography
- Nearly all refinery sales by rail car and road tanker
- Refineries operated by an independent refiner-marketer and an independent refiner with no retail operations. Major IOCs active in distribution/retail only
- Retail marketing network dominated by fuels retailers, with minimal supermarket presence

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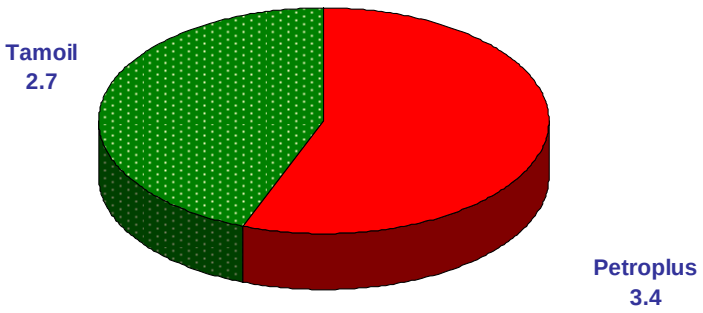
- Switzerland is a landlocked country, with no domestic crude oil production and only two refineries. The production by the refineries is low compared to total refined products demand. As a result, product imports to Switzerland are quite large in relation to product demand.
- Crude oil is delivered by separate pipelines to each refinery. Both originate from crude oil import terminals in the Mediterranean; from Marseilles/Fos-sur-Mer to the Cressier refinery, and from Genoa to the Collombey refinery.
- Owing chiefly to geography, the logistics network is quite restricted, with no product pipelines. Refined products are distributed mostly by rail car and road tanker for internal distribution or for cross-border sales. There is also the option for river barges to supply or export additional volumes via the river Rhine.
- Thus, the structure of the Swiss market is such that the largest distributors of refined products do not own refineries and, as a result of this, there is large trade in refined products between refiners and distributors.
- There is a fairly small presence of the supermarkets.

## There are only two refineries in Switzerland, each of similar size

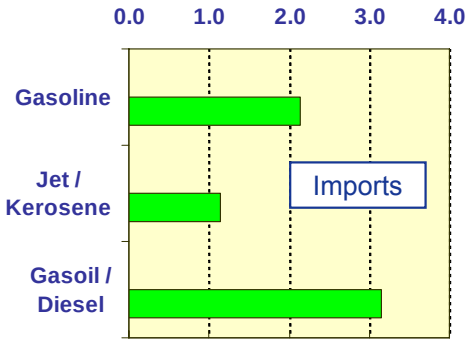
Refining Capacity on 1 Jan 2008:
Million Tonnes / Year




- Total refining capacity in Switzerland is just over 6.0 million tonnes, which is divided between two refineries: Cressier in the north and Collombey in the west, by Lake Geneva.
- The Cressier refinery was purchased from Shell by Petroplus in 1999. The Collombey refinery is run by Tamoil (Suisse), a local subsidiary of the Tamoil group.
- Almost all refinery production is consumed locally, with the only significant exports being of heavy fuel oil to Belgium, France and Germany

## Switzerland needs to import products to meet demand

(2007 data, Million Tonnes)





- Switzerland has to import light products to meet demand which exceeds the capacity of its refineries
- Unlike the UK, the Swiss refineries very rarely export any light products

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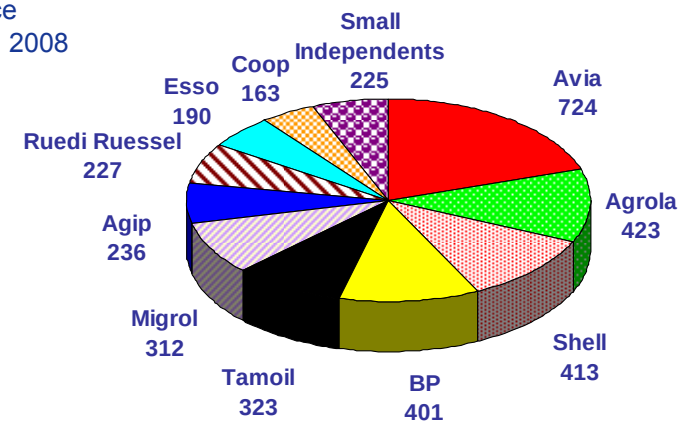
- As refining capacity represents only 50-55% of domestic consumption, Switzerland is a significant importer of light products.
- The main imports are for gasoline and gasoil/diesel. Diesel demand has been growing by 8.0% per year on average since 2003, resulting in growing imports. Gasoline demand is now falling.
- Since the demise of Swissair, jet fuel demand is 20% lower than its peak in 2000. Nevertheless, Switzerland still imports jet fuel, mostly from France and Germany.
- The SPMR oil products pipeline from Fos to Geneva allows import of products from the Mediterranean. A terminal at Basel allows imports by barge via the river Rhine. Some product is also supplied by truck from Northwest Italy.
- Prices in Switzerland would be set by competition among the various options offered by this complex mix of possible supply routes.

## The Major IOCs have a relatively small presence in the Swiss fuels sales sector

Number of Service Stations on 1 Jan 2008




- **There is a significant number of independent operators in Switzerland, accounting for almost 60% of the number of sites**
- **By comparison, the Major IOCs account for less than 28% of service stations**
- **There is minimal presence of supermarkets in fuels distribution and retailing**

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- The Swiss fuels distribution and sales business is characterised by a large number of independent companies. These companies are active either individually, under their own brand name, or under a larger, collective organisation.
- Examples of the latter include both Avia and Agrola, the two retailers with the largest market share by number of stations (21% and 12%, respectively). Avia operates in several continental European markets, including Belgium, France and Germany, and is an organisation that comprises a number of smaller companies. Agrola is an organisation comprising specifically of farming/agrarian companies. Both companies are also active in heating oil distribution as well as transport fuel sales.
- Three of the Major IOCs – BP, Esso and Shell – have a retail presence in Switzerland, but their combined share of the market is less than 30%.
- Average service station throughput in Switzerland is 1.4 million litres/year, although the largest are those on the autoroutes, which average 4.5 million litres/year.
- Unlike the sector in France and the UK, for example, there is a minimal presence of supermarkets in fuels distribution. The largest participant is COOP, with only a 4% share of service stations.

## Section 1 - Overall conclusions

- The oil industry is composed of three main segments, crude oil exploration and production, refining and distribution and sales. Exploration and production of crude oil is commonly referred to as “Upstream” and “Downstream” is a term used to cover refining of crude oil into finished products and the distribution/sale of refined products.
- The industry is very fragmented. The majority of large players are active in more than one segment. However, each segment has also a large number of “independents” i.e. companies that are active mainly in one segment only.
- There are many more distribution and marketing companies than refiners. The large investment needed in the upstream and the refining sector is a barrier to entry.
- The largest and best known oil companies have significant presence in all the main segments of the industry. However this does not mean that they are vertically integrated in the traditional meaning of the term.
- The amount of refining capacity owned by the “Majors” peaked in 2002 with the acquisition of some German regional players by BP and Shell. These companies have more recently divested capacity in other locations

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# SECTION II

## REFINERIES AND REFINERY PROCESSES

## Introduction to this section

- This section provides an overview of how refineries work.
- The role of refineries in the supply chain of the petroleum industry is to process crude oils into the finished products that are needed by the market.
- The section illustrates that refineries can use a variety of processes and can have very different configurations.
- The yield from a refinery will depend on the processes that it has and the type of crude oil that it processes.
- Once a refinery has been built with a certain configuration and designed for a certain type of crude, there is little it can do to change its yield structure significantly without major investment in new processes.
- Changing product demand patterns have had a strong impact on the investment decisions of the European refineries.

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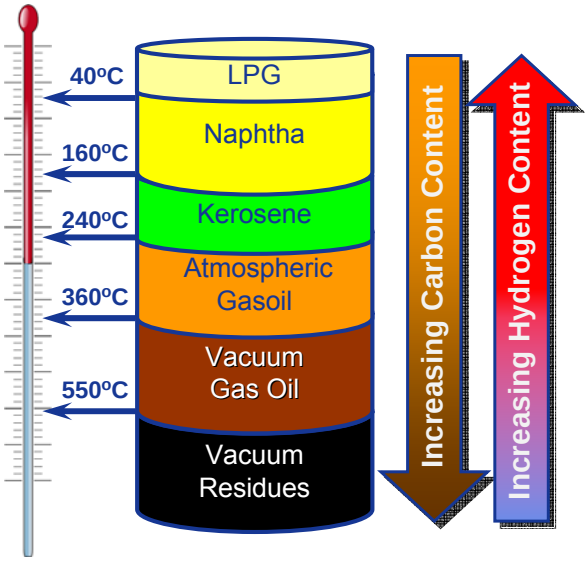
## Crude oil is a broad mix of hydrocarbons, which must be separated and refined prior to commercial use




- Crude oil contains many different hydrocarbon compounds
- Molecules range from very light to very heavy
- The first process of any refinery is the fractionation of crude into different fractions by distillation
- The fractions are characterized in the basis of their boiling temperatures (the values shown are indicative)
- Refineries exploit the different properties of each fraction to produce finished products

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- The first process of any refinery is the fractionation of crude oil into different fractions. This is done by distillation.
- Liquefied Petroleum Gas (LPG) is the lightest fraction and includes only propane and butane.
- As molecules become heavier, chemical structures become more complex and varied. From a certain point, a characterization by chemical compound is no longer practical and boiling temperature ranges are used instead.
- Distilled naphtha includes hydrocarbons ranging from five carbon atoms to about nine. The heaviest molecules contained in the naphtha fraction boil at 150-180ºC. The naphtha fraction includes those hydrocarbons that produce good quality gasoline, following relatively simple additional processing (see later).
- Kerosene includes hydrocarbons boiling at a temperature of around 200ºC (a typical average), with the boiling range normally chosen to produce a fraction suitable for processing to jet fuel.
- Atmospheric gasoil includes all of the hydrocarbons that boil between kerosene and up to 350-370ºC. This fraction normally has good combustion properties in diesel engines and is therefore used for the production of automotive diesel, following simple upgrading processes (see later). The gasoil fraction is also used for heating and industrial purposes.
- At higher temperatures hydrocarbons start decomposing. At 370-380ºC the distillation process must be stopped, and the remaining fraction that has not been recovered is referred to as the "atmospheric residue".
- The distillation can continue under vacuum conditions, which reduces the temperature at which molecules boil off. This also helps to explain why the next fraction, which includes hydrocarbons boiling up to 530-560ºC, is commonly referred to as "vacuum gasoil".
- The fraction that cannot be recovered even by vacuum distillation is referred to as vacuum residue. This is the heaviest crude oil fraction.

## The processes used by refineries can be classified into four categories

**SEPARATION**

- Crude oil distillation
- Vacuum distillation
- Solvent extraction

**TREATING (Quality Improvement)**

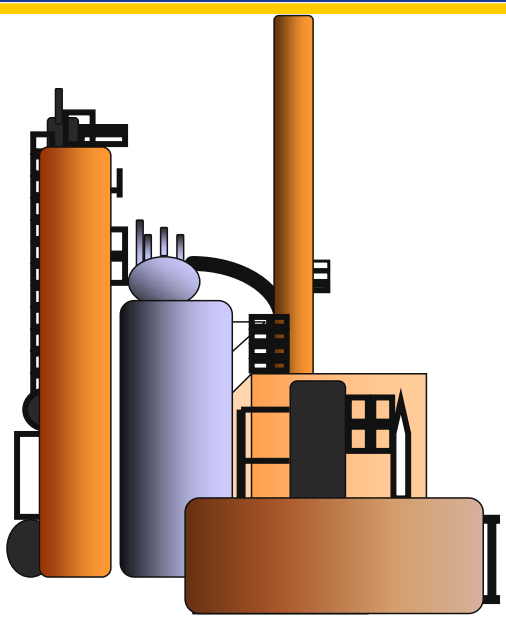
- Reforming
- Isomerisation
- Hydrotreating

**CONVERSION**

- Visbreaking/Thermal cracking
- Catalytic cracking
- Hydrocracking
- Coking

**TRANSFORMATION**

- Alkylation
- Etherification



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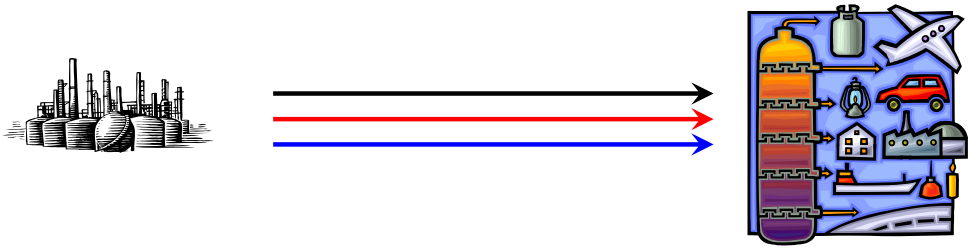
- Each refinery is different. The configuration of a refinery can be characterized on the basis of the processes employed to transform crude oil into refined products. Refinery processes can be classified into four categories.
- **Separation processes** separate mixtures including crude oil into fractions by distillation only, as no chemical reactions take place. The proportion of each fraction recovered is determined by the quality of the hydrocarbon processed.
- **Treating processes** improve the quality of petroleum fractions distilled in order to meet the specifications of finished products. Reforming and isomerisation "upgrade" naphtha into gasoline, as naphtha by itself is not suitable as a motor fuel. Hydrotreating processes use hydrogen and catalysts to remove sulphur and other contaminants.
- **Conversion processes** promote cracking reactions that break down less valuable, heavy hydrocarbon molecules into more valuable, lighter ones.
  - *a catalytic cracker uses catalysts and high temperature to crack vacuum gasoil or residue into mainly gasoline, gasoil and LPG.*
  - *a hydrocracker uses catalysts, hydrogen, high pressure and high temperature to crack vacuum gasoil or residue into mainly gasoil, kerosene and naphtha.*
  - *visbreaking, thermal cracking and coking use high temperature only to crack vacuum gasoil or residue.*
- In every conversion process, the cracking step is followed by recovery of the converted fraction by distillation. Depending on their quality these fractions are fed to treating processes for upgrading to finished refined products.
- **Transformation processes** are used to produce new compounds. Alkylation and Etherification are used to convert LPG from a cat cracker into gasoline blending components. Etherification with bio-ethanol can also be used for making bio-ether as part of a biofuels programme.

## Many "everyday" products originate from oil and oil refineries



| Refined products | Examples of general uses |
|---|---|
| LPG | Domestic cooking, heating, motor fuel |
| Naphtha | Solvents, feed to petrochemicals (for plastics, fibres) |
| Gasoline | Motor fuel and small aviation |
| Jet/Kerosene | Jet fuel, domestic heaters, solvents, petrochemicals |
| Gasoil | Domestic heating, petrochemicals |
| Diesel | Motor fuels, agricultural vehicles, small boats, trains |
| Heavy fuel oils | Power generation, fuel for large ships |
| Lube oils | Lubricants |
| Waxes | Waxes, polishes, candles, food paper |
| Bitumen | Road asphalt, roofing materials |

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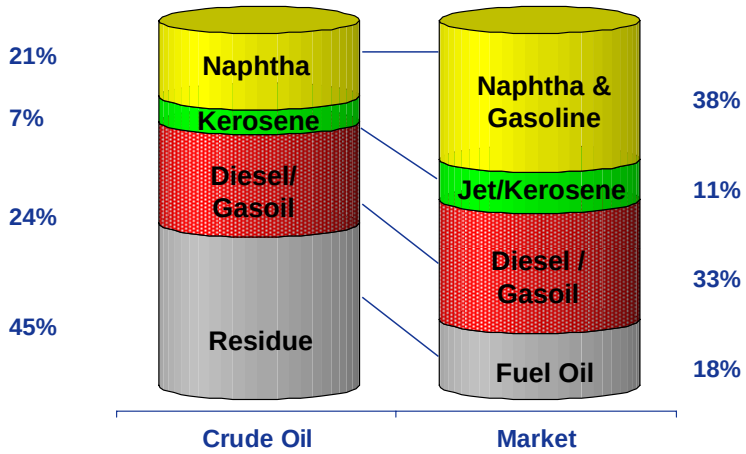
- Refineries produce a wide range of products commonly used in everyday life. The majority of refineries produce all or most of the six main products, i.e. LPG, gasoline, diesel, heating gasoil, jet fuel and heavy fuel oil. Naphtha is produced at refineries and traded to petrochemicals plants for the production of materials such as plastics and fibres.
- Products such as lubricants, waxes and special grades of bitumen are consumed in significantly lower volumes and are produced at a reduced number of specialized refineries. These are commonly referred to as "speciality refineries" to distinguish them from the majority of refineries, which are "fuels refineries". It should be noted that the speciality refineries also produce 'conventional' fuels alongside the speciality products.
- The six main refined products, as well as naphtha, are commodities, produced to standard specifications and traded within the various world regions or between different regions. They offer very limited opportunities for product differentiation in the market.
- The markets for lubricants, waxes and bitumens offer better opportunities for differentiation on the basis of product quality although still having to comply with standards. Lubricants and waxes require a considerable amount of treating to produce finished products.
- Lighter products, from liquefied petroleum gases (LPGs) to gasoil and diesel, are generally the most valuable among the commodity products, and also those with which the general public will be the most familiar. Fuels for transportation (i.e. automotive LPG, gasoline, diesel and jet fuel) account for about 64% of total petroleum demand in Europe (compared with 54% of total petroleum demand worldwide).
- Heavy fuel oil normally has the lowest value among the commodity products. It is used for large industrial boilers, in oil-fired heaters and, to a lesser extent, for heating. A growing part of the heavy fuel oil market is its use in low-speed marine engines to power ships, a segment referred to as bunker fuels.

## Refineries need to convert some residue to light products in order to keep markets supplied




- The average yield obtained from crude oil distillation does not match the proportion of products demanded by the market
- To rectify this refiners use different combinations of conversion and treating processes to produce more lighter products from residue

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- A refinery without conversion processes obtains a yield of refined products similar to the fractions obtained by simple crude distillation, which is modified only marginally by treating processes. However, this yield does not match the market demand profile in most markets.
- The proportion of residue that results from the distillation of an average quality crude oil is considerably greater than the combined shares of demand for residue type products, such as industrial fuel oil, marine bunker fuel and bitumen. Demand for transport fuels is considerably higher than that which can be produced simply by crude distillation and the treating of the processed fractions.
- This was not always the case or not to this extent. Use of heavy fuel oil by industry or for power generation used to be a much larger percentage. However, with the economic boom of the 1960s, European demand for light transport fuels started growing at much faster rates than total oil demand. This created the need for the refining industry to implement conversion processes, such as converting residues to gasoline, to change refinery yields and be able to follow market demand more closely.
- In the 1980s natural gas started replacing heavy fuel oil in the industrial and power generation sectors, with the result that demand for heavy fuel oil started falling. This added to the pressure on the industry to add conversion capacity, to convert heavy products into lighter ones.
- As a result of the various investment decisions made by refineries, there are now several types of refinery configuration in Europe. These are discussed later in this section.

## Refined products must meet many quality specifications. Some of the most important are listed here

Gasoline / Diesel

Sulphur content
Combustion properties
Volatile organic compounds (VOCs)
Density

Jet/Kerosene

Smoke point
Freeze point
Water content

Other Gasoils

Sulphur content
Combustion properties
Cold Flow Properties
Density

Heavy Fuel Oil

Sulphur content
Viscosity
Density

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- **Combustion properties:** are set in relation to the type of engine or device in which the fuel is burnt. In gasoline engines the fuel is ignited in a controlled manner by a spark and must not ignite spontaneously. A high octane number is the parameter that guarantees good combustion behaviour in the gasoline engine. In diesel engines, the fuel must ignite smoothly as a result of heating by compression; the appropriate parameter for road diesel is the cetane number. For jet fuel, combustion should be as smoke free as possible, determined by the fuel's smoke point. Heavy fuel oil must have a certain viscosity related to the design of the equipment that burns it. This ensures that the fuel can be atomized into small droplets, helping its combustion.
- **Environmental and health-related properties:** In the last 15 years there has been a strong focus on the impact that fuels have on health and the environment. Following the removal of lead in gasoline there has been a progressive reduction of the maximum allowed sulphur content in fuels. Limits have also been put on volatility to reduce harmful vapours, and on the maximum allowable content of certain hydrocarbon species that are known to be carcinogenic, such as benzene.
- **Cold flow properties:** the heavier the hydrocarbon, the more liable it is to solidify at low temperatures. However, a fuel or a lubricant must continue to flow at the temperature it is intended to be used. For example, jet fuels must not freeze at temperatures of -40 to -50ºC; diesel fuel and lubricants must not freeze in cold winter weather (not an issue of concern for gasoline as it is lighter and does not solidify at such temperatures).
- **Safety related properties:** fuels must meet specifications devised to mitigate safety risks involved with their handling and storage. An example is the flash point - the temperature at which fuels will ignite in the presence of a naked flame.
- All products must be virtually free of water.

## Specifications have evolved to improve the environmental performance of fuels

| Pre - 1980s | 1980s | 1990s | 2000s |
|---|---|---|---|
| **Mainly combustion and handling properties** | **Europe begins to tackle Lead and sulphur** | **EU Auto Oil set basis of new standards** | **Movement towards sulphur free fuels** |
| Combustion and safe handling set specification requirements, but environmental issues start emerging. | Unleaded gasoline introduced. Effort to tackle smog and acid rain by reducing SOx emissions gathers pace. | European standards introduced for gasoline and diesel. Auto Oil programme begins. Lead phased out, benzene capped, sulphur reduced | Diesel and gasoline are sulfur free. Sulfur of heavy fuel oil and heating fuels reduced further. The emphasis has now moved towards marine fuels. |
| Sulphur in fuels:<br>Diesel: >0.5%<br>Heavy fuel oil: >3.0% | Diesel: ~0.2%<br>Heavy fuel oil: 1-4.0% | Diesel: 0.05%<br>Heavy fuel oil: 1-4.0% | Diesel: sulphur free<br>Heavy fuel oil: 0.25-1.0% |

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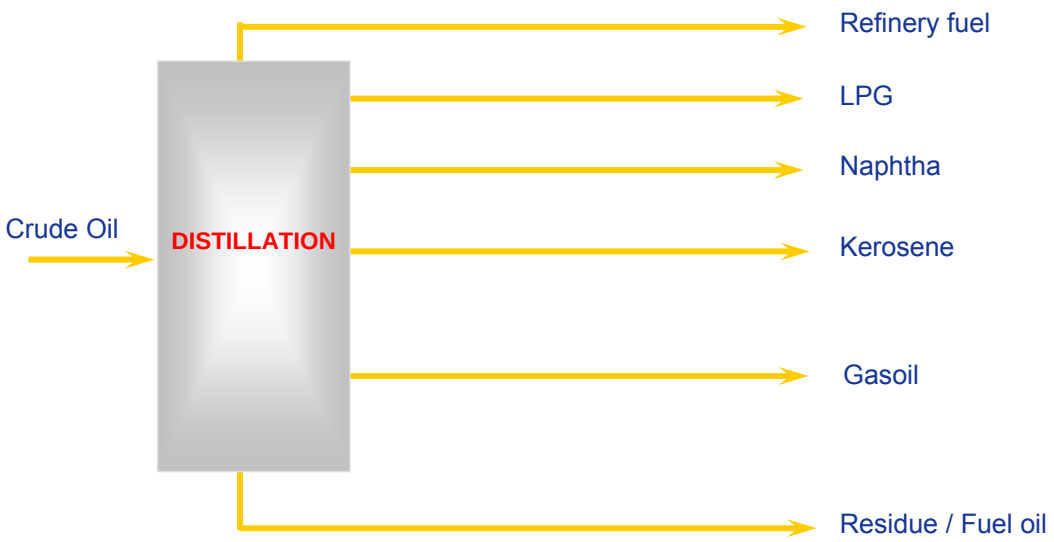
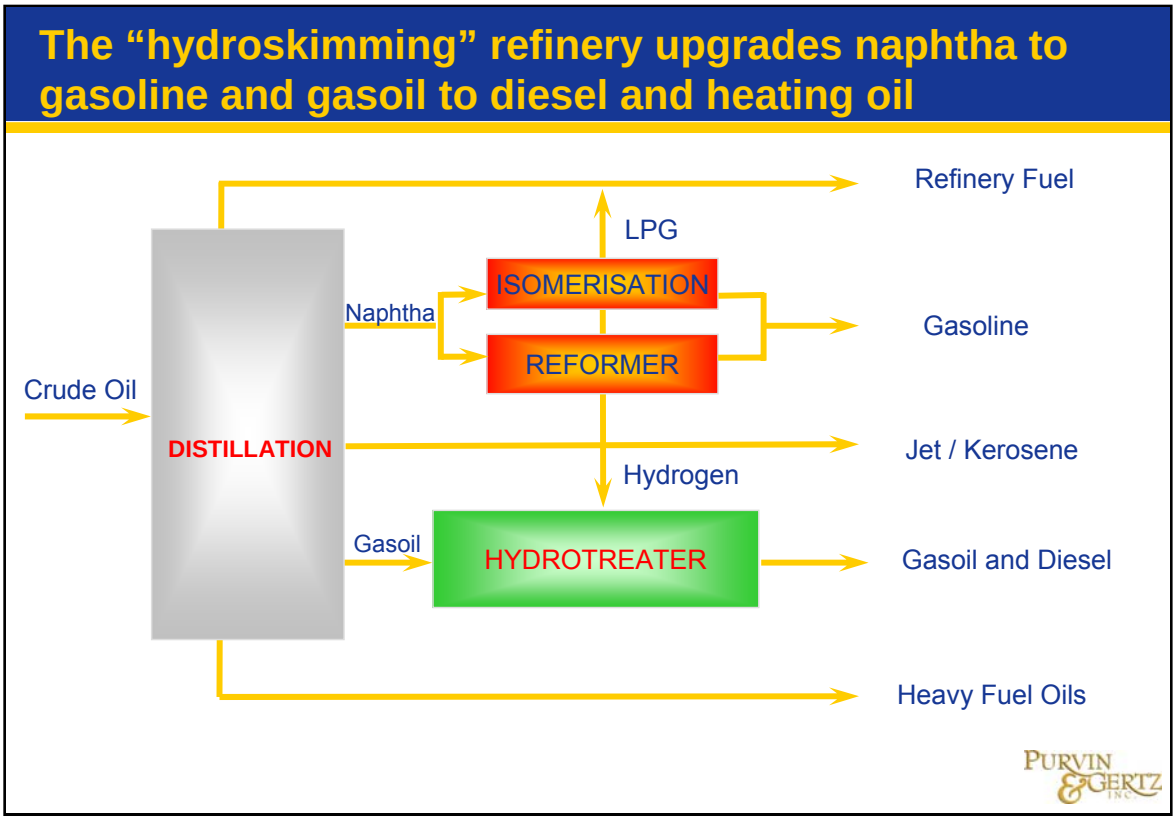
- For a long period of time the specifications of oil products have remained related to combustion and safe handling. At the beginning of the modern era of the oil industry, which can be see as coinciding with the rapid expansion of demand that followed the post World War II economic boom, focus on environmental issues was low in comparison to desire of feeding the growth of demand for energy and mobility.
- Oil was considered the life blood of the economy and modern life, but the increase of emissions resulting from oil consumption also increased awareness of the environmental impact. The issue was not specific to the oil industry as coal is a much more polluting fuel.
- In the last 30 years specifications have progressively evolved to take on what was considered the worst cause for concern at the time.
  - *The sulphur content of diesel and fuel oil was reduced in the 1980s.*
  - *Unleaded gasoline was also introduced in the 1980s with the widespread use of catalytic converters to reduce tail-pipe emissions from cars. Leaded gasoline was then phased out throughout the 1990s.*
  - *The benzene content of gasoline was capped at 1vol% in 1996 and the sulphur content of diesel was reduced further at the same time.*
  - *Between 2000 and 2009 diesel and gasoline have been made sulphur free and the specification of diesel has been enhanced to reduce the emission of particulate matter from diesel engines to a fraction of what it would have been only 10-15 years ago.*
  - *Inland facilities are now required to burn fuel oil with a maximum sulphur content of 1% and in some cases even 0.25%.*
- The refining industry has made large investments over the years to comply with these specifications.

## The "topping" refinery is the simplest configuration, with no conversion or treating

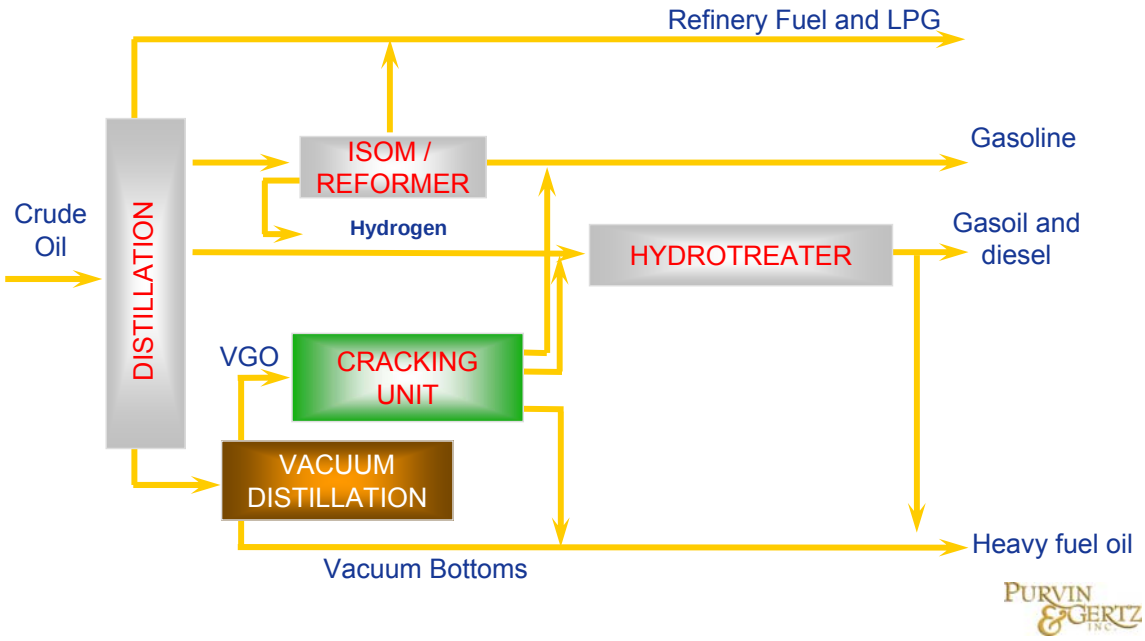



- Topping is a term commonly used in the industry to refer to the atmospheric distillation of crude, so called because a simple crude distillation unit distils the "top" off the crude. Crude distillation units are also referred to as "topping" units, and crude distillation capacity is often referred to as "topping" capacity.
- Although topping is the simplest configuration, it does produce some products suitable for use in the end-market.
- Fuel gas is used as fuel for the refinery and is not a tradable product.
- LPG is a finished product after removal of some contaminants by relatively inexpensive processes.
- Naphtha has a market as feedstock for petrochemicals plants.
- Kerosene has a market as domestic heating fuel, or it can be upgraded to jet fuel, simply by removing some contaminants by relatively inexpensive processes.
- Gasoil obtained from some very low-sulphur crude oils can meet heating oil specifications, although a recent tightening of specifications has greatly reduced the range of crudes suitable for this purpose.
- As no crude oil can produce gasoil that meets current European diesel quality specifications without desulphurisation, topping refineries cannot produce diesel for the European market.
- The atmospheric residue is a fuel oil with a quality that can vary, depending on the quality of crude processed. As an example, low-sulphur crudes produce higher quality low-sulphur fuel oils.
- Products such as naphtha, kerosene, gasoil and residue as obtained directly from distillation are often referred to as "straight run", as they are produced without any upgrading or conversion processes.



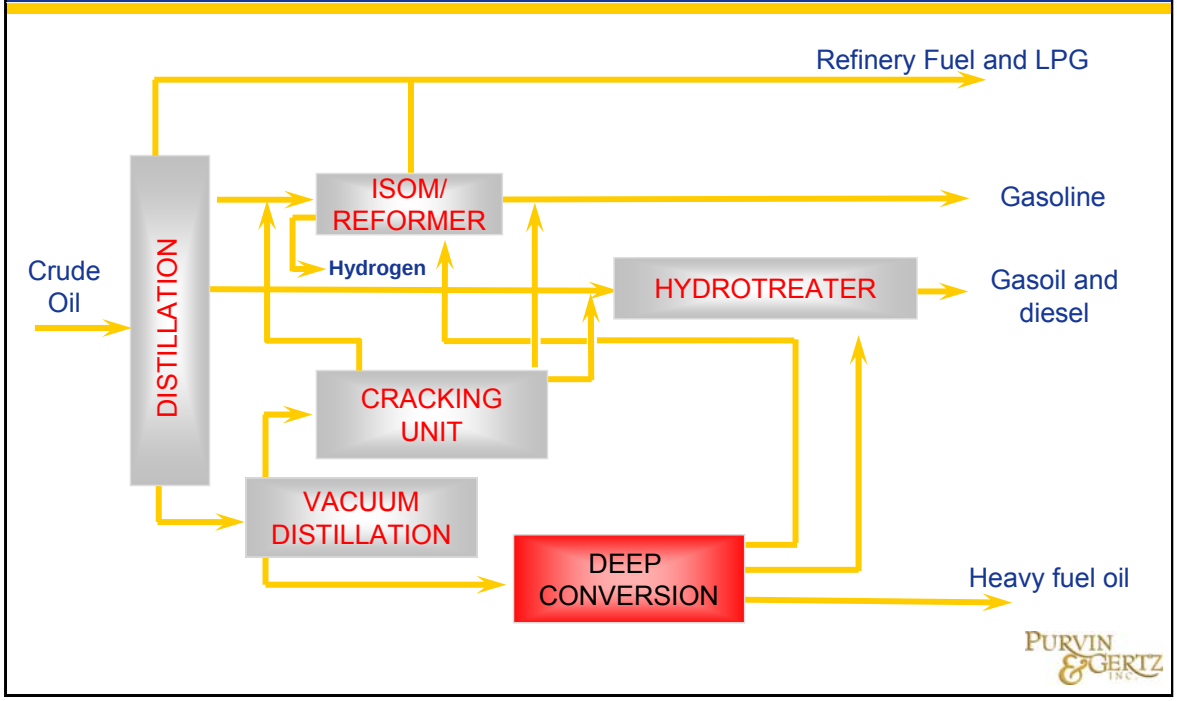

- The naphtha produced from distillation (straight run naphtha) is rich in normal-paraffins, which is a hydrocarbon species with low octane number and therefore not suitable for blending to gasoline. Straight run naphtha can be used for production of a wide range of petrochemicals.
- For the purpose of producing gasoline, naphtha is split into a light fraction and a heavy fraction.
- The reformer increases the octane number of heavy naphtha by converting a large proportion of it into a very high-octane mix of hydrocarbons. The isomerisation process increases the octane number of light naphtha by changing normal paraffins into iso-paraffins. This small modification of the hydrocarbon structure produces a substantial increase of octane. There is an upper limit of 35vol% aromatics in the gasoline specification in Europe. Because of this, European hydroskimming refineries can no longer rely solely on the reforming process to increase octane. Most European hydroskimming refineries now use the isomerisation process to upgrade their light naphtha as isomerate is low in aromatic content.
- A by-product of the reforming process is hydrogen, which can be used in hydrotreater units. These units remove sulphur from the straight run fractions, a treatment which is necessary to upgrade straight run gasoil to diesel. There are other possible applications of hydrotreating processes in refineries, but the production of diesel is the most common.
- Hydroskimming refineries must normally produce some gasoline in order to have the hydrogen needed to produce diesel. This link reduces the freedom of refineries to optimize gasoline and diesel production independently.

## The "cracking" refinery converts some fuel oil components into light products



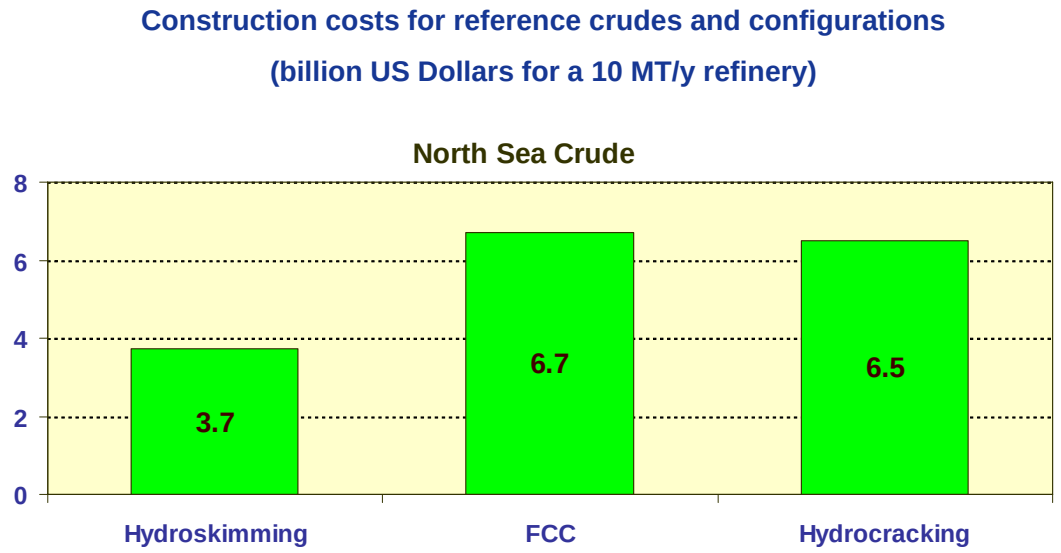

- In a cracking refinery the atmospheric residue is distilled under vacuum conditions to recover vacuum gasoil (VGO) and leave a vacuum residue. The use of vacuum conditions lowers the boiling point of the components being distilled and avoids the thermal cracking that would take place at higher temperature.
- VGO is fed to a cracking unit that converts part or most of it (depending on the technology used) into a mix of hydrocarbons that boil in the atmospheric distillation range. The most commonly used technologies are Fluid Catalytic Cracking (FCC) and Hydrocracking.
- FCC makes a greater proportion of gasoline and produces a small volume of poor quality gasoil. In the jargon of the industry this is described by saying that the FCC has a higher selectivity to gasoline. FCC was the preferred choice of European refineries in the 1970s and the 1980s, when there was strong growth in gasoline demand.
- Hydrocracking makes a greater proportion of good quality diesel and jet fuel. In the 1990s the focus shifted towards diesel, resulting in a gradual increase in investment in hydrocracking. In recent years, diesel and jet fuel have become products in very short supply in Europe, such that hydrocracking has become the preferred technology.
- There are relatively few remaining examples of refineries that have chosen thermal cracking to convert VGO as the diesel produced has low quality that does not meet current specifications.
- FCC gasoline must be blended with other gasoline components to meet European specifications. The proportion of gasoline and gasoil produced by an FCC refinery is relatively fixed. The ability to change yields and reduce gasoline production is limited by a number of constraints.
- Hydrogen produced from reforming is not sufficient to feed a hydrocracker, such that a hydrocracking refinery needs an additional dedicated hydrogen supply. Hydrocracking refineries can be designed with a greater ability to vary the relative yields of diesel and gasoline, resulting in an increased refinery flexibility.

## Deep conversion refineries also convert vacuum residue



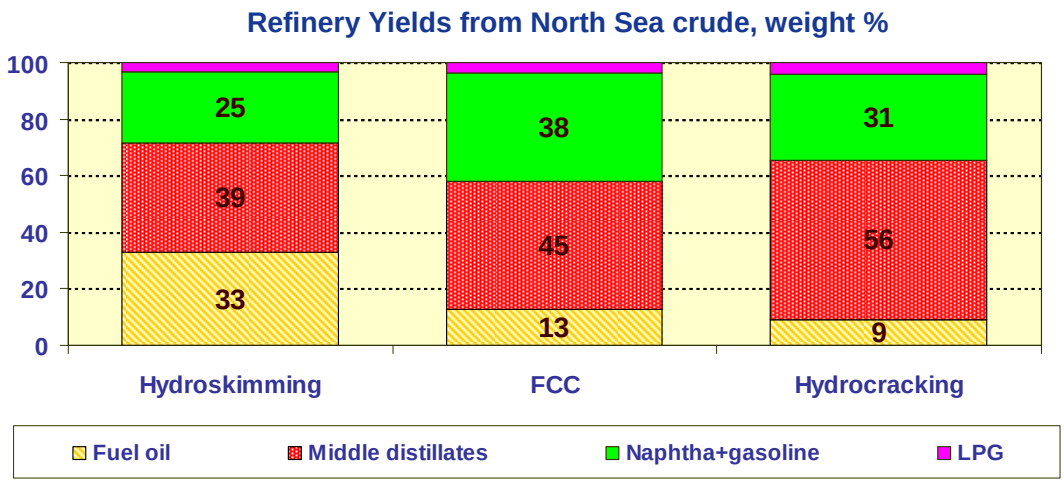

- A "deep conversion" unit converts vacuum residue into lighter products. These are the most sophisticated types of refineries.
- Examples of deep conversion technologies used in Europe are:
  - ***Residue FCC.*** *An FCC unit designed to crack residue as well as VGO. With good quality residues the additional cost to install a residue FCC instead of a standard FCC is moderate. Owing to the supply of suitable light crudes from North Africa and the North Sea, cracking of residues in blends with VGO is quite common practice in Europe. A residue FCC can achieve a conversion to light products of over 70wt%, but produces mainly gasoline.*
  - ***Residue hydrocracking*** *cracks residues rather than VGO. However, the incremental cost relative to a VGO hydrocracker is large, irrespective of the feed processed, and is therefore generally used for low-quality residues. It can achieve a conversion to light products of up to 60wt%. At lower rates of conversion the unconverted residue is of sufficient quality that it can be used to feed a residue FCC. The unconverted oil can also be used as low sulfur fuel oil.*
  - ***Delayed coking*** *is a very high-severity form of thermal cracking. It can achieve a conversion to light products in the region of 70wt%, the remainder being fuel gas and a solid petroleum coke. If the coker feed originates from crudes with low sulphur and metals content, the coke may be suitable to produce the anodes needed by aluminium smelters. In the opposite case petroleum coke is a very low quality fuel.*
  - ***Gasification.*** *In this process the residue is converted to synthetic gas, which is typically used as fuel for electricity generation or for hydrogen extraction.*
- **Visbreaking** is a technology very common in Europe. It is a mild thermal cracking of vacuum residue, which achieves a conversion to light products only in the order of 20-30wt%. Although the technology is used to convert vacuum residue, it is not classified as a deep conversion technology because of the modest level of conversion. Refineries with a visbreaker are not classified as deep conversion refineries

## Higher conversion refineries cost considerably more to build



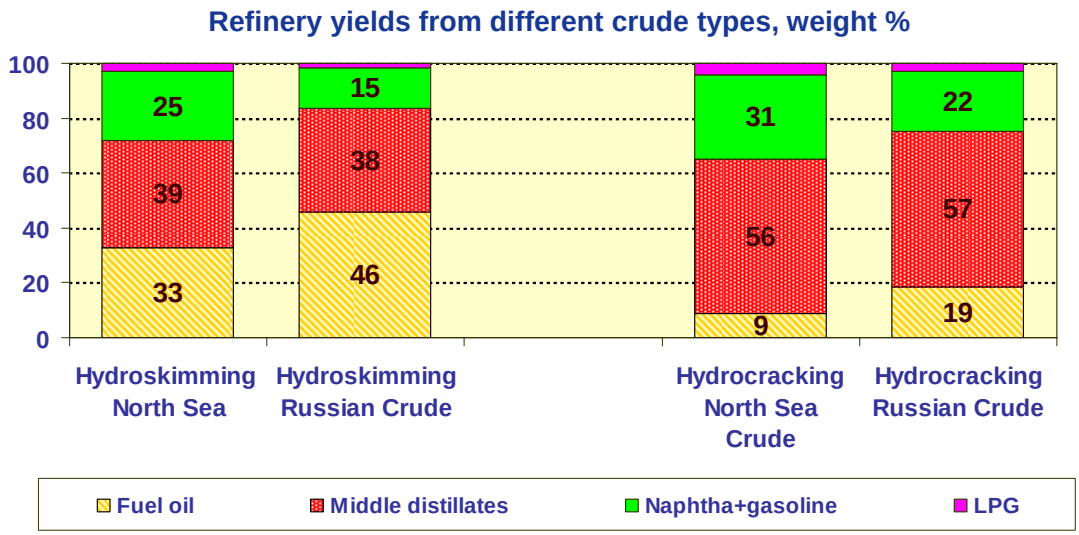

- The cost to build a 10 million tonne per year hydroskimming refinery at today's (2008) construction costs would be in the region of $3.5-4.0 billion.
- The costs increase substantially for a VGO cracking refinery. The total cost of a project to build a 10 million tonnes per year conversion refinery would be in excess of $6 billion.
- A typical project to add a hydrocracking complex of average size to an existing refinery would cost around $3 billion. Upgrading projects that include deep conversion capacity or expansion of crude capacity can cost several billions.
- The European refining industry operates about 800 million tonnes per year of capacity with average complexity somewhat higher that our FCC or hydrocracking benchmarks.
- A very rough estimate of the cost of rebuilding the existing European refining capacity would be close to $1 trillion. This equates to about half the annual GDP of Germany and much more than the entire annual GDP of any European country, except for the largest five.
- These sums are large by most standards. Any development that makes large investments necessary without providing an adequate return is viewed as a threat to the viability of a refinery. An "exit" option is often available and when difficult decisions are needed there is always a strong temptation to close (or sell) refineries and release funds to invest elsewhere.

## Different refinery configurations have different yields



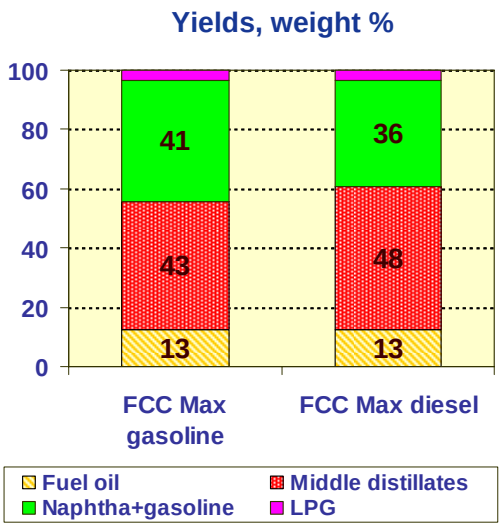

- An hydroskimming refinery designed to process North Sea crude (e.g. Forties) would achieve a fuel oil yield of approximately 33% of total finished products. Naphtha/gasoline accounts for approximately 25% and middle distillates (i.e. the total of jet fuel, diesel and heating oil) 39%. The remainder is LPG.
- An FCC refinery processing the same crude cracks the vacuum gasoil and usually has a visbreaker to process the vacuum residue. As a result of the conversion, the fuel oil yield of this refinery is only 13% of total finished products.
- The fuel oil yield of a hydrocracking refinery is similar to that of an FCC refinery, but a greater proportion of light products is middle distillate. The gasoline yield is correspondingly lower.
- No refinery can make 100% of one product. Different types of process units provide the refinery with higher yields of one product versus the others. However, all refineries make a variety of products.

## The quality of crude processed also has a significant impact on the refinery yields




- Owing to the different quality of various crude oils, the choice of crude will also have a significant impact on refining yields. Some crudes, such as those from Russia, have a higher proportion of residue than most North Sea crudes. Crudes with a high proportion of residue are referred to as “heavy crudes”, the opposite being “light crudes”.
- The other property generally used to classify crudes is the content of sulphur. Crudes with less than 0.5wt% of sulphur would be regarded as “sweet”, while crudes with more than 1% would be considered “sour”. Sweet and sour are common terms used in the oil industry to indicate low or high content of sulphur.
- Most of the North Sea and the North African crude is light and sweet. Most of the Russian and the Middle Eastern crude that is exported is sour and heavier. However, a typical Russian and Middle Eastern crude would not be considered very heavy, because it is still significantly lighter than Venezuelan and some Mexican crude.
- An hydroskimming refinery that chooses to process Russian crude, such as Urals, instead of a typical light sweet North Sea crude will produce much more fuel oil. This is because Russian crude has a much higher content of atmospheric residue and a lower content of lighter products than most North Sea crudes.
- Russian crude has also a much higher content of vacuum residue than North Sea crude, such that even after adding vacuum gasoil conversion capacity (e.g. hydrocracking) the fuel oil yield remains higher compared with that from the North Sea crude.
- In addition to this, the fuel oil produced from Russian crude has a higher content of sulphur and, thus, lower value. Refineries that have deep conversion capacity have a greater incentive to process high sulphur crudes, from which they obtain a higher profit because of the lower cost of crude.

## In the short term there is little a refiner can do to modify its yield structure




- Once a refinery has been built with a certain configuration, there is little it can do to change its yield structure, unless investments are made to change the configuration.
- The crude slate could be changed. However, if it has been designed for a certain type of crude, it would tend to find it optimal to process crudes of this or similar quality.
- It could modify its mode of operations by switching, as an example, from maximum gasoline to maximum diesel
- However, it would be unlikely to have the flexibility to "swing" more than 5% of product from gasoline to diesel and vice versa.

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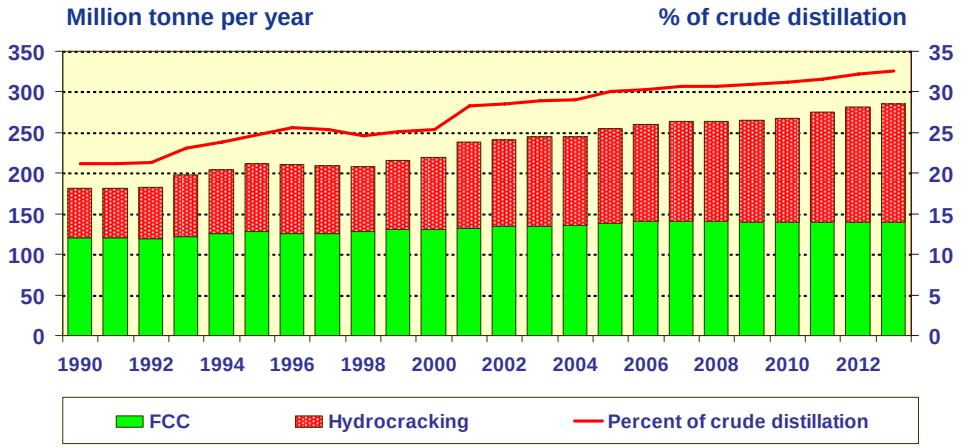
- Once a refinery has been built with a certain configuration and designed for a certain type of crude, there is little that can be done to change its yield structure significantly without investment in new processes.
- The refinery could process different crudes, but this may introduce a number of technical constraints that could prevent it from making an optimal use of its capacity, thereby reducing profitability.
- The refinery would tend to find that its profitability is higher when its conversion capacity is fully utilized. So, if the refinery has an FCC, which is a conversion process with high selectivity to gasoline, it would normally choose to utilize it at maximum capacity, irrespective of its possible desire to produce less gasoline and more diesel.
- The refinery has the ability to change the yields of its process units slightly. As an example, a crude distillation unit that fractionates Brent could have a yield of naphtha anywhere in the 20-24wt% range, depending on how the unit is designed and operated. The same is true of an FCC, where the amount of product recovered as gasoil could be adjusted to a small extent.
- The ability to use daily operating decisions to change the yield structure of a particular refinery is subject to a number of technical as well as commercial constraints and is normally fairly limited. No refinery has the ability to change its yield structure radically without changing its configuration.

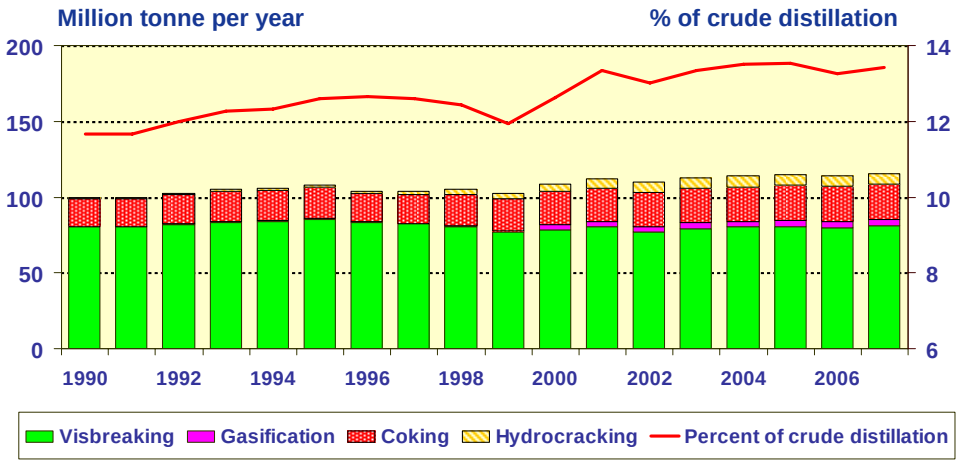
## Changing demand patterns have driven refinery investments away from FCC and towards hydrocracking




- Most FCC capacity was built in the 1970s and 1980s to keep pace with growing gasoline demand. This capacity continues to be operated but gasoline demand is now falling, requiring increased levels of exports. The last two FCC units built in Europe were at the Kralupy refinery (2001) and the Collombey refinery (2003). Both had specific local factors that drove the decision.
- Diesel demand is growing whilst gasoline is in decline. The focus of European refineries has now shifted firmly to diesel. The majority of refinery upgrading projects completed since the 1990s were based on hydrocracking. The bias to hydrocracking is even stronger for ongoing projects.
- Adding the portfolio of ongoing refining projects to existing capacity allows a reasonable projection of the capacity that is expected to be on stream in the year 2013.
- In 1990 FCC capacity was much higher than hydrocracking capacity, but hydrocracking capacity is catching up rapidly. In 2008 hydrocracking capacity represents 47% of the VGO conversion capacity in Europe. By 2013 hydrocracking capacity is expected to exceed FCC capacity.
- A large percentage of the hydrocracking capacity built before 2000 was designed for partial conversion and the unconverted residue would typically be cracked by an FCC. For this reason, FCC has continued to make a higher contribution to conversion of vacuum gasoil.
- The proportion of hydrocrackers designed for full conversion is increasing. These units produce a high yield of diesel and kerosene, but some gasoline and naphtha are also produced
- Some of the FCC capacity is used to crack residues and serves effectively as deep conversion capacity. However, the statistics do not allow an accurate identification of this capacity. It is thought that most FCCs crack some residue.

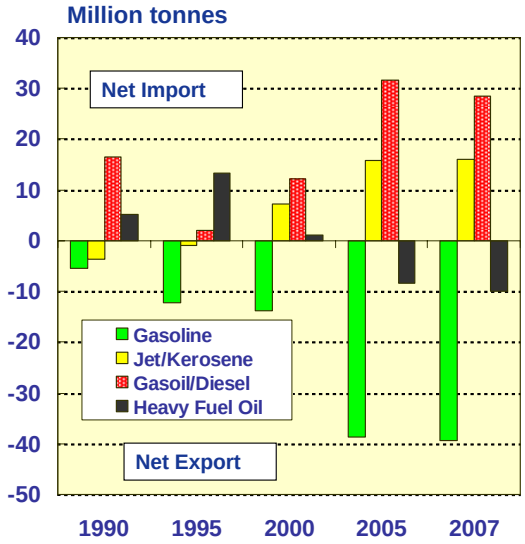
# Deep conversion capacity is low in Europe

## Vacuum Residue conversion capacity at European refineries




- Vacuum residue conversion capacity installed at European refineries is mainly visbreaking.
- Deep conversion capacity (i.e. gasification, coking and residue hydrocracking) accounts for less than 3.5% of crude distillation capacity. Some FCC units can crack high quality residues and provide some additional deep conversion capacity that is not shown above.
- As fuel oil demand reduced, only a minority of refineries chose to invest in residue conversion projects as the option to process light North Sea crude to reduce fuel oil yield was possible. Refiners will take this option as long as the crude is available and there are markets to export a surplus to.
- Some inland refineries do not have the flexibility to change their crude slate significantly or incur high costs to export surplus product. These refineries have had to invest in fuel oil conversion as their local fuel oil demand has fallen and the cost of exporting a surplus is prohibitive. This has resulted in a large proportion of the existing deep conversion capacity being located at the inland refineries.
- Coastal refineries have access to global markets and trading a surplus to distant markets is a means to avoid or postpone investment. Eventually, as the global market shrinks or the local need for light products grows, investment in conversion is made.
- Coastal refineries may also be located in or close to large bunker markets (e.g. Rotterdam, Gibraltar) which provide an outlet for fuel oil.
- The increasing need for middle distillates is likely to drive more European refiners to invest in residue conversion.

## European reliance on trade has increased strongly since 2000




- The gasoline surplus has quadrupled since 2000. Net exports accounted for 24% of refinery production in 2007, compared with 3% in 1990
- Jet/kerosene trade flows switched to net imports from 1997
- Net gasoil/diesel imports accounted for 12% of domestic demand in 2007
- Net heavy fuel oil exports have increased sharply on falling demand
- Developments in other regions were always instrumental in making these developments possible
- Refineries, by nature of their business, seek and exploit trading opportunities

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- While European gasoline demand was declining, strong growth of demand in the US was giving a shortage of gasoline in North America. It would have been very difficult for the European refineries to reduce total production of gasoline without reducing utilization. However, an export market was available in North America and a large and structural transatlantic trade developed as a result. US gasoline demand supported the utilization of European refineries.
- The shortage of jet/kerosene was met by export refineries in the Middle East.
- Structural gasoil supplies have been available from Russia since the 1980s. When the shortage of gasoil/diesel in the European market started to become acute (e.g. after 2000), utilization of Russian refineries was recovering from the troubles that had followed the break up of the Soviet Union and the financial crisis of 1998. Increasing supplies of gasoil became available from Russia and kept the market reasonably well supplied.
- The increase of heavy fuel oil exports was supported by Asian demand for bunker fuel and for industry and power generation as the economies in that region grew rapidly and trade volumes increased.
- The result of the above is that the European refining system has become much more integrated with the industry in other regions with a series of dependencies for imports and exports to balance supply and demand. As will be discussed in the remainder of this report, the developments in Europe can no longer be considered in isolation. Developments elsewhere have a strong impact on the European refining industry and can potentially threaten the long term viability of this vital industry.

## Section II - Overall conclusions

- Refineries are a necessary link in the petroleum industry, as they process crude oil to produce the finished products that are required in the market.
- A number of process technologies are available to refiners to implement different types of configuration and produce products that meet market specifications.
- All refineries have different configurations resulting in different product yields.
- No refinery can make 100% of one product. Most of them make all of the main products, i.e. LPG, gasoline, jet fuel, diesel, heating gasoil and heavy fuel oil.
- Once a refinery has been built with a certain configuration and designed for a certain type of crude, it has limited flexibility to modify its yield structure significantly without investment to change its configuration. Investment costs for this are very high.
- The configuration is the result of the need to produce the products demanded by the market using the crude oils that are readily available. The European refineries are being reconfigured to follow changes in the demand patterns and the available crudes.
- Despite the investments made to reconfigure the refineries, the European reliance on imported products has increased significantly in recent years.

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## SECTION III

# THE CRUDE OIL MARKET

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## Introduction to this section

- This section provides an overview of the origins and functioning of the crude oil market.
- It will show that most of the remaining reserves of crude oil are held by the national oil companies of the oil producing countries, most notably those in the Middle East.
- As a result of the segmentation of the industry the volume of crude oil bought and sold has increased dramatically. The second part of this section discusses the structure and working of the crude oil market.
- We will discuss the main drivers that influence the price of crude oil on world markets.
- The last part of this section provides the refiners' perspective of the crude oil market. The market attributes different values to different crudes in relation to the value of the products that can be obtained from them. It will show what considerations refineries have to make when choosing which type of crude to purchase and how this influences crude price differentials.

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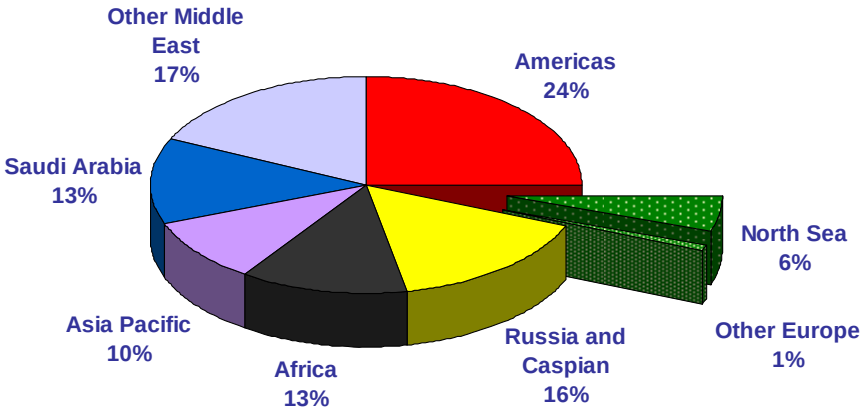
## Well over half of world crude oil is produced in countries with low oil demand




- Well over half of world crude oil is traded internationally
- Middle East is the largest crude oil producing and exporting region, as it only refines 27% of the crude oil it produces
- Europe has a comparatively higher dependence on Russia and the Caspian

Source: BP Statistical Review. Crude oil production in 2007

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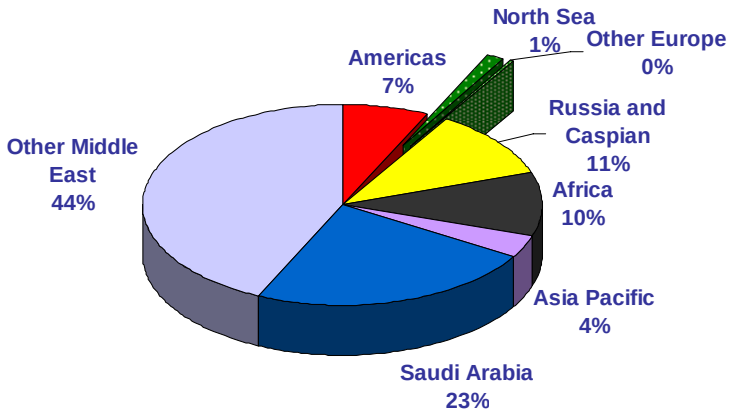
- The Middle East currently produces 30% of the world total crude oil requirements.
- Saudi Arabia and Russia are by far the largest crude oil producing countries, both exceeding 9 million B/D. However Saudi Arabia remains the world largest crude oil exporter because of its much lower domestic use. In 2008, Saudi Arabia produced about 9.5 million B/D of crude, but typically refines about 2 million B/D of it. As a result Saudi Arabia currently exports over 7 million B/D of crude oil.
- European production accounts for only 7% of world production, and is declining, currently covering only 30% of European needs. The European refining industry relies heavily on crude oil imported from other regions.
- Russia, the Caspian and North Africa meet a large proportion of EU crude oil import requirements. Europe is the nearest and most important market for most of the crude oil exported from these three regions.
- Reliance on crude oil traded to Europe from long haul sources (e.g. the Middle East) is moderate. This is in strong contrast with the current situation of the Asia/Pacific refining industry, which imports large volumes of Middle Eastern crude oil. Until the 1970s, the European refining industry was also much more dependent on Middle Eastern crude.
- North Sea production is now in decline and exports to Europe from Russia have stopped growing. In the future Europe is expected to import more crude from North Africa and the Caspian, where crude production is growing.
- The overall dependence of Europe on Middle Eastern crude oil is not forecast to increase significantly, at least for another decade.

## OPEC holds about three quarters of world crude oil reserves. Over two thirds are in the Middle East.




- **Most of the reserves in the Middle East and Africa are in OPEC member countries**
- **After 30 years of production, North Sea reserves are now only 1.1% of the world total**

Source: BP Statistical Review. Reserves at the end of 2007.

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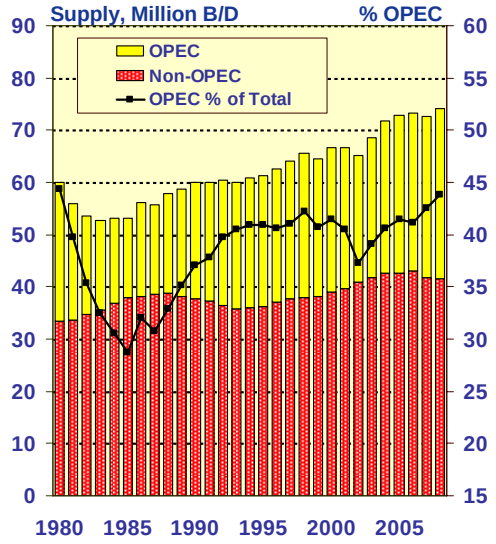
- At the 2007 world consumption rate (about 86 million B/D) current proven reserves (1238 billion barrels at the end of 2007) would last 39 years.
- The Middle East accounts for only 30% of production but 77% of reserves. Conversely, the rest of the world accounts for 70% of demand with 23% of reserves.
- In any event, the ratio between production and reserves is higher outside the Middle East and the result is that non Middle East reserves are being depleted faster. Ultimately the Middle East will gradually increase its share of overall world crude production as sources from elsewhere begin to run out.
- Today's reserves are tomorrow's production. This principle is well understood by the large oil companies, which continuously strive to replace their production with new reserves.
- Unfortunately the options to discover new oil provinces in locations with a favourable investment climate - like the North Sea or Alaska in the 1980s - are running out.
- Unconventional sources, like the Canadian oil sands, represent one of the better options to supplement producible reserves outside of the Middle East.

## OPEC share of world crude oil supply has varied with oil demand and non-OPEC supply




- **After the 1979 oil shock demand fell. New oil provinces were being developed outside of OPEC.**
  - *Non-OPEC supply increased. OPEC lost market share.*
  - *Production in Saudi Arabia fell from over 9 million B/D in 1979 to 2.5 million B/D in 1985.*
- **Oil demand started growing again in 1986. OPEC supply grew steadily until the late 1990s.**
  - *From 1986 OPEC started recovering market share.*
- **In 1999 demand fell because of the impact of the Asian financial crisis on economic growth.**
  - *Prices crashed and OPEC cut production to shore up prices.*
  - *The increase of oil prices in 2000 and the economic slow down of 2001 and 2002 resulted in weak growth.*
  - *Non-OPEC supply was expanding, mainly because of a strong contribution from Russia.*
  - *OPEC kept losing market share through 2003.*
- **In 2004 a rapid increase in demand led by economic growth in China tightened oil markets**
  - *No significant expansion of non-OPEC supply.*
  - *OPEC share now growing steadily.*

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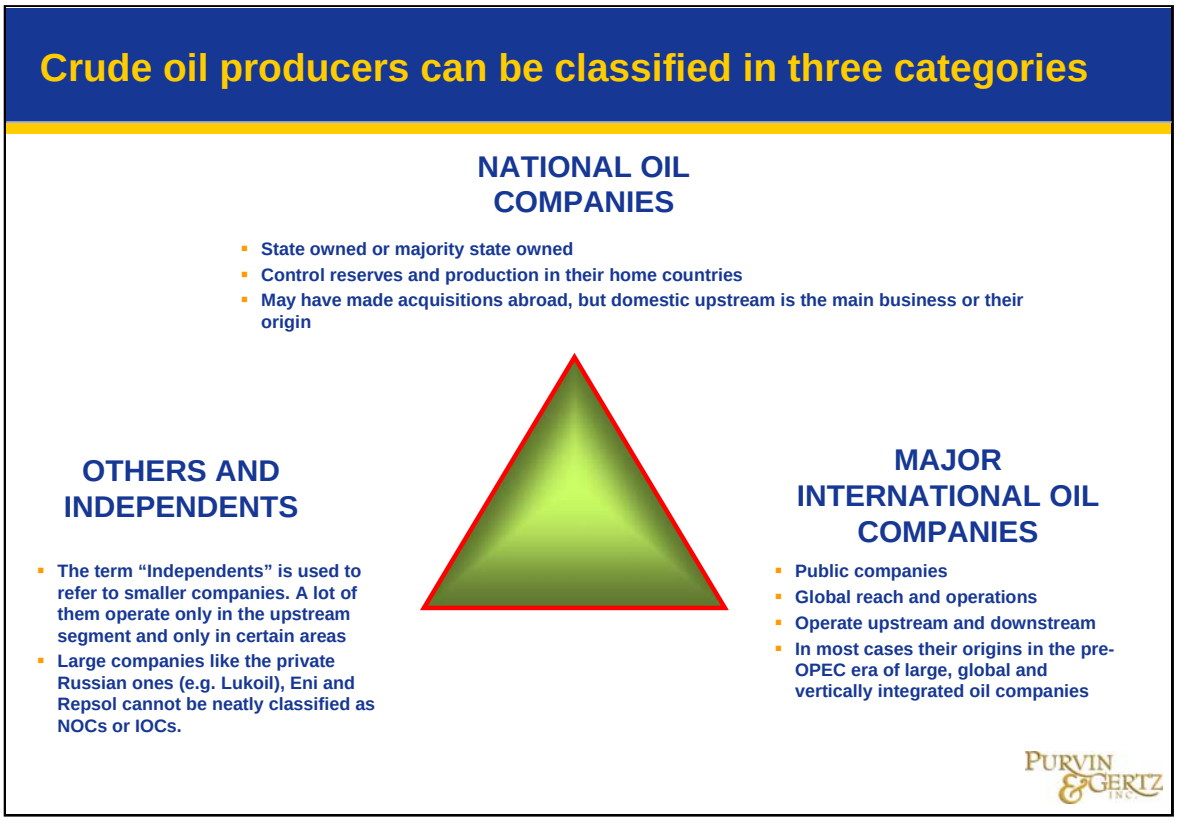
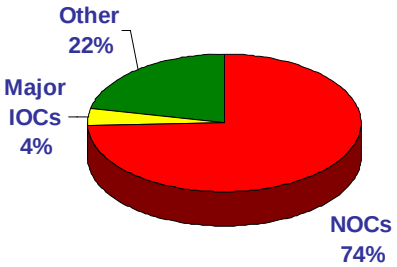
- The Organization of the Petroleum Exporting Countries (OPEC) was created in 1960, but became very prominent only with the oil shocks of the 1970s. Current members are Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.
- Member countries produce approximately 43% of the world's crude oil and their exports represent approximately 55% of oil traded internationally.
- The total OPEC production is set to balance supply and demand. The difference between oil demand and non-OPEC production is referred to as the "call on OPEC crude". Weak demand growth or a large expansion of non-OPEC supply tend to reduce the call on OPEC. If OPEC does not cut production there can be an oversupply with downward pressure on prices.
- OPEC operates a production quota system. Total OPEC production is agreed among members and each country is allocated a quota. Countries are expected not to produce in excess of their quotas. With this arrangement OPEC seeks to maintain the market balance and influence prices.
- Different behaviors exist in OPEC. Some member countries regularly exceed their allocated quotas, making it difficult to control the market at times of oversupply. Others struggle to reach their quota and favor lower production targets so as to keep the market tight and oil prices directionally higher. OPEC's policies have not always been successful. At times of oversupply a lack of compliance with quotas has made it impossible to prop up prices.
- The Middle Eastern countries have the largest reserves and no significant economic activity beyond oil. As such, they have the highest stakes in the long term future of the industry. They tend to attribute higher importance to stability and price moderation, as they need oil to remain a competitive source of energy in the very long term.
- The fall of demand for OPEC crude oil that occurred in the early 1980s left OPEC with a large amount of spare production capacity. Since then, this spare capacity has been used to meet growth of demand and to counter major supply disruptions such as the two Gulf wars, periods of unrest in Nigeria and a strike in Venezuela.



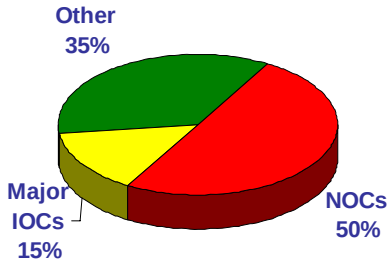

- Crude oil is originally owned by the government of the country from which it is produced. Most of the OPEC countries have national oil companies (NOCs), which have been assigned rights over oil production.
- In some cases, exploration and production activities may be conducted exclusively by the NOC. As an example, this is the case in Saudi Arabia and Kuwait, where Saudi Aramco and KPC are the sole producers of crude oil.
- In other cases, oil is developed through some form of partnership between a private company and the NOC. This can happen with concessions over areas of land with good prospects or with service contracts. In the latter case the private company develops reserves and is paid in oil for its services. Production in partnership is typical for the Caspian region, North Africa, Nigeria and Venezuela.
- In locations like the UK North Sea or the United States, oil production is now left entirely to the private sector, upon payment of licence fees, royalties and production taxes.
- The business model of the independent oil producer is typically based on looking for opportunities that may be regarded as marginal by the "majors".
- Vice versa, the business model of the majors is typically based on looking for large projects that are beyond the financial or technical capability of smaller companies.
- When an independent develops an attractive position in some location, it may become an acquisition target for a major, which would see it as an opportunity to add reserves by acquisition. An expression used to describe this strategy is to "drill for oil at Wall Street".
- The above represents a broad classification. There are several examples of companies that do not fit neatly in any of the above categories. Some Russian companies are large and present across all sectors, but do not have a global presence. Eni can be considered an IOC in the upstream business, but is only a regional player in the downstream and is 30% state owned.

## NOCs dominate production and reserves. IOCs ultimately could shrink without new strategies

**World Crude Oil Reserves by company type**




**World Crude Oil Production by company type**




- **The Major IOCs account for only 15% of oil production and 4% of reserves**
- **They are replacing reserves through acquisitions and to focus on unconventional oil, such as oil sands as well as conventional exploration**
- **Reserve replacement is becoming harder and unconventional resources will become more important**

Source: BP Statistical Review and Petroleum Intelligence Weekly. Shares are for 2006.

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- Collectively, the 6 largest IOCs (the "majors") are still significant crude producers, but they supply only 15% of world oil demand. Over half of world oil is produced by NOCs.
- The reserve ownership is ever more dominated by the NOCs, while the majors have only 4% of world oil reserves. The market share of the NOCs, particularly the large Middle Eastern ones, looks certain to increase with time.
- As a result of their limited access to conventional oil, the majors are increasingly turning their attention to acquisitions of independents and to unconventional sources to add reserves. High oil prices have made development of these resources viable. Moreover, in this area most of the majors have some form of proprietary technology to offer, so as to distinguish themselves from the competition.

## The six largest IOCs combined only just exceed the crude oil production of Saudi Aramco

| Company | Type | NOC Country | State Ownership | Production ('000 b/d) | Reserves (bn barrels) | Reserves, years at 2006 production |
|---|---|---|---|---|---|---|
| Saudi Aramco | NOC | Saudi Arabia | 100% | 10,475 | 264 | 69 |
| NIOC | NOC | Iran | 100% | 4,343 | 137 | 87 |
| Pemex | NOC | Mexico | 100% | 3,649 | 13 | 10 |
| CNPC | NOC | China | 100% | 2,705 | 20 | 20 |
| ExxonMobil | IOC | | | 2,681 | 12 | 12 |
| PDVSA | NOC | Venezuela | 100% | 2,524 | 80 | 86 |
| KPC | NOC | Kuwait | 100% | 2,496 | 101 | 111 |
| BP | IOC | | | 2,475 | 10 | 11 |
| Shell | IOC | | | 2,030 | 5 | 7 |
| Petrobras | NOC | Brasil | 32% | 1,920 | 8 | 14 |
| INOC | NOC | Iraq | 100% | 1,899 | 115 | 166 |
| Sonatrach | NOC | Algeria | 100% | 1,889 | 12 | 17 |
| Adnoc | NOC | UAE | 100% | 1,799 | 59 | 90 |
| Chevron | IOC | | | 1,759 | 8 | 13 |
| ConocoPhillips | IOC | | | 1,698 | 7 | 11 |
| Rosneft | NOC | Russia | 75% | 1,596 | 16 | 27 |
| Lukoil | Other | Russia | | 1,541 | 13 | 23 |
| Total | IOC | | | 1,506 | 8 | 12 |

Source: Petroleum Intelligence Weekly. Data are for 2006

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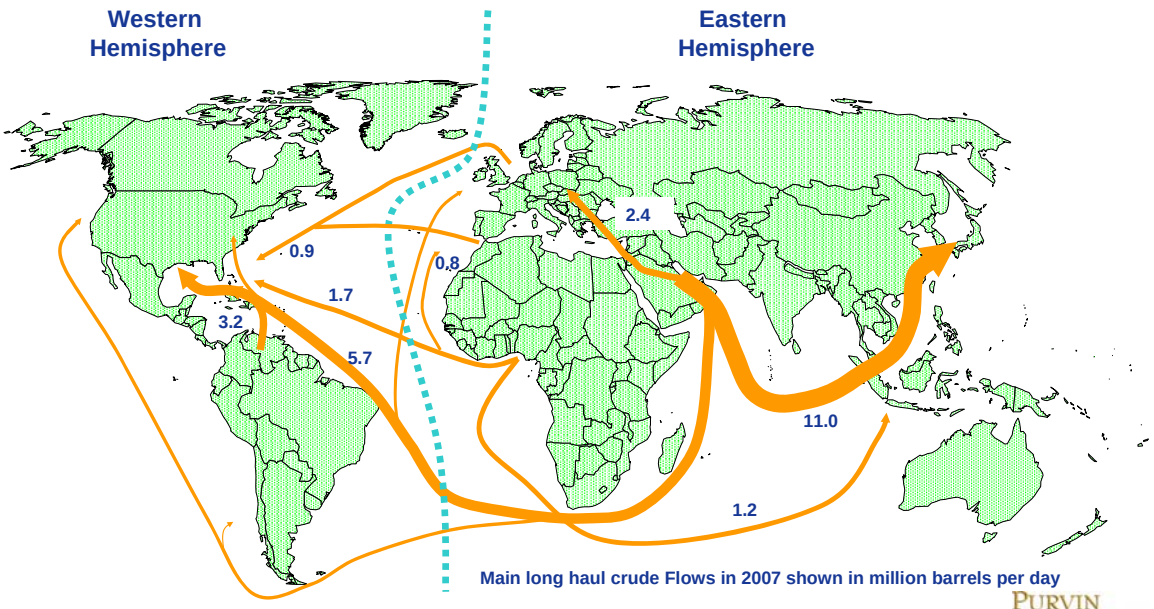
- The largest IOC by oil production is ExxonMobil which is ranked fifth overall. Its 2006 production was a quarter of Saudi Aramco, which has over twenty times the reserves of ExxonMobil.
- The six major IOCs produced 12.7 million B/D of oil, which is not much more than Saudi Aramco produced on its own. A comparison based on reserves would bring the NOCs even more to the forefront. The total reserves of the six IOCs at the end of 2006 were only 20% of those declared by Saudi Aramco.
- In Russia, Rosneft has now acquired Yukos and other assets. This has made Rosneft a 2.0-2.1 million B/D production company, just ahead of Shell.
- Without its stake in TNK-BP, BP's production would have been just over 1.6 million B/D.
- Iraq is considered to have a large volume of undeveloped reserves. INOC's reserves are equivalent to 166 years of 2006 production. The other interpretation of this number is that Iraqi oil production is very low in relation to potential. This is not surprising considering the last 30 years of the history of Iraq.
- The Middle Eastern OPEC producers have a vested interest in the long term future of the oil market and as such are keen to maintain prices at a level that does not destroy demand.

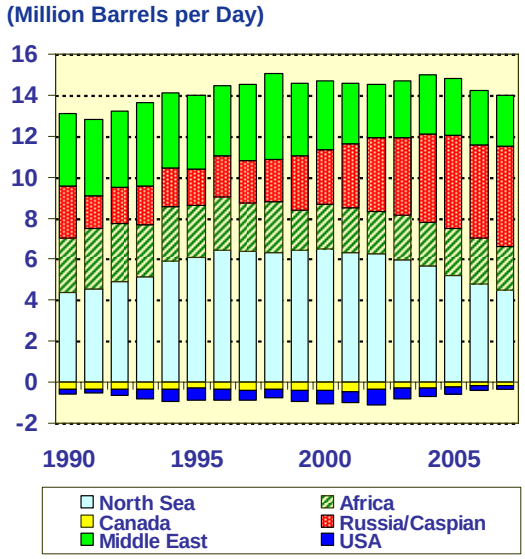
## The Middle East is the centre of gravity of long haul crude oil trade.




Source: Purvin & Gertz Global Petroleum Market Outlook

- The Middle East is the largest crude oil exporting region and supplies crude oil to all major demand centers.
- Most of the long haul seaborne crude oil trade takes place in the Eastern Hemisphere as shown in the figure above.
- Asia is by far the largest single crude oil importing region and the most important market for Middle Eastern crude.
- The Western Hemisphere imports around 6 million B/D from the Eastern Hemisphere. This net inflow is a result of the USA being the largest single world crude oil importer.
- Most of the crude oil traded to Europe is from Russia, the Caspian and North Africa. By the standards of the crude oil market, this is short haul trade.

## European supply from the Caspian region and Russia has increased to replace declining North Sea supply




- North Sea production peaked in 2000 at 6.1 million B/D
- Production has since declined at rates of about 280,000 B/D per year, and rate of decline is increasing
- Majority of supply has being made up by increased import of Russia/Caspian crude
- African imports are relatively stable; imports from Middle East have declined slightly.
- More crude oil coming from regions outside of European control, leading to greater concern about security of supply.

Source: Purvin & Gertz Global Petroleum Market Outlook

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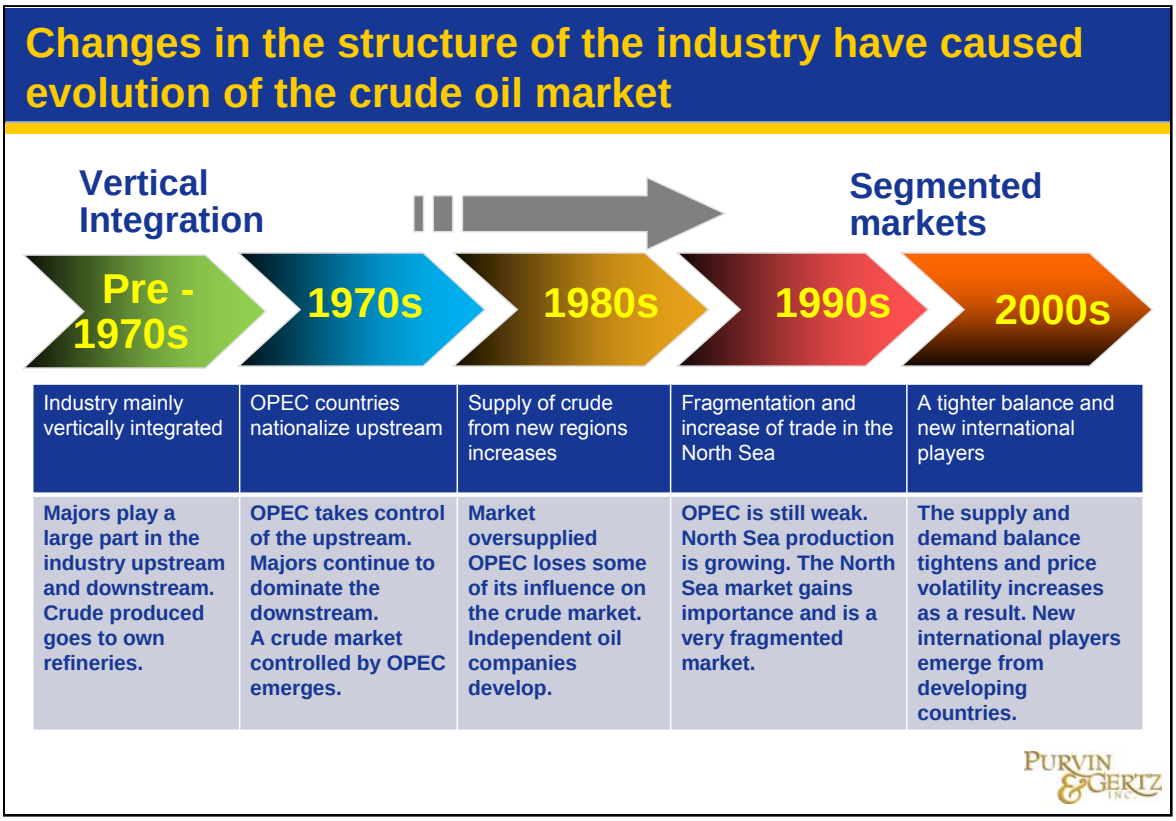
- The decline in North Sea production is continuing, despite investment in enhanced oil recovery techniques and some new discoveries. Among recent events, the most notable remains the development of the Buzzard field, which began production in 2007 and now produces about 200,000 barrels per day. The start of the Buzzard field halted temporarily the decline of production in the UK sector of the North Sea.
- The decline in North Sea crude oil production will have to be replaced by imports of crude oil from other regions.
- Russian crude oil production is expected to remain stable. However, trade to Europe is expected to reduce somewhat, owing to higher domestic refining activity and higher exports to the Asia/Pacific.
- Production increases in Kazakhstan and Azerbaijan will be key to the European market. Despite some direct overland export to China, Kazakhstani and Azeri crude will mainly be marketed from terminals in the Black Sea and the Mediterranean.
- As more of the crude oil required for European refineries will come from regions outside of direct European control (i.e. the North Sea), there is a greater risk to the security of European oil supplies.

## HOW DOES THE CRUDE OIL MARKET OPERATE?




- Before the 1970s, the major IOCs of the day were the main players in the oil industry, both upstream and downstream. Oil production in Saudi Arabia, Kuwait, Iran and Iraq was by joint ventures among the majors. Trade was limited. The major IOCs would tend to refine their own crude in their own refineries. This was the era of true vertical integration.
- Reserves in the Middle East were plentiful and oil was still being found in new provinces such as Libya in the 1960s. Oil prices were moderate. Supply was adequate. There was little incentive to develop new reserves and at times the challenge was not to overproduce. In an oversupplied market, the downstream was important to provide a secure market for crude.
- Throughout the 1970s many OPEC countries nationalized their reserves and production. The majors had lost their most valuable upstream assets and with them their grip on the value chain from well to consumer.
- The IOCs retained a large share of the global downstream and now needed to buy crude to supply their refineries. The NOCs had little refining capacity and could only sell their crude to refiners. The industry now had new players who were structural buyers and sellers of crude oil. A market for crude oil developed.
- The 1970s saw turbulence and two major oil price shocks in 1973 and 1979. Oil prices stood at 3 $/bbl in 1973 and had increased to 35 $/bbl in 1981. The increase in price and the need for new reserves by the IOCs prompted exploration and development outside of OPEC countries. The 1980s and 1990s were generally a period of oversupply and fairly weak oil prices.
- Independent upstream companies, with no downstream, had established in the new producing regions. They were in the market purely to sell crude and represented a new kind of market participant. Trade of crude oil around the North Sea developed as a result. Market fragmentation increased.
- In the 2000s the supply and demand balance tightened again. Strong and assertive players from countries such as Russia, India and China have entered the international scene either as crude seller (e.g. Russian companies) or buyers of upstream assets (mainly Indian and Chinese companies).

## The mechanisms used to price crude oil have followed the evolution of the crude oil market

**Virtually no market** → **Sophisticated market**

| Pre - 1970s | 1970s | 1980s | 1990s/ 2000s |
|---|---|---|---|
| **Industry mainly vertically integrated** | **OPEC countries nationalize upstream** | **Non-OPEC supply grows. Market is oversupplied.** | **Market related pricing and sophistication** |
| Very little crude is traded.<br><br>Crude is priced with posted prices set by the IOCs | Crude by the NOCs and purchased by the IOCs.<br><br>Posted prices still used, but set by the NOCs | Price volatility makes posted prices inadequate. Some OPEC producers try netback prices to defend market share but this adds to oversupply and destabilizes markets..<br>Spot trade has taken off in the North Sea.<br>In 1986 Saudi Arabia moves to market related prices. | Market related pricing firmly established. Sophistication increases. Derivatives linked to oil prices are launched. Derivatives were devised for risk management but have become a tool for speculation. |

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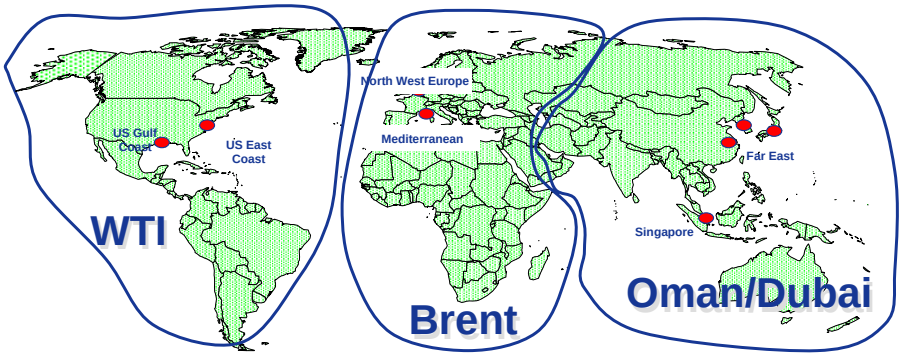
- Before the 1970s, very little crude was traded and market volatility was low. Crude prices would be posted by the IOCs and remain fixed for a certain period of time. The posted prices were published and known.
- After taking over large volumes of crude production in the 1970s, the NOCs maintained the system of posted prices in place. The IOCs were buying crude at the posted prices.
- After the oil shock in 1973, there was another shock in 1979 because of the supply disruption caused by the Iranian revolution. In the early 1980s non-OPEC supply increased, while oil demand fell as a result of the very high oil prices brought about by the shock. This created oversupply in the market and prices collapsed from 35 $/bbl in 1981 to 10 $/bbl in 1986.
- The price volatility made the old system of posted prices totally inadequate for the new market reality. Refiners plan their crude purchases weeks ahead and in volatile markets are exposed to the possibility that product prices have collapsed by the time the crude has been delivered and refined. This could result in large financial losses. New ways to price crude had to be found.
- Some OPEC producers, who were losing market share because of the oversupply, tried “netback prices”. Under this system, the price of crude oil was set in relation to a basket of refined products, so as to provide a guaranteed margin to refiners. This created additional demand for crude priced on a netback basis, which added to the product oversupply and so destabilized the market further.
- Meanwhile, a crude market had started to develop in the oil producing regions, most notably in the North Sea. The prices of North Sea crude were assessed and published. In 1986 the OPEC producers decided to link the price of their export crude to market prices for competing traded crudes. This was the beginning of a new era.
- Market pricing has remained in force and the sophistication of the market has increased over time. A number of derivatives linked to oil prices have developed. These are essentially contracts with value linked to oil prices. Their primary purpose is to allow management of the exposure to crude price volatility (i.e. hedging). However, they provide exposure to oil prices without the complication of trading in physical oil and, because of this, they are used by participants who are in the crude market to speculate on oil prices.

## The price of crude is established in relation to "marker" crudes




- **There are many crudes produced in the world, all of which have different quality and thus different value.**
- **A few "Marker Crudes" are used as reference to price crude globally.**
- **The Marker Crudes are traded independently of each other in transparent markets. Their prices are known and published. There are derivatives that allow managing exposure to the volatility of marker crude prices.**
- **Other crudes are priced by agreeing on a price differential to be paid against the most suitable marker. Each marker is the most influential in a certain geographical area.**

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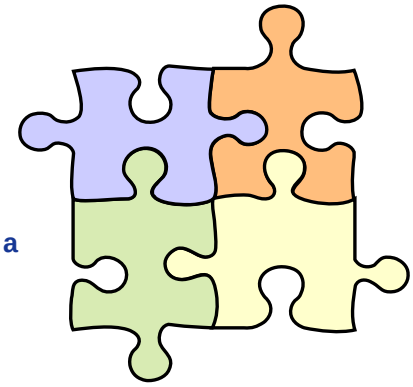
- All crudes are unique and derive their value from the value of the refined products that can be obtained by refining them. Different crudes have different values and trade at different prices.
- The industry uses a number of "marker crudes" to track crude oil prices. These are only specific types of crudes that, because they fulfil a number of criteria discussed on the next page, are considered the most appropriate to be used as indicators of global oil prices.
- The most important marker crudes traded globally are Brent, West Texas Intermediate (WTI), Dubai and Oman. They are all traded in a regulated manner in oil exchanges. Like most other commodities, marker crudes have a number of derivatives associated to their prices. The most commonly used derivatives are oil futures, which are also regulated. The less traded derivatives becomes progressively less regulated.
- The most important location to trade Brent is the Intercontinental Exchange (ICE) based in London. WTI is traded in the New York Mercantile Exchange (Nymex). WTI and Brent are light crudes, the jargon "Nymex Light Crude" and "North Sea Light Crude" are also used.
- The derivatives associated to the prices of marker crudes allow hedging to cover risks associated to oil price volatility. The mechanics of this will be explained later in this section.
- Marker crudes can be traded at outright prices, such that a refiner could buy a cargo of Brent by bidding at an outright price (e.g. 100 $/bbl). Other crudes are priced on the basis of differentials to the relevant marker crude. As an example, a refiner would buy a cargo of Urals (the common Russian export crude) at "Brent minus 3 $/bbl". As crude is purchased a few weeks ahead of loading and the price Urals is not known and would be calculated as the price of Brent at the time the cargo is loaded, less 3 $/bbl.
- Whether the refiner is buying Brent or Urals, he is exposed to the volatility of Brent prices and can use Brent related derivatives to manage this risk (see later).
- The agreed differential of 3 $/bbl reflects the value of Urals to the refiner relative to Brent.
- Each marker has an area where it is generally the most influential. Brent is mainly used to price crude traded to/from Europe and Africa.

## Only crudes that fulfil certain criteria can be used as markers

Liquid and transparent market

Multiple ownership, no dominance by a single player



Quality suitable to price a broad range of other crudes

Access to markets not restricted by logistics

- Moreover, producers must be willing to let their crude be traded in the spot market
- A number of National Oil Companies are adverse to this and only sell their crude under contract to refiners.
- For the Middle East the exceptions are Oman and Dubai, which are traded in the spot market

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- The requisites needed for a crude to be used as a marker reflect the need of buyers to be confident that its price is transparent and the crude can be used as a reference to price other crudes.
- **Volume:** the volume traded should be sufficient to make its market liquid. At its peak in the mid 1980s the average production of Brent was over 500,000 B/D. Cargoes used for the assessment of Brent prices are traded up to 21 days ahead of loading. Every day several Brent cargoes would be available for sale and any of them could be bought and sold several times before being fixed for delivery to a refinery. Several trades would take place every day.
- **Transparency:** as the price of the marker crude is used to price other crudes, it must be disclosed and published. To make this possible buyers and sellers that participate in the Brent market willingly disclose prices to a price reporting organisation (e.g. Platts).
- **Multiple Ownership:** the market should have the broadest possible number of participants. The possibility that a single company could have too much influence on the market is a deterrent.
- **Quality:** if a crude has unusual quality the number of refineries that are willing or able to process it reduces. The crude is not a good marker because its price may reflect specific technical issues related to its quality. Most North Sea crudes are of quality quite similar to each other and quite similar to Brent.
- **Logistics:** the export logistics should make it possible to trade the crude to the a wide population of refiners and, ideally, also outside of the region where is produced. This makes the crude responsive to supply/demand imbalances at a global level and reduces the risk of distortion related to regional issues.

## The Brent market has evolved to provide new and better ways to price crude

- **1978:** A market has emerged. Platts launch its price reporting service "Crude Oil Market wire" in response to the number of crude grades traded
- **1988:** The International Petroleum Exchange in London (IPE, now merged into ICE) launches Brent futures contracts
- **2000:** The price of Brent becomes very volatile. US refiner Tosco file a lawsuit against Arcadia for alleged manipulation of the Brent market. It is the considered view in the industry that Brent production is now too low and liquidity is no longer sufficient to exclude market manipulation
- **2002:** Platts decides to change the assessment of Brent price into "BFO". The assessment is still commonly referred to as Brent, but now the price published is the lowest among Brent, Forties and Oseberg (hence BFO).
- **2007:** North Sea crude production continues to fall. Platts add Ekofisk to BFO. The price published as Brent is now the lowest of four crudes (BFOE).
- **Future?** The BFOE arrangement is not ideal but the quest for a new global benchmark has not found a better option yet

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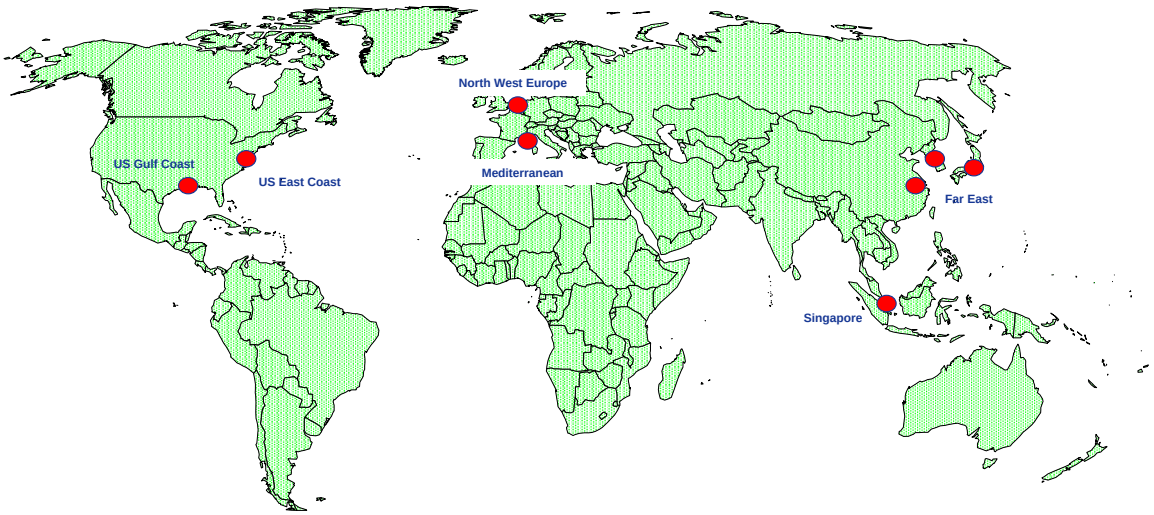
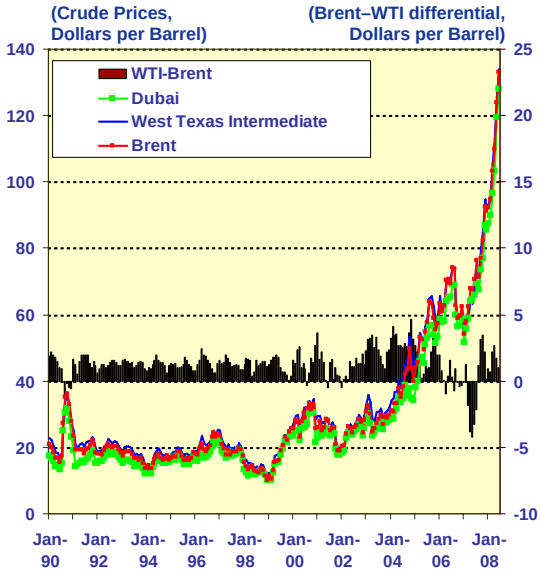
- Crude oil production in the North Sea started in the 1970s and a market for North Sea crude emerged quite rapidly. In response to this, Platts launched a crude oil price reporting service in 1978. There are several other companies that compete with Platts.
- The Brent futures contract, launched in 1988, was the first derivative linked to Brent prices. Derivatives like futures are primarily used to "hedge" the exposure to Brent price volatility, as shown later in this section. When a refiner agrees to buy crude at a certain differential to Brent, he is exposed to the volatility of Brent prices. Thus, the existence of derivatives that allow hedging is an important step in the adoption of a crude as a marker.
- The Brent futures contract paved the way for Brent to become the most widely used marker crude globally in the 1990s.
- The objective of the refiner is to buy crude at a price that reflects its quality. As highlighted earlier, this is achieved by buying on the basis of a differential to a transparently priced marker.
- By 2000 the fall of Brent production had reduced the liquidity of the Brent market and the confidence that Brent prices were a reliable indicator of market fundamentals had reduced accordingly. There were open allegations that the price of Brent could be manipulated.
- The move to BFO and then to BFOE increased liquidity by expanding the volume of crude used for the assessment. If the price of Brent were to become subject to upwards manipulation, the prices of Forties, Oseberg and Ekofisk would set the BFOE price.
- On any given day the price of BFOE may be set by a different crude. So there is no certainty on which quality corresponds to the price of the marker. This is not ideal for refiners, but, since the BFOE crudes are fairly similar in quality to each other, the uncertainty is tolerated. The adoption of BFOE can be seen as a compromise.

## The most important crude oil markets have developed at large regional refining centres




- Crude oil is bought by refiners, which process it for the purpose of producing saleable products.
- Large refining centres have developed at locations that were well positioned to take advantage of crude oil supply, access to refined product markets or both. Some of these locations now serve as reference points for the pricing of crudes. The most important of such locations are the US Gulf Coast, North West Europe (often referred to as ARA, Amsterdam-Rotterdam-Antwerp) and the Far East (Singapore). At a European level, the Mediterranean is also regarded as an important crude oil market.
- **North West Europe** is Europe's largest refining centre. Terminals located in Rotterdam also function as gateway to supply a large percentage of crude oil traded to Germany. North Sea production has increased the importance of Northwest Europe in the world crude oil market, by making it a large crude producing and a large crude consuming region at the same time.
- In the **Mediterranean** there is a large concentration of refining capacity on the Italian Islands, particularly in the bay of Augusta (Sicily). Augusta functions as a reference "pricing point" for a large proportion of the crude refined in Southern Europe.
- **The US Gulf Coast** is the primary US refining centre. Refining capacity has developed around the supply of crude oil from Texas, Venezuela and the Gulf of Mexico. The East Coast has less refining capacity and is partly served by excess production at the Gulf Coast refineries.
- The largest concentrations of refining capacity in the **Far East** are in Singapore, Korea, China and Japan. Singapore has historically had a more liberalized market and a more favourable investment climate. As such Singapore developed as the most important market for refined products and, because of this, the price of crude oil delivered to Singapore is relevant for other crude oil prices in Asia.
- The Far East in the most important consumer of Middle Eastern crude oil. The prices of crude oil exported from the Middle East are strongly influenced by the Far Eastern market.

## Crude oil prices in different regions are linked by trade and move together




- There is a large fleet of crude tank ships to move crude oil from one region to another.
- Very large tankers typically carry over 250,000 tonnes of crude and can deliver it across oceans at a cost of less than $4 per barrel.
- Therefore the different regions are linked to each other by trade.
- If crude was too expensive in one region, refiners could buy from other regions.
- The markets are volatile, but over time they stay in equilibrium.

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- Global crude oil prices are linked to each other because of the volume of international trade and established trade flows.
- Crude oil is traded in parcels that normally range between 70,000 tonnes (500-600,000 barrels) and 300,000 tonnes (over 2 million barrels). A population of crude oil tankers exist to serve the needs of crude oil buyers and sellers.
- A very large parcel of crude (e.g. 250,000 tonne) can be delivered across oceans (e.g. Arabian Gulf to anywhere in the world or West Africa to Asia) at a cost of only a few dollars per barrel. Costs can be very changeable with freight rates, but, as an example, $2-4 per barrel could pay for voyages of 10,000 nautical miles or more (i.e. Nigeria to China or Saudi Arabia to the United States).
- If crude oil was too expensive in one region, refiners could buy it from other regions. So, the maximum long term structural difference in price between two regions will be limited to the shipping freight rate between the two regions (arbitrage), with appropriate adjustment for any difference in crude qualities.
- However there can be larger short term differentials, usually driven by some kind of disruption to crude oil supply in a region.
- As an example, the disruption to crude production caused by hurricanes in the Gulf of Mexico impact the differential between Brent, WTI and Dubai crudes in 2006 and early 2007.
- Disruptions in the Gulf of Mexico cannot be quickly replaced by crude from the Middle East, because of the four to six week journey time between the Middle East and the Gulf of Mexico. Therefore the supply disruption can cause a short term spike in the local (WTI) crude oil prices, as consumers quickly attempt to buy any remaining crude in the region.
- A spike in prices in one region will also cause an increase in the prices of crude in other regions, although the spike in the other regions will be less pronounced and the impact more spread out.

## Different types of companies are active in the crude market in different ways

- Independent Producers
  - *Produce crude oil and must sell it.*
- National Oil Companies
  - *Produce crude oil and must sell it on behalf of host government, usually via long term contracts*
- Integrated Oil Companies
  - *Produce and purchase crude oil.*
  - *Usually have dedicated trading company to buy/sell crude oil.*
- Independent Refiners
  - *Need to purchase crude oil.*
- Independent Traders
  - *Buy and sell physical crude without producing or consuming it.*
- Banks, Investment Funds
  - *Mainly participate in the derivatives markets as speculators. Do not buy or sell physical crude oil.*

- There are many players in the International Crude Oil Markets, with very different objectives depending on the particular circumstances as to why they are in the market.
- **Independent Producers:** these companies specialize in the discovery and development of oil fields, and the subsequent production of crude oil. They usually have little or no downstream activity. Therefore they participate in the market to sell the crude oil that they produce.
- **National Oil Companies:** similar to independent producers these companies are large net producers of crude oil and therefore are in the market to sell crude. They may have some downstream activities, but have a large surplus of crude oil to sell. They normally sell crude directly to refiners with supply contracts and do not offer their crudes in the market.
- **Large oil companies**: these companies have significant crude oil production and also downstream refining activity. They both sell crude oil from their production and purchase crude oil to feed their refineries. They usually have dedicated trading companies to undertake these activities.
- **Independent Refiners:** these companies have no crude oil production but need to purchase crude oil to feed their refineries.
- **Independent Traders:** these companies neither produce or consume crude oil (or it is a relatively minor part of their portfolio). They buy crude oil from producers/sellers and then sell the crude oil on to consumers. They can also act on behalf of independent refiners, providing them with a crude sales or purchasing service, in which case they act as agents or brokers.
- The above types of company participate in the physical oil market, but trade also in derivatives linked to oil prices, as appropriate to reduce exposure to price volatility.
- Other market participants are **banks and investment funds:** they mainly trade in derivatives to speculate on oil prices. They do not buy/sell physical crude. They are in the market primarily to make money by speculation, but in doing so provide the physical players with counter-parties for their hedging.

## Crude can be sold in the spot market or through term contracts. It is the spot market that sets global prices.

**Spot Sale:** one time transaction for a single cargo or delivery

- Typically no restriction on resale. The cargo can be traded several times before is refined. When this happens, the spot market may be very liquid.
- Price may be fixed or indexed to a marker with a formula
- Prices can be disclosed to publications. The prices disclosed form the basis for the assessment of spot crude price
- Used by refiners to adjust crude requirements to market circumstances

**Term Contract Sales:** Deliveries over a defined period of time

- May have restrictions on resale. The transaction may tie the crude to a refiner with no opportunity to resell crude in the spot market.
- Price normally not fixed. Typically agreed by a formula applicable throughout the entire period.
- The formula usually refers to crude spot prices. Therefore crude purchased under a term contract is linked to crude spot prices.
- Used by consumers and producers to enter into a stable relationship that provides security to both parties.

- Most crude is sold under term contract
- Global crude oil prices are influenced by marginal changes of supply and demand, which are reflected in the need to trade more or less crude in the spot market.
- Spot crude prices react to changes of the supply/demand balance and are used to price other crudes. Thus, it is the spot market that ultimately determines world crude prices

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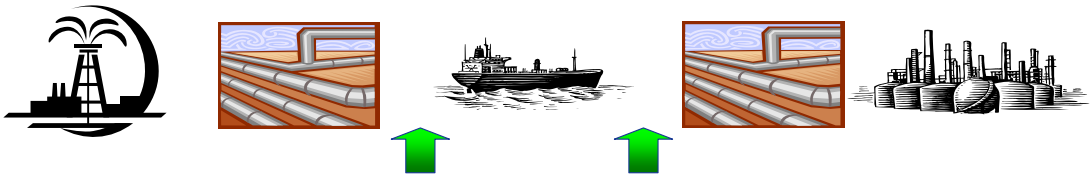
- Whether crude is purchased in the spot market or through term contracts, the contracts would set prices with formulae that link crude prices to the spot market prices. As an example, a refiner could have a contract to buy 12 cargoes of Russian crude over a period of six months, all of them at “Brent minus 3 $/bbl”. The spot price of Brent will determine the price of Urals for the refiner.
- Refiners normally buy part of their crude in the spot market and part with term contracts. The OPEC NOCs have been reluctant to allow their crude to be traded on the spot markets and most is sold under term contracts. So, to some extent refineries had to adapt to the situation imposed upon them by the NOCs. If a refiner wants or needs crude produced by an NOC, it needs to have a term supply contract and has no other choice.
- There are significant crude producers that sell crude with a mixture of term contracts and spot sales. In these cases the options to buy/sell either in the spot market or via term contracts both exist. As an example, Russian and North Sea crude is commonly available in the spot market, but a large buyer or a large seller could both be interested to enter into a term contract.
- The decision to purchase crude in the spot market or with term contracts is a decision of security versus flexibility. Contract sales provide security for both producers and consumers. The spot market provides flexibility to adjust rapidly to changed circumstances.
- While market circumstances can change at short notice, crude oil sellers and refiners remain tied by term contracts. To the extent they have retained some flexibility in their plans (e.g. crude production capacity or refining capacity not covered by contracts) they can use the spot market to adjust to the changed market circumstances.
- Thus, spot market prices react to the global crude oil balance and feed into the formulae of contract prices. Although far more crude is sold under term contracts than on the spot market, it is the spot market that ultimately determines world crude prices.
- In most cases, neither party wants to take the risk of making a very long term commitment and prefers the flexibility to change its strategic direction. For this reason, crude supply contracts tend to lock the two parties for periods of up to one year.
- Small crude producers will often sell their crude only in the spot market.

## Most crudes are priced at the export terminal. Refiners arrange delivery and incur delivery costs



Most transparent pricing points

| Production field | Export terminal | Import terminal | Refinery |
|---|---|---|---|
| Crude has no or limited access to refining capacity. It cannot be traded in a liquid market. | Crude can be loaded in tankers and traded to a wide population of refineries. This is the preferred pricing point. Most crudes are priced on a Free on Board basis (FOB) at the terminal they load. | The value at the import terminal is the FOB price, plus transportation costs, which includes insurance and freight. This is the CIF price (Cost Insurance and Freight). Some crude is traded on a CIF basis. | At a coastal refinery, the marine facilities function as a crude import terminal. Inland refineries may incur additional pipeline costs. |

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- After being produced, crude oil is usually transported to an export terminal, from where it is traded. Most crudes are sold on a Free on Board (FOB) basis. The buyer, e.g. the refiner, arranges transportation and incurs all the related costs. A notable exception to this is Russian crude, a large volume of which is traded on a "delivered basis", i.e. the pricing point is the point of delivery.
- Crude oil tankers are classified into three main classes on the basis of their capacity:
  - *Tankers with capacity of more than 200,000 tonnes are referred to as Very Large Crude Carriers (VLCC). The typical VLCC has a capacity in the 260-320,000 tonnes range, but the are are also some larger tankers which are referred to as Ultra Large Crude Carriers (ULCC)*
  - *Tankers with capacity in the 120-200,000 tonne range are called "Suezmax" and are the largest tankers that can sail through the Suez Canal.*
  - *Smaller crude tankers (e.g. 70-120,000 tonnes) are called Aframax. "Afra" is the acronym for the American Freight Rate Association.*
- Ports and refineries may have restrictions on the size of ship they can receive. Certain shipping routes may also have sailing restrictions that limit ship size. The Suez Canal, the Panama Canal, the Bosporus, and the shallow waters around Denmark are relevant examples of this. Few ports in North America can receive VLCCs.
- Large tankers provide economy of scale and allow moving crude over long distances at a lower costs on a "per barrel" basis. Smaller cargoes increase flexibility of operations and are preferred on short routes. Because of this, and the sailing restrictions mentioned above, only a small part of world crude is traded in VLCCs. Crude traded from the Arabian Gulf to Asia is typically in VLCCs, but use of VLCCs is much less common in Europe and North America.
- Crude oil that can be traded in VLCCs can access distant markets at lower cost. This provides the crude with a global reach, which is a desirable feature for a marker crude.
- As an example, over the last 5 years the cost to deliver crude oil from Saudi Arabia to Rotterdam with a VLCC has ranged between $1.2 and $3.1 per barrel

## Example: pricing of crude against a marker crude by NOCs

| Crude | Destination | Marker crude | Differential, $/bbl August 2008 |
|---|---|---|---|
| Kirkuk, FOB | USA | WTI | -4.45 |
| Kirkuk, FOB | Northwest Europe | Brent | -6.00 |
| Basrah Light, FOB | USA | WTI | -6.50 |
| Basrah Light, FOB | Northwest Europe | Brent | -8.05 |
| Basrah Light, FOB | Far East | Average of Oman and Dubai | -2.75 |
| Zueitina, FOB | Any destination | Brent | 0.00 |
| Es Sider, FOB | Any destination | Brent | -1.05 |

- **These crudes are produced in Iraq and Libya and sold by the respective NOCs through term contract**
- **They are priced with a formula, expressed as a differential to a marker crude**
- **The contract specifies the formula but does not say what the differential will be**
- **Seller will notify the buyer in advance what differential applies for next month**
- **Buyer has no option to negotiate the price**
- **However, if the price is always unfavourable he will not renew the contract**
- **Seller has interest to maintain a fair price to keep his buyer**

Source: MEES

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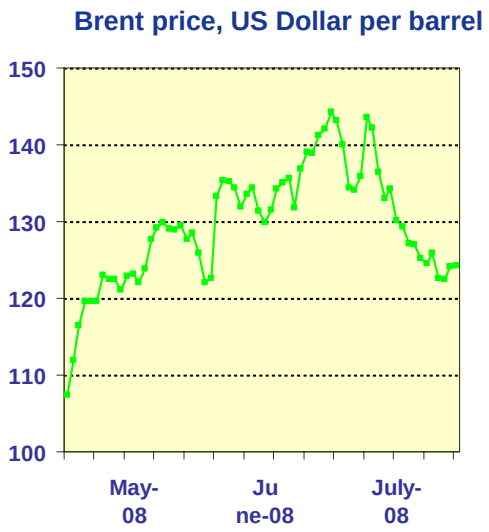
- A European refiner that wants to refine Es Sider needs to have a contract with the Libyan NOC. His contract would oblige the NOC to supply a certain volume of Es Sider for a certain period of time and the refiner to take delivery of it and refine it without reselling the crude.
- The contract would typically say that the price of Es Sider is equal to the price of Brent plus a differential that would be notified in advance by the NOC. A crude sold under arrangements of this nature are also referred to as a “formula crude” to distinguish it from “spot crude”.
- Sometime in July the refiner would be notified that the price applicable for August is Brent minus 1.05$/bbl. What can he do if this price is too high for his refinery? He may have some flexibility to adjust the volume of crude he wants to buy. As an example, his obligation to take delivery of the crude supplied by the NOC may give him the flexibility to “lift” only 90% of the volume he has contracted. To the extent he has this option, he can exercise this flexibility, but has no right to negotiate the price.
- If a formula is always too high a refiner would not renew its contract and would prefer to buy other crudes instead. Thus, it is also in the interest of the seller to adjust the published differential so as to price its crude competitively.
- In order to make a crude competitive in several markets, it may be necessary to price it against different markers depending on the destination. This is common practice for the largest Middle Eastern exporters, such as Saudi Arabia, Iraq and Iran. The same crude will have different prices in the different regions.
- As noted earlier, spot crudes other than the marker crudes are also commonly traded on the basis of formulae. For example, a European spot crude other than Brent would normally be traded on the basis of its differential to Brent.

# THE PAPER MARKET

## Refiners are exposed to short term oil price volatility




- Refineries buy crude a number of weeks in advance and are exposed to price volatility
- As an example, a refiner could have purchased a cargo of Brent at $145 per barrel in mid July
- He would have refined it in August, when oil prices were $125 per barrel
- Product prices would have fallen and the refiner would make a loss
- With the volatility observed in 2008, refiners were facing large risks
- Until the 1970s, the system of posted prices provided price stability
- Price volatility became an issue with the development of the spot market followed by the turbulence of the late 1970s early 1980s
- Trade in derivatives established to allow managing this important risk element

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- Crude is typically traded a few weeks ahead of loading. The standard practice is that crude export terminals prepare loading programs and communicate them to buyers. About one month ahead these plans become fairly firm and the crude is "dated", i.e. it is known that a certain parcel (e.g. 1 million barrels of Brent) would become available for loading at a certain date (e.g. on the 1st and 2nd of February).
- As an example, the standard for the North Sea spot market is to trade cargoes that would load between 10 days and 21 days in the future.
- On the 11th of July the price of "dated" Brent was assessed by Platts at $143.51 per barrel. On that day some buyers were buying cargoes of Brent presumably loading at the end of July. Assuming that those cargoes were bound to Rotterdam, they would have been received at the refinery early in August and the refined products would have been traded at a time when oil prices had fallen to about $125 per barrel.
- As shown in Section V, refining margins (i.e. the difference between the value of refined products and the cost of crude) are only a few dollars per barrel. Most refiners are likely to have made a large loss from refining that particular cargo of Brent.
- It follows from the above that price volatility is a large risk for any refiner.
- As noted earlier, the system of posted prices provided price stability. Prices would be posted and adjusted over time in a controlled manner to reflect new market circumstances. Spot trade was fairly limited.
- The turbulence of the late 1970s and early 1980s created the need to manage exposure to price volatility. Trade in derivatives established primarily for this purpose.

## Derivatives with prices linked to crude oil prices are traded to manage exposure to oil price volatility

- **Derivatives are contracts linked to the price of crude that do not necessarily involve the delivery of physical oil**
  - *The seller normally settles the obligation by paying a sum of money given by a formula that links to the price of physical oil*
  - *Hence the term "paper" crude oil market*
- **Futures are the most highly traded derivatives and the simplest to understand.**
  - *Brent futures are contracts that can be settled by paying a sum of cash equivalent to the price of Brent, multiplied by the volume of futures traded*
- **Numerous other more sophisticated instruments exist.**
- **The main exchanges for crude oil are the New York Mercantile Exchange (NYMEX) and the Intercontinental Exchange (ICE) in London.**
- **The use of derivatives to manage exposure to price volatility is referred to as "hedging"**

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- A wide range of derivatives have developed in association with crude trade. These derivatives are typically contracts that envisage a transaction in the future. The transaction is linked to oil price. For example:
  - *a "Brent Future" is a contract between a buyer and a seller to exchange Brent crude oil at a certain time in the future. Physical delivery of oil is not necessary. The seller has the option to meet his obligation by paying a sum of money identical to the price of Brent, multiplied by the volume traded in the contract.*
- Other futures contracts and more sophisticated derivatives are available.
- The main paper markets (futures exchanges) for crude oil are:
  - *New York Mercantile Exchange (NYMEX) is the main exchange for derivatives linked to WTI crude*
  - *Intercontinental Exchange (ICE) is the main exchange for derivatives linked to Brent crude*
- Nymex also offers futures contract on Russian Export Blend crude oil and on Dubai crude oil.
- Although the primary purpose of the futures market is risk management, futures are also used by speculators. This is because buying and selling oil futures provides the same exposure to oil prices as trading in physical oil, but without complications such as storage and transportation.
- Whether a market player trades in oil futures to manage exposure to oil prices or whether it does so to speculate on oil prices, most market players participate in the futures market with no intention of actually buying and selling physical crude oil. The majority of the futures contracts are settled in cash. Until recent, the Brent Futures contract specifically excluded the possibility to deliver physical oil. Hence the term "Paper Brent".

## Refiners do not have to take the risk of oil prices falling

- **Hedging is based on taking an exposure to oil prices in the futures market that is equal and opposite to the exposure in the physical market.**

**Activity in the "physical" crude market**

- 13 July: RefCo buys 1,000,000 barrels of Brent at $143.51 per barrel
- 5th of August: the cargo is received and can be refined. The price of Brent is $115.70 per barrel
- RefCo paid $27.8 per barrrel more than the value of crude at the time the cargo was received. He is very exposed to the fall in product prices that would occur as crude prices drop

**Activity in the "Paper" crude market**

- 13 July: Refco sells 1,000,000 barrels of Brent futures with maturity in August. Their price is $145.51 per barrel
- 5th of August: RefCo buys 1,000,000 barrels of Brent futures. Their price on that day is $117.52 per barrel.
- RefCo has made a profit of $27.89 per barrel in the futures market. This profit compensates RefCo for the loss he is very likely to make in the physical market.

- **There is a small difference between the fall of Brent prices and the profit made on the futures. Even this residual risk could have been hedged with more sophisticated derivatives.**
- **In a raising market, RefCo would have in the opposite situation: its refining margin would have been boosted by the raising oil prices, but he would have made a loss on the futures.**
- **Refiners that hedge incur transaction costs. Different attitudes exist in the industry. Some companies prefer to take the risk and rely on the fact that over time risks cancel out.**

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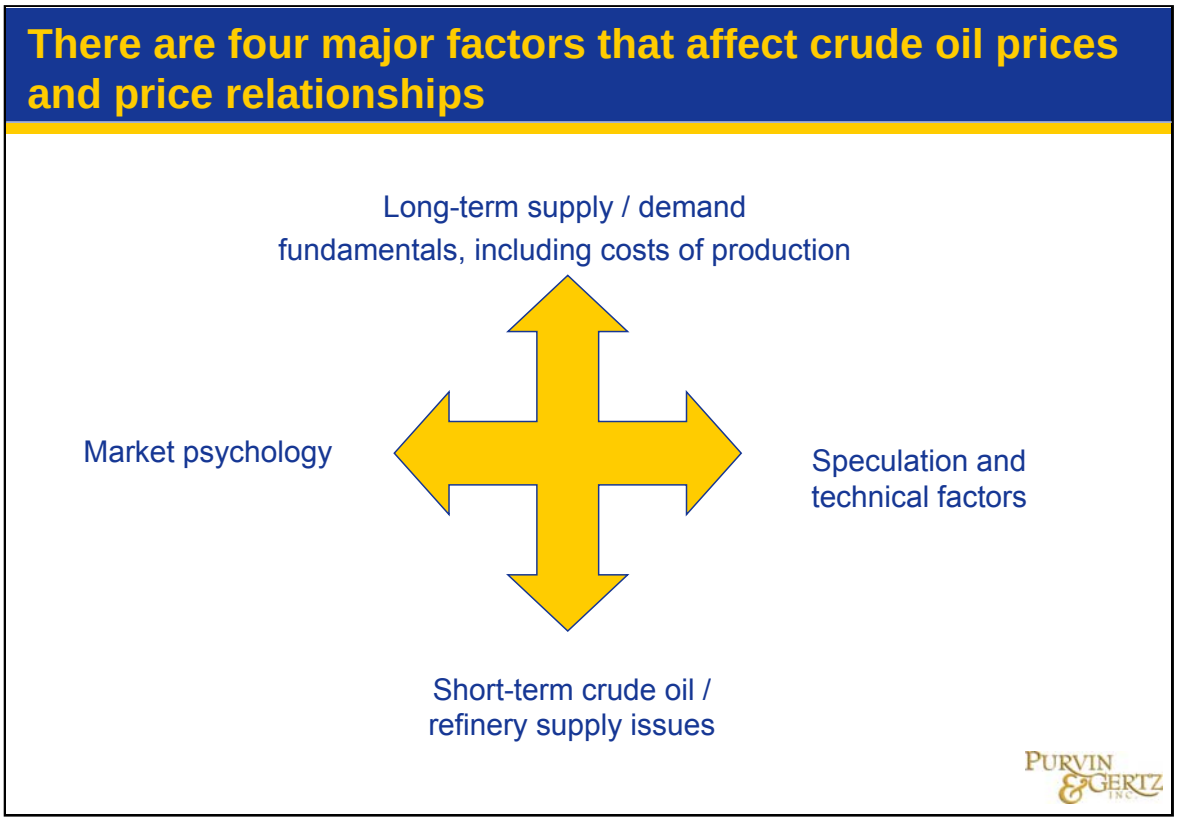
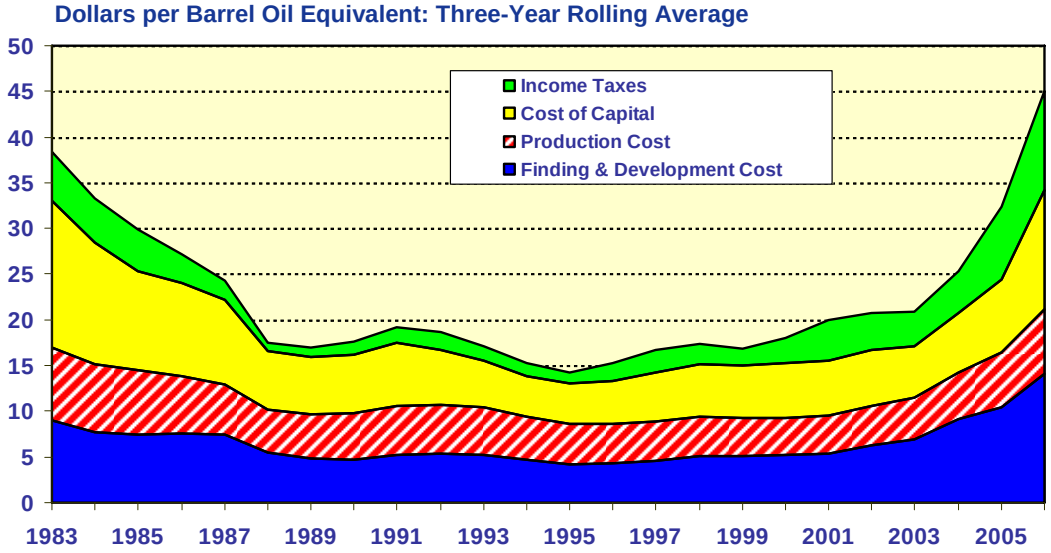
- The problem illustrated above arises from the fact that between mid July and early August the price of Brent (as published by Platts) fell by over $25 per barrel. Product prices fell by a similar amount.
- No refiner operating in a free market can absorb such a large decrease in the value of its production without making a loss. The refinery could tolerate this loss on the expectation that is a temporary one. It would also rely on the fact that the opposite scenario, i.e. a rapid increase of oil prices, plays in its favour. Over time, the impact of volatility tends to cancel out.
- If the refinery does not want to incur the short term loss, or feels threatened by it, it can hedge its exposure to crude prices by trading in futures as shown above.
- Since the Brent Futures, if kept until maturity, will eventually give rise to a payment equal to the price of Brent, the price of Brent Futures is never too different from the price of physical Brent. Because of this, the refiner has a certain degree of confidence that price movements in the "physical" market will be matched by the futures market.
- If the refiner chooses to hedge, it relinquishes the opportunity of making a gain from the possible increase of crude oil prices. Moreover, refiners that trade in derivatives incur transaction costs. For these two reasons, refiners that can tolerate the exposure to volatility may choose not to hedge. However, refiners that are threatened by the exposure would see hedging as an "insurance policy", i.e. the price to pay for security.
- There are a number of instruments that allow hedging the small residual risk related to the fact that the prices of futures do not match the physical market exactly. However, as the sophistication of derivatives increases, so do transaction costs. At some point the refiner would prefer to take the risk. All refiners that choose to hedge have a risk management policy to define their trading objectives and limits.
- The role of futures as a tool for speculation has been under scrutiny in the last few years. There are different opinion about this, but one inescapable reality is that over time the volume of futures purchased and sold must cancel out. Trading in futures does not add to oil demand.

## WHAT SETS THE PRICE OF CRUDE OIL?




- Changes in crude oil prices can generally be explained through one of four principal reasons: long-term supply and demand fundamentals; short-term issues, such as temporary disruptions to supply; market psychology, usually over geo-political issues; and market speculation.
- A critical component of long-term fundamentals is the cost of finding, producing and delivering crude oil to the market. As production in mature areas declines and new finds become increasingly expensive, the long-term price of crude oil would be expected to increase.
- Recent examples of short-term issues include the removal of crude oil production or refining capacity owing to hurricane damage in 2004 and 2005, and again in 2008. Although such disruptions are only likely to be short-lived, such as a few months, the effect can be to drive crude oil prices higher to meet continuing demand.
- Market psychology often has a big influence on crude oil prices. The most typical events that can result in rapid changes of the market psychology are those that concern Middle East countries. This is because, even though no actual changes to the supply/balance may take place, there is a heightened risk of - and greater perceived potential for - a disruption to supplies. This can be sufficient to drive prices higher. Market psychology can also change with the economic outlook, although this normally happens in a more predictable manner.
- Crude oil is also subject to technical rallies and market speculation, much as are other commodities, such as gold and wheat. On these occasions crude oil prices can rise or fall by several dollars in one day, irrespective of supply-demand fundamentals, as a result of traders increasing or reducing their holdings.

## Production and reserve replacement costs have increased strongly since 2003




*Source: US Department of Energy*

- In the long term, prices are determined ultimately by the costs of finding and developing oil reserves and bringing them to the market.
- Since the mid 1990s, production from the most mature oilfields in accessible areas, such as the North Sea and the shallow-water Gulf of Mexico, has declined. New discoveries are proving to be more expensive to develop for two general reasons:
  - ***More hostile operating environment:*** *Deep-water locations such as the Gulf of Mexico, offshore Brazil and West of Shetland in the North Sea incur higher costs owing to the nature of operating in these difficult environments*
  - ***More complex resource base:*** *Oil-bearing developments such as the Canadian oil sands are significantly more expensive to bring to market because of the additional complexity of extracting the oil and making it suitable for transportation to the market*
- From the above, it can be seen that the cost of finding and developing new reserves, as reported by a number of oil companies, rose from just over $20 per barrel of oil equivalent (boe) in 2003 to over $40 per boe in 2006. Since then, costs have risen even further.
- The above values represent averages. Marginal production, such as oil sands, now require oil prices greater than $70 per barrel to meet commercial criteria.

## The supply/demand balance is a key influence in both the short term and the long term

- If the supply of crude is tight compared with demand, then the price of crude oil will rise. Conversely if there is excess of production compared with demand then the price of crude will fall.
- However, determining the oil supply/demand balance is imprecise:
  - *Demand statistics for OECD countries are published frequently, but are subject to subsequent revisions*
  - *Data for developing countries often have to be estimated or are available only after a considerable period of elapsed time (e.g. 12-18 months)*
  - *Crude oil production data is also subject to delay*
  - *Oil stocks data also provide a useful guide. Declining stocks over a certain period indicate that consumption exceeded supply in that timeframe, and vice-versa for increasing stock levels*
- The spare capacity held by OPEC is an important factor in providing confidence to markets that there is a supply cushion to offset market disruptions
  - *In recent years OPEC spare capacity has reached a 30-year low, with the only country currently considered to have significant usable spare production capacity being Saudi Arabia*
  - *Reduced spare capacity has also been a significant factor behind the increase in oil prices since 2004*

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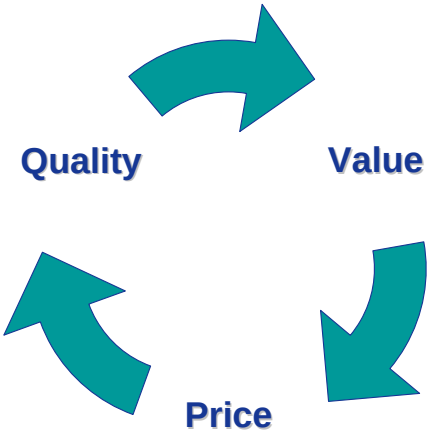
- It is generally the case that non-OPEC crude oil production is maximised and that OPEC provides a balancing flow of crude to the market to supply short-term changes in demand.
- Despite frequent references to geopolitical factors and market speculation, the increase of oil prices observed since 2004 can be explained quite well on the basis of market fundamentals.
- In 2004 oil demand grew by the largest amount recorded since the 1960s. Growth of non OPEC supply was severely limited as Russian production growth slowed down and hurricanes disrupted production in the US and Mexico. Only OPEC could provide oil to match the increase of demand.
- OPEC supply increased, but this caused most of the OPEC spare capacity to be used up. Currently, the most credible analyses about spare production capacity indicates that only Saudi Arabia has significant spare capacity and that the total spare capacity of OPEC has reduced from more than 5 million B/D in the late 1990s to under 2 million B/D in 2005 and 2006.
- The low level of spare capacity during a period of local and international tensions, and supply disruptions led to a heightened concern that there was a greater risk of a real shortage occurring.
- The recent weakness of the US dollar has also been quoted as a factor for high oil prices. This claim has some credibility related to the fact that oil is priced in US dollars. The weakness of the dollar has offset and dampened the impact of high oil prices at a number of locations in the world.
- As an example, oil prices in Europe were at an equivalent of €35-45 per barrel in 2001, when the price was $30-40 per barrel but the $ was worth about 1.2€. At the beginning of 2008 oil prices had increased to $90-95 per barrel (i.e. they had more than doubled), but this was only around €65 per barrel (i.e. an increase not much higher than the general inflation against the 2001 peak). It was only when oil prices kept rising above $100 per barrel that Europe started paying extremely high prices for oil.

## WHAT SETS CRUDE OIL PRICE DIFFERENTIALS?

## Refiners influence crude price differentials through their purchasing activity




- Refiners make their crude purchase decisions on the basis of the quality of a crude, the value of the products they can produce from it and the price at which a particular crude is available in the market.
- Only refineries have the ability to monetize crude quality, so they influence crude price differentials.
- Refineries that produce speciality products such as lubricants, bitumen and waxes tend to select crudes that are known to have better quality for the production of those products.
- Refineries select those crudes from which they obtain better margins. In the free market this is generally done irrespective of crude ownership.
- Refineries may have specific technical constraints that prevent them from processing certain crudes.

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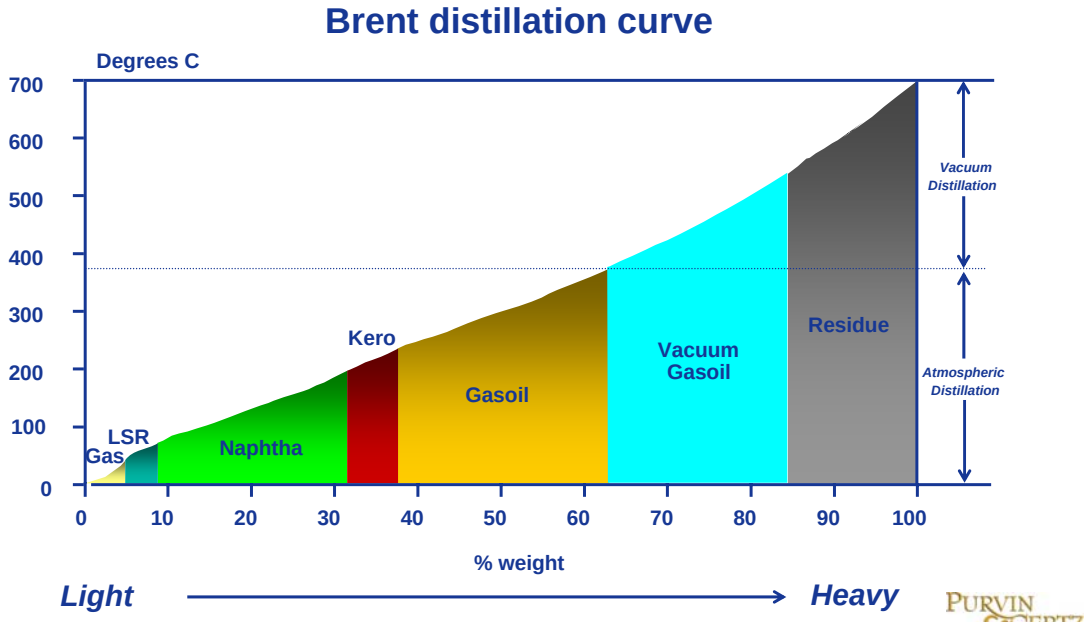
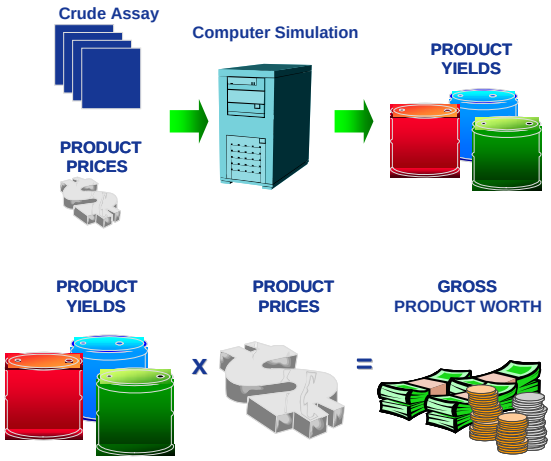
- When refineries buy crude they evaluate the products they will be able to produce from the different types of crude that are available in the market and seek to buy those from which they obtain a better margin.
- With their crude purchase activity refineries influence the price differential between different crudes. If a crude was suddenly trading at a price that is too low relative to its quality, that crude would tend to attract the buying interest of a higher number of refineries. The additional demand for that crude would push its price up relative to other crudes, until an equilibrium is reached.
- Refineries that produce speciality products tend to select crudes that are known to have better quality for the production of those products. As an example, Arabian Light and some other Middle Eastern crudes are known to have good quality for the production of lubricants. As another example, Iranian Heavy crude is quite desirable for the production of bitumen.
- Technical constraints may limit the flexibility of refineries to choose different crudes.
- Crudes may have some unusual quality that introduces specific technical constraints (e.g. high acidity that causes corrosion). Some refineries would be equipped to handle the unusual quality, while others would simply have to relinquish the opportunity to process them.
- Technical constraints may also be introduced as a result of a refinery having been designed for a certain type of crude. As an example, a refinery designed to process Brent would have set the basis of design of all of its process units on the basis of the Brent quality. As Brent is crude with low content of sulphur (**Section II**), this refinery may not have the ability to process high sulphur crude (e.g. Russian crude and Middle Eastern crude).
- It is directionally true that when a refinery is well configured to process a certain type of crude, it would tend to find it optimal to buy that type of crude. However, this is not always the case.

## When refineries select crude the first thing they need to understand is its quality




- Crude quality is analyzed by specialized laboratories on the basis of standard tests that are collected in a document called a "crude assay". The assay provides the refiner with a characterization sufficient to estimate how the crude would be processed by its refinery and the resulting yield of refined products.
- A very important test is the crude distillation. Refiners use the results of this analysis to derive an indication of the yields that will be obtained in their crude and vacuum distillation units.
- The next step is to carry out a number of tests to determine the quality of individual fractions.
- For a hydroskimming refinery, the distillation yields are closely related to the final yields of refined products that would be produced. Conversion refineries will feed vacuum gasoil and possibly vacuum residue to conversion units (Section II).
- The assay generally provides all of the information relevant to understand the following:
  - *What is the quality of a fraction for blending to finished products?*
  - *Does a fraction need treating. Is this within the capabilities of the refinery?*
  - *What is the quality of a fraction as a feed to a conversion unit?*
  - *What yields will the conversion unit achieve on that fraction and what would be the quality of the products after cracking?*
  - *Are there any properties that render the crude unsuitable for processing e.g. high acidity*
- All of the above allows a refiner to carry out a simulation of how the crude would be processed in its refinery and determine what the refinery could produce from the crude oil.

## Refineries use computer models to estimate a "Gross Product Worth" and establish a crude pecking order




- Refineries use computer models to estimate what crudes provide the best economics, given a set of product prices.
- The models estimate the product yields that would be obtained from different crudes that are being offered in the market.
- Product yields and product prices are combined to estimate the Gross Product Worth (GPW), i.e. the value of production obtained from the crude.
- The difference between GPW and purchase price provides an estimate of the possible margin.
- A refiner would try to acquire the crude from which it makes the highest margin.
- Different refineries will have different values for the same crude.

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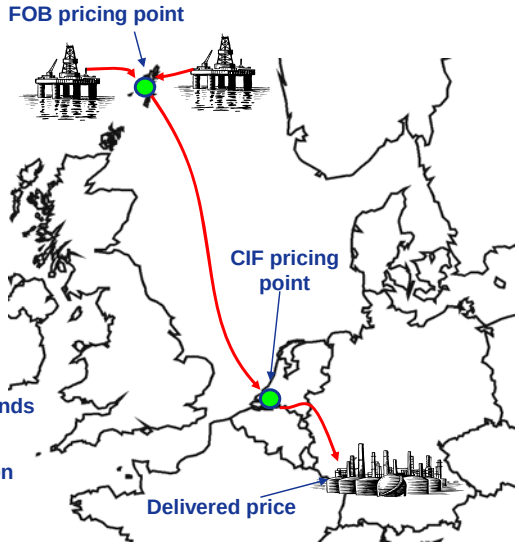
- Crude oil derives its value from the refined products that can be produced by refining it (the Gross Product Worth, or GPW).
- The differential between the calculated GPW for two crudes represents the amount which a given refinery will be prepared to pay to substitute one crude for another while maintaining an equal profit (or loss). This calculation reflects decisions that refiners are constantly making whether to continue purchasing one crude or switch to another crude with different characteristics.
- Each refinery will see a slightly different value for the same crude as the characteristics of the refinery and the patterns of demand for each are different. Each will be prepared to pay a slightly different price for the same crude, and this competition resolves the market price for the crude.
- Some crudes may have specific properties that individual refiners find appealing. The refiner will typically try to obtain a term deal on such crudes to secure its supply.
- The GPW of a crude can be compared with the purchase price of that crude to derive an estimation of the possible margin that could be obtained from processing that crude.
- A refiner would try to acquire the crude from which it makes the highest margin. Since it is only the refiner that can monetize the better quality of a crude, with its optimization activity, refiners influence the price differentials between various crudes.
- The next four pages will show some examples of the considerations that refiners have to make in their attempt to refine an optimal slate of crudes.

## The cost of buying crude includes delivery costs. Example: delivery of Brent to Germany

| Cost item | $/barrel |
|---|---|
| Crude, FOB Sullom Voe | 72.68 |
| Shipping costs | 1.00 |
| Insurance | 0.09 |
| Losses | 0.09 |
| Cost of working capital | 0.16 |
| Value of credit term | -0.48 |
| Total | 73.54 |




- The published price of Brent is applicable to cargoes loading at the Sullom Voe terminal in the Shetland Islands
  - *FOB stands for Free On Board*
- The buyer pays the FOB price and incurs transportation costs and other delivery costs
- Delivery costs are small relative to the value of crude
- An inland refinery incurs also a pipeline tariff

*The costs shown in the table are representative of 2007 average*

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- About 0.2-0.3% of crude is lost during transportation because of evaporation, clingage and measurement differences. This means that for every 1,000 barrels of crude as measured at the loading point, the average outturn at discharge would be about 997-998 barrels.
- Crude at sea is working capital and has a cost. In the example shown above, it is assumed that crude would be received 10 days after loading and the cost of capital is 8%. This cost element becomes relevant when comparing the prices of “short haul” crude (e.g. North Sea to Rotterdam) with “long haul” crude (e.g. West Africa or Arabian Gulf to Rotterdam). The working capital of a refinery with crude at sea for weeks is higher.
- Crude is purchased with a certain credit term that usually runs from the date of loading. The above assumes 30 days, which is quite typical in the industry. If two crudes are available with very different credit terms, it is important to include this element in the calculation of value.
- An inland refinery will have to pay “secondary transportation costs”, which is the cost of delivery from an import terminal to the refinery, usually a pipeline fee.
- The shipping costs shown above are representative of 2007 average. Shipping costs vary with market conditions. Tankers can be hired with long term contracts or on the basis of “spot” deals for a single voyage. Variations in the cost of shipping can make the purchase of crude from more distant locations more or less attractive.
- While spot tanker rates can be very volatile, all of the other elements of the calculation are fairly predictable in the short term (i.e. they are not likely to change much from one cargo to another).

## An example of gross product worth calculation

| | | Brent | | Arabian Light | |
|---|---|---|---|---|---|
| | Prices,$/t | Yield,wt% | Revenue,$ | Yield,wt% | Revenue,$ |
| Propane | 669 | 1.7 | 11.4 | 1.5 | 10.0 |
| Butane | 640 | -0.5 | -3.2 | -0.5 | -3.2 |
| Gasoline | 709 | 38.2 | 270.8 | 28.4 | 201.4 |
| Kerosene | 711 | 8.4 | 59.7 | 2.9 | 20.6 |
| Diesel | 675 | 15.7 | 106.0 | 18.8 | 126.9 |
| Gasoil | 641 | 15.7 | 100.6 | 18.8 | 120.5 |
| Low sulphur fuel oil | 360 | 14.6 | 52.6 | 0 | 0.0 |
| High sulfur fuel oil | 335 | 0 | 0.0 | 23.5 | 78.7 |
| Sulfur | 100 | 0.1 | 0.1 | 0.7 | 0.7 |
| Fuel and losses | | 6.1 | 0.0 | 5.9 | 0.0 |
| Total, $/tonne | | | 598.0 | | 555.6 |
| **Total, $/barrel** | | | **79.32** | | **76.67** |
| Differential to Brent | | | | | **-2.65** |

- **The refiner who is making this calculation concludes he can buy Arabian Light for up to $2.65 below Brent, on a delivered basis.**

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- In the example shown above a refinery is considering whether to buy a cargo of Brent or a cargo of Arabian Light.
- It has estimated that it would be able to process Brent into a slate of refined products that is worth 79.32$/bbl.
- The slate of products obtained from Arabian Light is worth 76.67$/bbl.
- Thus, the yields obtained by the refinery from Arabian Light are worth $2.65 per barrel less than those obtained from Brent.
- The refinery would take this into consideration when it has to decide which crude to buy and at what price.

## Ranking of crude oil prices: the pecking order

| | FOB Price | Delivered Price | GPW | Margin |
|---|---|---|---|---|
| Arabian Light | 68.67 | 69.76 | 76.67 | 6.91 |
| Forties | 72.46 | 73.16 | 79.71 | 6.55 |
| Urals | | 69.16 | 75.66 | 6.50 |
| Saharan Blend | 74.17 | 75.36 | 81.62 | 6.26 |
| Brent | 72.39 | 73.18 | 79.32 | 6.14 |
| Flotta | 70.55 | 71.44 | 76.72 | 5.28 |
| Oseberg | 73.87 | 74.74 | 79.97 | 5.23 |
| Statfjord | 73.96 | 74.60 | 79.82 | 5.22 |

- **The slate of products obtained from Arabian Light is worth $2.65/bbl less than Brent.**
- **However, the price of Arabian Light delivered to his refinery is $3.42/bbl less than Brent.**
- **Thus, his margin on Arabian Light is higher than that on Brent. He would try to secure Arabian Light supplies.**

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- The considerations made above would set the purchase strategy of the refinery.
- In the example, Arabian Light is the best crude. However, it is only available through a supply contract with the NOC of Saudi Arabia (Saudi Aramco) and is not traded in the spot market.
- The alternative would be to buy Forties, which is available also in the spot market. The next best option in the "pecking order" is Urals, also offered in the spot market.
- Since all refineries are different and see somewhat different economics from processing a certain crude they would each come up with different pecking orders. However, if too many refineries were seeking to buy Forties in preference to Brent the price of the available Forties cargoes would be bid up until an equilibrium is reached.
- This activity by refineries to optimize their profitability influences crude price differentials.
- In liquid and functioning markets three main competitive forces influence crude price differentials:
  - *The configuration of refineries and their ability to convert crude into products with certain yields.*
  - *The value of those products.*
  - *The ability of crude sellers to trade their crudes to a number of different refineries, possibly in different markets.*
- In our consulting activity we find that crude price differentials can be explained reasonably well consideration of the above competitive forces. We consider the crude market as one of the best examples of a globalized, liquid and competitive market. Historically incidents of alleged market abuse have been met with changes to prevent reoccurrence.

# The crude oil market - conclusions

- **The global crude oil market is dominated by National Oil Companies, most notably those of the OPEC countries.**
  - *OPEC seeks to influence prices by setting supply in relation to demand and maintaining a market balance*
  - *Increasing non-OPEC supply has historically weakened OPEC's position. OPEC has greater reserves and, therefore, will be the main source of future increases of oil supply. Its position is bound to strengthen.*
- **There is a highly developed, transparent, world-wide market for the sale and purchase of crude oils.**
  - *Some crude oils are traded in liquid spot markets and are used as marker crudes.*
  - *Other crudes are priced on the basis of differentials to marker crudes. The differentials reflect delivery location and crude quality.*
  - *The crude market is global. Crude prices in different regions move together.*
  - *The market has evolved over the past 40 years and has become more and more sophisticated.*
  - *There are oil exchanges that allow trading in a number of sophisticated derivatives linked to crude oil prices. The derivatives were devised to allow risk management, but have also become a tool for speculation on the future direction of the market.*
- **Refiners set the price differentials between crudes through their purchasing activities**
  - *Different crudes have different values to different refineries.*
  - *Refiners use models to estimate which crudes are likely to deliver the best margins.*
  - *Refiners can influence the price of one crude versus another by their purchasing behaviour.*
  - *Refineries influence crude price differentials but have little or no influence on the outright price of crude oil.*

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## SECTION IV

# THE REFINED PRODUCTS MARKET

## Introduction to this section

- This section provides an overview of the refined products market.
- It starts by showing key features of demand patterns and the main trade flows in and out of Europe. An understanding of these aspects is important because it has implications on product prices.
- The section will show why the region around Rotterdam has become the most important spot market for refined products in Europe and will illustrate how products at other locations can be priced in relation to the "Rotterdam" prices.
- We have made some parallels with the discussion of crude markets to show how the market sophistication has increased over time and how exposure to price volatility can be managed.
- The section also discusses the key global drivers of product prices. The most important is naturally the price of crude, but we will show that trade links and supply/demand imbalances also have significant implications on product prices.
- The concepts discussed above will be used to show that companies that supply their own wholesale or distribution affiliates with product from their own refineries do so at market related prices.

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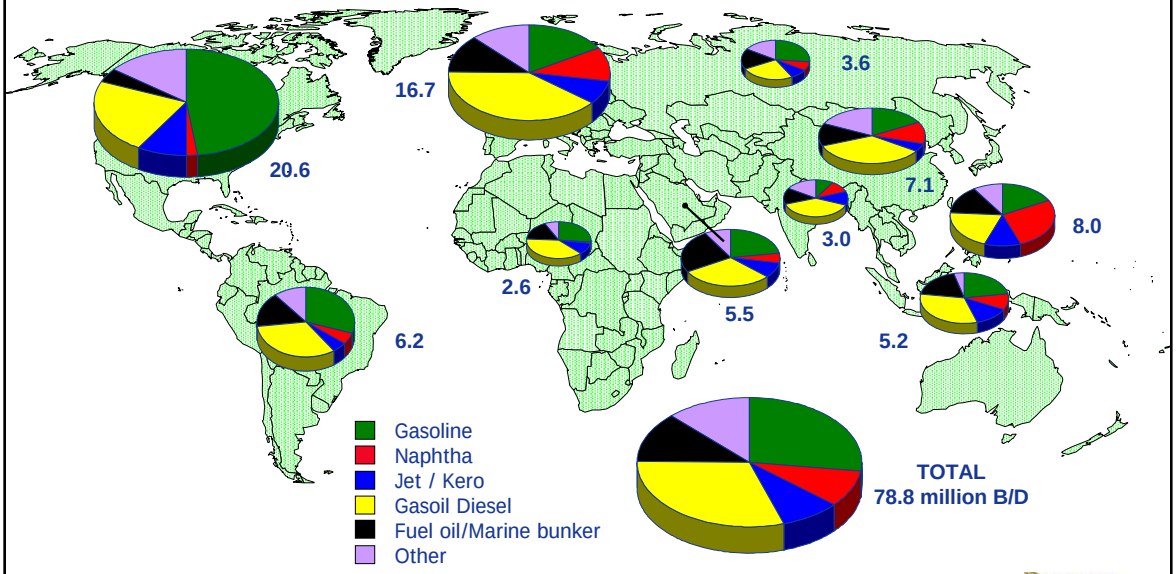
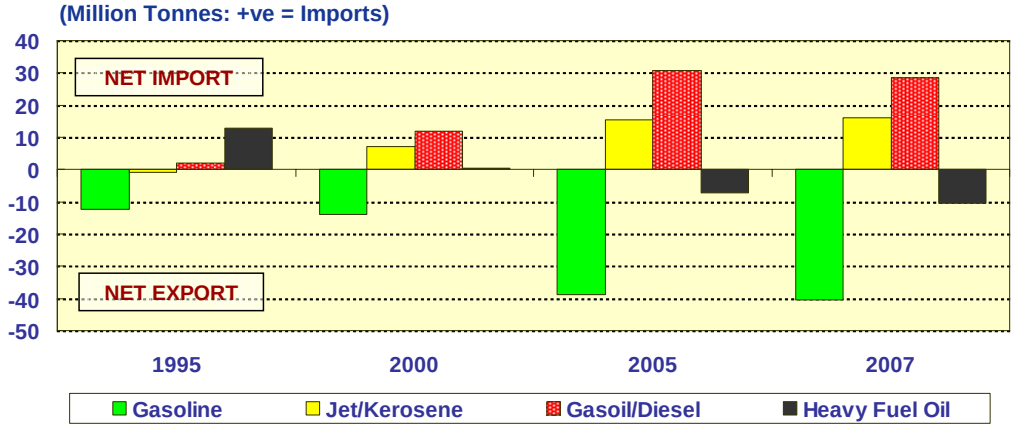
## In 2007, world refined product demand averaged 79 million B/D, with Europe accounting for 20% of the total




Source: Purvin & Gertz Global Petroleum Market Outlook

- World total refined product demand was approximately 78.8 million barrels per day in 2007, with the largest concentrations of demand in North America and Europe. Japan and a rapidly growing China are the next largest demand areas.
- The breakdown between refined product types is different in the different regions. In North America, gasoline represents 48% of the total demand, by far the largest single component. In Europe, diesel and gasoil represent the largest component group with 40% of the total.
- These demand differences are important, because they differ from the production capabilities of the refineries in these regions, and the only way to correct the resulting imbalances is through international trade in the short term, or appropriate investment in the long term.
- Imbalances between supply and demand of a given product in a region have an impact on the price of that product in one region versus another. If a region is short of product which it needs to import, the price will rise relative to other regions until supply is attracted.

## European imbalances are growing




- **Net export of gasoline is 24% of production, while net import of gasoil/diesel is 12% of demand**

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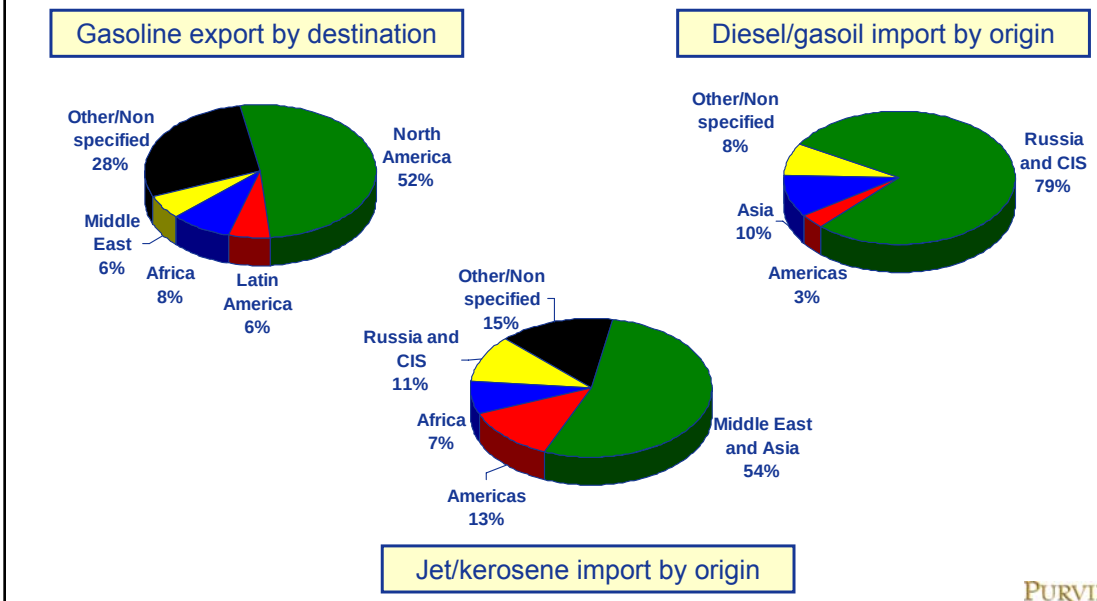
- Over the last few years large supply/demand imbalances have developed in the European refined product markets. As a result, Europe has become increasingly reliant on trade.
- All of the major regions have some imbalances and they all trade with Europe to different extents. With the exceptions of the Middle East and Russia, which refine for export, the other regions refine for local needs and use trade to balance supply with demand.
- Refinery capacity will not adjust quickly if there is an opportunity to balance markets by trade. The increasing imbalance between European product demand and European refinery capability will require new product sources and outlets to develop, or new investment in refinery capability in Europe.
- In 2007 24% of gasoline produced by European refineries was exported, a consequence of steadily declining European gasoline demand. The decline is expected to continue with a need for increasing exports or a change to decrease the production.
- Diesel/Gasoil imports are expected to increase. About two thirds of the European diesel demand is for commercial use (e.g. trucks) and grows with economic activity. The remainder is used by passenger cars and will grow depending on car registration preferences (currently biased to diesel).
- Jet fuel imports are also likely to increase as air travel is forecast to grow. Jet fuel is made from kerosene, although kerosene can also be used to make diesel. Increasing jet/kerosene imports provides an additional option to increase diesel production. For this reason trade of jet/kerosene and gasoil/diesel follow similar trends.
- In 1995, Europe was a net importer of heavy fuel oil, mainly in the Mediterranean where Italy was a large user in electricity generation. Since then a number of Italian power plants have been modernised to burn natural gas. Similar developments have taken place in Greece and Spain, with the result that the European heavy fuel oil balance has shifted to a position of net export despite a fairly strong growth in the bunker market.
- Although the net heavy fuel export is moderate, the European heavy fuel oil market is oversupplied because of the large volumes of heavy fuel oil exported from Russia via the Baltic and the Black Sea.

## Europe exports its gasoline surplus to North America. Gasoil and kerosene are imported from several sources.




Source: Purvin & Gertz Global Petroleum Market Outlook

- The largest single export market for European gasoline is the USA, primarily to the East Coast. As European gasoline demand declined, US gasoline demand grew very strongly. Europe and the US became reliant on each other to balance their gasoline markets by trade.
- The primary supplier of imported gasoil into Europe is Russia. Imports from Russia have long been a feature of European gasoil/diesel markets. However, between 1993 and 1997 the European market was well balanced and a corresponding volume of gasoil was re-exported to other destinations.
- Since the late 1990s, the European market has been short of gasoil/diesel. Russian gasoil and diesel are now a very important component of the European gasoil/diesel supply.
- Russian gasoil is no longer sufficient to balance the European market. Imports of diesel also come to Europe from North America and as far afield as Asia. This marginal component of supply is growing quite rapidly.
- The Middle East is the largest supplier of imported jet fuel into Europe, but imports from Asia are also growing. Most of the imports from the Middle East and Asia flow to Northwest Europe and tend to be on large product ships (e.g. over 60,000 tonne capacity). This allows an economy of scale on freight costs. A number of ports (e.g. Rotterdam and Le Havre) can handle these cargoes, which are either broken down into smaller sizes (e.g. barges and smaller tankers) for distribution to smaller European terminals, or are fed directly to an inland market by pipeline.

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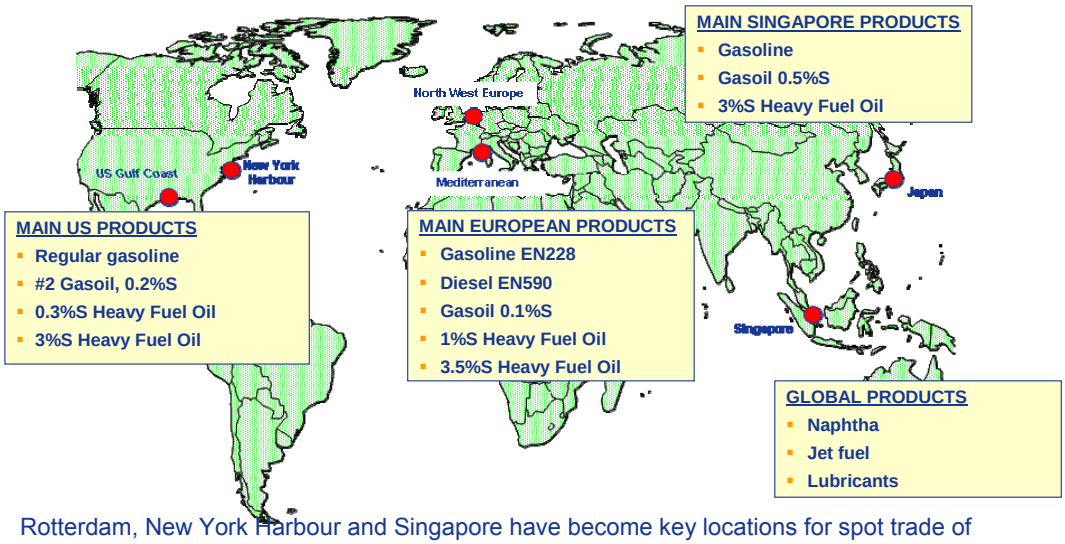
## HOW ARE PRODUCTS PRICED?

## There are three principal products pricing centres: the United States, Europe and Singapore




- Rotterdam, New York Harbour and Singapore have become key locations for spot trade of products
- Prices for the main products traded are published by Platts, Argus, etc.
- They are used as global indicators of product prices

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- The refined products pricing centres have developed at locations that had either a large concentration of refining capacity, and hence had products to sell, or an excess of product demand over refining capacity, and needed to buy products.
- The major pricing centres for refined products are the US Gulf Coast, New York Harbour, North West Europe and Singapore.
- The **New York Harbour** area is densely populated but relatively short of refining capacity. As such it is currently the world's most important market for gasoline.
- The **US Gulf Coast** has a large concentration of refining capacity and sells refined products to a number of locations in the US. It is connected by pipelines to the central regions of the US.
- North West Europe has the **Antwerp-Rotterdam-Amsterdam** (ARA) area which is a trading hub where products are refined, imported, exported, stored and traded. In ARA it is also possible to transship product for trading in barges along the Rhine. The ARA refined products market is one of the most complete, liquid and sophisticated in the world. This is often called the Rotterdam market.
- **Singapore** has export refining capacity to serve South East Asia. While trade in North Asia exceeds trade in Singapore, it was the latter that liberalized markets and created the conditions of market transparency to become the most important trading hub in the Far East. The Middle East exports a range of products but does not have an active spot market comparable to that of Singapore.
- The **Mediterranean** market has historically been a major export centre for refined products, mainly from refineries in Italy. However, it does not have the same transparency as North West Europe.
- **ARA, New York Harbour and Singapore have become three key locations for spot trade of refined products**. Refined product prices at these three locations are reported on a daily basis by specialized and independent price reporting services such as those offered by Platts, Argus and others.

## Rotterdam owes its prominence in the European market to its location, concentration of refineries and logistics


- The Antwerp-Rotterdam-Amsterdam area has numerous refineries and terminals used to produce, import, export and store refined products
- The area is connected to inland markets by pipeline
- River barges can be used to deliver products as far as Switzerland via the River Rhine and other waterways
- The ARA area serves as a product supply and trading hub for a significant proportion of the Northern European demand
- As ARA is the most important location for spot trade in Europe, product pricing there reflects the supply and demand situation of the wider North European market

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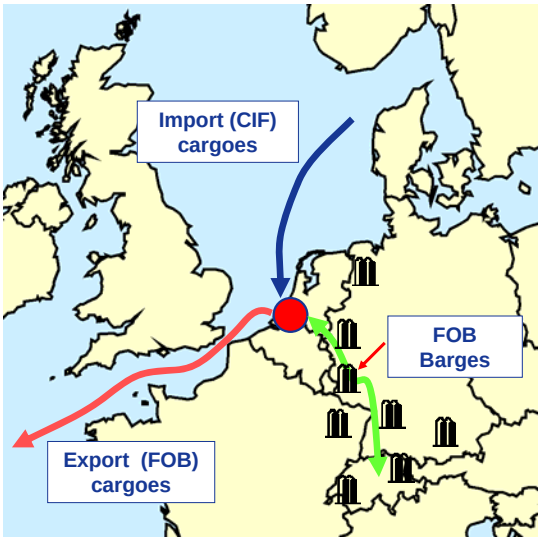
- Excluding three small sites that produce speciality products, the ARA area has a total of 8 oil refineries with a total capacity of approximately 2.1 million B/D (i.e. 105 MT/y). This is over 10% of the total European refining capacity.
- Besides its large concentration of refineries, the ARA area also has a number of oil product import terminals and pipeline connections. The terminals are used to import and export cargoes.
- The capacity available in independent storage terminals is around 12.5 million $m^3$.
- From ARA it is also possible to access the River Rhine and associated waterways to deliver products by barge to inland destinations.
- This is an example of a well supplied coastal location, where there are numerous sources of supply. The prices are influenced by the supply/demand position for the entire Northwest European region.
- Product that is in excess of the needs of the inland market can be exported by cargo to other locations in Europe or worldwide. As an example, fuel oil and gasoline are currently exported by cargo. The main destinations of fuel cargoes is Asia, while gasoline is mainly traded to North America.
- If there is a surplus of product in the inland market, as it is increasingly the case for gasoline, the flow of barges can reverse. Product is barged up the Rhine into ARA, where it is received at a terminal and used to assemble a cargo for export.

## Rotterdam prices are published for import cargoes, export cargoes and barges




- The variety of published assessments reflect the different types of trades and parcels
- Cargoes can be traded on a "delivered basis" to a named location
  - *This is an import cargo, traded on a CIF basis: Cost, Insurance and Freight (CIF)*
  - *Cost of delivery borne by seller*
- Alternatively, a refinery could make product available for loading on a cargo
  - *This is a cargo, traded on a FOB basis: Free on Board (FOB)*
  - *The buyer will load the product at its own cost*
- Smaller parcels are traded by barge along the Rhine and other associated waterways
  - *Product is made available for loading into barges*
  - *FOB Barges quote applies*
- Thus, prices are assessed for Cargoes CIF ARA, Cargoes FOB ARA and Barges FOB ARA

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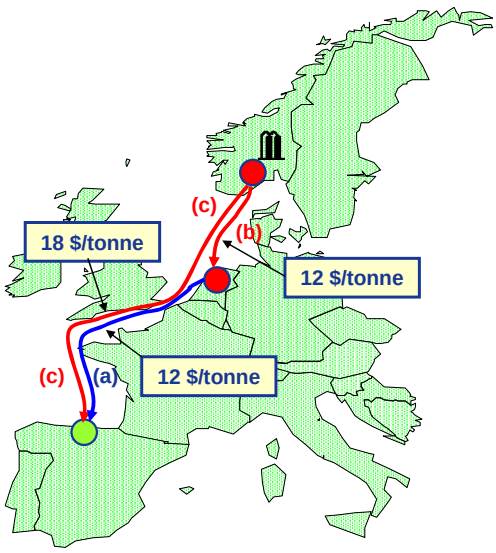
- For each product, there could be a number of "Rotterdam" price assessments available to reflect the type of parcel traded and the terms of trade. The basis for the published assessment is clearly stated on the company's website and literature.
- Product could be loaded to a cargo and traded "on a delivered basis" to a named location (e.g. Rotterdam). The pricing point is the named point of delivery at Rotterdam. Delivery costs would be borne by the seller. This product has been traded as a "CIF cargo".
- A cargo could be loaded for export and traded on an FOB basis. The seller makes the product available for loading from tank into a ship nominated by the buyer. The buyer lifts product and takes it elsewhere to an importing location. He pays all of the costs incurred to take the product to the desired importing location.
- Similarly, product could be made available for loading from tank into a barge and traded on an FOB basis.
- Thus, there are price assessments for Cargoes CIF ARA, Cargoes FOB ARA and Barges FOB ARA.
- For reference, a cargo to export product to another location in Northwest Europe (i.e. short-haul trade) would have a size in the 10-30,000 tonnes range. Export to North America would most typically be in parcels of 30-40,000 tonnes, but larger parcels can also be used. Trade to/from Asia or the Arabian Gulf would often be in parcels larger than 40,000 tonnes. By contrast, a barge would normally load up to 5,000 tonnes of product.

## Prices in other locations are linked to Rotterdam prices via trade : example of intra-regional linkages




Note: Freight costs are for illustration only. They are approximately correct as 2007 average and for parcels of ~30,000 tonnes

- **Diesel demand in Spain exceeds refinery production, such that extra diesel is imported**
- **Diesel can be purchased at ARA**
  - *Refiners or traders buying and selling in the ARA market receive the ARA spot market price.*
  - *If exporting from ARA to Spain, the cost of imported diesel would be the ARA price plus transportation costs from ARA to Spain **(a)**.*
  - *This option will set the ceiling for the price of diesel delivered to North Spain. (Import parity from ARA).*
- **A refinery in Scandinavia has surplus diesel**
  - *The refiner can supply into the ARA region and earn the ARA price less transportation costs to ARA **(b)**.*
  - *This defines the minimum value ("netback") of diesel to the refinery in Scandinavia. To secure the import the buyer in Spain must pay at least this price.*
  - *The price of product delivered to Spain must be higher than the ARA price less transportation costs (b) plus transportation costs (c). (Import parity from Scandinavia)*
- **These two options provide possible price setting mechanisms for diesel in the North of Spain**

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- Products in other locations can be priced in relation to ARA prices, taking into account the cost of supply from possible competing sources.
- At an importing location product prices would be set in relation to the cost of import (import parity). At an exporting location product prices have a value related to the "netback" that can be earned by delivering to a suitable importing location (export parity).
- Rotterdam prices can also be used to price products along the entire supply chain. This is still done in relation to the cost of delivery from one point on the chain to the next.
- As an example the price of product delivered to Basel (Switzerland) would be set in relation to Barges FOB ARA, plus the cost of delivery by barge from ARA into a suitable terminal at Basel. In 2008 the quoted barge rates from ARA to Basel have been in the 15-25 €/tonne range.
- From Basel, a smaller parcel of this product may be delivered yet to another terminal by rail, in which case terminal fees and rail costs would continue to add to the cost of delivery to the end user. Eventually the product would reach the end user.
- Refined products become more expensive as they move closer to the end user and parcel sizes reduce, leading to higher transportation costs on a per tonne basis.
- As an example, while it is possible to reach Basel from Rotterdam by barge for about €20/tonne, it would only be possible to cover half the distance for the same cost by truck.
- By a combination of barge, rail and truck it would typically be possible to distribute products to most locations in Switzerland at costs that are in the region of €30-50/tonne above ARA. This is low in relation to gasoline or diesel prices at ARA, which have averaged about €700/tonne in 2008.

## Products can be purchased on the spot market or with term contracts

**Spot Sale: one time transaction for a single cargo or delivery**

- Price may be fixed (e.g. $1000 per tonne) or indexed to a marker (e.g. Gasoil 0.1%S FOB Barges + 4$/tonne).
- In the second case when the product is supplied the buyer will pay a price equal to the spot FOB barges price on that day plus $4/tonne.
- Prices can be disclosed to publications. The prices disclosed form the basis for the assessment of the spot price
- Used by refiners to adjust production based on market circumstances

**Term Contract Sales: Deliveries over a defined period of time**

- Price set by a formula
- The buyer chooses this to guarantee a certain minimum volume of product supply
- The formula usually refers to the appropriate spot price. Therefore product purchased under a term contract is linked to spot prices.
- Used by consumers and producers to enter into a stable relationship that provides security to both parties.

- **A large part of the production of a refinery is sold under term contract. The spot market is used to source additional product or to dispose of excess product.**
- **The supply/demand balance position of each market participant is reflected in the need to trade in the spot market.**
- **Spot prices react to changes of the supply/demand balance of the whole market.**

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- The decision to trade products in the spot market or with term contracts is a decision of security versus flexibility. Contract sales provide security for both the refiners and the marketers. The spot market provides flexibility to adjust rapidly to changed circumstances.
- Neither refiners (as sellers of products) nor buyers may want to rely exclusively on the spot market. Refiners want to foster ties with the local markets and want to secure a desired amount of demand. Buyers want to conduct their business around a certain volume of guaranteed supply. They can use the spot market to source additional products, to dispose of excess product or to adapt to new circumstances as it may be the case.
- As buyers and sellers use the spot market to dispose of excess products, it is the spot market that ultimately determines product prices. Whether products are sold with term contracts or in the spot market, the prices will be tied to the spot market prices as shown above.
- The purpose of the formula may be solely to make an adjustment to reflect the higher or lower value of product at the point of delivery, in which case the formula may be as simple as a fixed differential. In other circumstances, (e.g. to reflect a customized quality specification) the formula may be more complicated.
- In the example shown above the buyer may be a heating gasoil distributor. He knows that by buying product at a premium of $4/tonne above FOB Barges he can sell competitively into his local market. Thus, his strategy is based on entering into a contract that guarantees the differential, but not the price. He knows that the prices he pays for product will go up and down with the market, but this will be the same for everybody else and he does not expect this to undermine his competitive position. By contrast, if he buys at a fixed price he is at risk of making a large loss in a falling market.
- At the same time the seller (e.g. a refiner or a trader) may not want to take the risk of selling at a loss if crude oil prices increase. So, he accepts entering into a contract that fixes the differential, but not the price.

## Spot market prices are assessed and published by a number of independent companies

- **A number of independent companies and organizations research the oil products markets and report on the prices of refined products.**
- **Information is gathered by contacting multiple market participants by telephone or electronically using standardised methodologies.**
- **The organisations then publish their assessment of product prices in the market place on a regular basis (e.g. daily), sometimes in real-time.**
- **This information is available to commercial organisations and the general public on payment of a subscription to the service.**
- **The fact that this pricing information is provided by independent organisations allows market participants to use these price assessments as one of the reference factors when trading with each other.**
  - *Term supply contracts use these assessments in their formulae*
- **Platts and Argus quotes are the most commonly used for pricing of oil products in Europe. ICIS specialise in petrochemicals and base oils (i.e. refined oils that are blended with additives to produce finished lubricants).**
- **Bloomberg and Reuters report on crude and main oil products prices, and provide coverage for a wide range of commodities.**

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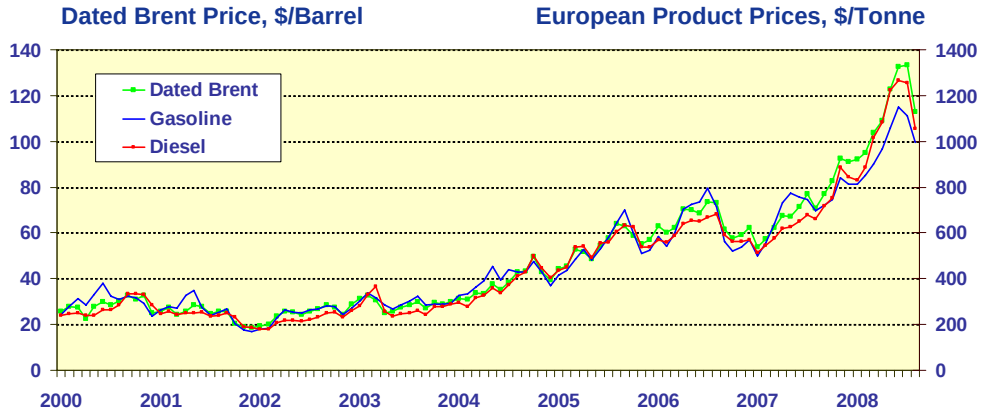
- These organisations undertake active research into the trades taking place in the refined product markets, and report on the trading activity. Platts and Argus in particular specialise in reporting on the refined oil products markets in significant detail, and provide numerous quotes for different product grades.
- Their price discovery effort relies on the facts that some buyers and sellers willingly disclose prices to them.
- In some cases these organisations publish real-time information on product pricing enabling traders to watch and track the market throughout the day. Daily, Weekly, and Monthly price averages are also produced.
- The methodology used to determine these price assessments is published on the company web-sites.
- The information and published prices are readily available on a subscription basis, together with detailed market commentaries.
- As the published price quotes are produced by independent organisations, this enables companies and traders that are actively competing with each other in the oil products market to trade with each other, confident that will be obtaining a fair market price.
- The fact that there are a number of independent organisations watching and reporting on the oil markets also provides some impediment to potential market price manipulation.

## The price of crude oil is a key determinant of product prices




**Product price movements are directly influenced by the price of crude oil, and match price trends very closely**

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- Crude oil prices and refined product prices follow nearly identical paths.
- In **Section V** we will show that, while crude oil prices have reached levels as high as $140-150 per barrel, the order of magnitude of the margin that a refinery makes on refining crude is only a few dollars per barrel.
- This implies that if a large increase in crude oil prices is not followed by an increase of refined product prices, refining profitability would fall and would possibly go negative. Refining activity would reduce, crude demand would decline and the product market would become undersupplied. This would cause product prices to increase to a level that would allow refining to start again.
- A similar concept applies when oil prices fall, although the dynamics are slightly different. A fall of crude oil prices, if not followed by a fall of product prices improves refining margins and encourages higher utilization of refining capacity. Eventually the products market becomes oversupplied and prices will fall.
- The mismatch between refinery yields and market demand can also result in different supply/demand balances for individual products. Thus, the price of a product could increase significantly relative to another product. However, the impact of crude prices is the dominant one and all product prices tend to go up and down with crude prices, to various degrees.

## Refined product markets have evolved in parallel with crude oil markets, reflecting changes in the industry

**Virtually no Market** → **Sophisticated and Developed Market**

| Pre - 1970s | 1970s | 1980s | 1990s |
|---|---|---|---|
| **Vertical integration** | **OPEC crude is nationalised** | **Emergence of a market for products** | **Sophistication increases** |
| Majors play a large part in the industry upstream and downstream.<br>Little or no trade of refined products. | Upstream decoupled.<br>Majors continue to dominate the downstream, but independent refiners grow. | Independent refiners need a market for products.<br>Majors focus on the upstream. | Margins remain low.<br>Trade moves to electronic platforms.<br>Derivatives needed to manage risk. |

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- The refined products market as it has been described in the previous pages started in the 1980s. Until the 1960s, there was vertical integration and the industry was dominated by the Major IOCs. In the 1970s the domination of the Major IOCs continued in the downstream sector.
- The development of a market for crude through the 1970s fostered the growth of independent refiners. They needed to sell products in the market.
- In the 1980s the business environment for refining changed completely. The construction of new refineries in the 1970s was followed by a fall of oil demand from 1980. A large refining overcapacity developed as a result and refining margins were very low. The Major IOCs focused on the upstream and started rationalizing their downstream.
- Prices became very volatile, but exposure to volatility could not be tolerated with the low margins of the 1980s. The spot market developed and futures contracts linked to spot prices allowed hedging. Nymex launched the heating oil futures contract in 1980 and the gasoline futures contract in 1985. The International Petroleum Exchange (now ICE) launched the gasoil futures contract in 1981.
- The 1990s saw a drive to develop more and more sophisticated instruments to limit financial risk by use of hedging. Swaps contracts (see next page) developed in the 1990s. The 1990s also saw the uptake of the electronic trading platform and the entrance into the market of the financial players. Their main activities are speculation and trade of derivatives for hedging.

## An active "paper" market has developed to allow companies to manage their exposure to product prices

- **Buyers and sellers are exposed to the volatility of product prices. A wide range of derivatives has developed in association with trade of refined products. These derivatives allow reducing the exposure to future variations of product prices**
- **Derivatives include Futures, Swaps and other, more customised and sophisticated instruments.**
- **The main futures exchanges are the New York Mercantile Exchange (NYMEX) and Inter-Continental Exchange (ICE) in London**
  - *The most highly traded product-linked derivative at ICE is gasoil futures.*
  - *At Nymex, the most highly traded product-linked derivatives are gasoline futures and heating oil futures.*

**Futures**

- Contract to exchange product at a certain time in the future.
- Physical delivery not necessary. Mostly settled in cash.
- Prices go up and down with the price of the commodity they are linked to.
- Liquid and transparent market.

**Swaps**

- Contract to pay or to be paid the difference between a set price and the actual price of a product.
- Used to "lock-in" the set price.
- They are private agreements.
- A fairly liquid market, but not as transparent as futures.
- Available only for few products.

**Others**

- Futures and swaps allow hedging a limited number of specific risks.
- Other more sophisticated derivatives are traded.
- These derivatives can be structured for specific needs.
- The market is less liquid and less regulated.

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- Buyers and sellers of refined products are exposed to the volatility of product prices. This exposure can be tolerated or can be managed through hedging with derivatives.
- Like the crude market, a wide range of derivatives have developed in association with products trade. These derivatives are typically contracts that envisage a transaction in the future. The transaction is linked to the price of refined products.
- The only futures contract available in Europe is the ICE gasoil contract. This is a contract between a buyer and a seller to exchange gasoil at a certain time in the future. Physical delivery of gasoil is not necessary. The seller can meet his obligation by paying a sum of money given by the price of "Gasoil, cargoes CIF ARA" as reported by Platts, multiplied by the volume of futures traded.
- In Northwest Europe there is a market for jet fuel, gasoline and low sulphur fuel oil swaps. Two counterparties that enter into a swaps contract agree to pay each other a sum given by the differential between an agreed price (the "fixed" price) and the actual price of a product. This is done to "lock-in" a certain product price as explained in the next page.
- Futures and swaps cover only some refined products, but not all. If refineries want to adopt a more comprehensive and sophisticated hedging policy, they must use other more sophisticated and customized derivatives.
- When moving from futures to swaps and then to the more customized derivatives, regulation and liquidity reduce. Futures are traded in regulated markets. Swaps are private agreements, but these agreements are regulated and can be traded on to other parties. This may not be possible with customized contracts.

## Example: how to use swaps to hedge the price of jet fuel

- **An airline has a contract to buy jet fuel at "Cargoes CIF ARA + 20 $/tonne"**
- **The airline is planning its business for the next six months and is concerned about a possible increase of jet fuel price**
- **The airline decides to hedge its fuel costs by trading in jet fuel swaps, so as to create an exposure to prices that is equal and opposite to the exposure in the physical market.**

**Activity in the "physical" crude market**

- April 2008: Contract to buy 10,000 tonnes of jet fuel per month at "Cargoes CIF ARA". Current jet fuel price is 1100 $/tonne.
- July 2008: Jet fuel prices are at 1300 $/tonne. This is the price the airline must pay for jet fuel
- The jet fuel price is 200 $/tonne above budget.

**Activity in the "Paper" crude market**

- April 2008: Enter into a swaps contract with a counterparty at a price of 1,150 $/tonne
- July 2008: with the swap, the airline is paid the difference between the actual price of jet fuel (1300 $/tonne) and the "swapped" price (1150 $/tonne)
- The airline receives 150 $/tonne by the counterparty

- **The airline has paid more for its fuel, but has been reimbursed by the swapping counterparty**
- **The effective cost of fuel is 1150 $/tonne, which is the price of the swap**

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- In the example shown above, an airline has a term jet fuel supply contract, whereby the price is set by a formula. The airline wants to hedge the price of jet fuel in order to operate on the basis of a firmer operating cost budget. This would be possible with swap contracts.
- With the swap, a counterparty may agree to pay or be paid by the airline the difference between a set price and the actual price of a commodity (jet fuel in this case).
- Once the transactions resulting from the swap contract are taken into account, the total cost incurred by the airline to purchase fuel is effectively the "swapped" price.
- Who could be the counterparty of the airline?
  - *A refiner may be interested in locking-in the price of jet fuel. Refiners would not normally expose themselves to the risk of selling at fixed prices in a rising oil market. However, when refining margins are good, they may hedge both the price of crude (see **Section III**) and the price of products. If they operate in this manner, refiners can "hedge" the refining margin*
  - *Anybody who wants to hedge his exposure to falling jet fuel prices, i.e. he has an exposure and motivations opposite to the airline.*
  - *The other possibility is a speculator who is betting on falling oil prices*

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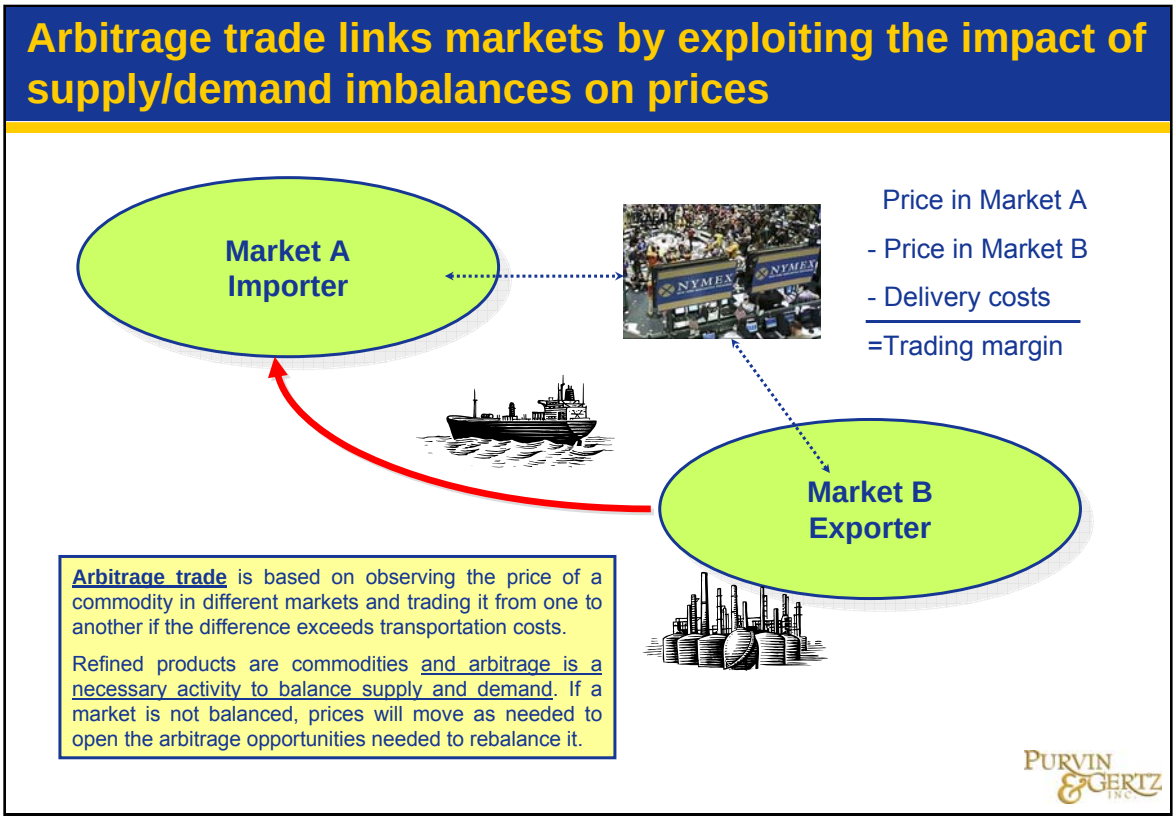
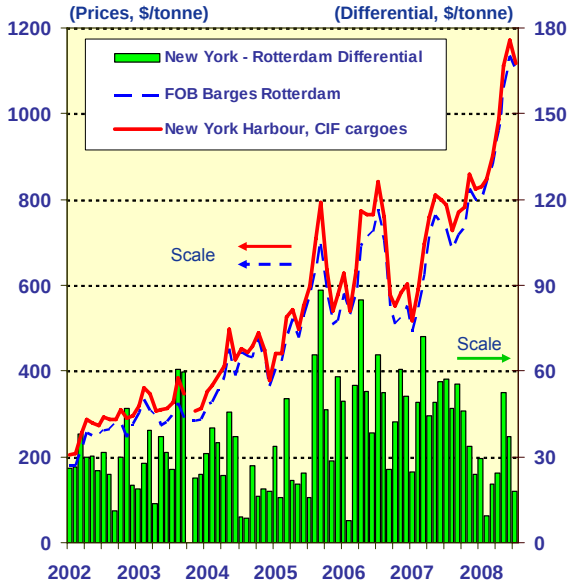
## PRODUCT PRICES IN DIFFERENT MARKETS ARE LINKED BY TRADE




- Principal products, such as gasoline, diesel, fuel oil, etc. have standard specifications that apply within a particular region. Although the specifications can change slightly between different regions, quite often the differences are not sufficient to make trade between regions impossible.
- As an example, European refineries may be able to produce products gasoline to US specifications, while Asian refineries may be able to produce diesel to European specifications.
- Sometimes products exported to another region are reprocessed. Gasoil traded from Russia to Europe can be treated to produce diesel. Because of the above, the majority of refined products are commodities that can be traded to other regions.
- When products are traded from one region to another, the difference of price between the two regions must make the arbitrage viable. This means that the price differential must exceed transportation costs, so as to leave a trading margin.
- Considering that Europe has significant supply and demand imbalances (as shown at the beginning of this section) it follows from the above that European product prices are strongly influenced by the prices in the regions that trade with Europe.
- Arbitrage trade can be seen as a speculative activity aimed at making a margin from a short term opportunity. However, arbitrage trade is a much needed market balancing activity. If a market is oversupplied with a certain product, arbitrage opportunities to export that product to other markets must be available as frequently as needed to export a sufficient volume of it.
- In the jargon of the industry, an arbitrage is “open” when it is economically viable and is “shut” when it is not viable.

## European gasoline prices are directly influenced by the arbitrage between Europe and the United States




- Because the US is a net importer, the price of gasoline is structurally higher in the US East Coast than in Europe
  - *Differential tends to be higher in summer because of the US "driving season"*
  - *The differential has varied from $9/tonne to almost $90/tonne over the period shown.*
- The cost to deliver gasoline from Rotterdam to the US East coast is typically in the region of $20-30/tonne
- When the differential exceeds this level, the arbitrage is open and product will move

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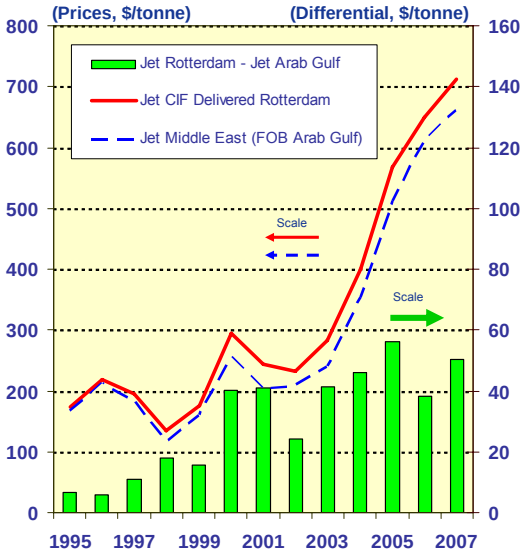
- Transatlantic delivery costs vary with tanker rates and with the cost of marine bunker fuel. Because of draught limitations at most US ports, use of very large tankers is limited and infrequent for spot trade. A commonly used tanker size is 30-40,000 tonnes, giving rise to delivery costs typically in the region of $20-30/tonne.
- When the price of gasoline in New York exceeds the price in Rotterdam by an amount higher than transportation costs, traders will move product from Europe to USA.
- Falling US gasoline prices would shut the arbitrage. However, the two markets are so dependent from another that at some point the arbitrage would reopen, either as a result of oversupply (and depressed gasoline prices) in Europe or shortage of gasoline supply in the US.
- A number of observations can be made to show how prices follow market conditions:
  - *The differentials are higher in summer, because of higher demand in the US. In winter the US is less dependent on imported gasoline.*
  - *There is a peak in May 2005. This coincided with a change of specifications in the US and was the result of supply disruption in the US market.*
  - *The highest ever differentials were observed in September 2005, just after Hurricane Katrina, which disrupted crude oil production and refining activity in the US Gulf Coast region to such an extent that emergency stocks had to be released.*
  - *This year (2008) US summer demand has fallen slightly and the requirement for imports has reduced. The summer differentials have been very low by historical standards.*

## Similarly, European jet/kerosene prices are determined by the arbitrage from the Middle East / Arabian Gulf




- The price differential between Middle East and Europe has increased as imports have increased, from under $20/tonne to over $40/tonne
- This differential pays for transportation costs in large cargoes making this trade viable on a regular basis
- Without this price difference, there would not be sufficient supplies of jet/kerosene in Europe

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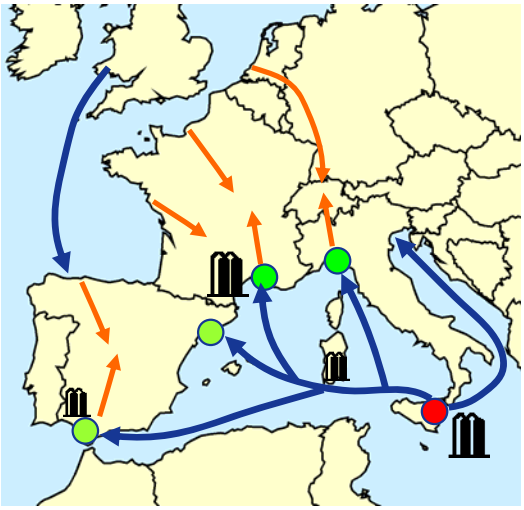
- Europe is short of jet/kerosene and has to import. The main suppliers are the export refineries in the Middle East. At the margin it also imports some diesel from the Middle East as well.
- As noted previously, kerosene can be used to produce either jet fuel, gasoil or diesel (collectively referred to as "middle distillates"). Thus, the prices of these three products are closely linked and trade of kerosene reacts to the supply and demand in the wider middle distillate market.
- Diesel and gasoil specifications are different in different regions, while the specification of jet fuel is global, with only minor differences from one region to another. Using the price of kerosene to compare middle distillate prices in the Arabian Gulf (AG) versus Europe removes any distortion related to product quality.
- The Arabian Gulf does not have a liquid spot market. Arabian Gulf prices are reported by Platts on the basis of the prices at Singapore by deducting transportation costs from the Arabian Gulf to Singapore.
- Between 1995 and 1999 the differential between the price of cargoes CIF ARA and the FOB AG price was less than $20 per tonne. Transportation costs from the AG to Rotterdam were generally higher than this. This implies that trade from the AG to Europe was not viable. The best option for an AG exporter would be to sell product in Asia.
- Since the year 2000 trade from the AG to Europe has been viable. Export of kerosene from the Arabian Gulf to Europe was about 500,000 tonnes in 1997 (i.e. probably no more than 15 cargoes in the whole year) and has recently reached levels in the region of 8 million tonnes per year (i.e. probably 10-15 cargoes per month).

## The Mediterranean market is less developed than Northwest Europe, but is linked to it by trade



- The established trading locations in the Mediterranean are Genoa and Lavera (Marseilles), but Spain has emerged as a significant importer of diesel
- There is over 50 million t/y of export refining capacity in Sardinia and Sicily, which trades products to the wider Mediterranean market, mainly to the west
- The traditional pricing point of CIF/import cargoes is Genoa/Lavera, while the reference point for FOB/export cargoes is "Italian Islands"
- Although the Mediterranean market is less transparent than the NWE/ARA market, the two markets are linked by trade and follow similar pricing trends.

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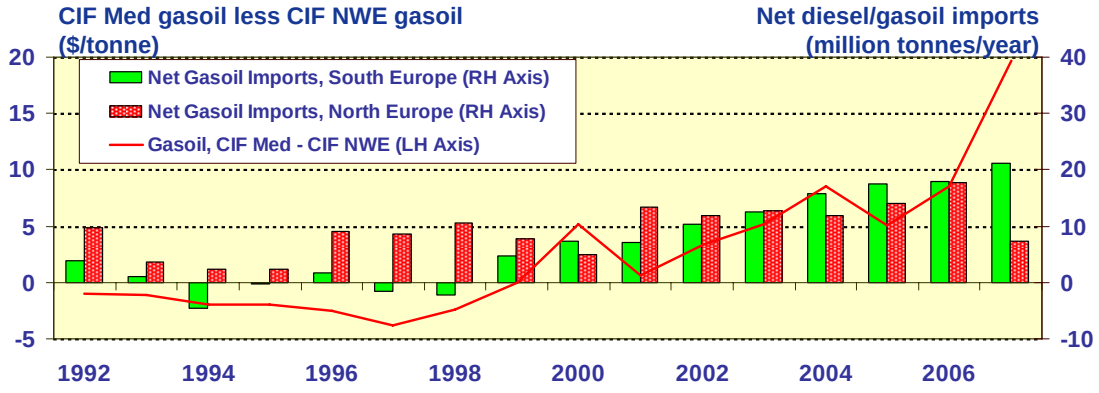
- In the Western Mediterranean, cargoes are imported in the North of Italy, the South of France and the South of Spain. Owing to the large oversupply of gasoline, there is not much trade of imported gasoline cargoes anywhere in the Mediterranean.
- The large export refineries in the Italian Islands (Sicily and Sardinia) have a combined refining capacity of over 50 MT/y of crude, but the local market absorbs only a small percentage of their production. These refineries sell most of their production as FOB cargoes.
- The Mediterranean products market is considered to be less transparent than the Northwest European market, but Mediterranean prices are linked to ARA prices by trade and by competition
  - *Product specifications are common throughout Europe and it would be easy to trade cargoes from one region to the other if a large price differential developed for any given product*
  - *Mediterranean products compete with Northwest European products in markets such as Spain, Portugal, France and Switzerland. Some inland markets (e.g. Switzerland) are supplied both from the North and the South.*

## The link between the Mediterranean and the ARA markets is evident in the trend of gasoil prices




- Gasoil is a commodity. It has a market as heating fuel or it can be upgraded to diesel
- Demand and trade statistics are available for the total of gasoil/diesel. As the deficit of gasoil/diesel in the Mediterranean has exceeded that in North Europe, Mediterranean gasoil prices have increased relative to ARA as needed to attract more product to the region

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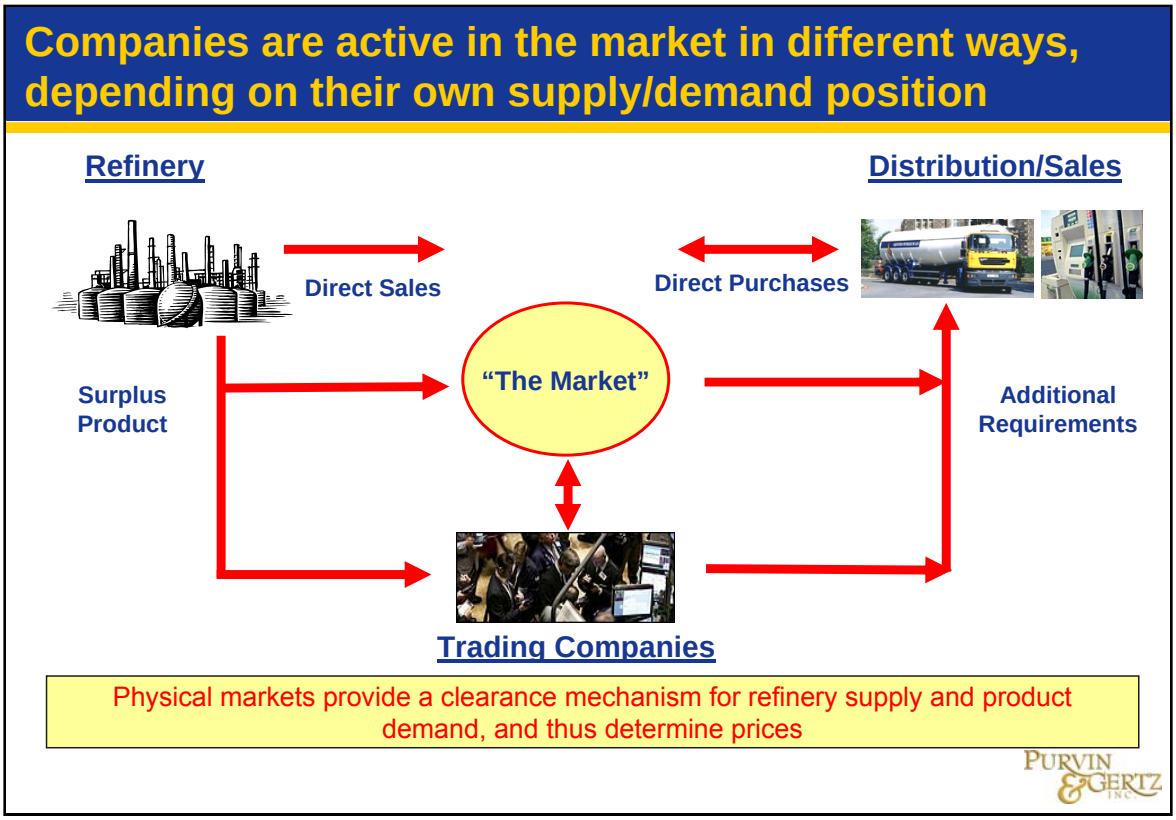
- Gasoil, if produced to the specification adopted for the price assessments has a market as heating fuel. Alternatively, it can be upgraded to diesel by hydrotreating. The price of diesel and gasoil track each other quite well with diesel at a quality premium to gasoil.
- In the chart above we have used gasoil prices as the specification has been common to both regions, whereas the North switched to low sulfur diesel in advance of the South.
- Between 1992 and 1998 the gasoil/diesel market of South Europe was balanced. On average there was a small net export (as shown by negative import values). At the same time North Europe was importing up to 10 MT/y of gasoil/diesel. Annual average gasoil prices were higher in ARA, reflecting the need to attract more supply into that market.
- In 1999 South Europe became a net importer of gasoil/diesel. Diesel car popularity was increasing, economic growth in 1999/2000 was generally strong and when the French and Italian economies slowed down, the Spanish economy continued growing at high rates.
- As a result a large shortage of gasoil/diesel developed in the South of Europe
- The supply/demand balance of North Europe has not changed much since the 1996-1998 period. This is because in Northern Europe there is larger consumption of gasoil for heating, particularly in Germany.
- Both regions are now net importers of gasoil/diesel, but the shortage is more acute in the South. CIF Mediterranean prices are now at a premium to North Europe.
- Despite the lower transparency of the Mediterranean market, the above shows that the expected price signals are reflected in the reported prices.

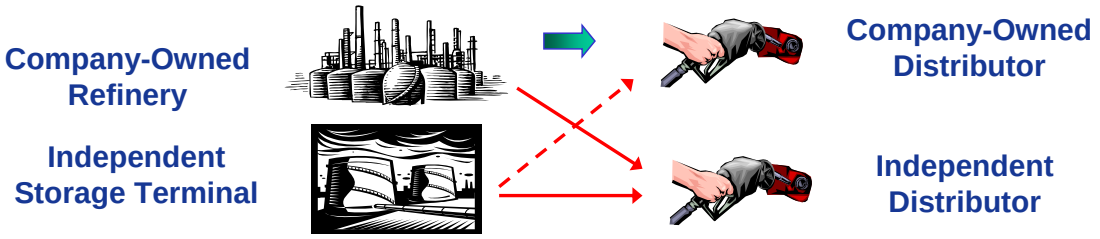
# THE USE OF MARKET PRICES TO DETERMINE TRANSFER PRICES BETWEEN SEGMENTS




- A company could be a pure refiner or may have refining capacity in excess of marketed volumes. Companies with this structure are net contributors of product to the market. Marketers with no refining capacity, or short of capacity are net buyers of product from the market.
- Other market participants are the pure traders. They have no need for products, but are in the market to make a margin by buying and reselling product.
- Trading companies play an important role. While refiners and marketers are driven also by security of supply or security of demand, traders have a very flexible business model. They operate in the ARA and other regions' spot markets and have a global reach. When markets are oversupplied or undersupplied, traders identify opportunities for arbitrage trade.
- Many companies that own refineries also own retail networks or product distribution affiliates. From the perspective of the refining arms of these companies, a presence in the distribution sector serves the same purpose as a long term contract, i.e. it secures product demand for the refinery. This is particularly valuable at inland locations.
- However, refiners/marketers do not necessarily supply their marketing arms from their own refineries. They may let each segment optimize its operations separately. As an example, the refining arm may be able to sell product at a higher price to a third party and the marketing arm may be able to find product at a lower price from a third party refinery.
- When product flows from own refineries to own marketing channels, the market provides a system to set a "fair transfer price" for product supplied within different business segments of the same company. The fair transfer price can be used to assess the financial performance of both business units independently. This is explained better in the next page with an example of a refinery that competes against imported products.

## Companies that transfer products between segments do so at market-related prices

**IMPORT PARITY EXAMPLE**




- A refinery has the option of selling product to its own distributor or an independent distributor
- The independent distributor can buy from the refinery or can import via a competing terminal.
- The refiner will look to realize the highest possible price, but he is aware that the marginal source of supply is import via the terminal. He would price his product accordingly.
- The independent distributor pays an import related price, regardless of its chosen source of supply. Likewise, the refiner is able to sell at an import related price, regardless of who is the customer
- An "import parity" transfer price would be set between the refinery and company owned distributor.
- The transfer price allows an understanding of the viability of both businesses in their own merit.

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- In this example the area imports products via a terminal that is in direct competition with a local refinery. The independent distributor could buy product from the refinery or from the importer. The refinery has no problems in selling its products locally and would price them in relation to the next best alternative of supply. Regardless of whether the independent distributor buys from the terminal or from the refinery, he pays an <u>import parity</u> price.
- For the same reason, a fair transfer price between the refinery to the company-owned distributor would also be the import parity price. If the company-owned distributor can take delivery of product at the market price (import parity) and make a distribution margin, it adds value to the system because it provides a secure outlet for products, while making a profit.
- The above is only an example. The most appropriate transfer price may be set in different manners depending on the supply/demand situation of the area. In general a fair transfer price would be set with regard to the following considerations:
  - *What price would the refinery be able to obtain from the market without the distribution affiliate?*
  - *At what price would the distribution affiliate be able to buy product via a different channel?*
- The transfer price allows understanding how much of the margin is made by the refinery and how much is made by the distributor. The viability of both businesses can be assessed independently from each other.
- Companies that are active in both segments and are operated on a commercial basis, as it is the case in Europe, will not cross-subsidise to any significant extent. Cross-subsidization essentially means that a company operates a business that is not profitable on its own merit. This does not allow the business to reach its best possible return on capital and may also breach competition law.
- Companies may keep otherwise marginal businesses for strategic reasons, such as security of demand and security of supply.

## The refined products market - conclusions

- Refined products are traded in reference to prices at a few key locations in the world. Their prices are set in relation to supply/demand pressures that are specific to the products markets, although the impact of crude oil prices is evident.
- The Antwerp-Rotterdam-Amsterdam area (ARA) is one of these locations. Product prices in ARA are assessed and published by organizations such as Platts or Argus.
- The ARA prices can be used to price products at other locations and at different points of the supply chain. This is normally done with price differentials set in relation to the cost of sourcing product in that particular location from a competing supplier.
- Europe has significant trade imbalances. European product prices are linked to prices in a number of other markets via arbitrage trade. This trade must remain viable in order to keep the European market supplied and in balance.
- Market prices can be used to set transfer prices between a refinery and a distribution affiliate, so as to understand how much margin is made in both segments.
- Although links between refining and distribution are often maintained for strategic reasons, the two segments are normally optimized independently from each other. There are several examples of companies that have sold refineries and retained distribution activities in a country.
- Cross-subsidization between segments is normally avoided and would risk breaching competition laws.

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# SECTION V

## THE BUSINESS OF REFINING

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## Introduction to this section

- The initial part of this section illustrates the elements that feed into the calculation of refining margins.
- After the introduction we illustrate how the different yields obtained by different refinery configurations have a strong and direct impact on the profitability of refineries.
- The historical trends of refining margins for some of Purvin & Gertz' benchmark refineries is shown to illustrate that the market sends strong signals to the industry by shaping a business environment with higher or lower margins, depending on what type of refining capacity is most needed to supply the market.
- The section also includes a discussion on the main factors that make refineries competitive and what operating and strategic decisions refineries have to make on the basis of margin and market trends.
- We show some example calculations of refining margins. In these calculations we have used actual prices where possible. Yields and costs are representative of a competitive European refinery of the type being discussed

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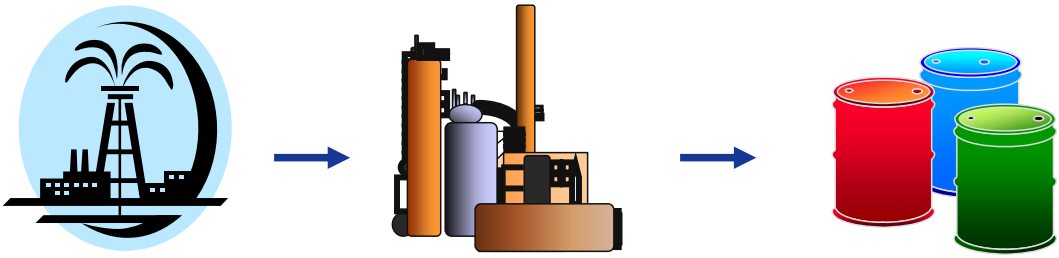
# INTRODUCTION TO THE ECONOMICS OF REFINING

## The refining industry is the connection between crude oil and refined products markets

**Crude Oil Input** → **Refinery** → **Refined Products**



- Refining is the link between the crude oil and refined products markets, each of which responds to different drivers and pricing pressures.
- The profitability of refineries is the result of the relationship between product prices and crude prices.
- Refineries need to make a profit to satisfy their shareholders and provide funds for reinvestment.

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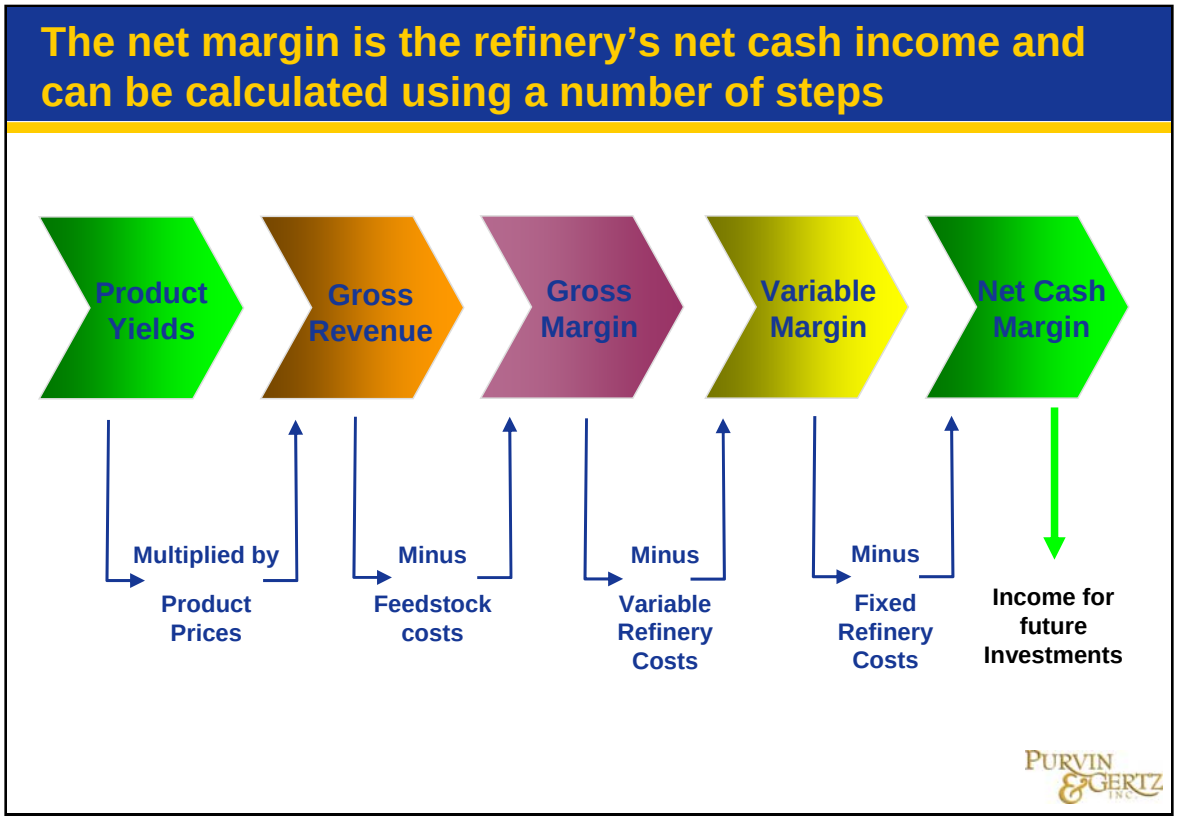
- The profitability of refineries is related to the difference between the value of the products made by the refinery, the cost of buying crude oil and other associated costs incurred to process the crude oil.
- At the fundamental level crude oil prices respond to the cost of crude oil production, the availability of crude oil supply and the demand of crude oil from the refining industry. Refined product prices respond to consumer demand and the availability of supply from refineries. Refining acts as the link between the crude and product markets.
- The refining industry is very capital intensive. It needs to make adequate profits to provide a return to shareholders and to allow for reinvestment to maintain reliable and safe operations. Refineries also need to be able to fund improvement projects and, possibly, justify the large capital projects that may be needed to maintain competitive operations.
- In this section we discuss the measures of refinery profitability and the factors that can impact it.




- Calculating different refinery margins for each type of refinery can be achieved in simple steps, beginning from the product yield of the refinery.
- The prices for each product multiplied by the refinery yield for each of the products concerned gives the gross revenue or Gross Product Worth (GPW) of the refinery. Subtracting the cost of crude (and other feedstocks) gives the gross refining margin.
- Using gross margin as a starting point, the "variable cost margin" is calculated by deducting the variable costs that refineries incur in manufacturing the products. These are costs that vary with throughput and include fuel, catalysts and chemicals, water and electricity.
- In addition to variable costs refineries also incur costs that do not vary as throughput goes up or down, these are referred to as fixed costs. These include the costs of labour, maintenance and spare parts, property taxes, service charges, insurance premiums etc.
- The "net cash margin" is calculated by deducting the fixed costs from the variable cost margin. The net cash margin is calculated by deducting only "cash costs". Financial costs such as interest or depreciation are excluded from the calculation. As a result the net cash margin is not a true measure of accounting profit.
- It is important for the net margin to remain positive in the long term, as this is the refinery's source of income necessary to provide a return on its past capital investments and to provide funds for future investments.

## All refineries are different. Their yields are different and so are their gross margins

| Product | 2007 CIF NWE Prices ($/t) | Hydro-skimming Yield (Wt%) | FCC Yield (Wt%) | Hydroskimming Revenue Contribution ($/tonne) | Cracking Revenue Contribution ($/tonne) |
|---|---|---|---|---|---|
| Propane | 669 | 0.7 | 1.7 | 4.7 | 11.4 |
| Butane | 640 | 2.3 | 1.6 | 14.7 | 10.2 |
| Naphtha | 674 | 5.0 | 5.0 | 33.7 | 33.7 |
| Gasoline | 709 | 17.6 | 30.9 | 127.0 | 226.9 |
| Jet/Kerosene | 711 | 8.0 | 8.0 | 56.9 | 56.9 |
| Diesel | 675 | 21.5 | 24.1 | 148.8 | 164.4 |
| Gasoil | 642 | 8.3 | 10.4 | 53.3 | 66.8 |
| Heavy Fuel Oil | 360 | 35.1 | 14.3 | 126.4 | 51.5 |
| Refinery fuel gas | 432 | 1.2 | 2.6 | 5.4 | 11.2 |
| Refinery losses | 0 | 0.3 | 1.4 | - | - |
| **Gross Revenue, $/tonne** | | | | **570.8** | **633.1** |
| **Gross Revenue, $/bbl** | | | | **74.52** | **82.65** |
| **Crude Cost, $/bbl** | | | | **73.05** | **73.05** |
| **Gross Margin, $/bbl** | | | | **1.47** | **9.60** |

Prices are 2007 average of Cargoes CIF ARA.
Revenue calculations include gravity adjustments

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- The gross revenues for each refinery depends solely on the product yields, the price of products and the cost of crude. Since all refineries have different configurations and, hence, different yields, they will also achieve different gross margins.
- The FCC refinery has a higher yield of gasoline, gasoil and diesel than the hydroskimming refinery and a lower yield of heavy fuel oil. As gasoline, gasoil and diesel all command higher prices than fuel oil, it may be seen that the gross revenue from the FCC refinery is greater than that from the hydroskimming refinery.
- For this comparison we have used 2007 annual average prices for cargoes CIF ARA (**Section IV**). The assumed crude oil feedstock for both refinery types is North Sea light sweet crude.
- Subtracting the crude cost from the gross revenue gives the gross margin. The calculated gross margin of the FCC refinery is notably higher than that for the hydroskimming refinery.

## Variable costs include utilities and chemicals needed to operate a refinery

**VARIABLE OPERATING COSTS**
**(Dollars per Barrel of Crude)**

| | Hydroskimming | Cracking |
|---|---|---|
| Gross Margin | 1.47 | 9.60 |
| Less: Variable Costs | | |
| Refinery fuel | (2.06) | (2.87) |
| Catalysts / Chemicals | (0.17) | (0.33) |
| Water | (0.02) | (0.03) |
| Total Variable Costs | (2.25) | (3.23) |
| Variable Cost Margin | (0.78) | 6.37 |

- The largest variable cost item for a refinery is the cost of energy
- Variable costs excluding energy are low in relation to the gross margin.
- The variable costs of the cracking refinery are about 50% higher than the variable costs of the hydroskimming refinery

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- In order to sustain their processes, refineries consume a quantity of fuel in the region of 3-5% of crude processed for simple hydroskimming refineries, increasing to 6-10% of crude processed for more complex conversion refineries. This fuel can be a combination of own produced heavy fuel oil, own produced refinery fuel gas and purchased natural gas. Some of this fuel may be used to produce electricity.
- The cost of fuel is typically the largest variable cost component of a refinery.
- Some refineries buy hydrogen under contract. When purchased, hydrogen is also a very large variable cost item. Alternatively, hydrogen is generated internally in which case its impact on the margin is captured as the cost of the feedstock and the fuel used to produce it.
- As was discussed in **Section II**, FCC (and hydrocracking) refineries use additional processes to convert heavier fractions to lighter products. These processes require additional catalysts, fuel, power, water and chemicals. As a result, these refineries cost more to run than hydroskimming refineries, thus increasing their operating costs on a per-barrel basis.
- Even though the operating costs for the cracking refinery are higher than those for the hydroskimming refinery, the variable cost margin for the cracking configuration is still significantly higher.
- Fixed costs do not influence short term operating decisions. Refineries will always optimize their operations by maximizing the variable cost margin. This would deliver the highest possible income at the end of a short term planning period (e.g. a day, a week or a month).
- A negative variable cost margin for a given set of refinery yields indicates that for each barrel of crude processed with those yields the refinery in question is losing money. Often in this case a refinery would respond by reducing the amount of crude it processes.
- A negative variable cost margin is not, however, necessarily an indication that a refinery should close down permanently, as refining margins can be very volatile. Capacity that loses money on a variable cost basis would be idled, waiting for margins to rebound. If the negative margin situation prevails over a long period of time, the viability of this capacity would be put into question.

## Deducting fixed costs provides the net refining margin

**REFINERY FIXED COSTS**
**(Dollars per Barrel of Crude)**

| | Hydroskimming | Cracking |
|---|---|---|
| Gross Margin | 1.47 | 9.60 |
| Less: Variable Costs | (2.25) | (3.23) |
| Variable Margin | (0.78) | 6.37 |
| Less: Fixed Costs | | |
| Maintenance | (0.70) | (1.20) |
| Labour | (0.45) | (0.60) |
| Other | (0.65) | (0.90) |
| Total Fixed Costs | (1.80) | (2. 70) |
| Net Cash Margin | (2.58) | 3.67 |

**The above does not include financial cost items such as interest and depreciation.**

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- Fixed costs represent those costs that do not vary with refinery crude runs. They include costs of personnel, administration, maintenance, insurance and local taxes, etc, and are in general a refinery-level overhead.
- FCC refineries are usually more labour-intensive than hydroskimming refineries. Maintenance costs are also higher because of the larger number of units to maintain and because of the higher mechanical complexity of the refinery. The FCC refinery has higher fixed costs than the hydroskimming refinery.
- Subtracting the fixed costs from the variable cost margin results in the net cash margin, which is an indication of the net income for the refinery.
- The combined fixed and variable costs for the FCC refinery have almost halved the value of the gross margin. Nevertheless, taking all these into account the income for the refinery is still positive by $3.67 for each barrel of crude oil processed.
- For the hydroskimming refinery, however, the fixed costs have only added to the weak financial position of this refining type in this particular example. With the 2007 average prices used here, a refinery with the assumed yields and prices would have made a significant financial loss.
- While the variable cost margin is used to optimize the refinery in the short term, the net margin is a better indication of the ability of a refinery to generate positive cash flows.
- Refineries continuously re-invest some of their income in the business. A certain amount of investment is compulsory, as it is necessary to keep pace with evolving technical and environmental standards. Additional amounts are typically invested on a discretionary basis to maintain the refinery competitive in the long term. The net margin of a refinery should be positive by an amount sufficient to cover re-investment needs and provide a return to its shareholders, as this secures its viability in the long term.

## The location of each refinery has a direct impact on the margin

- The example below assumes that a refinery which operates at an importing location sells products at Cargoes CIF ARA
- An identical refinery that operates at an exporting location sells products at Cargoes FOB ARA

| Product | Cracking Yield (wt%) | 2007 Import Parity NWE Prices ($/t) | 2007 Export Parity NWE Prices ($/t) | Import Parity-Based Revenue Contribution ($/t) | Export Parity-Based Revenue Contribution ($/t) |
|---|---|---|---|---|---|
| Propane | 1.7 | 669 | 629 | 11.4 | 10.7 |
| Butane | 1.6 | 640 | 608 | 10.2 | 9.7 |
| Naphtha* | 5.0 | 674 | 650 | 33.7 | 32.5 |
| Gasoline | 30.8 | 709 | 685 | 226.2 | 218.5 |
| Jet/Kerosene | 8.0 | 711 | 699 | 56.9 | 55.9 |
| Diesel | 24.0 | 675 | 655 | 163.7 | 158.9 |
| Gasoil | 10.3 | 642 | 624 | 66.2 | 64.3 |
| Heavy Fuel Oil | 11.9 | 360 | 348 | 42.8 | 41.4 |
| **Gross Revenue, $/t** | | | | **611.1** | **592.0** |
| **Gross Revenue, $/bbl** | | | | **79.78** | **77.28** |

Prices are average for 2007

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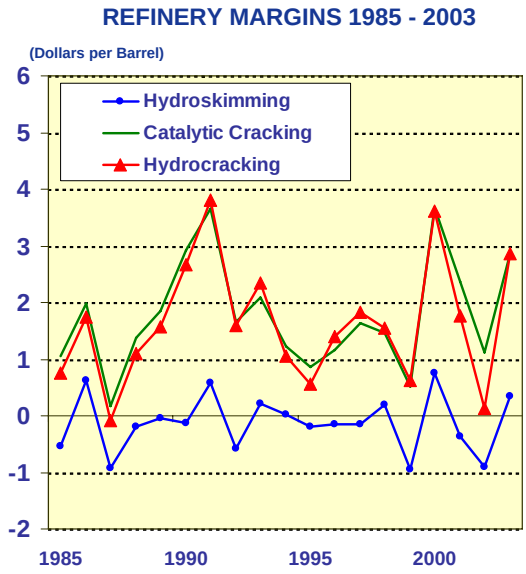
- The location of a refinery has an impact on the cost of crude delivered at the refinery gate and the price of products at the refinery gate. A refinery that operates in an export parity price environment will sell its products at lower prices than an import parity-based refinery.
- Using previous examples of refinery configuration and prices, the difference in gross revenue between the two operating environments for the above illustration amounts to $2.50 per barrel. Assuming similar crude costs (which will in practice vary according to location) this difference feeds to the final net cash margin. This difference is significant in relation to typical net refining margins. As a result, margins can vary considerably between refineries of the same configuration due to their location.
- The combination of crude and product prices relative to the reference market prices (e.g. CIF ARA) is often referred to as the “location factor” of the refinery. For example, once ARA has been chosen as the reference location, the location factor of a refinery is essentially the difference between the margin of the refinery and the margin that the refinery would have made if it had been located in ARA and was selling products at Cargoes CIF ARA.
- The location factor can be large and can determine whether a refinery’s net cash flow is positive or negative.
- In practice, most refineries operate with a combination of sales at import related prices and export related prices, depending on local market requirements. As gasoline is in surplus across much of Europe, most refineries have to dispose of some surplus gasoline production and may in effect be operating on an FOB basis for some of their gasoline sales.
- Inland refineries have a logistics advantage for supplying local markets and tend to earn prices above CIF ARA or CIF Med for products supplied in those markets. The potential exists for inland refineries also to be disadvantaged. If a refinery has a surplus of product to dispose of, it would incur higher costs to deliver that product to markets and would earn prices below CIF ARA or CIF Med. Inland refineries may also incur higher crude delivery costs, because of the pipeline tariff.

## Historical net cash margins show that hydroskimming refineries have not been profitable




- Over the 1985-2003 period the margin environment was relatively stable
  - ***Hydroskimming margins hovered around break-even***
  - ***Cracking margins averaged about $1.80 per barrel, with some spikes and some periods of weakness***
- Peaks were seen during the Gulf War of 1991 and with the gasoline shortages in the US in 2000 and early 2001
- Weak margins coincided mainly with periods of weak economic growth, which reflected negatively on oil demand and margins

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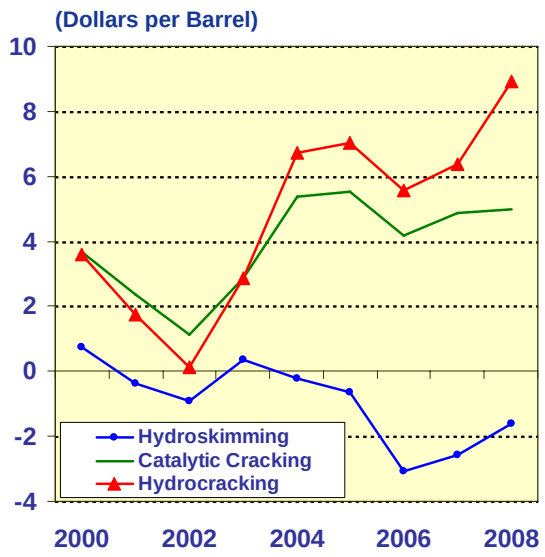
- One of the best known laws of economics says that in competitive markets prices move as necessary to make the marginal source of supply break-even. The refining industry makes no exception to this law, as noted below.
- There is very little topping refining capacity left in Europe. After topping, hydroskimming is the simplest type of refining capacity. The hydroskimming yields are a poor match for current market demand. As a result, hydroskimming refineries are at the lowest end of the spectrum of European refineries in terms of profitability.
- Hydroskimming net margins in ARA or a CIF priced location are normally negative or close to zero. At times of stronger refining margins, often driven by a shortage of refined products in the market, hydroskimming margins improve as necessary to promote higher utilization of an otherwise marginal type of capacity. In this respect, hydroskimming capacity is operated as a "supplier of last resort".
- The income earned by stand alone hydroskimming refineries has been below re-investment levels of several years. As a result, several hydroskimming refineries were closed and there is not much hydroskimming capacity left in Europe.
- Cracking refineries have a more competitive yield structure and normally make a positive cash margin. In the 1985-2003 period they were able to achieve a margin that most of the time was about $2 per barrel higher than hydroskimming refineries. At times of weaker refining margins, often driven by weak growth of global oil demand, cracking margins have reached break-even levels, indicating that, occasionally, even cracking capacity could become marginal.
- However, Europe operates a large amount of cracking capacity and it would not be possible to idle a significant amount of cracking capacity in Europe without leaving the market undersupplied. For this reason, cracking margins do not remain negative for too long.

## A new cycle for the industry began in 2004 when higher demand for light products increased the margins of conversion refineries

**REFINING MARGINS 2000-2008**




- The rapid growth in demand for light products since 2003-2004 has resulted in a significant increase in catalytic cracking (FCC) and hydrocracking margins
- Margins for hydroskimming refineries have deteriorated considerably, as these refineries have a higher yield of heavy fuel oil, the market for which has remained oversupplied
- The benchmark hydrocracking refinery has the highest yield of diesel. The increase of diesel demand has been reflected in higher prices relative to other products. Hydrocracking margins have strengthened considerably relative to FCC

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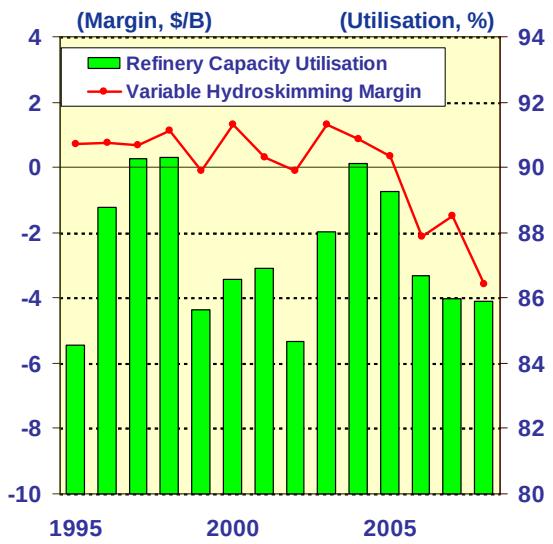
- At times of changing product demand, prices respond to short-term availability of each product, thus impacting refinery margins. Those configurations best placed to meet incremental demand will see their margins increasing the most.
- In 2004 a very large and unexpected increase in global oil demand tightened oil markets and resulted in a substantial increase of refining margins. This was the end of a long cycle that had started in 1980s when the industry had developed substantial overcapacity. After two decades of low margins and rationalization refining capacity became tighter.
- Demand growth was mainly for light products such as gasoline, diesel and gasoil, while demand for heavy fuel oil continued to stagnate. The prices of those light products strengthened considerably relative to heavy fuel oil. At the same time, the prices of diesel, heating oil and jet fuel (i.e. the middle distillates), have strengthened relative to gasoline as demand for distillates is growing faster.
- As a result of market and pricing trends, hydroskimming margins have diverged from cracking margins, while hydrocracking margins have strengthened relative to FCC margins.
- This is a signal that Europe needs more hydrocracking capacity. However, as investment projects have a long lead time, this development in the demand pattern will have a lasting impact on European refining margins.
- A contribution to this period of high margins came from a number of supply disruptions at the US refineries. The most notable one was the devastation caused by hurricane Katrina in 2005. This observation introduces the point that refining is a global industry. Margins in one region are also related to development in other regions. The extent by which margins in different regions track each other will be shown later.

## Comparing European refinery utilisation with margins reveals that hydroskimming capacity is marginal




- Hydroskimming refining economics are the weakest, such that this type is the "marginal capacity"
- When margins are very weak, or negative, then utilisation of this capacity declines as refineries reduce throughput
- Overall changes in utilisation follow changes in the "marginal capacity" configuration most closely
- Utilisation levels at cracking refineries likely to remain near maximum
- The variable cost margin is the driver for short-term optimization and correlates to utilization more directly

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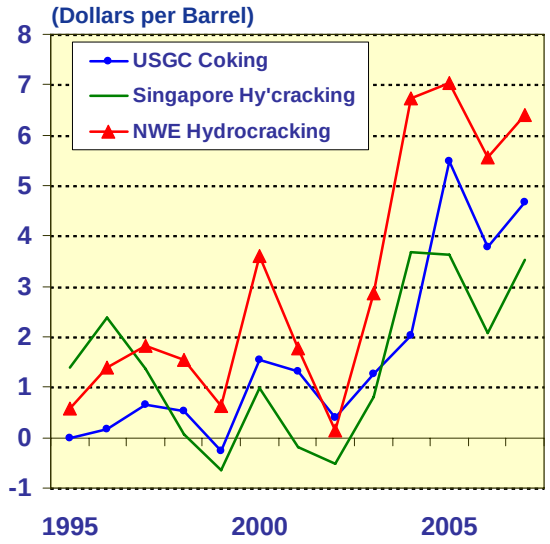
- When variable margins become negative, the most immediate action a refiner can take is to reduce throughput by idling capacity.
- The chart above plots utilization levels for the entire European refining industry against the variable cost hydroskimming margin of our benchmark refinery. The chart demonstrates quite well that changes in utilisation levels can often be seen to match changes in hydroskimming margins, confirming that hydroskimming is the marginal capacity.
- As conversion capacity tends to remain fully utilized in a poorer business environment, there is poor correlation between utilization and cracking margins. As an example, cracking margins remained fairly strong in 2006, 2007 and 2008 (to date), but this did not result in higher utilization of hydroskimming.
- In 2002 margins were poor for conversion refineries and utilization was the lowest level since 1995. It is quite possible that in 2002 some of the least competitive cracking capacity was also making a negative variable cost margin and throughput was reduced.

## Owing to worldwide trade, margins in the three main regions follow similar trends




- Oil markets are linked through global trade
- Owing to the resulting links between prices in each market, global refining margins follow similar patterns
- Thus, refining is a globalized business
- If European refineries become uncompetitive they will close and products will be imported from cheaper sources
- Already there are examples where export oriented refinery capacity is being encouraged by governments through tax and other subsidies

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- Although each major oil pricing centre – Rotterdam/ARA, US Gulf Coast and Singapore – operates independently, with crude and product prices determined by regional supply and demand, crude and product prices between regions follow similar patterns (**Section III and IV**). Trade flows of products from one market to another allow surpluses to be disposed of and deficits to be met by transporting products worldwide, thus effectively limiting the potential for large price differences.
- The consequence is that refining margins in different regions follow similar trends. Refining is a global business.
- Differences in absolute margin levels will be seen between different markets, according to regional refinery configurations, regional product demand patterns and regional crude supply. For example, as Europe is a net importer of middle distillates, prices must be high enough to attract product from other regions. Hydrocracking margins are therefore higher in Europe than in other regions.
- In 2005 disruptions in the US by hurricane damage resulted in a margin spike in Europe, which became a source of product whilst the US refineries were shut down.

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## WHAT MAKES A REFINERY COMPETITIVE?

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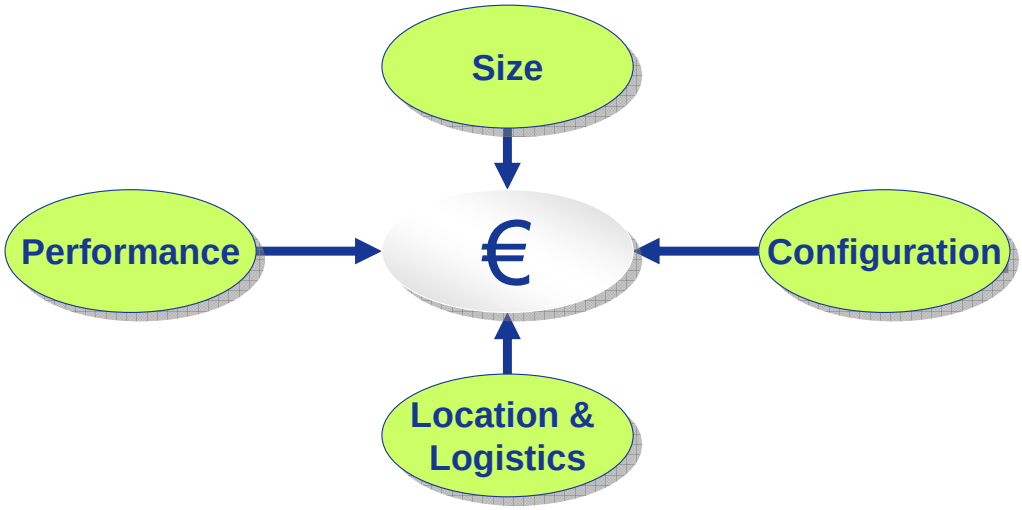
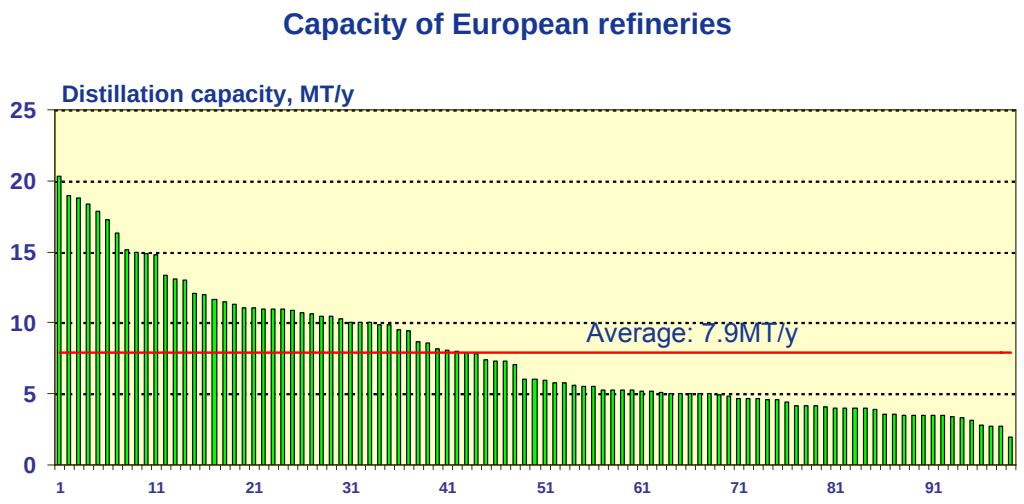
## There are four key elements that define the competitive status of a refinery




- The key factors that make a refinery competitive in a free market can be grouped in four categories
  1. ***Size:*** *Refineries are capital intensive. A larger plant reduces fixed operating costs and investment costs on a "per tonne of output" basis.*
  2. ***Configuration:*** *conversion refineries have more valuable yields.*
  3. ***Location and Logistics:*** *a competitive refinery needs to have access to crude supplies at competitive prices and should be able to deliver products at competitive costs. This can be achieved by a combination of good location and good logistics.*
  4. ***Performance:*** *good performance turns competitive advantages into results.*

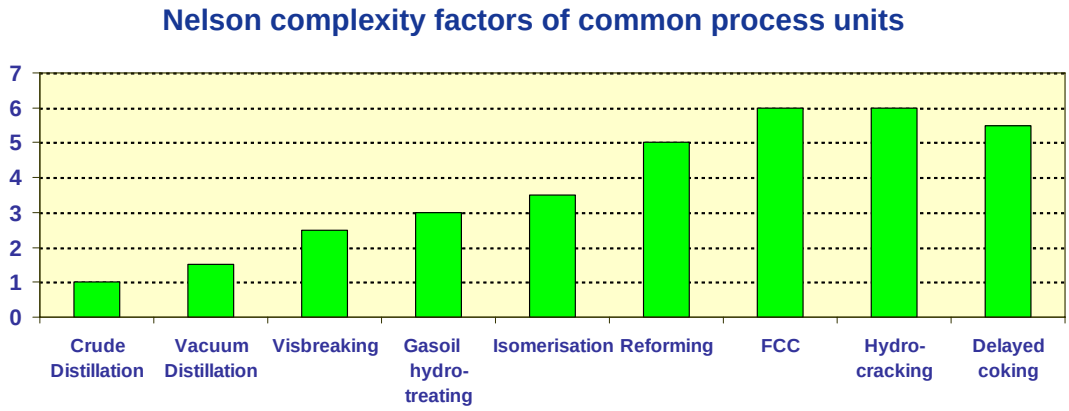
## About half the number of European refineries are of low capacity




Note: excludes speciality refineries smaller than 40,000 B/D

- The average capacity of the European refineries is 7.9 MT/yr. For reference, in the US Atlantic coast the average capacity is about 8.8 MT/yr, which is a higher but comparable number. This average excludes from the sample the very small refineries.
- Although size is important to deliver economy of scale, the importance of scale is often overstated. A number of large European refineries were developed in phases and have substantial duplication of process units, such as multiple distillation units (i.e. multiple trains), two reformers, three or more gasoil hydrotreaters and more than one VGO conversion unit. Duplication adds flexibility but negates some of the economies of scale.
- As an example, the operating costs for a 15 MT/yr hydrocracking refinery are estimated to be $0.40 per barrel lower than for a 10 MT/yr refinery of the same configuration. Reducing the capacity to 5 MT/yr would further increase the cost by $1.00 per barrel. Although these cost changes are significant in relation to a typical refining margin, they can be easily outweighed by location advantages or disadvantages.
- Size is important because, when investing, the larger refinery also realises an economy of scale in the project. Large refineries are more likely to justify the addition of costly conversion units. Investment costs expressed on a “per tonne of output” basis are lower at large refineries.
- 15% of European refining capacity is at sites with less than 5 MT/yr of capacity. A number of these refineries could be threatened by a business environment that requires a commitment to large capital expenditures.

## The term "complexity" is often used as a metric of refinery configuration




- **Process units are assigned a factor determined as the ratio between the cost of building that unit and a crude distillation unit of identical capacity**
- **Conversion units have high factors. As a consequence, conversion refineries have higher complexity**

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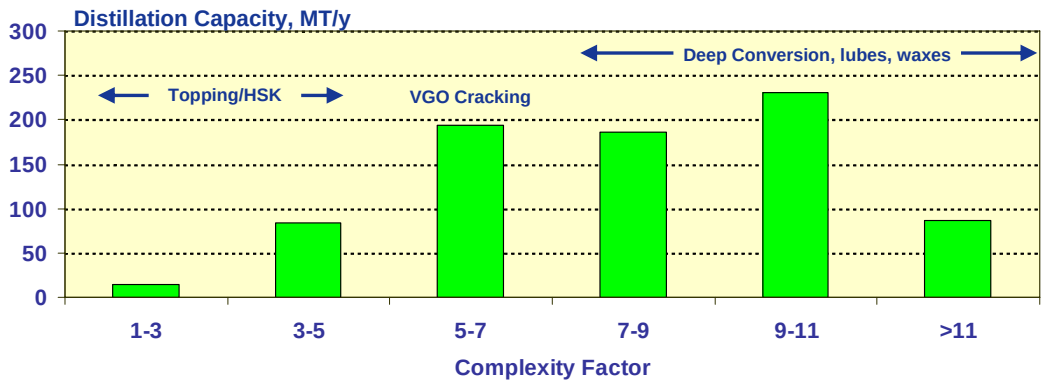
- "Complexity" is a term widely used in the industry, but what does it mean exactly?
- Each process unit is assigned a complexity factor determined as the ratio between the cost to build that process unit and cost to build a crude distillation unit of identical capacity.
- The methodology was first pioneered by Nelson, a petroleum engineer. Complexity factors calculated with this methodology is called Nelson Complexity.
- The average complexity of a refinery can be calculated as weighted average of the capacity of the process units, using the complexity factor of each unit as weight for the average. A topping refinery, which comprises distillation capacity only, has complexity factor of 1.0.
- FCCs, hydrocrackers and deep conversion units all have high complexity factors, owing to their greater cost relative to a distillation unit. As a consequence, cracking refineries have higher complexity.
- Complexity is commonly associated with conversion capacity and ability to achieve low yields of heavy fuel oil. This approximation is acceptable, but can be misleading, because certain process units contribute significant complexity but provide no or little conversion.
- For example, a reformer upgrades naphtha to gasoline. The unit provides significant complexity, but no conversion. Refineries designed for lighter crude oil tend to have more naphtha reforming capacity and can show fairly high complexity even if they are hydroskimming refineries.
- Similarly, the production of lubricants uses process units with very high complexity (>40) but provide a relatively small reduction of the fuel oil yields. Thus, lubricant refineries have very high complexity but this cannot be associated with low production of heavy fuel oil.

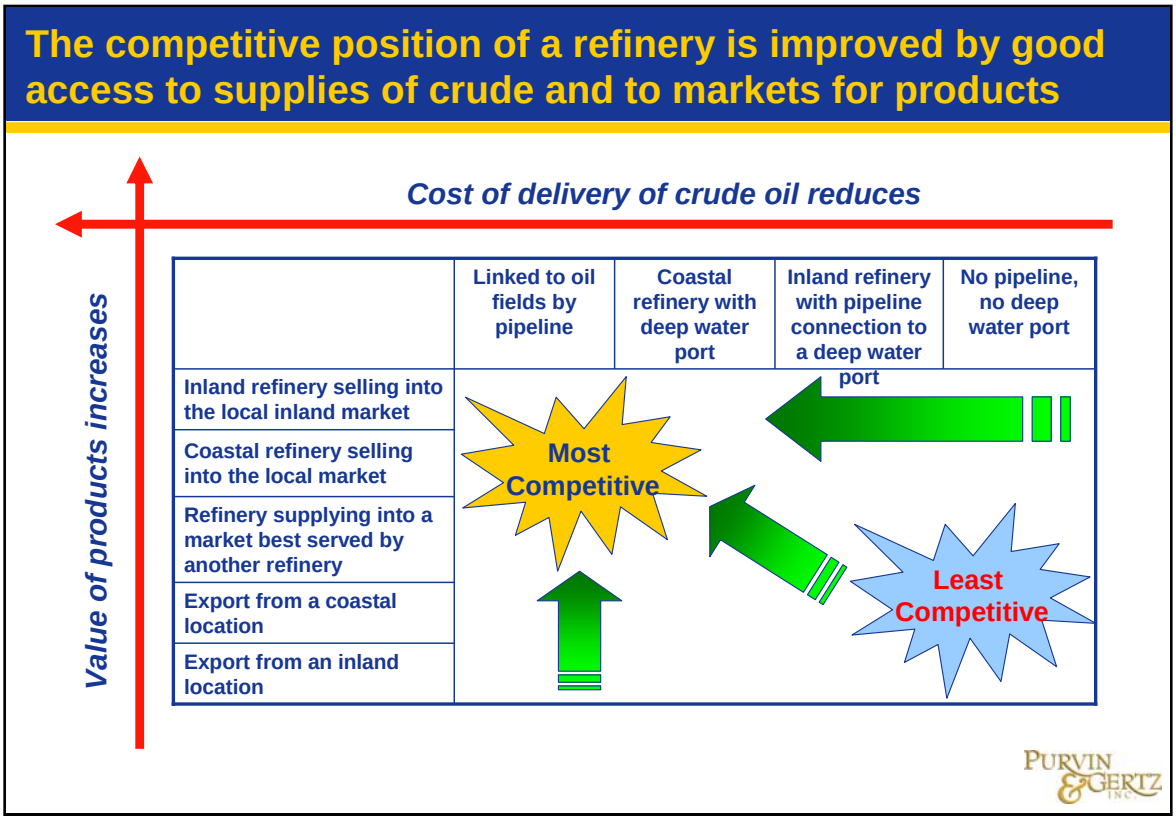
## European refineries have good average levels of complexity but are increasingly ill-matched to European product demand.

### Refining capacity in Europe by complexity range



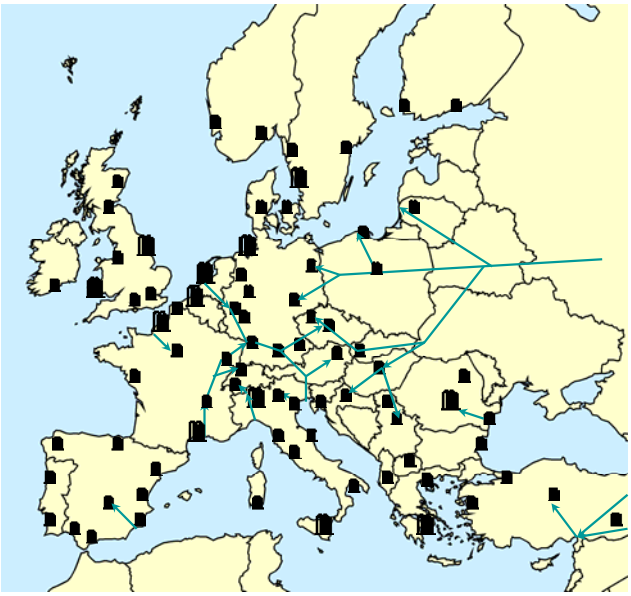

- **Conversion capacity is adequate in respect of the need to destroy fuel oil**
- **However, there is too much gasoline capacity and two little diesel capacity. The European refining industry needs to be reconfigured**

- The figure shows indicative ranges of complexity where each type of refinery configuration would tend to fall.
- As explained on the previous slide, within the same type of configuration, complexity can vary, depending on factors, such as the design crude slate or whether a refinery produces specialties such as lubricants.
- Thus, some cracking refineries have complexity below 5, while some others have complexity higher than 7. There are also hydroskimming refineries with complexity above 5.
- The European refineries have an average complexity factor of 7.7, somewhat higher than a typical VGO cracking configuration. There are three refineries with complexity lower than 2.0. These are topping and hydroskimmers with no upgrading of naphtha to gasoline. It follows from the discussion of refining margins shown earlier in this section that this refining capacity could be marginal by configuration.
- 12.5% of capacity has complexity below 5.0. These refineries tend to be hydroskimmers, thermal cracking refineries or refineries with undersized catalytic crackers. This type of capacity is the least competitive by configuration and needs to rely on other factors to remain viable in an adverse business environment.




- Location and logistics impact the competitiveness of a refinery in two ways: competiveness is enhanced as the costs incurred to take delivery of crude and to deliver products to markets reduce. In respect of these two parameters, a number of different situations exist in Europe.
- Several refineries in the former “Eastern” block take delivery of crude directly from Russia by pipeline. This is a good option, assuming the political situation is stable and supplies via this route can be considered secure. Historically, this source of crude supply has represented a competitive advantage for them.
- Besides these refineries, the typical European refinery takes delivery of crude at a deep water port or, if located inland, via a deep water port and a pipeline.
- Every refinery has an area where it is the most competitive to supply the market. This area can be considered its “local market”. Excess production would be delivered to areas that are better served by other refineries. This type of situation reduces the value of product.
- Coastal refineries are exposed to stronger competition because the cost to deliver product to a coastal location is lower compared to an inland location. The cost of moving product overland is higher and dedicated logistics may be needed. This increases the value of inland product.
- Thus, an inland refinery close to an area with high concentration of demand is in the best possible situation in respect of products it can sell locally. However, if this refinery has a surplus of product, it is in the worst possible situation because its cost to export is much higher than the cost of exporting from a coastal location. This is because the product to be exported must first be moved to a port.
- Finally, there are examples of refineries that operate predominantly in the export market. A large proportion of their production is loaded in cargoes and traded elsewhere. The value of product destined for the export market is lower, reflecting export costs.

## European refineries are generally well located for crude supply and access to markets



- The European refining capacity is distributed evenly over the region
- The majority of refining sites have good access to crude supply and markets
- Refineries reliant on export are at a competitive disadvantage and have been more exposed to rationalization
- Most of the remaining export refining capacity has been upgraded in scale and complexity to remain competitive

Refinery
Concentration of refineries
Crude Export Terminal
Crude Pipeline

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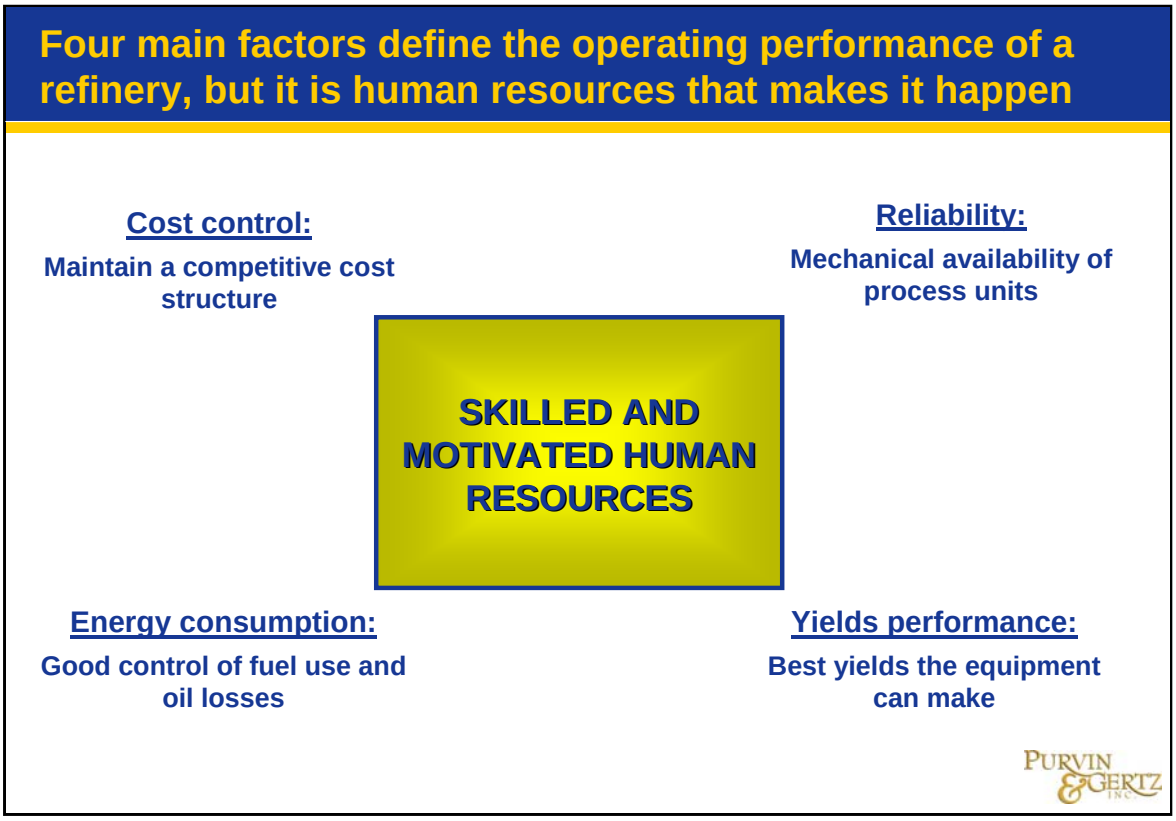
- Product demand in Europe is spread throughout the territory, with the result that most of the European refining industry has been developed at locations close to product demand or where it was possible to distribute products effectively.
- This has not removed the need to receive crude at competitive costs. Coastal refineries were generally developed at deep-water ports to import crude in large cargoes when the predominant source was the Middle East, and crude pipelines were built to serve inland refineries.
- In the former Eastern block crude is received directly by pipeline from Russia, while products are distributed directly from the refinery by truck or by pipeline. This is a good situation because crude is received at competitive prices and products are delivered into an enclave where the alternative cost of delivery is high.
- In Western Europe the inland refineries receive crude by sea via import terminals and pipelines. They generally serve local enclaves of demand but the advantage of the inland location only exists as long as the market is short of supply.
- Some refineries are located on the coast, but are linked to inland markets by pipeline (e.g. in Spain, France, the UK, the Netherlands and Germany). This type of logistics combines the ability to serve inland markets with the flexibility to trade surplus product globally. Pipeline is an efficient form of transport from a cost and energy standpoint.
- The refineries on the Italian Islands have production far higher than can be absorbed by their respective inland markets. They are mainly export refineries that trade products by cargo to other locations in the Mediterranean and elsewhere. Their production has lower value because of their location. Although they are less competitive from the standpoint of location, they have developed into large and/or complex sites, so as to remain competitive by virtue of their configuration.




- There are a number of elements that are under the direct control of the refinery management. These have been classified in four main categories as shown above.
- Assuming that two refineries with similar configuration operate in the same market, the difference in operating performance could have a significant impact on their profitability. However, it is unlikely that a large disadvantage related to configuration or logistics could be offset by operating performance alone. For example, the best operated hydroskimming refinery is unlikely to be more profitable than a poorly operated deep conversion refinery.
- Although economy of scale can deliver a better cost structure, the cost structure is also a result of management effort. Large differences exist between the best and the worst refineries.
- In order to achieve the planned levels of production a refinery needs its process units to operate reliably. The best operated refineries achieve reliability factors in the region of 98% or higher, while poorly operated ones may not reach 90%.
- Other technical reasons that could prevent a refinery from achieving the planned yields are the inability of individual process units to perform as expected. As an example, the actual conversion to diesel of a hydrocracker could be below plans or to design. Refineries have teams of engineers dedicated to solving problems of this nature, as well as to finding yield improvement opportunities. Their success, or lack of success, would show in yields that may be better or worse than expected.
- The European refineries generally have high focus on energy efficiency. The drive to energy efficiency is particularly strong when oil prices are high and has increased recently as a result of $CO_2$ pricing policies.
- A skilled and motivated work force is a necessary precondition to achieve good operating performance at all levels. Our view of the European refining industry is that its workforce is generally skilled and motivated. From a standpoint of technology, standards and work practices, European refineries are among the world leaders.

# OPERATING AND INVESTMENT DECISIONS

## Refineries react to a changing business environment with appropriate decisions

### Short term

Observe short term price scenario and optimize the variable cost margin of the refinery

This may involve:

- Adjusting the level of crude runs
- Optimize crude selection
- Exploiting all of the operational flexibilities of the refinery
- Pursuing opportunities for incremental profitable sales…
- …or withdrawing from marginal sales

Refinery may be constrained by

- Crude purchase commitments, ability to buy more crude or to sell unwanted crude in the spot market
- Product sales commitments

### Medium term

Consolidate profitable positions in order to seek higher future net margin and return on investment.

This may involve:

- Implementing improvement projects to increase the yields of products that are in demand
- Implementing small improvement projects to remove constraints and increase those flexibilities that have been found to be more valuable
- Pursue supply chain optimization to consolidate access to markets
- Review term supply contracts to remove possible constraints
- Review operating costs

### Long term

Take a view of margins 5 or 10 years in the future and define a strategy for the refinery

This may involve:

- Investment in large projects, as needed to reconfigure the refinery
- Expansion of capacity
- Partial closure of capacity that is expected to be loss making
- Closure or sale of refineries
- Acquisition of refineries
- Mergers or joint ventures with other refineries, as needed to pursue synergies
- Long term cost reduction possibilities

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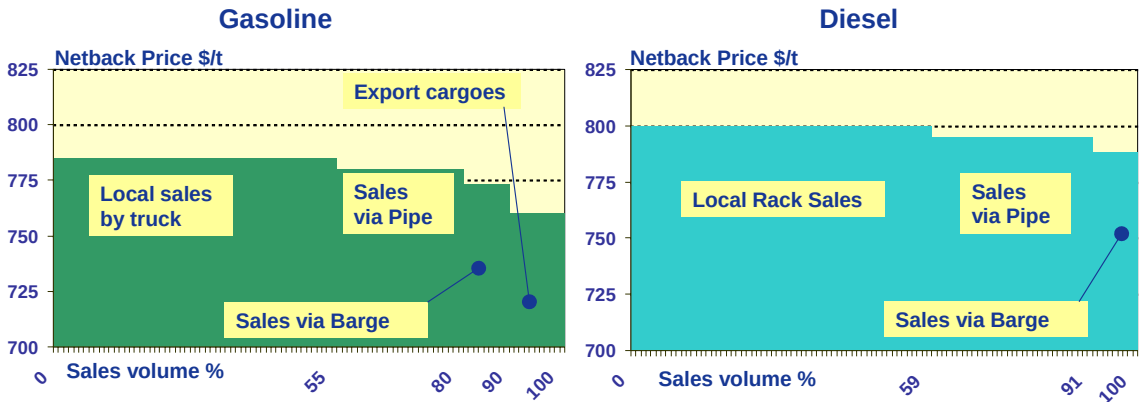
- In the short term (*up to 2 months*) the refiners' only options to respond to changes in the market are to increase or decrease the level of processing, make the modest yield shift that its processing equipment will allow and possibly change the crude slate. Some conversion refineries may have the option to substitute crude for purchased feedstocks (VGO or atmospheric residue) or vice versa.
- Refineries may have crude purchase commitments. If they have purchased crude but want to reduce crude runs they must be able to re-sell crude in the market. In the opposite situation they must be able to find an incremental cargo of crude in the market. Refineries are also constrained by their product sales commitments in a similar manner.
- In the medium term (*up to 2 years*) refineries seek the same kind of optimization that maximizes profitability, but have greater opportunity to change. The emphasis moves to the net cash margin as some steps that would influence operating costs are possible. Minor investment is possible and generally companies would look for a quick payback. Commercial changes are possible with existing contracts being ended and new opportunities sought. The decision may be taken to end some processing if it is not thought to be viable. The decisions involved (e.g. implement a small project) have a permanent impact on how the refinery will be operated, but are fairly reversible, if a new change of direction is warranted.
- In the longer term (*beyond 2 years*) the types of decisions that are needed require a strategic view of the business and possibly to commit large sums of capital, or even to to exit the business. These decisions can change the structure of the business completely. In making such strategic decisions the oil companies will make studies on the long term viability of their business and will be reluctant to invest in an unstable business environment.

## Example of a typical short term decision: cut crude runs and withdraw from marginal sales




- In this example, the refinery sells 55% of its gasoline in the local market by truck. The last 10% is sold as export cargoes at a lower netback than the tranche sold by truck
- If margins reduced such that the variable cost margin obtained from export sales is negative, the refinery would reduce runs and withdraw from sales of gasoline export cargoes and diesel barges
- When a refinery reduces throughput to produce less gasoline, it also produces less diesel

N.B.: This is for illustration and does not represent the situation of any specific refinery or location

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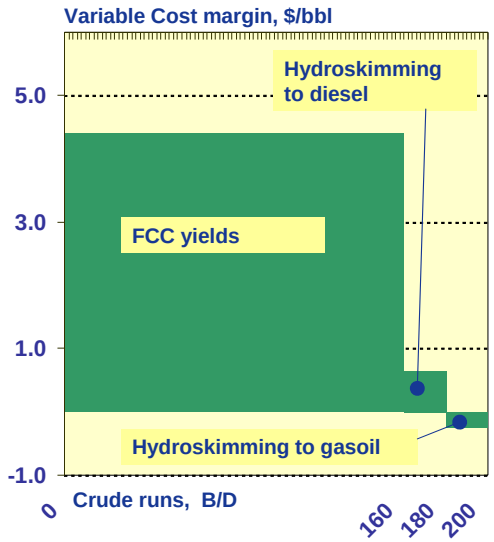
- As noted earlier, the value a refiner can realize for its products is different depending on how and where the refiner is able to sell the product. Every refiner will have tranches of sales which generate a different price.
- In this example, the refiner can sell 55% of the total gasoline produced into the local market by truck. This "tranche" of gasoline is the most valuable to the refiner. A further 25% is sold via pipeline, still in the domestic market. Another 10% is delivered by barge and the remaining 10% must be exported by cargo. The refiner will have to pay to transport the gasoline to the markets where is delivered, and so the value of the product to the refiner reduces as transportation costs increase.
- The tranche with the lowest value to the refiner is the export cargo. As Europe has an oversupply of gasoline, most refiners have to sell some of their gasoline production in the export cargoes market.
- A similar picture would exist for the diesel production, with one major exception. Since Europe is short of diesel a large number of refineries do not have to export diesel by cargo. If the local market cannot absorb all of the diesel production, refineries are typically able to find a near-local market accessible by pipeline, barge or with small ships. In the example, the least valuable tranche of diesel is that sold by barge.
- The gasoline market is likely to be more competitive than the diesel market, giving more bargaining power to buyers. There would also be refineries that evaluate the opportunity to sell incremental volumes of gasoline against the low value of marginal sales in the export market. In the diesel market the situation reverses.
- These are simple examples. In reality a refiner may have many different tranches of product sales, depending on the number of different markets the refinery can serve, and on the amount of competition in those markets from other refiners or suppliers. The export price generally represents the lowest value that a refiner will get for his product.

## Refiners have also different tranches of capacity, some of which may be marginal




N.B.: This is for illustration and does not represent the situation of any specific refinery or location

- A refinery has crude distillation capacity of 200,000 B/D, from which it could recover 50,000 B/D of FCC feed (i.e. 25vol%).
- However, the FCC capacity is only 40,000 B/D. The refinery needs only 160,000 B/D of crude to fill up the FCC.
- Crude processed in excess of 160,000 B/D is with hydroskimming yields.
- In the example we assume also that gasoil hydrotreating capacity is limiting, such that when 180,000 B/D of crude is processed, there is no more capacity to upgrade gasoil to diesel.
- If the refinery runs more crude, it must use the gasoil fraction to produce lower value heating gasoil
- This situation defines three tranches of capacity
- The three tranches would have different yields and different margins

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- In this example, the refinery has a crude distillation capacity of 200,000 B/D (about 10 MT/y), but an undersized FCC. The refinery can fill up the FCC with 160,000 B/D of crude, but crude processed in excess of this is with "incremental" hydroskimming yields. We have also assumed that at 180,000 B/D of crude the refinery runs out of capacity to upgrade gasoil to diesel (**Section II**, hydrotreating processes). If the refinery processes more crude, the gasoil can only be used to produce lower value heating gasoil. These two thresholds define three tranches of capacity, with different yields and different margins.
- The refinery would normally see that the variable cost margin of the 160,000 B/D of FCC capacity is positive and would typically process at least 160,000 B/D of crude. The incremental 20,000 B/D of diesel-hydroskimming capacity would be marginal and may or may not deliver a positive variable cost margin. The refinery would observe market prices and make weekly or daily decisions on whether to use this capacity or not. The last 20,000 B/D is even more marginal and there would be a lower probability that this capacity makes a positive variable cost margin.
- The above provides a simplified representation to illustrate how refineries have tranches of capacity at different profitability. A number of variables play a role. Here are some examples:
  - The refinery could choose to process a lighter crude with a yield of FCC feed of only 20 vol%. In this case, the refinery would need 200,000 B/D of crude to fill up the FCC. Depending on crude and product prices, the refinery would choose whether to process 160,000 B/D of the heavier crude or 200,000 B/D of the lighter crude.
  - If the refinery increases crude runs, either by processing crude with hydroskimming yields or the lighter crude, the incremental production is destined to the most marginal markets. This complicates the analysis of the economics further.
- Because of the extremely large analytical complexity of the problem, refineries prepare short term plans with the assistance of Linear Program (LP) models, which are mathematical representations of the refinery operations that use prices to determine an optimum.

## Prices and margins are also a signal for future investment decisions

| Margin | Signal |
|---|---|
| Strong margins for a certain configuration | Maximise output from refinery type and consider investment in expansion |
| Net margins average break-even | Facility is "supplier of last resort". Question over long-term survival in current form |
| Net margins are negative (short term) | Facility is unsuitable for immediate market demand |
| Net margins are negative (long term) | Facility should either close or reconfigure |

**In this case the focus is not so much on margins at the present time, but more on what margins are expected in 5 or 10 years time**

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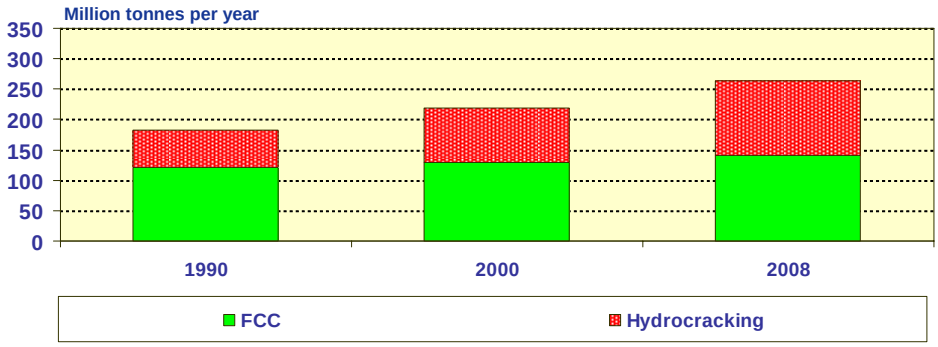
- As benchmark margins are a direct indicator of the profitability and the business environment for a refinery, or capacity within a refinery, they also act as a signal to the industry regarding modes of operations.
- The two most significant changes in the past three years have been an increase in hydrocracking margins relative to FCC margins and a sharp deterioration in hydroskimming margins.
- Although hydroskimming refineries may be able to survive short-term periods of negative variable cost margin, with the reduction of refinery runs being one option, in the longer term persistent losses are an indication for the capacity either to cease operating or to reconfigure. The large difference between hydrocracking and hydroskimming margins, for example, is an incentive to reconfigure hydroskimming capacity to hydrocracking, as by doing so it would be able to capture the additional margin available.
- In practice, refinery investment decisions are based on the anticipated return on investment which is a function not only of the incremental revenue generated, but also of the investment required. As shown in **Section II**, the cost to upgrade a 200,000 B/D (10 MT/y) hydroskimming refinery to hydrocracking is of the order of $3 billion. Regardless of future margin expectations, different companies would have different attitudes when facing the need to invest such a large sum in the refining business.

## Expansion of gasoline oriented FCC capacity has generally stopped and the focus is now on diesel production

### FCC and Hydrocracking capacity at European refineries




- Producing a high yield of diesel requires investment in hydrocracking
- Gasoline demand in Europe has peaked and the existing FCC capacity exceeds gasoline production needs
- The focus of investment activity is now on hydrocracking capacity

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- Most of the FCC capacity was built in the 1970s and 1980s to keep pace with growing gasoline demand. This capacity is still profitable and continues to be operated. The last two FCC units built in Europe were at the Kralupy refinery (2001) and the Collombey refinery (2003). There were specific reasons for these decisions.
- Although the focus on gasoline and FCC is currently low, FCC capacity has continued to creep up as technology has developed.
- The European refining industry now needs to be reconfigured for diesel production and the focus of European refineries has now shifted accordingly. The majority of refinery upgrading projects completed since the 1990s were based on hydrocracking. The bias to hydrocracking is even stronger for ongoing projects.
- In 1990 FCC capacity was much higher than hydrocracking capacity, but hydrocracking capacity is catching up rapidly.

## Refining margins: conclusions

- **The refining industry is the link between the crude oil and the refined products market. Its profitability is determined by the different dynamics of these two markets.**
- **Different refineries achieve different product yields and, therefore, different margins.**
  - *Conversion refineries achieve a higher yield of light products and, therefore, higher margins*
  - *Simple hydroskimming refineries have hardly ever been profitable over the last 20 years and their profitability has deteriorated further recently*
  - *The profitability of conversion refineries was also fairly low in the 1990s but has now improved considerably, especially in the last four years.*
- **The refining margin is also influenced by the location of the refinery and its logistics of crude supply and product offtake.**
- **Refineries make short term operating decisions on the basis of the variable cost margin and long term decisions on the basis of the net cash margin or on the basis of return on investment**
- **Prices and margins move to signal which investments are most needed to follow market trends**
- **Hydrocracking margins have improved considerably, relative to FCC margins, reflecting the shortage of diesel in Europe**

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