

Introduction to the Oil & Gas Sector

February 2013



Table of Contents (I)

	Page
What is oil?.....	3
What is oil used for?.....	4
Oil pricing.....	5
What is gas?.....	6
What is gas used for?.....	7
Gas pricing.....	8
Where does oil and gas come from?.....	10
Shale oil.....	14
Reserves and resources.....	17
Distribution of reserves.....	19
Oil demand.....	20
Oil supply.....	22
OPEC.....	24
Oil sands.....	26
Gas demand.....	28
Gas supply.....	29
LNG.....	30
Shale gas/coal bed methane/tight gas.....	34
Exploration and development.....	36
The exploration process.....	37

Table of Contents (II)

	Page
The development process.....	41
Onshore construction.....	45
Offshore vessels.....	46
Rig count.....	47
Oilfield services company activity.....	48
Refining.....	49
Marketing.....	54
Upstream performance measures.....	56
Accounting issues.....	57
Oil and gas taxation.....	59
Industry subsectors.....	60
Valuing oil companies: Integrateds.....	61
Valuing oil companies: E&Ps.....	62
Valuing oil companies: R&M and Oilfield Services.....	63
Appendix 1: Oil price (1861-now).....	64
Appendix 2: Conversion table.....	65
Appendix 3: Important dates in the history of the industry.....	66
Appendix 4: UBS oil and gas team.....	67
Appendix 5: UBS global oil and gas coverage.....	68
Appendix 6: Glossary.....	69

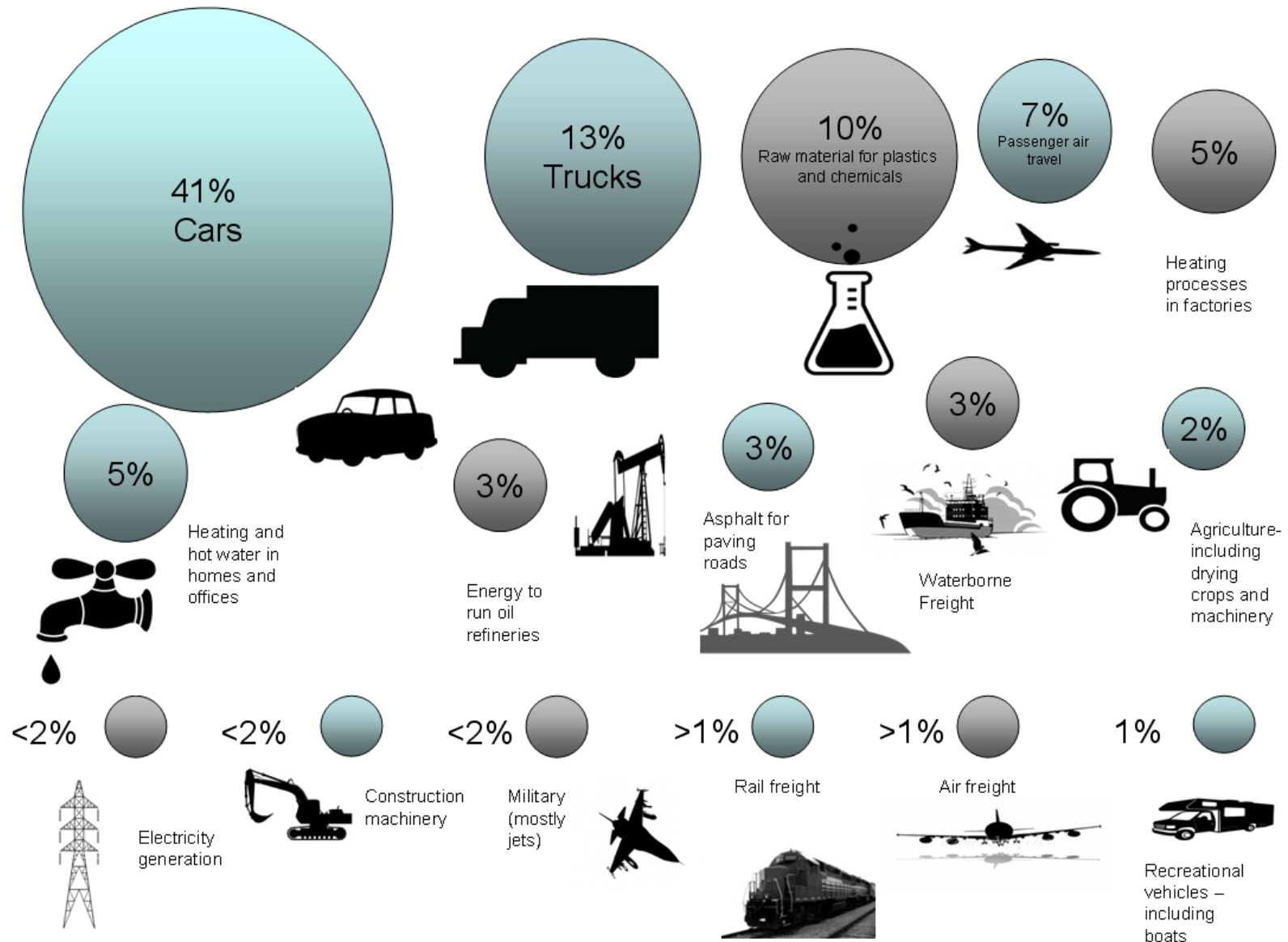
What is oil?

- Oil (like gas and coal) is a **fossil fuel**. Most of what is extracted today has been formed from prehistoric organisms whose remains settled at the bottom of oceans and lakes millions of years ago. As layers of sediment covered them, the pressure and temperature on them increased, causing the organic matter to 'cook', changing its chemical composition (by breaking down the complex molecules) and eventually transforming it into oil.
- Oil and gas is collectively known as **hydrocarbons** as it consists of carbon and hydrogen molecules. Coal is predominantly carbon.
- Fossil fuels are a finite resource with only a limited supply in the Earth's crust. Because it takes so long for them to form, they cannot be replaced once they have been used up.
- Oil is referred to as '**crude oil**' before it has been processed ('refined') to make usable products such as gasoline and diesel.
- Crude oil is not homogenous. Its physical appearance varies from a light, almost colourless liquid to a heavy viscous black/brown sludge. It varies by:

Density: oil can be "light" or "heavy". The hotter the environment in which it forms, the further the hydrocarbon chain breaks down, and thus the lighter the oil. Density is classified by the American Petroleum Institute (API), in degrees of **API gravity** (which is a measure of how light or heavy the crude is relative to water, which has an API gravity of 10°). The higher the API the lighter the crude (>38° for "light" crudes, <22° for "heavy" crudes). Lighter crudes are easier to refine and transport, hence priced more highly.

Sulphur content: oil can be "sweet" or "sour". "Sweet" crude has <1% sulphur content, while "sour" crudes have >1%. "Sour" crudes are generally cheaper as the sulphur makes them toxic and corrosive and usually needs to be removed.

What is oil used for?



Source: The Times

Oil pricing

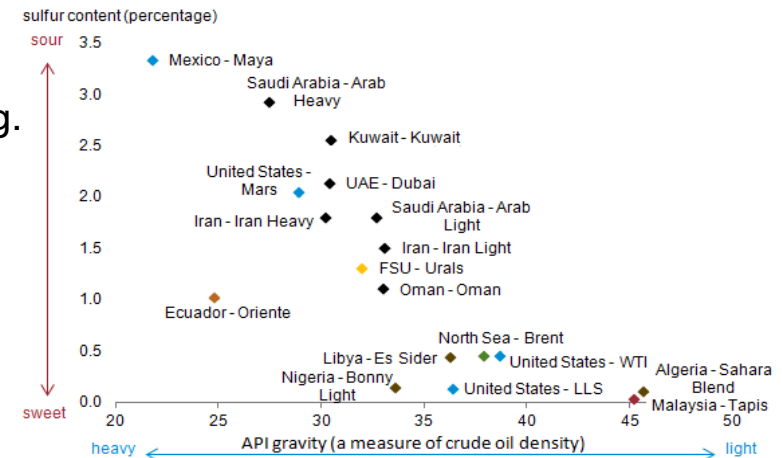
The 2 main global benchmarks for crude oil are **Brent** and **WTI** however there are many different types around the world, including **Mars** (a medium sour blend), **Dubai** and **Arab light**. To see spot prices of different crudes around the world, type *Boil* into Bloomberg.

Different types of crude oil (light and sweet crudes, heavy and sour crudes or crudes in different geographic locations) are priced differently. Pricing differences between grades were traditionally largely explained by different quality characteristics and transportation costs to Cushing, delivery point of the NYMEX WTI contract. However, more recently, WTI has traded at a wider discount to other crudes despite being a premium quality crude due to transport constraints.

The US has historically been a large importer of oil, so its oil infrastructure has been built around refining imported oil and then moving the refined products north. Now however, because North American oil production is rising (in particular from the Bakken shale and Canada's oil sands), oil needs to be moved from inside the country to the refineries and there is a major shortage of pipeline capacity to do this.

A refinery designed for sweet, light crude cannot switch to heavy, sour oil without upgrading (oil from the Bakken is generally mid-weight and sweet while oil from Canada's oil sands is very heavy). US refineries have invested a lot over the last decade to enable them to process heavy oil. Now, pipelines are required to transport the oil to the Gulf Coast, where the bulk of the refineries are (no new refinery has been built in North America since 1976). However, there is just enough capacity to get the oil to Cushing, where it then gets stuck. The recent reversal of the **Seaway** pipeline has helped (used to move refined products north from the Gulf Coast but now carries oil south) and the soon-to-come **Keystone XL** pipeline will also help (from Cushing to the Gulf Coast). The problem however is that production from the oil sands and the Bakken is simply growing too quickly for the infrastructure to keep up (limited pipeline capacity, limited storage capacity, limited (and expensive) truck and rail export capacity).

Density and sulfur content of different crudes



Source: EIA

What is gas?

- Gas is a mixture of different hydrocarbons, with **methane** the main component (70-90%). It can be found in separate accumulations from crude oil, '**non associated gas**', or is found in combination with or in solution in crude oil, this is known as **associated gas**. Natural gas also is often discovered with large volumes of **condensate**, a light oil which is gaseous under reservoir conditions and enhances the value of a discovery.
- Like oil, natural gas is also far from homogenous. Along with methane, the constituent elements typically also include ethane, propane, butane and heavier compounds, which are collectively known as **Natural Gas Liquids** (NGLs).
- There are different types of gas:
 - Wet**: hydrocarbons other than methane are present
 - Dry**: it is almost pure methane
 - Sour**: contains significant amounts of hydrogen sulphide
- Raw natural gas is rarely suitable for pipeline transportation or commercial use. It can be "dried" or fractionated to remove the NGLs. This breaks the "wet" gas into 2 components – marketable methane (which is now of 'pipeline quality' and enters the transmission network) and a mixture of liquids.
- Both natural gas and NGLs may require additional treating/processing, either before or after the extraction of liquids. The most common treatment is to remove excess water vapour, necessary to prevent its freezing in pipeline transmission systems. Another process, known as '**sweetening**', involves the removal of corrosive **hydrogen sulphide** and **carbon dioxide** (hazardous to breathe).
- Natural gas is the cleanest fossil fuel to burn because of its low carbon content, meaning that it contributes to lowering CO₂ emissions when it displaces coal or oil. It has therefore become increasingly more important in the energy mix at the expense of oil and coal as consumers look to take advantage of its environmental characteristics, including lower sulphide dioxide and nitrogen oxide emissions. In 1973 16% of the world's energy consumed was gas (25% coal, 46% oil). In 2011 it was 24% (30% coal, 33% oil).

What is gas used for?



- The uses of gas can be split into residential/commercial, industrial and electricity generation:

Residential/commercial: used for ovens, clothes dryers and heating/cooling (boilers, furnaces, water heaters). It is supplied to homes via pipes in much of the developed world (compressed natural gas, CNG, is used in rural homes without connections to public utility services). CNG is also cleaner than other automobile fuels such as gasoline (petrol) and diesel.

Industry: used to produce hydrogen, the latter being a primary feedstock for the chemical industry. It is also used as a major feedstock for the production of ammonia for use in fertilizer production. Natural gas is also used to manufacture steel, fabrics, glass, paint and plastics.

Electricity generation: this is through the use of cogeneration, gas turbines and steam turbines. It is also used in combination with renewable energy sources such as wind or solar. Burning natural gas produces 30% less carbon dioxide than burning petroleum and about 45% less than burning coal.

- In 1990 44% of gas globally was used by the Industrial sector, followed by Electricity Generation (34%) and Residential (23%). In 2010, Industrial and Electricity Generation accounted for 39% each (22% Residential). ExxonMobil forecasts that 46% of global gas will be used for electricity in 2040, with 37% used by the Industrial sector and 17% by Residential.

Gas pricing

- While oil is priced by volume (barrels), natural gas is sold by unit of energy. Natural gas liquids (NGLs), which include ethane, propane, butane and condensates, raise the energy content of natural gas and are therefore more valuable. Impurities however, such as carbon dioxide, hydrogen sulphide and nitrogen, are non-combustible and reduce the energy content. If there are enough quantities of NGLs in the natural gas, it is often economic to remove them for direct sale.
- Because natural gas is difficult to transport, prices tend to be set locally or regionally. We tend to talk about “spot” prices and “contract” prices.

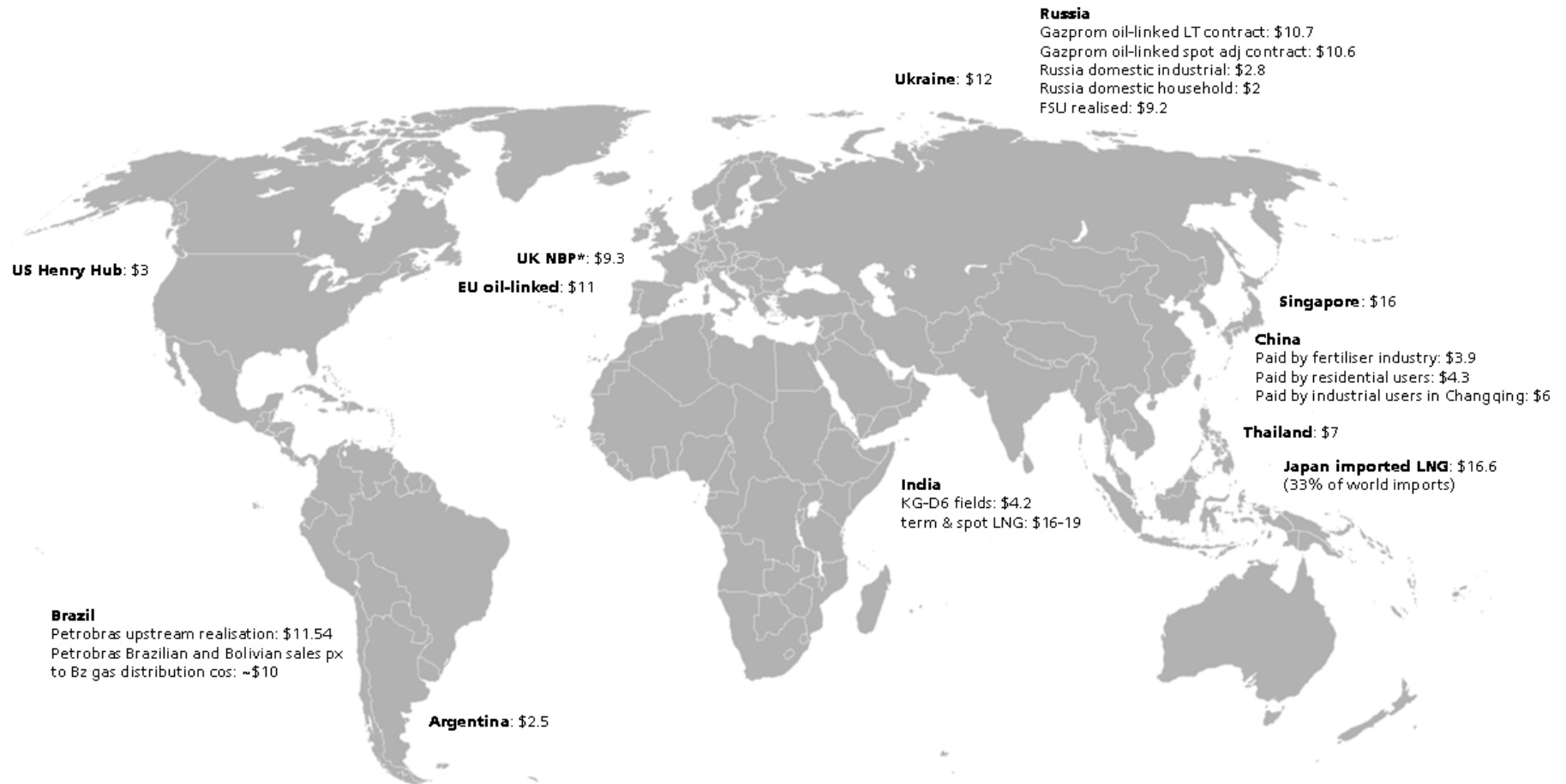
Contract prices: the price is negotiated directly between the buyer and the seller and tends to be linked to either oil, oil products, local inflation or a combination of all three. If the electricity generator can substitute the gas for other fuels, such as diesel or coal, prices of these would influence the gas price agreed. Examples of this would be European oil and oil-product linked prices.

Spot prices: the buyer pays the prevailing market price at the time. The price is mostly influenced by supply and demand. If it is used for space heating, the price may rise in cold winter months. If it is used to generate power used for air conditioning, it would rise in hotter months. If it is used by industrial consumers, weather would have a minimal impact on demand and thus the price. Disruptions in gas supply (hurricanes for example) would hit supplies and increase prices. Examples of this would be the US market which has a deep spot market due to extensive pipeline and storage facilities.

LNG prices: LNG has a (large) contract market and a (smaller) spot market. Generally the bulk of the contracts are pre-agreed volumes at a price fixed relative to oil prices (discussed in terms of “slope” – 14% slope would mean the LNG was priced at 14% of the price of oil).

Gas prices around the world

Gas prices around the world vary a lot, due, amongst other factors, to distribution and export constraints, government subsidies and sometimes a material mismatch in geographical supply and demand.



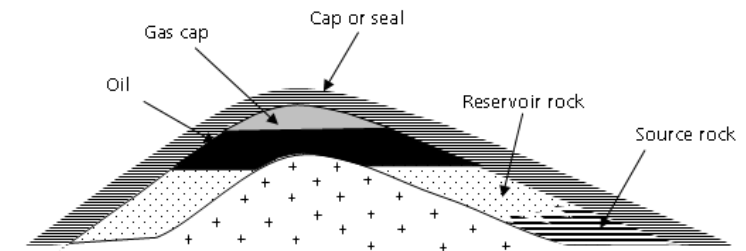
* NBP: National Balancing Point. It is a virtual trading location for the sale/purchase of UK natural gas. It differs from Henry Hub in the US in that it is not an actual physical location.

Source: Bloomberg, World Bank, UBS estimates, MercoPress

Where does oil and gas come from (I)?

Oil and gas fields are formed when there is a combination of 4 essential ingredients – a source rock, a reservoir rock, a cap or seal and a trap.

- **Source rock:** these are rocks containing a sufficiently high percentage of organic matter to form oil and gas. However due to the force of gravity (hydrocarbons are less dense than the surrounding rock) and the pressure created by the overlying rock layer, oil and gas seldom stay in the source rock in which they are formed. Instead they move through to underground layers of sedimentary rocks until they either escape at the surface or are trapped by a barrier of less permeable rock to form oil and gas fields.
- **Reservoir rock** (typically sandstones or limestones) : where the hydrocarbons are held. Oil and gas will rise upward through pore spaces and fractures in the rock, displacing water as they go. These rocks have 2 important characteristics: **porosity** and **permeability** (see slide 12).
- **Cap or seal** (such as a fault or a salt dome): in order to stop the hydrocarbons escaping to the surface, there must exist an impermeable layer of rock, known as the cap or seal. Suitable rock types are shale, micrite (a fine-grained limestone), or evaporite and salt (such as the salt layer in Iran).
- **Trap:** hydrocarbons only accumulate where the seal and reservoir rocks are in the right shape and relative position to form traps. The 2 main types of trap are **structural** traps formed by earth movements which fold the rock into suitable shapes and **stratigraphic** traps, where a suitable combination of rock types is deposited in a particular environment.

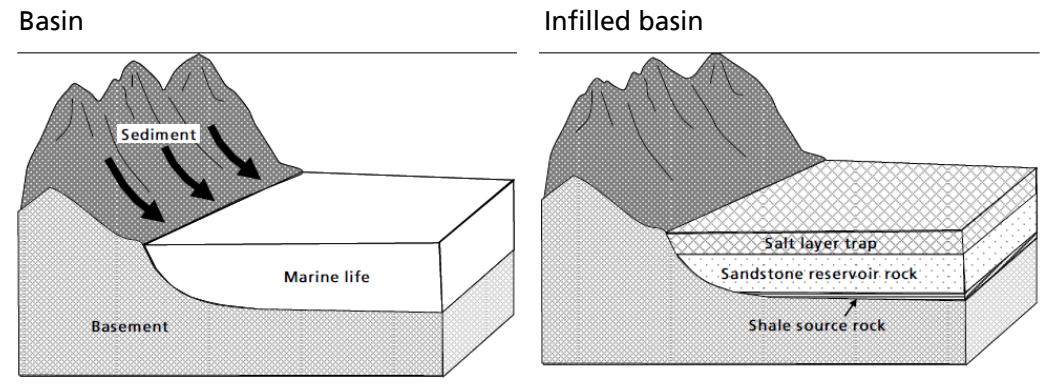


Source: UBS

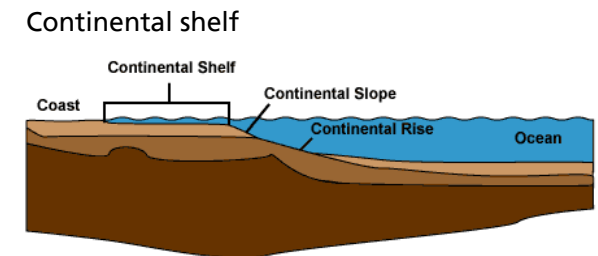
Where does oil and gas come from (II)?

The formation of favourable environments involves the link between mountain building, sea level changes and sedimentary cycles. Reservoirs most often form:

- in **sedimentary basins**: when oceans close due to movements in the earth's plates, there is usually a period of mountain building. Basins are found in the shadow of mountain ranges. As the basin gradually fills with sediment, the remaining water becomes more saturated with salt. In warm environments, the sea water evaporates and thick layers of salt are deposited, forming the **salt layer trap**. The basin below this sediment is known as **pre-salt**. Pre-salt oil is typically more difficult to develop because the salt has a distorting effect on seismic waves, making it difficult to image the rock layers in order to analyse them.
- on **continental shelves**: these are oil producing because of the abundance of marine life in the seas (see right).
- in **deltaic environments**: as rivers enter the sea they carry with them sediment which gradually builds at the mouth of the river, or delta. As the sea level then rises, it floods the delta, and marine shales are deposited over the sand.



Source: UBS



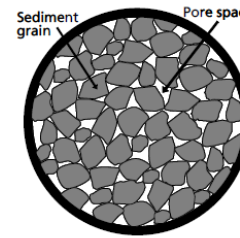
Source: Office of Naval Research

Where does oil and gas come from (III)?

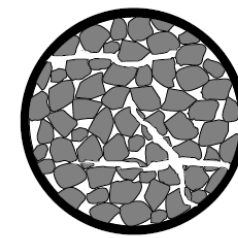
Once a source rock generates and expels petroleum, the petroleum migrates to the reservoir rock, where it is stored. Reservoir rock quality is measured by 3 general physical properties:

- **Porosity:** void space between the grains of reservoir rock, acting as storage for hydrocarbons. It is measured as a percentage of total rock volume. Porosity of a good reservoir could be >30%.
- **Permeability:** a measure of a rock's ability to allow oil/gas/water to flow from reservoir to the well bore. Good reservoirs have permeability of >1 Darcy (a unit of permeability). Highly porous rocks tend to have better permeability because the greater the number of pores and the larger they are, the more likely it is that they are connected.
- **Reservoir homogeneity:** reservoir quality/continuity can vary both vertically and laterally. Homogenous reservoirs tend to maintain a uniform geometry both vertically and horizontally, with high net/gross pay ratios. **Gross pay** refers to the total thickness of the reservoir column, including non-productive intervals (grey in image to the right). **Net pay**, on the other hand, is the net thickness of *productive* intervals. Development of homogenous reservoirs is much cheaper because of their predictable physical properties. Heterogeneous reserves have a low net/gross ratio and are therefore more complex to develop.

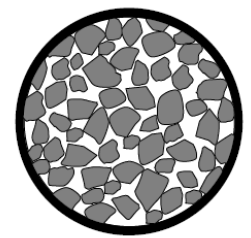
Low porosity,
low permeability



Low porosity, permeability
increased by fractures

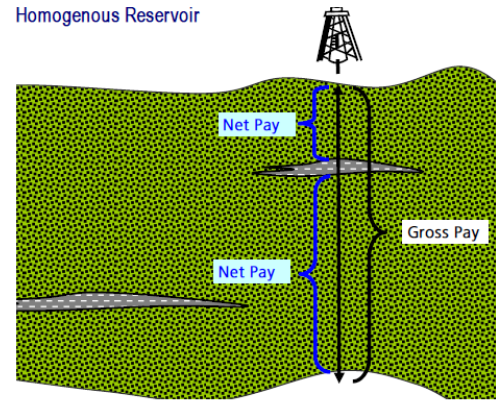


High porosity,
high permeability

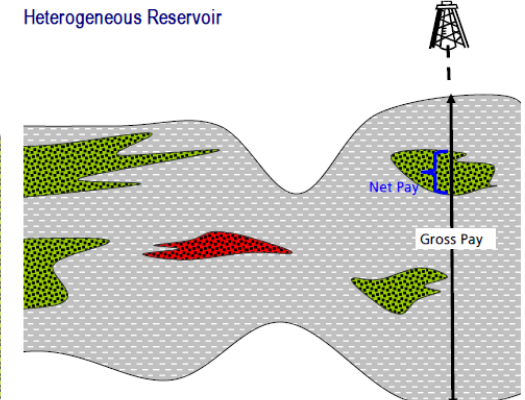


Source: UBS

Homogenous Reservoir



Heterogeneous Reservoir



Source: UBS

Where does oil and gas come from (IV)?

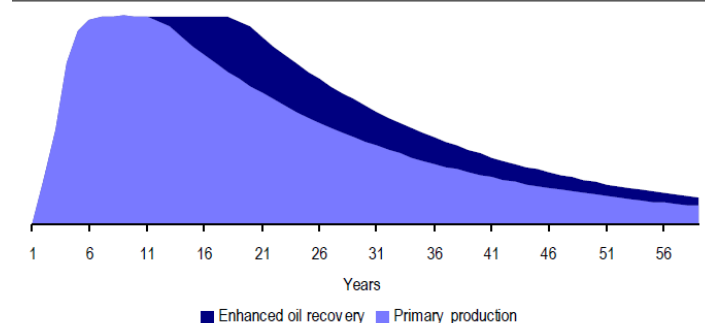
Recovery factor is the proportion of original hydrocarbon-in-place which can **economically** be recovered from the reservoir using available **technologies**. It is one of the most difficult reservoir attributes to estimate. Recovery is a function of reservoir rock, fluid characteristics and fluid recovery process. 2 recovery stages:

- **Primary recovery:** this is recovered through the reservoir's natural pressure combined with pumps (for oil) and compressors (for gas). It is the cheapest production method. Tight reservoirs (low permeability) have lower recovery rates compared to high permeability ones.
- **Enhanced Oil Recovery (EOR):** when primary recovery is low, methods are used to increase recovery, typically by a further 20-40%. Choice of EOR method depends on the trap type, reservoir rock characteristics, fluid properties and availability of displacing fluid (gas, water).

Common methods:

Waterflooding	Gas injection	Chemical flooding	In situ-combustion	Steam-injection	Gas cycling for condensate
Water is injected to sweep or displace oil and increase reservoir pressure.	Natural gas, nitrogen or CO ₂ are injected to increase reservoir pressure and help drop oil viscosity, thus enhancing oil flow.	Long-chained molecules (polymers) are used to help increase the effectiveness of waterfloods. They allow oil to mix with water and lower the surface tension that prevents oil droplets from moving through the reservoir.	Oxygen-enriched air is injected and ignited, heating the heavy oil reservoir, increasing the pressure and reducing oil viscosity.	Steam generated at surface (boiling water) is injected into heavy oil reservoirs, producing heat and pressure.	Gas is injected, aiding condensate to dissolve into the gas, producing condensate-rich gas. Once the condensate is stripped out at the surface, the gas is re-injected and the process repeated.

Effect of EOR on a field's production profile

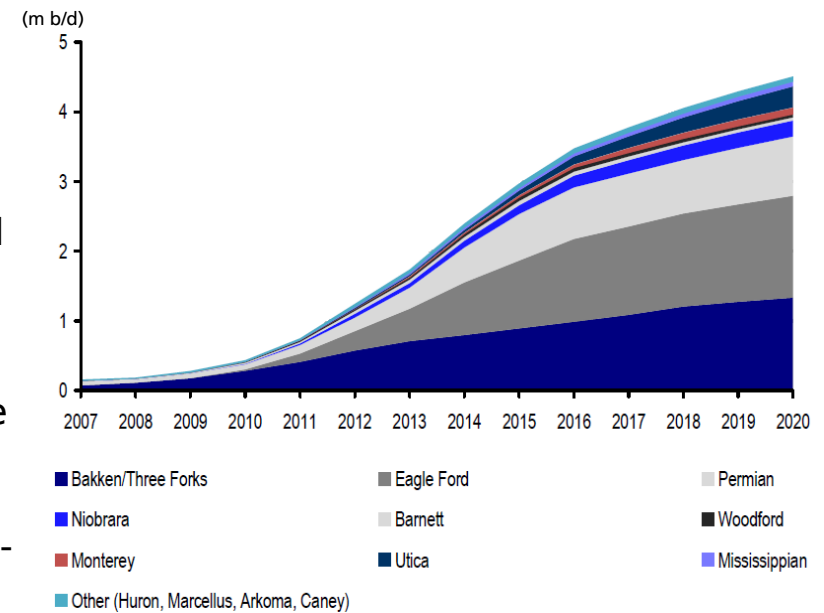


Source: UBS

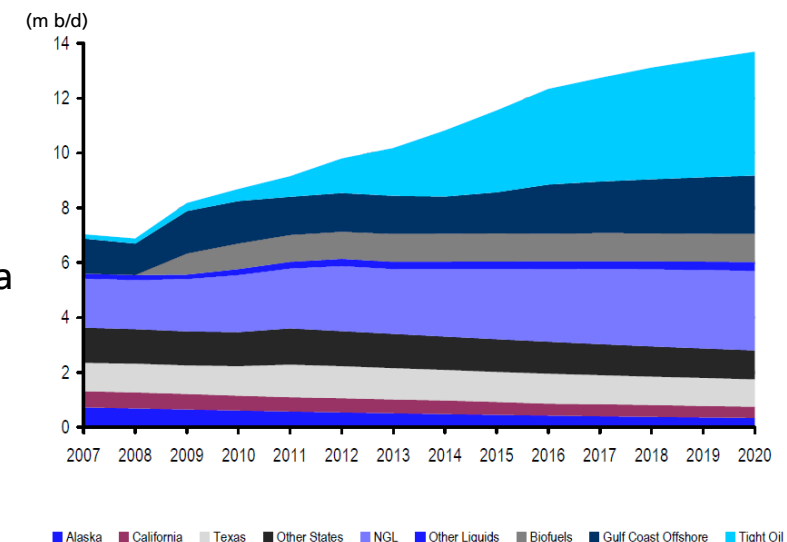
Shale oil

- Tight oil is conventional crude oil trapped in geological formations with low permeability. As it is sometimes found in shale formations, it is often referred to as **shale oil**. This is not to be confused with **oil shale**, which is a sedimentary rock formation containing kerogen (a complex waxy mixture of hydrocarbon compounds) and can eventually be turned into oil (not currently commercially produced).
- In 2012 the US produced 1.25m b/d of tight oil (see top graph). This is projected to reach 4.51m b/d by 2020. It has changed the dynamics of US oil production, which was in decline until 2007. Importantly, this huge growth is curbing the US' dependence on crude oil imports. It has also become the newest and fastest-growing source of crude oil.
- The US was strategically placed for the tight oil revolution for 4 reasons: a large and well-mapped resource base, skills and techniques gained in developing shale gas, fiscal and legal incentives to invest and well-developed infrastructure.
- China is the most likely place tight oil production will take off next. Large resources also exist in Russia, Canada and Argentina but environmental and technological challenges may prove obstacles to development in the medium-term.

US tight oil production by play



US oil production by source



Lower 48 shale plays



- US tight oil production was initially centred on the **Bakken** and **Three Forks** (a unit in the Williston Basin). formations in North Dakota. The latter basin alone currently accounts for around half of current US tight oil production.
- More recently however there has been a lot of attention on the **Eagle Ford** play in southern Texas, which has become the fastest-growing new production area, rapidly catching up with Bakken (see next slide). Other well-known names include the **Permian**, **Niobrara** and **Utica**.

Largest US oil shale plays by company interest

Total acreage	Oil shale play	Company	Acreage	Share of play	Total acreage	Oil shale play	Company	Acreage	Share of play	Total acreage	Oil shale play	Company	Acreage	Share of play			
6,595,000	Bakken	Continental	939,000	14%	3,201,600	Utica (Permian)	El Paso	75,000	1%	1,701,400	Horizontal Mississippiian	Sandridge	881,400	52%			
		Hess	900,000	14%			Rosetta	65,000	1%			Devon	545,000	32%			
		Whiting	702,000	11%			Cabot	60,000	1%			Chesapeake	230,000	14%			
		EOG Resources	600,000	9%			Goodrich	40,000	1%			Range	45,000	3%			
		ConocoPhillips	419,000	6%			Chesapeake	900,000	28%		1,267,780	Spraberry (Permian)	Pioneer	900,000	71%		
		Marathon	413,000	6%			Range	760,000	24%				Apache	367,780	29%		
		ExxonMobil	395,000	6%			Chevron	300,000	9%			890,000	Cine	Devon	556,000	62%	
		Statoil	375,000	6%			Anadarko	240,000	7%				Apache	334,000	38%		
		Oasis Petroleum	307,000	5%			Hess	200,000	6%				Energen	N/A	-		
		Occidental	277,000	4%			Devon	157,000	5%				Legacy	N/A	-		
		PetroBakken	210,000	3%			Total	154,800	5%				Concho	N/A	-		
		SM Energy	202,000	3%			EVEP	130,000	4%		788,000	Bone Spring (Permian)	Chesapeake	290,000	37%		
		Denbury	202,000	3%			CONSOL	100,000	3%				Devon	185,000	23%		
		Kodiak	157,000	2%			ExxonMobil	75,000	2%				Anadarko	145,000	18%		
		Newfield	100,000	2%			Rex Energy	71,400	2%				Concho	100,000	13%		
		QEP	90,000	1%			Gulfport	65,500	2%				Cimarex	38,000	5%		
		WPX Energy	86,000	1%			Petroleum Dvlpment	45,000	1%			Sandridge	30,000	4%			
		Triangle	83,000	1%			Carrizo	2,900	0%			726,300	Granite Wash (Permian)	Chesapeake	200,000	28%	
		Enerplus	74,000	1%			3,112,000	Niobrara (Permian)	Anadarko		1,260,000			40%	Apache	120,000	17%
		Crescent Point	64,000	1%					Chesapeake		595,000			19%	Forest	94,000	13%
EOG Resources	535,000	10%	Encana	380,000	12%	Cimarex			91,700	13%							
Chesapeake	460,000	9%	Noble	360,000	12%	Devon			62,000	9%							
Apache	450,000	9%	Devon	300,000	10%	Newfield			44,000	6%							
BP	450,000	9%	Marathon	133,000	4%	SM Energy			32,000	4%							
Newfield	335,000	6%	Continental	59,000	2%	Range			27,600	4%							
BHP	332,000	6%	SM Energy	25,000	1%	Questar			25,900	4%							
Pioneer	310,000	6%	Quicksilver	N/A	-	Plains E&P			19,100	3%							
Marathon	305,000	6%	1,824,499	Wolfcamp (Permian)	Pioneer	400,000	22%	Penn Virginia	10,000	1%							
Shell	250,000	5%			Chesapeake	290,000	16%	677,000	Tuscaloosa (Permian)	Encana	355,000	52%					
ConocoPhillips	220,000	4%			Apache	272,000	15%			Devon	190,000	28%					
Murphy	220,000	4%			Approach	145,000	8%			Goodrich	132,000+	20%					
Anadarko	200,000	4%			El Paso	138,000	8%			610,000	Avalon (Permian)	Chesapeake	290,000	48%			
CNOOC	200,000	4%			Laredo	135,000	7%				Devon	200,000	33%				
SM Energy	150,000	3%			EOG	131,400	7%		EOG Resources		120,000	20%					
ExxonMobil	120,000	2%			Devon	94,000	5%		540,000		Brown Dense Lower Smackover	Southwestern	540,000	100%			
Forest Oil	118,000	2%			Whiting	87,599	5%			Cabot	N/A	-					
Hess	100,000	2%			Cimarex	80,000	4%			Devon	N/A	-					
Swift Energy	80,000	2%			Forest	51,500	3%			Chesapeake	500,000	100%					
Talisman	80,000	2%			Sandridge	N/A	-		169,100	Central Basin	Sandridge	169,100	100%				
Statoil	80,000	2%			Anadarko	N/A	-				160,000	Wolfberry (Permian)	Devon	160,000	100%		

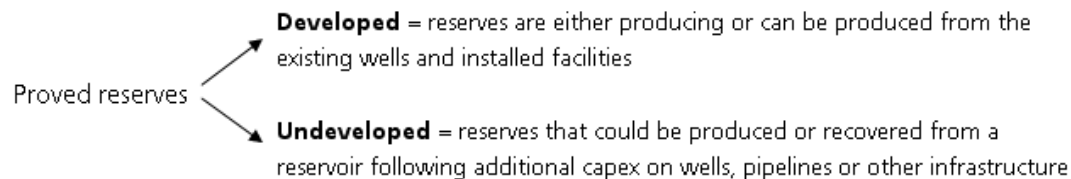
Reserves and resources (I)

Reserves are the most important assets of E&P companies since they are a direct indication of an enterprise's future cash generating potential. They are estimated remaining amounts of hydrocarbons that should be *economically recoverable* from known accumulations based on:

- Technical analysis of geotechnical, drilling and engineering data
- The use of technology (horizontal drilling, 3D seismic)
- Economic conditions (royalties, taxes, costs, commodity prices)

Estimated reserves are classified in 3 categories:

- **Proved reserves (P90 or 1P)**: commercial productivity has been demonstrated by actual production or flow tests, and there is a 90% probability that at least the proved reserves will be recovered (ie that actual reserves will exceed the estimated proved reserves). Proved reserves are further divided as follows:



- **Probable reserves (P50 or 2P)**: commercial productivity has not been demonstrated. There is a 50% probability that at least the proved + probable reserves will be recovered.
- **Possible reserves (P10 or 3P)**: commercial productivity has not been demonstrated. There is a 10% probability that at least proved + probable + possible reserves will be recovered.

We also talk about **reserve life** which is a company's reserves divided by its annual production, expressed in years.

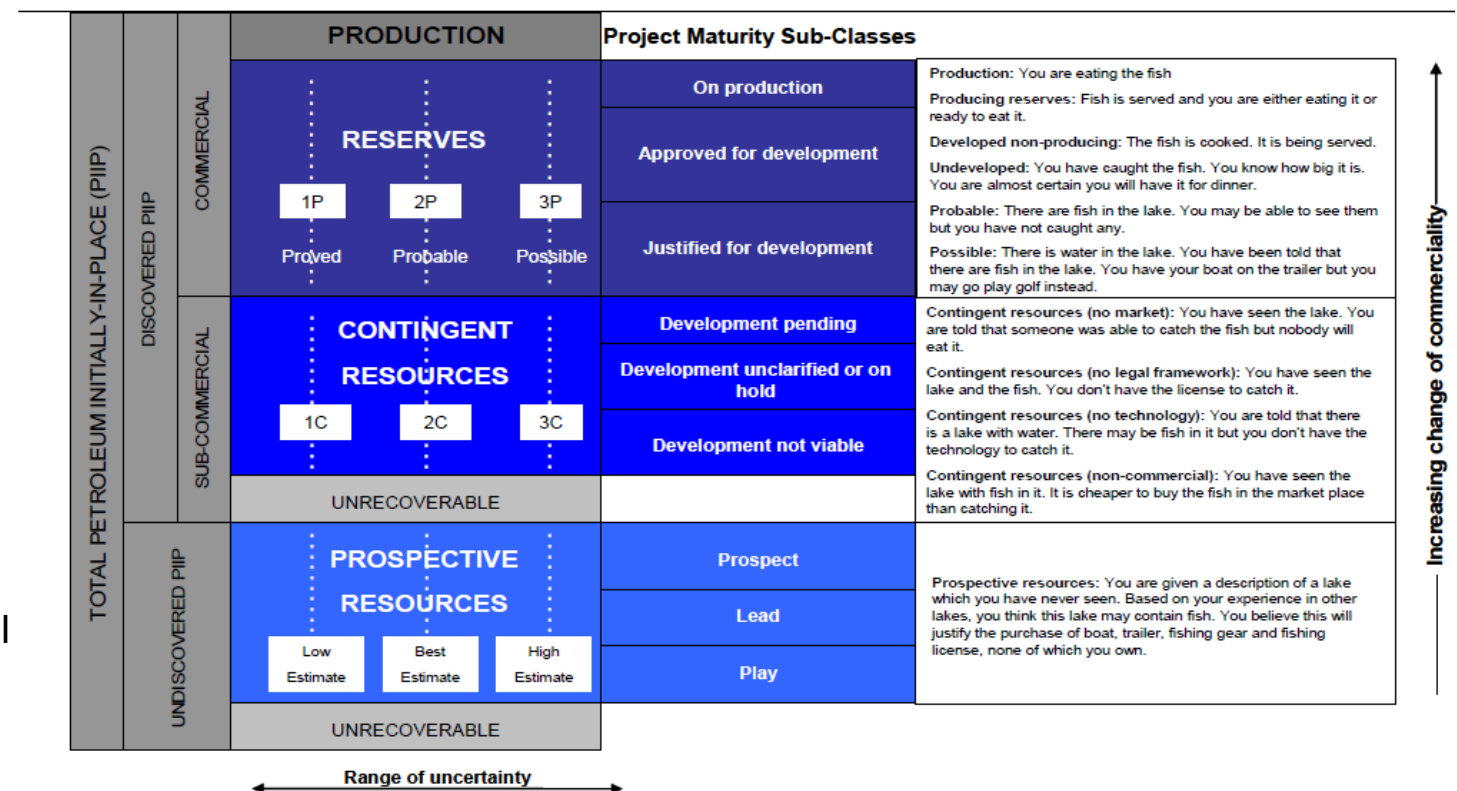
Reserves and resources (II)

Resources are sub-economic accumulations of hydrocarbons, which have been or are yet to be discovered. They are classified as follows:

Contingent resources: these are discovered accumulations which are not currently considered to be commercially recoverable. There may be no current viable market, commercial recovery may be dependent on the development of new technology or appraisal of the accumulation may still be at a very early stage. There is some ambiguity between the definitions of *undeveloped reserves* and *contingent resources*: the former are expected to be developed and placed on production within a reasonable time frame, while the latter have a high degree of uncertainty regarding the development time frame. Viable economic conditions (costs and prices) make the key distinction between reserves and contingent resources.

Prospective resources: hydrocarbons estimated to be potentially recoverable from undiscovered accumulations, which are typically estimated based on geophysical works such as seismic mapping and regional geological interpretation. No wells have been drilled into such accumulations.

Reserves and resource classification (and some nice analogies)



Distribution of reserves

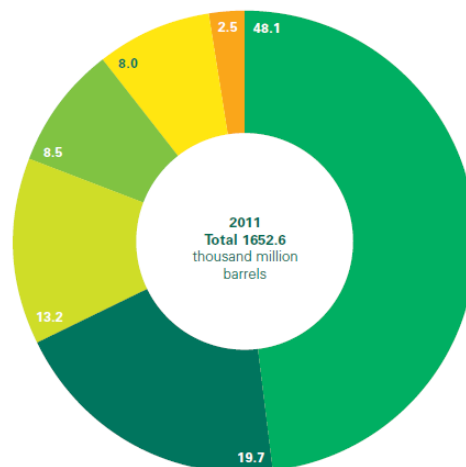
Oil reserves

Global proved oil reserves were estimated at 1.65bn barrels in 2011, sufficient to meet 54 years of global production. Proved reserves remain concentrated in OPEC, which controlled 72% of the world's oil reserves in 2011 (highest proportion since 1998). Asia Pacific is the continent with the smallest proved reserves (3% of global reserves), Venezuela holds the world's largest at 265m barrels (18%), followed by Saudi Arabia (16%) and Canada (11%). The long-term trend is that the world continues to add more reserves than it uses (so much for "running out").

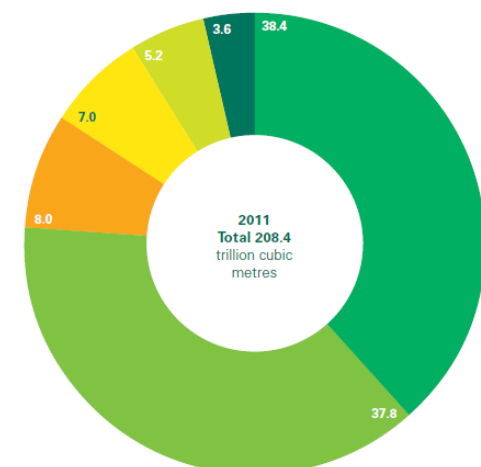
Gas reserves

Global proved gas reserves were estimated at 208 trillion m³ in 2011, sufficient to meet 64 years of production. The Middle East holds the largest reserves, followed closely by Europe and Eurasia. The country with the world's largest proved gas reserves is Russia (21% of total world) followed by Iran (16%) and Qatar.

Oil Proved Reserves



Gas Proved Reserves

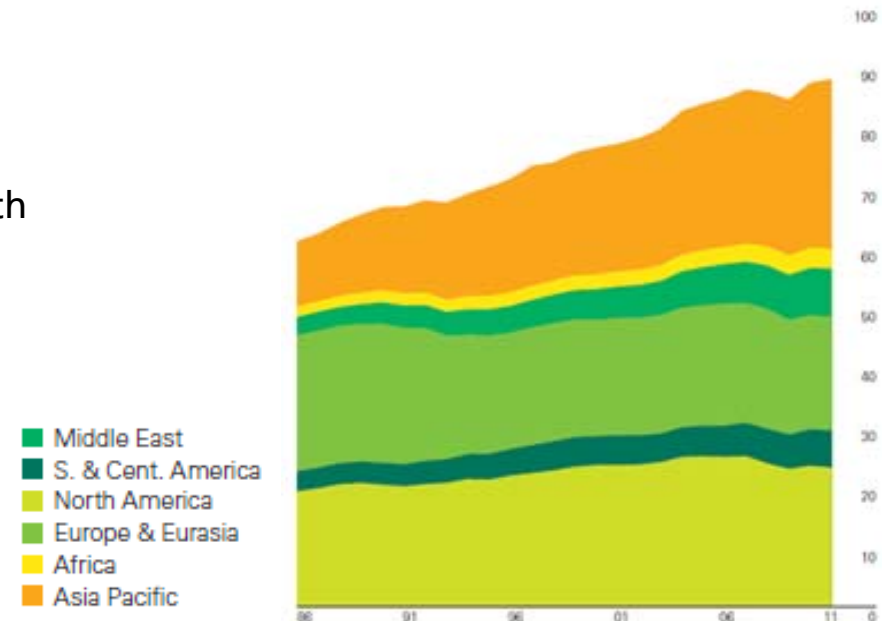


Source: BP Statistical Review of World Energy June 2012

Oil demand (I)

- In the past decades, the centres of oil demand growth have shifted (see top right graph). The biggest consuming region in 1986 was Europe and Eurasia (with 38% of global consumption), followed by North America (US, Canada, Mexico; 30%), the US being the main driver with 85% of the region's consumption. Strong economic growth in Asia, the Middle East and the former Soviet Union has contributed to non-OECD oil consumption increasing by 45% in the past decade, with Chinese demand more than doubling and Indian demand up more than 50%. In the OECD on the other hand, consumption has actually declined by almost 5%.
- In 2011 the biggest consuming region was Asia Pacific (32% of global consumption). This can largely be attributed to China's expanding population and strong income growth (with 34% of the region's total consumption). China has risen from 3% of global consumption in 1986 to 11% in 2011.
- Asia Pacific is now also the largest importing region, producing 8m b/d in 2011 but consuming 28m b/d.
- The International Energy Agency (IEA) projects oil demand to reach 95.7m b/d by 2017 vs 89.9m b/d in 2012.

Consumption by region (m b/d)



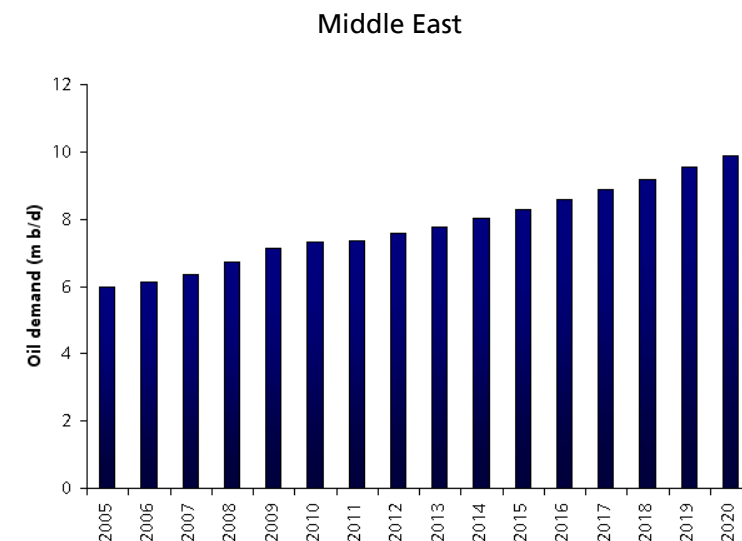
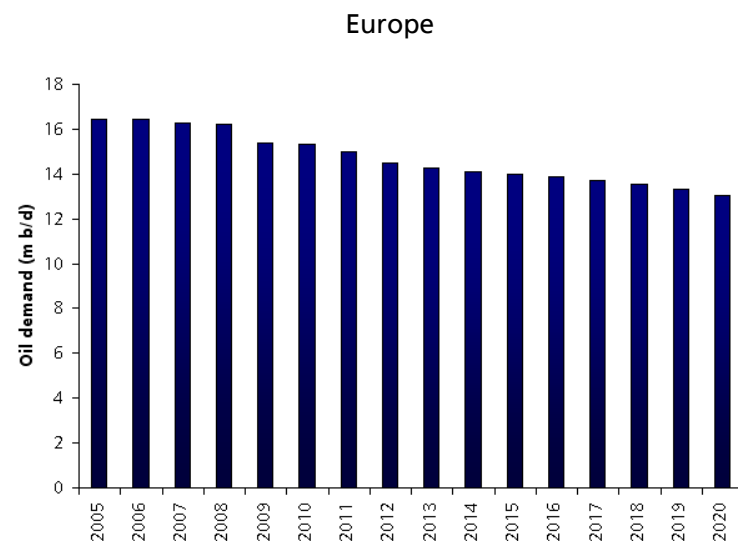
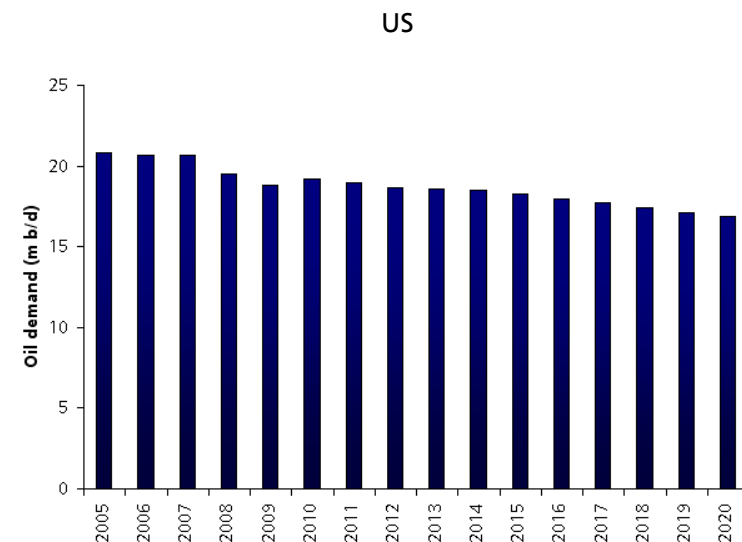
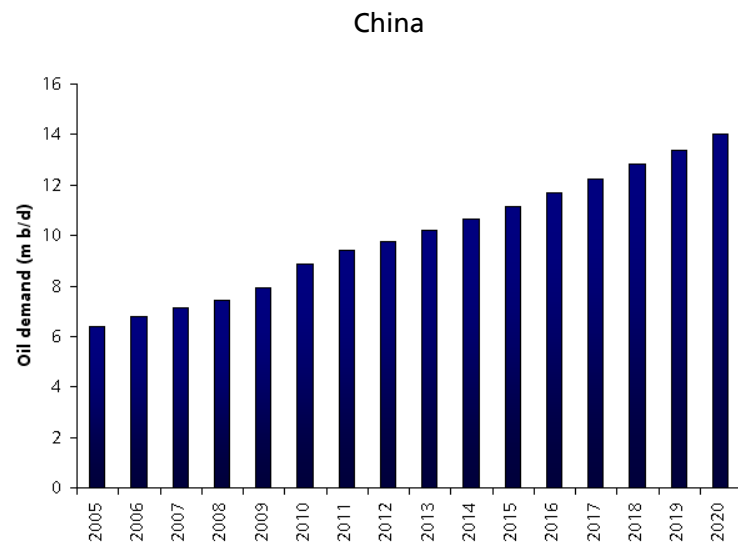
Source: BP Statistical Review of World Energy

UBS estimates for oil demand

(m b/d)	2012	2013	2014	2015	2016	2017	2018	2019	2020	CAGR 8yr
OECD Americas	23.8	23.7	23.7	23.6	23.4	23.2	23.0	22.7	22.5	-0.7%
OECD Europe	13.8	13.5	13.4	13.2	13.1	13.0	12.8	12.6	12.3	-1.4%
OECD Asia-Pacific	8.4	8.5	8.5	8.4	8.4	8.4	8.5	8.5	8.4	0.0%
Total OECD	46.0	45.7	45.7	45.3	44.9	44.6	44.2	43.8	43.3	-0.8%
FSU	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	0.0%
Other Europe	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	1.0%
China	9.7	10.2	10.6	11.1	11.7	12.2	12.8	13.4	14.0	4.6%
Other Asia	11.4	11.6	12.0	12.3	12.6	12.9	13.2	13.5	13.7	2.3%
Latin America	6.5	6.7	6.9	7.0	7.2	7.3	7.5	7.7	7.8	2.3%
Middle East	7.6	7.8	8.0	8.3	8.6	8.9	9.2	9.5	9.9	3.4%
Africa	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.1	2.5%
Total non-OECD	43.8	45.1	46.5	47.9	49.3	50.7	52.1	53.5	54.9	2.8%
Total demand	90.0	91.0	92.1	93.2	94.2	95.3	96.3	97.2	98.1	1.1%

Source: IEA, DoE, OPEC, national energy statistics agencies, Rtrs, Bbg

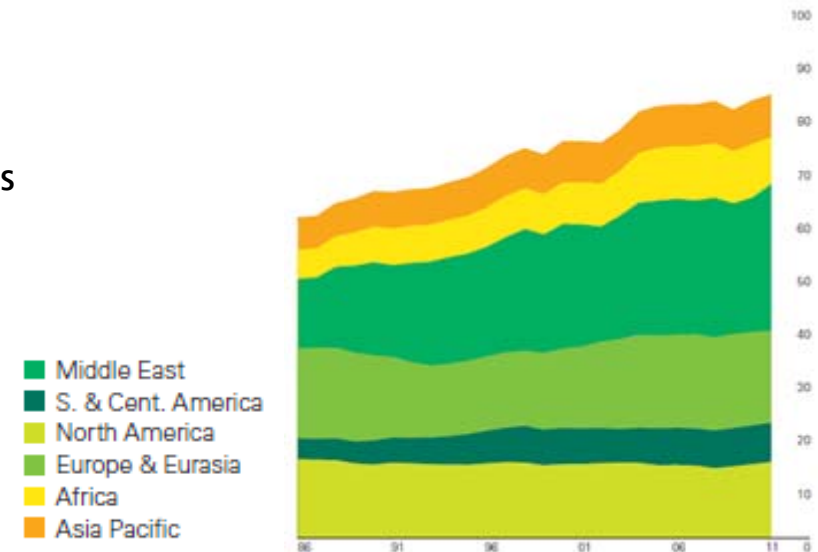
Oil demand (II)



Oil supply (I)

- In 1986 oil production was dominated by Europe and Eurasia (including Russia, Kazakhstan, Azerbaijan, Turkmenistan), which together accounted for 28% of global production. The biggest producing country was Russia (19% of total) followed by the US (16% of total). In 2011 however the Middle East was the biggest producing region (33% of total up from 22% in 1986), and the biggest producing country has become Saudi Arabia with 13% of global production, although Russia is a very close second.
- The largest exporting region is the Middle East, which consumes only 29% of what it produces.
- The IEA predicts robust supply growth of 9.3m b/d over the next 5 years with North America's oil sands and light-tight crude accounting for 40% of this gain (we think US tight oil production will grow from 1.5m b/d in 2012 to 4.5m b/d in 2020) and Iraq making up 20% (the main driver in OPEC supply growth).

Production by region (m b/d)



Source: BP Statistical Review of World Energy

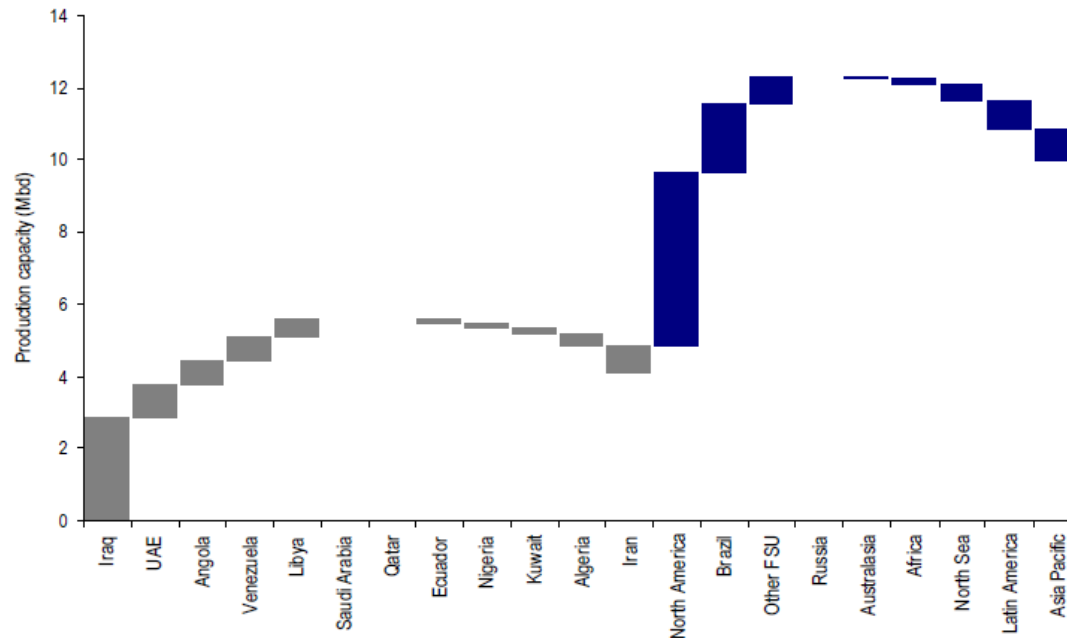
UBS estimates for oil supply

(m b/d)	2012	2013	2014	2015	2016	2017	2018	2019	2020	CAGR 0-20
OECD Americas	15.7	16.5	16.8	17.7	18.5	19.0	19.5	20.0	20.5	3.3%
OECD Europe	3.4	3.4	3.5	3.5	3.6	3.4	3.4	3.5	3.3	-0.4%
OECD Asia-Pacific	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.5	-1.0%
Total OECD	19.7	20.4	20.8	21.6	22.5	22.9	23.4	24.0	24.2	2.7%
FSU	13.7	13.7	13.9	14.2	14.3	14.4	14.4	14.3	14.4	0.6%
Other Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-7.1%
China	4.2	4.2	4.3	4.3	4.4	4.4	4.4	4.4	4.4	0.5%
Other Asia	3.5	3.5	3.5	3.5	3.4	3.1	2.9	2.7	2.5	-4.2%
Latin America	4.6	4.6	4.5	4.7	4.8	5.1	5.4	5.7	6.0	3.3%
Middle East	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.2	1.1	-3.3%
Africa	2.3	2.3	2.2	2.2	2.2	2.2	2.2	2.1	2.1	-1.1%
Total non-OECD	29.9	30.0	30.0	30.5	30.6	30.7	30.6	30.5	30.5	0.2%
Biofuels	1.9	2.0	2.2	2.3	2.3	2.4	2.2	2.3	2.3	2.1%
Processing Gain	2.1	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5	1.9%
Total non-OPEC	13.6	14.1	14.2	14.6	14.8	14.8	14.6	14.7	14.9	1.3%
OPEC non-crude	6.2	6.5	6.6	6.9	6.9	6.9	6.9	6.8	6.6	0.7%
OPEC crude production / call on OPEC crude	31.4	29.9	30.3	29.7	29.5	30.1	30.9	31.2	32.0	0.2%
Total supply	91.2	91.0	92.1	93.2	94.2	95.3	96.3	97.2	98.1	0.9%
OPEC effective spare capacity*	2.8	4.6	5.4	6.7	7.4	7.1	6.6	6.3	5.3	8.5%

* Excluding Iraq, Nigeria, Iran and Libya

Source: IEA, DoE, OPEC, national energy statistics agencies, Rtrs, Bbg

Oil supply (II)



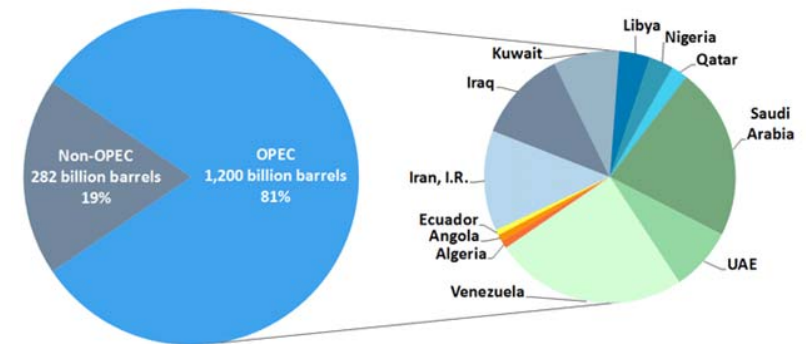
Source: UBS, IEA, Wood Mackenzie

- The chart above shows how we expect oil production capacity to change 2012-2020 (OPEC in grey, non OPEC in blue).
- We expect growth in global capacity to be driven by non-OPEC countries, mainly in North America and Brazil. Other regions will see a drop in capacity, with the biggest being in Asia Pacific and Latin America.
- Within OPEC, we expect to see highest growth in capacity in Iraq followed by UAE. The biggest drops in capacity are expected to come from Iran and Algeria.

OPEC (I)

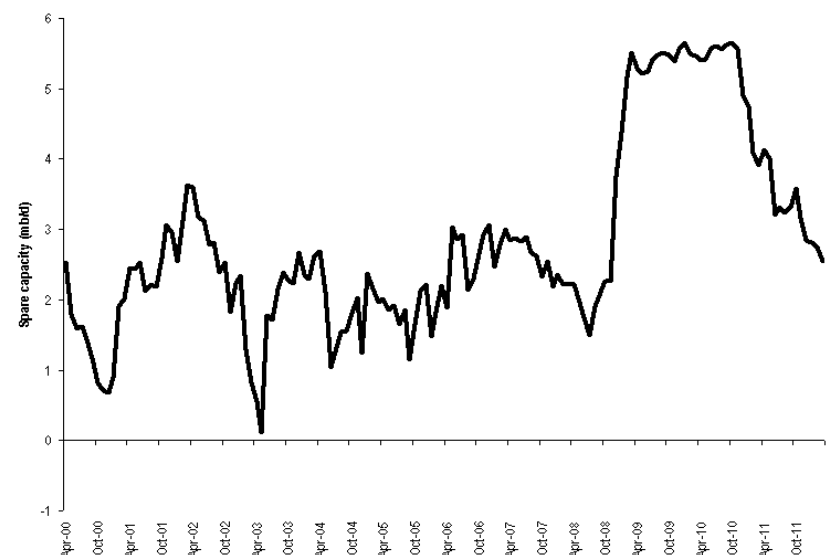
- The Organization of Petroleum Exporting Countries (OPEC) was founded in 1960 in response to rising global production. In 1973, after the Arab-Israeli war and the Arab oil embargo, 3 of the 4 Middle Eastern members nationalised their oil industries and the OPEC countries started co-operating as producers (first on prices, later on volumes). Quotas were introduced in 1982 however the group has not published individual country quotas since 2007 (target supplies and member allocations are still set however).
- Founding members: **Saudi Arabia, Kuwait, Iran, Iraq** and **Venezuela**. Subsequent member additions: **Qatar** (1961), **Libya** (1962), **UAE** (1967), **Algeria** (1969), **Nigeria** (1971), **Ecuador** (1973) and **Angola** (2009). Gabon and Indonesia also used to be members.
- Today OPEC produces just over 40% of the world's oil, up from 31% in 1986, but accounts for around 81% of the world's crude oil reserves.
- Most countries, with the exception of Iran (subject to sanctions) and Saudi Arabia (which has acted as "swing producer" for some years) are producing at effective capacity, hence only Saudi Arabia can act to dampen prices by increasing production. In 2009 for example, spare capacity rose dramatically due to OPEC cuts and the addition of production capacity in Saudi Arabia. It fell in 2011 on the curtailment of Libyan production and its replacement with Saudi spare capacity. It has been relatively stable since early 2012.

OPEC share of world crude oil reserves 2011



Source: OPEC

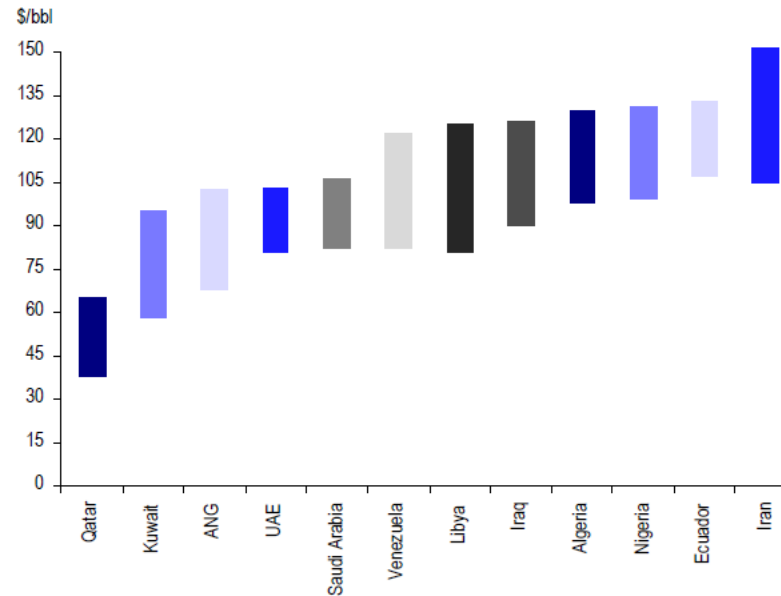
OPEC spare capacity 2000-2011



Source: IEA

OPEC (II)

Estimated oil price required to balance the national budget – the “fiscal break even price”



Source: IIF, UBS

- OPEC governments' budget spending tends to be funded primarily by hydrocarbon rent (the revenue above industry costs and returns). This is captured through royalties and hydrocarbon taxes. A fiscal break-even price is the oil price that helps balance the country's budget. Different countries have different price ranges, mainly because of differences in the structure and cost of the oil and gas industry as well as the degree non-hydrocarbon fiscal revenues contribute to balancing budgets.
- The chart above indicates why the OPEC nations got serious defending a \$60-70/bbl level in 2008-09. However, with the increased social expenditure following the Arab Spring we believe OPEC (and more importantly the GCC) would defend a higher price, probably around \$80-90/bbl, broadly consistent with our analysis of the price of the marginal barrel.

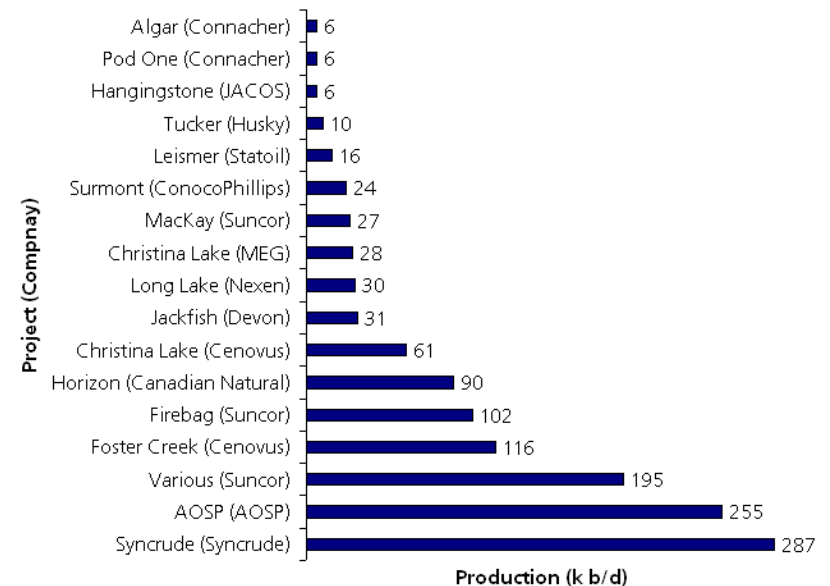
Oil sands (I)

- Oil sands, sometimes called tar sands, are a combination of water, clay, sand and heavy, viscous oil called **bitumen**. The oil sands have been producing since the 1960s, but it is only within the last decade that development has really taken off.
- The key difference between oil sands and conventional oil developments are characterized by: 1) higher up-front capital investments for oil sands, and 2) 30-40 years of steady production plateau for oil sands projects vs short plateaus followed by prolonged declines for conventional.
- Oil sand deposits are found in about 70 countries in the world, the largest reserves are in Canada. Canada had 173.6bn barrels of proven oil reserves at the beginning of 2012, controlling the 3rd largest oil reserves in the world (after Saudi Arabia and Venezuela), oil sands accounted for 98% of this. Most of them are located in 3 major deposits in Alberta: Athabasca, Cold Lake and Peace River.
- Canada's major players are Suncor and Syncrude:

Syncrude: is the world's largest oil sands mining operation and the largest single source producer in Canada. It is located in Athabasca and construction on the site began in 1973. In 2012 Syncrude produced 287k b/d of Syncrude Crude Oil (SCO) and had the capacity to supply 15% of Canada's petroleum requirements.

Suncor: formerly Great Canadian Oil Sands, pioneered the first commercial oil sands operation in 1967. In 2012 it produced 324k b/d of oil sands and has a 12% stake in the Syncrude joint venture.

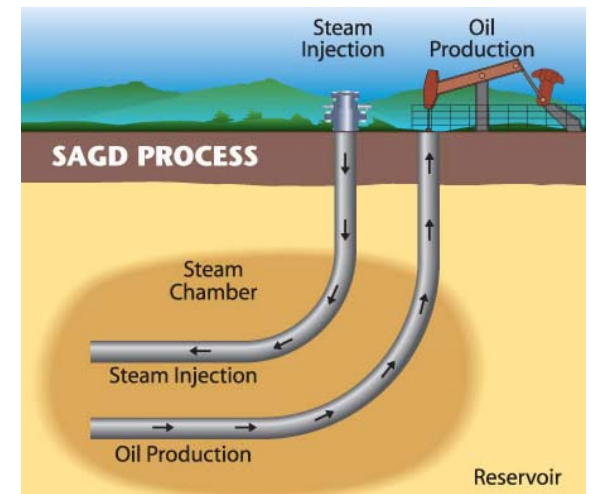
2012 Canadian oil sands production by project (total 1.29m b/d)



Source: UBS

Oil sands (II)

- The recovery process begins with the extraction of bitumen from oil sands, via mining or in-situ techniques (see below). Raw bitumen (API gravity 8-10°C) goes through an upgrading process, where carbon and impurities such as nitrogen and sulphur are removed, and it is then diluted with lighter hydrocarbons. This results in synthetic crude oil (SCO), with an API gravity of 31-33° (comparable to WTI). Roughly 2 tonnes of oil sands are needed to produce 1 barrel of upgraded synthetic crude. Main 2 recovery techniques:
- **Mining:** where possible, mining is the recovery method of choice due to its superior recovery rate of ~90%. It involves the simple scooping up of the oil sands and transportation to a separation vessel via a conveyor or pipeline, where the bitumen floats to the surface as a froth. Typically naphtha is added to the froth, which is then centrifuged to extract the bitumen that is ready for commercial sale or delivery to an upgrader (upgrading it to a higher quality product).
- **In-Situ:** 80% of oil sands are recovered through in-situ techniques because they are too deep for mining. **Steam Assisted Gravity Drainage (SAGD)** is the dominant in-situ technology, combining horizontal drilling with steam injection. 2 parallel wells are drilled, with the producer well positioned at the bottom of the reservoir, below the steam injection well. As steam is injected into the upper, the bitumen softens, allowing it to flow to the lower well. Bitumen and water are recovered through natural gas lift, gas lift or mechanical pumps. The technique is very natural gas intensive because of the need to generate steam. A second method, **cyclic steam stimulation**, pumps steam down a vertical well to soak/liquefy the bitumen, which is then pumped to the surface through the same well (this is repeated until the oil is removed).

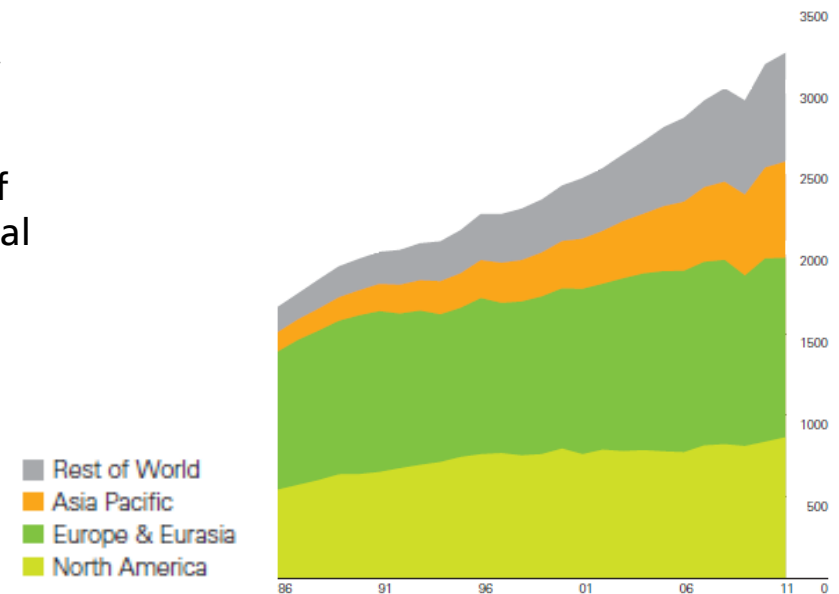


Source: Canadian Centre for Energy Information

Gas demand

- The biggest consuming region in 1986 was Europe and Eurasia, accounting for 51% of world gas consumption, largely attributed to Russia with 21% of world consumption, although the US was the world's single largest consumer at 33% of the world's gas consumption. In 2011 the biggest consuming region remained Europe and Eurasia with 34% of global consumption (Russia now accounting for 13% of global consumption). This was followed by North America (27% of global consumption) of which the US was 80%.
- Asia Pacific is the largest importing region, producing just 81% of what it consumed in 2011.
- Growth in demand in the coming years is expected to be driven by the non-OECD, mainly due to economic growth from industrialization, industrial policy, the power sector and the development of domestic resources. According to BP's Energy Outlook 2030, growth of gas consumption by 2030 will largely be attributed to Asia, with China driving 56% of the region's growth. The Middle East's share of global consumption is forecast to rise from 5% in 1990 and 12% in 2010 to 17% in 2030. Brazil, Russia, India and China (the BRICs) will contribute 40% to the non-OECD consumption increment (largely due to rising domestic production and imports). Within the OECD, growth in gas demand will largely be due to it displacing coal in power generation (natural gas emits half the CO₂ as coal in power generation).

Consumption by region (m b/d)

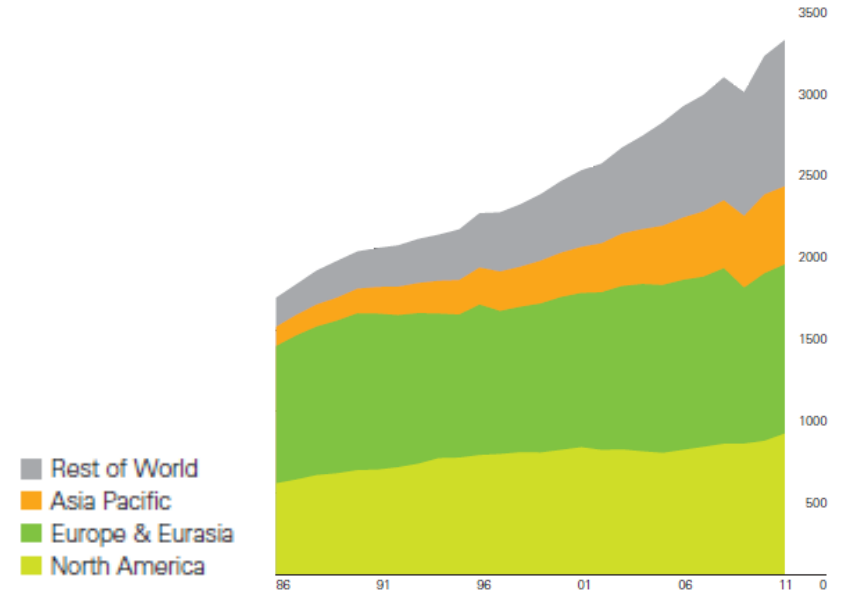


Source: BP Statistical Review of World Energy

Gas supply

- In 1986 gas production was dominated by Europe and Eurasia (including Russia, Kazakhstan, Azerbaijan, Turkmenistan) which accounted for half of the world's gas production. The two biggest producing countries were the US and Russia (each with 27% of global production). In 2011 Europe and Eurasia remained the biggest producing region (32%), with Russia accounting for 59% of the region's production. The biggest producing country in 2011 was the US (20% of global production), closely followed by Russia (19%).
- The largest exporting region on the other hand is Africa, which consumes only 54% of what it produces.
- BP's Energy Outlook 2030 projects gas production to grow at a slower pace 2010-30 (2.1% pa vs 2.4% pa 1990-2010) as the market base expands and demand-side efficiency measures take hold. Production growth is expected to be seen in every region except for Europe, where declining mature fields are likely to reverse the gains seen since 1975. The greatest production increments will be in Asia followed by the Middle East, with the latter's share in global production expected to grow from 15% in 2010 to 19% in 2030, while the US sees a decline from 26% in 2010 to 19% in 2030.

Production by Region (bcm)



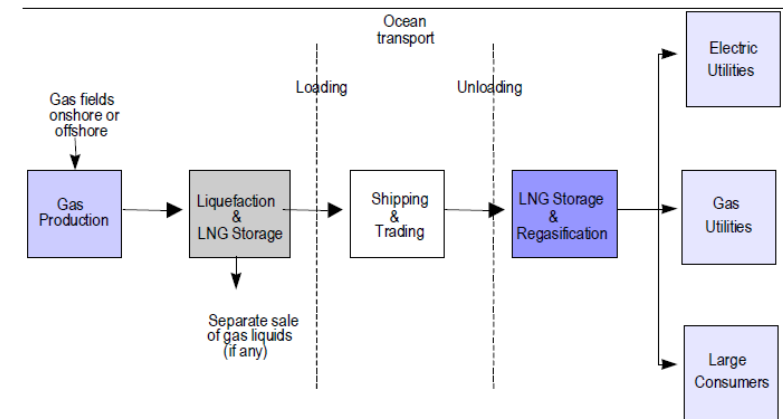
Source: BP Statistical Review of World Energy June 2012

LNG

- Many gas fields are located a long way away from consuming markets. Beyond certain limits (distance, terrain) pipeline transit becomes prohibitively expensive. LNG can be a viable alternative. Gas, a bulky commodity, can be cooled, which turns it into a liquid (“liquefied natural gas”) and reduces it to 1/600th of its volume – enabling it to be transported by ship to distant destinations.
- LNG accounts for 10% of natural gas consumption globally by volume.

- There are 4 main stages in processing natural gas into LNG. Firstly, impurities such as carbon dioxide and sulphur are removed, followed by the removal of water (would turn to ice during the liquefaction process). Heavier hydrocarbon molecules are then removed, leaving mainly methane and ethane. Lastly, the gas is progressively cooled until it reaches -160°C, when it becomes liquid at atmospheric pressure. The units involved in this process are known collectively as a **train**. The LNG is then stored in insulated tanks before being loaded into cryogenic tankers for shipment. Before use, it is regasified at a receiving terminal.

Typical LNG project structure



Source: UBS

- Largest **importers**:
Japan (33% of world LNG imports in 2011), South Korea (15%), UK (8%) and Spain (7%).
- Largest **exporters**:
Qatar (31% of world LNG exports in 2011), Malaysia (10%), Indonesia (9%) and Australia (8%, set to become 2nd largest exporter behind Qatar by 2016 with 6 projects currently under construction).

UBS LNG supply/demand model

Supply

- In the coming years LNG will represent a growing share of gas supply. According to BP's 2030 Energy Outlook, LNG will grow 4.5% pa to 2030, more than twice as fast as global gas production (2.1%).
- We think growth in the supply of LNG will be the highest in Asia Pacific and the lowest in the Middle East.

Demand

- We expect the region with the fastest growing demand to be Asia (boosted by China, where we forecast an increase of 252% by 2020). This is followed by Europe, while we expect a contraction in demand in North America.

bcm	2012	2013	2014	2015	2016	2017	2018	2019	2020
LNG supply									
Asia Pacific	117	118	126	141	162	193	221	261	295
Middle East	124	127	127	127	127	127	127	127	127
Atlantic Basin	84	95	104	104	109	115	123	142	160
Total supply	326	340	357	372	398	435	471	529	582
Growth	-1%	4%	5%	4%	7%	9%	8%	12%	10%
LNG demand									
Japan	111	114	115	114	116	118	119	120	121
South Korea	52	54	55	54	54	55	56	57	57
China	20	25	33	40	48	52	61	61	71
Taiwan	17	18	18	18	17	16	17	18	20
India	20	22	24	31	34	45	52	59	66
Other	10	24	27	29	32	33	37	43	51
Total Asia Pacific	230	257	273	287	300	319	341	358	386
Growth	12%	12%	6%	5%	5%	6%	7%	5%	8%
North America	8	7	7	7	7	7	7	7	7
Europe	63	54	60	65	70	79	83	94	94
Other	20	21	27	27	27	24	24	23	23
Total Atlantic Basin	91	82	93	98	104	110	115	123	124
Total demand	321	339	366	386	404	429	455	481	510
Growth	1%	6%	8%	5%	5%	6%	6%	6%	6%

Source: UBS estimates

LNG projects around the world (I)

Region	Country	Name	Status	Capacity (mt/a)	Start-Up	2012A	2013E	2014E	2015E	2016E	2017E	2018E	2019E	2020E
Atlantic Basin														
North Africa	Algeria	Skikda	Operational	5.2	1972	4	6.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
	Algeria	Arzew	Operational	15.6	1964	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
	Algeria	Gasà Touil	Under Construction	4.7	2013		2.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	Egypt	Damietta	Operational	5.1	2005	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
	Egypt	Egyptian LNG (ELNG) Tr1&2	Operational	7.2	2005	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
	Egypt	Damietta phase II	Proposed	5.1	?									
	Libya	Marsa el Brega	Operational	0.7	1971	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Libya	Marsa el Brega expansion	Proposed		?									
	Nigeria	NLNG	Operational	9.9	1999	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
	Nigeria	NLNGPlus	Operational	8.0	2006	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
West Africa	Nigeria	NLNGSix	Operational	4.1	2008	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Nigeria	NLNGSeven	FEED	8.0	?									
	Nigeria	Brass LNG	FEED	10.0	2018							2.0	6.0	10.0
	Nigeria	Olokola LNG	Proposed	12.6	?									
	Angola	Angola LNG (Soyo)	Under Construction	5.2	2012	1.0	3.0	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	Angola	Angola LNG 2	Proposed	5.2	2019								2.6	5.2
	Equatorial Guinea	EGLNG Tr 1	Operational	3.7	2007	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
	Equatorial Guinea	EGLNG Tr 2	Proposed	4.4	?									
	Norway	Snohvit	Operational	4.2	2007	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	Norway	Snohvit 2	Proposed	4.2	?									
North Atlantic	Russia	Yamal	FEED	16.5	2018							4	8	12
	Russia	Shtokman	FEED	7.5	?									
	Trinidad	Atlantic LNG Tr 1-3	Operational	9.6	1999	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
	Trinidad	Atlantic LNG Tr 4	Operational	5.2	2006	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
	Venezuela	Delta Caribe LNG	Proposed	9.4	?									
	United States	Sabine Pass 1-2	FEED	9.0	2016					4	8	8	8	8
	United States	Sabine Pass 3-4	Proposed	9.0	2018							2	4	6
	United States	Lake Charles	Proposed	7.8	?									
	United States	Freeport	Proposed	9.0	?									
	United States	Cameron LNG	Proposed	12.0	2019								2	4
US Atlantic	United States	Cove Point	Proposed	7.8	?									
Pacific Basin														
Asia Pacific	Indonesia	Arun	Operational (due to close in 2014)	9.0	1978	1.6	1.0	0.5						
	Indonesia	Bontang A-H	Operational	22.0	1977	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
	Indonesia	Bontang I	Proposed	2.5	?									
	Indonesia	Tanggul	Operational	7.6	2009	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
	Indonesia	Tanggul Tr 3	Proposed	3.8	2019								3.8	3.8
	Indonesia	Donggi Senoro	Under Construction	2.0	2015				1.3	1	2	2	2	2
	Indonesia	Abadi - FLNG	Proposed	2.5	2017						1.5	2.5	2.5	2.5
	Malaysia	MLNG (1)	Operational	7.4	1983	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
	Malaysia	MLNG Dua (2)	Operational	7.8	1995	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
	Malaysia	MLNG Tiga (3)	Operational	6.8	2003	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8	6.8
Russia Pacific	Russia	Sakhalin II	Operational	9.6	2009	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
	Russia	Sakhalin II	Proposed	4.8	?									
	Russia	Vladivostok LNG	Proposed	10.0	?									
	Australia	Northwest Shelf Tr 1-3	Operational	7.5	1989	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
	Australia	Northwest Shelf Tr 4	Operational	4.4	2004	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	Australia	Northwest Shelf Tr 5	Operational	4.4	2008	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	Australia	Darwin LNG (Bayu-Undan)	Operational	3.2	2006	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	Australia	Pluto	Operational	4.3	2012	3.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	Australia	Pluto Train 2	FEED	4.8	2018							2	4.3	4.3
	Australia	Pluto Train 3	Proposed	4.8	?									
Australasia	Australia	Browse	FEED	12.0	2020									3.0
	Australia	Greater Sunrise	Proposed	4.8	?									
	Australia	Gorgon	Under Construction	15.0	2014 / 2015			2.4	4.8	9.5	15.4	15.4	15.4	15.4

LNG projects around the world (II)

Region	Country	Name	Status	Capacity (mt/a)	Start-Up	2012A	2013E	2014E	2015E	2016E	2017E	2018E	2019E	2020E
Australasia	Australia	Gorgon 4	Proposed	5.0	2017							2.5	5.0	5.0
	Australia	Gorgon 5	Proposed	5.0	?									
	Australia	Ichthys	Under Construction	8.4	2017					0.8	5.3	8.4	8.4	8.4
	Australia	Wheatstone	Under Construction	8.9	2016						2.2	4.0	6.9	6.9
	Australia	Fisherman's Landing	Proposed	3.0	2017						1.0	1.4	3.0	3.0
	Australia	Gladstone LNG (CSG)	Under construction	7.8	2015				2.0	3.2	4.9	6.5	7.8	7.8
	Australia	Queensland Curtis LNG (csg)	Under Construction	8.5	2014			2.5	5.7	8.5	8.5	8.5	8.5	8.5
	Australia	Australia Pacific LNG	Under Construction	9.0	2016					3.0	4.5	6.0	9.0	9.0
	Australia	Australia Pacific LNG	Proposed	9.0	?									
	Australia	Shell Arrow LNG	Proposed	8.0	2018							2.0	4.0	4.0
	Australia	Shell Arrow LNG	Proposed	8.0	2019								2.0	4.0
	Australia	Prelude FLNG	Under construction	3.5	2016					2.0	4.0	4.0	4.0	4.0
	Australia	Scarborough/Thebe	Proposed	6.0	2020									3.0
	Australia	Bonaparte FLNG	Proposed	2.0	?									
US Pacific	PNG	PNG LNG (Juha, Hides)	Under Construction	6.6	2014			1.8	5.1	6.6	6.6	6.6	6.6	6.6
	PNG	PNG LNG (Juha, Hides)	Proposed	3.3	2018							1	3	3.3
	PNG	Elk/Antelope	Proposed	10.8	?									
	Brunei	Brunei LNG - Lumut	Operational	7.2	1972	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
	Brunei	Brunei LNG - Lumut	Proposed	4.0	?									
	United States	Kenai	Operational (closing down)	1.5	1969									
	United States	Alaska LNG	Proposed	10.0	2020									2
	Canada	Kitimat	FEED	5.0	2017						2.0	5.0	5.0	5.0
	Canada	LNG Canada	Proposed	12.0	2020									5.0
	Canada	LNG Canada Expansion	Proposed	12.0	?									
LatAm Pacific	Canada	Douglas Channel LNG	Proposed	1.8	2017						0.9	1.8	1.8	1.8
	Peru	Camisea	Operational	4.5	2010	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
	Bolivia	Pacific LNG	Proposed	7.0	?									
East Africa														
Middle East	Mozambique	Mozambique LNG Ph 1	FEED	12.0	2018							1.5	8.0	12.0
	Mozambique	Mozambique LNG Ph 2	Proposed	12.0	2022									
	Mozambique	Mozambique LNG Ph 3	Proposed	12.0	2024									
	Tanzania	Tanzania LNG	Proposed	5.5	2019								2.8	5.5
	Qatar	QatarGas I (Tr 1-3)	Operational	9.7	1996	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
	Qatar	QatarGas II (Tr 4)	Operational	7.8	2008	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Qatar	QatarGas II (Tr 5)	Operational	7.8	2009	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Qatar	QatarGas III (Tr 6)	Operational	7.8	2010	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Qatar	QatarGas IV (Tr 7)	Operational	7.8	2011	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Qatar	RasGas I (Tr 1-2)	Operational	6.6	1999	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
	Qatar	RasGas II (Tr 3-4)	Operational	9.4	2004	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
	Qatar	RasGas II (Tr 5)	Operational	4.7	2007	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
	Qatar	RL-3 (Tr 6)	Operational	7.8	2009	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Qatar	RL-3 (Tr 7)	Operational	7.8	2010	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Oman	Oman LNG	Operational	7.1	2000	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4
	Oman	Qalhat	Operational	3.7	2006	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
	UAE	Das Island I	Operational	2.5	1977	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
	UAE	Das Island II	Operational	3.1	1994	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
	Iran	Pars LNG	Proposed	10.0	?									
	Iran	NIOC LNG	Proposed	8.0	?									
	Iran	Iran LNG	Proposed	8.0	?									
	Iran	Persian LNG	Proposed	10.0	?									
	Yemen	Yemen LNG T1	Operational	?	?									
	Yemen	Yemen LNG T2	Operational	6.7	2009	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7
	Israel	Leviathan LNG T1	Proposed	5.5	2019								2.5	5.5
	Israel	Leviathan LNG T2	Proposed	5.5	?									

Global Volume 264.9 271.8 284.9 296.6 316.4 344.5 374.8 424.6 464.2

Source: UBS estimates

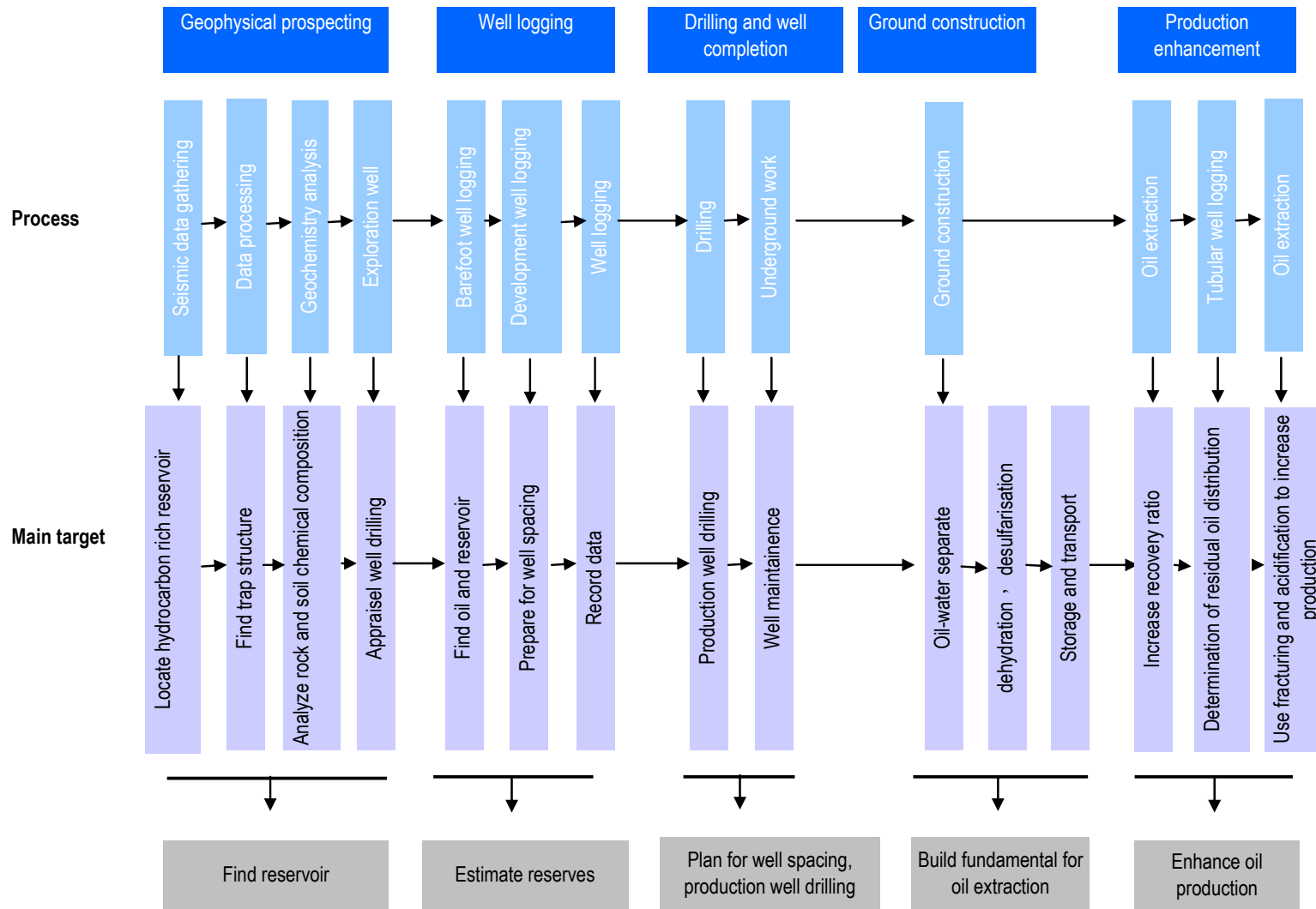
Shale gas/coal bed methane/tight gas

- Gas can be described as 'conventional', ie recovered by traditional methods, or 'unconventional'. Unconventional sources of gas are found in less permeable rocks (coal, sandstone and shale). Main types:
 - Shale gas:** shale gas is natural gas trapped within shale formations (which is a fine-grained sedimentary rock made of mud and clay minerals). Advances in technologies in well stimulation and horizontal drilling, together with higher prices has enabled the industry to 'unlock' several shale plays in the US.
 - Coal bed methane:** is trapped in coal seams, often with water pressure holding it in place. Typically, coalbed methane wells go through a period of de-watering before the gas begins to flow. The largest field in the world is the San Juan Basin in New Mexico.
 - Tight sands:** these formations are characterized by low permeability and porosity, requiring artificial stimulation (usually fracking) to enable high enough production rates to make field economics acceptable. South Texas, for example, is characterised as a tight sand.
- The techniques used to extract unconventional gas are:
 - Hydraulic fracturing** (aka 'fracking') – involves drilling a well and injecting large volumes of water underground under high pressure to create cracks in the rock. This frees the trapped gas and allows it to flow into the well bore.
 - Horizontal drilling** – allows the well to penetrate more rock in the gas bearing strata, meaning there is an increased chance of gas being able to flow into the well.
- In the US, tight gas has been produced for over 4 decades and coal bed methane for over 2. Production of shale gas began much more recently however, increasing rapidly from 2005 onwards. Technological advances over the last 2 decades (especially within fracking) and soaring gas prices in early 2000's prompted drillers in the US to pursue development of unconventional gas types, leading to rapid growth in shale gas production. This is referred to as the **shale gas revolution**.
- Shale gas is also present elsewhere in the world, in particular in China, Argentina, Mexico, Australia and parts of Europe, but commercial production is currently only taking place in North America.

Largest US gas shale plays by company interest

Total acreage	Gas shale play	Company	Acreage	Share of play	Total acreage	Gas shale play	Company	Acreage	Share of play	Total acreage	Gas shale play	Company	Acreage	Share of play						
9,985,400	Marcellus	Chesapeake	1,780,000	18%			EOG Resources	190,000	5%	1,586,140	Horn River	ExxonMobil	310,000	20%						
		Range Resources	1,080,000	11%			Forest Oil	169,000	5%			Encana	256,000	16%						
		Seneca Resources	745,000	7%			Devon Energy	157,000	4%			Apache	210,000	13%						
		Chevron	700,000	7%			Plains E&P	107,800	3%			Devon Energy	174,000	11%						
		ExxonMobil	700,000	7%			Goodrich	85,000	2%			EOG Resources	157,500	10%						
		Statoil	682,000	7%			Comstock	74,000	2%			Quicksilver	130,000	8%						
		Shell	650,000	7%			Penn Virginia	59,000	2%			ConocoPhillips	100,000	6%						
		EQT Corporation	530,000	5%			EXCO Resources	53,500	2%			Imperial	96,000	6%						
		CONSOL	361,000	4%			Questar Corp	48,000	1%			Nexen	88,000	6%						
		Anadarko	330,000	3%			GMX Resources	42,400	1%			Petrobank	54,400	3%						
		Noble Energy	314,000	3%			El Paso	40,000	1%			Crew Energy	10,240	1%						
		Ultra Petroleum	258,000	3%			Cabot Oil & Gas	33,000	1%			1,164,000	New Albany	Aurora Oil & Gas	450,000	39%				
		Talisman	223,000	2%			SM Energy	32,000	1%					CNX Gas	338,000	29%				
		EOG Resources	210,000	2%			Continental	26,000	1%					Noble Energy	179,000	15%				
		Cabot Oil & Gas	200,000	2%			Marathon Oil	20,000	1%					Atlas Energy	123,000	11%				
		Southwestern	186,900	2%			Noble Energy	20,000	1%					Continental	46,000	4%				
		EXCO Resources	140,200	1%			Carrizo	7,000	0%					Carrizo	28,000	2%				
		Chief Oil & Gas	125,000	1%			2,443,000	Cana /Anadarko Woodford	ConocoPhillips					1,700,000	70%	1,116,242	California	Occidental	1,100,000	99%
		Mitsui	122,000	1%					Devon Energy					243,000	10%			Royale Energy	16,242	1%
		Enerplus	110,000	1%					Continental					250,000	10%	923,386	Oklahoma Woodford	Continental	252,286	27%
		Carrizo	109,800	1%					Marathon Oil					110,000	5%			ExxonMobil	210,000	23%
		WPX Energy	99,300	1%					Climarex Energy					98,000	4%			Newfield	166,500	18%
		Hess Corp	89,000	1%					Range Resources					42,000	2%			BP	90,000	10%
		Marathon Oil	82,000	1%				2,081,884	Fayetteville			Southwestern	915,884	44%	Penn Virginia			58,200	6%	
		Rex Energy	69,200	1%								BHP Billiton	465,000	22%	Devon Energy			43,000	5%	
		Penn Virginia	52,000	1%								ExxonMobil	380,000	18%	SM Energy			34,000	4%	
		Newfield	37,000	0%								Petrohawk	142,000	7%	PetroQuest			32,000	3%	
3,776,000	Huron	Equitable	2,700,000	72%	BP	135,000				6%	Questar Corp	29,000	3%							
		Cabot Oil & Gas	412,000	11%	Carrizo	26,000				1%	Range Resources	8,400	1%							
		CNX Gas	300,000	8%	PetroQuest	18,000	1%			807,000	West Texas Barnett /Wolfcamp	Quicksilver	375,000	46%						
		Range Resources	150,000	4%	1,789,000	Ft. Worth Barnett	Devon Energy	622,000	35%			Encana	287,000	36%						
		EXCO Resources	128,000	3%			ExxonMobil	265,000	15%			Continental	67,000	8%						
		Penn Virginia	86,000	2%			Chesapeake	220,000	12%			Carrizo	58,000	7%						
3,510,700	Haynesville	Chesapeake	495,000	14%			EOG Resources	185,000	10%			Range Resources	20,000	2%						
		Encana	429,000	12%			Quicksilver	155,000	9%	410,000	Antrim	Atlas Energy	270,000	66%						
		Petrohawk	368,000	10%			ConocoPhillips	110,000	6%			Aurora Oil & Gas	140,000	34%						
		BP	340,000	10%			Encana	76,000	4%			134,000	Pierre Atoka	Pioneer	134,000	100%				
		Royal Dutch Shell	300,000	9%			Pioneer	70,000	4%	Continental	28,000			100%						
		ExxonMobil	215,000	6%			Carrizo	52,000	3%											
		Anadarko	200,000	6%			Williams Company	34,000	2%											

Exploration and development



Source: UBS

The exploration process (I)

Exploration

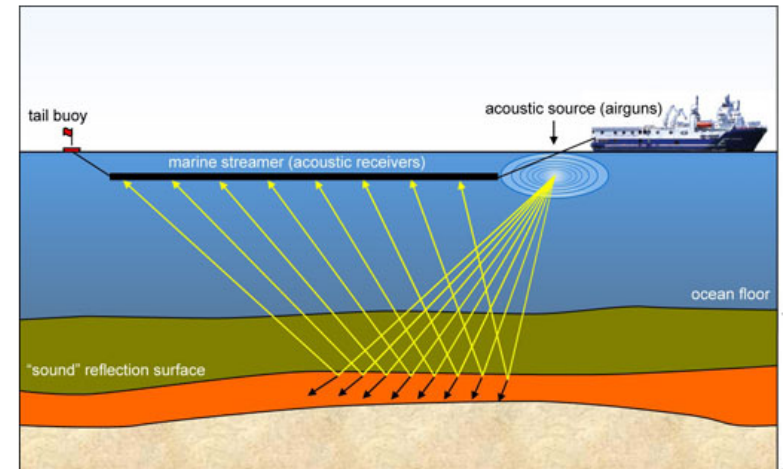
- The search for oil and gas is now much more scientific than it was in the early days of the industry but it is still not possible to say conclusively that oil exists in a specific area, much less that it exists in commercially viable quantities. Very approximately, around 1 in 8 wells drilled now finds oil, although this ratio will vary enormously depending on the region and its history.
- Firstly, once a company has decided that a region looks attractive, it must secure the legal rights to explore and produce from the acreage, and, in some cases (see slide 59) negotiate the fiscal framework. This generally involves bidding in licence rounds. Once secured, the successful party often '**farms-out**' acreage (ie brings in additional equity partners) to reduce risk/exposure.
- The next step in the exploration process is to assess the prospectivity by identifying geological conditions where hydrocarbons are likely to exist. This is often done using aerial or satellite photography. Prospective geological structures are identified through geophysical methods primarily using relatively inexpensive **gravity** or **magnetic surveys**. Detailed information over a smaller area of interest is then obtained through more expensive **seismic surveys** (see next slide).
- Once a successful survey has been carried out, the next stage is the drilling of an **exploration well**. Before seismic surveys were introduced, drilling was the main exploratory tool, now it is the second step (see slide 40 for details on the process).

Appraisal

- Once the discovery has been made the next step is to determine commerciality ie is it economic to develop. For example, the discovery might be large but the reservoir rock's porosity and permeability can limit flow rates and recovery factors, preventing the find from being commercial. Appraising the discovery involves collecting data from cores (pipe-shaped tools) and logs (electrical tools run down a well on a steel cable) from inside the well to determine the commerciality of it. Assuming the results are favourable, **appraisal wells** are drilled to delineate the size of the reservoir and the most effective means of developing the field.

The exploration process (II)

- Seismic data is used to probe below the subsurface. It is used by oil companies to decide on conducting exploration drilling and is also carried out on existing producing assets to detect the movement of hydrocarbons.
- Sound waves are emitted in a prospect area (onshore or offshore) and geophones are used to detect the waves that bounce back from the rock formations. Offshore, a ship tows a submerged water gun that emits sound waves (see right). Through complex computer data analysis, these signals are interpreted to create an image of formations and possible deposits of hydrocarbons. On the basis of this analysis, oil companies can make decisions on conducting exploratory drilling activity.
- The resultant seismic sections are 2D vertical representations of the underground structure. More expensive advances include **3D seismic** (includes a horizontal section) and **4D seismic** (includes a time element). Seismic surveys taken over a period of time enable the geophysicist to monitor the migration of oil in producing assets.
- Demand for seismic is generally driven by exploration budgets, but tends to be stop-start with a high degree of volatility. Seismic companies compete on technology, price and on locating vessels where exploration demand is likely to be highest.
- Companies conduct surveys either for a single client (an individual oil company or consortium) or for their own account, referred to as **multi-client surveys**. The latter are typically pre-sold to one or more oil companies, which will cover a substantial proportion of the costs of the survey. Subsequent sales are referred to as **late-sales** or **after-sales** (are very high margin as no cost is associated with them).



Source: BP

The exploration process (III)

Oil and gas wells are drilled using a **drilling rig**. The market is divided into 3 broad groups: onshore, shallow water and deep water. Transocean is the world's largest deep water operator while the shallow water and land business is fragmented. Prices are provided on a **day-rate** basis, where the oil company pays the drilling contractor a certain sum per day until the well is completed or abandoned. The cost to oil companies of drilling a well are however significantly higher, where consumables include mud, drill bits, other drill string components, casing and cement. A rig is '**stacked**' when it is not in use ('**cold stacked**' if it is shut down).

3 major categories of offshore rigs:

- **Jack-up:** for shallow water up to 300ft. It is bottom-supported, typically with 3-4 legs that are lowered in order to penetrate the seabed (the limit on water depth is due to the sheer scale of legs required). Typical operating cost: \$30-50k/d.
- **Semisubmersible (semi):** floating unit up to 12,000ft. These are usually classified by age and capability. The key advantage it offers over a drillship is greater stability to water movement (it can continue to drill with a wave height <30m), however it suffers from lower carrying capacity and generally lower transit speed. Typical operating cost: \$50-130k/d.
- **Drillship:** ship equipped as drilling platform, often for deep water. They are well-suited to drill in remote areas because of their mobility and high load capacity, however, they tend to be less able to deal with harsh environments. Typical operating cost: \$100-130k/d.

In 2012, there were 480 jack-up rigs, 217 semis and 84 drillships in the world.

Jack-up rig



Source: Maersk

Semisubmersible



Source: Husky

Drillship

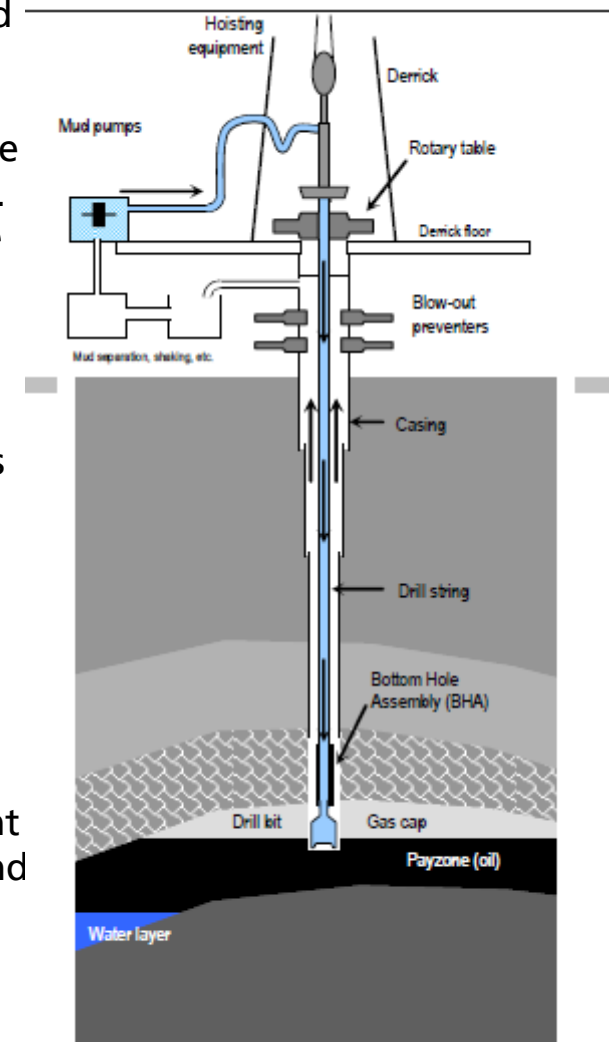


Source: EPCEngineer

The exploration process (IV)

- Initial drilling is known as **spudding** and the well is drilled with rotating **drill bits**, which cut and crush the rock as they descend and are lubricated using **drilling mud** (both cools the drill bit and controls the pressure in the well bore). Once each section of the well is complete, drilling is suspended and **casing** (steel pipe) is run down the hole and secured to the rock with **cement** pumped into the gap between the casing and the rock. The **bottom hole assembly** holds the tools and measuring devices while the **blow-out preventer** (most important safety mechanism) controls fluid pressure.
- When the drill bit encounters the reservoir, the pressure in the reservoir forces the oil upwards into the borehole. The speed at which this happens is known as the **flow rate**. Flow rates are measured in barrels of oil per day (b/d) and in commercial fields typically vary between a few hundred and several thousand barrels per day.
- Wells are becoming increasingly sophisticated, and they are no longer only vertical. **Horizontal** and **directional** wells are used to produce reservoirs faster and from multiple pay-zones. Another area of sophistication is the 'intelligent well'. Wells are completed with equipment at different levels of the borehole that allow the measurement of fluid and gas content, as well as the remote control to enable shutting production from certain areas of the borehole (used when a certain zone produces excessive water).

Offshore floating drilling unit

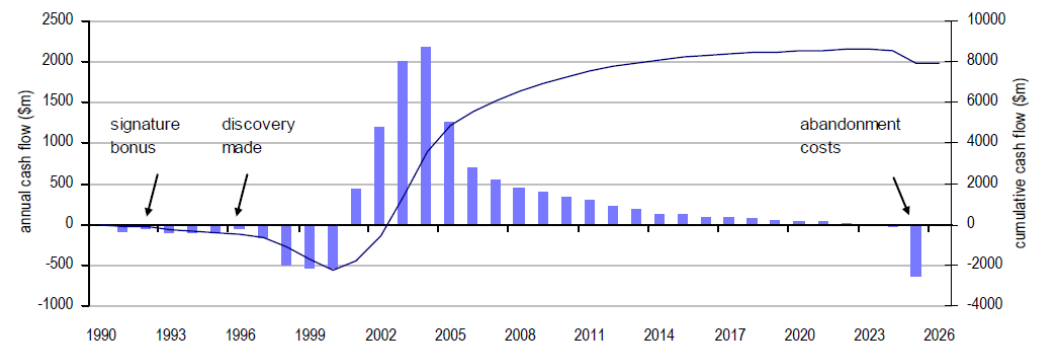


Source: UBS

The development process (I)

- The **Final Investment Decision (FID)** follows the appraisal of the discovery. This is the 'go-live' decision where all shareholders in the project agree to go ahead (based on current engineering plan and associated cost estimates).
- The discovery can then be developed. **Development wells** are drilled to actually produce hydrocarbons and wellhead infrastructure is installed to manage the field, making this the most expensive phase of the field life cycle. There are essentially 3 stages in a field's productive life: ramp-up, plateau and decline. Large upstream projects can take up to 50 years to work through the funnel. Operators frequently have to wait well over a decade to generate any return on their considerable investment (see above).
- Field production declines as the reservoir pressure decreases. To extend the field plateau and slow the subsequent decline, companies may use 'Enhanced Oil Recovery' techniques (see slide 13), the simplest being water injection through injection wells (the water sweeps some remaining oil through the reservoir toward producing wells). Gas can also be injected to increase reservoir pressure.
- When a field is abandoned (or decommissioned), the surface infrastructure is removed and the wells are 'plugged and abandoned' (typically involves filling the hole with cement to prevent salt water from the well polluting fresh ground water).

Field life cycle example: Girassol field in Angola



Source: WoodMac, UBS

The development process (II)

Once a well has been determined to have enough recoverable reserves and a sufficient flow rate, the operator decides on the type of completion most suitable for the well (cased or open hole) and the completion equipment to install.

- **Cased hole:** another string of casing will be cemented into the well bore. A contractor will then perforate and install the completion equipment, including **packers** (to seal the perforated area from the rest of the wellbore), **flow control** equipment and often **sand control** equipment.
- **Open hole:** the natural rock is left exposed and production equipment will be installed below the last string of casing to help control the flow of oil, gas and sand into the wellbore. Usually the operator will also have a string of **production tubing** installed inside the casing and connected to the wellhead and tree, which becomes the conduit for reservoir fluids out of the well.

Drilling Services: consist of directional drilling, wireline and drill bits.

- **Directional drilling:** used when a wellbore needs to be drilled at a certain angle to hit a target, or in formations where it is difficult to keep a wellbore vertical. **Measurement-while-drilling** (MWD) is a general term for equipment that gives continuous feedback on the position and orientation of the drill bit, enabling operators to accurately run directional drilling. **Logging-while-drilling** (LWD), on the other hand, records and transmits data in real time on the petrophysical properties of the formation. Used in combination with seismic data and well logs, LWD allows for effectively placing the bit in the optimal location in the reservoir.
- **Wireline:** involves using wire to lower tools down the well bore. Open-hole: used for formation evaluation to measure porosity, density, resistivity and permeability of the formation. Cased-hole: used for cement and casing evaluation.
- **Drill bits:** there are generally 2 types. **Roller cone bits** have 3 rotating cones with protruding teeth. **Fixed cutter bits**, on the other hand, have synthetic diamond coated inserts, and are therefore more expensive, with a longer wear life and an increasing range of drilling applications.

The development process (III)

- **Pressure pumping:** fracture stimulation involves injecting a fluid (water, gel or foam) mixed with a proppant (sand, glass beads or particulates) into the wellbore under high pressure. This is meant to cause the formation rock to fail and fracture, allowing more hydrocarbons to flow through the cracks. It is most widely used in unconventional resource plays.
- **Cementing:** involves pumping cement down the wellbore to seal the open hole formation to the casing.
- **Fluid services:** include both drilling and completion fluids (muds) used as a coolant, lubricator, wellbore stabilizer, pressure regulator, and transmitter of cuttings to the surface. Offshore activity uses a lot more fluids than wells drilled on land, due to their depth and complexity.
- **Completion services:** these are associated with bringing production online after drilling, cementing and stimulation have been complete. This includes **packers** (lowered into the well and expanded to isolate one part of the wellbore from another), **line hangers** (used to 'hang' segments of pipe in the wellbore from higher, wider pipe) and **slickline** (term the industry uses for the narrow cable used to support certain equipment being run into the well).
- **Artificial lift:** the cheapest form of artificial lift is the traditional nodding donkey, formally a 'reciprocating rod lift pump' (see right). The type of lift to be used is determined by the depth of the well, fluid volumes to be pumped, pressure and whether sand and corrosive fluids are present. Because they are primarily used in mature wells to increase production, they are less correlated to the rig count than most oilfield service markets.

Nodding donkey



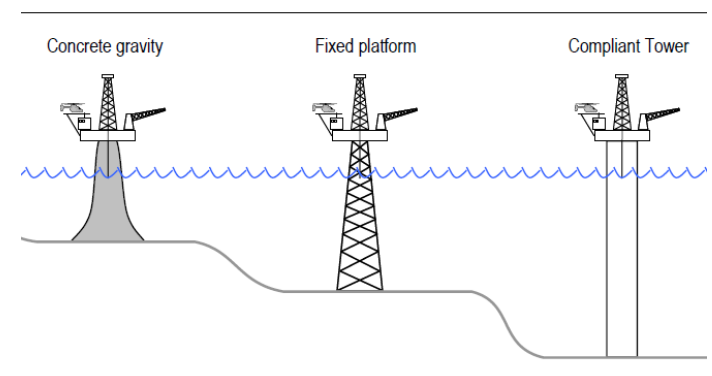
Source: RSC

The development process (IV)

Offshore production usually requires a surface facility to manage and power the oil wells and sometimes to continue to drill on the fields. A hub-and-spoke concept is often used nowadays where a large central hub is designed to act as a gathering station for pipeline export. FPSOs (Floating Production, Storage and Offloading) however are used where a pipeline would not be economic. In general platforms are designed by oil service but built by local shipyards. Stability is the challenge with floating units while fixed platforms are limited by water depth.

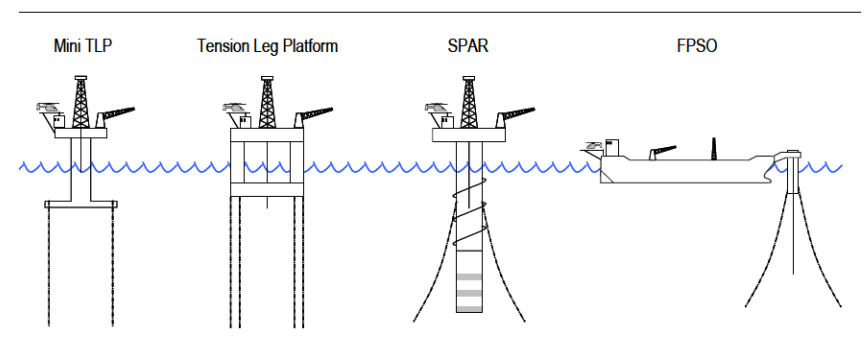
- **Fixed platforms:** consists of a **jacket** with a **deck** placed on top, providing space for crew quarters, a drilling rig and production facilities. The main 3 varieties (see right) are the **concrete gravity** (primarily used in the North Sea), the **fixed platform** (a steel structure used worldwide) and the **compliant tower** (yield to water/wind movements in the same way as floating structures).
- **Floating platforms:** held in place with seabed anchors or piles. The main varieties are the **mini TLP** (tension leg platform; relatively low cost with less equipment for production of smaller deep-water reservoirs), the **SPAR** (used for very deep waters and can support drilling, production and storage operations) and **FPSO** (a large moored vessel, which includes processing facilities and substantial storage).

Fixed platforms



Source: UBS

Floating platforms



Source: UBS

Onshore construction

There are numerous contract types in widespread use within onshore construction. The main difference between contracts largely rests on the risk transfer to the contractor. Risks include design risk, procurement cost uncertainty, site risks and construction productivity and equipment failure. 2 main contract types: **lump sum** or **fixed price** (contractor commits to deliver specific work for a pre-agreed price – therefore substantially riskier for the contractor) and **cost-plus, reimbursable** or **open book** (contractor commits only to working to a pre-agreed schedule of costs and the customer takes on the risk of cost over runs). Both types are bid for on a competitive basis but fixed price is more likely to be an open bid process whereas cost-plus is more likely to be relationship-based.

The following are common contracts (risk for the declines from left to right):

EPC	EPIC	EPCM	EPcma	DBM	EDS	FEED	Service
Engineering, procurement construction	Engineering, procurement installation, commissioning	Engineering, procurement, construction management	Engineering, procurement, construction management assistance	Design basis memorandum	Engineering design specification	Front-end engineering design	
Normally lump-sum with the contractor responsible for complete delivery of the contract	Effectively EPC contract with the additional requirement that the resultant facilities are commissioned (ie brought online before the contract is completed). These are generally fixed price.	Differ from EPC as the contractor is responsible only for project management in the construction phase rather than full construction	Contractor committed to a fixed price for the detailed engineering design work and the resultant procurement of the project, but the customer is responsible for actual construction of the facilities (customer is responsible for project management).	Early-stage feasibility study	Late-stage feasibility study, normally prepared to define terms for FEED	Generally before the final investment decision (FID)	Typically for engineering and project management only

Offshore vessels

The largest, highest value offshore installation vessels are:

- **Heavy-lift:** a heavy-lift vessel consists of a massive platform, to provide stability, and one or more cranes. These are used for module and jacket installation* (involves lifting individual components into place from transit barges), laying trunklines using a heavy pipelay and decommissioning (an emerging area of demand, especially in the North Sea where facilities are reaching the end of their working lives).

Construction vessels: these are more numerous than heavy-lifts. Different types:

- **SURF vessels** (Subsea tree, Umbilical, Riser and Flowline): specialise in the installation of the 3 major subsea components (umbilicals, risers and flowlines) and are often equipped with a crane. Owners of high-capacity vessels do not tend to rent them out but rather use them as tools to win specific EPIC-type contracts (Engineering, Procurement, Installation and Commissioning).
- **Dive support vessels** (DSVs): specialist construction vessels primarily to support divers. The value of these depends greatly on their capabilities in storage and the number of divers they can support.
- **Lightweight vessels:** tend to be used for surveying (providing information about the physical environment around the development), IRM (inspection, repair and maintenance of existing facilities) and ROV support (Remotely Operated Vehicle, a catch-all term for an unmanned submersible).

* Components from the sea bed to the surface are **jackets** while above-surface components are **modules**.

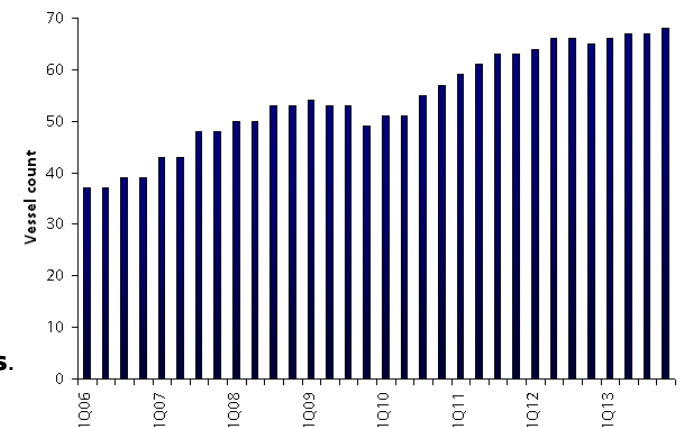
** Data for 2013 also includes vessels which are expected to be completed in the year.

Heavy-lift vessel Thialf



Source: Heavy Lift Specialist

Global 3D vessel count 2006-2013**



Source: UBS and company data

Rig count

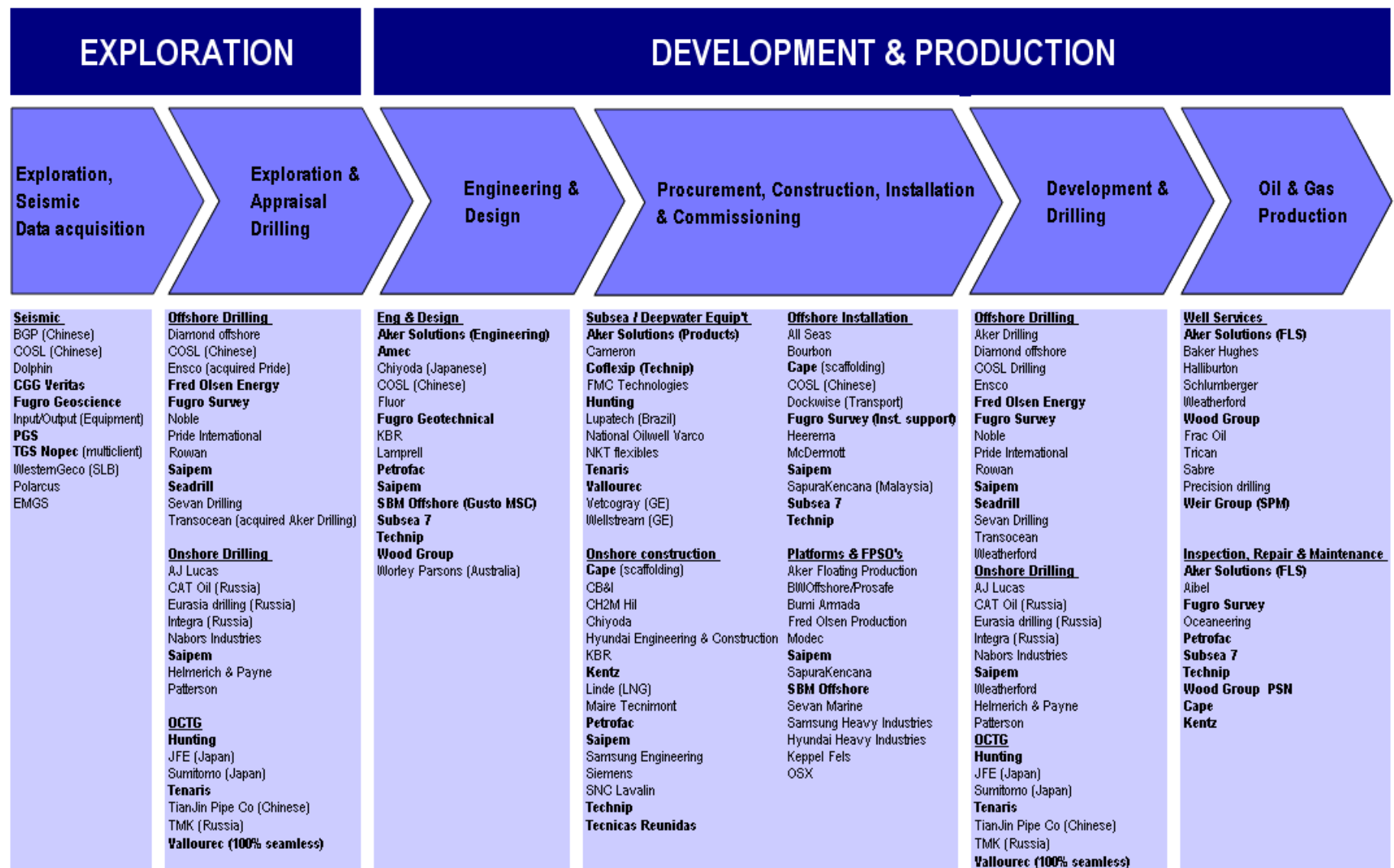
Baker Hughes each week releases data on the North American rig count and on the international rig count once a month. This is an important barometer for the drilling industry. When drilling rigs are active they consume products and services produced by oil service companies. The active rig count thus acts as a leading indicator of demand for products used in drilling, completing, producing and processing oil and gas.

Total world oil and gas rotary rig count 1987-2012



Source: Bloomberg

Oilfield services company activity

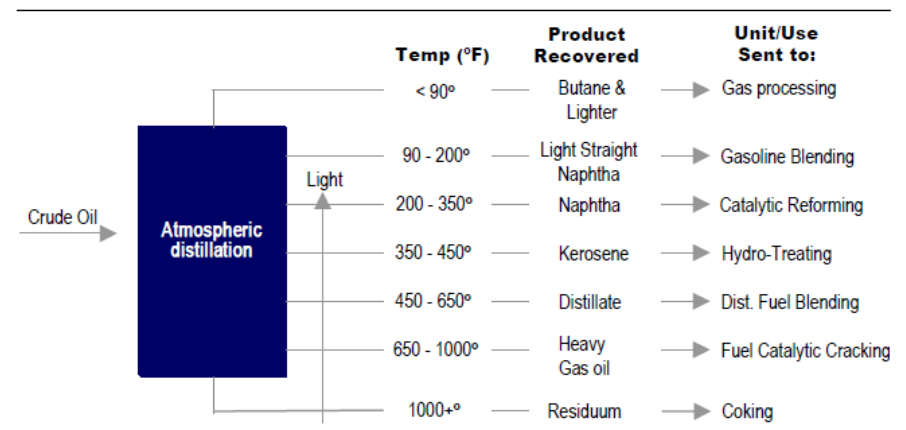


Source: UBS. Companies covered in bold are covered by UBS European oil & gas equity research

Refining (I)

- Refining refers to the process of separating crude oil into useable finished products (gasoline, diesel, etc).
- Refineries are categorised by **size** (measured by crude distillation capacity) and **configuration** (level of sophistication and complexity).
- **Nelson complexity index**: each piece of equipment is assigned a value and these are then added up to assign a value to the whole refinery. The higher the index, the greater the complexity of the refinery, indicating an ability to process inferior quality crude and to make higher quality products.
- **1st Step**: using the **crude distillation unit** (see right), the temperature of the oil is increased, and different components (**fractions**) boil off and can be recovered at different temperatures. Each different oil produces a distinct mix ('heavy oils' generally producing more heavy fractions and vice versa), leading to different values between crude oils. Highest demand is for lighter products: middle distillate, kerosene (for aircraft) and light straight naphtha (for gasoline). The heaviest products tend to be broken down to make lighter products.

Crude oil distillation: the first step



Source: UBS

Refining (II)

After heating the oil into its separate parts, the components are directed to **conversion** units to be chemically altered through the introduction of heat, pressure, catalysts or hydrogen. Some processes involve cracking (reducing the average sizes of molecules and thus expanding the volume of the resultant product) while others use different methods. The next step is to **treat** or **blend** the output.

Cracking conversion processes: essentially used to break up heavier high-boiling feedstocks into lighter products. 3 main cracking processes:

- **Catalytic cracking:** uses heat, pressure and a metallic catalyst to convert heavy straight-run gas oils and vacuum gas oils into gasoline. Fluid Catalytic Crackers (FCCs) generate harmful highly sulphuric and aromatic products, which requires further treatment for environmental compliance.
- **Hydrocracking:** introduces hydrogen into the process, producing cleaner final products. It also offers much greater processing flexibility than do standard FCCs, making it the costliest refining facility.
- **Thermal cracking** (coking): coking is the most severe form of thermal cracking and reduces the yield of low-value heavy products.

Non-cracking conversion processes:

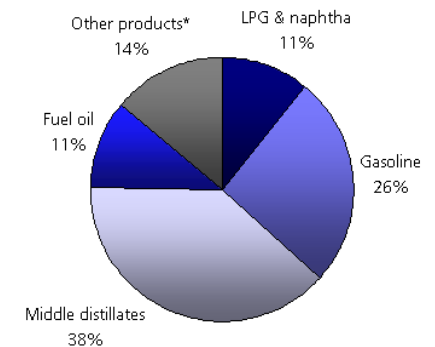
- **Reforming:** rearranges molecules rather than cracking them and is primarily used to convert low-octane naphthas into high-octane blending components. The catalytic reformer is a minimum requirement for simple refineries wishing to produce gasoline with sufficient octane content.
- **Alkalisiation** and **isomerisation:** the size of the molecules can be increased. These processes convert naturally occurring and cracked gaseous by-products into high-quality gasoline blending components.

Finished petroleum products

Petroleum products are usually grouped into 3 categories:

- **Light distillates** (LPG, naphtha, gasoline)
- **Middle distillates** (kerosene, diesel)
- **Heavy distillates** (heavy fuel oil, lubricants, asphalt, petcoke)

Global refinery products produced in 2012



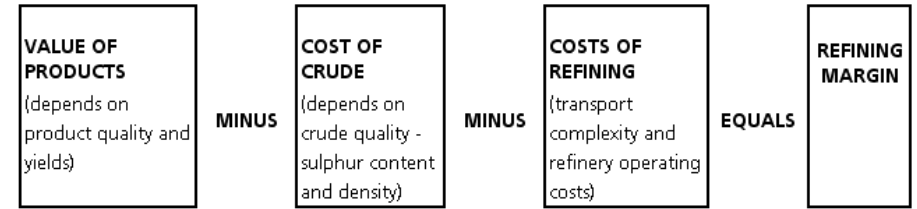
Source: UBS

Product	End-market	Global CAGR (%) 2010-16E	Demand pattern
LPG & naphtha	LPG: cooking fuel Naphtha: petrochemical feedstock	1.8%	Global petrochemical activity increasing on the whole as demand for plastics grows strongly. OECD: demand for petrochemical feedstock declining with substitution to cheaper gas feedstock and increased competition from emerging low-cost producers in the Middle East and Asia
Gasoline (inc ethanol)	Passenger vehicles	0.6%	Non-OECD: rapid expected on expanding vehicle fleets, favourable demographics, urbanisation and extensive price subsidies. OECD: growth dampened by somewhat stringent fuel economy rules and fleet saturation
Middle distillates	Diesel: passenger/commercial vehicles, municipal buses, emergency power generators. Kerosene: aviation, domestic/commercial heating, cooking	2.2%	Non-OECD: strong growth in transportation, industrial and agricultural demand for gasoil and diesel from robust economic activity. OECD: continued expansion of diesel fleets and rising marine gasoil bunker demand offset somewhat by displacement of heating oil by natural gas and marginal impact of heavy vehicle fuel efficiency standards. Jet fuel demand also robust, with increased air transportation and expanding aircraft fleets across all regions expected to offset fleet and operational efficiency gains and declining kerosene consumption for heating
Residual fuel oil	Bunker fuel, power generation	-0.6%	Bunker demand expected to increase globally in spite of new emission control areas (ECA's) in the OECD which imply marine gasoil switching. OECD: usage declining in power generation and being substituted with cheaper and cleaner natural gas. Non-OECD: modestly increasing demand for power generation especially in areas with limited access to natural gas.

Source: UBS

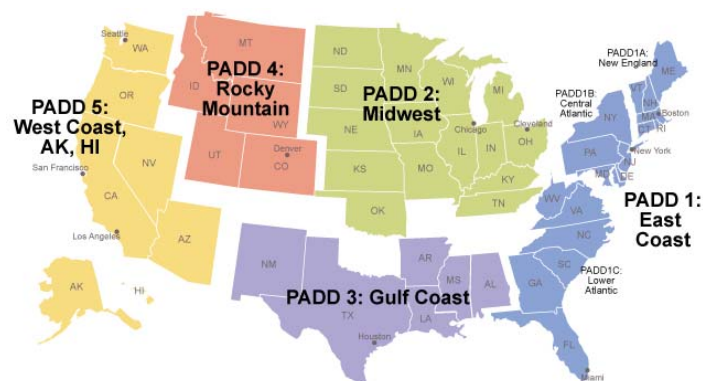
Refining margins

- The primary measure of refining profitability is the **refining margin** (see right). Margin variations among refineries are primarily due to the crude oils processed and a facility's individual configuration.
- Refineries in the same region generally receive the same prices for their products, have access to similar crude oils and must adapt their configurations to the same set of local constraints. This is why reference margins are usually quoted on a regional basis, the 3 primary ones being: **US Gulf Coast**, **Northwest Europe** and **Singapore**. Other proxies for margins include simplified cash or futures **crack spreads**, which are ratios of product to crude. One of the most well-known crack spreads is the **NYMEX 3:2:1**, which is calculated by deducting the NYMEX WTI price from a corresponding NYMEX product basket (67% gasoline, 33% diesel) to determine a per barrel product spread.
- Refining margins differ according to how much the oil has been processed – '**upgraded**'. The **upgrading contribution** (aka **conversion margin**) is the difference between the cash margin from a simple refinery and one from a refinery with more sophisticated conversion capabilities.
- The conversion margin tends to rise with oil prices, since refining profitability is principally determined by the differential between prices of light and heavy products. Prices of light products tend to respond directly to changes in crude prices (because they are not subject to short term substitution from alternative fuels), while heavy products tend to face more competition from natural gas (and to a lesser extent coal). Hence, as the crude oil price rises, light product prices tend to rise more, widening the spread between light and heavy products ('**heavy oil differential**'), in turn benefiting conversion margins (as light products are more valuable than heavy).



Source: UBS

PADDs and US refiners' exposure



Source: EIA

- The Petroleum Administration for Defense Districts (PADDs) are geographic aggregations of the 50 states and the District of Columbia into 5 districts (see map above).
- During WW2 the Petroleum Administration for War used these 5 districts to ration gasoline. Now they are used to analyse patterns of crude oil and petroleum product movements.
- In 2010 for example, the bulk of petroleum product pipeline movements took place among PADDs 1,2 and 3. More than half of the inter-PADD product pipeline movements were from PADD 3 (area with significant refining capacity) to PADD 1 (major population centre). PADDs 4 and 5, on the other hand, show small volumes entering/leaving by pipeline.
- The table to the right shows the exposure of the largest independent US refiners to each PADD.

CDU Capacity (kb/d)		PADD						PADD %					
Company	Refinery	1	2	3	4	5	Int'l	1	2	3	4	5	Int'l
HollyFrontier	Cheyenne, WY					52							
	El Dorado, KS		135										
	Navajo, NM			100									
	Tulsa, OK		125										
	Woods Cross, UT					31							
	Total		260	100	83			0%	59%	23%	19%	0%	0%
Phillips 66	Bayway, NJ	238											
	Belle Chasse, LA			239									
	Billings, MT				58								
	Borger, TX			73									
	Ferndale, WA					100							
	Humber, UK						221						
	Lake Charles, LA			239									
	Los Angeles, CA					139							
	Melaka, Indonesia						76						
	MIRCO, Germany						58						
	Ponca, OK		187										
	San Francisco, CA					120							
	Sweeny, TX			247									
Whitegate, Ireland						71							
Wood River, IL		153											
Total		238	340	798	58	359	426	11%	15%	36%	3%	16%	19%
Tesoro	Anacortes, WA					115							
	Kenai, AK					72							
	Martinez, CA					166							
	Mandan, ND		68										
	Salt Lake City, UT					58							
	Wilmington, CA					100							
Total			68			511		0%	12%	0%	0%	88%	0%
Valero Energy	Ardmore, OK		86										
	Benicia, CA					145							
	Corpus Christi, TX			205									
	Houston, TX			90									
	McKee, TX			168									
	Memphis, TN		180										
	Meraux, LA			135									
	Pembroke, UK						220						
	Port Arthur, TX			290									
	Quebec City, Canada						230						
	St. Charles, LA			190									
	Texas City, TX			225									
	Three Rivers, TX			95									
Wilmington, CA					85								
Total			266	1,398		230	450	0%	11%	60%	0%	10%	19%
Western Refining	El Paso, TX			128									
	Gallup, NM			23									
	Total			151				0%	0%	100%	0%	0%	0%
Marathon Petroleum	Gargville, LA			490									
	Catlettsburg, KY		233										
	Robinson, IL		206										
	Detroit, MI		106										
	Texas City, TX			80									
	Canton, OH		78										
Total		623	570					0%	52%	48%	0%	0%	0%
Largest US independent refiners		238	1,642	3,017	141	1,100	876	3%	23%	43%	2%	16%	12%

Source: Company data

Marketing

- Marketing refers to the distribution and sale of refined products beyond the refinery gate. This can be in the form of bulk shipments from a refiner to a wholesaler, down to the selling of a tank of petrol on a garage forecourt. The addition of marketing assets to the downstream portfolio generally creates a more stable, higher margin income stream.
- Spot and wholesale product prices tend to react instantaneously to crude price fluctuations whereas retail prices typically take up to 8 weeks to fully absorb price hikes. Hence in times of rapidly rising oil prices marketing profitability can be depressed.
- Retail (or 'filling') stations can be owned by major oil companies, independently owned but branded or simply independent – buying oil products from a wholesaler. However the majority of US gasoline is channelled to retail chains through independent jobbers ('petroleum marketers').
- Fuel retailing is hugely competitive and not very profitable. Most retail networks make their profit selling Coca-cola, newspapers and cigarettes!
- **Marketing margin:** as with refining, marketing profitability is tracked on a margin per barrel/tonne basis. Since there are no standard industry margins, we use indicative margins to track trends on a region-by-region basis.

Wild Bean Café at BP stations



Source: Mobile Marketer

BP truck filling plane with jet fuel



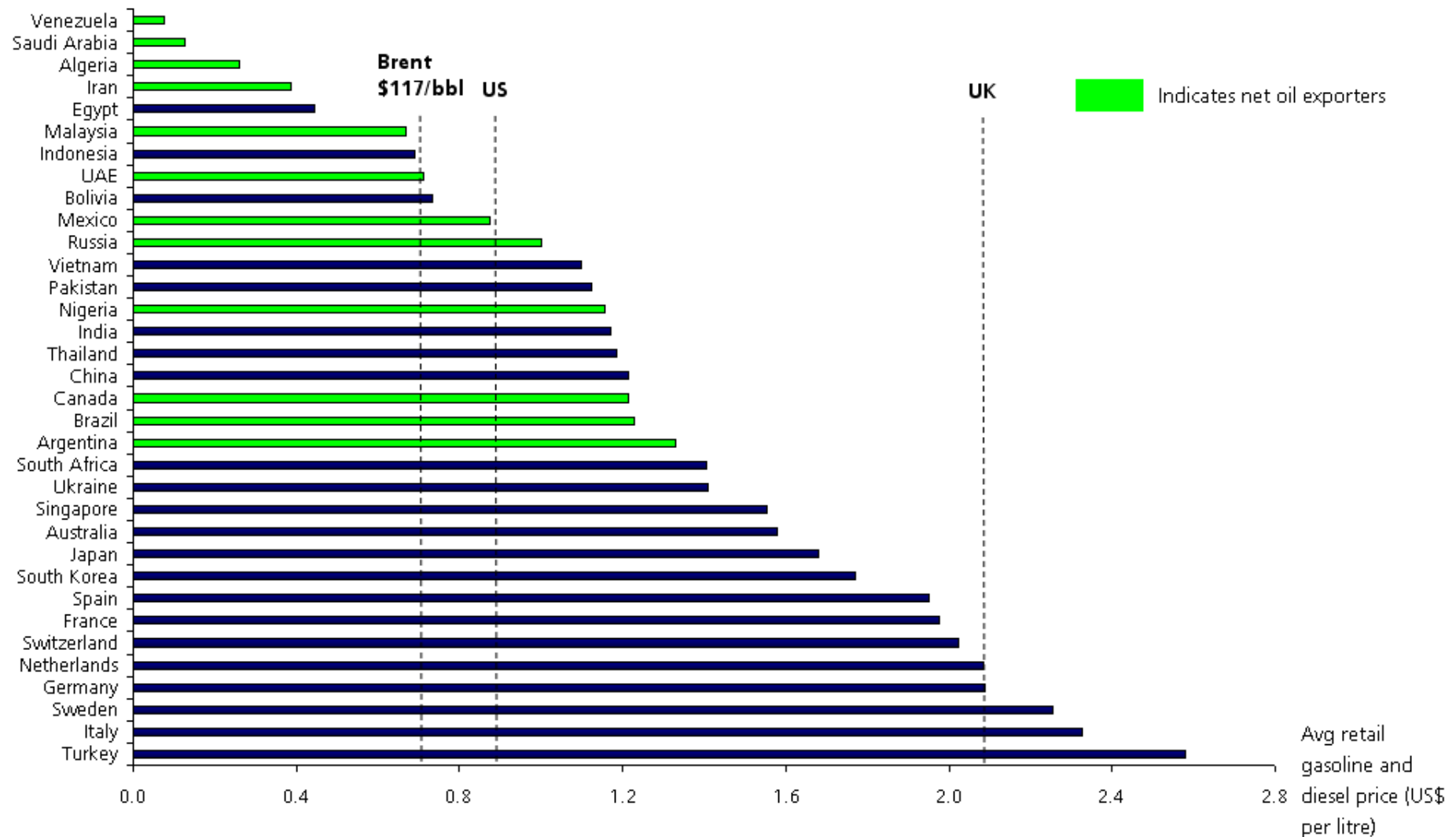
Source: BP

Shell petrol station



Source: BBC

Average retail gasoline and diesel price by major economy



Source: Gasoline Germany, World Bank, EIA

Upstream performance measures

The most important upstream performance measures are finding and development costs, production costs and reserves replacement.

- **Finding and development costs**

Finding costs: the costs of discovering and delineating the reservoir, including seismic, exploration and appraisal drilling costs, and gaining the legal right to extract the oil and gas (eg **signature bonuses**). There is no consensus regarding which precise costs should be included in finding costs, and different accounting methods are used which further complicates the picture (see next slide).

Development costs: encompass front-end engineering and design (FEED), procurement of equipment and vessels, construction of facilities, installation, drilling, project management, and include the costs of extending existing fields and discoveries.

Together these are known as “finding and development” or **F&D costs**, and are expressed in terms of \$/barrel.

- **Production costs** (‘lifting’ costs): include staff costs, on site energy costs, equipment rental (rig hire, etc...) and consumables (drilling mud, drill bits, etc...).
- **Reserves replacement:** a company’s ability to replace production with new finds, upward revision to earlier reserves estimates (once a field is in production), or acquisitions. A ratio of 100% indicates that a company has replaced all of the reserves produced during a given period.

Neither F&D nor reserves replacement ratios can be viewed totally in isolation. Clearly the company which slashes its exploration budget whilst bringing new fields on stream would tend to show lower F&D costs than the company investing heavily in exploration, which may, eventually, lead to much higher reserve replacement and higher rates of production in the future.

Accounting issues (I)

Different accounting standards make comparisons between companies difficult (the biggest difference is in the treatment of exploration expenditure). The two accounting conventions in use are **full cost** (FC) and **successful efforts** (SE). Primary differences:

- SE expenses while FC capitalises exploratory dry hole costs
- SE expenses while FC capitalises geologic and geophysical (G&G) and other ancillary exploration expenses (seismic acquisition and processing costs, topographical and environmental studies)
- Methodology for reserve write-down tests
- Delineation of cost centres (country by country for FC vs field by field for SE) for calculating DD&A rate
- Ability to capitalize certain G&A costs allowed for FC accounting

SE accounting is inherently more conservative than FC. The oil and gas sector is the only industry in which companies are allowed to choose between two considerably different accounting methods. Because of the highlighted differences, many traditional financial ratios (PE, debt to capitalisation, ROACE) are ineffective and we think cash flow-based metrics (CFPS, debt/EBITDX, reserve replacement efficiency ratio) should be used instead.

As a broad generalisation, smaller companies or ones with large exploration programs tend to adopt FC accounting, whereas bigger, more established companies with more diverse portfolios and smoother earnings tend to use SE, being better equipped to absorb fluctuating exploration write-offs.

Accounting issues (II)

- The standard for reserves reporting is the US FAS 69 statement. Since proven reserves often constitute the majority of an E&P company's assets (the value of the company being driven by the NPV of future cash flows generated from the production of the reserves), all oil and gas companies are required to disclose proved reserve estimates at year end according to FAS 69. 1P reserves are disclosed as a regulatory requirement, while company internal planning is generally done on a 2P basis.
- Some countries have distinct systems for reserve reporting that may have tax or regulatory consequences. Russia, in particular has a domestic reserve reporting system, GKZ, where the specific numbers discussed are different. In the UK, 2P reserves are more commonly used and Australian reporting uses a distinct system.

Areas where companies have the flexibility to be conservative or aggressive with respect to booking reserves:

- **Reserve reporting – use of outside engineers:** although required to disclose reserve estimates, it is optional for companies to use outside reservoir engineers. Not using an outside engineer is less conservative since the estimate is not reviewed or audited by an *unbiased* third party.
- **Reserve revisions:** revisions are changes to prior-year estimates, primarily caused by changes in year-end prices, which could shorten/lengthen the economic life of a property and therefore decrease/increase proved reserves. FAS 69 requires constant price and cost assumptions when booking reserves, meaning a field could be economical when prices are high, but then considered uneconomical as lower prices result in a downward revision to reserves. A second cause for revisions is when the company recognizes that a given field can physically yield smaller/larger amounts of hydrocarbons than originally estimated.
- **Proved undeveloped reserves:** proved reserves could be developed or undeveloped. The SEC defines *developed* reserves as oil and natural gas that can be recovered from existing wells with existing infrastructure and operating methods, while *undeveloped* reserves 'are expected to be recovered from new wells on undrilled acreage, or from existing wells where a relatively major expenditure is required for re-completion'. The latter should thus be viewed as somewhat higher risk and lower value.

Oil and gas taxation

A country's oil and gas tax system is the way in which the host government collects the excess profits of a nation's oil and gas activities. Excess profits are those over and above the returns required to pay the oil company for its capital, expertise and risk. Most host governments would regard the oil and gas in the ground as essentially belonging to them. 2 main types of fiscal systems:

Contract	Oil Company	Government
Tax & Royalty	all risk / all reward	reward is function of production and price
PSC	exploration risk / share in reward	share in reward
Service	no risk	all risk

Source: Oxford Institute for Energy Studies, 1999

- **Tax and royalty system:** a small royalty is taken, then after allowable deductions (operating and depreciation costs), a tax is levied. The government exerts a low degree of influence over day-to-day operations, and all wellhead production, and often the reserves, belong to the company. This approach is analogous to regular corporation tax: the company invests, makes money and is consequently taxed on its profits. These are common in the rich economies of the OECD (eg UK, Norway, US).
- **Contractual agreement:** these emphasize sovereign control over resources. The most common form is a **production sharing contract (PSC)**. This allows for the cost element to be reclaimed from production, and then the remaining production is split as profit oil* between the company and the government. Contractual agreements vary significantly because they involve negotiation. The attractiveness of these to oil companies is their relative stability – a critical issue when their investment horizons are multi-year or -decade.
- **Service contracts** are also employed, where oil companies are essentially employed as contractors to provide technical, financial and commercial services for a fee. This guarantees oil companies a profit, assuming it fulfils its contract terms, but also ensures no share in windfall profits, since the companies own neither the reserves nor production. These are sometimes found in the Middle East where the governments have the necessary capital but lack the technology and expertise.

* Profit oil: relates to the income remaining after cost oil, which is the production allocated to the oil company to recover the costs incurred on the project.

Industry subsectors

Integrateds

- Engage both in upstream and downstream activities. The **super-majors** (also known as “**big oil**”) are the world’s largest non-state owned oil companies, and are considered to be Royal Dutch Shell, ExxonMobil, Chevron, BP and Total. The **European majors** are Shell, BP, Total, Eni and Statoil.

Upstream (‘E&P’ – Exploration & Production)

- Upstream refers to all activities involved with the exploration, drilling and production of oil and gas. Upstream companies are essentially portfolios of exploration acreage, development projects and producing fields, all at varying stages of maturity.
- Work on these asset bases is a process of explore → develop → produce → and as the projects are monetised, the cash is returned and must then be recycled into the next opportunity. Therefore upstream longevity is determined by an ability to grow the project base.

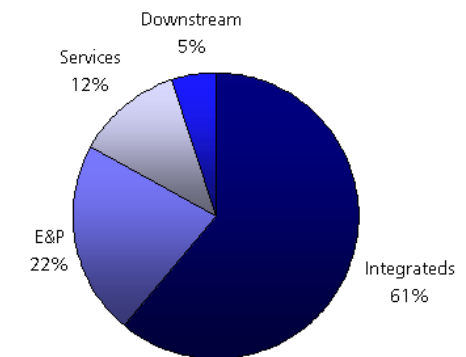
Downstream (‘R&M’ – Refining & Marketing)

- Downstream includes refining and marketing operations.
- Midstream covers oil and gas transportation and pipeline infrastructure connecting the upstream and downstream.
- Marketing refers to the distribution and sale of refined products, from bulk distribution to retailing.

Oil Services

- Oil services covers multiple activities – from the manufacturing of components used in well construction, to the operation of offshore platforms, to the engineering of refineries.
- The major segments of the oil services companies are: seismic, drilling, production optimisation, completion & production, offshore construction, onshore construction

Global sub-sector weightings by market cap



Source: UBS

Valuing oil companies: Integrates

Valuation in the integrated oil sector is tricky due to differences in accounting policies (treatment of acquisition effects and taxes). We prefer to concentrate on cash based methodologies however there is no single metric that works for all companies and comparison between companies is complex. We think the following approaches capture all the key valuation issues:

- **EV/DACF** (enterprise value/debt adjusted cash flow) – our main metric, essentially comparing the full value of the business to a taxed EBITDA (instead of using the conventional EV/EBITDA). It is good for use in the industry because tax rates vary widely between companies and resource taxes are high in the industry. The greatest weakness however is that it does not take into consideration the company's capital intensity as it is before all capital expenditure.
- **P/E** – the use of P/Es in the European oil sector is limited due to differences in accounting policy between companies. However, because it is widely used within the market and the fact that earnings should track cash flows broadly, P/E does have some influence on the market.
- **Dividend & FCF yield** – note however that dividends are a management decision and dividend yield does not determine value without reference to its sustainability. FCF (free cash flow) is cash flow from operations before working capital changes minus capex.
- **DCF** (discounted cash flow) – helps to identify companies that deserve to trade at a premium relative to peers (because it incorporates a sense of the relative risk one equity with others).
- **Sum of the parts** –
Upstream: we apply a valuation to proved reserves and known projects and assess the value of exploration acreage.
Downstream: we use an appropriate multiple based on the location of earnings. We show output as a multiple of refining capacity and equivalent refining capacity (adjusted for complexity) for comparison within the refining sector.

Valuing oil companies: E&Ps

- **NAV**

Outside the US, NAV is the dominant approach for valuing E&Ps.

Core NAV: this is the value of a company's producing fields and development projects and values the current 2P reserve base. To this we add the PV of other sources of future revenue (eg tariff income), a charge for the running of the business, the PV of the current hedging portfolio and the net debt balance. This makes the conservative assumption of no future exploration success.

Unrisked NAV: this is the opposite extreme and is based on the (highly unlikely) assumption that every exploration well drilled yields a commercial discovery (industry's historic exploration success rate is only 13% over the past 10 years). It is however useful as a means to quantify the upside potential on offer from a particular drilling program.

Risked NAV: risks the value of a prospect by the probability of the well being successful (high risk 0-10%, medium risk 10-30%, low risk >30%). This value of the exploration portfolio is then added to the core NAV.

- **Multiples based approach**

This has its merits for more production (rather than exploration) focused companies.

- **What are you paying per barrel of reserves?**

EV/1P or EV/2P is attractive because of its simplicity however has many shortcomings because not all barrels of reserves trade at the same value (oil reserves typically worth more than gas, the fiscal environment is a key driver of value and the timing of production has a significant effect on value).

Valuing oil companies: R&M and Oilfield Services

R&M

- The most important valuation multiples are **P/E** and **EV/EBITDA** however in Europe we prefer to use **EV/DACF** because of countries' varying tax rates. Other key metrics specific to the refining sector is to look at companies' valuation relative to their refining capacity. This is done in 2 ways:

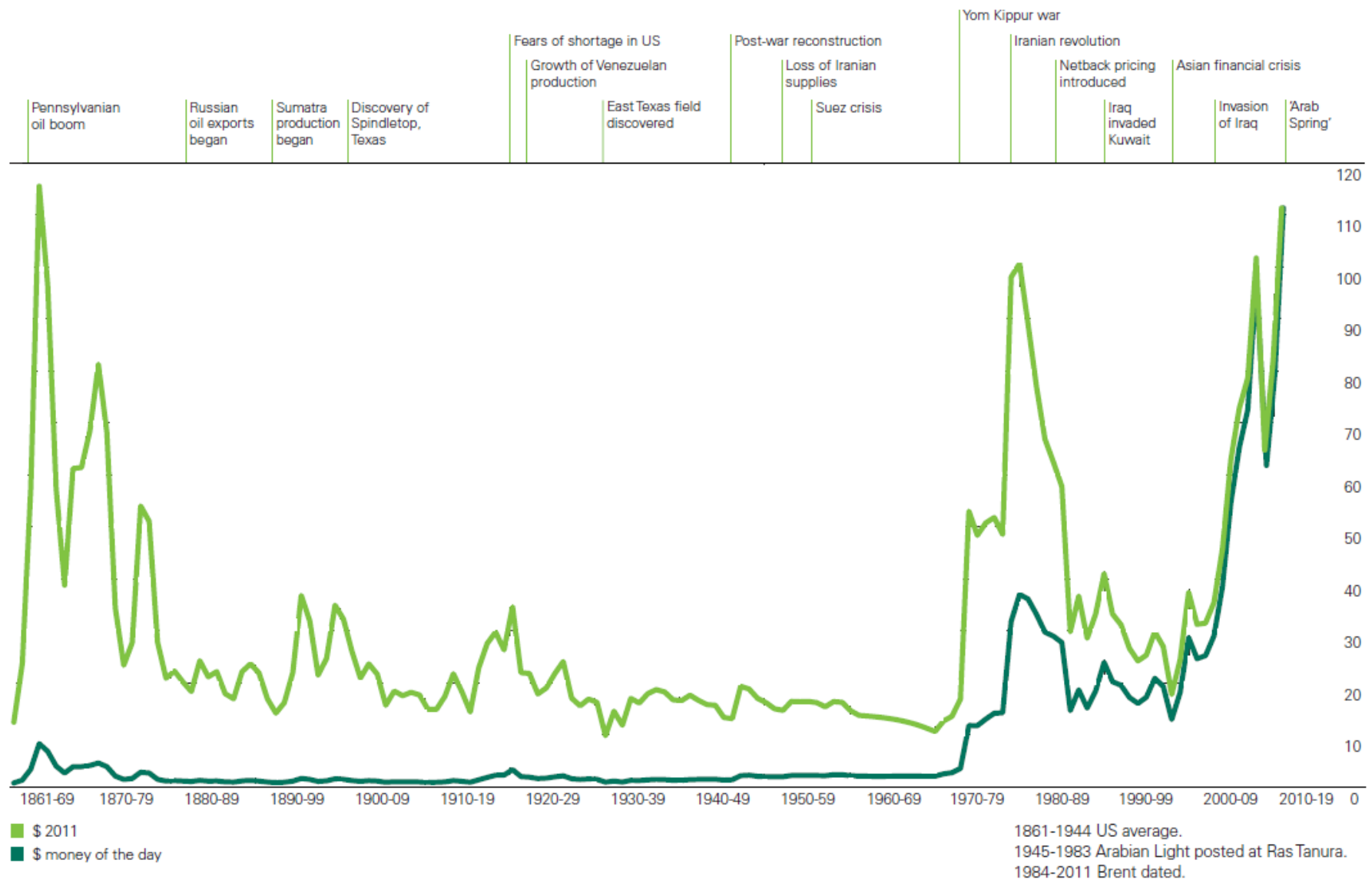
EV/bbl – gives a simple comparison of what you are paying per barrel for each company. We can further adjust it to take into account **Nelson complexity**: the amount of investment that has gone into the refinery relative to its distillation capacity. It indicates the investment intensity of the refinery but also its potential value addition (the higher the index, the greater the cost of the refinery and also the higher the value of its products).

Replacement cost – we do not believe that this is a fair way to value refiners since it is ultimately cash flows that drive the value of a firm. It suffers from a number of problems: it is highly unlikely that a new refinery will be allowed to be constructed in most European countries, replacement cost in Europe will be much higher than that in developing nations and many refineries are being built for strategic/political reasons without much attention paid to the returns from the projects.

Oilfield Services

- These are often conventional manufacturing or service companies and so valued using the usual range of multiples and DCF. Typically P/E is the most important one even though it varies significantly by sector, with asset-intensive companies (drillers, subsea, seismic) in general on substantially lower multiples than the asset-light companies (E&C).
- We tend to be wary of EV/EBITDA because, as with integrated companies, tax rates can vary dramatically from one company to another (3% to 40%) and, in addition, seismic companies tend to book part of cost-of-goods sold as amortization (EBITDA is before both tax and amortization).
- As an alternative we also estimate value for asset-based companies from the replacement cost of their operating assets. This approach is most applicable to drillers (are essentially tool hire companies).

Appendix 1: Oil price (1861-now)



Source: BP Statistical Review of World Energy June 2012

Appendix 2: Conversion table

FROM	TO					
Crude oil				Gallons	Gallons	Tonnes/Year
	Tonnes	Long Tons	Barrels	(Imperial)	(Us)	
	MULTIPLY BY					
Tonnes (metric)	1	0.984	7.33	256	308	-
Long tons	1.016	1	7.45	261	313	-
Barrels	0.136	0.134	1	35	42	-
Gallons (imperial)	0.00391	0.00383	*0.0286	1	1.201	-
Gallons (US)	0.00325	0.00319	0.0238	0.833	1	-
Barrels/day	-	-	-	-	-	49.8

TO CONVERT				
Products	Barrels to tonnes	Tonnes to barrels	Barrels/day to tonnes/year	Tonnes/year To barrels/day
	MULTIPLY BY			
Motor Spirit	0.118	8.45	43.3	0.0232
Kerosine	0.128	7.80	46.8	0.0214
Gas oil/diesel	0.133	7.50	48.7	0.0205
Fuel oil	0.149	6.70	54.5	0.0184

TO						
Natural gas and LNG	Billion Cubic metres NG	Billion cubic feet NG	Million tonnes crude oil	Million tonnes LNG	Trillion British thermal units	Million barrels of oil equivalent
	MULTIPLY BY					
1 billion cubic metres NG	1	35.3	0.90	0.73	36	6.29
1 billion cubic feet NG	0.028	1	0.026	0.021	1.03	0.18
1 million tonnes crude oil	1.111	39.2	1	0.805	40.4	7.33
1 million tonnes LNG	1.38	48.7	1.23	1	52.0	8.68
1 trillion British Thermal Units	0.028	0.98	0.025	0.02	1	0.17
1 million barrels oil equivalent	0.16	5.61	0.14	0.12	5.8	1

Source: BP Statistical Review

Units

1 metric tonne = 2,205lbs

1 kilolitre (m³) = 6.29bbls

1 therm = 100,000 BTU = 100ft³

Calorific equivalents

One million tonnes of oil equals approximately

Heat Units 40 x 10¹² BTU

397 x 10⁶ therms

10,000 Teracalories

Solid Fuels* 1.5 x 10⁶ tonnes of coal

3.0 x 10⁶ tonnes of lignite

Electricity 12 x 10⁹ kWh

One million tonnes of oil produces about 4 x 10⁹ kWh of electricity in a modern power station. calorific values of coal and lignite, as produced

1 cubic metre = 9,000 kcal

1 kWh = 3,412 Btu; 1 kWh = 860 kcal

Appendix 3: Important dates in the history of the industry

1859 First oil well drilled at Titusville, Pennsylvania.

1871-2 First oil wells drilled in Baku by the Nobel brothers, in what is now Azerbaijan – the beginnings of the Soviet oil industry.

1897 The 'Shell' Transport and Trading Company came into existence.

1890 Launching of the Royal Dutch Company.

1907 After years of negotiation, Shell and the Royal Dutch Company were combined in the ratio 60:40. Both became holding companies with RD holding 60% of the stock in the operating companies and Shell 40%. There was no Group Board as such, but a Committee of Managing Directors composed of the active members of the Boards of both companies.

1901 Oil found in Mexico.

1908 Oil discovered in Persia (Iran) by Burmah Oil.

1909 The newly founded Anglo-Persian Oil Company went public with Burmah Oil taking the majority of the shares. By 1912 the company was in financial difficulties.

1914 The British Government, led by Churchill and driven by the rapid expansion of oil powered battleships, acquired 51% of Anglo-Persian for £2.2m in order to secure fuel supplies for the Admiralty.

1911 The US Supreme Court orders the dissolution of the Standard Oil Trust under the 1890 Sherman Anti-Trust Act. 7 new entities are formed in its place: Standard Oil of New Jersey (eventually Exxon), Standard Oil of New York (Mobil), Standard Oil of California (Chevron), Standard Oil of Ohio (eventually the US arm of BP), Standard Oil of Indiana (Amoco), Continental Oil (Conoco) and Atlantic, which became part of Atlantic Richfield Company (ARCO).

1913 Oil found in Venezuela.

1927 Oil found in Iraq.

1938 Oil found in Kuwait and Saudi Arabia.

1956 The Suez crisis: Nasser takes control of the Suez Canal from French and British interests, temporarily disrupting supplies. The second post-war oil crisis.

1956 Oil discovered in Algeria and Nigeria.

1960 OPEC founded in Baghdad by Saudi Arabia, Iran, Iraq, Venezuela and Kuwait in response to aggressive price cutting by the Soviets and Standard Oil of New Jersey. The 5 founding members were at the time the source of over 80% of the world's crude exports. The OPEC members agreed to defend the price of oil, with each member country agreeing to insist that companies consult them on pricing levels.

1967 Six Day War – Suez Canal closed. Third post-war oil crisis.

1969 Oil discovered in the North Sea.

1973 Yom Kippur War, Arab oil embargo: fourth post-war oil crisis. Oil prices rise from \$2.90/bbl in September to \$11.65 in December.

1979/81 Oil price rises from \$13 to \$34/bbl : fifth post-war oil crisis.

1990 Iraq invades Kuwait; OPEC countries increase production to help stabilise shortfall.

1990-91 Gulf War. Sixth post-war oil crisis.

1998 Asian economic downturn and mild winter contribute to rising inventories; the price of oil drops to \$10/bbl. OPEC agrees production cuts in March and June. Non-OPEC Mexico attends OPEC conference for first time in March. Attends again in June, joined by representatives from the Russian Federation and Oman.

2001 OPEC cuts quotas four times in response to weak global demand.

2004 Supply disruptions (Hurricane Ivan, Nigerian strikes) and production capacity constraints limit supply at a time of growing global demand (China).

2007 Brent oil continues to rise as higher prices have little impact on demand. Venezuelan government nationalises certain Orinoco Belt projects, agreeing compensation with some companies. China agrees to pay oil-equivalent prices for LNG in Asia, triggering a scramble for LNG cargoes in the region. Oil discovered in the Campos Basin offshore Brazil.

Appendix 4: UBS oil and gas team

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Appendix 5: UBS global oil and gas coverage



Appendix 6: Glossary

Abandon: to cease work on a well which is nonproductive/uneconomic.

Acidisation: a process where acid is squeezed into tight and/or damaged (usually limestone/chalk) reservoirs, to try to dissolve a portion of the rock, and to improve the porosity and permeability characteristics of the reservoir, thereby improving the flow of hydrocarbons to the well.

ACQ: Annual Contract Quantity, specifying the contracted level of annual gas deliveries.

Acreage: the area over which a company has hydrocarbon exploration interests.

Acrylonitrile: a colourless liquid that is flammable and explosive (used in acrylic fibres, ABS, nitrile rubber).

Alkylation: a refining process for chemically combining isobutane with olefinic hydrocarbons (eg propylene, butylene) through the control of temperature and pressure in the presence of an acid catalyst (usually sulphuric acid or hydrofluoric acid). The product alkylate (an isoparaffin) has a high octane value and is blended into motor and aviation gasoline to improve the antiknock value of the fuel.

Annex B: operator's development plan for an installation. It requires government approval before it can be implemented.

Annulus: the space between the drill string and the well wall, or between casing strings, or between the casing and the production tubing.

Anti-clinal traps: essentially formed as a result of a folding of the strata into the shape of a dome, enabling any gas or oil contained in a reservoir rock to collect at the crest of the fold.

Antiknock: the resistance to detonation in sparkignition or compression-ignition internal combustion engines. The value is measured in terms of octane number for gasoline engines and of cetane number for diesel fuels.

API: American Petroleum Institute, which publishes a large number of technical standards widely used in the industry.

API gravity: is specific gravity at 60° Fahrenheit. The higher the API, the lighter the oil.

Appraisal well: a well drilled to determine the physical extent, reserves and likely production rate of a field, to assess the commerciality of the discovery.

Aromatics: a group of unsaturated cyclic hydrocarbons containing one or more structural carbon rings. They are highly reactive and chemically versatile. The group name is derived from the strong and not unpleasant odour characteristic of most chemicals in this family.

Associated gas: natural gas associated with accumulations of oil, which may be dissolved in the oil or may form a cap of free gas above the oil.

Backwardation. The futures market is in backwardation when the near delivery months trade at a premium to distant months.

Barrel: a unit of volume measurement used for petroleum and its products (7.33 barrels = 1 ton. 6.29 barrels = 1 cubic metre).

Baseload (in electricity generation): capacity that is run continuously, independent of demand on the electricity network. Generally coal-fired power stations or nuclear power, as these are normally the cheapest suppliers.

Basis: difference between a spot or 'cash' price and the nearest equivalent futures price or the price difference between different delivery points of the same commodity. In general, the difference between the actually received price and the index marker used to trade.

Bed: the geological term defining a stratum of any thickness, and of uniform homogeneous texture.

Benzene: a flammable and explosive liquid, used to make ethylbenzene, phenol, cyclohexane (for nylon), and detergents.

Biodiesel: includes methyl-ester (from vegetable or animal oil, of diesel quality), biodimethylether (from biomass), Fischer Tropsch (from biomass), cold pressed bio-oil (from oil seed through mechanical processing only) and all other liquid **biofuels** which are added to, blended with or used straight as transport diesel.

Biofuels: these are transportation fuels derived from biological sources, inc cellulosic (wood) materials, cereals, sugar and other crops, and organic waste.

Appendix 6: Glossary

Bit: see *Drill bit*.

Bitumen: the black/brown sludge or solid that is used to produce asphalt. Although it can occur naturally, bitumen also results from the distillation process.

Block: an acreage sub-division approximately 10x20kms, forming part of a quadrant. For example, Block 9/13 is the 13th block in Quadrant 9.

Blow-down: condensate and gas is produced simultaneously from the outset of production.

Blow-out: occurs when well pressure exceeds the ability of the wellhead valves to control it, resulting in uncontrolled hydrocarbon flow.

Blow-out preventer: high-pressure wellhead valve, designed to shut off the uncontrolled flow of hydrocarbons.

Boe: barrels of oil equivalent (see **Conversion Table** section).

Borehole: the hole as drilled by the drill bit.

Bottom-hole assembly (BHA): lower part of drillstring from the bit to the drill pipe. Can consist of drill collars, subs such as stabilizers, reamers, and jars, mud motors, MWD, bit sub and bit.

Cantilever jack-up: type of offshore rig jacked up on self-elevating legs using a rack and pinion system. It enables the drilling package to move, enough to allow it to be cantilevered over the side of the rig and extend over an existing platform. Provides increased drilling and work-over flexibility.

Cap rock: an impervious layer (eg clay) overlying a reservoir rock and preventing the petroleum from escaping.

Carbonate rock: a sedimentary rock, sometimes a reservoir rock primarily composed of calcium carbonate (limestone, chalk) or calcium magnesium carbonate (dolomite). It sometimes forms petroleum reservoirs.

Casing: the steel lining that supports the sides of the well and prevents the flow of fluid both from and into the well bore. In addition, it provides a means of controlling well pressures and oil production.

Casing perforation: in cased wells, the casing is pierced in the hydrocarbon-bearing formation in order to allow the hydrocarbon to flow into the well. This operation is done by a perforating gun made up of a number of linked-shaped explosive charges.

Catalyst: a substance that enables a chemical reaction to take place at a faster rate or under different conditions, such as a lower temperature than otherwise possible.

Catalytic cracking: whereas distillation separates a liquid (or solid) into its constituent parts, but does not change them, catalytic cracking alters the molecular structure of the constituent parts.

Catalytic reformation: the use of a catalyst to rearrange certain hydrocarbon molecules without altering their composition appreciably (conversion of low-octane gasoline fractions into higher octane fractions).

CCGT: Combined Cycle Gas Turbine: a design of gasfired power plant that recycles exhaust gas for further energy extraction. CCGT plants can achieve thermal efficiencies of >65%.

Cement/cementing: the filling of the space between the casing and the borehole wall with cement. This keeps the casing in the hole stationary and prevents leakage to/from other strata that have been drilled through.

Cetane number: a measure of diesel fuel's propensity for self-ignition. The higher the number, the greater the combustibility (more desirable).

Choke: a steel orifice contained within a Christmas tree to regulate the flow of hydrocarbons from the well to the manifold or production separator, or to regulate the flow of water or gas in injection wells.

Christmas tree: the assembly of fittings and valves on the top of the casing that controls the production rate of oil. Also known as a 'tree'.

Appendix 6: Glossary

CIF: Cost, Insurance and Freight. The seller must pay the cost, insurance and freight necessary to bring the oil/LNG to the named destination.

Clastic rocks: sedimentary rocks composed of fragments of pre-existing rocks.

CNS: Central North Sea.

Coflexip: French pipeline company, acquired by Technip in 2003. The name is also used as a generic name for composite flexible pipelines.

Commercial field: hydrocarbon field judged to be capable of producing enough net income to make it worth developing.

Completion: a single operation involving the installation of equipment in and on a well, after drilling and evaluating the well, to bring on production from one or more zones.

Condensate: a mixture of pentanes and higher hydrocarbons which are gaseous under reservoir conditions and which become liquid when temperature or pressure is reduced.

Conventional oil: crude oil derived from a traditional oil field containing oil held under pressure in a permeable rock in the subsurface.

Coring: taking rock samples from a well by means of a special tool – a 'core barrel'.

Crane barge: a large barge, capable of lifting heavy equipment onto offshore platforms. Usually known as a 'derrick barge'.

Creaming Theory: a statistical technique which recognises that in any exploration province after an initial period in which the largest fields are found, success rates and average field sizes decline as more exploration wells are drilled and knowledge of the area matures.

Coke: the residue of coal left after catalytic cracking of oil that is used as fuel.

Coking coal: coal with a quality that allows the production of a coke suitable to support a blast furnace charge. A category of hard coal (see below).

Condensates: liquid hydrocarbons recovered from non-associated gas reservoirs. They are composed of C4 (butane, etc...) and higher carbon number hydrocarbons. They normally have an API of 50°-85°.

Contango: occurs when the price of near delivery is lower than future delivery. The opposite of *backwardation*.

Core: a cylindrical rock sample cut from the well during drilling by means of an annular cutter. These are examined to obtain geological information.

Crack: any of a number of differentials indicating relative refinery profitability, eg 'gas crack' = the difference between the gasoline and crude prices.

Crack spread is a crude measure of gross refinery profitability, based on the price difference between a basket of products and a specific crude price, usually in the forward market.

Cracked gas: gas which forms as a by-product of the cracking processes. Can be used as an input in the production of chemicals.

Cracking: the refining process of breaking down the larger, heavier, lower-value and more complex hydrocarbon molecules into simpler, lighter, and higher value molecules (transforming lower-value crude oil into a higher-value crude oil such as gasoline.) Cracking is accomplished by the application of heat and pressure and, in certain advanced techniques, by use of a catalyst.

Crude assay: a procedure for determining the general distillation and quality characteristics of crude oil.

Crude oil: a mineral oil of natural origin, comprising a mixture of hydrocarbons and associated impurities. It is generally assumed to be from *conventional* fields unless specified.

Cryogenic: of or relating to the production of very low temperatures.

Cubic foot: a standard unit used to measure a quantity of gas (at atmospheric pressure); 1 cubic foot = 0.0283 cubic metres.

Cuttings: rock chippings cut from the formation by the drill bit, and brought to the surface with the mud. Used by geologists to obtain formation data.

Appendix 6: Glossary

DCQ (Daily Contract Quantity): specifies the contracted level of daily gas deliveries.

Dehydrogenation: process by which hydrogen is removed from compounds by chemical means.

Delivery point. a location designated by the futures exchange where a physical commodity may be delivered against a futures contract.

Depositional environment: the conditions under which a series of rock strata were laid down. Depositional environments are divided into essentially 6 groups: marine (laid down under oceans or seas), lagoonal (laid down under sheltered, near-shore marine conditions), deltaic (laid down by a river at its delta), alluvial/fluvial (laid down by a river), lacustrine (laid down under a lake), and aeolian (laid down by wind).

Derrick: the tower-like structure that houses most of the drilling controls.

Derrick barge: a sea-going barge fitted with one or more cranes, capable of lifting large weights (up to 14,000 tonnes). Eg jacket installation/positioning.

Development well: well drilled to bring a proven oil or gas field into production.

Deviated wells: these are directionally drilled, primarily to allow as large an area as possible to be drained of hydrocarbons from a single location.

Dew Point: the temperature and pressure at which a liquid begins to condense out of a gas. For example, if a constant pressure is held on a certain volume of gas but the temperature is reduced, a point is reached at which droplets of liquid condense out of the gas – the dew point. Similarly, if a constant temperature is maintained on a volume of gas but the pressure is increased, the point at which liquid begins to condense out is the dew point at that temperature.

Diesel fuel: a general term covering the oils used to make up fuel for diesel engines.

Directional drilling: intentionally drilling a well at an angle from vertical. Used in offshore wells, for sidetracking a well. Technology that evolved into capability to drill horizontal wells.

Distillation: process via which the various components of the mixture to be distilled can be separated off (fractionated) by the difference in relative boiling points. The distillation of crude oil is usually referred to as ‘topping’. To prevent the cracking of less volatile distillates (those with a higher boiling point), distillation can be carried out under vacuum.

Drill bit: cutting tool used in drilling. Most common types are the roller cone bit and the polycrystalline diamond compact bit (PDC). Roller cone bits have rotating cones mounted on legs that are welded to the shank. The legs hold bearings around which the cones spin. Roller cone bits are either milled tooth – steel teeth or tungsten carbide insert (TIC) button bits. Rotary bits can also be drag bits, which have blades that tear into soft formations. PDC bits are drag bits that have no moving parts, using man-made diamonds embedded into the bit, and are good for directional drilling. Both types of bit have an opening in the bit body and nozzles between cones or on the face through which drilling fluid (mud) flows.

Drill Stem Test (DST): this is a procedure whereby the well is alternately flowed and shut-in for varying periods in order to allow the bottom hole pressure to be monitored and the reservoir’s response analysed.

Drill string (drill pipe): this is made up of lengths of steel pipe (usually each of 30ft) connecting the drill bit with the drilling rig. The drill string is used to rotate the drill bit and to act as a conduit to circulate drilling mud to the cutting face.

Drilling fluid (mud): fluid circulated down the well during rotary drilling to cool and lubricate the bit and remove well cuttings. Drilling mud is also used to control sub-surface fluids and pressures and provide support to well walls by building a filter cake. 3 types: water-base muds, oil-based muds and gas. Variations can depend on the salinity of the water used from fresh to brines. Additives to muds are clays such as bentonite.

Appendix 6: Glossary

Drilling rig: any kind of drilling unit: land, platform, submersible, semi-submersible jack-up or drill ship. Also means the derrick and its associated machinery.

Drillship: a ship-shaped drilling vessel, normally capable of operating in very deep water. The ship drills through a hole in the hull. In general drillships are dynamically positioned, although some older vessels are moored.

Dry gas: natural gas composed mainly of methane with only minor amounts of ethane, propane and butane and little or no heavier hydrocarbons in the gasoline range.

Dry hole: a well that has proved to be non-productive.

Dynamic positioning (DP): a system of keeping offshore vessels on station, using propellers, thrusters, combined with satellite positioning.

E&A: Exploration and Appraisal.

E&P: Exploration and Production.

Effective permeability: the permeability of a rock to fluid when the saturation of the fluid is less than 100%.

Enhanced Oil Recovery (EOR): any process whereby oil is produced other than by natural reservoir pressure.

EPC: Engineering, procurement and construction. A common contract form for onshore projects.

EPCM: Engineering, procurement, construction and management. A contract form for projects, which separates engineering responsibility from construction responsibility and is generally low risk for the engineer.

EPIC: Engineering, procurement, installation and commissioning. A common contract form for offshore and subsea construction.

Ethane: part of the methane series, this forms one of the main components of naturally occurring gas.

Ethylene: a colourless gas with a slightly sweet odour. It turns from liquid to gas at -155°F . It is flammable and explosive, and is used to produce petrochemical products such as PE, SM, EG, MEG EDC, PVC.

Exploration: the search for oil or gas using detailed geological and geophysical processes followed up, where appropriate, by exploratory drilling.

Exploration well: drilled in areas not already proven to have reserves, to find the limits of a reservoir, or to find new reservoirs in fields where reserves are known to exist. Also known as a *wildcat well*.

Farm in: the acquisition of a part interest in a project or prospect by taking over all or part of the financial commitment of development, most commonly exploration or appraisal work.

Farm out: when the holder of a block sells part of the block in exchange for the buyer making a financial commitment to fund part or all of the development.

Fault: a fracture along which the rocks on one side are displaced relative to those on the other.

Fault trap: caused when a reservoir layer (eg sandstone) is faulted and juxtaposed against an impervious rock, which prevents the migration of hydrocarbons. Consequently oil or gas accumulates against the fault.

FEED: Front-End Engineering Design. Generally the full design specification for facilities to be constructed.

Feedstock: raw material supplied to a machine or processing plant. Here it refers to materials such as natural gas and petroleum used to make petrochemicals.

Field: a geographical area under which an oil or gas reservoir lies.

Appendix 6: Glossary

Fischer-Tropsch (F-T) synthesis: a process that combines carbon monoxide and hydrogen into liquid hydrocarbons, using catalysts usually based on iron and cobalt. When combined with gasification, F-T can be used with natural gas, coal or biomass as feedstock to produce synthetic diesel or lubricant. F-T is the core technology of GtL plants.

Fishing: retrieving objects from the borehole, such as a broken drill string or tools.

Fixed cutter bits: See *drill bits (diamond and PDC)*.

Flare: a vent for burning off petroleum products, which cannot be produced or re-injected into the reservoir.

Flaring: see *Flare*.

Flexible flow lines: pipelines that are transported to the installation site on reels and uncoiled and laid simultaneously.

Flow rate: the rate at which the hydrocarbons flow up through the oil well, expressed in terms of bbls/day for oil and standard cubic feet per day for gas.

Fluidised catalytic cracking (FCC): a cracking process in which the catalyst is kept in a liquefied form, allowing it to flow back and forth from the regenerator where the coke is burned off, thereby regenerating the catalyst.

F.O.B.: Free on board. The transfer of ownership of crude oil/LNG from the seller to the buyer when the oil/LNG is loaded on board a transportation vessel, as specified in the sales contract.

Formation fracturing (frac job): a well stimulation process in which frac fluids are pumped down casing or a temporary work string under high pressures to artificially fracture a reservoir rock so as to increase permeability and production. Frac fluid is usually water (sometimes with acid) or diesel oil and can carry thickening agents to increase viscosity or proppants such as sand or aluminium oxide pellets that are suspended in the fluid and are used to hold the fractures open after pumping is complete.

FPS(O): Floating production system, or Floating production, storage and offloading.

Fraction: that part of petroleum separated off from other parts at a particular boiling range.

Fractionating column: a vertical cylindrical vessel in which oil is distilled (broken down into its constituent parts).

Gas cap: this is a free-gas phase overlying an oil zone and occurring within the same reservoir as the oil.

Gas field: a field containing natural gas but no oil.

Gas injection: the process whereby separated associated gas is pumped back into a reservoir for conservation purposes or to maintain the reservoir pressure.

Gas lift: process where productivity rates from a well are increased by injecting gas into the production tubing. The gas, injected deep in the well, mixes with the oil, reduces its density and viscosity, increases the pressure and hence improves the flow rate. The gas can be recovered and re-injected. If the oil in the reservoir has a high associated gas content, this will have a similar effect (and is referred to as a 'natural gas lift' as opposed to 'artificial gas lift').

Gas/oil contact (G.O.C.): the interface between the gas cap on a reservoir and the underlying oil column in the reservoir.

Gas/oil ratio (G.O.R.): the volume of gas at atmospheric pressure produced per unit of oil produced.

Gasoline: a light petroleum product; also known as petrol.

Geophone: an instrument that detects seismic waves passing through the earth's crust, used in conjunction with seismography.

Gravel packing: the installation of artificial gravel between the production tubing and the well bore in the reservoir. The gravel prevents the collapse of the well bore and the production of fine sediments that can block or erode the production equipment.

Appendix 6: Glossary

Gravity platform: generally constructed from reinforced concrete, and its design often incorporates a large storage chamber in its base. This chamber may be flooded with water when the platform is on its proposed location, allowing the platform to sink to the sea bed and remain there under its own weight. When oil is being produced, the water contained in the chamber may be replaced by oil for storage purposes.

GtL: the production of fuel products – low sulphur diesel and naphtha – from natural gas reserves, using gas-to-liquids technology.

Hard coal: coal of gross calorific value greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis and with a mean random reflectance of vitrinite of at least 0.6. Includes coking and steam coal.

Heavy crude oil: a crude oil of relatively low API gravity. In the North Sea, crudes with API° of 20 or lower are heavy.

Heavy lift vessel: a ship equipped with a large crane. Large vessels can lift up to 5,000 tonnes.

High pressure high temperature (HPHT): a well with a closed-in wellhead pressure of >10,000 psi and a bottom hole temperature >150°C.

Horizon: a plane, level or rock stratification assumed to have been once horizontal and continuous. A stratum or set of strata characterised by a particular fossil or group of fossils.

Horizontal drilling: drilling of a well that deviates from the vertical to the horizontal. Horizontal completion is frequently used with thin reservoirs for better recovery.

Hydrocarbon: an organic compound consisting only of the carbon and hydrogen, derived largely from petroleum, coal tar, and vegetable sources.

Hydrocracking: a cracking process in which heavy hydrocarbons are broken down using a catalyst under high pressure.

Hydrodesulphurisation: used to clean products or inputs by reducing the sulphur content by using hydrogen under pressure over a catalyst. The process is becoming increasingly important, as new environmental legislation requires low sulphur content to improve air quality. Also referred to as 'hydrotreating'.

Hydrogenation: chemical combination of hydrogen with another substance, usually an unsaturated organic compound, by means of heat, pressure, and catalysts.

Hydrogen skimming: a topper refinery with reformer.

Improved Oil Recovery (IOR): techniques that result in an increased oil recovery factor from a reservoir compared with previous flow rates. May be achieved by using conventional methods including improved reservoir management and cost-reducing measures, or by using advanced methods (see *EOR*). Conventional methods include injection of water and/or gas, infill drilling, horizontal wells for drainage of thin oil zones or remaining oil pockets, long reach wells for drainage of oil in the outer flanks of the reservoir, reduced wellhead pressure or artificial lift in the wells, upgrading of treatment capacity for produced water and/or gas, change of completion strategy.

Injection well: a well used for pumping water or gas into the reservoir.

Inorganic chemical: any chemical compound that does not contain carbon.

Intelligent completion systems: a down-hole completion system that uses sensors and communication equipment to monitor down-hole conditions in real-time. The system's production equipment can also be controlled from the surface to adjust to changing production conditions and maximize hydrocarbon recovery.

Isomerisation: a refining process that alters the fundamental arrangement of atoms in the molecule without adding or removing any atoms from the original material. It is used to convert normal butane into isobutane (iC4), an alkylation process feedstock, and normal pentane and hexane into isopentane (iC5) and isohexane (iC6) (high-octane gasoline components).

Appendix 6: Glossary

Jacket: the lower section, or 'legs', of an offshore platform.

Jack-up rigs: drilling vessels with 3 or more extendible legs, which are jacked down to the sea bed when a drilling location is reached. The hull must be lifted clear of the water, consequently few rigs of this type can operate in water depths of more than ~90 metres (350 feet). A jack-up rig is equipped with a drilling derrick which projects out away from the hull, enabling the rigs to be used to undertake drilling operations from wellhead platforms.

Kerosene: a petroleum product defined by a particular boiling range. Used as lamp oil and jet fuel. Part of the light distillate group.

Lay barge: a barge specially equipped to lay rigid and flexible submarine pipelines.

Light crude oil: a crude oil of relatively high API gravity (usually $\geq 35^\circ$).

Lignite/brown coal: non-agglomerating coals with a gross calorific value $< 17\,435$ kJ/kg ($4\,165$ kcal/kg) and $> 31\%$ volatile matter on a dry mineral matter free basis. Used in power generation, but generally not valuable enough for export.

Liquefied natural gas (LNG): as the name suggests, this is simply naturally occurring gas liquefied at certain temperatures and pressures to facilitate storage, transport and handling.

Liquefied petroleum gas (LPG): propane and butanes liquefied under relatively low pressure and ambient temperatures. LPG is a gaseous fuel, ~95% propane. It is stored under pressure at the refinery, sold in pressure cylinders as the familiar bottled gas for domestic use or industrial use where other fuels are less appropriate.

Load factor: mathematical term to express fluctuations in gas demand which is calculated as: average daily demand ÷ peak daily demand

Logging-while-drilling (LWD): using measurement while-drilling tools to acquire down-hole information in real-time or on a recorded basis. Key measurements include resistivity, porosity, density and sonics.

Logs: see *wireline logs*.

Lower 48: the mainland states of the US, excluding Alaska and Hawaii.

Lubricants (lubes): hydrocarbons produced from distillate or residue, mainly used to reduce friction between bearing surfaces. This category includes all finished grades of non-synthetic lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.

Mboe: million barrels oil equivalent.

Mcf/d: millions of cubic feet per day (of gas).

MD (measured depth): the linear distance of a well measured along its drilled projection.

Measurement while drilling (MWD): a method and tool used to record or transmit information in real time about well direction and/or formation evaluation during the drilling of the well. The tool is installed in nonmagnetic drill collars, as close to the bit as possible. Power is obtained either from turbine generation from drilling mud circulating through the tool, or from batteries. The data can be transmitted to the surface using fluid pulse, telemetry, or wireline run in the drill string or by storing it down-hole and retrieving it after each bit run. The pulses are detected by a surface pressure transducer and decoded by computer.

Methane: the main constituent of naturally occurring gas.

Middle distillate: kerosene and distillate fuel oil.

Appendix 6: Glossary

Modules: an assembly containing numerous components, designed to be installed and disconnected as one. Using modules can significantly reduce installation and commissioning times.

Mogas: motor gasoline.

Moonpool: a gap in a ship's hull to give access to the sea. Generally used in drillships and in offshore construction vessels for divers, ROVs etc.

Mt: million tonnes.

MTBE: Methyl tertiary butyl ether, $(\text{CH}_3)_3\text{COCH}_3$. An additive used for gasoline blending, particularly for high-octane grades. Changes to US legislation in 2006 led to widespread curtailment of its use with refiners using ethanol as a substitute in gasoline.

Mud: a mixture of base substance and additives used to lubricate the drill bit, bring cuttings to the surface and to counteract the natural pressure of the formation by lining the borehole.

Mud logging: the recording of information derived from examination and analysis of formation cuttings made by the bit and mud circulated out of the hole. A portion of the mud is diverted through a gas-detecting device and examined under ultraviolet light to detect the presence of oil or gas.

Multi-client survey: a seismic survey that is conducted and owned by the seismic services company for its own library. The costs of such surveys may be partially underwritten by oil company clients or by the service company themselves. These surveys are typically recorded in areas where multiple clients have widespread access to acreage and can be sold to several customers at a time.

Naphtha: generic term applied to refined, partly refined, or unrefined petroleum products and liquid products of natural gas that boil at 347-464°F.

Natural gas: gas, occurring naturally, and often found in association with crude petroleum.

Natural Gas Liquids (NGLs): liquid hydrocarbons found in association with natural gas.

Netback: sales price at destination minus the full cost of transportation, and in some cases taking account of certain production taxes. Usually expressed as netback-to-wellhead.

Neutral Zone: the territory between Saudi Arabia and Kuwait where production is shared 50/50 and is included within each countries' respective OPEC quotas.

Octane: the level of gasoline's resistance to pre-ignition. High-compression engines can induce early ignition in lower octane fuels during the compression stroke resulting in engine locking.

Oil: a mixture of liquid hydrocarbons of different molecular weights.

Oil field: a geographic area under which an oil reservoir lies.

Oil in place (OIP): an estimated measure of the total amount of oil contained in a reservoir, and, as such, a higher figure than the estimated recoverable reserves of oil.

Oil water contact (OWC): the interface between the oil in a reservoir, and the underlying water.

Olefins: a class of unsaturated aliphatic hydrocarbons with the general formula of one carbon for every two hydrogens. They are the 'ene' form of paraffins (ie ethylene is the olefin of the paraffin ethane). The 'ene' suffix means that the polymer contains one or more double bonds, and is chemically reactive.

Operator: the company that has legal authority to drill wells and undertake production of the hydrocarbons found. The operator is often part of a consortium and acts on behalf of this consortium.

Appendix 6: Glossary

Organic chemical: any chemical that contains carbon.

Orimulsion: a proprietary trade name for a boiler fuel produced from the bitumen in the Orinoco Belt in Venezuela.

Packer: an expandable device that is run in either an open well, cased hole or in tubing to prevent fluids from flowing vertically. Consists of a sealing element, a holding or setting device, and a fluid passage. Often used to isolate zones for well testing, for cement and acid jobs or to complete a well. Can be reusable or permanent, depending on the application.

Paraffins: class of aliphatic hydrocarbons characterised by a straight carbon chain and having the generic formula C_nH_{2n+2} (also called alkanes). Occur primarily in Pennsylvania and mid-continent in the US.

Pay sand: the producing formation, often one that is not actually sandstone. It is also called pay, pay zone, and producing zone.

Pay zone: rock in which oil and gas are found in exploitable quantities.

PDC: Polycrystalline Diamond Cutter. A form of drill bit which uses synthetic diamonds to create a fixed cutting surface.

Peaking: (in electricity generation) capacity that is used to satisfy the daily peak in demand, rather than baseload capacity that runs 24h/day.

Perforate: to pierce the casing wall and cement to provide holes (perforations) through which formation fluids may enter the well-bore, or to provide holes in the casing so that materials may be introduced into the annulus between the casing and the wall of the bore hole. This is done by lowering into the well a perforating gun that fires electrically detonated bullets or shaped charges radially through the casing.

Permeability: the measure of the ability of the reservoir rock to allow the hydrocarbons to flow – measured in milli-Darceys (mD).

Petrochemical: any organic chemical for which petroleum or natural gas is the ultimate raw ingredient.

Petroleum: a generic name for hydrocarbons, including crude oil, natural gas liquids, natural gas and their products.

Petroleum coke (petcoke): a black solid residue, obtained mainly by cracking and carbonising residue feedstock, tar and pitches in processes such as delayed coking or fluid coking. It consists mainly of carbon (90-95%) and has a low-ash content.

Piling: refers to the steel 'pins' which are driven through specially designed slots on a jacket platform on a subsea template, and into the sea bed, in order to hold the structure in place. The 'pins' are often driven down to a depth of 45 metres (150 feet) or more.

Plastic: a high polymer, usually synthetic, combined with other ingredients, capable of being formed or moulded under heat and pressure, and of being machined to high dimensional accuracy, trimmed, and finished in its hardened state.

Platform: an offshore structure that is permanently fixed to the sea bed.

Play: a hydrocarbon play is a set of circumstances that combine to create the conditions necessary for the accumulation of oil and/or gas. A single play may contain a number of discoveries and prospects, but the favourable combination of the controlling geological parameters usually occurs over a limited geographic area, sometimes referred to as a 'fairway'.

Plugged: when the bore hole is sealed – either dry, uncommercial or awaiting further assessment.

Polyethylene (PE): a solid, white, wax-like material made by polymerising ethylene, and is a good electrical insulator that can be moulded. Applications include: LD/LLDPE (used in packaging film, toys, water bags, electrical insulation, wire and cable coating), HDPE (a substitute for polystyrene – used in blow-moulded products, injection-moulded items such as piping, fibres, gasoline and oil containers, man-made paper).

Appendix 6: Glossary

Polypropylene (PP): is a commodity thermoplastic resin that is translucent, readily coloured, and maintains its strength after repeated flexing. The primary end markets for PP are film (snack food wrappers), yarn and fibre (carpet backing, rope and upholstery), and moulded parts (auto bumpers and electrical components).

Polystyrene (PS): transparent, hard solid with high strength and impact resistance. 4 subgroups: GPS (general), EPS (expandable), HPS (high impact) and FRPS (fire resistant). GPS is used to produce containers, toys and plastic boards. HIPS is a co-polymer of SM and BR, which may be processed into safety helmets, and auto and electrical parts. EPS can be used to produce food containers and packaging. Consumer products include PS foam (eg disposable coffee cups). There is a lot of competition between PS and the other 5 big thermoplastics: LDPE, LLDPE, HDPE, PP and PVC. PS continues to lose market share, but seems to have a permanent place in some applications, particularly moulded foams (for carry-out food containers, some extrusion, sheet and film applications).

Polyvinyl chloride (PVC): a synthetic thermoplastic polymer that can be decomposed at 148°C, emitting toxic fumes of hydrogen chloride. End uses include piping and conduits of all kinds, electrical insulation, film, raincoats, door frames and magnetic tapes.

Porosity: the percentage of void in a porous rock compared with the solid formation.

Possible: those reserves that at present cannot be reserves regarded as 'probable' but are estimated to have a significant but less than 50% chance of being technically and economically producible.

Primary Migration: the initial displacement of the oil and gas from the source rock to the surrounding strata.

Primary recovery: recovery of oil or gas from a reservoir purely by using the natural pressure in the reservoir to force the oil or gas out.

Probable: reserves which are not yet proven but are estimated to have a better than 50% chance of being technically and economically viable.

Processing gain: the increase in volume of oil products compared to the oil used to produce them, which arises as the products have a lower density than crude oil. Also applies to refinery units which produce lower density output than input.

Proppant: small, well sorted grains that are hard and granular or spherical shaped used to hold open fractures created during a frac job. Sand is the most common proppant (ceramic beads are another popular product).

Propylene: a colourless gas that is flammable and explosive. Used to make AN, PP, and isopropyl alcohol.

Proven field: an oil and/or gas field whose physical extent and estimated reserves have been determined.

Proven reserves: those reserves, which on the available evidence, are virtually certain to be technically and economically viable (ie have a better than 90% chance of being produced).

PTA: purified terephthalic acid. A white crystal or powder, a key ingredient for polyester resins and fibres.

PTD: prognosed or predicted total depth of a well.

RBOB: reformulated gasoline blendstock for oxygenate blending, unfinished gasoline that is blended with ethanol to make RFG.

Recoverable: that proportion of the oil and gas in a reservoir that can be removed using currently available techniques.

Recovery factor: the ratio of recoverable oil and/or gas reserves to the estimated oil and/or gas in place in the reservoir.

Refinery catalytic cracker: facilities in a refinery where petroleum is cracked with the use of a catalyst.

Appendix 6: Glossary

Reforming: the process by which the molecular structure of straight-run gasoline fractions is altered to improve the so-called 'anti-knock' quality. This increases the octane level, which in turn reduces the flash point of a fuel. This allows greater performance from a compression engine, allowing the spark to ignite the fuel, rather than the heat from compression prematurely causing the explosion.

Reforming process: the use of heat and catalysts to effect the rearrangement of certain hydrocarbon molecules without altering their composition appreciably (conversion of low-octane gasoline fractions into higher-octane stocks suitable for blending into finished gasoline).

Re-injection: natural gas produced in association with crude oil can be re-injected to maintain reservoir pressure or avoid flaring it.

Residue: the leftover from the refining process. Long residue forms from the atmospheric distillation of crude, and can be distilled under vacuum to produce a heavier residual, called short residue. Cracked residue is that substance left over from thermal cracking operations.

Reservoir: the underground rock formation where oil and gas have accumulated. It consists of a porous and permeable rock holding the oil or gas.

RFG: reformulated gasoline, finished motor gasoline which meets the requirements of the reformulated gasoline regulations promulgated by the US Environmental Protection Agency (EPA) under Section 211(k) of the Clean Air Act.

Rig Count: statistical measure of industry activity that essentially seeks to determine how much drilling, completion and work-over activity is occurring around the world. There are many different types of rig count, but the Baker Hughes rig count has been the industry standard for many years.

Riser: pipe connecting wells or subsea production equipment to the surface.

Rotary steerable system: a tool designed to drill directionally with continuous rotation from the surface, eliminating the need to slide a steerable motor. Tools generally come in two designs – push the bit and point the bit. Push the bit systems use external pads on the side of the tool to push the drill bit in the desired direction. Point the bit systems use an internal rod that rotates in an elliptical fashion to point the drill bit in the desired direction. RSS systems tend to drill faster, smoother, more accurate directional/horizontal well bores than conventional down-hole motors.

Roughneck: drill crew members who work on the derrick floor, screwing together the sections of drill pipe when running or pulling a drill string.

Roustabout: drill crew members who handle the loading and unloading of equipment and assist in general operations around the rig.

ROV: Remotely Operated Vehicle. An unmanned submersible used for various tasks. ROVs are generally connected to their surface mother ship with an umbilical. ROVs come in work class (capable of intervention) and observation class (equipped with cameras and other sensors).

Royalty payment: the cash payment or payment in kind paid to the owner of the mineral rights (often the state).

RVP: Reid Vapour Pressure. A measure of the surface pressure required to maintain a gaseous material in a liquid state at 60°F. Low RVP gasoline (reduced tendency to vaporise) is used to avoid vapour lock and static emissions in warm climates and at higher altitudes. Higher RVP gasoline is required for cold starts during the winter.

Sand control: methods for preventing and dealing with loose, unconsolidated sands that drift or wash into the bottom of the well or into the down-hole pumping equipment during petroleum production. A gravel pack, expandable sand screen, and chemical consolidation are examples of sand control.

Sandstone: a detrital, sedimentary rock composed of individual grains of sand (commonly quartz) stuck together by silica, calcium carbonate, iron oxide or other cements. Sandstone is a common rock in which petroleum and gas accumulate.

Secondary migration: long globules of oil are forced through pore spaces in the rock by the force of moving water. Being lighter than water, it is usually forced upwards until it emerges at the surface or is trapped under a cap rock to form an accumulation of oil or gas.

Appendix 6: Glossary

Secondary recovery: recovery of oil or gas from a reservoir by artificially maintaining or enhancing the reservoir pressure (done by injecting gas, water or other substances into the reservoir rock).

Sedimentary rocks: formed by the compaction of mineral grains, which have been laid down as a result of denudation of land surfaces by water, ice, wind and sea. They often contain some amount of organic matter, the source material for oil and gas. Some sedimentary rocks have suitable properties of porosity and permeability.

Seismic survey: a technique to obtain geophysical data by projecting pressure waves from the sea through the sea-bed and into the rocks.

Semi-submersible rig: a floating platform moored on location by anchors on the sea-bed and/or with a dynamic positioning system of computer controlled thrusters. Stability in the water is achieved by submerged pontoons. Suitable for deep water, hostile sea environments, and development drilling in particular.

Separators: processing equipment that splits the wellhead fluid into separate oil, water and gas streams.

Shale oil: oil extracted by heat from clays which are impregnated with oil.

Show: an indication of the presence of gas or oil in the formations penetrated during drilling (ie a trace amount of oil or gas).

Sidetracking: is the use of an existing well bore to drill an additional bore laterally.

Sour crude/gas: has a high sulphur content (commonly means >1%) in the form of hydrogen sulphide and mercaptans.

Source rocks: hydrocarbons originated from organic matter, deposited and preserved within sedimentary rocks. Any sediments that have high organic carbon content and produce hydrocarbons in significant amounts are known as source rocks.

Spudding: the operation of drilling the first part of a new well.

Spur lines: generally small diameter pipelines connecting a production facility to either a terminal platform or to a main pipeline leading to the shore.

Steam coal: coal used for steam raising and space heating purposes, including all anthracite coals and bituminous coals not included under coking coal.

Steam crackers: crackers that use steam heat to initiate the process of breaking down larger, heavier, more complex hydrocarbons into simpler and lighter ones.

Steam reformation: the use of steam heat to affect the rearrangement of certain hydrocarbon molecules without altering their composition appreciably. The process changes the naphthenes in naphtha to aromatics, which increases the aromatics content of the oil from 20% to 50% (also the conversion of low octane gasoline fractions into higher-octane stocks suitable for blending into finished gasoline).

Straight-run: a production resulting from the distillation of petroleum without chemical conversion (ie no adjustment to the molecular structure or size).

Stratigraphic traps: can occur where sedimentary layers have changed in character. For instance, a deposit of coarse sand near the shore may have given place to finer grained sediment in deeper water and, as these sediments will vary in porosity/permeability, an apparently isolated reservoir can occur within this layer. Another case would be where a sand layer wedges out onto an impermeable clay or shale and becomes isolated from its own sedimentary layer. The latter type of trap is sometimes known as a pinch-out trap.

Structural traps: result from some local deformation (folding, faulting or both) of the reservoir and cap rock. Typical examples are anti-clinal and fault traps which are sometimes connected with salt domes.

Subsea production system: these are essentially wells drilled from a mobile drilling rig and completed with a series of Christmas trees and manifolds on the sea-bed. This wellhead equipment is then connected to a central collecting area (either a platform, or FPS) by flexible or rigid pipelines.

Appendix 6: Glossary

Suspended well: a well that has been capped off temporarily.

Sweet crude gas: hydrocarbons relatively free from sulphur compounds.

Swing: the fluctuation in gas demand and, as a result, supply during a specific period (day, week year, etc.). The higher the swing, the greater the fluctuation (see also *load factor*).

TCF: trillion cubic feet (of gas).

Tertiary recovery: methods of increasing the percentage of oil from fields beyond that achieved by secondary recovery. Methods include injecting solvents or high-pressure carbon dioxide, igniting part of the oil in the reservoir to generate steam, and biological breakdown of oils to enable them to flow more freely.

Thermal cracking: the use of heat to reduce the size of hydrocarbon molecular structure to convert heavy oils into lighter, more value added products.

Tight hole: well results that are not disclosed for commercial reasons.

Toluene: aromatic with many uses, including the production of dye stuffs and pharmaceuticals.

Topping: alternative term for crude oil distillation.

Tops: the lightest grade of gasoline, its name being derived from the fact that it is often the product taken from the top of the fractionating column.

Topsides: the superstructure of a platform, contains processing facilities and/or living quarters.

Trap: an arrangement of sedimentary strata which have the ability/potential to hold hydrocarbons, should they have been produced in the vicinity. By definition, the strata will contain a reservoir rock and cap-rock. Traps are commonly combinations of the above types, sometimes termed 'combination traps'.

Treating processes: these are in addition to the standard processes undertaken at a refinery and are used to clean up products in to prepare for marketing. An example is the reduction of sulphur content to fulfil quality requirements.

ULCC: ultra-large crude carrier.

ULSD: ultra-low-sulphur diesel. Generally refers to diesel fuel with a sulphur content of less than 15 ppm (in the US), or less than 50 ppm (in the EU).

Umbilical: the cable connecting subsea equipment to the surface control facilities. Umbilicals generally carry hydraulic and/or electric power, and may also have lines for the injection of fluids.

Unitisation: occurs when interest holders of petroleum reserves pool their individual interests in return for an interest in the overall unit, which is then operated by one company on behalf of the group. Unitisation should lead to increased efficiency from maximising production and minimising development and production costs.

Vacuum distillation: use of a vacuum to maintain stable temperatures to prevent cracking (change in the chemicals make-up of a hydrocarbon).

Vinyl chloride (VCM): compressed gas that is easily liquefied, and usually handled as a liquid. Phenol is added as a polymerisation inhibitor. Used in PVC and copolymers, organic synthesis, adhesives for plastics.

Visbreaking: thermal cracking used to reduce the viscosity (essentially, thickness) of long or short residues (see *Residue*).

Viscosity: the measure of a fluid's internal resistance to flow. Excess viscosity normally applies to residual fuel oils, which need to be maintained at temperatures of around 65-70°C to maintain their fluidity. At temperatures below 0°C diesel and gasoil can become cloudy and viscous, preventing their use in engines or boilers.

Appendix 6: Glossary

VLCC: very large crude carrier.

Volatility: the ease with which gasoline evaporates. Gasoline specifications generally require lower volatility in summer (due to higher temperatures) than in winter. The standard measure is *Reid Vapour Pressure* (RVP) – see above.

Water flood: a method of secondary recovery in which water is injected into a reservoir in order to remove additional quantities of oil that would otherwise be left behind after primary recovery.

Water injection: see secondary recovery and water flood.

Watered-out: when a production well is shut-in due to its unacceptably high proportion of water production.

Wellhead: see *Christmas tree*.

Wellhead platform: a minimum-facilities offshore platform used to locate well control and production facilities on the surface. No accommodation, processing or drilling facilities are provided. Wells are drilled from the platform with the assistance of a mobile drilling rig.

Wildcat: refers to an exploration well drilled without comprehensive geological knowledge of the locality.

Wireline logs: electrical tools run down a well on a steel cable. The equipment measures rock properties such as gamma radiation, which are used to determine rock properties through petrophysical equations such as lithology, permeability, porosity, formation fluid type, cement bond effectiveness etc.

Well log: a record of the geological formations penetrated during drilling, including technical details of the operation.

Wellbore: the inside of the well drilled by a drill bit.

Wildcat well: speculative drilling on unproven acreage. Also known as an *exploration well*. Etym: The term comes from exploration wells in West Texas in the 1920s. Wildcats were abundant in the locality, and those unlucky enough to be shot were hung from oil derricks.

Work-over: remedial work to the equipment within a well, the well pipe-work, or relating to attempts to increase the rate of flow.

Worldscale: the standard system for assessing freight rates, which calculates a benchmark price for standard voyages. Shipping prices are frequently expressed in worldscale points, a percentage of the notional benchmark price.

Yields: the ratio of light products to residue for any given barrel of oil from the same process will be influenced by the specific gravity of oil. For example, lighter crudes such as Brent will yield a greater proportion of lighter products compared with Arab Heavy.

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