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The Global Oil and Gas Industry

The oil and gas industry is one of the largest, most complex, and most important global industries. The industry touches everyone's lives with products such as transportation, heating and electricity fuels, asphalt, lubricants, propane, and thousands of petrochemical products from carpets to eyeglasses to clothing. The industry impacts national security, elections, geo-politics, and international conflicts. The prices of crude oil and natural gas are probably the two most closely watched commodity prices in the global economy. In recent years, the industry has seen many tumultuous events, such as the growth in oil and gas production in the United States; sanctions on Russia and improved international relationships with Iran; continued technological advances in unconventional oil and gas; ongoing strife in Iraq, Libya, and various other oil-exporting nations; continued heated discussion about climate change and non-hydrocarbon sources of energy; and continued uncertainty in crude and gas prices. All of this comes amid predictions that the global demand for energy will increase by 30%–40% by 2040.

Oil and Gas Industry Background

When Colonel Edwin Drake struck oil in northwestern Pennsylvania in 1859, the first phase of the oil industry began. John D. Rockefeller emerged in those early days as a pioneer in industrial organization. When Rockefeller combined Standard Oil and 39 affiliated companies to create Standard Oil Trust in 1882, his goal was not to form a monopoly, because these companies already controlled 90% of the kerosene market. His real goal was to achieve economies of scale, which he did by combining all the refining operations under a single management structure. In doing so, Rockefeller set the stage for what historian Alfred Chandler called the "dynamic logic of growth and competition that drives modern capitalism."[1]

With the Spindletop discovery of oil in East Texas in 1901, a new phase of the industry began. Before Spindletop, oil was used mainly for lamps and lubrication. After Spindletop, petroleum would be used as a major fuel for new inventions, such as the airplane and automobile. Ships and trains that had previously run on coal began to switch to oil. For the next century, oil, and then natural gas, would be the world's most important sources of energy.

Since the beginning of the oil industry, there have been fears from petroleum producers and consumers that eventually the oil would run out. In 1950, the U.S. Geological Survey estimated that the world's conventional recoverable resource base was about one trillion barrels. Fifty years later, that estimate had tripled to three trillion barrels. In recent years, the concept of *peak oil* has been much debated. The peak oil theory is based on the fact that the amount of oil is finite.

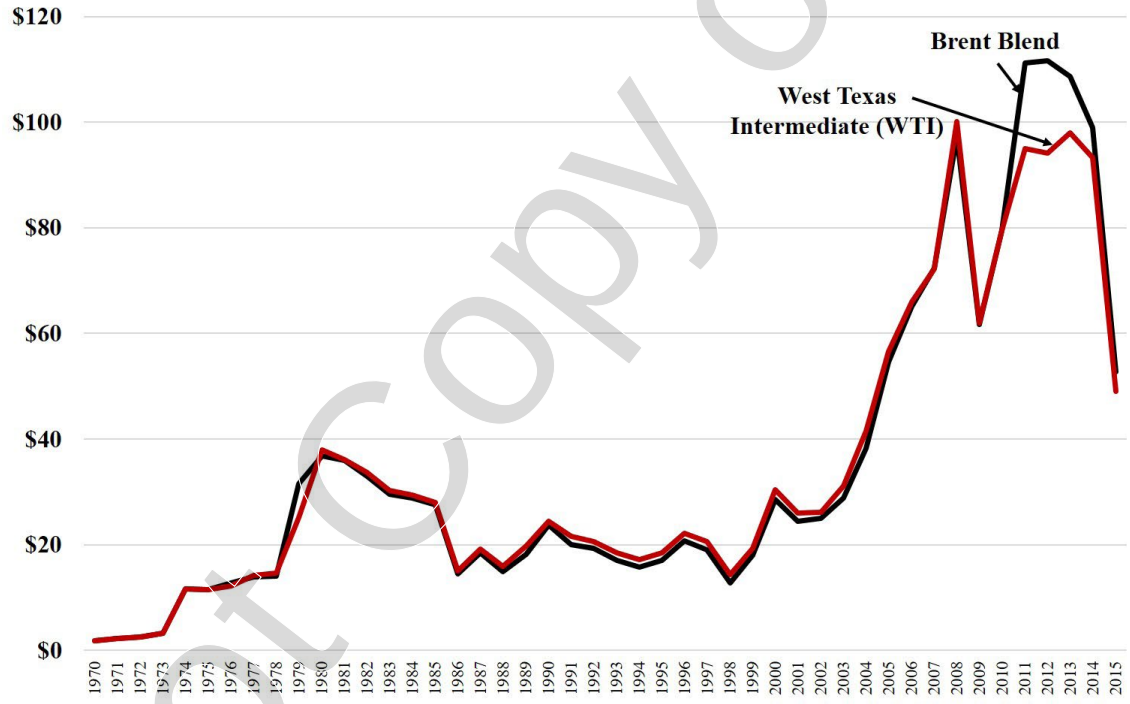
After peak oil, according to the *Hubbert Peak Theory*, the rate of oil production on Earth will enter a terminal decline. At various times, some analysts have argued that the peak has occurred, whereas others have argued that peak oil is a myth. An article in *Science* stated:

> *Although hydrocarbon resources are irrefutably finite, no one knows just how finite. Oil is trapped in porous subsurface rocks, which makes it difficult to estimate how much oil there is and how much can be effectively extracted. Some areas are still relatively unexplored or have been poorly analyzed. Moreover, knowledge of in-ground oil resources increases dramatically as an oil reservoir is exploited.*
>
> *To "cry wolf" over the availability of oil has the sole effect of perpetuating a misguided obsession with oil security and control that is already rooted in Western public opinion—an obsession that historically has invariably led to bad political decisions.*[2]

Regardless of whether the peak has or has not been reached, oil and natural gas are an indispensable source of the world's energy and petrochemical feedstock, and will be for many years to come. The difficulty in determining oil and gas reserves is that true reserves are a complex combination of technology, price, and politics. While technical change continues to reveal new sources of oil and gas, prices have demonstrated continued volatility, and resource owners have sought more control over access. As prices rise, reserves once considered non-economic to develop may become feasible. As prices fall, the opposite occurs.

The oil and gas industry has always been cyclical, with the price of oil and gas moving up and down. Exhibit 1 shows oil prices over the period 1970–2015. The Arab oil embargo of 1974 resulted in a large price increase and events in Iran and Iraq led to another round of crude oil price increases in 1979 and 1980. The period 1985 to 1998 was largely a period of low prices. Prices then started back up, only to fall after September 11, 2001. After 9/11, prices rose until the recession at the end of the decade, continued rising until 2014, and then fell significantly.

Exhibit 1. The Price of Oil, 1970–2015 (US$ per barrel)



Source: Annual average prices in U.S. dollars per barrel from *BP Statistical Review of World Energy, 2015*; 1970-73 is Brent Blend.

Oil and Gas Reserves

Discovering new oil and gas reserves is the lifeblood of the industry. Without new reserves to replace oil and gas production, the industry would die. However, measuring and valuing reserves is a scientific and business challenge because reserves can only be measured if they have value in the marketplace. The oil sands of Alberta, Canada, are a good illustration of how difficult it is to accurately measure oil and gas reserves. Oil sands are deposits of bitumen, a molasses-like viscous oil that will not flow unless heated or diluted with lighter hydrocarbons. Although the oil sands in Alberta are now considered second only to the Saudi Arabia reserves in the potential amount of recoverable oil, for many years these were not viewed as real reserves because they were non-economical to develop. For most of the 2000s and through 2014, the main town in the oil sands region, Fort McMurray, was in the midst of a boom not unlike the gold rush booms of the 1800s. Housing and labor were scarce and the infrastructure struggled to keep pace with the influx of people, companies, and capital. The development of the oil sands occurred because of a combination of rising oil prices and technological innovation. With the fall in oil prices after 2014, the oil sands region has seen many projects postponed or canceled. In 2016, the housing market in Fort McMurray was being called a housing bust.

Oil and Gas in the Global Economy

Oil and gas play a vital role in the global economy. The International Energy Agency (IEA) predicts that energy demand will rise significantly over the next three decades, with most of the increase coming from developing countries. Most of the world's growing energy needs through 2040 will continue to be met by oil, gas, and coal. With increased energy efficiency, energy as a percentage of total GDP has fallen and is expected to continue to fall.

Oil and Gas Supply

All countries are consumers of products derived from the oil and gas industry, but only a small set of nations are major oil and gas producers. Over the past decades, the large developed economies of the world have become net importers of oil and gas, giving rise to challenging geopolitical issues involving a diverse set of oil consumers and producers. Exhibit 2 shows the major oil- and gas-producing nations. The impact of unconventional technologies can be seen in the significant increases in U.S. and Canada production. From 2000 to 2014, Canadian oil sands production more than tripled, from about 600,000 b/d to over 2.2 MM b/d. The United Kingdom is a notable absence from the list of top oil producers, having dropped from 2 MM b/d in 2004 to less than 900,000 b/d in 2014.

Exhibit 2. Major Oil- and Gas-Producing Nations

Oil-Producing Nations			Gas-Producing Nations		
Country	Production Million bpd 2014	Change Over 2013	Country	Production Billion Cubic Meters, 2014	Change Over 2013
United States	11.6	5.9%	United States	728	6.1%
Saudi Arabia	11.5	.9%	Russia	579	-4.3%
Russia	10.8	.6%	Qatar	177	5.2%
Canada	4.3	7.9%	Iran	173	3.8%
China	4.2	.7%	Canada	160	3.8%
United Arab Emirates	3.7	.9%	China	134	7.7%
Iran	3.6	2.0%	Norway	108	.1%
Kuwait	3.1	-.5%	Saudi Arabia	108	8.2%
Iraq	3.3	4.6%	Algeria	83	2.2%
Mexico	2.8	-3.3%	Indonesia	73	1.7%
Venezuela	2.7	1.1%	Turkmenistan	69	11.1%
Nigeria	2.4	2.5%	Malaysia	66	-1.2%
Brazil	2.3	11.2%	United Arab Emirates	58	5.8%
Qatar	2.0	-.9%	Mexico	58	-.2%
Norway	1.9	2.9%	Uzbekistan	57	.7%
Angola	1.7	-4.9%	Netherlands	55	-18.7%
Kazakhstan	1.7	-1.2%	Australia	55	3.6%
Algeria	1.5	1.8%	Egypt	48	-13.1%
Colombia	1.0	-1.4%	Thailand	42	.8%
Oman	.9	.3%	Pakistan	42	-1.6%
World Total	88.7		World Total	3460	

Source: *BP Statistical Review of World Energy 2015*.

Industry Financial Performance

The oil and gas industry has been regularly criticized by politicians and the media for its high profits. In the U.S., proposals for industry excess profits taxes are common during high price cycles, prompting Lee Raymond, former ExxonMobil CEO, to comment in 2005, "I can't remember any of these people seven years ago, when the price was $10 a barrel, coming forward and saying, 'Are you guys going to have enough money to be able to continue to invest in this business?' I don't recall my phone ringing and anybody asking me that question."[3]

The oil and gas industry is highly cyclical and the cycles can last many years. In the 1990s, crude oil prices stayed low, and for the first 14 years in the new millennium, prices steadily rose (except for a brief dip in 2009). In 2014, oil prices fell significantly and continued downward in 2015. Many independent exploration and production (E&P) firms found themselves in financial distress.

Although the oil industry is highly profitable in some years, its long-term profitability is not much higher than average profitability across many industries. As evidence, some years ago *Fortune* reported that the oil industry ranked 30th out of 36 industries in return to investors over the 1985-95 period, 34th out of 36 U.S. industries in return on equity in 1995, and 32nd in return on sales.[4] In the U.S., the oil and gas industry has earned return on sales (net income divided by revenue) of about 8%, compared to an average of about 6% for all U.S. manufacturing, mining, and wholesale trade corporations.

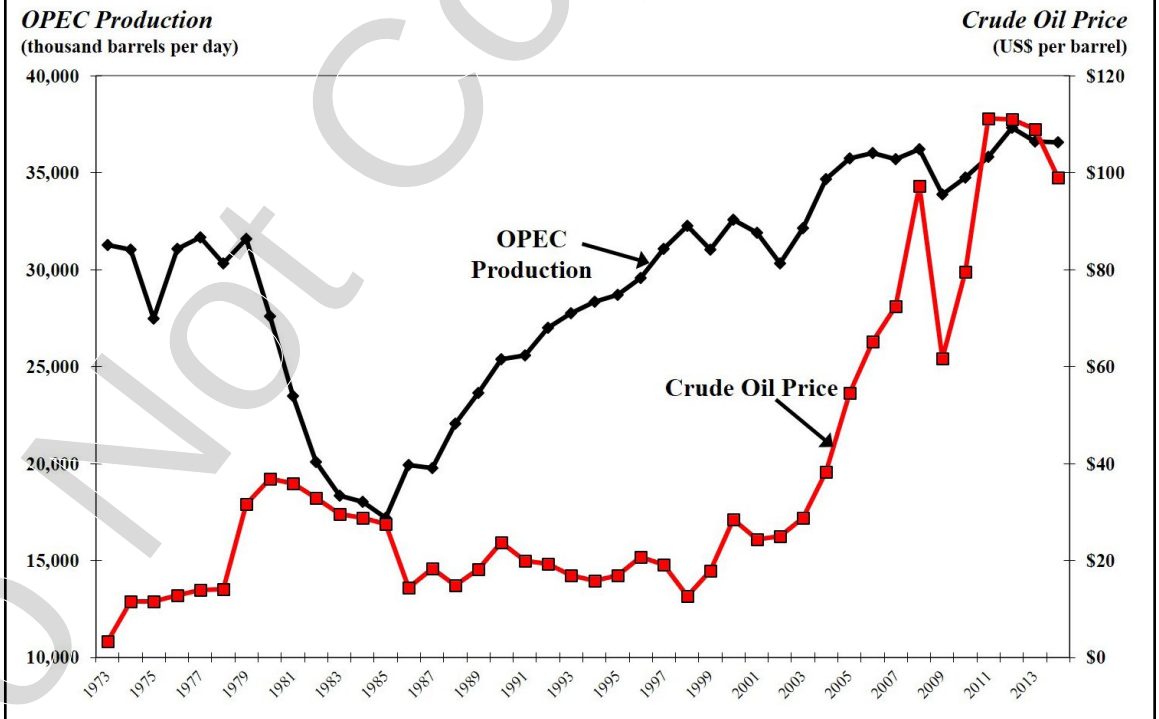
The Role of OPEC

The oil and gas industry has seen a remarkable bevy of government regulations and interventions over the past century, from heavy taxation of petrol in Europe to U.S. price controls on domestic production in the 1970s. The creation of the Organization of the Petroleum Exporting Countries (OPEC) represents government intervention on a global scale. OPEC was founded in 1960 with the objective of shifting bargaining power to the producing countries and away from the large oil companies. In 2006, Angola became the 12th member of OPEC.

OPEC's mission is "to coordinate and unify the petroleum policies of Member Countries and ensure the stabilization of oil prices in order to secure an efficient, economic, and regular supply of petroleum to consumers, a steady income to producers, and a fair return on capital to those investing in the petroleum industry."[5] Despite being a cartel, OPEC's ability to control prices is questionable. Surging oil prices in the 1980s resulted in energy conservation and increased exploration outside OPEC. Maintaining discipline among OPEC members has been a major problem (as is typical in all cartels). Massive cheating was blamed for the oil price crash of 1986, and in the 1990s Venezuela was considered one of the bigger OPEC cheats in regularly producing more than its quota.

Exhibit 3 shows OPEC production and crude oil prices. Although OPEC in the past was instrumental in sending periodic shocks to the system, by 2016 it appeared that OPEC's influence was waning.

Exhibit 3. OPEC Production and Crude Oil Prices



Source: *BP Statistical Review of World Energy, 2015*. Data are annual average.

The Resource Curse

The resource curse is a paradox of the oil and gas industry. Despite high resource prices, the living standards in many oil-producing countries are low because of the inability of countries rich in natural resources to use that wealth to strengthen their economies. Counter-intuitively, many of these countries also have lower economic growth than countries lacking an abundance of natural resources.[6] When times are good and oil prices are high, oil-rich countries may prosper. When oil prices fall, as they inevitably do, an overreliance on the oil sector can leave a country in a perilous situation. For example, Russia's GDP fell by 4% in 2015, inflation increased, and the country was running a sizeable budget deficit. Moreover, the oil industries of the petroleum-nationalistic countries often suffer from a lack of investment and heavily subsidized domestic petroleum products. As another example, Iran has huge oil reserves but the country's upstream oil industry is in a shambles. Iran's 2015 oil production, although up from a decade ago, was only about two-thirds of the level reached under the government of the former Shah of Iran in 1979. Although new refining capacity was added in recent years, Iran was still importing refined products to meet domestic needs. With Iranian sanctions ending, Iranian production could significantly increase in future years.

Mexico has declining production and significant imports of refined products. Until recently, the Mexican constitution did not allow foreign direct investment in the oil and gas industry. After many years of underinvestment and of Mexican governments using the oil industry as their primary source of revenue, the industry is in dire straits. Without major investment and new technology, Mexico's oil production is poised to fall. For example, production at the Cantarell oil field, one of the largest fields in the world, fell from more than 2 million b/d in 2004 to about 340,000 b/d in 2014.

Major Industry Players and Competitors

The organizations that dominate the global oil and gas industry have changed dramatically over time in who they are, what they do, and, of critical significance for the future of the industry, how they compete.

Integrated Oil Companies

The term integrated oil companies (IOCs) refers to companies that operate in many industry segments from exploration to refining, marketing, and retail. In the early days of the industry, there was true vertical integration in which producers refined most of their production and then marketed refined products through their company-owned retail outlets. In the modern industry, the IOCs operate in many segments, but the true vertical integration seen in the days of John D. Rockefeller is long gone. Somewhat confusingly, the term IOC can also refer to international oil company.

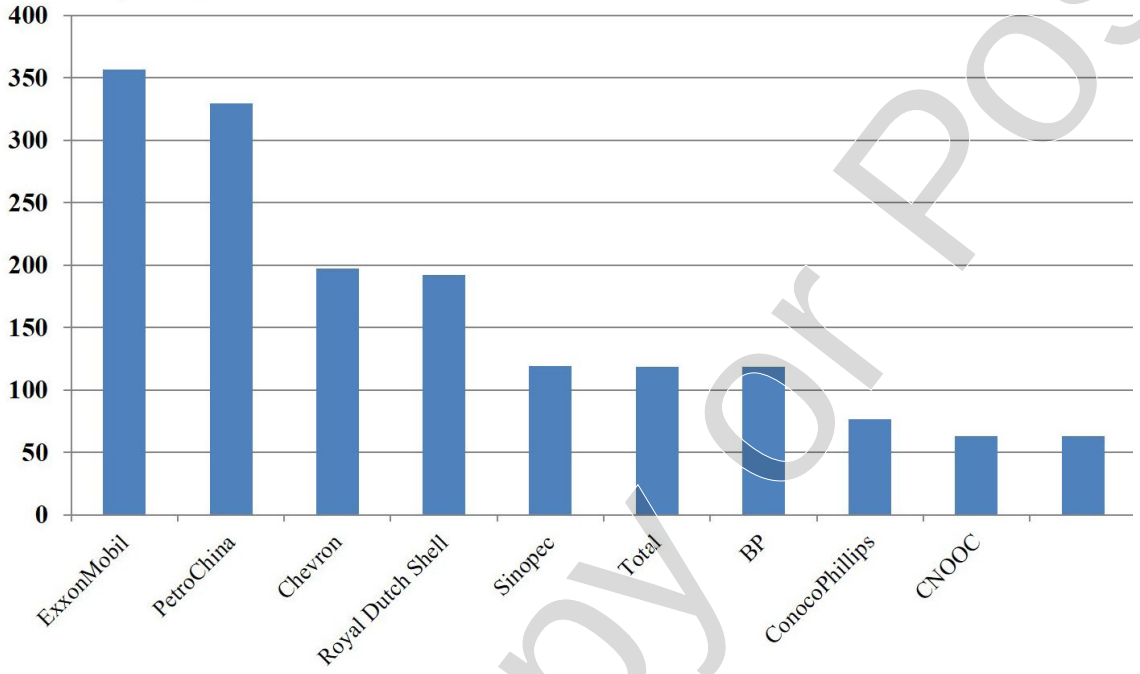
For many years, the largest IOCs (also known as oil majors) were the *Seven Sisters,* and included:

- Standard Oil of New Jersey (Esso), which later became Exxon and then merged with Mobil to create ExxonMobil
- Royal Dutch Shell
- Anglo-Persian Oil Company, which became British Petroleum, then BP Amoco following a merger with Amoco (which was formerly Standard Oil of Indiana). The company is now known as BP.
- Standard Oil of New York (Socony) became Mobil, which merged with Exxon
- Standard Oil of California (Socal) became Chevron
- Gulf Oil, most of which became part of Chevron
- Texaco, which merged with Chevron in 2001

Exhibit 4's list of the largest oil and gas companies by stock market capitalization is evidence that the industry is dominated by a mix of global IOCs and national oil companies (NOCs). Based on market capitalization, the largest publicly traded (and in some cases, government-controlled) companies are a diverse and global set of firms such as Petrochina (China), Gazprom (Russia), Sinopec (China), Total (France), and Eni (Italy).

Exhibit 4. Largest Oil and Gas Companies, 2015

Market Capitalization (billions of US dollars)



Source: *Financial Times* Global 500 list, March 2015. PetroChina, Sinopec, and CNOOC are National Oil Companies with both publicly traded shares and government-owned shares. ENI is partially owned by the Italian government.

The urge to get larger and more integrated can be seen in comments from the Oil and Natural Gas Corporation (ONGC) chairman. ONGC, an Indian state-controlled firm and primarily an upstream company, had made public its commitment to participate in the entire hydrocarbon value-chain. According to the former chairman of ONGC:

> *We have to be an integrated oil company. Every major global oil company is an integrated player. I'm not being arrogant, but oil and gas is big business where the big boys play. You can survive in this business only if you are integrated; otherwise, you will be out.*[7]

Given the long product life cycles and the huge capital investment required in the oil industry, the large IOCs are often described as stodgy and conservative. Before its bankruptcy, Enron executives regularly derided the oil majors as dinosaurs that were too slow moving and that would eventually become extinct. The reality, of course, is very different. Oil majors like BP, ExxonMobil, and Shell and their predecessor companies have been around for more than a century. Through experience that is occasionally painful, the IOCs have learned how to deal with the enormous financial and political risks of the oil and gas industry. The IOCs take a long-term view and recognized that cycles and uncertainty are an inherent part of the industry. Lee Raymond, former ExxonMobil CEO, said: "We're in a commodity [business]. We go through peaks and valleys but our business is to level out the peaks and valleys, so that over the cycle our shareholders see an adequate return on their investment."[8]

On the surface, the IOCs looked similar in terms of the activities they performed. All appear to be vertically integrated from exploration to distribution of refined products. However, there are fundamental cultural, organizational and financial differences among the firms. The IOCs used various organizational designs to deal with vertical integration. The IOCs had different portfolios of projects and business lines around the world and over the years developed different relationships with various governments and national oil companies.

Exhibit 5 provides one perspective on the origins and distinctive capabilities of a few major companies.

Exhibit 5. Distinctive Capabilities as a Consequence of Childhood Experiences: The Oil Majors

Company	Distinctive Capability	Historical Origin
Exxon	Financial management	Exxon's predecessor, Standard Oil (NJ), was the holding company for Rockefeller's Standard Oil Trust
Royal Dutch/Shell Group	Coordinating a decentralized global network of 200+ operating companies	Shell Transport & Trading headquartered in London and founded to sell Russian oil in China and the Far East
BP	"Elephant hunting"	Discovered huge Persian reserves; went on to find the Forties field (North Sea) and Prudhoe Bay (Alaska)
Eni	Deal-making in politicized environments	The Enrico Mattei legacy; the challenge of managing government relations in post-war Italy

National Oil Companies

One of the most important trends of the past few decades has been the growing importance of NOCs. Although BP, ExxonMobil, and Shell are among the largest publicly traded companies in the world, they do not rank in the top ten of the world's largest oil and gas firms measured by oil and gas reserves. The largest firms based on reserves are, by a large margin, NOCs partially or wholly state-owned. The NOCs control about 90% of the world's oil and gas and most new oil is expected to be found in their territories.

Viewed from a business perspective, the NOCs have a mixed reputation. The national oil company of Indonesia, Pertamina, was described a few years ago as a bloated and inefficient bureaucracy:

> *. . . [Pertamina] operated almost as sovereignty unto itself, ignoring transparent business practices, often acting independently of any ministry, and increasingly taking on the role of a cash cow for then-President Suharto and his cronies. During the 32-year tenure of President Suharto, Pertamina awarded 159 contracts to companies linked to his family and cronies. These contracts were awarded without formal bidding or negotiation processes….Indonesian petroleum law dictated that every aspect of operation in the country was subject to approval by Pertamina's foreign contractor management body, Bppka. Dealing with the incomprehensible Bppka bureaucracy on simple matters, such as acquiring work permits for expatriate personnel, can take hours of filling in applications and months of waiting.*[9]

Venezuela nationalized its oil industry in the 1970s and created Petróleos de Venezuela (PDVSA). PDVSA developed a reputation for professionalism and competence and was relatively free from the corruption and cronyism that pervaded, and continues to pervade, so many of the NOCs.[10] By 1998, 36 foreign oil firms were operating in Venezuela, and PDVSA had ambitious expansion plans. In 1999, Hugo Chávez became president and almost immediately began to question the management and autonomy of PDVSA. After a bitter strike in 2002, PDVSA lost about two-thirds of its managerial and technical staff. From a peak of 2.9 million b/d in 1998, output was 2.7 million b/d in 2014 and the company imported a significant amount of motor fuel. As a company, PDVSA is indistinguishable from the government. Its top officials are appointed from the government. The company is required to spend much of its investment budget on social programs. Company hiring policy is based on social and political goals; e.g., candidates from larger families are given priority. In 2006, the Venezuelan Congress approved new guidelines to turn 32 privately run oil fields over to state-controlled joint ventures. ExxonMobil, alone among the foreign oil companies, rejected the new joint venture agreements and sold its stake in the 15,000 b/d Quiamare-La Ceiba field to its partner, Repsol YPF. ExxonMobil subsequently filed an arbitration claim.

According to many analysts, nationalization has failed to live up to expectations almost everywhere. NOCs often suffer from excessive and misguided government intervention. Many NOCs operated as the de facto treasury for the country. In Nigeria, for example, the oil industry contributed about 75% of the government's total revenue and about 90% of export revenue. It is estimated that hundreds of billions from the oil industry have

been stolen or misused since 1960. Some of the Middle Eastern NOCs are required to hire large numbers of locals, leaving them heavily overstaffed. PDVSA and all of the Gulf country NOCs must sell their products at hugely subsidized prices. Underinvestment in the downstream is a chronic problem for many NOCs, resulting in countries like Indonesia and Iran, with huge reserves, having to import petroleum products. Monopoly positions held by many NOCs contribute to underinvestment. In Russia, Gazprom controls the pipeline network, making it difficult for other Russian gas producers to expand their production. Russia also uses its NOCs as agents of foreign policy. Disputes between Russia and its neighbors Belarus and Ukraine have resulted in disruption of oil and gas shipments to Western Europe.

Some NOCs are well-run and profitable enterprises. Statoil of Norway is considered among the best of the NOCs. The NOCs of Brazil and Malaysia are viewed as reasonably well-run companies. Petrobras has developed leading technology in deepwater drilling and, until its 2014 corruption scandal, had a market capitalization rivaling that of the IOCs.

The role that NOCs will play in the future is not clear. Some analysts see NOCs as inefficient and corrupt arms of government that will never compete in a true economic sense. Other analysts raise different issues, suggesting that the NOCs are in a period of transition and will become competitive forces to be reckoned with. Regardless of what happens, the NOCs and their sovereign owners control most of the world's oil and gas reserves. As Paolo Scaroni, the chairman of ENI, the Italian IOC, commented:

> *Big Western oil firms are like addicts in denial. The oil giants are trying to do business as usual as if nothing was wrong. Yet they are, in fact, having trouble laying their hands on their own basic product. State-owned national or state-controlled oil companies are sitting on as much as 90% of the world's oil and gas and are restricting outsiders' access to it. Worse, the best NOCs are beginning to expand beyond their own frontiers and to compete with the oil majors for control over the remaining 10% of resources. The first step in overcoming this predicament is admitting that it is a problem.*[11]

Independents

Independents are the non-government-owned companies that focus on either the upstream or the downstream. Many of these companies are sizable players and rank in the top 50 of all non-government-owned oil and gas companies. Among the largest E&P independents are U.S. firms such as Occidental, ConocoPhilips, Anadarko, and Woodside of Australia.

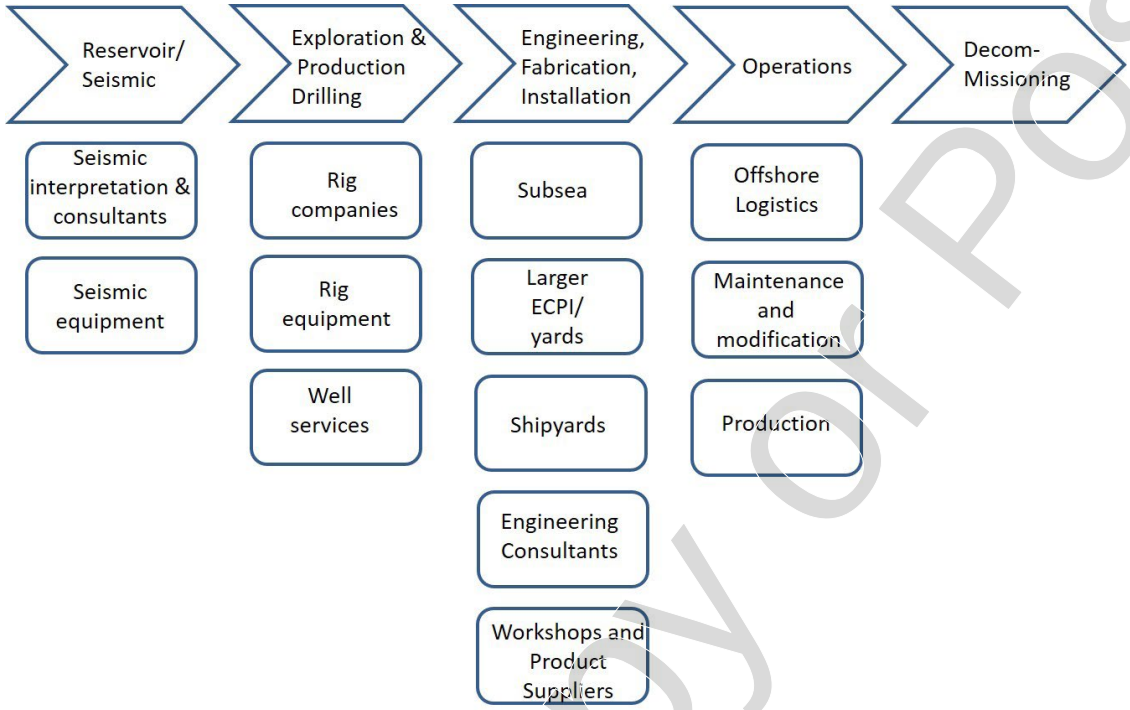
In the downstream sector, the largest independents are scattered around the world's largest energy-consuming countries. The downstream independents include Phillips66 and Valero in the United States and Neste and Tamoil in Europe. Some downstream independents are involved in multiple businesses such as refining, pipelines, and retail distribution, and others in only one core business area. The downstream independents tend to have lower market capitalizations than the upstream independents.

Other Firms

In addition to the IOCs, NOCs, and independents, the oil and gas industry includes a huge number of other firms that perform important functions. The oilfield services firms, the three largest of which are Schlumberger (105,000 employees), Halliburton (65,000 employees), and Baker Hughes (46,000 employees), play a critical role throughout the exploration, development, and production phases. These firms provide both products and services that, according to Baker Hughes' website, help oil and gas producers "find, develop, produce, and manage oil and gas reservoirs." Because the oilfield service firms do not seek ownership rights to oil and gas reserves, their role could become increasingly important in the future as partners to the NOCs. Exhibit 6 shows the vast range of activities performed by oilfield services firms.

Thousands of other firms provide a vast array of services and products for the industry. For example, gas utilities such as Gaz de France and Tokyo Gas are major customers for gas producers. Pipeline companies distribute gas, crude oil, and petroleum products. The firms involved in drilling and seismic services provide drilling rigs and expertise for onshore and offshore wells.

Exhibit 6. Oilfield Services Firms



Source: The Norwegian Oilfield Services Analysis 2014, EYGM Limited.

The Oil And Gas Industry Value Chain

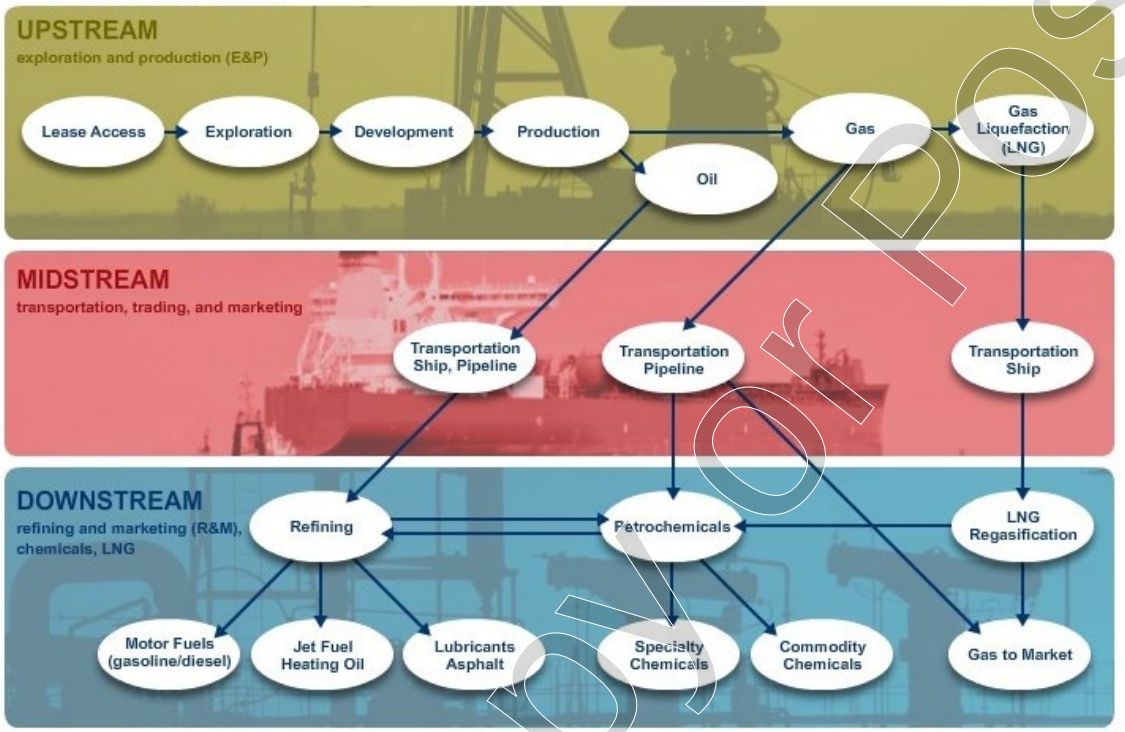
In every industry, there are various activities that transform inputs of raw materials, knowledge, labor, and capital into end products purchased by customers. A value chain helps identify the independent and economically viable segments of an industry.[12] Value refers to what customers are willing to pay for, so the value chain helps identify specific activities that create value throughout the chain. Companies can use value chains to determine where they are strong and where they have limited competitive strength. All industries have upstream (close to raw materials and basic inputs) and downstream (close to the customer) segments. The oil and gas industry value chain is shown in Exhibit 7. In the oil and gas industry, the terms upstream, midstream, and downstream are important descriptors of industry activities.

Upstream: Exploration, Development, and Production

Upstream activities include exploration, development, and production. In simple terms, after a lease is obtained, oil and gas are discovered during exploration; the discovery requires development; and production is the long-term process of drilling and extracting oil and gas. Since exploration and development must take place where resources are located and most oil ownership regimes are based on state sovereignty, companies have to deal with complex government policies and regulations. Most countries grant oil and gas development rights to private companies through a process of either negotiation or bidding. The main aim of the private company is profit maximization, whereas the host country government is usually interested in maximizing revenue. Not surprisingly, these two aims often conflict.

The method used to bid for, grant, and then renew or extend oil and gas rights varies from country to country. Once the rights to explore are acquired, a well is drilled. A financial analysis is a determining factor in the classification of a well as an oil well, natural gas well, or dry hole. If the well can produce enough oil or gas to cover the cost of completion and production, it will be put into production. Otherwise, it is classified as a dry hole, even if oil or gas is found. The percentage of wells completed is used as a measure of success. Immediately after World War II, 65% of the wells drilled were completed as oil or gas wells. This percentage declined to about 57% by the end of the 1960s. It then rose steadily during the 1970s to reach 70% at the end of that decade,

Exhibit 7. Global Oil and Gas Value Chain



primarily because of the rise in oil prices. This was followed by a plateau or modest decline through most of the 1980s. Beginning in 1990, completion rates increased significantly. The increases of recent years have more to do with new technology than higher prices.[13]

Most upstream projects are done in some type of partnership structure. For example, a production sharing agreement for the Azeri, Chirag, and Gunashli development in Azerbaijan was signed in September 1994. BP was the operator with a 34.1% stake; the partners were Chevron with 10.3%, Socar 10%, Inpex 10%, StatoilHydro 8.56%, ExxonMobil 8%, TPAO 6.8%, Devon 5.6%, Itochu 3.9%, and Hess 2.7%.

Reservoir Management

For companies involved in the upstream, reservoir management is an essential skill. Reservoir management involves ensuring that reserves are replaced and that existing oil and gas fields are efficiently managed. Asset acquisition, divestiture, and partnering are key aspects of reservoir management. Upstream companies try to replace more than 100% of the oil and gas produced. Determining the level of proved reserves (the amount of oil and gas the firm is reasonably certain to recover under existing economic and operating conditions) is a complex process. Consider the following comment on the auditing of reserves:

Though the word "audit" is customarily used for these evaluations, oil and gas reserves cannot be "audited" in the conventional sense of a warehouse inventory or a company's cash balances. Rather, "proved reserves" are an approximation about formations thousands and even tens of thousands of feet below ground. Their size, shape, content, and production potential are estimated in a complex combination of direct evidence and expert interpretation from a variety of scientific disciplines and methodologies. Added to the science is economics; if it costs more to produce oil from a reservoir than one can sell it for profitably, then one cannot "book it" as a reserve. Reserves are "proved" if there is a 90% chance that ultimate recovery will exceed that level. As perverse as it may sound, under the "production sharing agreements" that are common in many oil-producing countries, when the price goes up, proved reserves go down.[14]

Matthew Simmons, founder of the energy-focused investment bank Simmons and Company, commented that "95% of world's 'proven reserves' are in-house guesses," "most reserve appreciation is exaggerated," and "95% of the world's 'proven reserves' are unaudited."[15] The pressure to replace reserves has on occasion resulted in some unintended behaviors. In 2004, Shell's CEO left earlier than anticipated after revelations that the company had overstated its reserves by nearly 25%.

Upstream Profitability

The profitability of crude oil is a function of the market value for oil and the costs to extract and transport it to market. The most important cost determinant is the reservoir—where oil is found and how much there is. For example, onshore production in Saudi Arabia and Kuwait had the lowest breakeven price—about $20/barrel. For offshore Angola, the breakeven price for new projects was about $70/barrel. New oil sands projects in Alberta had breakeven prices of between $70 and $90/barrel depending on the technology used. For U.S., shale oil breakeven prices depended on the field location. Some analysts were predicting that future production costs for U.S. shale oil could get as low as $5–$20/barrel as technological advances continued.

Production costs change over time. Technological advances continue to drive down costs, especially for deepwater and unconventional oil. The economic cycle also impacts costs. Costs for labor, energy, and materials rise and fall through the cycles. For example, it was estimated that operating costs in the Alberta oil sands fell about 20% in 2014 as the industry went through a down cycle in oil prices.[16]

The term breakeven price was also used to understand the relationship between oil exporting nations and their fiscal management. In other words, what is the oil price that a country requires in order to match oil revenues to planned government expenditures—its fiscal breakeven price? Many oil-exporting nations have seen their fiscal breakeven prices rise significantly over the past decade as they increased spending on social and military programs. In 2016, the major oil-exporting nations of Africa and the Middle East were seeing huge budget surpluses swing to deficits in the low price environment.

Midstream: Trading and Transportation

The midstream in the value chain comprises the activities of storing, trading, and transporting crude oil and natural gas. As shown in Exhibit 7, once oil and gas are in production, there is a divergence in the value chain. Crude oil that is produced must be sold and transported from the wellhead to a refinery. Natural gas must be moved to markets via pipeline or ship; we provide an overview of the gas business in a later section.

Crude oil has little or no value until it is refined into products such as gasoline and diesel. Thus, producers of crude oil must sell and transport their product to refineries. The market for crude oil involves many players, including refiners, speculators, commodities exchanges, shipping companies, IOCs, NOCs, independents, and OPEC. Market-making activities in the oil business have become front page news, and the daily price of crude oil is as frequently reported in the news as the weather.

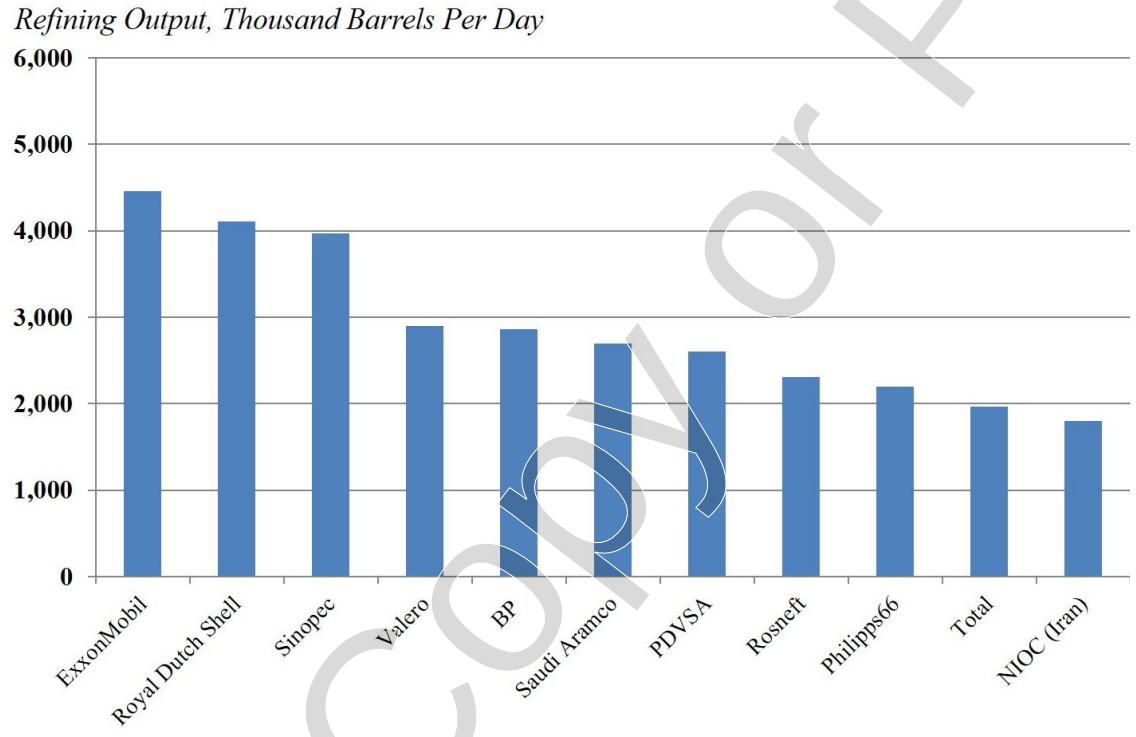
The ease by which liquids can be transported is a key reason why crude oil has become such an important source of energy. Although pipelines, ships, and barges are the most common transportation platforms for crude oil, railroads and tank trucks are also used in some parts of the world. In recent years, railroads have made a resurgence in the United States and Canada because of the rapid growth in production of oil in North Dakota and Alberta and a shortage of pipeline capacity. The shipping industry is very fragmented and, because oil tankers travel for the most part in international waters, largely unregulated. New technologies in ship building in recent decades have allowed ships to become larger and safer.

Pipelines in Alaska, Chad, Russia, and other countries have allowed oil to be transported from very remote locations to markets. The construction and management of pipelines is fraught with geopolitical challenges, which means the pipeline development process takes many years or even decades. Pipelines that cross national borders are enormously complex to negotiate and build. Countries with pipelines that cross their territory have been known to use them as bargaining chips. Terrorists often sabotage pipelines and, in some countries, such as Nigeria and Iraq, oil theft from pipelines and the associated environmental and safety issues are daily occurrences.

Downstream: Oil Refining and Marketing

The refining of crude oil produces a variety of products, including gasoline, diesel fuel, jet fuel, home heating oil, and chemical feedstock. In the U.S., about 60% of refinery product volume is gasoline. Refined products are sold directly to end users through retail locations, directly to large users, such as utilities and commercial customers, and through wholesale networks. Exhibit 8 shows the world's largest refining companies.

Exhibit 8. Largest Refiners



Source: Company data; Energy Information Agency; Saudi Aramco adjusted for joint ventures.

The financial performance of the refining sector has always been volatile. The primary measure of industry profitability is the refining margin, which is the difference between the price of crude oil and refined products. Crude prices fluctuate for many reasons. Weather in the Gulf Coast states, political instability in oil-producing countries, or economic growth reports from China can all impact the price of crude oil. These fluctuations are not always accompanied by matching changes in the price of finished products, leading to large expansions or contractions in the refining margin.

Refiners also get squeezed between the commodity markets for crude oil (crude is the largest cost to a refiner) and commodity markets for refined products like gasoline. According to the New York Mercantile Exchange:

> *A petroleum refiner, like most manufacturers, is caught between two markets: the raw materials he needs to purchase, and the finished products he offers for sale. The prices of crude oil and its principal refined products, heating oil and unleaded gasoline, are often independently subject to variables of supply, demand, production economics, environmental regulations, and other factors. As such, refiners and non-integrated marketers can be at enormous risk when the prices of crude oil rise while the prices of the finished products remain static, or even decline. Such a situation can severely narrow the crack spread, the margin a refiner realizes when he procures crude oil while simultaneously selling the products into an increasingly competitive market. Because refiners are on both sides of the market at once, their exposure to market risk can be greater than that incurred by companies who simply sell crude oil at the wellhead, or sell products to the wholesale and retail markets.*[17]

Profits on refining are usually lower than profits in other lines of business for oil and gas companies. Shell's head of downstream operations described the business as, "Grubbing [i.e., begging] for pennies in a street… If this industry, and especially the downstream, were to let its cost base slip, then we're going to have difficulty getting through those down-low cycles."[18] The refining sector typically does well during a period of falling oil prices, then flattens out and starts declining in profit as oil prices stop falling or start rising.

The profitability of refining is driven primarily by the following factors:

- The costs of crude oil and energy to run the refinery.
- The supply and demand for refinery products (i.e., if refining capacity is tight, refining margins usually rise).
- Refinery product prices, which are set by a combination of the supply and demand of refinery products and crude oil prices.
- Refinery location.
- Company technology and operational skills.

After a so-called golden age of refining from 2002 to about 2006, refining entered a new and more uncertain age. Many U.S. and European refineries were either shut down or on the verge of closure. A report by ATKearney concluded that by 2021, every refinery in Western Europe and North America would have to restructure, strategically reposition their assets, or leave the market.[19] Interestingly, despite the closure of various refineries in North America, total refining capacity continued to rise through debottlenecking and expansions to existing sites.

Although no new greenfield refineries have been built in the United States for many decades, in Asia, Eastern Europe, and the Middle East, aggressive expansion of refining capacity was the story. In 2009, Reliance Industries completed the world's largest refinery complex at Jamnagar in India. The Jamnagar complex has a capacity of 1.24 million b/d. In the near term, Jamnagar is expected to focus on export markets. The largest market for Jamnagar is in the Middle East followed by Africa, Europe, and the United States. Shipping costs are only pennies per gallon for finished products, even from India to the United States.

In thinking about the future of refining, various questions can be identified:

1. In 2011, the United States became a net exporter of refined products for the first time since 1949. Will this continue?
2, How will U.S. exports of crude oil impact refining margins?
3. Will the demand for electric and hybrid cars have a major impact on refined product demand?
4. Where is global biofuel (mainly ethanol) demand going?
5. How much refining capacity will open or close in Europe, Japan, and the United States?
6. Will natural gas gain more traction as a transportation fuel?
7. Will there be more integration between refining and petrochemicals assets for the large NOCs?

Finally, there is no best competitive model in refining. In North America and Western Europe, the oil majors were divesting or closing refineries. ConocoPhillips and Marathon split into upstream and downstream companies. In contrast, Petrobras, one of the largest integrated NOCs, was expanding refining capacity. Middle East NOCs were also increasing refining capacity. Russian upstream firms were looking to acquire downstream assets.

Transportation Fuels Retailing

In the transportation fuels retail sector, competition is intense and margins have eroded over the past few decades. The entry of hypermarkets, supermarkets, and *petropreneurs* into retail sales in Western Europe and other markets displaced small dealer networks, and national players found they could make good money from convenience store sales.

In most countries, transportation fuel was seen as a commodity product, which meant spending money on brand development had questionable results. The weakness of brands favored the entry of supermarkets because they compete on price and proximity and can sell fuel as a loss leader. With traditional retail barriers to

competition gone, the majors had sold most of their company-owned service stations in countries around the world. The buyers were a mix of convenience store specialists, such as Couche-Tard of Canada (about 15,000 fuel stores around the world), franchisers, distributors, and independent dealers.

Natural Gas

In recent years, natural gas has played a much more important role in the global energy mix. Two factors help explain the increased importance of gas. The first is the continued growth in liquefied natural gas (LNG) supply. For many years, natural gas was a niche product because, unlike crude oil, natural gas is not easily transported. Without a pipeline infrastructure, natural gas in its gas form cannot be transported far from its source. In some parts of the world, such as Western and Central Europe and North America, a network of pipelines allows gas to be produced and distributed efficiently. In the U.S., gas pipeline companies operated more than 285,000 miles of pipe. In other parts of the world, such as offshore Africa or Qatar, pipelines to a large customer base are not feasible. To transport stranded gas, it must be converted to LNG. To liquefy natural gas, impurities such as water, carbon dioxide, sulfur, and some of the heavier hydrocarbons are removed. The gas is then cooled to about -259 degrees F (-162 degrees C) at atmospheric pressure to condense the gas to liquid form. LNG is transported by specially designed cryogenic sea vessels and road tankers.

Historically, the costs of LNG treatment and transportation were so huge that development of gas reserves was slow. In recent years, LNG has moved from being a niche product to a vital part of the global energy business. As more players take part in investment, both in upstream and downstream, and as new technologies are adopted, the prices for construction of LNG plants, receiving terminals, and ships have fallen, making LNG a more competitive energy source. LNG ships are also getting much larger and more efficient.

Major technological and structural changes continue to occur in the LNG business. The floating liquefied natural gas (FLNG) vessel is a technology that allows producers to commercialize offshore gas deposits without pipelines and onshore infrastructure. FLNGs create opportunities to commercialize gas fields that would otherwise be untouched. Another innovation is the floating natural gas liquefaction, regasification, and storage (FLRSU) vessel which moves the various industrial processes offshore and makes the equipment available for redeployment at the end of the resource life.

Changes in the LNG market and in LNG shipping increased flexibility for producers and consumers, and shorter contracts were being negotiated. The agreement to develop the huge Qatargas 2 project, jointly owned by ExxonMobil and Qatar Petroleum, was finalized without contracts for gas sales in place. An LNG ship can deliver its gas anywhere there is an LNG terminal, making LNG almost as flexible in delivery as crude oil. There is also speculation that the rapid growth in Middle East LNG supply could lead to a global convergence in gas pricing and markets, with LNG becoming a traded commodity. As well, buyers and sellers have been taking on new roles. Buyers have been investing in the upstream, including liquefaction plants (e.g., Tokyo Gas and the Tokyo Electric Power Company invested in the Darwin liquefaction plant in Australia). Producers, such as BP and Shell, have leased capacity at terminals and are extending their role into trading. New buyers have been emerging, including independent power producers.

The second factor that helps to explain the increased importance of gas is shale gas. The impact of shale gas on U.S. and global gas markets has resulted in a game changer for U.S. energy supply. As recently as 2003, the consensus was that the United States would have to import large quantities of LNG to satisfy gas demand. A decade later, U.S. production easily met domestic gas demand and several dormant LNG import terminals were being converted to LNG export facilities. Although the rest of the world has lagged behind the U.S. shale gas experience, many other countries have the potential to develop shale gas resources. According to the U.S. Energy Information Administration, a number of countries such as France, Poland, Turkey, Ukraine, South Africa, Morocco, and Chile could significantly reduce gas imports if they develop their shale gas resources.

Petrochemicals

Petrochemicals are the farthest downstream activity in the value chain. Although all of the major IOCs were involved in chemicals to some degree, they have different strategic approaches. Exhibit 9 shows the world's largest chemical companies. ExxonMobil Chemical, one of the world's largest chemical businesses, produced both

cyclical commodity type products, such as olefins and polyethylene, as well as a range of less cyclical specialty businesses. Many of ExxonMobil's refineries and chemical plants were co-located, providing opportunities for shared knowledge and support services and the creation of product-based synergies. In the past, BP and Shell had chemical businesses that were among the largest in the world.[20] In 2005, BP decided that its chemical business was non-core and divested the majority of the business. BP's remaining chemicals businesses became part of the refining and marketing division and were no longer considered a separate corporate division. Shell also downsized its chemicals business. The rising players in chemicals in the Middle East and Asia include state-controlled companies, such as Sabic (Saudi Arabia) and ChemChina, and non-state companies, such as Reliance (India).

Exhibit 9. Largest Chemical Companies

Company	2014 Sales $M	2014 Operating Profit $M
Basf	90,011	9,235
Sinopec	68,875	-351
Dow Chemical	58,167	5,265
ExxonMobil[a]	56,393	5,705
SABIC	50,122	10,114
LyondellBasell Industries	45,608	5,736
DuPont	34,723	4,991
Mitsubishi Chemical[b]	30,478	1,381
INEOS	27,003	-
Bayer	26,962	2,331
Shell[a]	24,607	-
Total[a]	24,600	-
LG Chem	20,675	1,200
Linde Group	20,644	2,283
Sumitomo Chemical[b]	19,812	1,062
Air Liquide	18,599	3,209
PTT Global Chemical	17,443	428
Braskem	17,320	1,343
AkzoNobel	17,313	1,195
Toray[b]	16,791	1,029

[a] Chemical figures only
[b] Financial year-end 31 March 2015

Source: "Special Report, ICIS Top 100 Chemical Companies," *ICIS Chemical Business,* September 2015.

The commodity side of the petrochemical sector is capital-intensive and deeply cyclical. Margins and profitability for commodity chemicals depend on scale, capacity utilization, operating cost discipline, and access to low-cost feedstock. Specialty chemicals, at the other end of the spectrum, are sold on the basis of their performance in customer applications, not chemical composition. Patented products or technologies can enhance the value of specialty chemicals. Product differentiation may be the result of proprietary technologies such as unique catalysts or chemical processes, and it can also be the result of brand names, marketing, customer service, and delivery.

Evolution of the Industry

Innovation and Technology

Innovation plays a key role across the oil and gas value chain. Innovations in areas such as deepwater drilling and LNG shipping were discussed earlier. In the upstream, many important technologies have been developed in the past few decades, including increased use of 3-D seismic data to reduce drilling risk and directional and horizontal drilling to improve production in reservoirs.[21] Innovations in financial instruments were used to limit exposure to resource price movements. In oilfield management, wireless technologies allowed for faster and cheaper communication than the traditional wired underground infrastructure. In refining, nanotechnology has enabled refiners to tailor refining catalysts to accelerate reactions, increase product volumes, and remove impurities, which has led to increased refining capacity. In retailing, innovations such as unmanned stations have reduced retail costs.

Mergers and Acquisitions

Mergers and acquisitions have been an important element in the oil and gas industry since its inception. Although the mega-mergers, such as BP-Amoco, Total-PetroFina, Chevron-Texaco, and Exxon-Mobil, receive much of the press, there have also been many smaller deals. In recent years, NOCs have done many acquisitions to gain access to resources and to new technology. Private equity-backed acquisitions and start-ups have become more prevalent.

In looking at the mega-mergers over the past few decades, one might conclude that eventually there will only be a handful of oil companies in the world. The reality is different. Research shows that the oil industry is much less concentrated today than it was 50 years ago.[22] There are opportunities for new entrants despite the huge size of the largest IOCs and NOCs. In the downstream, new entrants have had a significant impact on industry structure. In chemicals, Ineos, the privately held British company, grew through a series of related acquisitions to become one of the world's largest chemical companies. In the upstream, the huge financial scale of projects such as Gorgon, Kashagan, or Sakhalin I and II make it unlikely that a new entrant could challenge the majors in the largest and most technological projects. However, if NOCs in China, India, and the Gulf continue to acquire and grow, they may develop the technological and financial skills to compete for large complex upstream projects.

China and India

In 1998, China became a net importer of oil for the first time. In 2013, China overtook the United States to become the world's largest importer. By 2030, China will likely be importing about 80% of its oil. Clearly, China and Chinese companies are going to be major players in the oil and gas industry. Thousands of Chinese gas stations are being built, and Chinese companies are aggressively investing in upstream projects around the world. Unlike the U.S. and Europe, China has no qualms about allowing its oil companies to invest in countries like Sudan and Iran. Chinese companies have also been actively buying assets outside China, including the $15 billion purchase of the Canadian company, Nexen. These acquisitions have met varying success.

India is also a force to be reckoned with in the global oil and gas industry. India, the fifth largest oil consumer, needs energy to feed its rapidly growing and industrializing economy. Companies such as Reliance are moving aggressively into the upstream, and stodgy state-owned companies such as ONGC, Oil India Limited, and Gas Authority of India are slowly becoming more productive. Like China, India is far from self-sufficient in energy and must find new energy sources.

Unconventional Oil and Gas

Growth in unconventional oil and gas production has had a profound impact on the world's energy supply. In fact, what is currently called unconventional will likely lose that label in the coming years. Unconventional gas, mainly shale gas, coal bed methane and tight gas (gas locked in impermeable hard rock) will constitute the majority of the growth in natural gas production over the next few decades. The production of unconventional oil, primarily the crude produced from oil sands and shale, will also grow substantially. The exploitation of unconventional resources is the result of technologies such as hydraulic fracturing and horizontal drilling, as well as the entrepreneurial initiatives of industry participants doing what has been done for more than a hundred years—searching for innovative ways to economically create value from scarce resources.

Industry Substitutes and Alternative Fuels

Various factors have contributed to a large investment flow into alternative fuel projects, including the rapid rise in oil and gas prices in recent years, concerns about global climate change, perceived competitive opportunities by energy companies (new entrants and entrenched players), and government subsidies. Despite these investments and the often strong public support for them, hydrocarbons will continue to be the world's primary energy source for years to come. Renewables will make up only about 8% of global energy by 2035.[23]

What's Next for the Global Oil Industry?

A few predictions seem fairly safe: the global demand for oil and gas will continue to rise over the next few decades; NOCs will continue to expand beyond their home markets; finding new conventional sources of oil and gas will get harder and require innovative new technologies; unconventional oil and gas production will grow substantially; investment in non-hydrocarbon energy sources will continue; the oil and gas industry will remain one of the most vital for the global economy; and the industry will continue to go through up-and-down cycles. Finally, oil and gas firms, and especially the majors, will continue to do what they have done for more than a century: take a long-term view, invest for the future, push the boundaries of technology, and seek new resources and markets in every corner of the world.

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