Introduction to Oil and Gas

The announcement of Cambodia's first significant petroleum discovery in January 2005 has put Cambodia on a path to becoming a new oil producer. The world petroleum industry has a long history and oil has not always benefited people in the countries where it is discovered for reasons not always easy to understand. This is the first of a series of Public Briefing Notes designed to familiarize the reader with important concepts in the oil and gas industry and the challenges and dilemmas associated with it.

Surging world oil prices since the end of 2003 have prompted many governments of net oil-importing countries to consider various ways of reducing dependence on imported oil through conservation and energy diversification. For net oil exporters, much higher revenues are welcome news overall but pose a considerable challenge in how best to spend the extra income sustainably in the long-term interest of society. Recent rises in petroleum[1] prices have spurred many new exploration activities. Spending on worldwide exploration and production is estimated to have risen 30 percent in 2006 to US$268 billion [Upstream, 2007].

Natural gas prices have risen with oil prices. Natural gas can be produced during oil production—in which case it is called associated gas because it is associated with oil as it is extracted—or on its own (called non-associated gas). Consumption of natural gas, which offers many environmental benefits, has been growing faster than that of oil.

World consumption of oil in 2005 amounted to 82.5 million barrels[2] a day and 2.7 trillion cubic meters (equivalent to about 47 million barrels a day of oil) of natural gas. At the end of 2005, it was estimated that world oil production could be sustained for another 41 years if no more oil was discovered and the rate of production remained the same. The corresponding number of years for natural gas was 65 years [BP, 2006]. Oil and gas consumption has been growing faster than the rate of their discoveries, raising concerns about long-term petroleum supplies.

Crude oil is almost never used as produced. It is refined to make "white" products—liquefied petroleum gas (cooking gas), gasoline, kerosene, and diesel—and residual fuel oil. Worldwide, demand for white products is growing much more rapidly than that for residual fuel oil (used to generate electricity or heat).

The petroleum industry is commonly considered to comprise upstream and downstream sectors. Upstream involves exploration, development, and production of oil and gas. During exploration, wells are drilled in search of an undiscovered pool of oil or gas. If a commercial discovery—demonstrated to contain reserves that justify the investment of capital and effort to bring the discovery into production—is made, some development work is carried out until commercial production can begin.

Ownership of petroleum resources is typically specified in legislation or in the constitution. With the exception of the United States, oil that is underground is considered to belong to the state in all countries. After oil is extracted out of the ground, title to the oil is typically transferred, at a point agreed upon with the state, to the producer who can sell it freely and retain a portion of the earnings. Downstream covers transport, refining, petrochemicals, distribution, and retail. This note first discusses the upstream sector, followed by a section on downstream.

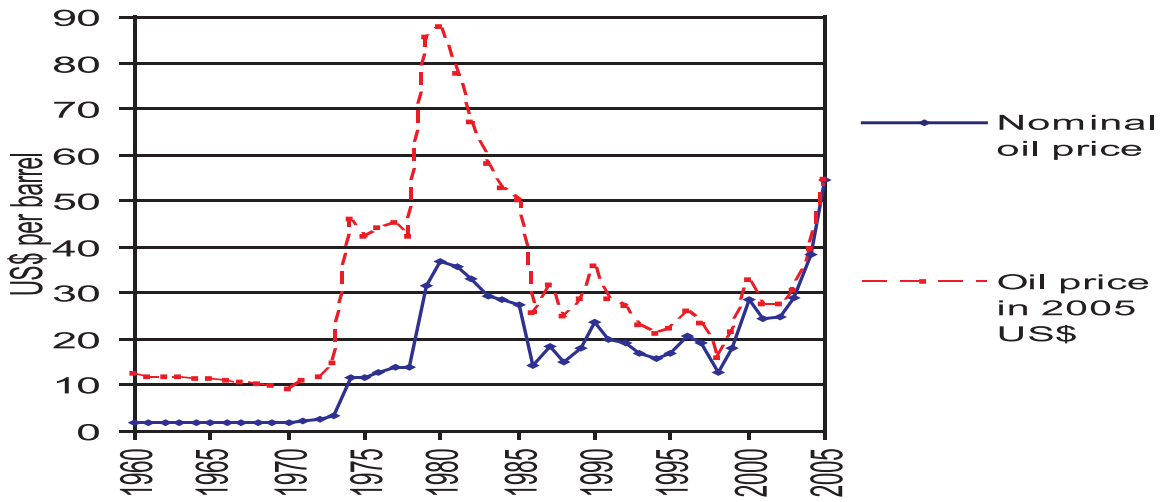
Oil Price Volatility

Crude oil and petroleum products are widely traded and effectively have a single price after allowing for transportation costs and quality differences. One characteristic of oil that is much talked about is its price volatility. Figure 1 shows annual world oil prices from 1960 through 2006 in nominal and real terms. Nominal prices represent prices paid by consumers at the time of purchase. Real prices take nominal prices and adjust them for inflation (rising cost of living) over time. For example, $1 in 1960 would have been worth 6.6 times more in 2005. This means that the average oil price of $1.9 a barrel in 1960 is equivalent to $12.59 a barrel when expressed in 2005 U.S. dollars. In real terms, oil prices averaged US$32

[1] The word "petroleum" is used in this note to refer to oil and gas. Another commonly used term is "hydrocarbons."

[2] A barrel is 159 liters.

Figure 1: World Crude Oil Prices



Sources: [2] and *Energy Intelligence*.
Note: Prices are Arabian Light posted at Ras Tanura until 1983, and dated Brent from 1984 onward.

per barrel between 1960 and 2006. There were large price swings during this period, ranging from a low of $9 in 1970 to a high of $88 a barrel in 1980.

For several decades now, oil prices have stayed far above production costs. Saudi Arabia, the lowest-cost producer, can produce oil and deliver to the nearest port for about US$3.50 a barrel. The difference between the market price of oil and the price needed to induce oil production—that is, the price above which oil production occurs because it is profitable—is called "rent," which is a measure of excess profit. Even at $30 a barrel, oil production was already handsomely profitable; world oil prices were more than double that in 2006. Oil has a large rent, meaning it is extremely profitable to engage in oil production and sale. How this large rent should be split between the oil company and the government is an important policy and strategic question. All governments want to maximize their revenues, but if they try to keep too large a proportion of the rent, few investors will sign contracts for exploration and production. An even more difficult challenge is how to spend the oil rent, once received, for sustainable economic development.

Factors Affecting Supply and Demand—And Oil Prices

The price of any commodity goes up if supply falls short of demand, and conversely falls if demand exceeds supply. Crude oil prices behave no differently. Political events, weather, and other factors affect the supply-demand balance. The two largest spikes in oil prices in Figure 1—1974 and 1980—were both caused by political events disrupting oil supplies: the Arab oil embargo following the Yom Kippur war fought between Israel and a coalition of Arab forces in October 1973, and the Iranian revolution which began in 1978 and which resulted in a reduction of 3.9 million barrels a day of crude production by 1981.

A very important determinant of world prices unique to the oil industry is the policy of the Organization of Petroleum Exporting Countries (OPEC). Formed in 1960, OPEC today consists of 12 large oil producers: Algeria, Angola, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates, and Venezuela. They account for about 40 percent of world oil production and hold two-thirds of proven reserves. Since 1982, OPEC has been setting oil production quotas for its members in an attempt to ensure that oil prices do not fall too low from over-production, or rise too high from under-production. If oil prices rise too high, high energy costs could cause a worldwide recession, which in turn would reduce

demand and potentially lead to an oil price collapse. Although OPEC members produce less than half of global oil, it holds the majority of the world's spare capacity. This means that only OPEC can increase or decrease production at will. OPEC's united production policy through quotas (even if compliance is an issue), ability to adjust supply, and relatively high share of global oil production give it an enormous ability to affect world oil prices.

Sweet and Sour

Although a single price is often quoted in news reports, there is a variety of crude types and associated prices. Two most commonly quoted benchmark crude prices are for Brent, produced in the North Sea, and West Texas Intermediate (WTI), produced in the United States. They are both light and "sweet." "Sweet" and "sour" are two words used to indicate the amount of sulfur in a given crude oil. If the level is relatively low (say less than 0.5 percent), the crude is sweet; conversely, if there is a lot of sulfur, the crude is sour. Heavy crude yields proportionally more residual fuel oil than light crude.

The lightness of crude is indicated by a measure of density called API gravity. API gravity is specific to the oil industry; the higher the API, the lighter the crude. Brent contains 0.35 percent sulfur and has an API of 39.5; WTI contains 0.32 percent sulfur and has an API of 39.0. An analysis of the samples from the wells drilled by Chevron in Cambodia in 2004–05 reportedly had an API gravity of 44, which would make the analyzed crude very light.

The lighter and sweeter the crude, the easier and less costly it is to refine it into usable products. Demand for white products as well as for products with low levels of sulfur has grown rapidly in recent years. Against this backdrop, the supply of light, sweet crude has been declining. The price difference between sweet and sour crude oils has, as a result, been widening in recent years. In August 2006, WTI spot prices averaged US$73.68 a barrel, but Mexican Maya, which is heavy and sour, averaged $58.83, giving a price difference of $17.85 a barrel in that month.

Special Case of Natural Gas

Oil and gas are often discussed together but in many respects they are very different commodities.

- *Ease of transport* Oil, being a liquid, is easily transported by ship, rail, and truck. Gas takes up too much space if it is to be transported by truck or ship as a gas. Natural gas is transported in pipelines, but for very large distances crossing water, natural gas is cooled to –163ºC and carried in specially designed sea vessels as liquefied natural gas (LNG). The infrastructure for LNG costs billions of dollars and requires liquefaction plants at export terminals and regasification plants at import terminals. Once gas arrives at a market, it requires a distribution pipeline network. All this makes natural gas much more expensive to transport, distribute, and store than crude oil and refined liquid products. This means that potential markets for gas are significantly more restricted than for oil. As a result, half of the world's discovered gas has not been commercialized. Today, more than 150 billion cubic meters of associated gas are estimated to be flared (burned) or vented annually because there is no financially viable market for the gas.

- *Size of rent* Natural gas typically has a much smaller rent than oil.

As with oil, gas exploration and production is capital-intensive with high upfront costs, but market prospects are much less certain for gas. For this and other reasons, gas development and commercialization take longer than oil development.

Where a market for natural gas does exist, natural gas is the fuel of choice for many applications. It is much cleaner than liquid fuels, emitting far fewer fine particles than diesel or residual fuel oil when combusted. Fine particulate matter causes serious respiratory (lung-related) illnesses and premature deaths, and is the most serious pollutant in many developing country cities. On the global environmental front, switching from coal to natural gas in power generation halves emissions of greenhouse gases (gases that are considered responsible for global warming). Another advantage of natural gas in the power sector is the higher efficiency that can be achieved. Power plants fueled by residual fuel oil may achieve thermal efficiencies of 38–40 percent and coal-fired plants have historically achieved efficiencies of 33–38 percent. Against these numbers, combined cycle plants using gas turbines typically achieve 50–55 percent

efficiency. Higher efficiencies mean that more fuel is used to make electricity and less fuel is wasted in the production process.

Downstream Oil and Gas

Crude oil is taken to a refinery and processed into various fuels, solvents, lubricating oils, asphalt, and coke. Complex refineries are designed to maximize production of white products by "cracking" residual fuel oil, but they are more expensive to build and operate, and have larger economies of scale (that is, smaller refineries are proportionally more costly than larger ones, so that the refinery has to be very large to be profitable) than simple refineries. Simple refineries do not convert residual fuel oil into white products nor can they make ultra-clean fuels. These limitations have made small, simple refineries more and more uneconomic. Increasing economies of scale mean that there are fewer and larger refineries today than in the past.

The first call on natural gas is large-scale applications, such as power generation and industrial use. Large-scale applications are attractive because laying down a large pipeline to one destination (such as a giant power plant) is much cheaper than laying down a complex network of small-diameter pipelines to serve numerous small users (such as households, restaurants, and shops). In industrial applications, natural gas is a feedstock for fertilizers and chemicals such as ammonia and methanol. Residential and commercial use of natural gas includes space heating, cooking, water heating, and commercial cooling. Natural gas is also compressed and used as an automotive fuel in the form of compressed natural gas (CNG).

Competition is usually possible in theory at most stages across the supply chain in oil and gas. One notable exception is gas transmission (that is, transporting gas over long distances) and distribution, which exhibit characteristics of a natural monopoly. A natural monopoly occurs when one firm can meet most or all of market demand and still achieve a lower average unit cost than if there are two or more firms in the industry. That is, there is great scope for economies of scale over a very large range of output. In transporting natural gas, it would be much more economic and efficient to lay down one large-diameter pipeline, even if that means no competition, than four parallel pipelines of small diameter, together amounting to the same total capacity. Where the most efficient production and operation is through a monopoly, economic regulation by the government becomes very important, so that the monopoly operator does not extract a "monopoly rent"—that is, gaining a profit far in excess of what might have been realized if there was effective competition—from consumers.

Oil and Gas in Cambodia

In January 2005, Chevron announced Cambodia's first significant petroleum discovery, stating that it had found oil in four exploration wells and gas in one well during a six-well program in an offshore area called block A. Appraisal work is ongoing to obtain a better estimate of how much oil and gas block A is likely to contain and their quality. The results are expected some time this year.

International experience suggests that the most important role for the government is regulation of the sector to ensure—where competition is possible—fair and vigorous competition in a level playing field to safeguard the interests of both producers and consumers as well as the environment, and economic regulation to mitigate potentially adverse effects of natural monopolies.

This is the first in a series of briefing notes to familiarize readers with issues and concepts in the petroleum industry that may have special relevance for Cambodia. There is increasing recognition around the world that citizen participation can contribute to better financial management in a way that brings benefits to the entire country. Chances of having meaningful citizen participation are enhanced when the public is well informed.

References

[1] *Upstream*. 2007. "E&P players plan New Year fireworks." January 5.
[2] BP. 2006. "Statistical Review of World Energy 2006." www.bp.com/productlanding

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