PARTEX OIL AND GAS: A VISION OF THE WORLD MARKET AND THE ROLE OF GAS AS THE FUTURE OF OIL

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1. INTRODUCTION

2004 witnessed a consistent trend of high oil prices explained by a combination of factors ranging from a strong increase in the world demand, the rapid economic growth of Asian countries specially China and India, the erosion of the spare capacity of OPEC countries and political instability induced by geopolitical factors namely in the Middle East, West Africa and South America. Most of these factors will remain in 2005 and it is unlikely that the oil prices could return in the short-term to the previous lower level.

WHY CURRENT HIGH OIL PRICES	
FACTORS	**EVIDENCE**
Tight Supply/Demand Balance	• Continuous trend of high prices. • OPEC's abandonment of price range.
Erosion of OPEC Extra-Capacity	• Inability of OPEC to control the prices. • Inability to respond to world demand.
Change in World Pattern Demand	• No seasonal effects in 2004/2005 • Fastest growth in demand in China/India • High consumption in USA.
Lack of Investment in E&D Activities following 1998 Crisis	• Inability of producing countries to respond to growing demand.
Lack of Flexibility in Terms of Production Alternatives	• Decline in production in North Sea and Alaska.
Geopolitical Factor	• Instability in Iraq, Venezuela and Nigeria. • Terrorist threats in Saudi Arabia, Qatar and Kuwait.

TABLE I - WHY CURRENT HIGH OIL PRICES

This paper discusses the consequences of the current price trend for the oil and gas industry on various issues, such as the current level of proven oil and gas reserves, the role of probable and possible reserves which can not be ignored, the high technological intensity of the industry that can drive it to new appealing breakthroughs, the triggering of Research and Development projects on new forms of energy like hydrogen, renewables and nuclear.

In particular an analysis of the current crisis and its roots will be performed, as it is depicted in Table I, highlighting its specific content: it is a crisis induced by the demand not by disruptions in the supply; it is a crisis induced by the access to reserves not by the actual lack of them. In this context, economic growth will remain the main driver of oil demand. The expansion of oil and gas production and supply capacity will call for an huge amount of investment, much of it in developing countries. The main consequence for the future is that the investments made now will make effect only in a few years time. The lack of investment experienced after the 1998 crisis, which implied price levels below US$10/bbl, is one of the reasons that explain the current tight demand/supply balance. But besides that it is necessary to take into account that the oil production in a global scale is approaching its peak and after that, the decline in production is irreversible. The assessment of the impact of this major feature is of utmost importance in order to avoid a large-scale crisis with unforeseen consequences for the world

economy and financial markets. In this regard the role that can be played by the probable and possible reserves, the non-conventional oil reserves, technology and gas is important to delay the peak for sometime and set the framework for a better preparation of the future.

In fact more important than making guesses about the future, is to prepare it.

2. WHY THE CURRENT CRISIS?

The world energy market has experienced in 2004 a significant surge in oil prices, fears of disruption to supplies and great volatility.

The current crisis is characterized by a tight supply/demand balance, by the erosion of the extra capacity from OPEC countries (Fig. 1), by the increase in demand from China and India, by the lack of investment in Exploration and Development activities (following the down cycle of 1998-2003), by geopolitical factors (linked to instability in key producing areas) and by more competition for the access to Petroleum Reserves[(1)], as it is depicted in Table I.

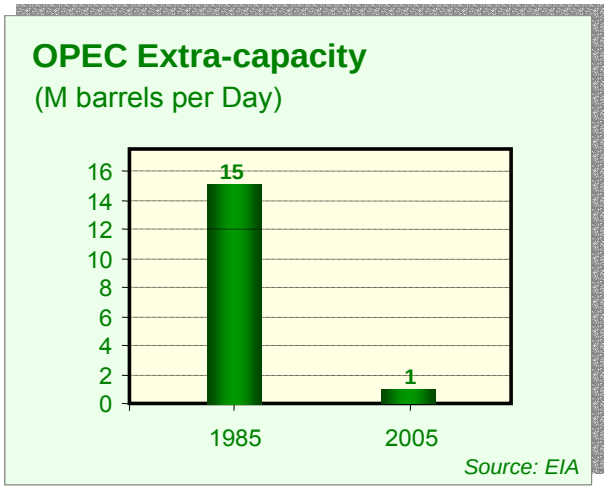

FIG. 1 - OPEC EXTRA-CAPACITY

The main issue at stake is that the oil and gas industry in experiencing structural changes that explain the level of high prices. These structural changes are linked to a new emergent pattern of oil world demand and the inability to respond in terms of production due to a trend of lack of investment (Fig. 2) in the last years before the surge of the oil price in 2004. These structural changes will remain in the near-future: this is not a short-term problem, it is a medium/long term overall shift in the world pattern of demand induced by the role of giant Asian Countries, by the bold and aggressive competition for reserves and by the lack of flexibility in terms of production alternatives.

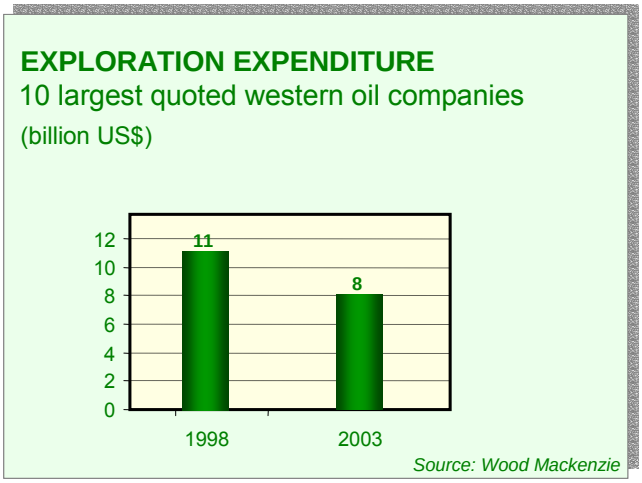

FIG. 2 - EXPLORATION EXPENDITURE

2.1 The Oil Reserves Issue

The problem is not related with reserves scarcity and in fact there is a continued growth in oil and gas reserve volumes. Comparing BP statistical review for world energy of the oil reserves evolution in the last decade (Figs. 3 and 4), we can notice that in the end of 2003 total reserves amounted to 1,147 billion barrels reflecting an increase of 14.7% when compared with 1993[(2)]. However it is important to note that this upward trend of remaining reserves over the past few decades should be taken with caution because, to a certain extent this can be due to poor reporting procedures aggravated by not back-dating the reserves to the timing of discoveries, as it is pointed out by Campbell and Zagar[(8)].

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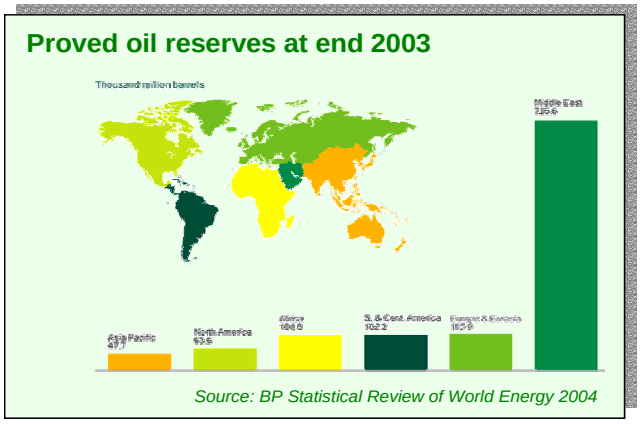

FIG. 3 - PROVED OIL RESERVES AT END 2003

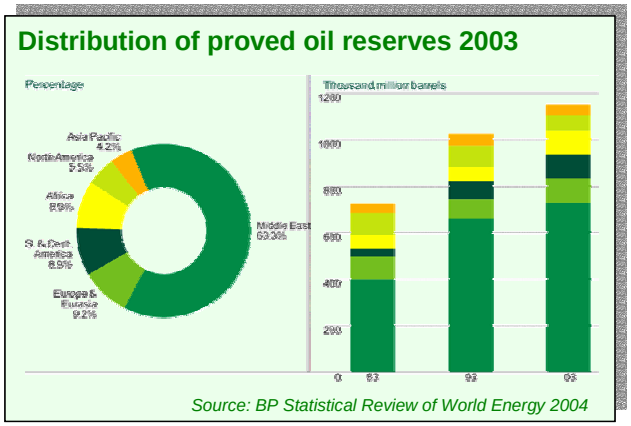

FIG. 4 - DISTRIBUTION OF PROVED OIL RESERVES 2003

Fig. 5 shows a comparison of oil and gas discovery and production for the 20th century. Total world oil production was 950 billion barrels and 98% was extracted from conventional oil. This amount is of the same order of magnitude as the estimated proved reserves that exist today from conventional oil. But on top of this it is necessary to take into account for the future the following basic elements:

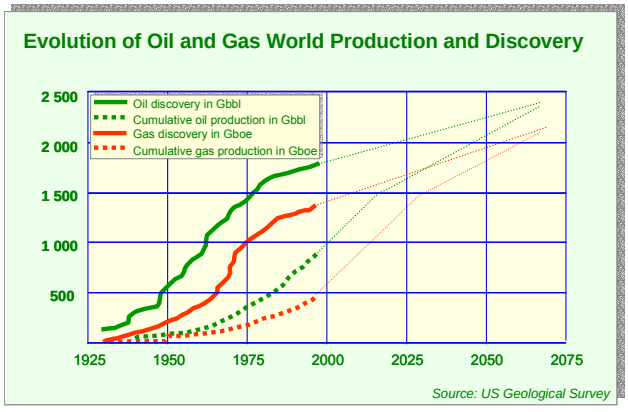

FIG. 5 - EVOLUTION OF OIL AND GAS WORLD PRODUCTION AND DISCOVERY

i. There is still potential in the deep off-shore of the Gulf of Mexico, Brazil, Angola and Gulf of Guinea[3], that may amount to 80 billion barrels.

WORLD OIL AND GAS RESERVES
(in billion barrels)

	ESTIMATED REMAINING RESERVES	ESTIMATED UNDISCOVERED RESERVES
Conventional Oil	1147	470
Heavy Oil	430	70
New Technologies	200	50
Gas	1153 (*)	850 (*)

(*) barrels of oil equivalent (boe)

Source: BP, TOTAL, USGS,CERA and IFP

TABLE II - WORLD OIL AND GAS RESERVES
in billion of barrels

ii. At present around 75% of the world's production come from fields that began producing over 25 years ago and there is additional potential to recover the probable and possible reserves of the conventional oil using Enhanced Recovery Methods (EOR). Fig. 6 shows the evolution of the overall EOR production and its contribution to world production from 1978 to 2004 and Fig. 7 depicts the contribution of different EOR methods. EOR production represents only 4% of overall worldwide production being thermal methods the most common. There is still some potential to improve the recovery considering that the current average ultimate recovery in a worldwide basis ranges from 30 to 35% and an enhancement in recovery even small may generate additional reserves.

iii. The access and production of unconventional oil reserves like Canadian Tar Sands and Venezuela extra-heavy oil

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from the Orenoco Belt and the Arctic and Polar oil[3], may contribute to generate additional reserves amounting to 500 billion barrels (Table II). The ability of oil companies to produce this oil may impact the evolution and the peak of the world oil production.

iv. Finally the existence of a huge amount of gas reserves (Table II) including the undiscovered, is an important factor to be taken into account in the analysis of the resources and the prediction of production. Estimated remaining gas reserves are 1153 boe (barrels of oil equivalent)[2] and the estimated undiscovered are 850 boe[15].

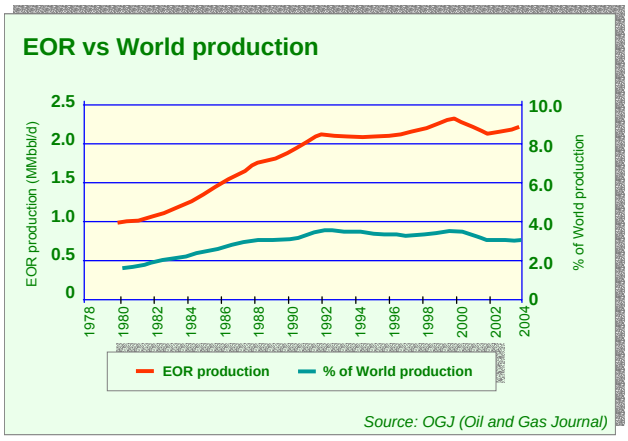

FIG.6 - EOR VS WORLD PRODUCTION

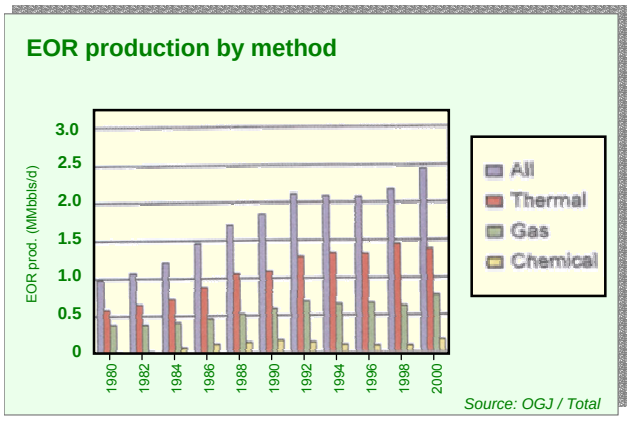

FIG. 7 - EOR PRODUCTION BY METHOD

Nowadays the situation is difficult more due to a lack of investment in the past years than to a reserves scarcity issue. But, in overall terms, it must be stressed that this century will witness the peak of oil production followed by an irreversible decline.

2.2 Unbalanced Demand/Supply and Consequences

One feature that explains the current surge in oil prices is the unbalanced demand and supply situation and the fears regarding energy security. The fastest growth in the demand came from China and reached 16% in 2004 (Fig. 8). China has now overtaken Japan as the world's second largest consumer of oil behind the United States. Other countries in Asia like India showed also a large increase in demand.

To worsen the problem in terms of the tight supply/demand balance, the domestic production in the United States continues to decline while the increase in demand reached 3.5% in 2004 (Fig. 9). The US production decline [4] is, as a matter of fact, a result of higher exploration and production costs coupled with lower than expected finding rates. Parallel to that, the decline in production in the North Sea is affecting developed economies like the UK which became a net oil importer instead of an oil exporter. These changes increased the pressure over an already tight market. The decline of production in Alaska (Fig. 10) and North Sea [1] has a strong geopolitical effect: western countries are more and more dependent on external oil and gas reserves and the role of OPEC countries is reinforced. The challenge is that some OPEC countries are restricting the access to their oil reserves creating a difficult situation for Western oil companies. The competition from China and India and the links and networks that these countries established trough their state-owned companies with the state companies of the producing countries, is a new element with strong geopolitical consequences. Prices were also influenced by the confirmation of a lower than expected spare capacity from OPEC countries and the political unrest in Venezuela and Nigeria, the war in Iraq and the fear of terrorist attacks in Saudi Arabia.

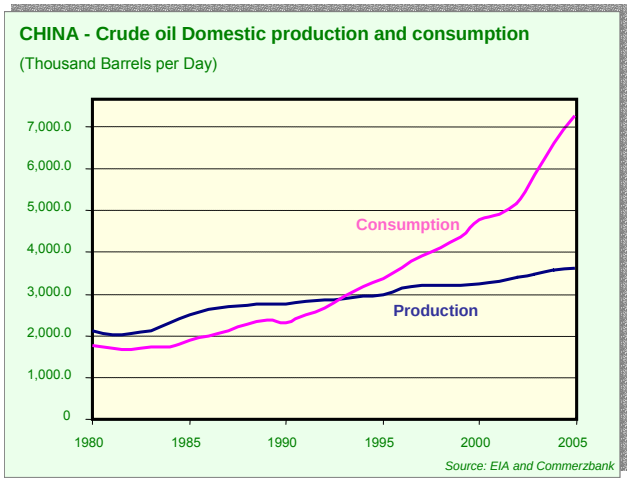

FIG. 8 - CHINA - CRUDE OIL DOMESTIC PRODUCTION AND CONSUMPTION

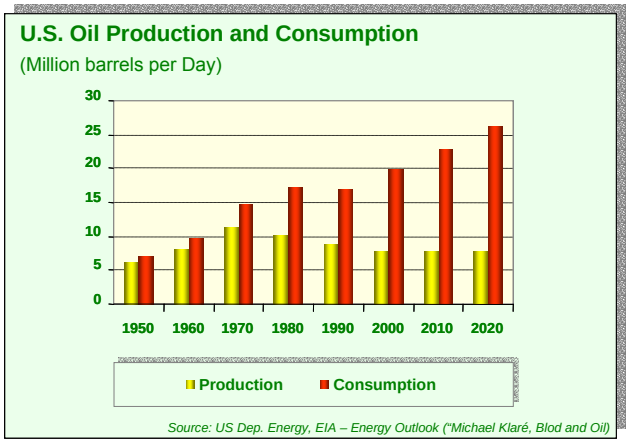

FIG. 9 - U.S. OIL PRODUCTION AND CONSUMPTION

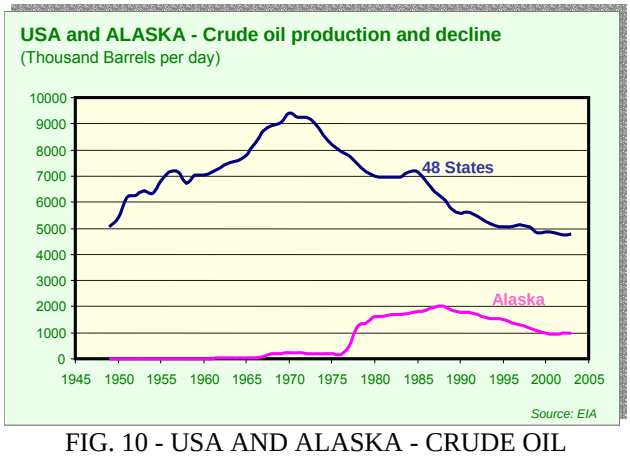

FIG. 10 - USA AND ALASKA - CRUDE OIL PRODUCTION AND DECLINE

In spite of the fact that the current high level oil prices in the range of 50 to 55 US$/bbl are still, in real terms, half of the level reached in 1980, there is a critical situation in the market characterized by the question on whether economic and political factors can stabilize the prices in a lower range or definitively push the prices up to the limit of an energy crisis.

One effect of the high level oil prices has been the drive for a more balanced energy mix with a continued growth of demand for natural gas. Especially the trade in Liquefied Natural Gas (LNG) increased significatively [(5)]. But the high oil prices created also conditions for the reactivation of the consumption of other fuels like coal. Demand and consumption of coal have been strong in the last year. Nuclear power generation contracted by 2% in 2003 but with current oil prices a surge in demand is expected and the same applies to other alternative energy sources (Fig. 11).

As it is depicted in Fig. 11 oil will maintain its leading position in the energy market for the next decades. However, this century will witness the decline of the oil share in the energy matrix. The development of a Hybrid-Energy Model where the role of gas, coal, nuclear and renewables will increase substantially promoting a more diversified and multidimensional energy portfolio. It is important to use the next decades to promote this Hybrid-Model and diversify the use of energy sources preparing the planet for the future.

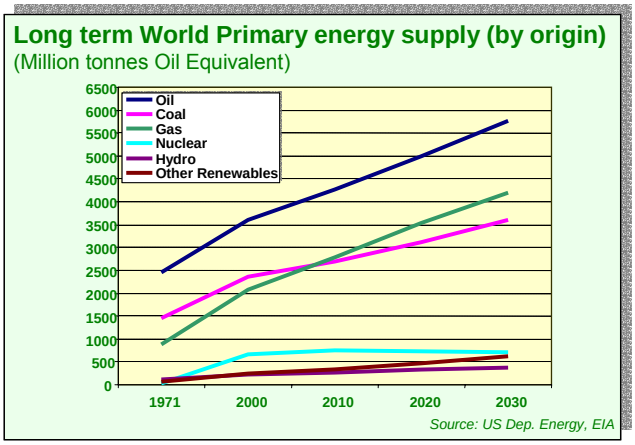

FIG. 11 – LONG TERM WORLD ENERGY SUPPLY BY ORIGIN

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3. HOW MUCH OIL IS LEFT?

Reserves estimates have been a source of many discussions and opposite opinions along the time. The need for cheap energy puts the oil and gas industry at the centre of the reserves debate, given its position as the most important energy supplier of our time.

It must be said that the industry has not been kind to those who have dared to make predictions, but we can make sense out of the trends extracted from the many educated guesses coming from different sectors of the industry, which are based on the historical values of cumulative production and total proven reserves[2] (Fig. 12). These clearly show an upward trend of remaining reserves over the past few decades. However, forecasts have remained relatively constant over the past few years, as the industry has basically replaced consumption with newly discovered deposits and additional amounts of oil and gas recovered from existing reservoirs.

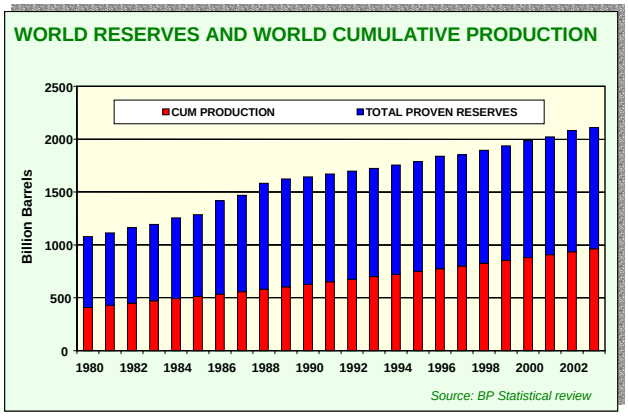

FIG. 12 - WORLD RESERVES AND WORLD CUMULATIVE PRODUCTION

Since the middle of the 20th Century, ultimate oil reserves estimates have shown a natural scatter but a clear upward trend. The exercise of putting together the most publicized predictions is shown in Fig. 13. It is based on the analysis conducted by Colitti and Simeoni[15] summarized in Table III and it accounts for the original world reserves including cumulative production to date and present proven and expected reserves. A strong tendency to a 2500 billion barrels level of ultimate oil reserves is clearly apparent.

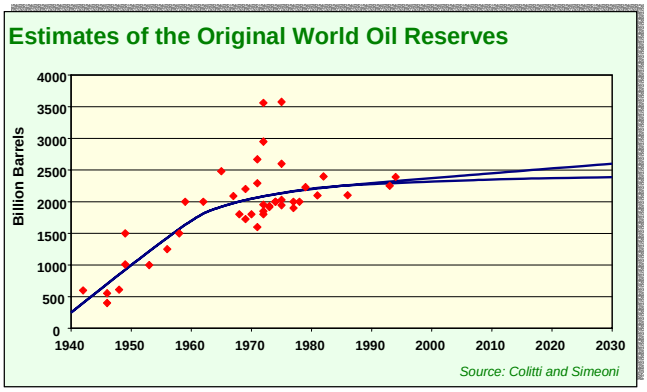

FIG. 13 - ESTIMATES OF THE ORIGINAL WORLD OIL RESERVES

Naturally, predictions have increased throughout the past century, based on the better knowledge of the oil and gas basins of the world combined with the stronger technology supporting exploration and production.

However, we would not be far from the truth by saying that reserves growth has basically followed demand. To an extent, “resources come out of peoples’ minds more than out of the air or the ground”, as stated by the American economist Julian Simon.

Having said that, it can be argued that reserves figures can be adjusted to meet commercial interests, such as the Middle East reserves increases of the 1980’s, as mentioned by Zagar and Campbell[8]. This is shown in Fig. 14, where a plot of proven reserves along time confirms a clear jump in the Middle East values in the last part of the 80’s decade, followed by a period of relative stabilization. Independently of that sudden adjustment, however, we can observe a stable growth over the period of time shown, indicating that this correction does not seem to impact, in the long term, the global estimates of proven reserves.

Estimates of the original World Oil Reserves

Date	Estimator	Organization	Billion Barrels
1942	Pratt, Weeks and Stebinger		600
1946	Duke		400
1946	Pogue		555
1948	Weeks		610
1949	Levorsen		1,500
1949	Weeks		1,010
1953	MacNaughton		1,000
1956	Hubbert		1,250
1958	Weeks		1,500
1959	Weeks		2,000
1962	L.G. Weeks	Consultant	2,000
1965	T.A. Hendricks	USGS	2,480
1967	W.P. Ryman	Esso (Exxon)	2,090
1968	--	Shell Oil Company	1,800
1969	M. King Hubbert	National Academy of Sciences	1,350-2,100
1969	L.G. Weeks	Consultant	2,200
1970	J.D. Moody	Mobil	1,800
1971	H.R. Warman	BP	1,200-2,000
1971	Weeks		2,290
1971	U.S. National	Petroleum Council	2,670
1972	J.D. Moody and H.H. Emmerick	Mobil	1,800-1,900
1972	Richard L, Jodry	Sun	1,952
1972	Linden		2,950
1972	H.R. Warman	BP	1,800
1972	Weeks		3,560
1973	Wim Vermeer	Shell Oil Company	1,930
1973	H.R. Warman	BP	1,915
1974	J.D. Moody and R.W. Esser	Mobil	2,000
1974	M. King Hubbert	USGS	2,000
1975	J.D. Moody and R.W. Esser	Mobil	2,030
1975	--	Exxon	1,945
1975	B. Grossling	USGS	2,600-6,500
1975	P. Odell	Erasmus University Rotterdam	3,575-4,233
1977	M. King Hubbert	Congressional Research Service	2,000
1977	--	World Energy Conference	1,900
1978	Richard Nehring	Rand Corporation	1,700-2,300
1979	A.A. Meyerhoff	Consultant	2,230
1981	Colitti	AGIP	2,082
1982	--	Exxon	1,800-3,000
1993	C. D. Masters	USGS	2,250
1994	Colitti and Simeoni	AGIP	2,330

Source: Colitti and Simeoni

Table III - Estimates of world ultimate crude oil recovery

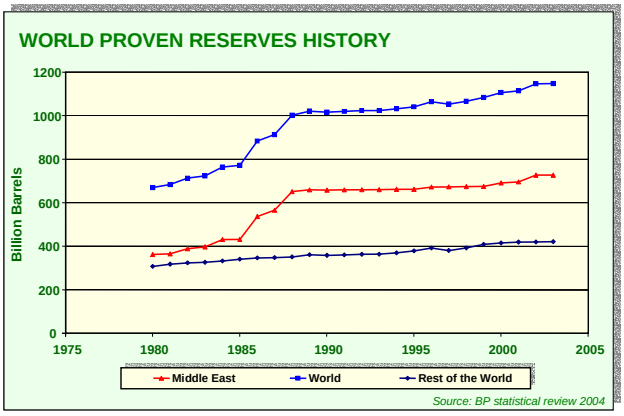

Fig. 14 -WORLD PROVEN RESERVES HISTORY

There is no doubt that the oil and gas reserves are finite, but they should have the potential to be the major component of the world's increasing energy needs until other sources become commercial later in the new century.

Much has been said about the replacement of production with new reserves. This is a critical indicator for the business of any oil and gas company. Being above 100% is a clear sign of a healthy company. The 2004 year end indicators put the majors close or below that number, depending on how reserves are established. The conservative SEC (Securities and Exchange Commission) rules, which are normally followed in the business, can help create a pessimistic view on future reserves. In addition, companies tend to add reserves through the development of resources that have already been discovered, rather than focussing on exploration to achieve new discoveries. Middle East countries, on the other hand, with the vast resources they dominate, give low priority to exploration activities when compared to the optimization of field development planning and the maximization of known reserves.

4. THE ROLE OF GAS

Demand for natural gas is growing faster than that for any other primary fuel. With an annual growth of 2.5% per year, gas will overtake coal in the next decade, as the world second largest energy source. In fact this trend has been present in the market for some time: US gas consumption has been growing more rapidly than oil since the late 1980's. Gas accounts for 24% of world energy consumption compared with oil's 40%. It is expected from the last estimates, that after the next 30 years the absolute amount of gas consumption will overtake oil, resulting in the age of gas. This is why the expected scenario is that gas can be the future of oil and there is strong evidence to support this trend.

4.1 The Gas Reserves Issue

First a comparison study shown in Fig. 15 and based on the BP Statistical Review Data of Gas Reserves[(2)] in 1983, 1993 and 2003 shows clearly that the total world gas reserves approximately doubled between 1983 and 2003. This comparative study shows that in terms of reserves there is an expansion in the last decades and there is some support for entering in the age of gas. In fact the last decade witnessed a huge increment of gas reserves unlocked while for the oil reserves the increase is less significative showing a trend for the stabilization followed by a decline.

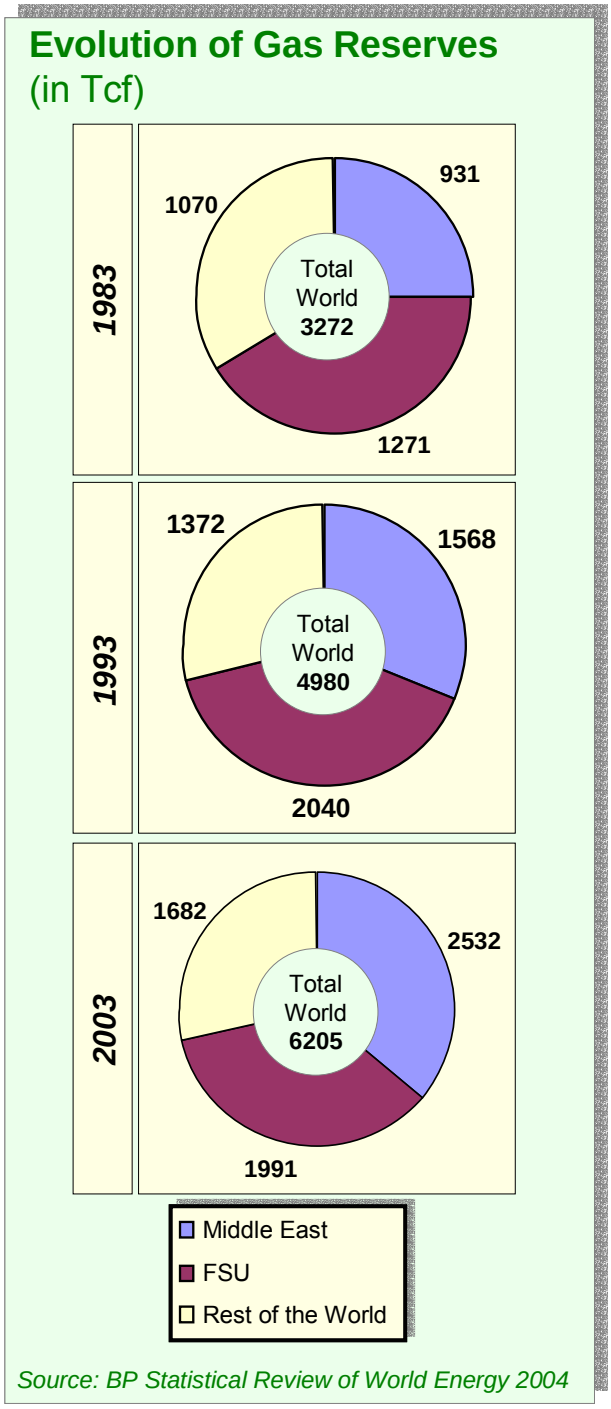

FIG. 15 – EVOLUTION OF GAS RESERVES: 1982, 1992 AND 2002

The second point to be emphasized is that the comparison of the BP Statistical Review data for the gas reserves in the last years (Figs. 16 and 17) shows that the total gas reserves amount to 175.78 trillion cubic meters (6,204.9 tcf) in 2004. In terms of geographic distribution the Middle East holds 40.8% followed by Europe and EuroÁsia with 35.4%.

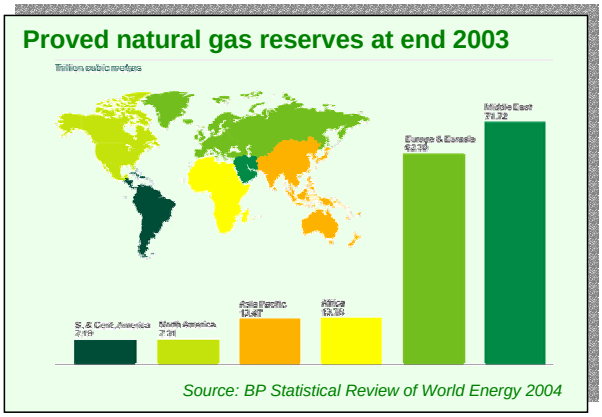

FIG. 16 - PROVED NATURAL GAS RESERVES AT END 2003

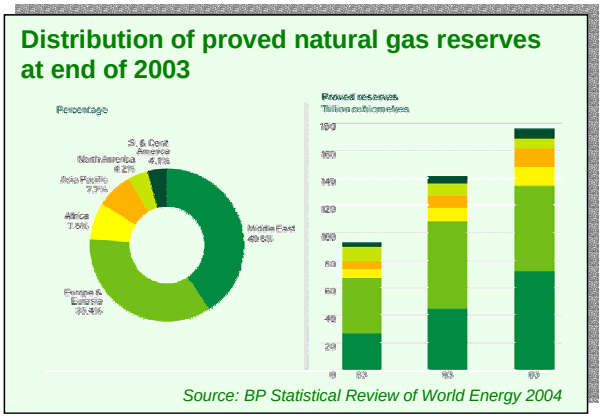

FIG. 17 – DISTRIBUTION OF PROVED NATURAL GAS RESERVES AT END 2003

Finally it is important to stress that there are some good reasons justifying the expansion of gas utilization namely the following ones:

- Substitution for power generators
- Use in transportation
- Liquefied Natural Gas (LNG) technology expansion
- Gas to liquids (GTL) technology improvements
- Environmental pressures

4.2 Gas Demand and Consequences

In terms of gas consumption the forecast shows a strong increase from 2,577 bcm in 2000 to 3,377 bcm in 2010 and 4,254 bcm in 2020 which means almost the double in 20 years (Fig. 18).

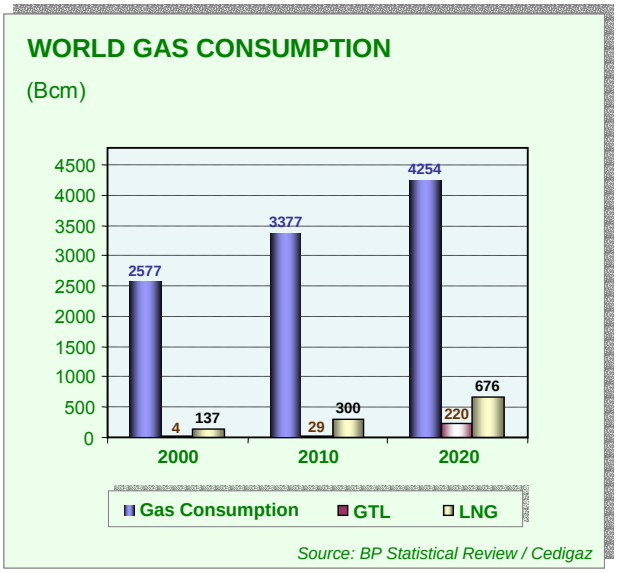

FIG. 18 - WORLD GAS CONSUMPTION

Gas demand grows more rapidly in the fledging markets of developing Asian countries notably China and Latin America. Nevertheless, North America, Russia and Europe remain by far the largest market in the next decades. The share of gas in the global primary energy mix will increase from 23% in 2000 to 28% in 2030.

Key features explaining the emergence of primary gas consumption are the LNG demand which will double in the next decade and the development of Gas-to-liquids (GTL) technology as a major alternative to liquefied natural gas. GTL is a different alternative of exploiting gas reserves that cannot be piped to markets economically. And it is important to point out that a third of the world's gas reserves are currently "stranded" which means more than 1,800 tcf. Global GTL demand for gas is projected to increase from 4 bcm in 2000 to 29 bcm in 2010 and 233 bcm in 2030 (Fig. 18).

Regarding LNG the business developed in Asia as a result of Japan's imports but it is set to expand in the Atlantic basin as the US becomes a large-scale importer[(5)]. LNG consumption grew 7.9% per year from 1995 to 2004 and for the next decade the forecast is to grow at 10% rate per year (Fig. 19). The drivers for LNG development are the continuing demand for clean-burning fuel, the costs lower trend for

LNG infrastructure and the booming of the US market. Ten years ago, only nine countries imported LNG but by 2003 the number of consuming countries had increased to 13 and the volume of LNG traded internationally had nearly doubled to 169 bcm (billion cubic meters) of regasified gas. Market experts forecast that the emergence of the US as a large-scale LNG importer will accelerate increasing LNG demand. This is also reflected in the major's strategy and Exxon announced plans to increase its production of Liquefied Natural Gas six-fold by 2020 versus the four-fold rise expected for the industry as a whole.

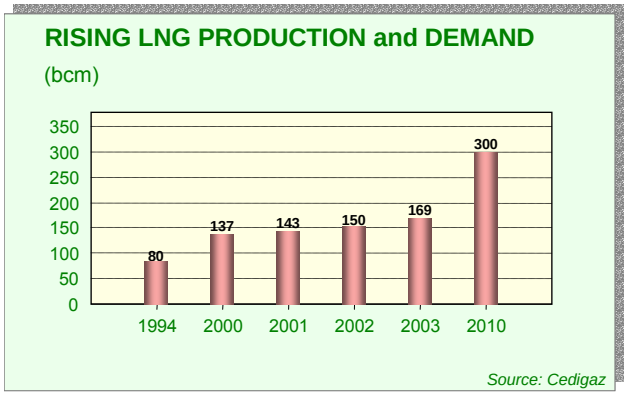

Fig. 19 - RISING LNG PRODUCTION and DEMAND

The projected increase in LNG consumption will require massive investment in production facilities and infrastructure. Technology–driven reduction in unit production and transport costs will offset the effect of distance on total supply costs.

The role of gas in the next decades will increase substantially and with the current level of reserves and the expansion of the business it is probable that gas will be the future of oil and it will contribute to extend the consumption of hydrocarbons as the world most consumed primary energy source, far beyond the timing of oil peak is reached and overcome. In fact one of the most important features of current world market energy analysis is that after the peaking of oil, a period of expansion of gas consumption will continue and the peaking of gas production, to be reached in five to six decades, is a key reason to support the idea that this century will be dominated by the hydrocarbons consumption till the two or three last decades. In this regard, the world will be faced with a sufficient period of time to challenge first the peak of oil and afterwards the peak of gas production, with a planned shift for a multi-use energy model, able to prepare the future without major disruptions and discontinuities.

5. WHEN WILL SUPPLY START DECLINING? THE PRODUCTION PEAK

It is all right to estimate oil reserves, it is a different issue all together to estimate future production profiles, the growth rate, the time for peak production and the start of decline. There are many factors involved, from reserves themselves to the cost of producing them in relation to other sources of energy, as well as the strategies of different countries in what concerns energy dependence.

If nothing else was to be discovered, reported proven reserves would be able to sustain present production levels for around 40 years. In fact, expectations are that both reserves and production will increase. Production will follow demand growth not only in the more industrialised countries but especially in the developing economies, lead by India and China, where long term internal product growth is forecasted by Deutsch Bank to be around 5% per annum. Reserves growth will be based on new exploration and, very strongly, on the optimization of existing developments, which will lead to additional reserves. Technology and expertise will definitely play a fundamental role in turning uneconomical reserves into real barrels and in reaching new exploration frontiers, such as the artic and the deeper oceans.

In fact, continental North America and much of continental Europe have already been heavily explored, and any new discoveries are likely to be small. But many areas of the globe are largely unexplored and many large new deposits are waiting to be found. Companies

have experienced major success in discovering significant new oil and gas reservoirs offshore Brazil, the Gulf of Mexico, Alaska, offshore Western Coast of Africa, Russia, and many areas of Asia and the Pacific. These are just the current main areas of growth. In addition, most observers agree that significant deposits of oil and gas remain undiscovered in the Middle East, an area where the industry has been concentrating its efforts on the development of the huge known reserves rather than on exploration.

5.1 – Peak of Oil Production: Campbell and Laherrère Previous Work

Following the prediction of King Hubert of the US oil production peak, reached in 1970, efforts have been developed to forecasting the global production peak.

The most consistent work has been produced by Colin Campbell and Jean Laherrère. In their seminal work[11] they stated: "Using several different techniques to estimate the current reserves of conventional oil and the amount still left to be discovered, we conclude that the decline will begin before 2010".

In another important contribution[8], Zagar and Campbell discussed in depth the complexity of the situation regarding the prediction of world peak production, namely the reliability of data, the role of conventional and non-conventional oil reserves, the role of technology and the characteristics of remaining world oil production. Colin Campbell established a clear conclusion from this analysis: "The exact decline point will be dependent on price driven demands of the global economy, conservation measures enacted by governments and the ability of industry to bring non-conventional reserves to the market".

Other researchers have used Hubbert's approach to forecast the peak of global oil production: Ivanhoe[33] predicted the peak as early as the year 2000; Deffeyes[16] settled a range between 2004-2008; Duncan and Youngquist[34] prefer the year 2007; Hatfield[35] predicted that the maximum production will come between the years 2010 and 2015.

5.2 - PARTEX Model: Basic Assumptions

Taking into account these factors and conclusions we developed in PARTEX a model that follows the previous work methodologies but presents new scenarios for the world peak production. In fact there are no absolute certainties regarding the timing of the peak production and the best approach is to define a range of possibilities supported by meaningful assumptions.

PARTEX MODEL FOR WORLD OIL AND GAS PEAK PRODUCTION	
Reserves	• Not restricted to proven reserves • Amount of ultimate oil recovery 2,500 bill. barrels • Amount of ultimate gas reserves 2,500 boe
Technology	• Exploration technology emerging from Seabed Logging. • Integration of technologies • Deep water/Arctic/Middle-East-Irak
Non-Conventional Oil	• Canadian Tar Sands • Orenoco Belt in Venezuela (heavy oil) • Ability to produce.
World Demand	• Equilibrium demand/supply will control growth • Economic growth "cooling" effects. • Annual oil demand growth at minimum 1 to 3%.
Hydrocarbon-Model	• In the long-run look to both oil and gas peaks. • Gas will be the future of oil. • Political will to prepare the future Hybrid Energy Model.

TABLE IV - PARTEX MODEL FOR WORLD OIL AND GAS PEAK PRODUCTION

The PARTEX model explores some of Campbell's remarks and is based on the following assumptions (Table IV):

i. The reserves considered for the analysis are not restricted to the proven reserves given the conservative rationale of SEC methodology. We used the amount of ultimate oil recovery that can be derived from different estimations, which point to a 2,500 billion barrels level[15] (Fig. 13). As

Daniel Yergin[6] pointed out, SEC rules "had become overly conservative" and had moved from requiring "reasonable certainty" to "absolute certainty" in company measurements. SEC rule to calculate reserves using year-end energy prices lead to "under-booking" and distort the investment pattern, as it becomes more an issue of timing rather than the existence of oil and gas.

ii. The role of technology is also recognized in particular in exploration for oil and gas in the 21st century. It is true that most of the giant fields have been found but in some basins like the Brazilian deep-offshore (Fig. 20) it is noticed that the size of the fields discovered in recent years are more and more important[7]. The new exploration technology emerging from Seabed logging (SBL) based on electromagnetic methods combined and integrated with 3D Seismic methods may foster a new exploration wave and target new discoveries in deep water, hostile areas like the Arctic or even the Middle-East deserts where some yet-to-find resources may exist like in Western Iraq.

New approaches to the gathering and processing of field data are being put in place, which provide quick visualisation of the reservoirs and wells, allowing for real time interaction between the operations and field development teams. Decision making in terms of well placement in the reservoir can be extremely accelerated and optimised. We are talking of the digital field concept[39], which covers five main components:

- **Remote sensing** detects what is happening in the reservoir through a combination of seismic and sensors placed down the well for the gathering of reservoir data and detection of fluid movement.
- **Visualisation** through three-dimensional imaging and modelling of the reservoirs lets engineers place wells better, avoid geological obstacles and detect oil and gas accumulations that could have been overlooked.
- **Intelligent drilling and completions** allow engineers and geologists to steer and complete wells through different zones of the reservoir, and so be able to plan for the control of production from each zone. The steering of the well through the reservoir can be done in real time, through drilling data communication and its integration into the reservoir models that can be visualised in state of the art virtual reality centres.
- **Automation** allows for the remote gathering of well and field data with reduced human intervention.
- **Data integration** incorporates the various sources of field information in a way that can be easily accessed by experts, resulting in an optimised decision making process.

According to Cambridge Energy Research Associates (CERA), this kind of technology should add around 125 billion barrels of oil to global reserves in the next 10 years[39]. According to CERA, digital oilfields should result in an improvement of recovery from 30% - 35% to as much as 40%.

iii. It is important to stress that the technology can only play a role with the existence of skilled manpower and the industry is short on that on a global scale, especially regarding Petroleum Engineers. In the next 10 to 15 years half of the existing experts will retire and the industry has not been able to attract young talented people. The root of the problem is in the 1998 crisis when the price of the barrel dropped below 10US$ and the oil companies went through down-sizing and merger processes. It affected also the quality of Research and Development programmes with the spending dropping from 3 billion US$ in 1990 to below 2 billion US$ in 2000 (both in current dollars). Without capacity to innovate and a strong skilled work force the industry may

face huge challenges in the future to expand the current production capacity.

iv. The role of non-conventional oil may also be important as an upside potential specially the Canadian tar-sands and the extra heavy-oil from the Orenoco Belt in Venezuela. The issue here is the ability of the oil companies to produce these reserves which may amount to 500 billion barrels (Table II).

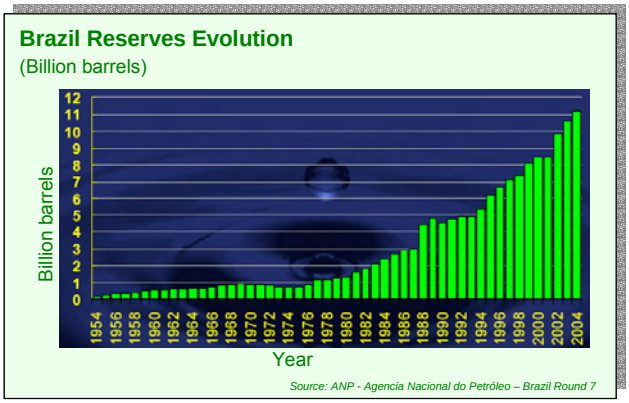

Fig. 20 – BRAZIL RESERVES EVOLUTION

v. The projections of the oil world demand take into account the fact that the current high oil prices will imply a future equilibrium between demand and supply, which will tend to reduce and stabilize the demand once the market mechanisms are fully in-place. On top of that, the current rates of economic growth will not be sustained continuously on a long-run, some "cooling" effects will emerge in the short and medium-term for the economy. In this regard, the production annual growth for oil demand is assumed to range between a lower growth scenario at an average level of 1% and a higher growth scenario of 2 to 3%.

vi. Finally the model is a Hydrocarbon-Model encompassing oil and gas. We believe that in the long run gas will overcome oil as the primary energy source. Gas demand is increasing significantly and, as it is shown in point 4, the gas reserves are significative and can provide a continuous development of the energy resources based on hydrocarbons. This is an important feature that will impact strategically on the energy model and will give enough time, if there is a political will, to prepare the changes for a future hybrid and multidimensional energy model that can encompass different sources including the renewables.

5.3 – PARTEX Model: Production Forecasts

Assuming a figure of 2500 billion barrels of ultimate oil recovery, associated with a production annual growth of close to 1%, it is easy to forecast the corresponding production profile. Applying the same methodology to gas, which is expected to have ultimate reserves similar to oil and to have production growing at a faster annual rate of around 2.5%, we can put together a lower growth scenario (Fig. 21) that passes the message of an expected production peak for oil by 2040, with the gas peak delayed until 2060.

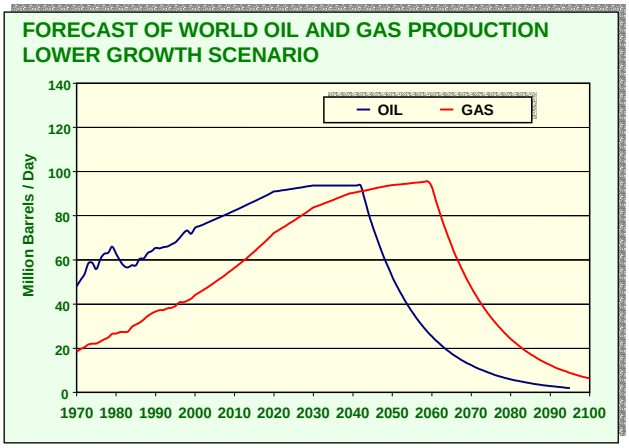

Fig. 21 - FORECAST OF WORLD OIL AND GAS PRODUCTION - LOWER GROWTH SCENARIO

Assuming a stronger oil production growth in line with the IEA (International Energy

Agency) forecasts, as well as a slightly stronger growth for gas, another scenario can be raised (Fig. 22). It considers an oil consumption growth in the order of 2% to 3% per annum, corresponding to a global increase of 60% over the next 20 to 25 years, resulting in an expected production peak for oil by 2025. As for gas, a slightly higher annual growth of close to 3% results in a gas peak delayed until 2055.

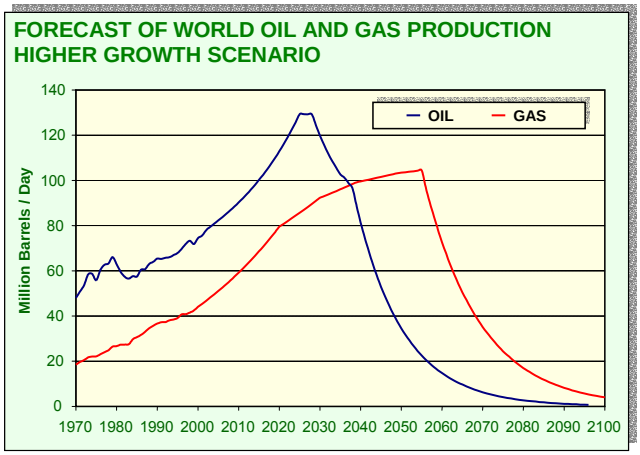

Fig. 22 - FORECAST OF WORLD OIL AND GAS PRODUCTION - HIGHER GROWTH SCENARIO

Technology innovations will play a strong role in the access to reserves, both from pure exploration projects to field development optimization. Incremental technologies may clearly lift recovery in existing fields. In fact, ultimate recovery is considered in the oil industry to be good at levels between 30% and 40% depending on the complexity of the reservoirs. It is not at all unreasonable to accept that, later in the century, we will have the technologies to improve, in an economical way, the recovery levels. Flattening the decline curve could actually mean more than a big discovery[(38)].

In figure 23 we show a simple conceptual exercise of applying new technologies at a time where conventional oil developments and new discoveries are clearly declining. A global increase of 5% to 10% to field recoveries could represent some additional 200 to 250 billion barrels of reserves.

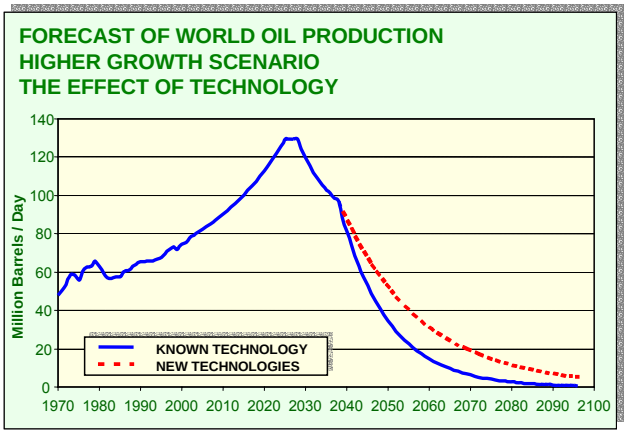

Fig. 23 - FORECAST OF WORLD OIL PRODUCTION (HIGHER GROWTH SCENARIO) - THE EFFECT OF TECHNOLOGY

The sort of analysis we are conducting needs to understand the Middle East supply and that of the rest of the world. Different costs and different reserves will obviously result in different business behaviours.

Especially in what concerns oil production, the contribution of the Middle East will become more and more dominant, when compared to the rest of the world. Considering the respective reserves expectations and the above higher production scenario, we should expect a potential stabilization of the production of the rest of the world within the present decade, while the contribution of the Middle East will start rising strongly to accommodate the growing demand and should overtake the rest of the world in something like 15 years (Fig. 24).

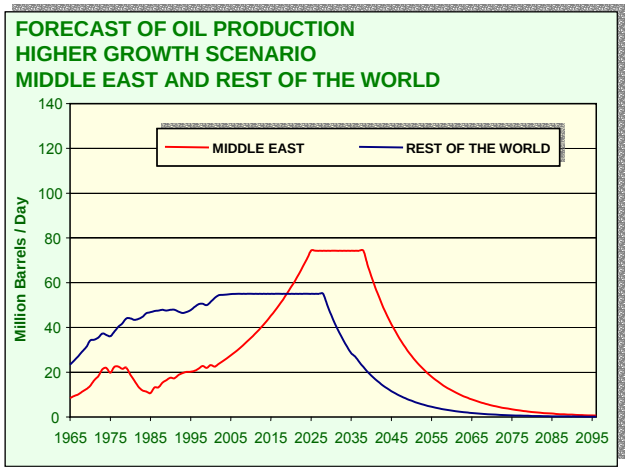

Fig. 24 - FORECAST OF OIL PRODUCTION (HIGHER GROWTH SCENARIO) - MIDDLE EAST AND REST OF THE WORLD

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5.4– PARTEX Model: The investment Factor

It is important to note that production increase is not solely dependent on reserves, but also on the cost to develop them, one of the critical elements composing the price of the barrel. Cost will keep increasing at different rates, mostly representing the exploration and development of reserves in areas of more difficult access. This is expected to be less critical in the Middle East, where large volumes are more easily available, when compared to the rest of the world. In global terms, expectations are that over 3 trillion USD (2000 $) must be spent in the oil sector alone over the next 25 to 30 years, to meet the forecasted 60% surge in consumption [31][36]. This compares to a similar investment for gas over the same period and close to 10 trillion USD for the electricity generation and transportation sector, according to the World Energy Investment Outlook[36]. It is important to note that overall investment should clearly impact oil production growth expectations, as it may limit exploration and development activities and also become the trigger to the implementation of other energy alternatives.

Considering a lower capital investment per barrel and a cost escalation of 2% per year for the Middle East, with higher corresponding figures for the rest of the world, it is possible to put together a possible scenario of annual investment evolution, as shown in Fig. 25. Figs. 24 and 25 show that it is possible to correlate the start of production decline in the rest of the world with the time when overall investment approximately doubles in relation to its present level. In the Middle East case costs will be lower, but it is expected that stabilization and decline of production will also be linked to the higher investment levels.

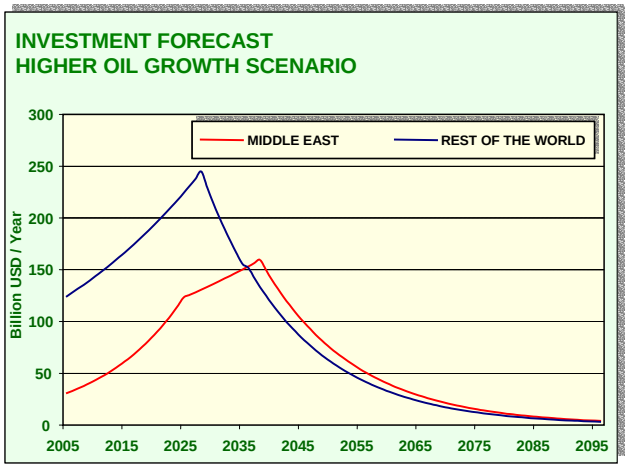

Fig. 25 - INVESTMENT FORECAST (HIGHER OIL GROWTH SCENARIO)

In other words, it has to be understood that oil supply will not be limited only by reserves and that investment should play a critical role in halting supply growth.

In what concerns production decline after the peak, it depends, of course, on the relative contribution, at that time, of the various sources of energy. As previously mentioned, oil and gas should keep us going until a sound portfolio of energy alternatives is in place. It is up to the world governments, both consumers and producers, to ensure a stable progress into that time, through the implementation, in a phased and timely way, of those alternatives.

It is not a probable scenario to assume that oil consumption could start declining now, given the availability, low cost and enormous flexibility of this source of energy. At this particular point, it is expected that consumption will continue to rise and so will production, until a peak is reached and a decline is established.

5.5 – The Short Term

In what concerns short term investment, the International Energy Agency has expressed concerns over the low level of investment in new capacity by oil producing countries and energy companies, which, in the IEA's opinion, is too small to meet the future growth in demand[37]. Many analysts think that the oil majors are establishing conservative business plans based on a low oil price environment[37], which, given the companies' objective of sustainable growth in an unstable business scenario, may indeed be the case. An excessively conservative business now, based on the continued production of the most accessible reserves, may have a negative impact on the medium to long term growth, with the companies starting to lose reserves assets. However, a scenario of over supply is also possible as suggested by Julian West of CERA who says that "the supply problem in two to four years may be too much oil"[38]. Of course, geopolitics can and will always play a major role in balancing any potential signs of under or over supply.

Companies need to survive within this complicated demand-supply system of equations. National Oil Companies (NOC's) normally control the world's largest reserves and it is difficult for the integrated majors and the smaller independents to access them. Any strategy for the majors and independents must centre on technology, an area where they have a clear advantage over the NOC's, and on acquisitions, a quick (although normally expensive) way of accessing reserves.

Although, at present, the majority of the NOC's are perfectly capable of producing the existing easy reserves, technology will play an ever increasing role as the most difficult reserves start to be developed.

6. THE GEOPOLITICAL GREAT GAME

GEOPOLITICAL GREAT GAME	
FACTORS	**EVIDENCE**
Increasing Energy Dependence of Western Countries	• Decline of production in Alaska and North Sea. • Difficulty of Oil Companies to access new reserves.
Balance of Power: State-Owned Companies of Producing Countries	• Role of OPEC countries. • Middle East has 64% of oil reserves.
Emergence of China and India	• More competition for oil and gas reserves. • Links through State-Owned Companies.
Growing Depletion of World Oil Reserves	• Inability to respond to growing world demand.
Difficulty of Oil Companies to replace and have access to Reserves	• Low reserves replenishment ratios.
Demographic Factor	• Growth in population. • Growth in energy needs. • Limited resources
Weaknesses Of Great Economic Powers	• Scarce domestic resources. • Fierce competition and new alliances.

TABLE V – GEOPOLITICAL GREAT GAME

There are some undergoing geopolitical changes in the world energy market[1] namely the following (Table V):

- The increasing energy dependence of the Western countries and the decline in the North Sea and Alaska production.
- The new balance of power in terms of oil companies with a more significative role of the state-owned companies of the Middle-East and OPEC countries.
- The emergence of the Asian giants like China and India which are starving for new energy sources necessary to feed their huge economic development.
- The growing depletion of the world oil reserves introducing new elements of competitiveness for the remaining ones.

- The increasing difficulty of Western oil companies to replace the reserves produced annually due to the maturity of existing assets and restrictions in the access to new oil fields which is reflected in the increasing decline in production (Fig. 25).

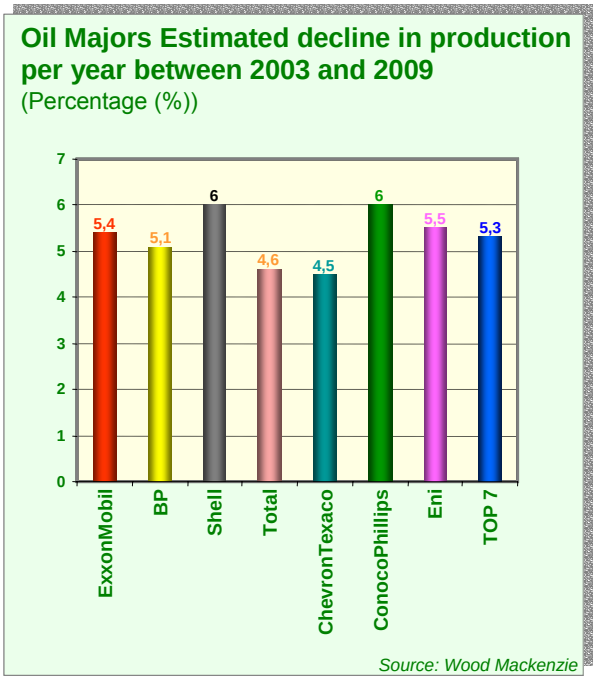

FIG. 25 - OIL MAJORS ESTIMATED DECLINE IN PRODUCTION PER YEAR BETWEEN 2003 AND 2009

6.1 The Demographic Factor

These changes are induced by the fast growing economic development of China, India and other nations, by the needs in terms of energy to feed their Gross Domestic Product and by the exponential growth of population in some areas of the world(1). There is a correlation between oil consumption and population growth. From 1953 to 1993, the world population doubled and the consumption of primary energy increased exponentially. Nowadays the world consumption amounts to 9 billion of tep (tonnes equivalent of petroleum) corresponding to 180 MB/D. From this, 40% is oil, 25% gas, 25% coal and 10% other energies. The current model is dominated by the fossil fuels: oil, gas and coal. In 1973 the world consumption was four times more for oil and five times more for gas when compared with 1953 consumption.

In the last 15 years the world consumption of oil reached the same order of magnitude when compared with the whole past period of human life.

The demographic growth is a key variable to characterize the evolution trend in terms of energy (Fig. 26). In 1900 the world population was 1.6 billion people and in December 2000 was 6 billion. Spanning one century the population growth was multiplied four times. This demographic revolution has consequences in the world energy market. In 2050 the current estimation is that the world energy consumption will amount to 15 to 25 billion of tep per year which means two to three times the current consumption. In this regard, a big question mark is to understand what are the alternatives to fulfill the future energy needs.

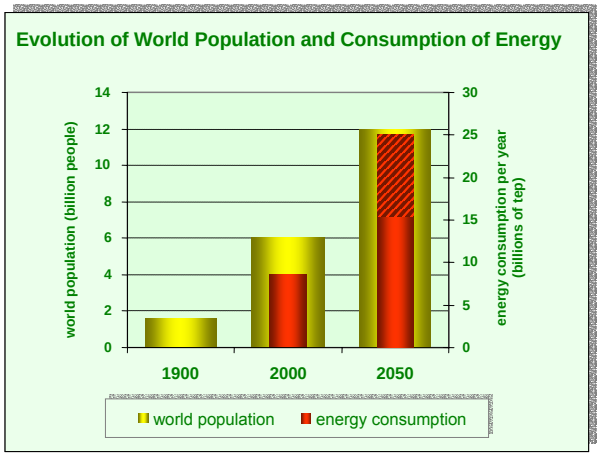

FIG. 26 - EVOLUTION OF WORLD POPULATION AND CONSUMPTION OF ENERGY

6.2 The Energy Weaknesses of the Great Economic Powers and Consequences

One of the current paradoxes is that the great economic powers have scarce domestic resources(1). US is experiencing an increasing internal production decline and an increasing

dependence from external resources (see Fig. 9). US consumption will increase from 19.7MB/D in 2001 to 28.3MB/D in 2025. In two decades, this is an increase of 44%. In the same period the domestic production will decline from 5.7 to 4.6 MB/D[(4)]. This combined effect causes the increasing energy dependence of US from external resources going from 55% in 2001 to 70% in 2025. This explains the current US efforts to access and control oil reserves. In fact the Cheney Report of 2000 on US energy policy clearly states that the access to oil reserves must be the priority of commerce and US external policy.

Japan has no oil and gas resources. Europe is experiencing an increasing dependence from the Middle-East, Russia and Africa since the North Sea production starts declining. The geopolitical consequences are wide: reinforcement of OPEC countries and increasing energy dependence for European countries. In 2004 UK became an oil importer rather than an oil exporter.

The emergence of China and India brought some changes in the geopolitical set and this is affecting the economy, the energy model, the diplomacy and the system of international alliances.

China economic growth in 2004 reached 9.5% and has become the world number one consumer of raw materials. In 2004 China overcome Japan to become the second world oil consumer behind the US. Chinese oil imports increased 35% in 2004 reaching 2.43 MB/D (see Fig. 8). As the domestic production will remain stable, China has to rely in external resources to fulfill its energy needs. China has 22% of the world population but only 2.3% of proved oil reserves (Figs. 27 and 28). Till 2010 the forecast is that China demand for oil will increase 66% to reach 10 MB/D. If this forecast of growth and demand is maintained, the Asian giant will dispute the first place to the US in two to three decades. This emergence introduces a new element in the international scene where the access to oil and gas reserves becomes critical.

The emergence of the other Asian giant, India adds complexity to this situation. Indian economic growth in 2004 reached 6% and will continue in the coming years. The country has 16% of the world population but only 0.4% of the proved oil reserves (Figs. 27 and 28).

The elements of competition for new oil and gas reserves are fueled by the characteristics and situation of the existing and emerging powers and the fierce fight for raw materials and energy sources which will be a key component of the history of this century. The emergence of China and India is changing the center of gravity of the world economy, is changing the power relations in the markets and is shaping the new geopolitical scene[(1)].

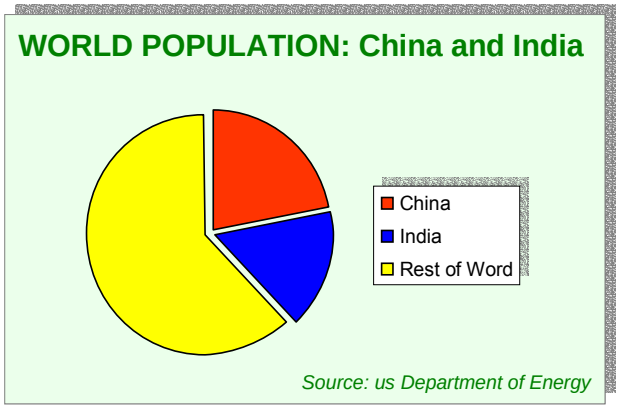

Fig. 27 - WORLD POPULATION: China and India

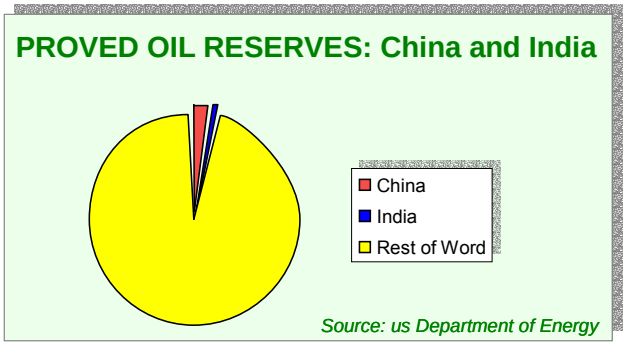

Fig. 28 - PROVED OIL RESERVES: China and India

7. PARTEX VISION

PARTEX OIL AND GAS has a long tradition in the oil and gas industry since its inception by Calouste Gulbenkian as partner of Iraq Petroleum Company in the first decades of the twentieth century. In this regard PARTEX vision has its roots in a realistic assessment of the Middle East oil and gas reserves which are far away from being depleted. A discussion of their role in the future is a must.

PARTEX VISION: A MULTI-ENERGY COMPANY	
THE VISION	**THE FUTURE**
Renew the Portfolio of Oil Reserves	• Consolidate/Extend existing partnerships. • Reinforce strategic positions. • Access to competitive new reserves.
Diversification of Assets	• Broader presence in gas. • Special attention to LPG, LNG, GTL. • Promote renewable energies. • Geographical diversification.
Production Growth	• Balance exploration risk with assets already in production. • Ability to prospect identification and evaluation. • Improve the Internal Rate of Return.
Prudent Financial Strategy	• Efficient use of capital to support revenues, growth and profitability. • Global portfolio management to reach an equilibrium among risk, profitability and growth. • Good Cost Control.

TABLE VI - PARTEX VISION: A MULTI-ENERGY COMPANY

The main details of the oil and gas demand trends can be summarized as follows:

- Fewer but stronger players in an increasing competitive business.
- Price volatility but within a cycle of structural changes in the industry maintaining a medium/long term high price level.
- Significative growth of energy demand induced primarily by the economic development of China and India.
- Shift to gas with the rise of the diversified energy company.
- Increasing market liberalization, diminishing governmental role in the energy business and increase of privatization.
- Decline in oil production in North Sea and Alaska with increasing energy dependence of Western countries.
- Aggressive competition in the access for new oil reserves.
- Strong role of geopolitical factors with emerging new alliances to ensure long-term energy supply.

Taking into account the oil and gas dominant trends, PARTEX developed a vision for the future which recalls the following elements (Table VI):

- Consolidate and extend the existing partnerships and alliances in Abu Dhabi, Oman, Brazil, Algeria and Kazakhstan.
- Renew the portfolio of oil reserves with the reinforcement of strategic positions and access to competitive new reserves.
- Search the best outlook for production growth and sustainable development stemming from large projects with low technical costs.
- Follow a prudent finance strategy in a volatile market environment.
- Diversification of the portfolio of assets with a broader presence in the gas sector using also targeted projects to promote renewable energies.
- Improve the management of the portfolio of New Ventures with the refinement of a solid risk assessment methodology and the development of the Group's ability for prospect identification, evaluation and farm-out.
- Identify assets already in production with potential to guarantee cash-flow in order to balance the risk of exploration assets and improve the Internal Rate of Return.
- Pay special attention to LPG, LNG and GTL opportunities, projects and associated facilities.
- Make an efficient use of capital to support revenues, growth and profitability increase focusing attention on good cost control.

- Adopt a global assets portfolio management to reach an equilibrium among risk, profitability and growth.

Basically PARTEX vision for the future favors the creation of conditions for conversion from an oil-based company to an oil, gas and multi-energy company. The notion of a diversified energy company will generate an energy portfolio encompassing the development of other resources with special focus on gas and renewable energies.

8. CONCLUSIONS

From the analysis presented above the main conclusions to be emphasized are as follows:

- The current oil price spike is explained by structural changes in the oil and gas industry namely the tight supply/demand balance, the erosion of the extra-capacity from OPEC countries, the change in the pattern of demand with the increasing role played by China an India, the lack of investments in Exploration and Development activities following the down-cycle of 1998 and geopolitical factors.
- These structural changes will remain in the near-future: this is not a short-term problem, it is a medium/long term shift in the world pattern of demand which will induce more aggressive competition for reserves given the lack of flexibility in terms of production alternatives.
- The root of the problem is not reserves scarcity and in fact there is an upward trend of remaining reserves over the past few decades. The forecasts have remained relatively constant over the past few years.
- Nevertheless oil and gas reserves are finite and with the current levels of demand and production it must be stressed that this century will witness the peak of oil production followed by an irreversible decline.
- PARTEX model for the peak of oil production is based on previous work developed by Campbell & Laherrère[8][10][11][12] and by Colitti & Simeoni[15] but presents new scenarios given that there are no absolute certainties regarding the timing of the peak and the best approach is to define a range of possibilities supported by meaningful assumptions.
- In the PARTEX model reserves are not restricted to proven reserves, the role of technology is also recognized in particular in exploration and the optimization of field recovery, non-conventional oil may also play a role depending on the ability of oil companies to produce these reserves, the projections of world demand are a key variable and a major unknown and the model encompasses oil and gas.
- Based on the previous assumptions and assuming a figure of 2,500 billion barrels of ultimate oil recovery, PARTEX lower production scenario shows an expected production peak for oil by 2040 and for gas by 2060; assuming a stronger oil production growth in line with EIA forecasts, our higher scenario case shows an expected oil peak by 2025 and the gas peak delayed until 2055.
- It is important to stress that production increase is not solely dependent on reserves, but also on the cost to develop them, the most critical element in the price of the barrel. This element is less critical in the Middle East, where large volumes are easily available, when compared to the rest of the world.
- Overall investment should clearly impact oil production increase expectations since it will be the trigger to the implementation of other energy alternatives.
- One effect of the high level oil prices has been the drive for a more balanced energy mix with a continued growth of demand for natural gas. The role of gas in the next decades will increase substantially and with the current level of reserves and growth it is probable that the gas will be

the future of oil and it will contribute to extend the consumption of hydrocarbons as the world most consumed primary energy source, far beyond the timing of oil peak is reached.

- High oil prices created also conditions for the reactivation of the consumption of other fuels like coal, nuclear and renewables. A new Hybrid-Energy Model will emerge promoting a more diversified and multidimensional energy portfolio. It is up to the world Governments, both consumers and producers to ensure a stable change in the energy matrix, through the implementation, in a phased and timely way, of these alternatives.
- However, geopolitical factors may play a significant role in the world energy market given the fierce competition for oil and gas reserves, the decline in the North Sea and Alaska production, the reinforcement of OPEC countries role, the increasing dependence of Western Countries, the emergence of China and India and the new balance of power in terms of the increasing role of the state-owned companies of producing countries.
- The demographic factor is also a key variable to shape the evolution trend of the energy market and a big question mark is to understand what the alternatives to fulfill the future energy needs are.
- In terms of the future, one clear trend is the conversion of the oil-based companies to multi-energy companies. The notion of a diversified energy company will foster a new balance of the energy portfolio, promoting the development of other resources with special focus on gas and renewables.

9. UNIT CONVENTIONS AND CONVERSIONS

Unit	Symbol	Exponent	Equivalence
Trillion Cubic Feet	TCF	10^12	185.8 million boe
Billion barrels	bn bbl	10^9	159 million m^3
Tonnes (metric)	Ton	1	7.33 bbl

Note: Approximate equivalences are based on average values for crude and gas gravities.

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