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Predicting the Peak in World Oil Production

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Abstract. The US Department of Energy's Energy Information Administration recently predicted that world oil production could continue to increase for more than three decades, based on the recent US Geological Survey (USGS) evaluation of world oil resources and a simple, transparent model. However, it can be shown that this model is not consistent with actual oil production records in many different regions, particularly that of the US, from which it was derived. A more careful application of the EIA model, using the same resource estimates, indicates that at best non-OPEC oil production can increase for less than two decades, and should begin to decline at the latest sometime between 2015 and 2020. OPEC will at this point completely control the world oil market and will need to meet increased demand as well as compensate for declining production of non-OPEC producers. OPEC could control the market even sooner than this, given its much larger share of proven oil reserves, probable difficulties in transforming non-OPEC undiscovered reserves into proven reserves, and the converging interests of all oil producers as reserves are depleted. This has significant implications for the world economy and for US national security.

Key words: oil, petroleum, oil production, peak oil, Hubbert.

INTRODUCTION

It is widely believed that increasing supplies of low-cost petroleum are vital to the US and to the world economy. It is also widely understood that petroleum reserves are limited, and that production cannot continue to increase indefinitely. Thus, there is evidently a day of reckoning sometime in the future; the point at which production can no longer keep up with increasing demand will mean a radical and painful readjustment globally. Given the profound economic, military and political importance of this issue, several groups have attempted to predict the point when demand would exceed supply by using different methodologies and different reserve estimates (Campbell and Laherre, 1998; Hubbert, 1962; Duncan and Youngquist, 1999).

Unfortunately, for a variety of reasons, predictions of the exhaustion of oil reserves seem to have lost all credibility, and the pendulum has swung so far in the other direction that the public now implicitly assumes that inexpensive oil will be available essentially forever. Yet oil is a finite resource, and there are only so many places to look for it. Sooner or later petroleum will run out, so sooner or later the prophets of depletion will be correct. The issue may be stated as follows: Can a forecast that is useful to the petroleum industry and to consumers, one that will alert them to problems about to be encountered and allow for a redeployment of resources, be made?

All approaches have in common the aggregation of reserves and producers into a single unit, and the explicit neglect of political and market forces in determining production. Considerable insight into the problem can be gained by disaggregating reserves and producers and understanding the other factors that determine how much petroleum is produced.

This can be illustrated by examining the recent effort of the Energy Information Administration (EIA) to predict the year in which world oil production will peak. The following assumptions were made in the EIA analysis:

1. USGS World Petroleum Resource Estimates (mean values) (Ahlbrandt, 2000) were assumed (Table 1).
2. The exponential annual rate of growth in world oil demand was taken to be 2%, based on rates observed over the past decade; several other scenarios were explored as well.
3. Peak production is estimated to occur when a proven reserves to annual production ratio (R_P/P) of 10 years is reached. This is based on the pattern observed in the US (excluding Alaska) where oil

production peaked in 1970 at this ratio. The R/P ratio measures how many years at constant output an entity can continue to exist. The petroleum industry itself and external investors use this ratio routinely to determine future potential and profitability of an oil company or an oil field; obviously an organization with a low R/P has a limited life and must either prove more reserves or merge with a company with better prospects.

Given these assumptions, world oil production, according to the EIA (Hakes, 2000), "…is likely to continue increasing for more than three decades." With a 2% growth rate, world oil production rises exponentially from current levels of about 27 billion barrels per year to a maximum of about 55 billion barrels per year in 2037. After this peak, production declines very rapidly to only 20 billion barrels per year by 2050, a decrease by a factor of 2.75 in only 13 years. (This, as will be evident from this analysis, should be considered a worst-case forecast as it is unlikely that producers would follow such a self-destructive path.) Higher or lower rates of growth lead to more or less rapid depletion of reserves and earlier or later production peaks, but the general behavior of oil production as a function of time is the same, that is a sharp peak in production and followed by a rapid decline.

ESTIMATE OF WORLD PETROLEUM RESERVES

The USGS World Petroleum Assessment (Ahlbrandt, 2000) is certainly the best such evaluation that exists to date. The study was made over a period of several years by statisticians, geologists, geochemists, petroleum reservoir modelers, and other experts. It is the first to use a detailed knowledge of geology to estimate undiscovered petroleum deposits, and the first to evaluate the phenomenon of reservoir growth to better estimate ultimate oil production. The depth and breadth of this work indicates that these estimates should be the reference values used to understand the future of the petroleum industry.

In the USGS Assessment, petroleum deposits are placed in one of three reserve categories. Remaining reserves, or proven reserves, are those that can be recovered with certainty. Undiscovered reserves are those that are highly likely to exist and to be recoverable with current technology, based on the best evaluation of geology and reservoir flow available. Yet reserve evaluations are notoriously difficult to make, and have generally been quite conservative. The addition of the term "reservoir growth," allocated according to proven reserves, is an attempt to take into account the observed continued substantial production from old US fields, and is applied to world oil proven reserves. This term is comparable to the proven and undiscovered reserves.

While the resource estimates are the best available, they still must be used with caution. The EIA methodology has a number of hidden assumptions:

- The EIA simulation implicitly assumes that all reserves are really proven reserves. That is, all undiscovered oil would be actually discovered, all reservoir growth does occur, and that these latter resources are all as available as the current proven reserves to provide increased production. The EIA criterion should actually be written as $R_T/P=10$ years, or a total reserves to production ratio.
- Reserves in all areas, even those with constant or declining production, are aggregated in the global reserve base and assumed available to meet increased demand.
- Substantial oil reserves located in extremely hostile environments, such as Greenland, are included on the same basis as much more accessible deposits, for example those in the Middle East.
- All producers (OPEC and non-OPEC) are aggregated and implicitly assumed to be independent, and the $R_T/P=10$ criteria applied to global production, not individual producers.
- The EIA model assumes an exponential growth followed by an exponential decay of oil production. This yields a sharp peak in production followed by a rapid decline. The actual production record as a function of time in the US is a bell-shaped curve.

In addition, the hypothesis that a production peak could be predicted by aggregating all reserve categories together was not tested against actual production records of other oil producing regions, or even recent US production records.

The unstated EIA assumptions have a dramatic impact on the conclusions that can be drawn from the model, as is demonstrated below.

R/P DECISION CRITERION FOR OIL PRODUCTION IN THE US

Applying the EIA methodology to current US oil production reveals significant contradictions. According to the USGS (Table 1), US proven reserves are 32 billion barrels, undiscovered reserves, 83 billion barrels, and reservoir growth is 76 billion barrels (data normalized to 1/96). Current US annual production is about 3 billion barrels, giving a proven reserves to production ratio of about 10 years. However, given the 191 billion barrel total reserve estimate, which yields an $R_T/P=65$, it would seem that these total reserves should support a much larger current production. US oil production, as previously noted, peaked in 1970, and has been in decline ever since, in spite of much higher prices and in spite of the existence of large US total reserves.

Clearly, some petroleum deposits must be much more difficult to exploit than others. Any delay or difficulty in turning other reserve categories into proven reserves will mean that peak production will occur sooner than predicted by the EIA methodology. Since the large undiscovered reserves and reserve growth have not been shifted to proven reserves rapidly enough to avoid a production decrease in the US, it is hard to see why this should be the case elsewhere in the world.

Based on the US production record, it is clear that considering undiscovered reserves and reserve growth on the same basis as proven reserves is unjustified, and a that different approach is required. The most reasonable would seem to be to include both proven and undiscovered reserves together (R_{U+P}) as indicating the maximum available reserves, and to apply the reserve to production criterion only to this category. One can then consider reserve growth as available to support production only after production had begun to decrease. This gives an upper limit for the point at which output might begin to decline, although political, social or market factors might cause producers to restrict output even sooner.

The validity of this approach is verified by looking at petroleum production of other non-OPEC regions in a following section.

Market Factors Influencing US Oil Production

Further insight into the EIA methodology can be gained by attempting to understand why US producers behaved as they did as peak oil production was approached in 1970. Why did US producers wait until $R_P/P=10$ to stop increasing production? Why did they not stop increasing production at $R_P/P=15$ or even $R_P/P=20$?

One can propose several reasons for this behavior based on the then-existing market rules. Private individuals or corporations own oil reserves in the US, and they attempted to maximize their profits without regard to the collective good. Some of the factors influencing them were:

- In the late 1960s the supply of Middle Eastern oil seemed limitless: deferred production in the US would simply be replaced by imports.
- Oil prices in the US had not kept pace with inflation, and were actually declining in real terms due to competition from inexpensive oil from the Middle East.
- US prices, long kept at elevated levels by restricting production, were far above production costs, and immense profits were possible for even moderately competent producers. Oil companies and individuals became enormously wealthy as a result of this system.

Thus, there were compelling reasons for US producers to continue to increase production as long as possible. It was only when proven reserves actually began to decline that production also began to decrease. At this point there still remained significant undiscovered oil reserves, but they evidently could not be brought into production at the same rate as more easily accessible deposits. The production decline occurred at R_P/P =10, which presumably represented some sort of balance between short-term profit and the long-term survival of a company.

Note also that about 30 years after this point, oil production had decreased to about half the level attained in 1970. This is a much slower decline than postulated in the EIA model, and is due to the introduction of new technologies and prospects. Oil production in older fields has continued due to the use of enhanced oil recovery methods, such as carbon dioxide injection. Previously inaccessible oil deposits such as those in the deep waters of the outer continental shelf can now be exploited economically. However, while the development of new enhanced recovery techniques will continue, vast new production regions are not expected to be found. Thus, future declines in world production, all other factors being equal, may well be steeper than those in the US.

On the other hand, given a different set of market rules, US producers might have decided to decrease production before R_P/P=10. For example, if they had known with certainty that oil prices would double in 1973, they might have restricted production several years before 1970, when their R_P/P was larger.

Using the proven reserves to production criterion can therefore be regarded as a subtle means to include market-based factors in the evaluation. This criterion can be used to predict a best-case scenario, which is the latest point at which oil production could be expected to decrease. Oil producers are extremely unlikely to increase or maintain production once their reserves to production ratio declines to 10, since at that point the future of their enterprise is clearly threatened.

Validation Of R/P Decision Criterion For Oil Production In Other Non-OPEC Oil Provinces

The validity of the hypothesis that a reserve to production ratio is a reasonable criterion for determining when production will begin to decline can be tested by examining production records in eleven different non-OPEC oil provinces. OPEC producers, who may have their production restricted by quotas, are excluded from this analysis. This comparison is shown in Table 2; total oil production among these producers is about 8 billion barrels per year (Bbbl/y), about 50% of total non-OPEC production. It is important to note that these producers have only 35% (188 Bbbl) of the accessible non-OPEC reserves, indicating that these are being depleted comparatively rapidly relative to other non-OPEC Producers.

A wide range of producers is examined, with the largest producer being the US (3 Bbbl/yr), and the smallest, Yemen (0.16 Bbbl/y). Of the eleven countries, six have decreasing or peaked production, two (India and China) have maintained roughly constant production for the last five years, and only three have increasing production.

If reserve growth is included, the model fails to predict decreasing production in every case. Only with Syria and the UK do the R_T/P ratios, at around 15, even approach the threshold value. The most striking instance, as has previously been noted, is that of the US, where production has been declining for over 30 years. For China and India, the high R_T/P ratios and flat production regimes may reflect less efficient or aggressive state owned industries, or problems encountered developing more remote deposits.

Excluding the reservoir growth term and using only proven and undiscovered reserves gives better results, but this is still a far from definitive criterion. With the exception of the US, the range of R_{P+U}/P lies between 16 years (Egypt, Norway) and 9 years (UK, Syria) for the producers with decreasing or peaked production.

Therefore, one should expect that, all other factors being equal, other non-OPEC producers might find oil production begin to decline for this range of R_{P+U}/P.

The anomalous case of the US, with an R_{P+U} of 32 and decreasing oil production might be accounted for by the following factors. While new technology does allow continued production from older fields, production rates are not nearly as high as for new fields. Thus, while half the oil in a given formation might ultimately be recoverable, the first 25% might be available over ten years, while the second 25%

might only be economically recoverable over twenty or thirty years, or even longer. In addition, undiscovered reserves are generally less accessible than older oil deposits. Substantial oil production now comes from offshore platforms on the continental shelf; exploitation of deposits on the outer continental shelf with the seabed 10,000 feet below the surface is now economical. Such ventures entail much greater risk and require much greater capital investment as well as highly skilled professionals in many disciplines.

WORLD OIL RESERVES: OPEC AND NON-OPEC PRODUCERS

Based on the USGS World Petroleum Assessment, oil reserves can be allocated to OPEC and non-OPEC* producers (Table 3). The category of world reserve growth (Table 1) is divided between these two groups according to their remaining or proven reserves. Although OPEC has much larger proven reserves compared to non-OPEC producers, and also much larger reserve growth, non-OPEC producers have a much larger amount of undiscovered oil. These latter reserves are located in widely different regions, so that it is highly likely that total is reasonable, even if one oil province has larger or smaller undiscovered reserves than is estimated by the USGS. Nonetheless, it is likely that these undiscovered reserves will prove to be more inaccessible and more difficult to exploit than proven reserves, as pointed out earlier. The largest undiscovered reserves are located in the US (83 Bbbl), Russia (77 Bbbl), Greenland (47 Bbbl) and Brazil (47 Bbbl).

It is also significant that the total reserves of OPEC and non-OPEC producers are, according to USGS estimates, quite comparable. However, current OPEC production levels of about 11 Bbbl/y are far below those of non-OPEC producers at 16 Bbbl/y, so that, assuming both groups increase production at the 2% rate, non-OPEC producers will deplete their reserves first.

The ratio of undiscovered plus proven reserves to annual production (R_{U+P}/P) for OPEC and non-OPEC producers is listed in Table 3, and quantifies the disparity between these two groups. This is even greater if one takes into account that a significant fraction of the much greater non-OPEC undiscovered reserves might only be available to maintain, but not to increase, production.

The weakness of the decision to aggregate producers is even more striking if individual producers within these two groups are examined. For example, in the EIA model, towards the year of peak production in 2037 Persian Gulf producers would be supplying virtually all of the oil for the entire world. According to this scenario, by 2030 world production would be about 135 million barrels per day, or somewhat less than twice current world levels, and more than five times current Persian Gulf production. Obviously, the entire market system would collapse, if only due to a traffic jam of super tankers in the Persian Gulf, long before this point was reached.

Current World Market Factors

OPEC and even other oil producers are in one respect in a similar position compared with pre-1973 US producers: stupendous profits are possible from petroleum production. The lifting cost (EIA, 2000) for oil in the Persian Gulf is on average $1.50/barrel (1997 dollars). Oil produced by non-OPEC producers has a lifting cost of about $4.00/barrel (1997 dollars). Thus, at current prices of $18-$28/barrel, the oil business is incredibly lucrative. These stunning levels of profitability again provide strong incentives to produce as much oil as possible as quickly as possible.

Non-OPEC producers also feel, as did the domestic US oil producers in the 1960s, that if they do reduce production, others will simply take their place.

In many other respects, however, current oil producers are in a completely different situation compared to these same US producers. In other regions, oil reserves are the property of the states, not private

* Undiscovered reserves of Greenland (47.1 Bbbl), Surinam (13 Bbbl) and the Falklands (5.8 Bbbl) excluded as inaccessible.

individuals, and petroleum exports provide most if not all of these states' foreign exchange. As their reserves are depleted they are effectively conducting (Betancourt, 1978) a "going out of business sale." They may become less and less willing to increase or even maintain production to meet increasing demand. Even those producers desperate for revenues to finance civil wars or to support an insatiably corrupt government might also conclude that production should no longer increase well before they descended to $R_T/P=10$ based on total reserves, as assumed by the EIA.

Another important difference is the lack of any set of market regulations and enforcement procedures (Yergin, 1991) comparable to what the Texas Railroad Commission (Weaver, 1986), the Interstate Oil Compact Commission, and the Federal government provided in the US beginning in 1935. A major problem with OPEC is that, while it can set quotas, unlike the Texas Railroad Commission it has no legal enforcement mechanism. Its only recourse is to discipline the market by flooding the world with oil to drive the price down. This is quite crude and obviously is rather disruptive. It does not appear likely that the current system will be replaced with something more rational in the immediate future.

APPLYING THE R/P DECISION CRITERION TO NON-OPEC WORLD OIL PRODUCTION

The EIA model can be applied to estimate when non-OPEC oil production might begin to decrease, given the following assumptions:

- Production will begin to decrease when $10< R_{P+U}/P <15$.
- Reserves are aggregated, and producers are independent of one another.
- Non-OPEC production increases at a rate of 2%/year.
- USGS Reserve Estimates are used, but non-accessible undiscovered reserves of 65 Bbbl are excluded. Total proven plus undiscovered reserves are thus about 606 Bbbl (2001).

The results of this simulation indicate that non-OPEC oil production will begin to decrease sometime between 2015 and 2020, with the earlier date corresponding to the larger value of R_{P+U}/P. If some undiscovered reserves were more difficult to exploit than others the production peak would occur even earlier.

However, the assumption that all producers act independently and are willing to increase production to whatever levels the market requires is highly questionable. This model implicitly assumes that producers with the largest R_{P+U} will increase their production not only to meet increased world demand, but also to compensate for decreasing production of other non-OPEC producers.

The states of the Former Soviet Union (FSU: Russia, Uzbekistan, Kazakhstan and Turkmenistan) account for 40 % of the accessible non-OPEC reserves (R_{P+U} =242 Bbbl). FSU production was 4.2 Bbbl/y in 1990, but dropped to 2.6 Bbbl/y in 1995, not due to any lack of resources, bur rather due to mismanagement during the Soviet regime and the collapse of the communist political and economic system. Current production is about 3.1 Bbbl/y, or 20% of non-OPEC production, and is increasing rapidly (Table 4). Around 2015, the countries of the former Soviet Union might be the only non-OPEC producers able to increase supplies. A substantial fraction of total non-OPEC projected production of 22 Bbbl/y (compared to current non-OPEC production of 16 Bbbl/y) would need to originate from these areas. Yet tripling or quadrupling the current production rate is probably both physically and politically excluded.

Thus, it is highly likely that non-OPEC production will level off long before 2015, not because of reserve depletion but due to a combination of political and transportation constraints on production.

OTHER ATTEMPTS TO PREDICT PEAK OIL PRODUCTION.

Other attempts to forecast a peak in oil production are based on the methodology of M. King Hubbert (Hubbert, 1962), who predicted that the year of peak production in the US would be about 1970. When maximum production did actually occur at this time, his model was widely and uncritically accepted.

Hubbert noted that resource extraction as a function of time often followed a bell-shaped curve, with an exponential rise in production followed by a leveling off, followed by an exponential decrease. This could be described empirically by a simple exponential equation with three free parameters to be determined by the available data. One critical piece of information needed to predict the peak in production is the total size of economically available reserves.

What is generally not realized is that Hubbert, using this same methodology, also predicted a peak in world oil production in 2000 by assuming an ultimate potential reserve of 1250 Bbbl and a peak production rate of 12.5 Bbbl/y. He also predicted a peak in US natural gas production in 1978 at about 20 trillion ft^3/year (Tcf/y). Of course, the world oil market has not behaved at all as Hubbert predicted: current oil production is now about 27 Bbbl/year and shows no sign of decreasing. US natural gas production peaked in the early 1970s at about 22 Tcf/y, decreased to 16 Tcf/y in 1985 and has increased again, reaching the early 1970 levels in 2001, with significant increases in production expected over the next ten years (EIA, 1997).

Although Hubbert's model is actually referred to as a classic example of how exploitation of a finite natural resource will unfold, it is easy to find examples where production does not conform to this pattern. One such instance is oil production in Saudi Arabia, which has enormous reserves and a small population. Oil production has ranged between 6.4 Mbbl/d and 8.3 Mbbl/d over the last eleven years, and has been approximately constant at around 8 Mbbl/d from 1991 through 2001.

Clearly Hubbert's model did work in one instance and thus has some range of applicability. The conditions for the validity of the model would seem to be:

- Accurate estimates of easily accessible proven reserves.
- Political and market stability.
- Affordable, stable prices for consumers and enticing profits for producers.
- Exponentially increasing consumption.
- Independent producers focused only on maximizing their immediate profits.
- Perceived abundance of and availability of other (in the US, Middle Eastern) reserves.

These indicate that Hubbert's model should be useful in a limited set of circumstances. His prediction of the peak year in world oil production used grossly inaccurate estimates of oil reserves and he implicitly assumed a political and market stability that proved to be unjustified. In 1962, the North Sea, offshore Africa and South America and the outer continental shelf were all unknowns as significant oil provinces, and enhanced oil recovery technologies had not yet been developed. OPEC had only been founded in 1960, and the major oil companies still owned the oil concessions in the Middle East.

Similarly, Hubbert's forecast of the peak year of natural gas production used low reserve estimates and assumed market stability. At the time, natural gas was usually produced in association with oil, and prices were set at such a low level by federal regulators that it was not worthwhile to search for new natural gas deposits. In 1973, the wellhead price of natural gas (EIA, 1996) was about $0.60 per mmBtu (million Btu)(1996$). Once natural gas prices were allowed to increase, they rose to nearly $3.60/mmBtu by 1983, and consumption dropped substantially. In response to higher prices, supplies increased once again, prices decreased to around $2/mmBtu by 1990, and a new equilibrium developed, based on the new market rules. The decrease and subsequent increase in production and consumption responded to the much higher, but still quite affordable, price of the resource.

What these examples show is that any model will have assumptions and a range of applicability and that these limitations must be explicitly stated. Otherwise, the model will be applied inappropriately, and invalid forecasts used to direct the political process. When the flaws are discovered, the entire process is discredited, leaving the system vulnerable to much greater disruptions.

A recent application (Campbell and Laherrere, 1998) of Hubbert's model predicted a world oil production peak in 2004. The authors use reserve estimates derived from a proprietary database; their estimates are about 60% of those of the USGS. They also believe that the proven reserves of the Persian Gulf are overstated to allow certain countries to increase their production quotas. The model is treated as a mathematical formalism rather than an attempt to describe a dynamic and volatile enterprise, with political and economic components that are difficult, but not impossible, to describe and quantify.

EVALUATION OF R/P BASED ANALYSIS

This approach has the advantage of transparency, simplicity, and flexibility. A reserve to production ratio is widely used in the oil industry to mark the relative soundness of a given company, and is easily understood. In addition, there is no need to assume an exponential growth in consumption, and any type of production can be easily accommodated. As has been noted earlier, there are many instances when production does not follow an exponential rise and fall, so that this feature may be quite useful. The USGS Resource estimates are publicly available and quite detailed, and can be used by anyone to understand the world oil reserves.

In addition, the assumptions used in the model are discussed and the limitations noted. Market factors are evaluated and taken into account at least qualitatively.

While one key in predicting a production peak is the magnitude of oil reserves, equally important is their location. Unless there is much more oil to be found outside of the FSU and OPEC, the years of abundance in oil must soon come to an end.

CONCLUSIONS AND RECOMMENDATIONS

It must be emphasized that a peak in oil production does not mean that the world will run out of oil in the near future. The reservoir growth term in the USGS estimates, in addition to the large proven and undiscovered reserves in OPEC and the FSU, implies that significant amounts of petroleum will continue to be available for many decades following peak production. However, the transition to a sustainable economy may be extremely painful unless it is managed with great skill and understanding.

The market, as it is currently constructed, may naturally lead to an economy much less dependent on petroleum in particular and fossil fuels in general. As oil production is restricted, and oil prices increase, alternative fuels and technologies will quickly become more competitive. The market is large enough to accommodate both higher priced petroleum as well as more expensive alternatives. Higher priced oil should signal neither the end of oil nor the end of civilization.

Technical (Johannson et al., 1993; von Weizsacker et.al., 1997) and political solutions exist to the challenge posed by higher priced petroleum. For example, in the immediate future, personal transportation can become much more efficient using hybrid engines, diesel engines, battery powered cars and intensive use of mass transit. Geothermal heat pumps can be used extensively for heating and cooling.

In the US, which consumes about 25 percent of world oil production, and where gasoline prices are extraordinarily low, gasoline taxes should gradually be increased over a period of five to ten years to at least $3/gallon, with rebates targeted to lower income groups to ease the shift to higher fuel prices.

This transition will be manageable given one essential condition, which is that the industrial world does not intervene militarily in the Persian Gulf in order to control oil extraction rates directly. Intervention would be an error of enormous proportions. It should be kept in mind that even with the US directly controlling Persian Gulf producers, the best that can be expected is a production peak sometime after 2030, with a rapid falloff thereafter. Hopefully, the US public would see the folly in such an attempt to subsidize (Cavallo, 1996) the continued extravagant use of fossil fuels.

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Table 1 Mean Estimated World Petroleum Resources (1/96) Billions of Barrels (Bbbl)			
Reserve Category	World excluding US	US	World
Undiscovered Conventional	649	83	732
Reserve Growth	612	76	688
Remaining Reserves	859	32	891
Totals	2120	191	2311

Table 2 Comparison of Reserve to Production* Ratios for Several Oil Production Regions, 2001				
Country	R_{P+U}/P 2001, years (Less Cumulative Production)	R_T/P 2001, years (Less Cumulative Production)	2000 Annual Production Bbbl/y	Production Status 2001
UK**	9.70	16.68	0.99	Decreasing
Norway**	16.12	24.07	1.21	Peak
Egypt	16.06	24.48	0.30	Decreasing
China	25.15	39.96	1.18	Constant
Australia**	19.27	23.90	0.28	Increasing
India	28.55	46.44	0.27	Constant
Syria	9.01	15.20	0.20	Decreasing
Argentina	12.50	18.14	0.30	Decreasing
Oman	14.80	22.38	0.35	Increasing
USA**	32.86	58.53	2.96	Decreasing
Yemen	22.48	28.05	0.16	Increasing

*Production statistics are taken from trade publications: *World Oil,* 10/2001; 9/1998 and *Petroleum Economist*, 9/2001; these publications use data furnished by the International Energy Agency (IEA).

**Production figures include condensates and natural gas liquids (NGL). For the USA this is about 28% of total production, while for OPEC it is about 10%. Condensates and NGL volumes are included in total world oil production figures, and may or may not be included in production statistics for individual producers. Whether or not these volumes are included does not change the overall conclusions of this paper. For the case of the USA, inclusion increases R_{P+U}/P by about 28% and makes declining production in this province even more exceptional.

Table 3 Mean Estimated World Petroleum Resources, Annual Production, Billions of Barrels (Bbbl) (1/96) and Reserves to Production Ratios OPEC and Non-OPEC Producers		
Reserve Category	OPEC	Non-OPEC
Undiscovered Conventional	281	451
Reserve Growth	408	280
Remaining (Proved) Reserves	572	318
Totals	1261	1049
Annual Production (Bbbl/year, 2001)	11	16
R_{U+P}/P (years) (2001)	72	37

Table 4 Accessible Reserves (R_{P+U}) and Production Allocation (2001) Non-OPEC Producers		
Category	R_{P+U} Reserves (Bbbl), (%)	Production Bbbl/y (%)
USA, UK, Norway, etc. (Table 2)	188 (30%)	8.2 (50%)
FSU	242 (40%)	3.1 (20%)
Other	176 (30%)	4.7 (30%)
Total	606 (100%)	16 (100%)