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HUBBERT REVISTED---1: Imbalances Among Oil Demand, Reserves, Alternatives Define Energy Dilemma Today

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Background

A sizzling world economy is expected to grow 2.7 percent in 2004, the second highest rate since 1990. The biggest oil consumer in the world, the United States, finally has its economy back on track and its gross domestic product (GDP) is set to expand by 4.4 percent during 2004. China is continuing its oil consumption increase at a rate of 6 percent per year. All this economic growth is generating a strong demand for energy and oil prices are on the rise. Oil (Brent) prices entered 2004 at $30 per barrel and by March 19 had risen to their pre-Iraq-war peak of $33 per barrel, the highest since 1990. Current projections of the US Energy Department (DOE) indicate that world oil demand is expected to grow from 78 million barrels of liquids per day in 2002 to 118 million in 2025. This represents an increase over the 1.5 percent average growth rate in world oil consumption since 1995.

With an assumed robust or even a moderate growth in demand, there is an evident need to substantially increase oil reserves and to develop new production. After a dip in 2000 to a meager $90 billion, global capital spending on oil exploration and production[1] has been on a steady climb and is expected to top $160 billion in 2004. World proven conventional oil reserves[2] have increased only slightly since 1994, averaging about 6 billion barrels annually. This increase of new reserves generated about 1 million barrels per day of new oil production per year, enough to satisfy the annual growth in global demand over the same period.

In January 2004, Shell made a surprise announcement that their proven oil and gas reserves had been overestimated by 20 percent! Shortly after, BP announced a larger than normal downward adjustment in their reserves revisions which raised some concerns on Wall Street. Changes in proven reserves, especially downward ones, ring an alarm in the financial markets, as reserves are vital to a company's assets, its stock market value, and its ability to borrow. The association with recent events of financial data mis-representation by some corporations only serves to create a cloud of uncertainty on the accuracy of proven oil reserves and their capability to satisfy the expected long-term global energy demand. Furthermore, there is a shroud over the peaking of world oil production[3] due to natural depletion by the 2010s.

Apparent imbalances between increasing demand, diminishing reserves, and no visible alternate substitute for oil, ultimately define the energy dilemma.

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Energy Alternatives

Oil is the world's most important primary energy source, providing 39 percent of the total energy consumed. Sixty-one percent of the oil produced is used as fuel for transportation and electrical power plants. Both of these sectors are projected to grow at a higher pace than energy demand as a whole[4]. It is essential to explore, at least on a cursory level, the alternatives to pick-up the slack in these sectors when oil supplies go on the decline, and to help extend the life of this important non-renewable energy source.

Table 1. Primary Energy Consumed in the World - 1999

(billion barrels oil equivalent per day)

Oil	**74.9**	**39.0%**
Natural Gas	**42.8**	**21.7**
Coal	**41.7**	**26.0**
Nuclear	**12.4**	**5.8**
Hydro, other*	**16.2**	**7.5**
Total	**188.0**	**100.0**

***Includes biomass, geothermal, wind, solar, photovoltaic**
Source: DOE-International Energy Outlook, March 2002

Worldwide electricity consumption, which utilizes 10 percent of world oil production as fuel, is projected (DOE) to increase at a high annual rate of 2.7 percent through 2020. In the early 1970s, with the advent of commercial reactors, nuclear power seemed the most attractive alternate energy source for electricity generation, which at that time was powered principally by coal[5]. Nuclear powered electricity generation grew rapidly through the 1980s. Its use was mainly concentrated in developed countries and has remained that way. The US is the world leader with a 30 percent share of the total installed nuclear generation capacity.

Nuclear powered electricity accounts for 16 percent of the worldwide electrical fuel market but is expected to decline as a result of safety concerns, waste disposal issues, etc. At the moment, nuclear powered electricity is not sociably acceptable. Not a single new reactor has been brought on line in the US since 1996. Moreover, natural uranium reserves are expected to peak in the next 25 years based on the existing global fleet of nuclear reactors. Although coal is still the dominant fuel in this market, natural gas is the preferred fuel to take up the slack because of environmental concerns.

The case for the transportation sector, which consumes more than one-half of the world oil production, is by far the most complex and critical. Alternatives being developed range from those with short term goals, such as, CNG, LPG, and gasohol to hydrogen-based fuels which in the best circumstances, would have a long term impact.

Other possible energy alternatives to replace oil in other diverse applications are wind, solar, geothermal, photovoltaic, and biomass. All these together provide less than 0.4 percent of the total primary energy consumed and the outlook for any significant impact on the world energy scenario is beyond 2020. Some energy conservation seems inevitable.

To quote Matthew Simmons, Energy Advisor to President Bush, "We need a wake up call. We need it desperately. We need basically a new form of energy. I don't know that there is one."

The Reserves/Production (R/P) Issue

Of the 90 countries that produce oil, the top ten account (see Table 2) for 83 percent of the world's reserves and more than half of the world's oil production. The 20 countries with proven reserves exceeding 5 billion barrels, account for more than three-quarters the world's oil production and 93 percent its proven reserves.

The reserves/production ratio (R/P ratio) is a quick-look indicator of the duration of the reserves at the present production rate. Consequently, the current (2002) world oil reserves of 1,031 billion barrels would last 43 years at a rate of 66 million bpd. More importantly, the R/P ratio is a useful tool to highlight comparative differences in the volumes of reserves reported among the different countries. In general, reserves are developed to support a determined level of production capacity, Pmax. The R/Pmax ratio between countries should fall within a narrow range of values. Variations would reflect geologic differences in productivity among the wells and the mix of oils, from heavy to light that may characterize the country's production.

Table 2. World Proven and Probable Oil Reserves, and Production - 2002

Country	Reserves, billion barrels		Production (P)	R/P	R/Pmax
	Proven(R)	Probable	million b/d	years	
The Top Ten					
Saudi Arabia	259	40	6.8	104	84
Iraq	112	52	2.0	153	118
Kuwait	94	27	1.6	160	103
Abu Dhabi	92	12	1.6	158	126
Iran	90	40	3.7	67	65
Venezuela	78	20	2.3	93	69
Russia	60	48	7.4	22	22
Libya	30	1.4	1.3	63	55
Nigeria	24	7.9	1.9	35	31
United States	22	2.7	5.7	10	9
Sub-Total	861	251	34.3		
The Next Ten					
China	18	0.7	3.4	14	14
Qatar	15	47	0.64	64	45
Mexico	13	25	3.2	11	9
Norway	10	1.4	3.1	9	9
Algeria	9.2	0.8	0.85	31	21
Kazakhstan	9.0	3	0.81	30	30
Brazil	8.3	3.4	1.5	15	15
Azerbaijan	7.0	1.4	0.30	64	64
Oman	5.5	2.3	0.90	17	17
Angola	5.4	4	0.89	16	16
Sub-Total	100	89	15.6	17	17
All Others	70		16.1	12	12
World	1031	340+	66	43	40

Notes: Reserves and production exclude unconventional oil and liquids from natural gas.
Sources: Oil and Gas Journal, Wood MacKenzie, DOE.

As illustrated in Table 2, half of the top twenty producing countries have R/Pmax values between 9 and 21. The top six countries, all belonging to the OPEC group and accounting for 70 percent of the world's reserves, have R/Pmax values between 31 and 126. Figure 2 is a graph of Reserves versus Production Capacity for the top 20 producing countries in the world. The two trend lines shown essentially represent the correlation limits for OPEC and non-OPEC countries. As you can see, OPEC countries report almost five times the reserves required to sustain the same level of production capacity. For instance, to develop 180,000 bpd of new oil production capacity would require discovering one billion barrels of reserves in countries in the lower tier versus 5 billion barrels in the upper tier OPEC countries!

These extreme differences do not necessarily imply that the reserves values are flawed just that different standards are used in estimating the reserves. The Security and Exchange Commission (SEC) rules that are used to define proven reserves are not applicable to countries, only to the oil companies. The oil companies in turn have to comply with the rules set up in the countries where they operate. For instance, tax rules in a country could encourage reporting low reserves since amortization of investments is tied to the R/P ratio. On the other hand, during the 1980s many of the OPEC countries upped their 'book' reserves, in some cases by a factor of three, to position themselves in anticipation of a quota system[6].

The important issue, however, is that the relationship between discoveries and new oil production capacity needs to be standardized in order to quantify the true reserves and investments required to meet our future demand. Our preference is that the lower tier trend be used since it errs on the side of conservatism rather than excess. The derived algorithm for the lower tier is:

$$\text{Pmax} = 180\ R \qquad (1)$$

Pmax is the production capacity expressed in barrels per day and R, the new reserves in millions of barrels of oil. As a rule of thumb, 600 million barrels of new reserves will generate 100,000 bpd of *new* oil production capacity.

At current world oil production rates, 25 billion barrels of oil reserves are consumed each year and have to be replaced just to maintain the existing production rate. The DOE forecasts future world oil demand to increase at an average annual rate of 1.7 million barrels per day. Generation of this new production would require (using Equation 1) finding an additional 10 billion barrels of new reserves each year. As a result, world reserves would have to grow annually by 35 billion barrels of oil, of which roughly three-quarters goes to production replacement and the remainder to give an incremental jump in the production rate.

In its recent World Petroleum Trends report, IHS Energy's assessment of the period 1993 through 2002 states "137 billion barrels of new oil discoveries were added. The combination of reserves revisions and new discoveries has exceeded global liquids consumption during the past 10 years".

Of the 137 billion barrels discovered, 33 billion barrels (estimated with Equation 1) went towards generating 6 million barrels per day of new oil production. Production grew from 60 to 66 million barrels per day over the 10-year period. The remaining 104 billion barrels of discovered reserves contributed partially to meet the 230 billion barrels required to replace production in existing fields. Reserves revisions during the 10-year period made up the difference and amounted to a hefty 126 billion barrels of oil!

Revisions include reserves obtained by *improved oil recovery*[7] (IOR), *pool extensions* from in-fill and step-out drilling, and *adjustments* for improved technology in existing fields, field micro-management, and oil prices. A breakdown of the distribution of the entire package of reserves additions (discoveries plus revisions) for ten major oil companies from 1993 through 2002 is shown in Table 3. Reserves additions that amount to 70 billion barrels are split 50:50 between discoveries and revisions. IOR provides 12 percent, extensions 6 percent, and adjustments one-third of the total reserves additions. The ten major oil companies together generated an average of 7 billion barrels of reserves annually over the 10-year period.

Table 3. Proven and Probable Oil Reserves (2002), and Additions (1993-2002) for Ten Major Oil Companies

(billion barrels)

	Additions		Proven	Probable
Discoveries	**35**	**50%**		
Revisions				
IOR	**8.6**	**12**		
Extensions	**4.1**	**6**		
Adjustments	**22.3**	**32**		
Sub-Total	**35**	**50**		
Total	**70**	**100%**	**108**	**30**

Source: Merrill Lynch, Wood MacKenzie

Probable Reserves

Reserves are classified into three categories: proven, probable and possible. In simple terms, proven refers to reserves recoverable with present technology and prices; probable reserves are those subject to development if determined commercially viable; and possible reserves are those still highly speculative in quantity and viability. Probable reserves are sometimes referred to as technical reserves. The CIS countries to encompass proved, probable and possible reserves, use an additional category of "explored reserves".

It has been proposed that a better measure of a company's resource base would be a combination of proven and probable (P+P) reserves. The SEC imposes stringent restrictions on the commitment of capital based on proven reserves. Recently most of the new large E&P projects, especially those in deepwater regions, got the industry's go-ahead based on P+P reserves. It is difficult to justify capital for these high cost projects based only on proven reserves. The SEC remains concerned about companies that book probable reserves, given the obvious risks that they may not materialize during the lifetime of the project. Qatar is a good example of this dilemma. It has 47 billion barrels of probable reserves (Table 2) associated with a potentially large E&P project, the well-known North Field. These reserves are well audited but can only be classified as probable. The country's proven reserves are 15 billion barrels.

From the data presented in Table 2, combining the P+P reserves would increase the world's current resource base by roughly one-third. Table 3 shows a similar percentage increase for the resource base of the ten major oil companies.

Highlights

- **The DOE energy demand forecast requires increasing world oil production rates by 40 million barrels per day - from 78 million barrels per day in 2002 to 118 barrels per day in 2025. This production growth would require adding more than 35 billion barrels of oil reserves each year, averaged over the forecast period.**

- **E&P capex needed to meet the projected production goals would be $200 billion annually.**

- **A simple algorithm (Equation 1) was developed to estimate the volumes of discoveries required to generate *new* oil production. Using this algorithm, it is estimated that to generate the 40 million barrels per day increase of new oil would entail finding 10 billion barrels of *new* reserves each year.**

- **The total reserves to be added each year - more than 35 billion barrels - consists of 10 billion barrels of discoveries plus an additional 25 billion barrels from revisions of reserves to replace production in existing fields. Revisions comprise IOR, extensions, and adjustments for improved technology, field micro-management, and oil prices.**

- **There is a critical need to connect demand and supply projections that at this time are almost done independently. The large volumes of reserves and capital required to meet future oil demand far exceed what we have done in the past.**

Can we find these significant amounts of oil or substitutes to attenuate the natural depletion of this valuable resource? Will F&D costs skyrocket as oil resources inevitably become scarcer? Are higher oil prices unavoidable? Doomsday or heyday?

"Brain power is the one source of power that will never run out" – Epcot's Universe of Energy exhibit.

Acknowledgements

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Fig. 1 Worldwide Oil Demand vs E&P Capex, 1971 - 2003

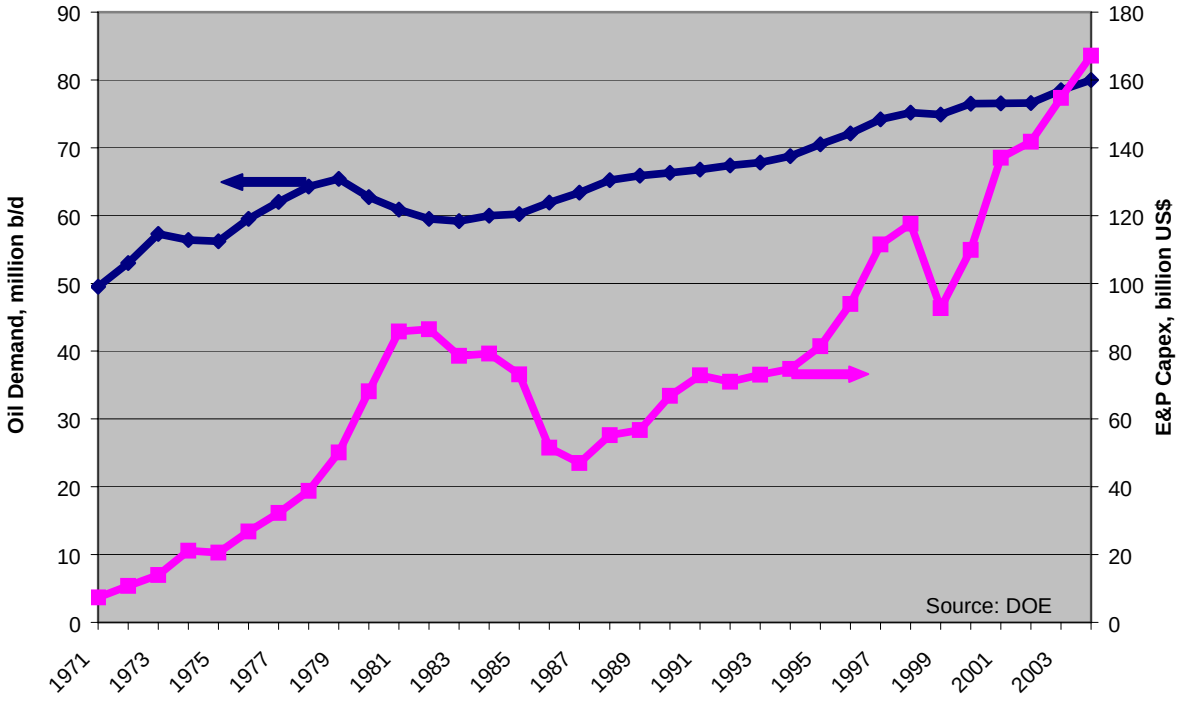

Fig. 2 Proven Oil Reserves vs. Production Capacity
Top twenty Countries