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PROCEEDINGS

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Oil--An Unlimited Resource?

by Ian Nalder

Ian Nalder is currently studying Environmental Science at Carleton University. His background, however, is engineering. After seven years as an Engineering Officer in the Royal Australian Air Force, he changed countries and jobs to work in England designing and marketing communications systems for customers world wide. He came to Canada in 1981 and has since worked for various companies in the fields of systems engineering, program management and consulting.

"The powerful myth is 'limited resources'. There is no such thing. "The amount of any mineral in the earth is an irrelevant non-binding constraint." These words by an energy expert at M.I.T. echo a persistent criticism of *The Limits to Growth*[1]: that resource depletion isn't a problem or, at the least, is overstated. It is a frequent criticism and oil is usually the example.

Critics claim that proven reserves of oil are greater today than ever before. And there is truth in these claims. In the US. between 1930 and 1988, proven reserves increased from 13 billion barrels to 20 billion even though 120 billion had been extracted in the meantime. Another example comes from the Middle East where "in 1944, a special expert mission estimated Persian Gulf reserves at 15 billion barrels proved, 6 billion probable. As of 1975, those same fields (excluding later discoveries) had already produced 42 billion barrels and counted 75 billion 'remaining'[2]. We have reached the point where "all fear of a shortage seems to have disappeared."[3]

The history of "expanding reserves" is shown in Figure 1 (next page). The bars show world proven reserves of oil expressed as years of supply. The difficulty with expressing reserves in this way is that the data is very dependent on production rates; as shown in the figure: as production expands, reserves decrease and vice versa. Despite this ambiguity, it is obvious that real reserves have increased considerably. Over 20 years, production has increased by a third while years of reserve have increased from 35 to 42.5 years[4].

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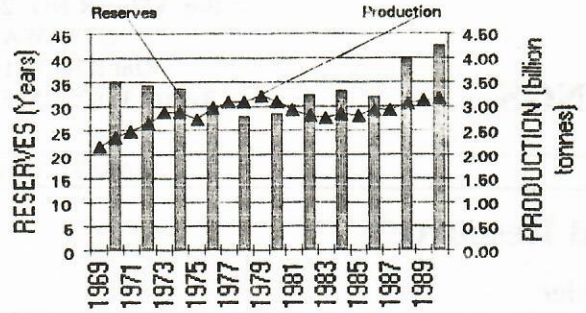
[1] *The Limits to Growth* by Dennis and Donella Meadows; Universe, 1972.

[2] M.A. Adelman. "World Oil Supply: Continuity and Change", *Proceedings of IFAC Energy Systems, Management and Economics Conference*, Tokyo, Japan, 25-27 Oct 1989. Oxford: Pergamon Press. p. 448.

[3] World Energy Conference. *1989 Survey of Energy Resources*. Oxford: Holywell Press Ltd.. 1989. p.35.

[4] Data taken from The British Petroleum Company, *BP Statistical Review of World Energy*, BP: London, June 1991.

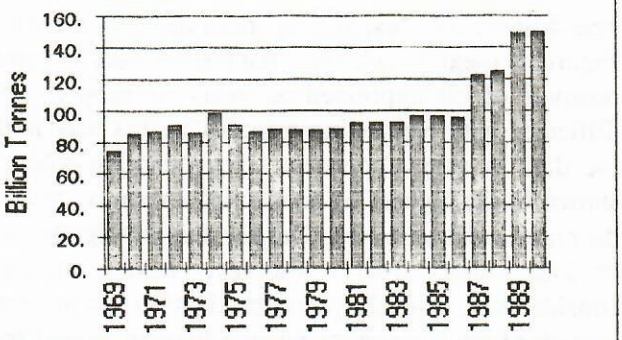
Figure 1--World Proven Reserves of oil v. annual production



Data taken from BP Statistical Review of World Energy
BP London, June 1991

It is easier to understand what is happening when reserves are expressed in absolute terms. Figure 2 shows proven world reserves expressed in tonnes.

Figure 2--World Proven Reserves of Oil



Data taken from BP Statistical Review of World Energy
BP London 1991

The reserves remained fairly constant from 1970 to 1986 (i.e. development of new reserves has kept pace with extraction) and increased sharply thereafter. This increase was mainly due to revised estimates by Iraq, Iran, Abu Dhabi, Venezuela and Saudi Arabia[5]. How much of these revisions is due to improved technical assessment and how much is due to political considerations is a moot point[6]. Regardless, it appears that the critics have a point: where is the shortage?

Part of the problem is that using one energy resource as an example of reserves inevitably distorts the picture. This is particularly so in the case of oil which has declined from 47% of commercial energy in 1973[7] to 38% in 1990[8]. Coal is the largest fossil fuel resource, yet it has not shown the same pattern of "increasing reserves". Over the period 1968 to 1988, when proven reserves of oil increased from 31 to 41 years, proven reserves of coal decreased from 2300 years to 218 years[9].

The statistics supporting increasing oil reserves can also be very misleading. Obviously, such trends cannot continue indefinitely. The easy-to-develop reserves have already been exploited. The "new" oil fields are all offshore in increasingly inhospitable areas, first the North Sea and Alaska, more recently Hibernia and the Arctic shelf. Yet despite the move into more expensive and risky areas "no major new oil fields have been discovered in the 1980's"[10].

The real problem, however, is that we are looking at the wrong data. "Proven reserves" is an economic statement, not a resource assessment. By definition, proven reserves are those that can, with reasonable certainty, be extracted from known resources under existing economic and operating conditions. They represent that fraction of total resources that have been surveyed and may have little to do with the ultimate amount recoverable. Until oil actually does start to run out, proven reserves are as big as our investment in exploration.

Data for ultimately recoverable oil is much more speculative than proven reserves. Nevertheless, there tends to be a reasonable consensus[11] which is reflected

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5 Data taken from The British Petroleum Company, *BP Statistical Review of World Energy*, BP: London, June 1991.

6 World Energy Conference. *1989 Survey of Energy Resources*, Oxford: Holywell Press Ltd.. 1989. p.35.

7 Don Hedley, *World Energy: The facts and the future*, 2nd ed. London: Euromonitor Publications Ltd. 1986. p. 44.

8 The British Petroleum Company, *BP Statistical Review of World Energy*, BP: London, June '91. p.3 .

9 Ian A. Nalder. "The Limits to Growth and the Message for Sustainable Development" in *Proc. IEEE Interdisciplinary Conference Preparing for a Sustainable Society*, Toronto, June 21- 22, '91. p. 68.

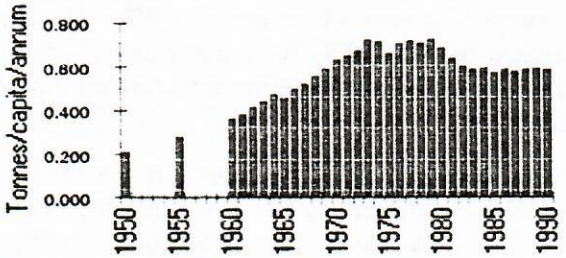
10 Walter Goldstein, *Energy Policy*. Guildford: Butterworth Scientific Ltd. February 1989. Vol. 17, No. .

11 Manfred Grathwohl, *World Energy Supply*,. Berlin: Walter de Gruyter. 1982. Table 3.11; also: US. Council on

in the 1980 World Energy Conference (WEC) estimates. These give total recoverable conventional oil as 354 billion tonnes of which 53 billion had been extracted as of 1 Jan 79, leaving 301 billion tonnes to be extracted[12]. More recent reviews tend to confirm these assessments[13]. There are also considerable quantities of oil in shales and oil sands which could possibly add 656 billion tons coal equivalent (456 billion tonnes oil)[14]. Interestingly, *The Limits to Growth* model assumed that there were 250 years supply of resources at 1968 consumption rates, which in the case of oil, gave 500 billion tonnes. If we accept the WEC estimates as at least the right order of magnitude then how long will they last?

To answer this question, some assumptions are necessary. Substitution effects can be ignored since these are unlikely to be important until reserves are nearly exhausted. Population is assumed to follow the latest UN. median projections through to 2025[15] and thereafter increase more slowly to reach a stable level of 11.24 billion in 2075. Per capita production of oil is assumed to increase by 0.5% per annum. It is anyone's guess what the rate of increase will actually be, but historical trends are worth considering. Per capita production over the last four decades has increased at an average annual rate of 2.66% . Production data by year is shown in figure 3.

Figure 3: World Production of Oil
(per capita basis)

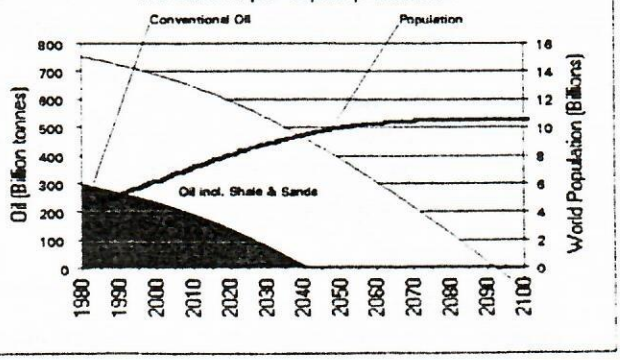


Data taken from BP Statistical Review of World Energy, BP London, June 1991; Energy Supply, 1982 and World Population Prospects, June 1991

The three decreases correlate closely with the OPEC oil embargo, the price hikes of the earlier 80's and more recently the Gulf War, and thus appear to be market responses to international crises rather than long term trends. In any case 0.5% increase seems a modest level of growth, and much less than the aspirations of most of the world - according to one estimate, a 3% growth in the world economy would require a 1.0% increase in oil consumption[16].

Given the above assumptions, depletion of oil resources will happen quite rapidly. Figure 4 graphs the remaining reserves by year through to the year 2100. Conventional oil runs out in 2041. Exploitation of shale oil and oil sands would extend the day of reckoning to 2092.

Figure 4--Oil remaining assuming 1/2% p.a. increase in per capita production



Environmental Quality. *The Global 2000 Report to the President of the US., entering the 21st century.* NY: Pergamon Press. 1980. Vol II Table 11-3.

[12] Manfred Grathwohl, *World Energy Supply.* Berlin: Walter de Gruyter. 1982. Table 3.12a.

[13] C.D. Masters, D.H. Root, E.D. Attanasi, "World Oil and Gas Resources-Future Production Realities" *Annual Review of World Energy*, Palo Alto: Annual Reviews Inc. Vol. 15, 1990 p.33 notes that the 1960's estimates of ultimate world oil (around 2,000 billion barrels = 272 billion tonnes) "matches, very closely, the estimates of almost all more recent analyses, including this paper.";; also: John P. Holdren, "Population and the Energy Problem", *Population and Environment*, Spring 1991, Table 4 shows "Probable Remaining Recoverable Resources" of petroleum as 600 terawatt-years (451.721 billion tonnes oil).

[14] Manfred Grathwohl, *World Energy Supply.* Berlin: Walter de Gruyter. 1982. Table 3-1.

[15] UN. Department of International Economic and Social Affairs, *World Population Prospects 1990.* United Nations: New York, 1990. Table 30 (medium variant).

[16] World Energy Conference. *1989 Survey of Energy Resources*, Oxford: Holywell Press Ltd.. 1989. p.35.

It should be noted that only a small fraction of oil in the ground can be extracted with existing technology. The recoverable fraction has increased from around 26% in 1955 to 32% in 1976 and may well increase further[17]. The above estimates of ultimately recoverable resources assumed 40%. If this is increased to, say 50%, total conventional oil would increase by around 88 billion tons, an additional 10 years supply.

Of course the important parameter is not the size of resources but the growth rate in per capita production. With the 2.66% growth rate of the last 40 years, total reserves of oil, including oil shale and tar sands, would be depleted by 2049. Conversely, if the per capita production was stabilized immediately depletion would not occur until 2122.

In summary, the often quoted "years supply of proven reserves" is meaningless in regard to depletion of oil resources. The data of interest is "ultimately recoverable resources". Although these cannot be estimated accurately there is general agreement on their magnitude. How long they will last is another question--as always, the future remains cloudy. It is, however, difficult to escape the central message of *The Limits to Growth.* The growth to which we have become accustomed cannot continue for long. Within 2 or 3 generations there will be no oil left to fuel it.

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17 Manfred Grathwohl, *World Energy Supply.* Berlin: Walter de Gruyter. 1982. p.111.