Future world oil supplies: There is a finite limit

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Unscientific reserve claims for political reasons may obscure the fact that most large, economic oil fields have been found, and permanent oil shock is inevitable early in the next century

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The question is not whether, but when, world crude productivity will start to decline, ushering in the permanent oil shock era. While global information for predicting this "event" is not so straightforward as the data M. King Hubbert used in creating his famous curve that predicted the U.S. oil production peak, there are indications that most of the large exploration targets have been found, at the same time that the world's population is exploding.

This theme and a discussion of "reserve" and "resource" definitions and use, or abuse, are the subjects of this article. Discussions and illustrations give one indication of where the world is in crude production and reserves, and where it is headed.

EXPLORATION MILESTONES: AN OVERVIEW

Petroleum exploration is an efficient technical procedure. Shooting of a modern seismic net of lines across any basin will delineate virtually all significant prospects, thus outlining where to lease for further test drilling. However, it is a fact that the largest oil and gas fields in any basin or oil province are also the biggest targets and the easiest to find with any given technology; thus they are normally found early in any exploration phase.

Dates when past exploration techniques were routinely used by large oil companies include: surface geology (1900), refraction seismic (1925), electric well logs (1930), analog reflection seismic (1935), mud logging (1940), digital reflection seismic (1965), and 3-D digital reflection seismic (1978). Significant drilling developments include: rotary drilling (1920), offshore drilling barges (1950), deepwater drillships (1956), semi-submersible rigs (1964) and horizontal drilling (1985).

All of these were significant steps in the improvement of land and marine exploration. There are today virtually no areas where petroleum exploration cannot be successfully carried out if preliminary geological studies indicate a good chance of finding major petroleum fields.

OIL FIELD DISCOVERY TIMING

H. D. Klemme made exhaustive studies of oil field discovery patterns in different types of basins, e.g., cratonic, deltas. [1] His analyses showed that in all types of basins, 100% of the reserves in the five largest fields were, on average during 1970-80, made within six years after the first field was found. Of course, the area had to be politically accessible, i.e, leasable, or no exploration could be conducted. The average figure noted decreased steadily to the 6-yr level, from 37 years pre-1930, as geophysical techniques improved.

We should be reminded that some of our grandfathers were excellent oil finders even though they worked with the crudest of tools. For example, the peak year for discoveries of world-class oil field giants, i.e, ultimate recovery of 500 million bbl oil, in the U.S. was 1930—in the world, 1962.

The present phase of petroleum exploration began with introduction of 3-D digital seismic methods in the late 1970s. This technical refinement coincided with the Iran-Iraq war and the accompanying 1980 oil price surge to $40/bbl, which produced a global public energy panic. A worldwide exploration boom followed immediately to find oil anywhere outside the Persian Gulf. Unfortunately, despite intense efforts by all of the world's oil companies, only a few of the new major fields, i.e., ultimate recovery of 100 million bbl promised by their geologists, were actually found.

The world's accessible oil provinces had all been previously recognized and most of their major fields found earlier. No new major oil provinces, i.e., ultimate recovery 7.5-25 Bbbl, were found—the world is finite. [2] The 1,311 known major and giant oil fields contain 94% of the world's known oil, and are, accordingly, the most critical for future global oil supplies. [3]

We must "think to scale" on global problems, as the following table shows.

U.S. vs. world statistics Area (time period) Discovered Extracted Consumed U.S. (15 yr, 1977-91) 5 Bbo 45 Bbo 92 Bbo World(10 yr,1982-91) 91 Bbo 221 Bbo 221 Bbo Bbo = Billion bbl crude oil.

Fig. 1 summarizes when and where the known global oil fields were discovered. The peak global finding year was 1962. Since then, the global discovery rate has dropped sharply in all regions. [4]

3-D seismic and horizontal drilling techniques improved oil recovery in known fields, but made no substantial change in global discoveries of major fields. When the world oil price collapsed in 1986, exploration funds and efforts were cut back drastically everywhere; and by 1989, all major companies were consolidating and eliminating most of their geological/geophysical staffs. The minimum 6-yr period needed to discover the five largest fields in any basin had passed without making enough discoveries to whet top management's enthusiasm—so the money dried up except for prime prospects and farm-ins.

This is unfortunate because the huge remaining resources postulated by scientists will never be converted to reserves unless explored for. It is unlikely that increasing global oil price to the 1980 maximum would make any substantial improvement in the discovery rate of new major fields, as the golden age of oil exploration has passed its peak. For one example, much of the current attraction for Russian oil deals is production—rather than exploration—oriented. Western petroleum engineers and service companies are needed there to get additional production out of known pools, rather than explorationists to find new fields.

RESERVES VS. RESOURCES

Like the mining term ore, oil reserves are by definition economic, or profitable. Resources, conversely, are less tangible. Two practical definitions are:

Reserves: Engineers' (conservative) opinions of how much oil is known to be producible, within a known time, with known techniques, at known costs and in known fields. Conservative bankers will loan money on reserves.

Resources: Geologists' (optimistic) opinions of all oil theoretically present in an area. Conservative bankers will not loan money on resources.

Explorationists must first find—and then petroleum engineers convert—theoretical resources into producible reserves. An example of a resource that will never become a reserve is gold dissolved in seawater.

Use of either term by any group depends greatly on whose money is involved, e.g., resources mean your money—reserves mean my money. Differences can be enormous. Government agencies and academic scientists tend to estimate resources, whereas industrial/oil companies appraise only reserves. The public, using its money to buy gasoline, is interested in producible reserves, not in theoretical resources.

It is known oil that matters for production planning—not oil yet to be found. Published geological and political estimates of undiscovered oil resources have no set time limits stated or implied for the postulated discoveries. Such open-ended estimates effectively imply that the volume of resources yet to be discovered will lie somewhere between zero and infinity and will be found sometime between now and eternity. Such resource appraisals are only considered scientific opinions—regardless of the competence of the scientific or economic committees that originated them, or the elegance of the mathematical assumptions or computer programs involved.

As C. D. Masters, Chief of USGS Petroleum Resource Analysis once acknowledged, [5] "Assessing world oil is only the beginning of the search for oil. Assessment means nothing more than a judgement on its occurrence. Whether it will be discovered depends on discovery activity. In that sense, Ivanhoe's method of discovery index analysis, or finding rate, [6] comes closest to predicting exploration success, given that the wells are drilled." Well-intentioned, but irresponsible scientists who continue to discuss resources instead of reserves may be a significant cause of our government's lack of realistic energy policies.

ACTIVE VS. INACTIVE RESERVES

Oil companies are in business to make money—not to find oil per se. The present discounted economic value of oil to be produced more than 20 years in the future is virtually zero, regardless of its price. Major oil companies commonly distinguish between:

Active reserves: Those producible within the foreseeable future, i.e., 20 years or less, and

Inactive reserves: Existence known but not considered producible within 20 years, i.e, inaccessible or producible only with as-yet non-commercial methods like enhanced oil recovery, etc. Conservative bankers will not loan money on inactive reserves.

Some inactive reserves are called "inferred" reserves by USGS and U.S. Department of Energy scientists. [7] Inactive reserves gradually get shifted to the active category as years go by and the field gets drilled up by infill wells and stepouts.

U.S. DOE and the Energy Information Administration (EIA) report official U.S. government reserves as only active. [8] But scientific geological committees have recently blurred the older firm distinction of known reserves by including inactive with active—thus increasing the U.S. national reserves by modifying critical-term definitions and creative bookkeeping. Their definitions, while scientifically acceptable to specialists who read the fine footnote print have little bearing on planning for next year's production by either oil companies or the nation. Mature oil fields continue to decline as predicted by the petroleum reservoir engineers.

POLITICAL RESERVES

Government petroleum ministries have an inherent interest in announcing the "good news" of large national hydrocarbon reserves inasmuch as large political reserves are useful for national prestige and in negotiations for OPEC production quotas, World Bank loans and grants, etc. [9] Sudden unsubstantiated reserve increases announced by any government ministry should be viewed with considerable skepticism. They may be mostly the puffery of political reserves which will increase a nation's paper reserves, but have no effect on near-term oil production. [10]

Natural gas is commonly converted to BOE (at the conversion of some 6 Mcf/BOE) to increase a company's or nation's BOE reserves. However, gas is not the economic or social equivalent of crude due to the inherent convenience, safety and flexibility of oil. Natural gas's main global use is still as a boiler fuel for electric power plants to which a pipeline or LNG tankers must provide an umbilical from gas field to generator. Remote gas discoveries may accordingly be assigned to the inactive reserve category for decades while the special transportation lines are negotiated, financed and built.

A flattening of total U.S. (50 states) oil production from 1976-85 was due to Alaska's new supergiant (ultimate recovery of 5.0 Bbbl) Prudhoe Bay field coming onstream, Fig. 2. However, U.S. (48) onshore core production continued to decline as M. King Hubbert predicted in 1956, except for a flattening from 1981-85.

Undue significance has been given to this relatively minor increase in total U.S. (48) production by committees of resource-calculating scientists. Such theoreticians now tend to factor in a blanket increase in the estimated ultimate recoveries (EURs) of all rations' oil fields. Consequently, hyperinflation of global oil reserves (or resources) occurred after 1986. Many of these increases are political reserves which tend to lull public, politicians and stockbrokers into complacency. But the critical numbers are U.S. and world oil production and new-oilfield discoveries in recent years, which are not encouraging, see accompanying table.

The basic assumption is unrealistic that all of the world's, non-U.S. (48), oil fields (mostly discovered since 1962) should have the same reserve increase pattern as the older U.S. (48) oil fields, most of which date from the 1930s or are of tiny size. Reservoir engineering technologies improved greatly from the discovery of the supergiant East Texas field in 1930 (pre-seismic, pre-E logs, on many small land blocks) to discovery of the Alaskan supergiant at Prudhoe Bay in 1968, (post digital seismic, post-electronic well logs, on a single large U.S. government permit to a major oil company). Again, it is the major and giant oil fields (EUR >100 million bbl) that matter globally—not the tiny oil fields so common in the U.S. [3]

HUBBERT'S CURVES

The only truly valid scientific projection of future oil production yet made was that by M. King Hubbert in 1956, [11] when he correctly forecast—on the basis of statistical projections of past U.S. (48) (onshore and offshore lower—48 states without Alaska)--that oil production would peak in 1969, give or take one year. Since then, U.S. (48) oil production has declined within 5% of Hubbert's 1956 prediction, Fig. 2.

Non-U.S. statistics were too vague for Hubbert to use for a valid projection of ultimate global crude oil recovery. He did publish several examples for a hypothetical global EUR of 2,000 Bbbl oil to show how future, virtually unrestricted global oil production might peak and then decline, Fig. 3A. Note that the gross EUR of oil has little effect on date of peak production if unrestricted, e.g., Peak year = 1988 for EUR of 1,500 Bbbl vs. Peak year = 1996 for EUR of 2,000 Bbbl. Note: Area under the curve must equal EUR volume at the scale in upper left corner of the figure. This simple "area under the curve and scale" should be included, as a control, on any theoretical analyses of potential oil reserves/production.

Fig. 3B shows two alternate Hubbert curves for EUR = 2,000 Bbbl, i.e., area under both curves = 2,000 Bbbl, for unrestricted and restricted production. Since 1973, OPEC oil policies and prices have restricted global oil production. Any additional U.S. oil produced by EOR from inactive/inferred reserves will modify Hubbert's ideal curve into a horizontal line for some years after year 2005, Fig. 2. The ex-USSR's oil production since 1950 has closely followed an unrestricted Hubbert curve and is now declining even faster than that of the U.S. (48).

Fig. 4 compares the actual restricted global oil production plotted with the concurrent population explosion in less-developed-countries (LDCs). By year 2000, global population will be 50% greater than in 1975, with a corresponding increase in LDC demand for crude. The industrializing LDCs will soon become hard competitors with western nations for world crude exports.

CONCLUSIONS

It is reluctantly concluded that there is strong evidence that the restricted Hubbert Curve for the world's total EUR of oil may first peak about the year 2000, Fig. 4, after which it may fluctuate along a horizontal production line (restricted by Saudi Arabia/OPEC) before inevitable decline towards a low baseline after year 2050. At an annual global production of 20 BbbVyr, an ultimate difference of global EUR of 300 Bbbl will defer the inevitable doomsday by only 15 years, i.e., 300/20.

Fig. 5 combines past global production with all known reserves plotted per 1989 reserve-to-production ratios (R/Ps), arranged from top to bottom by: developed, communist and OPEC nations. The heavy dotted line shows a realistic 21st Century world oil production curve. This predicted supply curve will change only slightly from year to year.

The critical date is the inflection point (peak) after which global public demand will substantially exceed available supply from the then few oil exporters. A sudden global crude shortage of 5% could bring back the gasoline lines of the 1970s-to the American public's surprise and dismay.

Thus, the question is not whether, but when, the foreseeable permanent oil crunch will occur. This next paralyzing and permanent oil shock will not be solved by any redistribution patterns or by economic cleverness, because it will be a consequence of pending and inexorable depletion of the world's inexpensive conventional crude oil supply.

The global price of oil after 1999 should follow the simplest economic law of supply vs. demand—resulting in a major increase in crude and all other fuels' prices, with the accompanying global economic/social problems of hyperinflation, rationing, etc. After the associated economic implosion, many of the world's developed societies may look more like today's Russia than the U.S.

A successful oilman once remarked, "I would never hire an exploration geologist who is not an optimist, or a petroleum engineer who is not a pessimist." By this logic, the engineering conclusions offered above are, regrettably, more conservative than tile opinions of the many exploration geologists. But haven't Hubbert's predictions for the U.S. been proved realistic, with attendant negative economic ramifications? And decline time for the global industry is not that far away. The economic and social ramifications of that event will require serious planning.

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