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FOR PETROLEUM SUPPLY STUDIES

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HOW LONG CAN OIL SUPPLY GROW?

by
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Nations understandably strive for growth in production and consumption of goods. This basic characteristic of society conflicts with recognition that many important natural resources are finite. To attack economic growth is clearly unpopular, which is why society essentially ignores the limits to growth in consumption of finite resources. It is ironic that the viewpoint of limits to growth, briefly popular decades ago, should be unpopular in the late 1990s, when we are so much nearer to nature's imposition of such limits. Petroleum illustrates this point as clearly as does any natural resource. The industrialized world's unprecedented economic growth during the last 100 years has been based in large part on increasing availability of cheap petroleum.

In the history of a petroleum-producing country or region, rate of oil discovery reaches its maximum years before the maximum in proven reserves of oil. That is, after the original discovery, proven reserves continue to increase because of oil field development. Maximum oil production rate, in turn, is achieved several years after the maximum in proven reserves. For example, United States (48 states) oil discovery rate was maximum in 1957 and has since decreased (1). United States (48 states) proven oil reserve, however, was greatest in 1962 and has diminished since (2). United States oil production rate reached its peak in 1970 and has since declined (2). For this reason, the United States now relies on foreign sources for more than half of the oil its consumes.

The 1970 peak in United States oil production rate was accurately predicted in 1956 (3) with use of a model that permits growth in production rate until approximately half of the producible petroleum has been consumed, after which production rate declines until exhaustion of the resource. What can this model tell us about the future of global oil production?

Global oil discovery rate was greatest in the early 1960s and has since diminished (4). Estimates of the global proven reserve of oil currently hover near a maximum attained in 1990 (2). The question of when global oil production rate will reach its maximum and begin its permanent decline is profoundly important to the economic futures of both developed and developing countries. The reported global oil reserve is about 1000 billion barrels. This plus a very optimistic estimate of about 550 billion barrels of producible oil yet to be discovered (5) gives us 1550 billion barrels of oil yet to be consumed, which, when added to the approximately 800 billion barrels that already have been consumed, yields 2350 billion barrels of total ultimate oil production.

This figure may be too large. Collapse of oil discovery rate in recent decades of intense exploration suggests that new discovery may not reach 550 billion barrels. Moreover, part of the 1000 billion barrels of reserves is questionable and may be political rather than real (6,7).

If world oil consumption rate [about 26 billion barrels for 1996 (8)] should continue to grow about 2% annually (it grew 2.5% in 1996), the world will have consumed half of the optimistically estimated 2350 barrels of ultimate oil production well before the end of the first decade of the 21st century. This mid-point could coincide with maximum production rate. The peak in world oil production rate, however, could come later, during the second decade of the coming century, because growth in OPEC oil production has been restricted during many of the years since 1973. This can delay the arrival of maximum OPEC production rate and thus possibly maximum global production rate to dates later than the mid-points of ultimate production. New oil recovery technology could have a similar effect in delaying for a few years the beginning of production decline.

Of course, the many oil-producing nations will not all experience the beginning of decline in oil production rate simultaneously. The United States reached this point in 1970 with its record high production rate of 9.6 million barrels per day (2) and had experienced a drop in crude and condensate production to 6.4 million barrels per day by 1996 (9). The former Soviet Union passed its maximum oil production rate in 1988 (2). Several oil-producing nations will experience the beginning of permanent decline in oil production between the years 1999 and 2010. Only the OPEC (primarily Middle East) nations have the potential to compensate temporarily as the rest of the world experiences diminishing oil production rates.

If, with probably unjustified optimism, we accept as valid the gigantic 246-billion-barrel increase in estimated reserves reported by Iran, Iraq, Saudi Arabia, and Abu Dhabi in 1988 and 1989 (2,6), the Middle East has oil reserves of 660 billion barrels (2). A large part of this reported reserve appeared very abruptly without benefit of new oil discovery, is suspect, and probably is political rather than real (6,7). Because most of the Middle East has been extensively explored for oil, perhaps it is reasonable to assume that genuine new Middle East discovery will not exceed the portion of reported Middle East reserves that probably is invalid. In this case, we can work with the obviously imprecise assumption that the Middle East has 660 billion barrels of oil yet to be produced.

Middle East nations already have produced 210 billion barrels of oil. The 1996 production rate of about 7 billion barrels per year would require 32 years for these nations to produce half of their crudely estimated 870 billion barrels of ultimate production. Middle East oil production rate, however, will not remain at 7 billion barrels per year. Growing demand caused Middle East oil production rate to increase 14% from 1990 through 1995 (2) even without decrease in non-OPEC production. When non-OPEC oil production rate begins its permanent decline, demand for Middle East oil will grow much faster than in recent years. As a result, Persian Gulf nations will have produced half of their ultimate oil production by sometime between the years 2010 and 2015. This means that, even allowing for considerable conservative error, decline in world oil production rate surely will occur well before the year 2020 and possibly before 2010, depending on rates of increase in global demand for oil and rates of decrease in non-OPEC oil production.

Popular and scholarly publications commonly dismiss the view that fuel supply problems are imminent by presenting various potential sources of energy as alternatives to conventional petroleum. Nevertheless, development of economically feasible sources of energy adequate to compensate for the coming decline in petroleum production requires time and huge capital investment. Time may be the more severe restriction.

Oil shales, tar sands, and heavy oil have been touted as potentially important sources of fluid fuels. The amount of fossil fuel that they contain is huge, exceeding the world's economically producible conventional oil by a staggering margin (10). If all of the Green River Formation oil shale resource of Colorado, Wyoming, and Utah, all of the Athabasca tar sand resource of Alberta, and all of the Orinoco heavy oil of Venezuela could be economically produced at unlimited rates, the oil supplied could fuel the world for several decades at current oil consumption rate (10). Such an optimistic generalization, however, does not convey the difficulties involved in large volume fuel production from these resources.

Although the total amount of fossil fuel present in the Green River Formation is much larger than all of the oil ever consumed by the United States (10), only a small fraction of the formation is sufficiently kerogen-rich to have inspired serious development effort. Even this richest portion, in the Piceance Creek Basin of Colorado, would require gigantic capital investment and innovative new processing techniques in order to contribute even a small fraction of current United States oil supply (10). Perusal of the literature reveals that significant commercial production of oil from the Green River Formation oil shale has been intermittently viewed as imminent for 75 years.

It has been suggested that large volume production of fuel from oil shale or tar sands will be economically feasible after the price of oil has risen appreciably in response to the beginning of permanent decline in global oil production rate. But, for several decades, the estimated cost of production of shale oil and oil from tar sands has remained higher than the cost of conventional oil and has risen with world oil prices (10), because the cost of conventional oil influences the cost of production of these resources by controlling the cost of materials required.

This raises the fundamental question of the amount of net energy to be produced in exploitation of oil shales, tar sands, and other potential alternative fuel resources. Some estimates of energy yield from future development of potential fuel resources are overly optimistic because of failure to adequately consider the amount of fuel consumed to produce a given amount of new fuel. If the net fuel gain is small enough, the venture is essentially worthless. Consideration of net energy gained greatly reduces the potential addition to our energy supply from many prospective energy sources. This factor is altogether unaffected by higher fuel prices and helps to explain why today, 70 years after the earliest industrial research on and attempted development of United States oil shale, we still lack commercial shale oil production.

Because the United States has larger coal reserves than any other country, coal liquefaction has been suggested as a source of synthetic oil. As is true in the cases of oil shale and tar sands, quantitative consideration of the total probable contribution of coal liquefaction to our fluid fuel supply tends to temper enthusiasm.

If we assume that a ton of coal will yield 5.5 barrels of liquid fuel (11), and that the United States could mine coal for liquefaction at a rate sufficient to replace 2.6 billion barrels of oil per year (which is only 10% of global oil consumption for 1996), then we would liquefy annually an amount of coal approximately half as great as the total amount mined annually in the United States during the 1990s. This would require a roughly 50% increase in rate of United States coal mining. If we ignore the environmental concerns associated with such great expansion of coal mining and consider only the liquefaction facilities required, the cost would be many tens of billions of dollars. Such facilities would have to liquefy several dozens of times more coal annually than do the current South African coal liquefaction plants.

Is the United States or any other country capable of adhering to a commitment to such gigantic long-term investment regardless of short-term fluctuations in the price of oil? During the 1980s, when the price of oil was declining, synthetic fuels projects were abandoned as rapidly as they had been initiated during the 1970s. Development of substitutes for even a small fraction of our conventional petroleum consumption is a gigantic undertaking that is guaranteed to fail if it can be abandoned in response to short-term changes in the price of oil.

Even if society commits itself to the staggering capital investment necessary for oil from coal to replace the coming decline in conventional oil production, such an approach would rapidly deplete coal reserves and thus would be only a very temporary solution to the problem. If we ignore recent downward revisions in coal reserve estimates and fancifully assume that the United States has a 300-year-supply of producible coal at current coal consumption rate, then a mere 4% per year growth in consumption rate will reduce the 300-year-reserve to a 64-year-supply (with the unrealistic assumption that coal production rate could continue to grow until depletion of the resource).

A frequently expressed view is that we should use coal, oil shale, and tar sands as a bridge to satisfy our increasing energy demand during just the next several decades until the development of a new, innovative, inexhaustible substitute for petroleum sometime during the 21st century. This philosophy does not include a prudent examination of the probability of such a long-term substitute for conventional fossil fuels actually being developed. Science and technology offer no guarantees whatever concerning this. Nuclear fusion has been suggested as the savior, but we do not know how to build a fusion reactor, and it is not clear that we ever will.

Surely there is a potential satisfactory solution for this problem. But time is not on our side, and society must quickly develop a stronger and more sustained interest in the energy problem, because, so far, we do not have a satisfactory solution. Our nation's current attitude toward this dilemma is a serene apathy. We have no long-term energy policy. We don't even seem to recognize the existence of a long-term problem. Rather, we simply vacillate from panic to complacency in response to short-term shortages and surpluses.

Perhaps this myopic attitude is caused in part by economic theory, which commonly treats petroleum as though it were an infinite resource with its availability controlled entirely by market forces. But market forces are largely impotent in this case. The high oil prices and record rates of exploration for oil during the early 1980s did not result in a proportional increase in oil discovery. Rather, in spite of improved exploration technology, the amount of oil discovered globally per year has continued to decrease since the early 1960s. During the exploration boom of the early 1980s, we were drilling more and finding less, and we have virtually run out of places to search for giant new oil fields. Market forces will not increase the amount of petroleum that exists to be discovered.

Economic theory also has told us that, in a free market economy, shortage of a product is followed by higher prices for it, and higher prices cause demand to decrease to match supply, thus eliminating the shortage. This is an easy way to solve the problem, in that we have simply defined shortage out of existence, even though prices may become astronomical and supply infinitesimal. Maybe it would be better to face the impending reality of genuine shortage.

The coming decline in petroleum production rate presents an ominous economic problem with potentially catastrophic consequences. Serious and unflagging efforts to deal with this intractable difficulty are overdue.

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Dr. Hatfield's earlier publications in geological journals are primarily stratigraphic. During the last sixteen years, however, he has authored, in both scholarly and popular outlets, several articles that deal with long-term fuel supply problems. The most recent of these, in the May 8, 1997, issue of Nature, received international news media coverage via radio, television, newspapers, and magazines.

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H.C. NEWSLETTER

The M. KING HUBBERT CENTER FOR PETROLEUM SUPPLY STUDIES
located in the Department of Petroleum Engineering
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The Hubbert Center has been established as a non-profit organization for the purpose of assembling and studying data concerning global petroleum supplies and disseminating such information to the public.

The question of WHEN worldwide oil demand will exceed global oil supply is stubbornly ignored. The world's oil problems, timing and ramifications can be debated and realistic plans made only if the question is publicly addressed. A growing number of informed US and European evaluations put this crisis as close as the years 2000 - 2014. The formation of this center is to encourage a multi-field research approach to this subject.

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