

## **The Bottom of the Barrel**

by Leonard Rodberg

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Estimates of the available U.S. and world supply of petroleum are essential ingredients in any consideration of energy policy. Until recently, estimates made by different sources have disagreed sharply. In the last few years, though, oil company, government agency, and individual estimates have begun to converge. It is now possible to know, with a high degree of certainty, how much oil remains in the ground – though not, of course, exactly where it is! – and to forecast that oil production in the United States will decline rapidly in the coming years.

In the context of this growing consensus, Barry Commoner, well known for his environmental studies, has stirred up renewed controversy in a lengthy article published in *The New Yorker* (February 2, 1976). He attacks the generally-accepted estimates made by M. King Hubbert, the leading practitioner of the art of fossil fuel forecasting, and argues that "there is no need to act as though we were now running out of oil, for we are not." The decline in U.S. oil production in recent years "is a result of [oil] company decisions to cut back on exploration efforts, rather than a result of the depletion of accessible Deposits." He then draws the conclusion that we can continue to rely on domestic petroleum, do not have to turn to synthetic fuels, and can take our time in developing renewable energy sources.

Recently, I looked into the current state of fossil fuel estimation, and then interviewed Hubbert at his office in the labyrinthine headquarters of the United States Geological Survey in Reston, Virginia.

Hubbert, a geophysicist, has spent 50 years in petroleum operations and research, including the last 13 with the USGS. Since the late 40s, his chief preoccupation has been with demonstrating the finite limits of the earth's supply of fossil fuels. Hubbert reacted to the Commoner article with, he says, "a certain amount of astonishment." In what follows, we will see why.

Hubbert presented his first analysis of the oil production process before the Centennial Symposium of American Association for the Advancement of Science in 1948. In that paper, for the first time, he pointed out clearly that the total pool of petroleum lying beneath the United States was finite and, as a consequence, production could be expected to climb to a peak and then gradually decline to zero, as the pool was depleted (as in the dotted curve in Figure 1). In such areas as Illinois and West Virginia, oil production had already gone through that complete cycle.

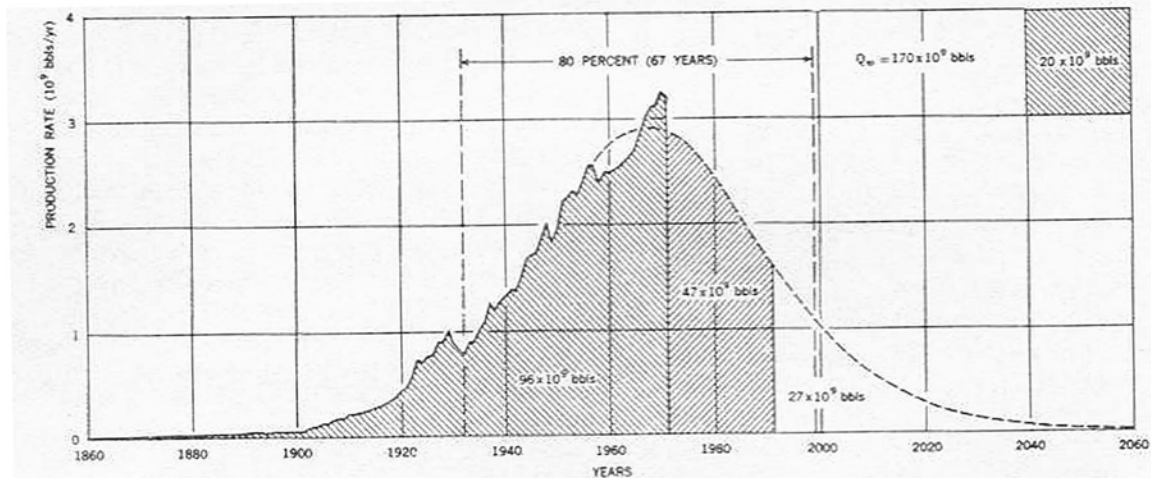


Figure 1. Complete cycle of crude-oil production in the United States (excluding Alaska). From "US Energy Resources, a Review as of 1972," by M. King Hubbert, Senate Committee on Interior and Insular Affairs.

It was not though, until the mid-50s that he had sufficient data actually to compute the production curve. At that time the generally-accepted value for the total petroleum recoverable from under the continental United States (excluding Alaska) was in the range of 150-200 billion barrels. Up to that time a total of 52.5 billion barrels had been produced (over period of more than 70 years), and it was widely believed that the remaining oil would last for at least 100 years more. Instead, Hubbert, in a paper published in 1956, forecast that domestic production would peak within the next 10-15 years, that is, between 1966 and 1971, and would then start to decline.

This paper created a sensation. Oil industries officials reacted, says Hubbert, with "incredulity and dismay," but they could not refute his conclusions. In fact, these have stood the test of time, Oil production in this country actually did peak in 1970, and it has been dropping steadily since then.

This remarkably accurate forecast was based, however, on an assumed figure for the total U.S. petroleum supply. Hubbert thereupon undertook an intensive study to determine, as exactly as possible, the size of our total recoverable petroleum pool. By 1962, with the aid of new data from explorations conducted in the intervening years, he was able to obtain an estimate of 170 billion barrels for the size of this pool. This figure remains valid today, when about 107 billion barrels (63 percent of the total) have been recovered. Even more important, he sowed that the rate of discovered of new oil reserves had peaked in 1957 and was already beginning to decline. The oil companies, realizing that exploration within the United States was proving less and less fruitful, were starting to shift their activities overseas.

Hubbert's computations were based on extrapolations from the actual rates of production of oil and discovery of new reserves. On the other hand, these rates depending upon economic decisions made by the oil companies, and a more reliable method was needed, one that would be independent of such influences.

Two were available. The first grew out of a suggestion made in 1961 by A.D.Zapp, an employee of the USGS. Zapp had attempted to estimate the total production pool under the United States by drawing on the oil companies' experience in drilling for oil. There had been about 1.1 billion feet of exploratory drilling conducted by the end of 1960, leading to the discovery of 130 billion barrels of oil, or 118 barrels for each foot drilled. Zapp estimated that a total of 5 million feet of drilling would be needed to explore the United States fully and, assuming that oil discoveries per foot remained at 118 barrels, a total of 590 billion barrels would be found. Commoner cites this estimate with approval.

A striking thing about this recent (1975) study is that this is the first time that the USGS, responsible for charting the nation's natural resources, has ever conceded that our petroleum reserves might be severely limited.. As recently as 1974, the USGS had declared the total recoverable oil of the United States was in the range of 300-500 billion barrels. For over a decade, until its most recent release, USGS officials concerned with resource estimation had ignored the work of Hubbert, though he was literally down the hall. V.E. McKelvey, who directed the USGS studies and is now Director of the Survey, is a firm believer in the unlimited potential of the earth's resources. He writes in 1973: "Person ally I am confident that for millenia to come we can continue to develop the mineral supplies needed to maintain a high level of living...our experience justifies the belief that these processes have dimensions beyond our knowledge and even beyond our imagination at any given time." Setting aside such a mystical belief in the power of technology, sober analysis, now including even that undertaken by his own agency, has forced a more limited, and realistic, vision.

The key assumption of a constant rate of discovery is not evident in the brief note which Zapp wrote. It was demonstrated by Hubbert several years later, after Zapp's death in 1962. Hubbert recognized that the rate of discovery was, in fact, unlikely to remain constant, but would more probably decline as less promising fields were explored. He computed the actual rate of discovered, per foot of exploratory drilling, during each time period and found the result show in Figure 2.

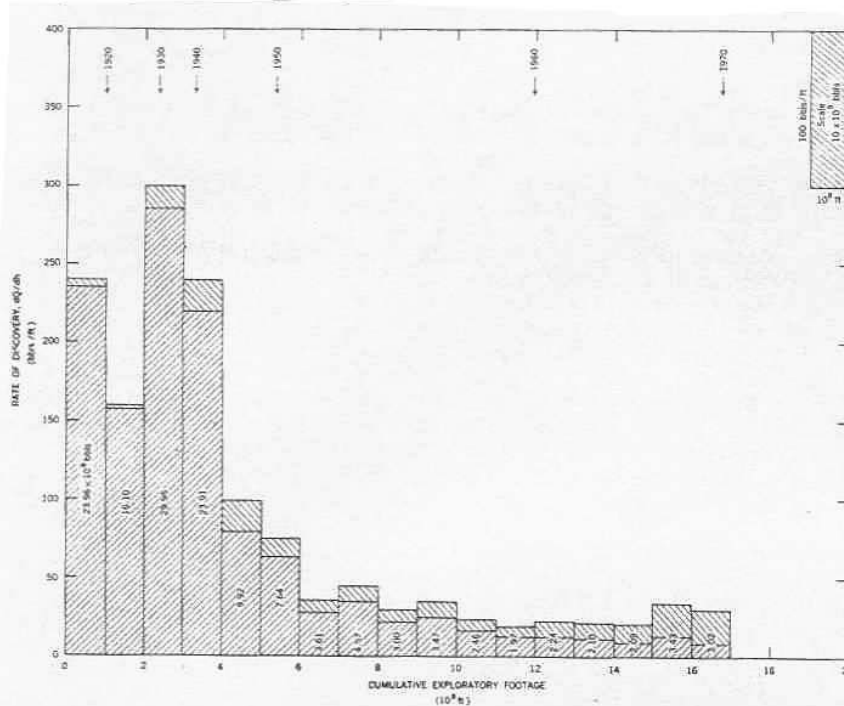


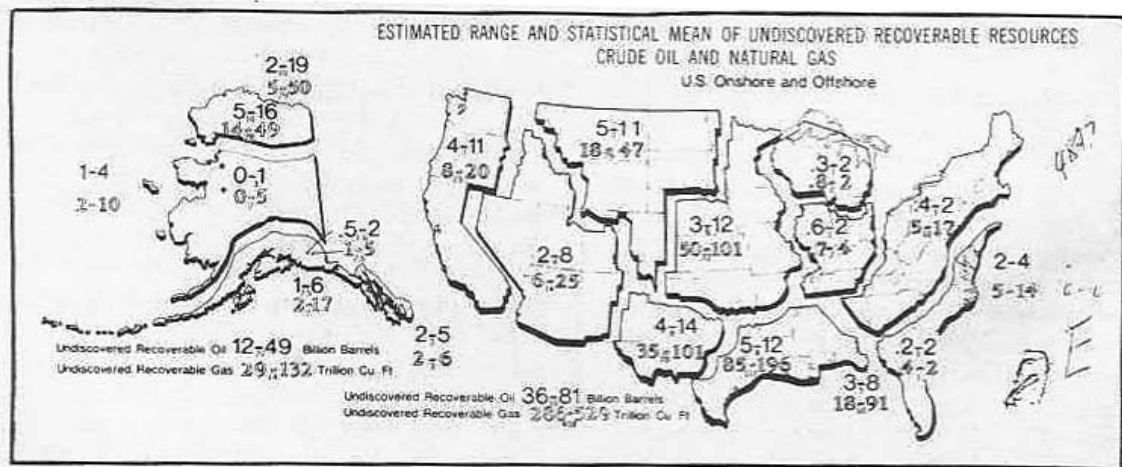
Figure 2. Average discoveries of crude oil per foot for each 108 feet of exploratory drilling in the United States (excluding Alaska) from 1860 to 1971. The upper cross-hatching indicates a correction required to give the cumulative production expected from wells discovered in each indicated time period. From "US Energy Resources, a Review as of 1972."

Evidently, the rate of discovery has been dropping sharply since the mid-30s. Today it is averaging only about 30 barrels per foot drilled. Most striking – and in direct conflict with the position adopted by Commoner – the steep decline in the discovery rate occurred during the period of peak effort by the oil companies. New exploration and production techniques were introduced, and the number of wells drilled increased six-fold between 1935 and 1955. Yet the rate of discovery declined ten-fold over that same period. Whereas in 1945 some 51 “wildcat” wells were needed, on average, to make a significant discovered (yielding at least a million barrels), today over 140 such wells must be drilled. Clearly the limits of America’s petroleum reserves were being reached. It is not surprising that the companies began looking elsewhere for less-expensive sources of oil.

Hubbert used this method to obtain an independent estimate of 172 billion barrels for total U.S. petroleum resources, quite close to his earlier figure. He estimated that future discoveries would amount to no more than 29 billion barrels (a mere five years’ supply at our current consumption of 6 billion barrels per year).

A third method for estimating the total oil pool, used by others at USGS as well as by oil company researchers, is the use of geological analogy. By comparing the geology of new areas with that of regions which have been previously explored, the amount of oil likely to be found can be estimated. This method is subject to great uncertainties, though, and to subjective errors as well.

More recently the USGS has undertaken an exhaustive survey using the geologic method and has obtained a mean estimate of 206 billion barrels for the total pool, with 55 billion barrels yet to be discovered (see Figure 3). While still somewhat higher than Hubber's estimates, these figures, derived by a completely different method, seem close enough to indicate that all methods are in fact converging toward the range of 170-200 billion barrels for the total pool, and 30-50 billion barrels for the amount yet to be found. Recent oil company estimates concur (and, of course, support their case for federal subsidies for synthetic fuel development, to offset the declining supply of natural petroleum).



In the late 1960s, the oil industry, through the National Petroleum Council, commissioned a study of unexplored oil resources by the American Association of Petroleum Geologists. It apparently encouraged the geologists to make their most optimistic projections, hoping thereby to provide vindication for industry efforts to continue federal tax breaks and import quotas. The study dutifully found that there were likely to be future discoveries of 300 billion barrels of oil, more than 10 times the Hubbert estimates using production and exploration data (and three times what would be found if the discovery rate were to remain at its current level of 30 barrels per foot and never decline!) It is this study which Commoner cites as his primary source for resource estimation.

In its attempt to maximize the apparent oil reservoir beneath the United States, the NPC study assumed that 60 percent of the oil in the ground could be recovered. Using the best techniques available today, little more than 30 percent can be recovered, and there is no reason to expect such a large increase to take place. (The water-drive technique that Amoco is touting in its TV commercials has been used in the Texas oil fields since the mid-30s). Indeed, a table in the NPC study summarizing the results of the analysis used a recovery rate of 31.3 percent. The editor of the study, subsequently presenting his own interpretation, chose to use the highly speculative figure of 60 percent. If the more realistic figures had been retained, the undiscovered oil would have been estimated at 64 billion barrels, twice Hubbert's estimate, but consistent with the uncertainties inherent in the geological method.

Several questions still suggest themselves: Will the Alaskan oil find change this picture substantially? Not really. Both Hubbert and the USGS estimate that the Alaskan oil fields contain about 43 billion barrels, little more than seven years' supply at our current rate of consumption.

Will the recent price rise change this picture? Again, this seems unlikely. Stimulated by higher prices, the oil companies increased their exploratory drilling by 30 percent in 1974. Discoveries were disappointing, and oil reserves continued to decline.

And, finally, is the world's supply just as limited? Hubbert estimates that the total world supply of petroleum is 2,000 billion barrels, and that production will peak around 1995, less than 20 years from now. Other geologists, including John D. Moody, president-elect of the American Association of Petroleum Geologists, are predicting it will peak even earlier, perhaps as soon as the late 1980s. Clearly, for the time being, U.S. needs can be met by imports (now supplying over 43 percent of our domestic consumption), but there are severe restrictions on the overseas supply. The pattern of petroleum consumption in this country must begin to deal with nature's limit on the resources available to us.

It is clear, as the above article demonstrates, that the earth's supply of petroleum is limited. It is not so clear how we should react to this. We know how the oil companies have responded, by fast becoming conglomerates selling all forms of energy, and by trying to force us, through our tax dollars, to subsidize their development of oil shale and synthetic fuel processes.

But there are other choices which I believe would serve the American people far better. The projections embodied in Figure 1 (and in the analogous forecast for world oil production) will hold only if we continue to use petroleum in our current lavish style. If, instead, we treat petroleum as the precious *public* resource that it is, move rapidly toward expanded public transportation, require that industry adopt strict energy conservation measures, and facilitate (through tax and other public incentives) the adoption of solar energy and other renewable energy sources, we can avoid the high cost and environmental destruction that the oil companies' approach would impose on us.