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A Critique of the Hubbert Model for Historic U. S. Oil Production with Implications for World Oil Production

This paper suggests that a flaw exists in the model for predicting future prediction of oil production proposed by M. King Hubbert, as explained by Kenneth Deffeyes. Hubbert's projections of the peak of U. S. and world oil production are recognized as important because Hubbert accurately predicted in 1956 that U. S. production would peak in the early 1970s. The Hubbert/Deffeyes logic may be summarized by the following assertions:

1) Oil production is controlled primarily by the total amount available to be produced. Economic, political, and technological effects produce a noisy signal, but are not fundamental to the relationship;
2) Production (P) can be related to ultimate cumulative production (Q_t) by plotting the ratio of P to cumulative production (Q), that is, P/Q, against Q;
3) The relationship is linear, with a negative slope and the Q-axis intercept is the ultimate cumulative production.

The linear fit results in a plot of P vs. Q that is a symmetric curve (the logistic curve) with a peak when half the cumulative amount has been produced, a fundamental feature of the model. This symmetry constrains the projection of ultimate recovery to values significantly lower than the estimate of U. S. reserves proposed by the U. S. Geological Survey (USGS), a disagreement that has raised questions about the Hubbert/Deffeyes approach, especially when applied to global production. Deffeyes calculates a U. S. production peak in 1976, and an ultimate cumulative production of 228 billion barrels. This number is substantially lower than the USGS 2000 estimate of 362 billion barrels. However, Deffeyes does not use 30% of historic U. S. production, including all of the data used by Hubbert in his original projection.

One obvious feature of the P/Q vs Q plot is that, for the first year, P/Q must be one. If production increases for the next year, P/Q must be greater than 0.5, and for year three, greater than 0.33. That is, the curve must lie above 1/x, where x is the number of years of production. The actual curve is almost certain to be non-linear, decrease in slope with increasing Q, and to violate, therefore, the model proposed by Hubbert according to Deffeyes. Numerous alternative curves that decrease in slope with increasing value also have two adjustable parameters (equivalent to the slope and intercept in the linear model).

A decreasing slope (non-linear model) for the curve defining P/Q vs Q may still reflect constraints of petroleum generation, trapping and preservation. The ultimate production predicted by the linear model tends to increase with more data, exactly what many who oppose the simple model are saying – experience and technology development increase the available economic resource. The ultimate production amount one would estimate from the days of Colonel Drake (using the linear model) should indeed be lower than later estimates, when deeper holes and subtler traps can be drilled, and produced.

An asymmetric curve readily preserves the peak of U. S. oil production, but relaxes the estimate of ultimate cumulative recovery of oil, potentially reconciling the difference between the estimates for ultimate cumulative recovery. Thus, relatively modest changes in the model of oil production fit more of the data, have reasonable explanations in the real world, and may enable better projections of the peaking of world oil production from historic data.