Peak Oil: The Hubbert curves through the lenses of biologists, geophysicists, and economists

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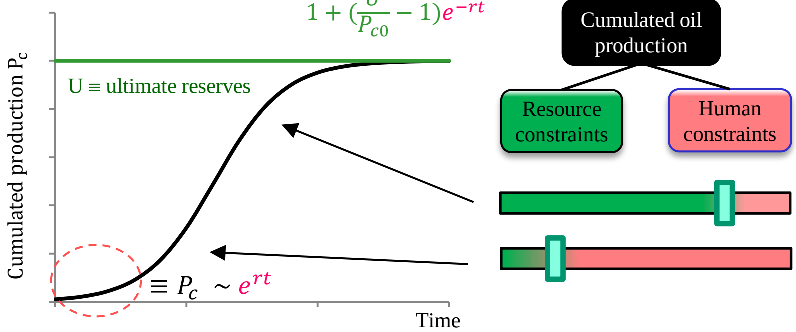
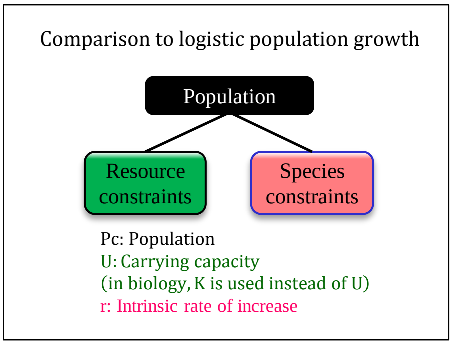
In 1956, the geophysicist M. K. Hubbert presented a model that predicted a peaking of the US oil production in 10 to 15 years. Few believed him, as oil production had been growing for one century. But in 1970 the peak did occur, and in 1974, Hubbert testified to the US House of Representatives why the US oil production was in decline. The title of his talk was “On the Nature of Growth”.

Growth phenomena are familiar in biology and economy. The Hubbert curve describing the growth of production of oil, a limited resource, is also used by biologists to describe population growth in a resource-limited environment. The parallelism is obvious: both the oil industry and populations have more difficulties to grow when they are approaching natural limits. Today, while a worldwide peak oil is looming, few believe in the Hubbert model to predict future oil production, as technology and rising oil prices are seen to push the limits. As biologist’s models deal with variable limits, they can help addressing many concerns raised by the economists. Here, we discuss a dynamic Hubbert model.

The Hubbert Model

$$P_c = \frac{U}{1 + (\frac{U}{P_{c0}} - 1)e^{-rt}}$$

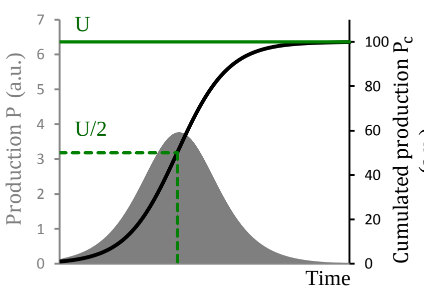


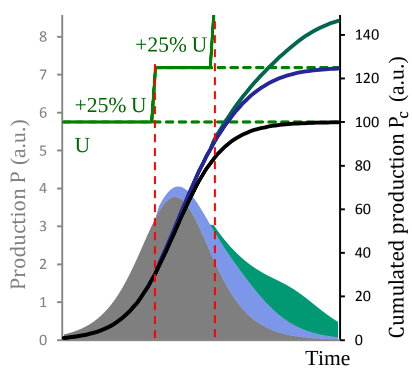


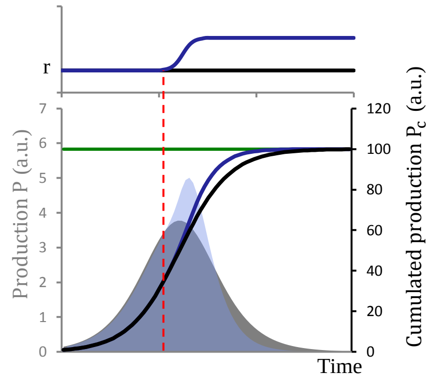
Early in the history of oil production, cumulative production *Pc* evolves exponentially, as in a world without physical limits. The limiting factor is human: *r* in the equation reflects the pace at which the oil industry expands on a territory and invests to extract oil. Later, Pc deviates from exponential growth, as physical constraints play a growing role.

At the worldwide level, oil production spans a large timeframe, from the XIX to the XXII century probably. Thus, while at an early stage of oil extraction, in the XX century, purely economic models were appropriate to model future production, today in the XXI century, the growing role of resource constraints on the oil flow is apparent, and models should be adapted. However, many energy policies are still based on “remaining reserves” and not on oil flow. Even the International Energy Agency is late to include physical constraints (they studied decline rates of oil fields in details only in WEO2008).

Static versus dynamic Hubbert models

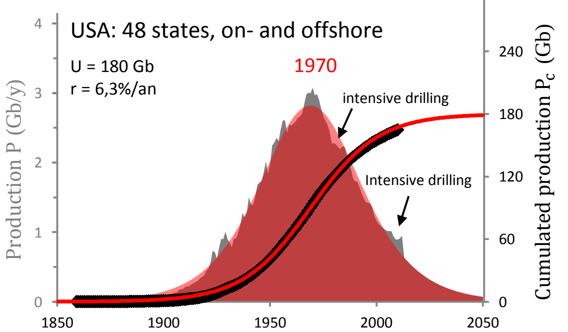


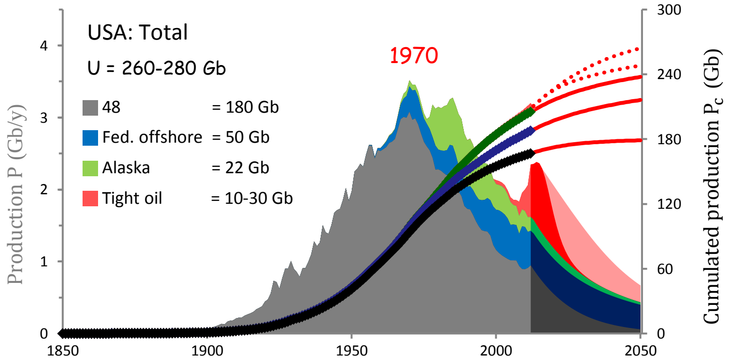




In the classical Hubbert model, production peaks once half the ultimate reserves *U* are gone (left). But *U* can change with time due to technology or new cycles of discoveries, and *r* can change with time due to changes of the pace of investments, thus modifying both height and timing of peak oil. However, when peak oil is imminent, the peak date is influenced by current trends of discoveries and technology, not future ones (center). And while an increase of *r* can indeed postpone the peak, the side effect is a faster decline post peak (right). On the short term, it is difficult to evaluate whether a rebound of production is due to an increase of *U* or *r*.

A case study: the USA





The U.S. peak occurred in 1970 and was imposed by the first production cycle. Production cycles often accompany extensions of the geographical area covered by the industry: onshore in 1859, shallow water in 1950s, Alaska in 1970s, deepwater in 1990s, ultra deep in 2000s. Further extension is now limited. The last cycle, tight oil after 2007, is geological instead of geographical. Responsible of the rebound of the oil production, its rate *r* is ~35%/y, against 6%/y for the first cycle, due to furious drilling. Decline rates are very high, and *U* very uncertain. Two scenarios are proposed, with U=10 Gb and 30 Gb, based on rapid drilling of the remaining well locations in the Bakken and Eagle Ford. Although a better outcome cannot be ruled out, it is more likely that the rebound will be short-lived and followed by a decline that is hardly a reason to declare U.S. energy independence.

Source: crude oil production, eia; US ultimate reserves (except tight oil), Jean Laherrère; tight oil ultimate, based on eia data.

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