The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

Tech Talk - California Oil and Hubbert Linearization

Posted by Heading Out on July 3, 2011 - 11:23am

Last week, when I was writing about the heavy oil fields of California, I used a plot from Jean Laherrère to illustrate the potential ultimate production from the Kern River oilfield as a way to illustrate its potential future. Jean has written, via Luis de Sousa, to point out that the curves that I used are out of date, and was kind enough to send along the more up-to-date curves, not only for the Kern River, but also for the Midway-Sunset field, which, as I noted, is the largest remaining field. It seems to be too good an opportunity to miss to also briefly discuss the basis on which these projections are made, since they allow an estimate of the ultimate oil recovery from a field and a projection, as the following figures show, of when the field will effectively run out of oil. Let me start by putting up his figures for Kern River to facilitate the discussion, and then I will explain, and add the Midway-Sunset plots at the end. Jean has (since the initial post went up) written to point out that it is important to note that despite oil price increases and more wells, the field has steadily declined in production, at a rate of about 5% pa, since 1998.

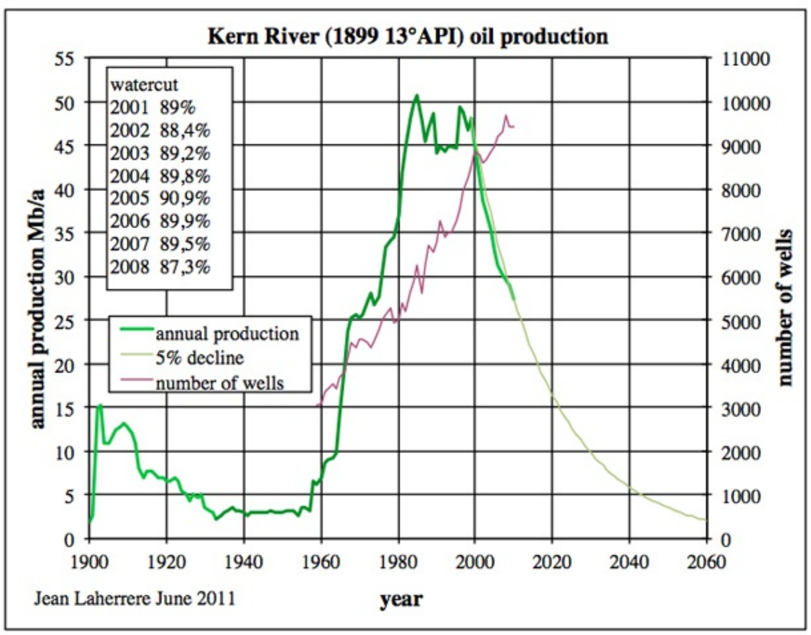

Figure 1. Past and projected future production from the Kern River oilfield in California (Jean Laherrère).

This projection of field decline involves an estimate of ultimate recovery from the field which is derived from this curve.

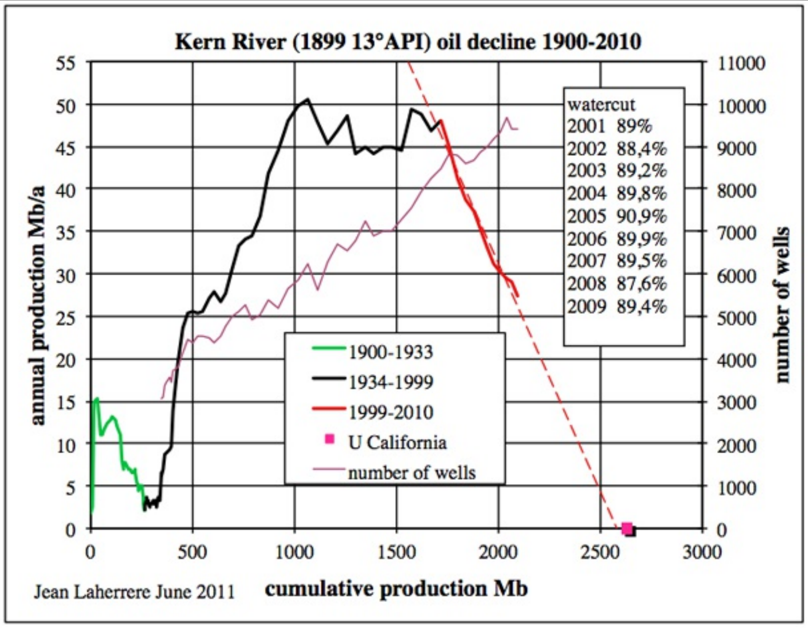

Figure 2. Kern River production decline and total estimate of production (Jean Laherrère)

So how are these plots derived?

This is a topic that has been covered almost since the time that The Oil Drum was founded (back in March 2005), since it was in May of that year that Jean published a paper describing how to "Forecast Production from Discovery." (His pioneering work, internationally recognized in this field, did not start with this. For example, he co-authored with Colin Campbell the Scientific American article on "The End of Cheap Oil" in 1998.)

Within the pages of TOD Stuart Staniford had briefly explained it while comparing different methods of estimating future production back in September 2005, with a follow-on post looking at specific examples where it might be applied.

The technique derives from a process known as Hubbert Linearization (after King Hubbert, who is largely remembered for predicting the date of peak oil production in the US before it happened). Examining the data from oil production over time, Dr Hubbert postulated that it followed a logistic curve, which as Stuart pointed out, is an accepted model of how exponential growth occurs in a system that is of a certain finite size. It has been used since its original discovery in 1838.

The mathematics of the equation are fairly straightforward, and for consistency I am going to quote Stuart's explanation:

> In terms of oil production, the differential equation looks like this:
>
> $dQ/dt = kQ(1-Q)$
>
> Here, Q is the cumulative production as a proportion of the ultimately recovered resource, t is time, and k is a constant that sets the width of the peak.
>
> The solution Q(t) to this equation is a sigmoid function, and the derivative is the famous Hubbert peak. The idea behind the equation is that early on, the oil industry grows exponentially - the annual increase in production is proportional to the total amount of

> knowledge of resources, oil field equipment, and skilled personnel, all of which are proportional to the size of the industry. Thus dQ/dt is proportional to Q.
>
> Later, however, the system begins to run into the finiteness of the resource - it gets harder and harder to get the last oil from the bottom of the depressurized fields, two miles down in the ocean, etc, etc. The Hubbert model assumes that all of this complexity just comes down to that annual production gets an extra proportionality term of (1-Q) - the amount still to produce.
>
> Now, there's a nice trick which I learned about from Deffeye's book "Beyond Oil", but I don't know if he thought of it or got it from somewhere else. The idea is that if we plot dQ/dt / Q versus Q, the above equation says that it should be a straight line, since
>
> $dQ/dt / Q = k(1-Q)$
>
> So we plot the ratio of annual production to cumulative production to that date, versus cumulative production. In his book, Deffeyes does this on p37 for US oil production. In the beginning, the data are crazy, but after about 1958, they settle down into pretty much a linear regime (with a little noise) that has held good ever since. The nice thing about this method is that you do not need to input an estimate for the URR. Instead, you extrapolate the straight line, and it tells you the URR.

You will note that Figure 2 shows this for the Kern River field, with the extrapolated out to an Ultimate Resource Recovery (URR) of around 2700 Mb of crude. One can then project out the decline in current production (Jean notes that it remains at around 5%) with an estimate of how long the field will last. (Figure 1).

The technique has some limitations in fields that are produced under political control, or due to other external forces where production can be shut off for significant periods (one thinks of Saudi Arabia, Iraq and now Libya as examples) however when political constraints are removed (such as for example in Texas) then the decline does assume a linear trend.

It does not, however, always apply, and Robert Rapier has explained, in two posts (here, and here) why he has concerns about using the technique. But in terms of giving a ballpark for production (and recognizing that there are always new discoveries and inventions that can be, as they say, game changers) the technique has considerable support. And the consistency with which the Californian fields are following the predictions provide evidence for such an opinion.

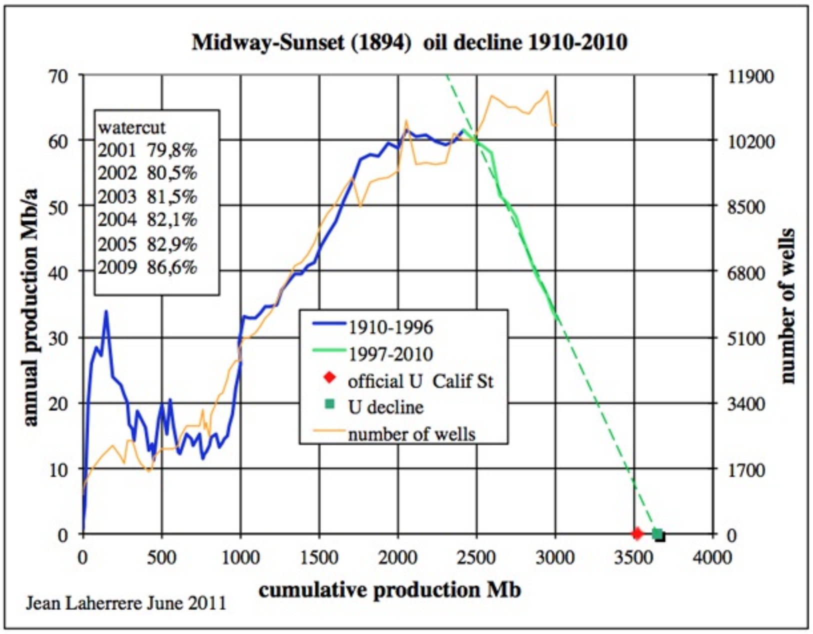

Figure 3. Midway-Sunset production decline and total estimate of production (Jean Laherrère)

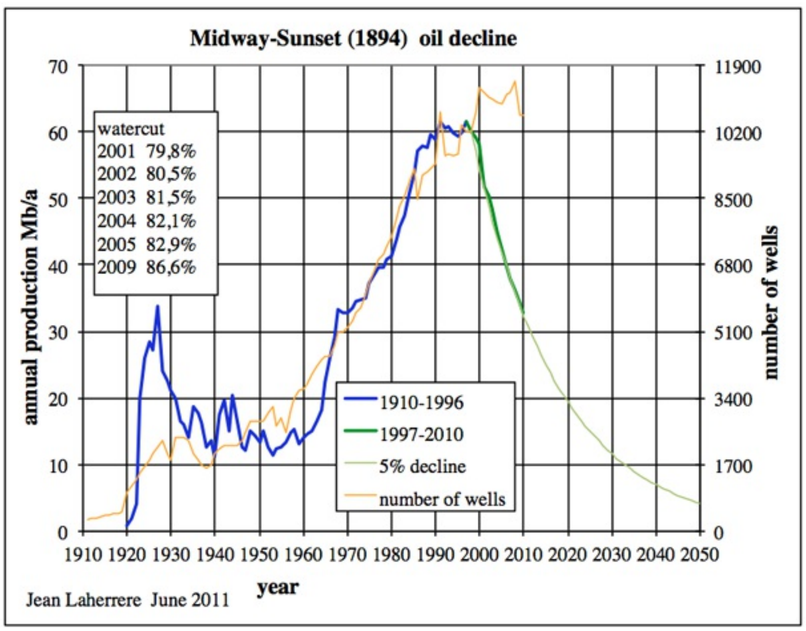

Figure 4. Past and projected future production from the Midway-Sunset oilfield in California (Jean Laherrère).

I am deeply indebted to Jean for making this updated information available, as well as his indefatigable work in examining the remaining oil reserves in the oilfields of the world.

P.S Jean has also discussed results from this region in other material, such as, for example, here.

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