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Nearing The Top Of Hubbert's Peak  
( Revised from my " Hubbert " =eports of 8/08/01 & 10/25/02

*While this piece in its original form was =ublished nearly three years ago, I believe that it is more relevant to our =nergy situation now than when it was first written. For this reason, we =re issuing it again with several small updating =hanges.*

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The noted USGS and Shell geophysicist, M. King Hubbert =1903-1989), was the first man to effectively apply principles of geology, physics =nd mathematics (in combination) to the projection of future oil =roduction from the US reserve base. He was a brilliant scientist but was =escribed by contemporaries as sometimes abrasive and with a short temper. =e did not suffer fools gladly and was always a center of controversy. =is contributions to geology included seminal research papers on the =ormation of geological structures, the theory of petroleum migration, and =he influence of fluid pressure on the movement of faults. His most =amous predictive analysis was published in 1956. In it, he indicated =hat United States conventional crude oil production would peak in the early =970s and start down. Much scientific heat was generated by Hubbert's =onclusion at that time. It was widely assumed that America's oil output could =till climb for many decades as new areas were opened up and new =echnologies were applied.

In 1970-71, the US hit its high point of oil output. It =ubsequently entered a period of production decline that has carried to this =ay. Hubbert had been right on target. He had accomplished one of the =ost challenging intellectual goals of the 20<sup>th</sup> century: =easurement of the rate of depletion of a main commodity resource underpinning = society, with the implicit warning that it was not inexhaustible, =nd that its peak production was closer than many believed. Hubbert's =iews logically suggested that America would soon have to make a =ransition from oil surpluses to oil deficits, from cheap oil to expensive oil, =nd that this new universe of tightening supplies would create quite a =ifferent social and economic environment from what we were experiencing =hen (and are still experiencing now).

Hubbert lived to see his projections for the US come true. =owever, the oil industry and academia never fully accepted his views despite =heir apparent accuracy. Partly owing to this and partly because US =ompanies soon took their technology, experience, and capital to foreign =ands where oil output quickly surged, allowing our national needs to be met =y increasing imports of crude (close to 62% total US demand in the =ast six months), Hubbert's name, and the concepts he developed, are not =o well known today. However, it seems likely that they will be again, =ince the principles he used, now refined by computers, better data, and =mproved modeling techniques, are applicable to world crude output today in =he same way they were to US output in the 1950s. Depletion of the =lobal resource base of crude oil continues to accelerate, while the =lassic days of successful exploration (in terms of tens of billions of barrels =dded each year to the world's reserves) are falling far behind =s.

Has anyone pointed out to you recently (after proper adjustments for the true discovery date of reserves) that the world is now consuming approximately three-and-a-half-times the volume of crude the oil industry is finding each year? That the peak global oil discovery rate was in the mid-1960s and that we have been in an inexorable descent since then? That in the late 1980s, new discoveries fell below the level of current production, and they are still falling, despite the application of any powerful technological tools in the 1990s? And, that 70% of the oil you are consuming today was found 25 years ago or longer?

These are points that oil companies (and governments) find it awkward to discuss. One reason is that there are so many conflicting views of "experts". Who is one to believe? Another is that while Hubbert's Peak cannot be "proven" to work in any exact time sequence, widespread debate about it would certainly raise warning flags for some elements in society, and environmental passions in others. Should sleeping dogs be awakened in this case? Lastly, recognition of the effects of Hubbert's math would imply an end to volumetric growth for most oil companies in the intermediate term...not an eagerly awaited event.

However, we are at a point now where these issues need airing. Effective energy policies are part of an ongoing international debate, and investors are asking where the flow of funds into the energy sector should be concentrated in order to bring the best results. The shadow of King Hubbert looms large over these discussions. Suddenly, we are troubled by issues on a world scale that he was dealing with on a national scale back in the 1950s. And the resolution of them is just as elusive today as it must have been back then, only now we have no new world of exploration to turn to as an alternative to our depletion of the old one.

Hubbert's projections in 1956 were embodied in a rising line of conventional US oil production that eventually was to run over the top (1970-71), leading to a long and inevitable descent on the other side. Enhanced oil recovery techniques, new seismic methods of finding oil, and new types of drilling and fracturing as examples of ongoing technological changes have not been able to displace this depletion curve very much. That is the truly frightening aspect of Hubbert's Peak. Up to now there has been such a vast effort to push it out in time, with so little results to show for it.

Why does Hubbert's Peak work so well on the predictive side? Obviously, explorationists look for the largest, most accessible, easiest complex prospects to drill first. So, early drilling in a particular region tends to be more productive in building reserves than later drilling. New seismic techniques applicable to land drilling in the 1950s and to ocean drilling in the 1960s allowed most of the world's oil basins to be mapped in the 20 years after World War II, so it is not surprising that discovery rates were high in those times. (Recent applications of technology might have encouraged additional field discoveries in the 1980s and 1990s. However, in the event, these tools were focused more on rapidly draining existing reserves than on finding new ones, thus accelerating later depletion rather than significantly adding to reserves at the time.) Most of these points were, of course, well known to the country's geology professionals. Hubbert's genius was to fit them into a coherent mathematical system that would portray the future course of oil production with reasonable accuracy.

Suppose that, in the short period of years we may have before "facts on the ground" close in on us, we are unable to shift the Peak from the configuration it is likely to take. What does that mean to us as energy consumers and investors?

Every expert will have his or her own view as to whether, when, or where the Peak will impact us. So, for the moment, let me give you my personal take on it, starting with developments that could occur in the relatively near future.

The non-OPEC world may well reach a peak in liquids output in the period around 2010 at 54-55 million b/d vs. a current level of close to 50 million b/d. That is my own projection. However, it's

clear that forecasting is an art, not a science, and the assumed 2010 number would easily arrive in 2009, or 2011. Such a peak would be an important harbinger of a new era of oil pricing and higher in-the-ground reserve values because it would imply that all incremental barrels produced after that by the oil industry to meet global increases in demand would have to derive from OPEC. That organization would then be left to determine the terms and conditions on which this crucial new supply would be made available to the non-OPEC world.

I am not suggesting that in this situation oil prices would immediately skyrocket. There is no reason to believe that OPEC would wish to "kill the goose that laid the golden egg". At least, not right away. However, the key point is that the price would no longer reflect the ebb and flow of supply and demand in a relatively free market, as it has for many years (with occasional manipulations thrown in). The price of oil would be largely determined by a few powerful oil producers in the organization that could still lift the incremental barrel, mainly Saudi Arabia, followed by Iraq, Kuwait, Iran, the UAE and possibly Venezuela.

My own guess would be that OPEC's pricing policy under these circumstances would, at first, be quite reasonable. Oil prices might climb at, say, double the rate of low world inflation in order to get back the purchasing power that OPEC has always claimed it lost from the mid-seventies onward. However, no consumer-country statesman in the non-OPEC world could afford to be comforted by such apparent rationality. OPEC is, after all, intent on running the crude oil system for its own benefit, not for ours. As the margin of excess produceability worldwide would be expected to tighten, the Organization would surely be tempted to allow crude prices to rise a bit faster, and then a bit faster...

The peaking of non-OPEC production that I am describing here would, likely resemble a large flattish dome in the 2009-2011 period. The top could even extend longer. This is owing to the coincident start up of the Kashagan field in the north Caspian region of Kazakhstan in 2008, as I foresee it. Output here could add perhaps 300,000 b/d each year for the next six years, on my numbers. This would represent what I would consider to be a "last hurrah." Nothing like it would probably be seen again... a field known to exist 25 years ago that was developed later for political and environmental reasons. Kashagan, with up to 2-15 billion barrels in estimated recoverable reserves as I make it, would extend the peak of non-OPEC production by a year or so.

For the record, the U.S. reached its peak production of crude oil in 1970-71, and Russia in 1987. It appears likely that the North Sea, comprising the UK, Norway, the Netherlands and Denmark, hit its top in 2002. China, with new offshore production coming onstream from Bohai Bay in the years just ahead could peak in 2008-2009. Mexico appears to be 6-7 years from its top and could be declining in output by 2010. Canada, with its growing tar sands output, may be able to push to modest new highs in the next decade, but it is unusual in this capability. These are the principal non-OPEC producers. They are currently showing only small near-term gains as a group, while staring at large future declines.

How would the peak of production from OPEC (2020- 2030) and non-OPEC (2010) look when put together? Much here depends on one's outlook for oil pricing in the interim period after 2010. If the peak of non-OPEC production touched off a sharp rise in crude prices after 2010, when the slowing of world demand as a consequence of that would impact oil output and would obviously delay the overall peak. Under "normal" pricing conditions, one might make a guess in the area of 2015 for the global peak of crude oil output. However, as we approach that period, the effect on pricing of wider recognition that incremental barrels of oil might cease to be available from the system altogether by, say, 2015, could force oil prices substantially higher, and delay the global topping out of production to, say, 2020.

In any case, the point of these paragraphs concerning the peak of oil output for the non-OPEC world, and then the world as a whole, is to make the case that rising prices could be expected to ration

supplies, and, in investment terms, raise returns for those oil-based entities that might still hold sizable reserves and production growth potential in an operating universe that was critically short of both after 2010.

The wider implication of Hubbert's methodology is that it could define limits to non-OPEC production increases over the next six years, and then bring it to a halt altogether. This would, over time, encourage significant crude oil price increases that might:

- Slow developed countries' growth, forcing political changes in the way energy is produced, used and conserved, and also influencing land usage laws, transportation systems, immigration laws, and tariff regulations, to name a few priority issues.
- Place developing countries without sustainable oil, gas, or coal reserves at a sizeable disadvantage in achieving future economic growth.
- Impose energy conservation policies on every political unit and every private citizen throughout the non-OPEC world by reason of the power of pricing, the law, and the influence of social cohesion.
- Modify the relative power of states in today's international order, with the oil "haves" ascending on the scale and the oil "have-nots" descending. To thwart this, "crises" might be instigated by countries which would suffer most from these changes, with unknown consequences.
- Create internal civil stress in countries where the lower economic orders of citizens would have their economic lives substantially altered by lack of petroleum products they could afford (examples would be kerosene for cooking in India, two-stroke fuel for motor bikes and small cars in China, diesel for trucks in Turkey, Brazil, sub-Saharan Africa, and so on).
- Change the relative valuation of stock markets, and the relative valuation of sectors within stock markets around the world.

In terms of timing these possible developments, it should be noted here that the oil industry does not have fee ownership of crude oil reserves in the OPEC nations. So, by and large, though the major integrated companies may buy volumes from OPEC countries, their own production is almost entirely in the non-OPEC world. As such, this production would be well distributed around the non-OPEC peak in a time sequence but it would still be tied to it in aggregate. So, the period 2010-2011, in the aftermath of the non-OPEC peak, is anticipated to be the critical one for oil companies as well as consumers who draw supplies from them.

It should be noted again that Hubbert's Peak only applies to conventional crude oil production, not natural gas liquids or condensates, and not the heavy oils of Saskatchewan, or Cold Lake and Peace River in Alberta, or the tar sands of Athabasca (all of these in Canada), or the Orinoco (Venezuela), or the many other reserve bases of low-flowing or non-flowing oils around the world. Companies developing these heavy oils or "synthetic" crudes would escape (for a reasonable time) the problems of accelerated depletion and declining discovery rates that are presently affecting 99% of the oil produced today, and which might affect as much as 96% of the oil produced in 2010.

I see the energy business as capable of attracting and successfully employing vast amounts of capital in future years, as well as the talent to manage it. However, the new basis for doing business, that is, restrained supplies at higher prices vs. virtually unlimited supplies at the lower prices of the past, will entirely change the structure of opportunities, supplier-customer relationships, the establishment and direction of energy producing organizations, and the valuations we have historically put on

them. After 145 years of Col. Drake's petroleum industry, a wholly new one is emerging. None of us has ever seen the like of it before.

If you believe that markets discount the future, near or far, and sometimes both, then it is not too early to ponder the possible effects of M. King Hubbert's work on the lessened availability of future crude supplies, and how this might bear on consumers, industry, governments, and not the least, the oil business itself. It is, of course, the sudden appearance of such potential developments that constitutes the greatest danger to our economic and political system. A situation might arise where it is obvious that radical change is required in the use or output of energy but we have difficulty deciding what steps should be taken and how we should execute them. This might cause delays that could sharply penalize our standard of living. So, in becoming alert to this possibility, far-seeing observers might begin considering the trend of events from the perspective of the Peak.

-CTM

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