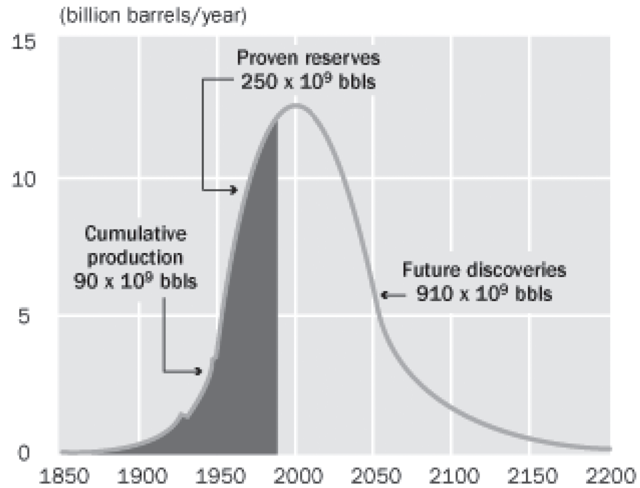
Tight Gas to Tight Oil: Squashing Hubbert's Bell Curve

By Ross McCracken*

In 1865, the eminent British economist William Stanley Jevons pointed out in his treatise *The coal question; An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal Mines*, "the painful fact that such a rate of growth will before long render our consumption of coal comparable with the total supply." Jevons was ahead of his time making the peak oil argument for coal.

In 1956, the eminent U.S. geologist Marion King Hubbert said in his paper *Nuclear Energy and the Fossil Fuels*, "On the basis of the present estimates of the ultimate reserves of petroleum and natural gas, it appears that the culmination of world production of these products should occur within half a century."

The big difference between the two was that while Jevons was at best out on his timing by a century or two, Hubbert was to all intents and purposes proved right. U.S. oil production peaked in 1970, to be followed by natural gas in 1973.

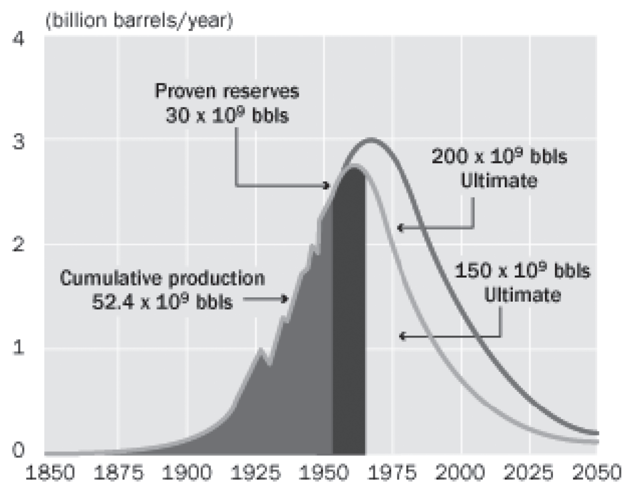


Note: Hubbert based his 1956 prediction on initial world reserves of 1.25 trillion barrels of crude oil. Today, **remaining** reserves are larger than this at an estimated 1.317 trillion barrels. However, Hubbert estimated peak production in 2000 at 12.5 billion barrels a year, while world crude production in 2007 is likely to be two and a half times greater at an estimated 31.3 billion barrels.

Ultimate World Crude Oil Production

(based upon initial reserves of 1,250 billion barrels

Source: Nuclear Energy and the Fossle Fuels, M. King Hubbert, 1956



Ultimate U.S. Crude Oil Production

(based on assumed initial reserves of 150 & 200 billion barrels)

Source: Nuclear Energy and the Fossle Fuels, M. King Hubbert, 1956

Bell Curves

Hubbert reasoned that what was true for U.S. oil was true for world oil production. A finite resource cannot be produced indefinitely at a continually ever greater rate of production. His argument was highly seductive and mathematically elegant.

He constructed a bell curve that put world peak oil production, rather too neatly perhaps for someone writing in the 1950s, at the year 2000. He assumed initial world reserves of 1.25 trillion barrels and peak production at 12.5 billion barrels a year, which equates to about 34 million b/d.

Today, even remaining proved oil reserves, at 1.38 trillion barrels, are larger than his initial assumption for the total resource, suggesting a much later peak, but consumption is almost three times as great, suggesting a much earlier peak. (A caveat here is that OPEC's official reserve estimates are highly unreliable and most likely exaggerated, but no-one is sure by how much). Oil consumption this year is expected to amount to somewhere in the region of 90 million b/d.

More importantly though, a facet of the bell curve is that even if the total resource figure (represented by the area contained by the bell curve) is expanded -- even doubled -- the point of peak production doesn't shift that much into the future. A model produced by UKERC in 2009 showed that doubling the ultimate recoverable resource would only push peak oil out by about 30 years. That study suggested a global peak was likely to occur before 2030, with a significant risk of supply constraints before 2020.

The acceptance of the bell curve also implies a rather dramatic drop-off in production post-peak, a development which, if the world was caught unprepared, could cause major economic dislocation. These fears found one of their most fantastical expressions in the 2007 film *A Crude Awakening: the Oil Crash,* which predicted a coming Armageddon and the reversion of society to an Amishesque agrarian economy of donkey driven carts.

Yet, as oil prices sky-rocketed in 2008, peak oil theory gained in legitimacy, underpinned by the inescapable logic that a finite resource cannot be produced indefinitely at an increasing rate of production. And at the level of individual

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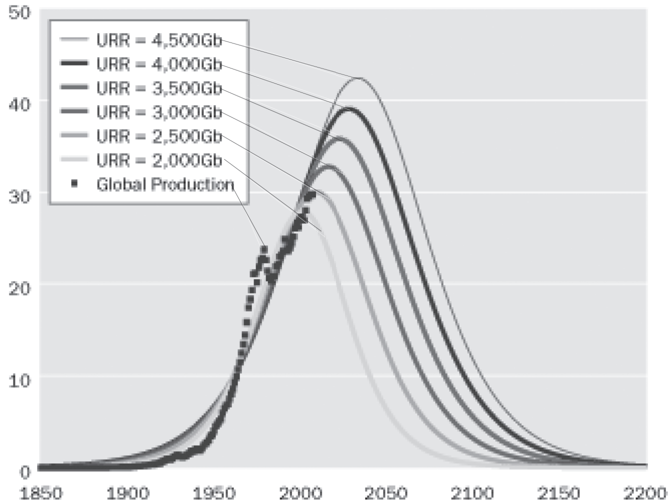
conventional oil provinces, such as the North Sea, Hubbert again appeared pretty much correct.

Tight Gas to Tight Oil

However, Hubbert's theory seems to be going the way of Jevons for two reasons: first, the ultimate recoverable resource does indeed seem to be expanding; and second, in some countries at least, peak demand appears to have arrived before peak production.

The impact of the first development is to increase the volume under the bell curve, while the effect of the second is to squash it. The effect of both combined is to push the real peak in oil production way out into the distant future. The related forces driving this are high oil prices and technology.



Oil Peak Using Different URR Assumptions
Source: UKERC 2009

In April, the U.S. Energy Information Administration published a report on shale gas reserves that is likely to prove one of the most influential energy reports of all time. It said that the world's technically recoverable shale gas resource for 32 countries was 6,622 Tcf of gas in contrast to proved natural gas reserves of 1,001 Tcf. It did not include some of the most prolific gas bearing regions of the world, for example areas in Africa, the Middle East or Russia.

The implication of the report was that countries previously thought either to have little or no gas to speak of and heading towards ever-increasing import dependency had an alternative. For countries like Poland, South Africa, Argentina and China, the results are potentially transformational in terms of their previously assumed energy trajectories.

Underpinning this estimate was the United States' own experience, in which a future dependent on LNG imports had suddenly morphed into one of abundant and cheap domestic gas supply. Directional drilling and hydraulic fracturing had delivered new life to the U.S. gas industry and the figures were there to prove it. Having peaked in 1973 at 59.5 Bcf/d, U.S. natural gas production was heading back towards new highs, reaching 59.1 Bcf/d in 2010 on a rising trend.

The success of shale gas meant U.S. gas prices dropped -- they were near \$3.50/MMBtu in December -- and completely decoupled from oil, which over 2011 has seen its highest average prices ever based on the international Dated Brent benchmark. It didn't take long for the shale gas pioneers to realize that the liquids produced alongside shale gas were more valuable than the gas itself and that some shale plays were much more liquid-rich than others.

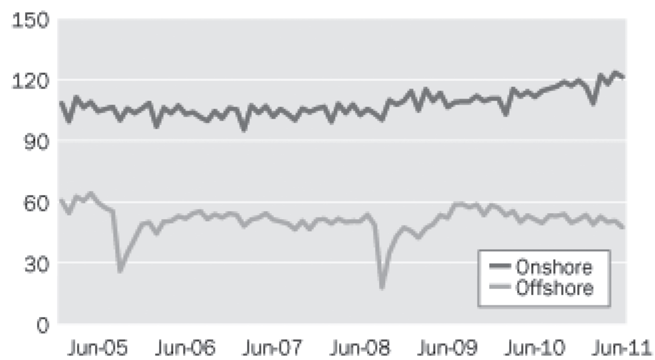
The new drilling techniques could equally well be applied to oil trapped in tight, low porosity formations. There was a dramatic shift in focus from shale gas to liquids -- tight gas had become tight oil. The number of rigs drilling for oil in the U.S. in 2011 became higher than for gas, inverting the historical relationship.

A look at U.S. liquids production shows that onshore production has reversed its downward trend. Some forecasts suggest that the Bakken shale formation in the northern U.S. could produce 1 million b/d by 2015 and that the Eagle Ford shale could produce similar amounts by 2020. Other shale plays could add a further 1 million b/d over the same 2020 time frame.

Shale Goes Worldwide

As the U.S. shale gas experience unleashed a frenzy of exploration worldwide, companies internationally have been quick to look at both the liquid and gas potential of their new plays. In November, Spain's Repsol announced that it expected to invest \$20 billion in a huge shale oil and gas discovery in Argentina. The company's Argentine unit YPF said it had found nearly 1 billion equivalent barrels of recoverable shale oil at the Loma La Lata field in northern Patagonia.

The Loma La Lata discovery lies in a 428 square kilometer area, a fraction of the 12,000 sq km concession which Repsol is exploring in the vast Vaca Muerta formation. The



Monthly U.S. Oil Production (millions barrels)
Source:EIA

field currently produces 5,000 boe/d of shale oil and gas from 15 vertical wells, but Repsol planned to start horizontal drilling late in 2011, and is targeting production of some 350,000 barrels of oil over the lifetime of each well.

According to Repsol's chief financial officer Miguel Martinez, the field contains 741 million barrels of light oil with an API of 40-45° and the production cost should be around $26-$29/b. The remainder is heavy oil. Repsol is also starting to produce oil from a similar-sized, nearby area in the same basin that could rival the Loma La Lata field in size.

And if the potential is large in Argentina and the U.S., it is huge in Russia. Several companies are researching how to extract oil from the huge Bazhenov formation in West Siberia, which some geologists estimate may hold 50 billion mt (365 billion barrels) of recoverable reserves. Russia's subsoil agency Rosnedra projects that output from Bazhenov could reach 1.7 million b/d by 2030 -- nearly a fifth of current Russian production. Rosnedra foresees output growing to 1.1 million mt by 2015 and to 15.4 million mt by 2020, according to the Russian news agency Prime.

How much tight oil exists worldwide, what the recovery rates will be and how much it will cost to produce remain open questions. (Repsol's estimate for Loma La Lata of $26-$29/b is way below what is currently viewed as the marginal cost of production for oil sands, for example). Organizations like OPEC and the International Energy Agency are fairly cautious in their initial assessments, but there seems to be a significant disconnect between this conservatism and what U.S. companies involved in tight oil plays in the U.S. think is achievable -- just as there was with shale gas.

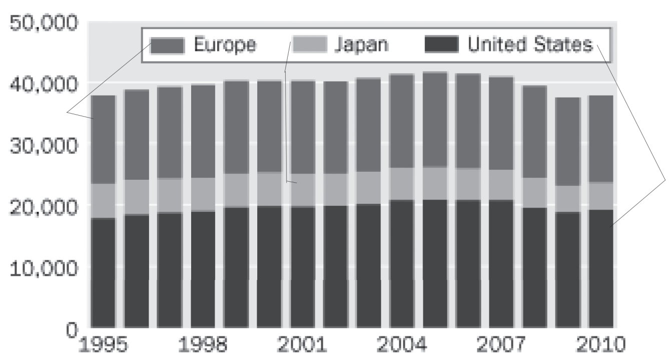
In short, tight oil may make a very significant contribution to a much enlarged recoverable oil resource. The Bazhenov formation alone contains more potentially recoverable reserves than Saudi Arabia's proved conventional reserves.

Peak Demand

The other side of the equation is peak demand. In its World Energy Outlook 2011, published in November, the IEA sees world oil demand growing from 87 million b/d in 2010 to 99 million b/d in 2035 under its New Policies Scenario. But there are marked regional differences. All demand growth comes from non-OECD countries, while oil demand in the OECD contracts. The OECD, it seems, hit peak oil demand some time ago.

The advent of peak oil demand in the OECD reflects the combination and alignment of multiple policy drivers: a response to high prices, concern over increasing dependence on oil imported from a dwindling band of major exporters, and the need to reduce greenhouse gas emissions. The past five years have seen a policy and price-led upsurge in alternative technologies designed to eradicate demand for oil. The introduction of biofuels to the fuel pool, combined with more fuel efficient vehicles and greater energy efficiency more broadly, is giving way to longer-term solutions such as electric cars.

While recession following the financial crisis has exaggerated the drop in OECD oil consumption, there is a clear underlying trend in permanent price-driven demand destruction. European oil demand peaked in 2006 pre-financial crisis. Japanese oil consumption has been on a downward trend since 1996, although the Fukushima nuclear disaster may produce a temporary upturn this year and next. U.S. oil consumption rose in 2010 from 2009, but remains below the peak of 2005.



Regional Oil Consumption (million b/d)
Source: BP Statistical Review of World Energy 2011

What matters for peak oil is world demand and that is expected to continue rising, but of all the possible future scenarios two might be set against the prevalent view of ever-rising non-OECD demand. First is that the non-OECD might see peak demand earlier than the OECD in respect of relative levels of economic development. Just as Europe and Japan have different levels of vehicle usage, there is no iron law of development that China must have the same number of cars per person as the United States. Second, is that the OECD contraction proves much deeper than is currently expected, perhaps as a result of much higher than expected uptake of electric cars, perhaps in the short-term as a result of renewed recession.

That a large proportion of the consumption side of the oil market is on a downward trend suggests not necessarily that the world is approaching the top of Hubbert's bell curve, but that the overall path of world consumption is more semi-circular than bell shaped. Combine this with much more available oil, and peak oil not only recedes into the future, but there is no sudden cataclysmic drop off in production.

Crystal Balls

Predicting peak oil looks like the extrapolation of conditions prevalent in the 2005-2009 period into the immediate future. Arguing that tight oil and peak demand have changed that outlook is simply to extrapolate from a changed present. Neither have much value as forecasts. The fact is that if tight oil does, over the next decade, change the course of the oil market, it implies softer oil prices than currently expected. That in itself will have an impact on the incentive to reduce oil consumption.

However, the lesson for both Jevons and Hubbert is that what technology achieved in the late 1800s with respect to coal, and what may now be occurring for oil, it can do again. The surface of subsalt potential has arguably only been scratched, while beyond tight oil lies the prospect of the confusingly named oil shale -- kerogen containing rock which is different to the tight oil found in shale plays. The problem is not a lack of resource, but a clash of economics versus environmental policy which will be played out in terms of investment levels.

If there is no, or perhaps less, danger of running out of oil, then it throws into sharp relief the interaction of energy and climate policy. Up until now, these have been broadly aligned. Lower oil consumption meant a reduction in energy insecurity, prices and carbon emissions. If oil is cheap and more widely available, then reductions in oil use will have to be justified on climate grounds alone.

It is too early to proclaim tight oil the game changer on a world scale that shale gas has been for a single country, the United States, but it is much easier to replicate processes than create them from scratch. Moreover, Repsol's find in Argentina could transform the company's fortunes; other oil companies' CEOs will take note.

Water Management Economics.. (continued from page 27)

to consider when making water management decisions. The traditional status quo approach to water management will continue to be challenged from a public perception, operational, regulatory, and environmental perspective. There has already been a major public backlash to shale gas development activities in the Marcellus play due to water management issues. Intermittent shortages of water hauling trucks in the Bakken and the Eagle Ford have already created challenges to daily operations for many operators. Shortages of water in the Eagle Ford due to drought conditions have also made water acquisition difficult and led local cities and counties to think twice about allowing E&Ps to source water from their municipal water systems. It's critical that E&Ps of the future consider both intangible factors, along with tangible economic benefits, as outlined in this paper, when evaluating their options for oilfield water management.

E&P Decision-Making Tool

This economic model was not conducted as an academic exercise, but as a tool to facilitate management decision-making. Since the initial water modelling exercise, we have continued to refine the model and have since applied it to evaluate water economics for other E&P shale resources. The model has now reached a level of maturity to support rapid water cost modelling of multiple water management scenarios. When combined with a better understanding of existing water management operations and costs, the model can serve as a critical tool to quickly understanding the costs and implications of E&P long-term water management operations.

Footnotes

[1] The acreage layout has been simplified and geographic details removed to maintain client confidentiality.