ecolonomics[16]

Paul Mobbs' newsletter of thoughts, ideas and observations on energy, economics and human ecology

http://www.fraw.org.uk/mei/ecolonomics/ ecolonomics@fraw.org.uk

What, is peak oil dead? Then show me the body! (of statistical evidence)

ecolonomics journal no.16, Paul Mobbs, Mobbs' Environmental Investigations, May 2015

A decade ago my first 'solo' book, 'Energy Beyond Oil', was published. The text examined peak oil theory, but more widely the issue of ecological limits and energy and resource depletion.

In some respects the content was prophetic; between then and now we've had record high oil prices, followed by an economic recession.

What the book didn't foresee was the rise of 'unconventional fossil fuels'. In the wake of the economic crash, "fracking" and other forms of 'extreme' energy production were hailed by some as a saviour – liberating society from the 'limits to growth' mentality which was implicit within peak oil theory.

It was a natural jump that, six years ago in mid-2009, I began to research unconventional fossil fuels, and what it meant for Britain's energy economy. The 'New Labour' government had quietly promoted unconventional fossil fuels – initially through the 13th On-shore Oil and Gas Licensing Round in 2008.

What Labour started at a small scale the new Con-Dem government made manifest – promoting "fracking" as a new economic miracle for Britain, as significant as the North Sea. This message had a strong resonance with the pundits who, around the same time, were dismissing the basis of peak oil theory, and ecological limits generally.

Now, in 2015 – as Boëthius' consolatory history wheel turns full circle – on the back of fracking's collapse has the statistical evidence for 'peak oil' finally become apparent?

I came across the concept of 'peak oil'[1], and the more general concepts of resource depletion[2], in the mid-1980s – reading books such as *The Energy Question*[3], *Fuel's Paradise*[4] and, of course, *The Limits to Growth*[5].

Resource depletion is an issue which exists at the highly indistinct interface between *geophysics* – a 'hard' science – and *economics* – a 'social' science. It is in part defined by: the fixed quantity of non-renewable resources[6] which can reasonably be produced from the accessible levels of the Earth's crust[7]; and, at the same time, the shifting sands of the economic realities of resource extraction[8] and its technological underpinnings.

My first book, *Energy Beyond Oil*[9], published ten years ago this month in 2005, tackled energy depletion head on. Long before $147 oil and the resultant economic crash that followed, the book analysed the evidence for the peaking[10] of various energy resources, and the economic problems that might result from the practical realities of these phenomena.

Is 'peak oil' determined by web sites?

Following the economic crash, around 2009/10, no one wanted me to talk about energy supply and economics. They didn't need me to – they were living the reality already.

As a result I changed the focus of my research from ecological limits and economics towards unconventional gas and oil[11] in Britain – otherwise commonly labelled, "fracking"[12]. Though seemingly obscure at the time, like my shift to the 'peak oil' issue eight years earlier it was a fortuitous choice.

Since the economic crash unconventional energy sources – such as tight oil[13], shale gas[14], coalbed methane[15], underground coal gasification[16] and the Canadian 'tar' or oil sands[17] – have become a magic bullet for economists. They promise to undermine the shortages and geopolitical restrictions which created the high prices which caused the crash.

It was perhaps for that reason that the *"peak oil is dead"* phenomena really took off around 2011/12 – using "fracking" as its justification.

It began in 2011 with Daniel Yergin's[18] book, *The Quest*[19] – which contained a technologically-based critique of peak oil[20]. This argument was uncritically echoed by the media – for example, the poorly researched article[21] by the BBC's environment correspondent in 2012.

Many subsequent claims were simply echoes of this meme[22]; endlessly recycling the same arguments regarding new drilling technologies and the vast untapped reserves of unconventional fossil fuels. For example, in early 2013, the economic pundit Rob Wile from *Business Insider*[23] said –

> *But today, it is probably safe to say we have slayed "peak oil" once and for all, thanks to the combination* [of] *new shale oil and gas production techniques and declining fuel use.*

In mid-2013, *The Oil Drum*[24], a web site popular with the peak oil analysts who invested time in data collection and analysis, closed. As the Forbes headline[25] triumphantly bellowed about this event –

> *As fracking rises, peak oil theory slowly dies.*

Is the geophysical phenomena of peak oil determined by the existence of certain web sites? *What an absurd idea!*

What Forbes claimed – echoed by Reuters[26] and pundits for economic blogs and media – was that because the 'experts' no longer maintained a web site, it demonstrated that their theory was hollow.

Was this logically sound? Clearly not.

In reality, given the changing economic conditions initiated by the 2008 crash, many of those 'experts' were having to find other income sources to support their work. Most of those involved around *The Oil Drum* are still out there, providing a similarly incisive analysis of current data – *just not from the same web site*. Go the *The Oil Drum's* last post and you'll see a list of where they moved on to[27].

In response to these spurious claims, academics such as James Hamilton had noted the "death" clamour[28] and challenged its basis – pointing out the failure to provide any statistical analysis to back up the claims of peak oil's demise.

In late 2013, as the media moved on from the supposed death-throws of peak oil theory, so the clamour died down. As austerity bit, and the market failed to response to quantitative easing, there seemed be other, more troubling problems for them to consider.

Peak oil... *Banquo's ecological ghost?*

I use technology to sift huge amounts of on-line material, digesting the parts which have the greatest relevance to my current work. I also tend to leave the old search criteria active... *just in case*.

Towards the end of 2014 the search criteria on 'peak oil' started firing off again. It was back in the news.

Seemingly from nowhere, the media seemed to find the need to re-confirm the death of peak oil theory, as some sort of comforting reminder of things past, and as a continued justification of the 'pro-fracking' argument. The question which immediately crossed my mind was, *why now?*

At the time there had been a number of critical reports on the long-term viability of unconventional fossil fuels. For example, David Hughes' article in *Nature*[29] and his report, *Drilling Deeper*[30], for the Post Carbon Institute; or Mason Inman's later article in *Nature*[31].

The resurrection of the "peak oil is dead" meme began during the Summer of 2014: in the *FT*[32]; *The Motley Fool*[33]; and then, in December 2014, on the back of Mason Inman's critical *Nature* article, both the *Wall Street Journal*[34] and *Energy in Depth*[35] (a lobby group maintained by the unconventional gas and oil industry's PR representatives, FTI Consulting[36]).

Once again, they repeated the mantra that unconventional fossil fuels made a mockery of the notion of 'peak oil'; and Daniel Yergin's argument that technology would overcome any limits to production.

Arguably this content was put out to deflect from the economic failures[37] which were becoming apparent within the unconventional fossil fuels industry. Perhaps more significantly, the shady economics of the industry, whose 'junk' debt had ballooned over the course of that year to a few hundred billion dollars – which threatened the wider US economy[38].

Following OPEC's decision to hold down oil prices[39] in November 2014 the US fracking industry, already reeling from the weight of the debt which created it, was starting to fall apart. The resultant media panic sent the industry's PR machine into overdrive – leading even environmentalists to misunderstand[40] the economic and resource trends behind what was happening[41] inside the industry.

"it's all business... numbers sanctify"

The problem with the debate about the "death of peak oil" is that it is a largely ideological attack, fuelled by a belief in the power of technology to maintain 'business as usual' economics.

As Marcuse stated[42], the *a priori* assumption within any social theory is that "life is worth living" – that the ideological framework which is being advanced represents the ideal, the natural and the inescapable "best of all possible worlds".

Unless, however, they are able to prove their case with reference to objective data, which define causality within the trends they describe, any such claims to ideological superiority are worthless.

The problem with the neoliberal economic theory[43] which underpins much of the political and economic discourse today is that it does not have a firm statistical basis. It is a series of assumptions[44] about human economic processes which its own founders, one to two centuries ago, did not consider valid.

If we look at classical economists such as Adam Smith or John Stuart Mill, they all believed that the economy would grow with time and improving technology – but that, at some point, the physical ecological restrictions over the human species would assert themselves to prevent further growth.

For example, Adam Smith states in chapter 9, Book I of the *Wealth of Nations*[45] –

> *In a country which had acquired that full complement of riches... which could, therefore, advance no further... both the wages of labour and the profits of stock would probably be very low.*

What's really interesting is the way that neoliberal economists interpret this today – for example, as outlined the Adam Smith Institutes's commentary[46] on the *Wealth of Nations* (page 24) –

> *Today we see no limit to economic growth. Our capital and technology give rise to all kinds of new business sectors and opportunities for employment. In Smith's time, however, the economy was dominated by agriculture, and he mistakenly sees the impossibility of developing land beyond its fertility as a limit to economic growth.*

The reality today is that we are as dependent upon the the limitations of the Earth – albeit in the form of crude oil, copper or gallium – as those in Smith's time were dependent upon agricultural produce. And of these, it is mineral energy resources[47] which have the greatest impact upon the economy[48].

At the root of the attack on peak oil, and the issue of ecological limits generally, is a Cornucopian belief[49] in limitless growth[50] and technological progress[51] – as embodied in neoliberalism's denial of the limits foreseen be their classical antecedents. This denial offends many physical principles[52] – not least the *Laws of Thermodynamics*.

The offence of peak oil theory then is not that it seeks to describe oil production with reference to historical statistics. The offence of peak oil theory is that it attacks the philosophical heart of neoliberalism, because if energy supply cannot grow[53] inexorably then neither can the global economy[54].

From 'watching brief' to 'active investigation'

Since 2009 my work on ecological limits[55], and peak oil in particular, has been a 'watching brief'. As noted earlier, my IT systems scan for relevant information, but the issue hasn't been a core part of my work for the last five or six years.

That changed in December 2014. The combined resurrection of the "death of peak oil" meme, combined with the information from the US of the collapse of unconventional gas and oil drilling, piqued my interest once more.

In March 2015 I began actively searching for and analysing the available statistics on global energy production. The US Energy Information Agency[56] (USEIA) had just issued their monthly *Drilling Productivity Report*[57]. This stated some curious statistics about unconventional oil production, but the text of the press release[58] was more revealing –

> *EIA's most recent Drilling Productivity Report (DPR) indicates a change in the crude oil production growth patterns in three key oil producing regions: the Eagle Ford, Niobrara, and Bakken. The DPR estimates, which were issued on March 9 and cover the months of March and April, include the first projected declines in crude oil production in these regions since publication of the DPR began in October 2013*

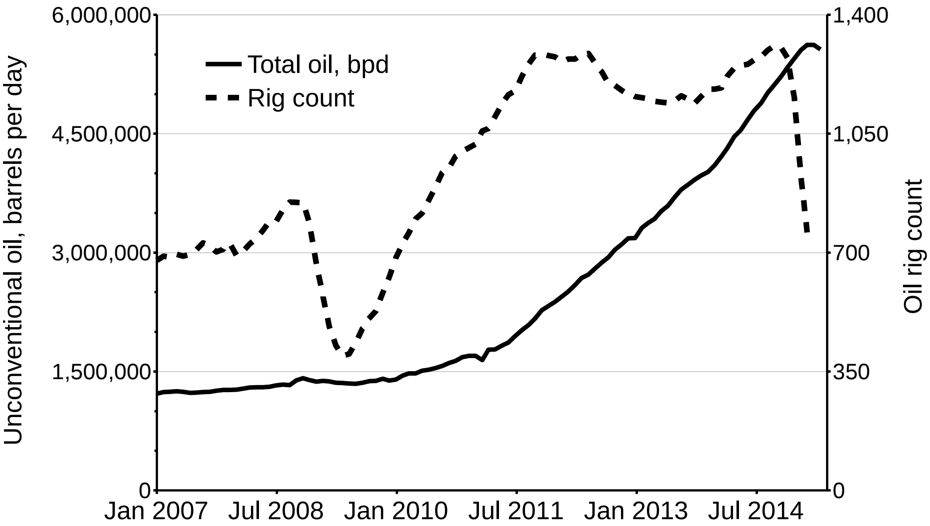
The data from the April 2015 drilling report is shown in the graph 1 below. It would be very easy to draw a correlation between the recent fall in drilling rig numbers over the last six months and the current turnaround in shale/tight oil production. Unfortunately the statistics are not that straightforward.

Shale oil wells have a short production life. For example, USEIA data for wells in the Eagle Ford region[59] show a large, exponential decline in produc-

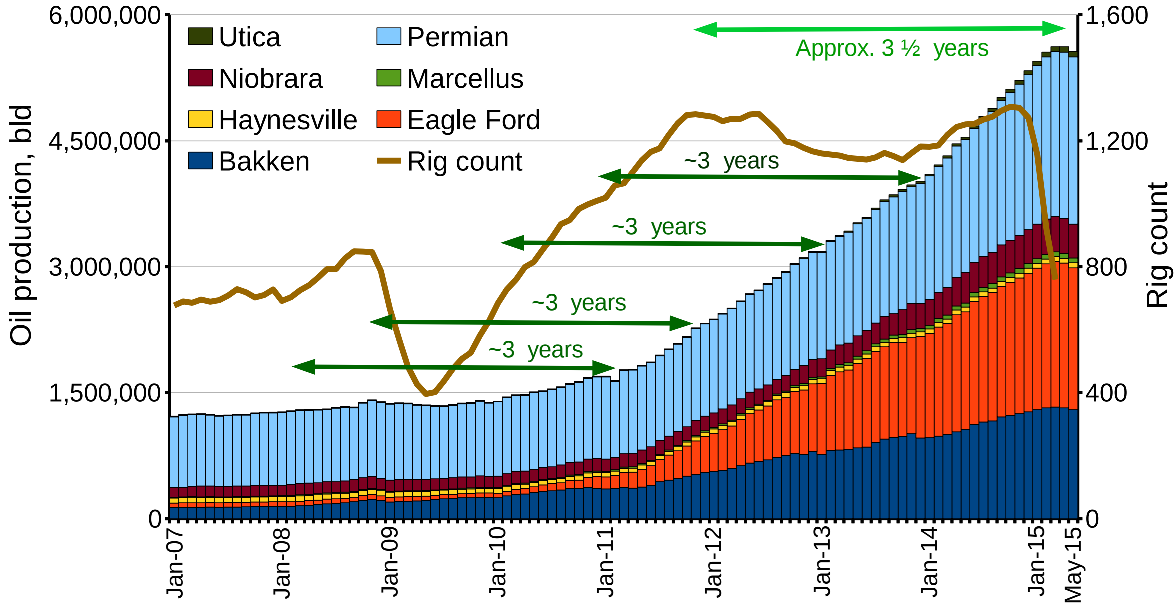
Graph 1. USEIA Monthly Drilling Report, April 2015 – Unconventional Oil Statistics

This graph shows the total shale/tight oil production from all the regions covered by the report (left scale, barrels per day), and the total oil rig count (right scale).

This graph shows the problems of attributing drilling rates to production levels – either on the upswing or down-swing of production. There is not a direct correlation over time, in part due to changing field and well production trends.



Graph 2. USEIA Monthly Drilling Report, April 2015 – Oil Statistics for each region



tion over the lifetime of a well; but that same data also shows per well production increasing over time due to higher recovery rates and the greater extent of horizontal drilling.

This adds to the problems correlating the USEIA's production data to the number of active drilling rigs. The large historic swings in drilling rig numbers do not result in marked changes in production – only the general trends of increasing rigs to increasing production is demonstrable within the data.

Graph 2 above shows the monthly production statistics for each region[60]. This again illustrates another complexity in the data, and why it makes predicting future trends difficult.

For example, the Permian region[61] on its own makes up a approximately a third of total production, and production is still increasing. Thus changing performance in the Permian will have a disproportionate effect on the trend in unconventional oil production overall.

In contrast the Bakken region may have passed its maximum production, so too the Niobarra and Eagle Ford. As production reaches its limits, such as in the Bakken[62], increased drilling would not produce the same change in the production trend – weakening the link between rig count and production response.

If we try to match changes in the drilling rig count to changes in production, even within individual fields, there is no constant relationship over time. There is long, and variable latency between changing drilling rig numbers and changing production of up to three years – as illustrated in the graph above.

There are small changes in the production trend roughly three years after changes in the drilling rig count, but the statistical relationship is weak due to other variable factors. The constant is that, over time, each change in the drilling rig trend results in a magnified change in the overall production trend.

As a result, it would be wrong to read a strong decline in unconventional oil production in the very near future, as a result of the recent decline in the rig count. Recent improvements in per-well production could account for the differing relationship between the drilling rig count and production levels over the last four years.

However, there is no doubt that such a decline is on its way, dependent upon the latency between changing rig numbers and production. The current peak in production is as likely be the result of the fall in rig numbers during late 2012/early 2013, as it is the very recent fall in rig numbers.

How production levels change will not be clear for at least six months. The recent steep reduction in rig counts may manifest itself as a sudden fall in production. Conversely the present peak my be the result of flattening rig numbers two years ago, combined with the peak production of some fields.

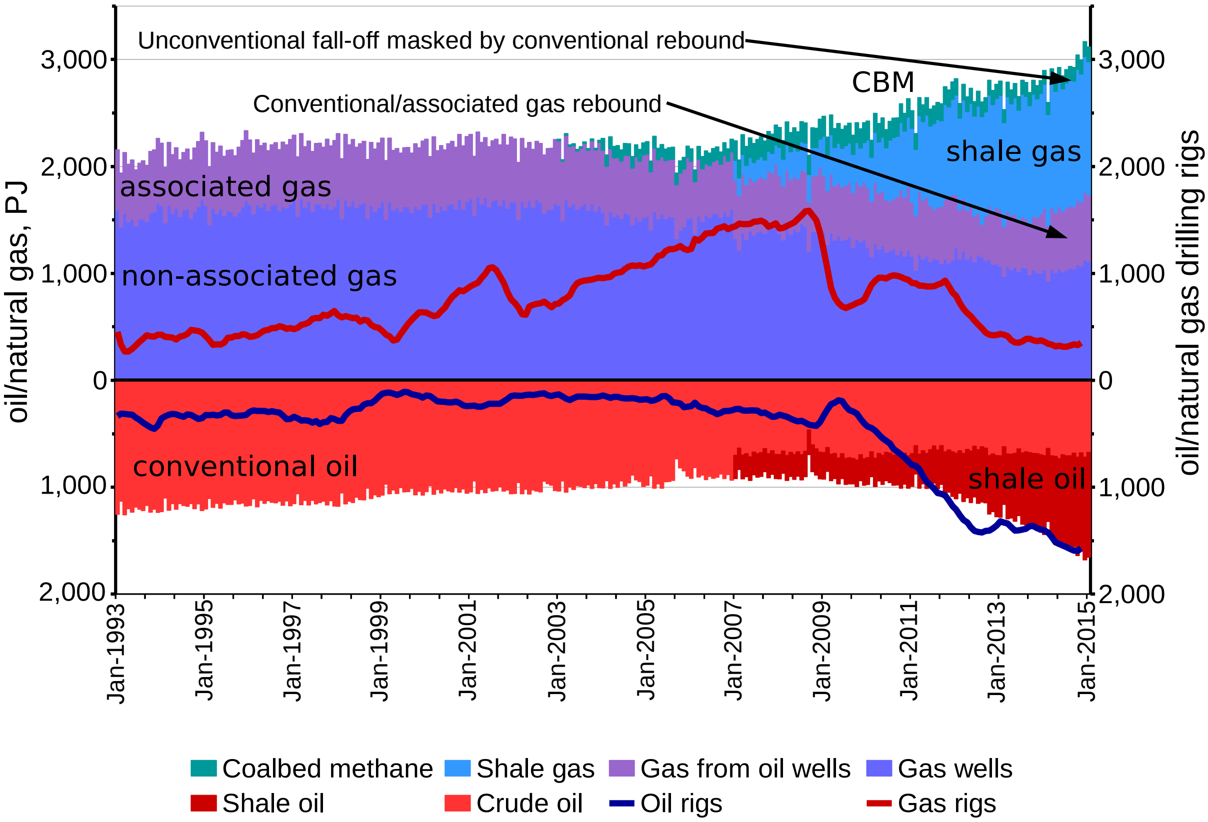
Therefore a significant decline due to recent falls may be 6 to 18 months away.

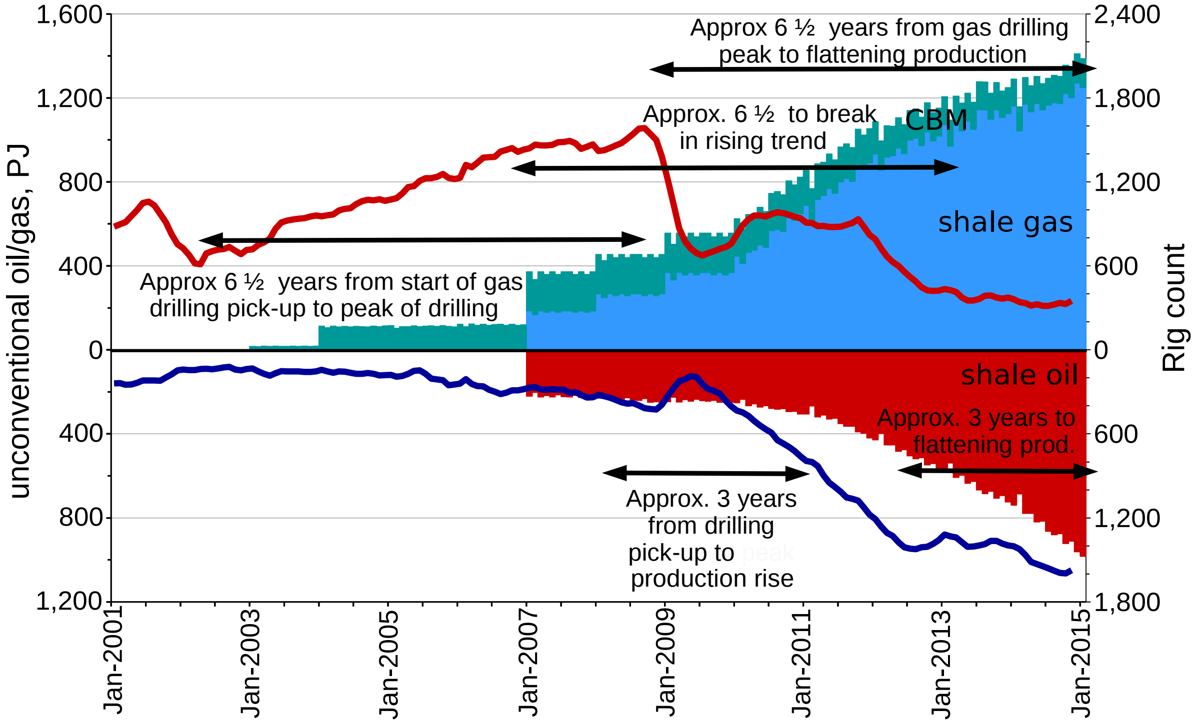
A broader view of US production data

The US consumes around 20% of the world's oil, and a similar quantity of gas (BP's 2014 statistics[63]). That is why changes in the US market have significant effects on the tight global market for oil and gas – affecting the rest of the world's consumers.

Thus far the analysis has focussed on US unconventional oil production. In practice the USA's oil consumption comes from a wider collection of domestic sources, as well as Mexican and Canadian imports – and the dynamics of this 'North American' market are critical to the global supply situation.

Graph 3a (upper) and 3b (lower). USEIA national oil and natural gas production data





These graphs have 'mirrored' axes. Natural gas production is shown above the '0' value of the Y-axis, and oil production is shown below. This allows the changing relationship between oil and gas production to be compared – for example, the re-tasking of drilling rigs from gas to oil production after 2009.

The upper graph shows conventional and unconventional oil and gas production; the lower only unconventional. This illustrates the relationship between the two production trends – in particular, how the upswing in conventional gas has hidden the slower growth in unconventional gas production.

In order to produce more meaningful information about US oil and gas production it is necessary to combine various low-level USEIA datasets:

- Field Production of Crude Oil[64];
- Crude Oil Rotary Rigs in Operation[65];
- Natural Gas Gross Withdrawals from Gas Wells[66];
- Natural Gas Gross Withdrawals from Oil Wells[67];
- Natural Gas Gross Withdrawals from Shale Gas[68];
- Natural Gas Gross Withdrawals from Coalbed Wells[69];
- Natural Gas Rotary Rigs in Operation[70];
- Natural Gas Gross Withdrawals[71].

Statistics from these datasets were merged into a spreadsheet for analysis[72], and then used to generate the graphs reproduced in this paper.

By merging these different data sources the substantive trends within US oil and gas production are revealed. These provide a contrasting narrative to the 'US shale energy revolution'[73] trumpeted by politicians and economists (especially by those who saw 'shale' as the antidote to peak oil theory).

There are a series of inter-relationships between oil and gas production. Oil wells often produce associated gas[74] – which may be captured for the market or, such as in North Dakota[75], flared because the economics do not support its capture and use.

Natural gas production also gives rise to natural gas condensate/liquids[76] (NGL) – light oils, with high concentrations of aromatic hydrocarbons, useful for the chemicals industry but not for transport fuels.

Crude oil statistics do not always differentiate between ordinary crude oil and condensate/NGL (for example, the BP dataset which is used later); likewise the natural gas statistics may contain some inconsistencies between associated, non-associated and unconventional gas production data.

The 'big picture' trends – *graph 3a*

The upper graph (3a) on the previous page shows a series of data from 1993 until the present.

Note that both graphs 3a and 3b have 'mirrored' axes to allow comparisons between oil and gas production. Natural gas production is shown above the '0' value of the Y-axis, and oil production is shown below.

Graph 3a illustrates the dominant long-term trends in US oil and gas production:

- US crude oil production peaked in 1970 – as predicted by M. King Hubbert's[77] peak oil projections made in 1956[78]. Though there has been a boost from Alaskan conventional oil production since the 1980s (not included in Hubbert's original projections), conventional oil production (the red block shown below the '0' line) is still tracking the predicted post-peak oil steady decline.
- Until 2007 tight and shale oil was aggregated with conventional oil – hence why it makes a sudden appearance in 2007 (the darker red block). This data shows, reflecting the data shown in graphs 1 and 2, how after a long period of slow change there was a steep upswing in unconventional production, driven by a large increase in oil drilling rigs.
- Natural gas is more complex:
  - Conventional 'non-associated gas' wells (the lower blue block above the '0' line) – which produce natural gas and some natural gas liquids – make up the bulk of historic production. Production has grown since the 1980s, but peaked around 2000/2001. It was trending down, but has shown a sharp upswing over the last 16 months.
  - Associated gas, produced from oil wells (the purple block) has a fairly constant trend – as expected, mirroring the change in conventional oil production.
- Unconventional gas production is split between two different sources:
  - Coalbed methane production (or CBM, the turquoise block) shows up in the USEIA statistics in the early 2000s, reaching a peak in the late 2000s. It has declined as investment has shifted into shale gas – which has a higher per-well productivity than coalbed methane.
  - Shale gas appears separately in the USEIA's data from 2007. It has grown consistently since, but the rate of increase began to weaken from late 2011/early 2012. The production trend is gradual flattening – driven in part by falling productivity[79] and the peaking of shale gas production[80].
- The latency within the unconventional oil drilling data, approximately 3 years, appears to be half that of natural gas, approximately 6 to 6½ years. However, the data is imprecise because of the delays which often occur between the drilling of wells and the installation of infrastructure to allow full-scale production to begin. The backlog of drilled but uncompleted wells varies with time, causing a mismatch between the rig count and production trends.
- The recent gas series data illustrates how the recent upswing in conventional non-associated gas production is masking the falling trend in unconventional gas production. This 'rebound' in production is in part due to the reallocation of finance from unconventional to conventional production.
- Finally, while there was an expansion of gas drilling in the early 2000s, since the 2008 crash the finance industry has shifted its attention to

shale oil. This can be seen in the correlation between the falling drilling rig count for gas, and the rising count for oil. Again, this change in emphasis reflects the changing dynamics of the North American oil and gas market – as well as the changing fortunes of the finance industry before and after the crash.

Unconventional trends – *graph 3b*

To determine the 'revolutionary' nature of unconventional gas and oil we need to consider the short-term trends in US production, and what is driving them:

The development of unconventional 'tight' and shale oil and gas has changed the apparent long-term trends in US energy production – for which reason it has been labelled 'revolutionary'[81].

However, does the underlying data support such a conclusion? Or, in the case made by its opponents, is unconventional gas and oil a short-term process driven by risky capital[82] – labelled by some a 'Ponzi Scheme'[83] – which must maintain a costly 'drilling treadmill'[84] in order to support continued production.

Graph 3b is similar to 3a except that it shows a shorter time interval, January 2001 to 2015, and only unconventional oil and gas data is shown.

The first thing to note are the early step changes in statistics – caused by the USEIA reclassifying production, progressively disaggregating 'unconventional' production data from the general conventional production figures.

The reclassification of production creates another problem with analysis of the data. Coherent data to model trends is not produced by USEIA until after January 2010 – which makes drawing accurate statistical trends difficult.

What we can say is that the decline in gas drilling six years ago is likely to manifest itself during the course of 2015 in falling unconventional gas production. At the same time, the fall-off in oil drilling two years ago is the likely cause of the present downturn in unconventional oil production.

While the recent reduction in oil drilling will have a serious impact on production, this may not manifest itself until late 2015 or 2016.

The combined effect of the oil and gas trend is likely to create a significant decrease in US energy production over the latter half of 2015, and certainly during 2016 – unless there is a turnaround in the economics of US unconventional oil and gas production in order to alleviate that trend.

Even so, the production response to renewed investment would not see increasing production for a number of years. That is because new investment would have to first overcome the inertia of falling production, created by the short productive life of unconventional wells, before it could begin to add 'new' production.

And of course, on the back of the short-term unconventional trends, the longer-term conventional trends are still in decline – and must be matched by new unconventional source to prevent an overall decline in production.

Consequently, due to the decline in gas drilling over the last six years, and oil drilling over the last two, the US faces an unavoidable decline in oil and gas production over the next year to three years.

The 'North American' oil system

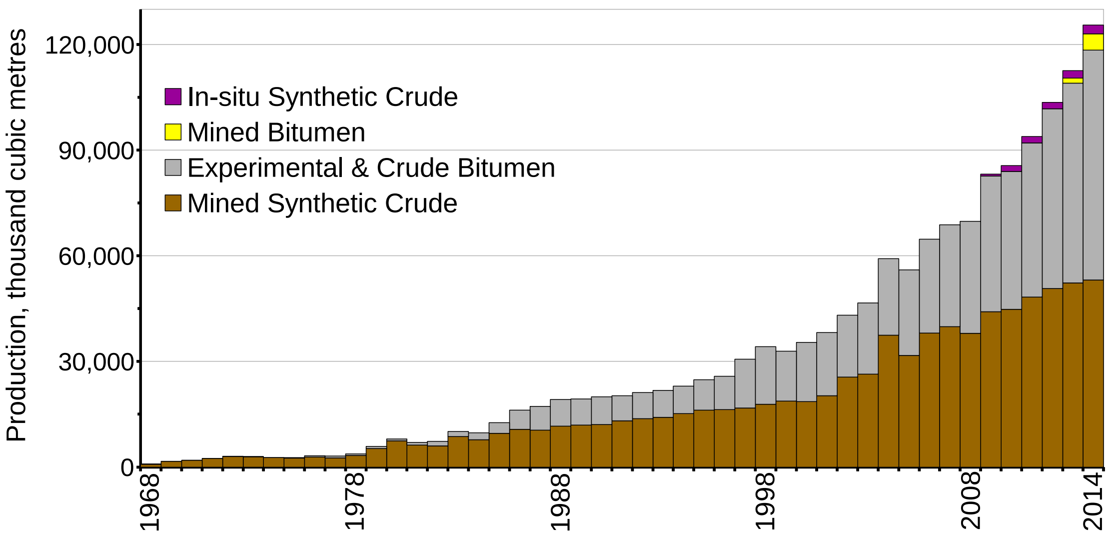
Globally the US is a major consumer of energy. However, when we see energy discussed in the USA it is often in the context of “North American” production – inclusive of Canada and Mexico – rather than just US indigenous production.

Right now that North American market is in flux – and arguably this has great implications for the global market.

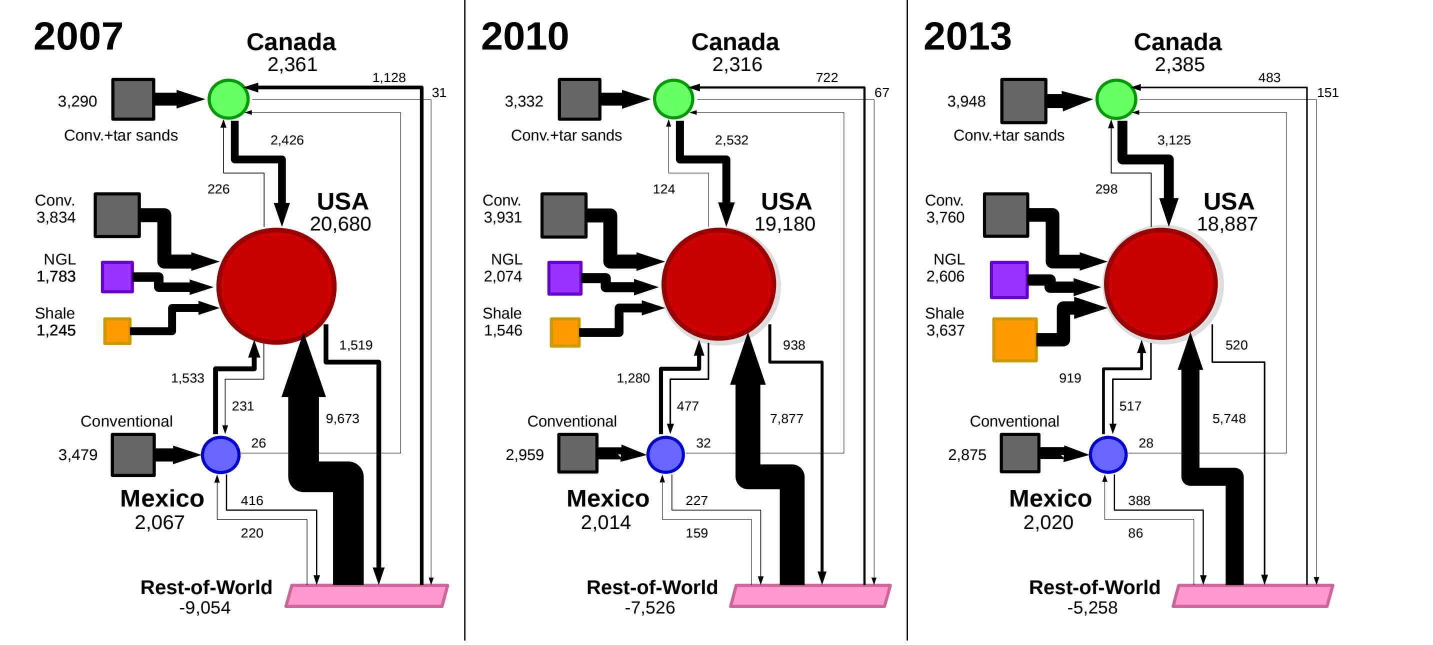
Much has been made of Canada's increasing

Graph 4. Canadian Unconventional Oil Production

This graph shows production from the different types of unconventional 'oil sand' recovery technology – from the physical mining of rock (mined syncrude), to the use of steam injection for heavy bitumen recovery (crude bitumen).



Figures 1a-1c. North American Oil Production and Flow Model



These graphics – created using the *'production'*, *'consumption'* and *'trade movements'* datasets from BP's annual statistical reviews of 2008 to 2014 – illustrate how North American oil production and transportation has changed over the last eight years.

The diagrams are drawn to scale – all figures are in thousands of barrels of oil per day.

The graphics show how Canada's increasing output has been balanced by Mexico's post-peak decline. The major impact on the global market is not just the increasing production of unconventional oil within the US, but also the near 10% fall in US consumption.

Falling unconventional production in the US and/or Canada will translate into greater global demand.

production[85] of unconventional oil – shown in graph 4 on the previous page. This began in the late 1960s, but received a large boost following the 1970s oil crisis, and the high oil prices of the 2000s.

Today the production of 'oil sands'[86] – where large volumes of minerals are physically mined with drag lines or excavators – is hitting its physical limits. This can be seen in the flattening of the production levels of 'mined syncrude'[87]. In contrast production of bitumen from the Athabasca region[88] is growing – using similarly energy intensive[89] methods to shale extraction[90], such as steam extraction[91].

Under current market conditions neither of these methods is economic – requiring a far higher oil price in order to reach break-even point[92]. That casts doubt on the ability of Canada's syncrude producers to maintain present supply, or increase production in future. Already projects are being shelved[93], and other investors have announced reductions in expenditure[94] within existing projects.

Canada's oil production has increased significantly, while its consumption has stayed fairly static. This has meant that most new production in Canada has gone south into the US market.

At the other end of the continent there are problems of a different kind. Mexico's conventional oil production peaked in 2003, and over the next few years it will enter the steep part of the post-peak depletion curve. In the meantime its national consumption has stayed fairly static. As a result, exports to the US have fallen for the last decade.

Neither Canada nor Mexico significantly import oil from the global market – both being roughly self-sufficient.

However, Mexico will have a problem over the next decade as its own production falls more steeply – shifting it from being a major global producer (peaking at about 5% of global production in the early 1980s) to become a significant net importer (currently consuming over 2% of global production).

In contrast to Mexico and Canada, from 2007 to 2013 US oil consumption has shrunk significantly as a result of the economic crash – down almost 10%. This 'missing growth' accounts for around a third of the value of unconventional oil production, and is arguably as significant in terms of its effect on the global oil market – alongside the decrease in consumption in Europe – as is the increase in unconventional oil production within the USA.

Overall then, what has happened in the North American market over the last eight years is that Mexico's post-peak contraction, and subsequent fall in exports to the US market, was almost exactly balanced by Canada's increasing exports to the US market. At the same American's falling domestic consumption, combined with the rising production of unconventional oil, has significantly reduced the importation of oil from outside North America.

Should US oil consumption rise, or US unconventional production fall, that will translate into a direct increase in global demand. At the same time any decrease in Canadian production, as this will fail to balance Mexico's continual fall in production, will translate into an additional call on global demand.

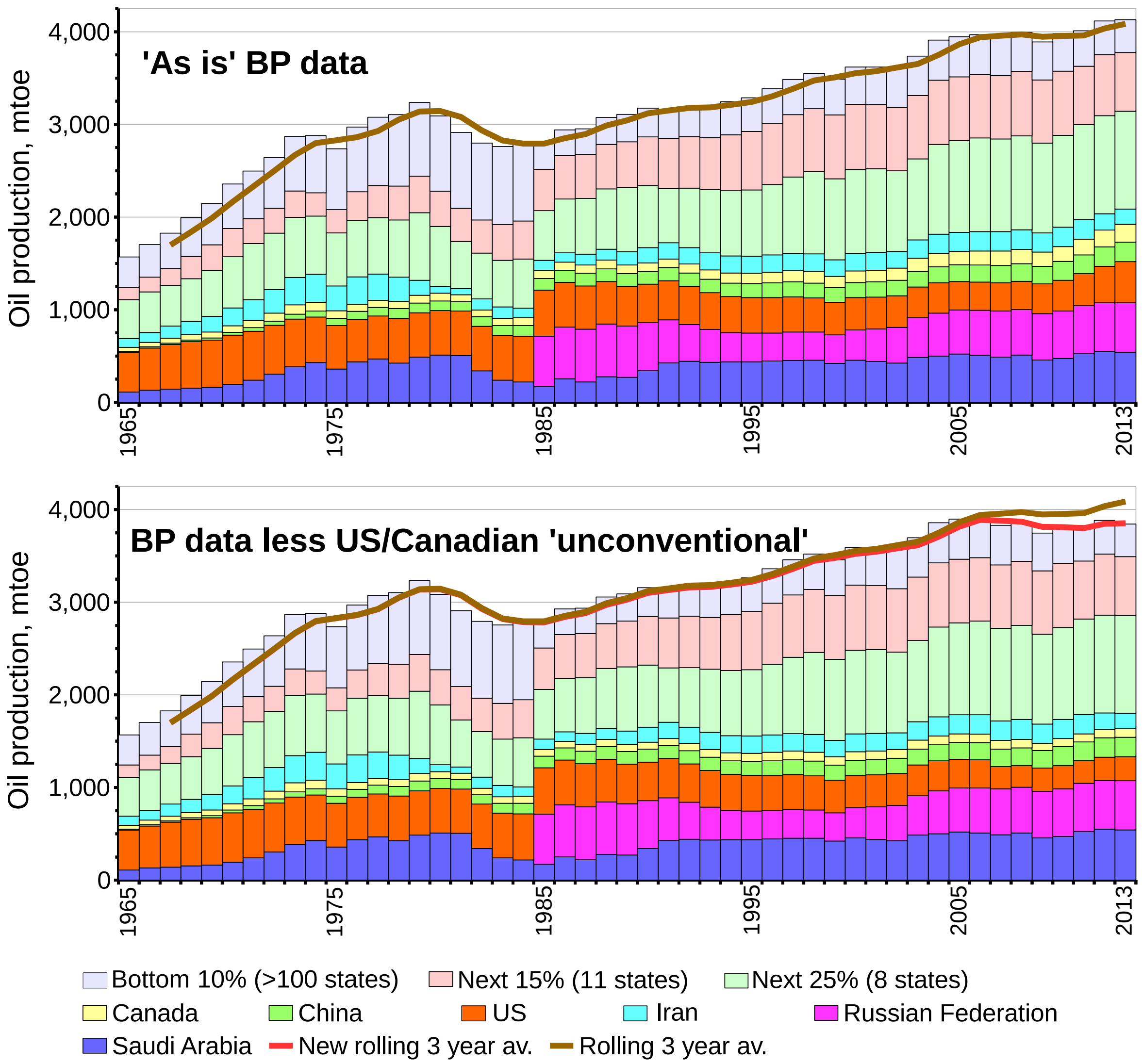
This has significant implications for the operation of the global market.

The global picture

There are three triggers, singularly or together, in North America which will increase global demand for oil: rising US consumption should an economic recovery arrive; falling Canadian production, or at the least the failure of Canada to cover Mexico's decline; and falling US unconventional production.

Relatively, what does this do to global demand?

Graph 5a (upper) and 5b (lower). BP data with/without US/Canadian unconventional oil



The top graph reproduces BP's global oil production dataset from the annual *Statistical Review*. The data for producing states has been grouped as follows:

- the six largest producers, who between them make up 50% of global production;
- the 'next 25%' of production (8 states – UAE, Iraq, Kuwait, Mexico, Venezuela, Nigeria, Brazil and Angola);
- the 'next 15%' of production (11 states – Qatar, Kazakhstan, Norway, Algeria, Colombia, Libya, Oman, Azerbaijan, Indonesia, India and UK); and
- the 'bottom 10%' of production (over 100 states, each producing relatively small amounts of oil).

This illustrates the reliance of global production on a small number of states.

In the bottom graph the unconventional oil production statistics for the USA and Canada have been subtracted from BP's annual totals. Arguably the cut should be larger as US unconventional gas production creates significant quantities of gas condensate/natural gas liquids – which are included in BP's statistics.

To illustrate the trend in the data a 3-year rolling average total is shown as a line at the top of the data. The line from the top graph is reproduced in the lower graph in order to illustrate the difference with the 'new 3-year average' due to unconventional oil production.

With their failure to cut production, OPEC announced that it was no longer willing to be the world's swing producer[95] of oil to ensure price stability. This renders a large proportion of the world's oil production uneconomic because OPEC has some of the lowest production prices.

Even if the price rises in future, that does not mean that global production will rise as other sources – such as unconventional oil – are priced back into the market.

Not only are the economics of unconventional oil suspect, and their impacts upon health[96] and the climate[97] uncertain, but an effective global climate deal in Paris in December 2015[98] would undoubtedly limit production[99] of the most polluting sources of oil – such as shale oil and oil sands.

The other significant factor is the accelerating depletion of the former major suppliers – such as Mexico, the North Sea and the other non-OPEC suppliers who came on stream from the 1980s. New unconventional production would have to match this increasing level of annual decline before global supply could increase overall.

The difficulty is that the fundamental characteristics of unconventional oil and gas production make matching the decline of conventional sources a harder engineering and financial problem.

On a per-well basis, unconventional sources of oil and gas are less productive than conventional production – which is the root of their higher cost, and higher levels of both carbon emissions and other polluting impacts. That requires a far higher expenditure of energy and resources to match the decline of convention sources from unconventional sources.

The graph on the previous page, using BP's data[100], shows global oil producers grouped by proportion of global oil production[101]. The top six producers, together producing 50% of global production in 2013, are shown individually. The next 25% of production, from 8 states, is shown as a single block, as are the next 15% (11 states) and bottom 10% (>100 states).

What is significant about this list is that:

- The USA and Canada are in the top 6 – and as discussed earlier, both have problems going forward maintaining oil production given their dependence upon unconventional sources;
- Also in the top 6, Iran peaked production in the 1970s, and has been affected by economic sanctions since;
- Of the 'next 25%', 3 of the 8 have peaked (Angola, 2008; Mexico, 2003; and Venezuela, 1970), and Iraq is in civil crisis;
- Of the 'next 15%', 6 of 11 have peaked (Norway, 2001; Algeria, 2006; Libya, 1970; Azerbaijan, 2010; Indonesia, 1991; and UK, 1999);
- The 'bottom 10%' block peaked in the 1980s, and has been falling for the last decade.

Taking BP's data and subtracting the unconventional production from the US and Canada produces a change in the global trend. As shown in graph 5b, indicated by the difference between the brown (*BP data*) line and red (*BP data less unconventional*) lines, conventional oil production peaked around 2006, and has been very slowly trending down since.

Now take that list of the oil producing nations who have peaked: 75% of global oil production centres on just 14 states, and roughly two fifths of those states (totalling about 30% of global production) have peaked. As a result conventional supply is unlikely to rise in future – at best continuing the plateau in production of the last decade.

How this plays out is again price dependent – as this governs the employment of 'enhanced oil recovery'[102] techniques which are able to maintain supply for a slightly longer period.

Peak supply, or peak demand?

The issue regarding the ability of unconventional oil production to avert peak oil is not simply a matter of problematic supply.

There is an argument emerging[103] from ecological economics[104] that the recent low levels of economic growth is not just an issue of bad credit[105] – it is inextricably linked[106] to high resource and energy prices[107]. That in turn relates to the lower energy and financial returns[108] (EROEI) of the alternative supply options[109] to replace conventional fossil fuels. Therefore economic growth is unlikely to rise strongly as the lower returns of these alternatives inevitably reduce growth.

Recent low prices are arguably the result of low growth depressing demand – the result of continuing economic stagnation in Europe[110] and the downturn in China[111]. And due to the continuing tight supply situation – driven by peaking conventional production and now the downturn in unconventional production – any future upturn would test the present production limits, causing prices to spike once more.

This is the 'cleft stick' within today's global energy supply: too little 'cheap energy'[112] to enable economic growth, too low a return[113] on investment to allow investment in higher production.

In terms of a definition of 'peak oil' which encompasses both its economic and geophysical nature – this is a situation which demonstrates the reality of oil's ecological limits.

However, that is not how the energy economics lobby see this issue.

In response to peak oil theory, neoliberal analysts have evolved a theory of *'peak demand'*[114]. Again we see the names of Daniel Yergin and CERA[115] associated with this concept. Practically, the difference between 'peak oil production' and 'peak oil demand' is a matter of how we interpret the trend of high prices and stalling oil demand.

As stated at the beginning, the basis of peak oil does embodies a strong economic component as well as geophysics. In contrast, what 'peak demand' does is steer the debate away from the concept of 'ecological limits' influencing the market – such as the geophysics of oil production – back towards the idea of technological innovation curtailing demand.

Peak demand states that oil supply will not be limited[116] by physical restrictions on production, but rather we'll just stop wanting to consume it. The root of this claim is: the advocacy of far higher technological efficiency – in particular, road vehicles; and that oil demand will become more "elastic" – that is, people will cut consumption in response to higher prices.

Question is, in response to less demand, where do the higher prices – creating this greater 'elasticity' and driving more efficient technologies – come from?

Why were prices high before the 2008 crash? – because of rising demand for oil and the limitations on production. Have unconventional sources solved that? Clearly not because they are not sustainable – physically, economically or environmentally.

'Peak demand' seeks to reconcile the problems with oil supply and consumption without recourse to ecological limits. That is why it does not stand up when we look at what is driving those trends[117] – *the impact of limits, not just economy and technology*.

Just as the "peak oil is dead" argument sought to counteract the discussion of the limits to oil supply, so 'peak demand' seeks to provide an alternative explanation for current trends. The unfortunate problem for the proponents of this theory is causality – *what initiates the price and demand cycle?*

'Peak demand' cannot explain the causes of current trends because it cannot explain what drives higher prices or lower economic returns without recourse to geological constraints. In contrast, ecological economics, which internalises both the changing quantity and quality of energy supply, can provide a mechanism to explain current trends.

Conclusion and prognosis – *peak oil is here*

The problems of unconventional oil production are not simply technical or geophysical.

If we look at the North American market, the collapse of US energy demand is as significant as the upswing in unconventional production. The key role of Canada's rising unconventional production has not been to augment supply, but to offset the Mexico's post-peak decline.

What's more, if we look at the US experience, after less than two decades of intensive exploitation they are already beginning to hit the limits to production. This negates the claim that unconventional fossil fuels, enabled by new technologies such as horizontal drilling, has the capacity to overcome ecological limits such as 'peak oil'.

Thus far, the growth of unconventional fossil fuels has been enabled by the easy finance created by near to zero interest rates and quantitative easing – and prior to that the lax standards of Wall Street's credit market. This has resulted in an industry which has poor economic returns a high level of 'junk' debt.

The challenging economics of low prices today, or if interest rates were to rise significantly in the future constricting the money supply, would not allow a repeat of that process again.

Arguably the lobby against peak oil is largely ideological – basing its opposition not on evidence, but on a reactionary objection to any concept which challenges neoliberal economic theory.

Any substantive theory must be able to explain both statistical trends based on observed data, and the causation of the conditions creating those trends. The ideological opposition to 'peak oil' – notably the theory of 'peak demand' – cannot do that.

'Limits to growth'[118] were at the heart of classical economics; the politicization of economics in the latter half of the Twentieth Century expunged these ideas[119] from the canon of their philosophy – replacing it with assumptions based upon abstract ideas about society not based within physical laws.

The recent emphasis on 'economic growth', above all other metrics, skews the political debate – avoiding any discussion of the demonstrable ecological limits to the functioning of human society[120].

If we look at the statistical evidence, the role of unconventional gas and oil as the 'saviour' of economics from peak oil is a forlorn hope. It's not just that ideas such as 'peak demand' do not work when we look at recent trends; the actual data on oil and gas production, explored in this paper, show these theories to be false.

In reality, when we look at global oil production, we see is a series of trends which meet the geological criteria for 'peak oil' – oil production in a field rises, reaches a peak, and then falls, and this roughly correlates to a common statistical distribution which defines it. More broadly than that, recent trends demonstrate that peak oil is a process with an inter-related economic and geophysical component, which combine to limit oil production.

When we combine those individual local peaks – such as Mexico, the USA's conventional production, or the North Sea – what we see is a shifting profile of global production; from one dominated by growth to one increasingly dominated by contraction.

'Conventional' oil production has peaked[121]. Over the last decade, unconventional oil production has masked that fact; but as unconventional production collapses, so the peak oil trend will reassert itself on the market – repeating the commodity price and economic feedback cycles which have previously destabilized the operation[122] of the economy.

What we need is not a new source of energy – we need a new economic philosophy[123] based upon a realisation that ecological limits[124] are here to stay[125]. That's an uncomfortable concept for many in government – but that is the reality of what the available data describes today. The demonstrable peak in oil production is a sign that this transition needs to begin immediately.

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