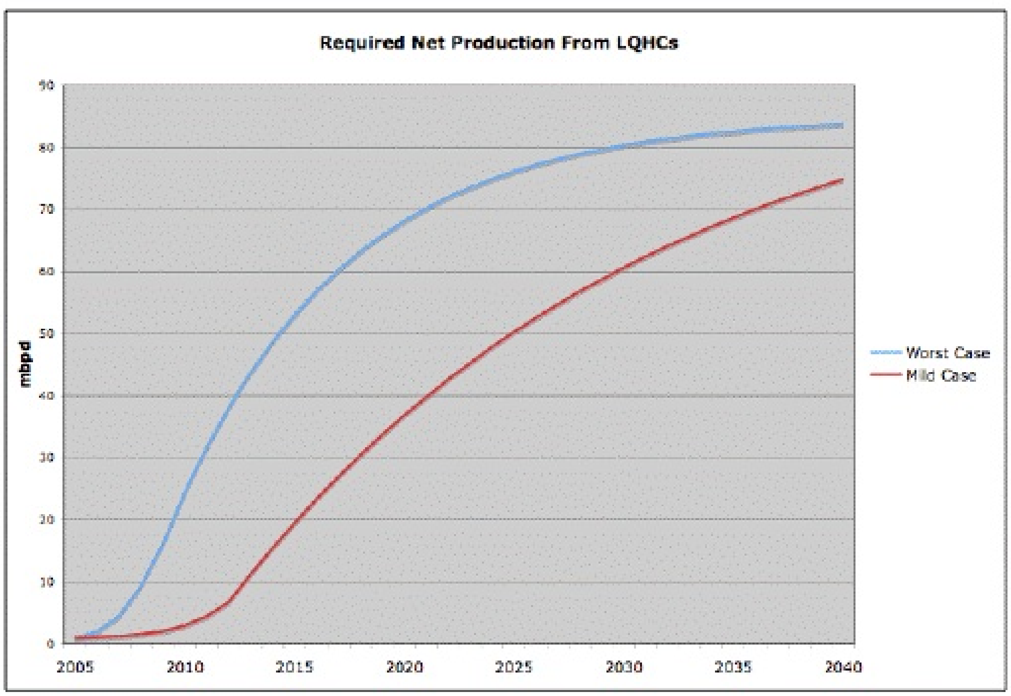
On Low Quality Hydrocarbons (Part I)

Posted by Stuart Staniford on September 22, 2005 - 12:49am
Topic: Supply/Production

As most of us here know, the planet offers extremely large amounts of low quality hydrocarbons (LQHCs) that could, in principle, be converted to synthetic crude to displace conventional oil as it depletes. The major sources are tar sands (especially in Alberta), oil shale (especially in Colorado), and extra-heavy oil which will not flow readily (especially in the Orinoco region of Venezuela). Then there is also the possibility of converting coal to liquid hydrocarbons via the Fischer-Tropsch process.

Many peak-oil sceptics believe these resources will save our high-acceleration gasoline-powered lifestyle. In this two part series, I'll look at some models of how such a transition might occur.



Several of these LQHC processes have been commercially demonstrated. Canadian oil sands are in production today to the tune of about 1 million barrels per day. Venezualan heavy oil has been sold as an electricity feedstock (in the form of an emulsion with water called Orimulsion) and about 600,000 mbpd of upgraded crude is being produced (I've seen varying numbers here). Coal was converted to fuel by the Germans during WWII, and by the South Africans during the sanctions regime. Oil shale has not been commercially developed in the US, but there's been some production elsewhere in the past, and apparently, Shell is having some luck with a pilot in-situ process (which does not require water - the main scalability curse of prior schemes). More projects are being contemplated.

Although all of these resources differ in exactly how they are obtained, they are similar in that they are much more expensive to extract - requiring lots of capital, energy input, etc, to produce a useful output. One measure of this is the EROEI - the energy return on energy invested - how much energy you have to put in to to extract and make usable a resource versus how much you get out. In the early years of conventional oil, EROEI was often over 50. These days it's probably in the low teens (10-12). EROEI on LQHCs tends to be around 3.

However, the total amount of these resources is at least as big as the world's endowment of conventional oil, perhaps significantly bigger depending on eventual recovery rates. Canada has nearly 2 trillion barrels of tar in the tar sands, though only 300GB are currently viewed as recoverable, Venezuela has 1.4 trillion barrels of extra heavy oil, though recovery rates are unlikely to ever exceed 20%. Colorado has entire mountains of oil shale. The governor of Montana has argued that Montana has enough coal to provide the US with all the syncrude it needs for 40 years.

Folks who are sceptical that peak oil will be a significant problem are fond of pointing to these resources. For example, a Hubbert linearization analysis makes it fairly clear that CERA is relying on these resources to support its optimistic view that peak oil production will be a bumpy plateau several decades long. On the less thoughtful end, Marshall Brain used them to argue oil depletion would not be a problem.

Alternatively, folks who are very concerned about peak oil tend to discount these resources. Deffeyes in his book *Beyond Oil* says:

> As the Middle East swings into its decline phase, a rapid and enormous investment in tar-sand facilities would be required. In my opinion, the preliminary steps to acquire government permits, investment capital, and construction capability are not going forward on a scale large enough to postpone the Hubbert Peak.

Hirsch argues that coal-to-liquids will be the dominant mode of adaptation for vehicular transport post peak, but that we need to start work on it twenty years in advance of conventional oil peak to avoid a significant liquid fuels crisis. We probably didn't start twenty years in advance.

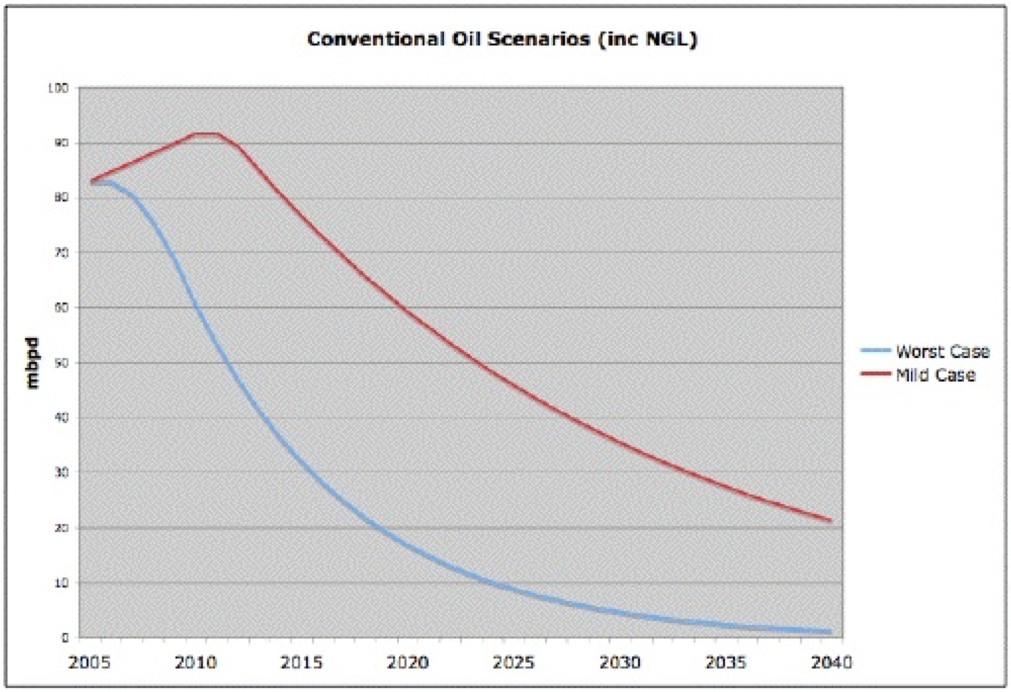
I have argued elsewhere that the main variable controlling our ability to adapt to peak oil is the post-peak depletion rate. Gentle depletion (a few percent a year) give us time to develop and deploy conservation technologies, better electric cars, more nuclear and renewable electricity generation, etc. On the other hand, rapid depletion means we will be running out of liquid fuels faster than we can develop these alternatives and will be in a world of hurt. I deliberately defined the depletion rate there to be inclusive of LQHCs, since you can't tell the difference when you pump it into your tank at the gas station.

Now clearly, the depletion rate of conventional oil is moderated by the ramp-up in production of LQHCs. If LQHCs could be ramped up fast enough they could fully offset depletion, and maybe even allow continued growth in liquid fuel use (with some non-trivial climatic consequences). If not, then we indeed have a bad problem.

The arguments for saying we have a bad problem tend to be threefold. One comes from looking at the relatively modest expansion plans of the industry right now and arguing they aren't sufficient to offset depletion in conventional crude, either because peak is coming soon, or because we extrapolate that the industry in future won't be able to expand much faster than it is at present. The second argument comes from looking at the poor EROEI of these fuels and suggesting this fundamentally limits the ability to grow the usage of these fuels. And the third issue is the climate implications of burning all that gunk.

Let's dig into the problem in more detail with a little scenario analysis.

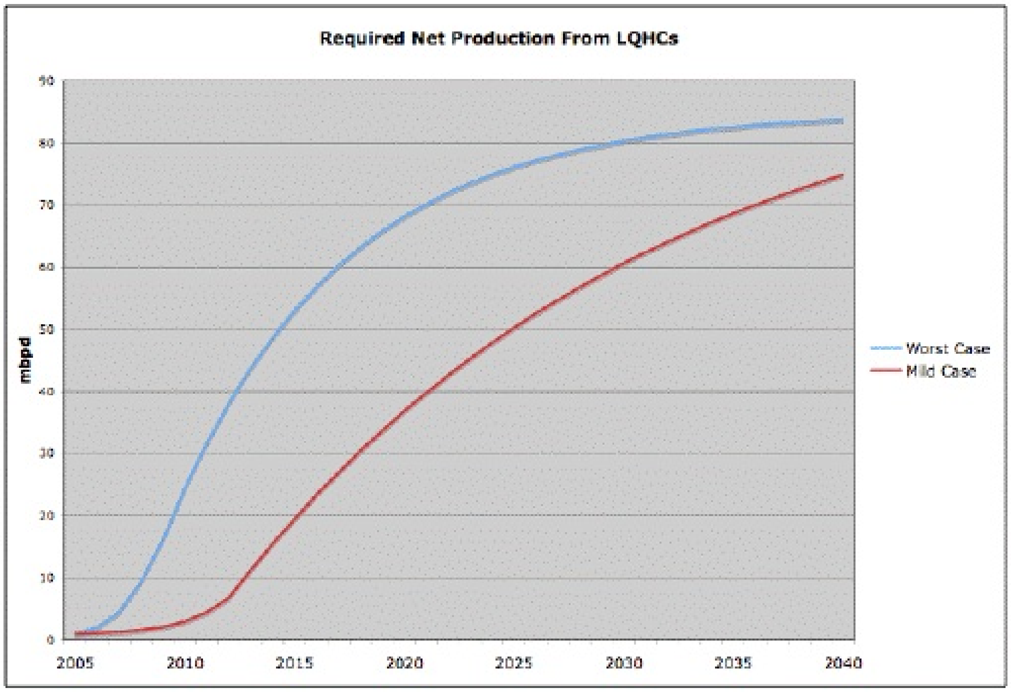
The situation today is that conventional oil production (including NGL but excluding LQHCs) is around 83mbpd (depending on whose production statistics you like), while production from LQHCs is around 1.6mbpd. (1mpbd from tar sands and about 600,000 mbpd from Venezuelan extra-heavy oil). We're going to take two scenarios for conventional oil production.



Our worst case scenario is that it's peak now (as Deffeyes has argued, and as the absence of any worldwide spare capacity might suggest), and that annual depletion will go 3% in 2007, 6% in 2008, 9% in 2009, and then consistently 12% after that. Ie the whole world is going to start behaving like the North Sea (which has started depleting at 10-15% annually).

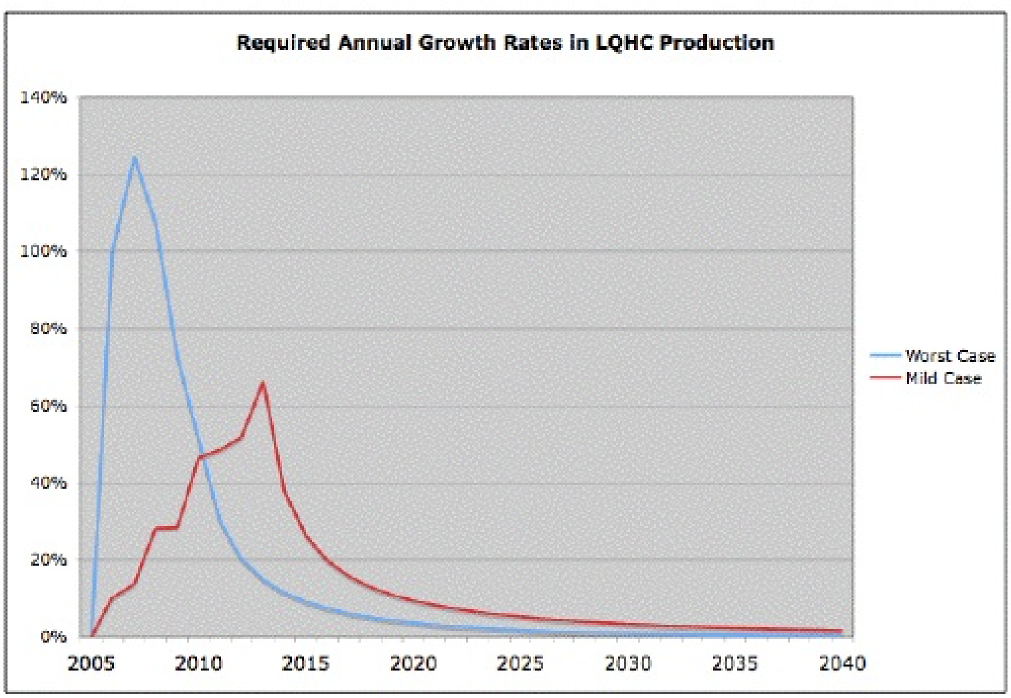
My mild case assumes that CERA is right that a bunch of new deep water projects will allow production to grow at 2% annually until 2010, and then depletion will set in, rising quickly to a sustained rate of 5% annually.

I believe the truth will lie somewhere between these two scenarios, but I wouldn't like to try to pin it down too exactly just yet.



Now, if we would like post-peak total hydrocarbon fuel to be flat, instead of declining, the balance is going to have to be made up from the LQHCs. Just above are the LQHC production numbers needed to do that under the two scenarios. Note that these are *net* numbers (ie *after* whatever must be burned just in getting the stuff out of the ground and into a usable form). These numbers are whatever we can actually pump in the pipeline from Canada or Colorado or put into a a tanker in Venezuala. I also stress this is what is required to get **flat** global production. Not flat production per-capita, and certainly not business-as-usual 2% annual liquid fuels growth post conventional oil peak.

On the face of it, these graphs don't seem outrageous given the enormous size of the resource. But there's a problem, which I would like to christen the **Hirsch gap** in honor of the lead author on the Hirsch report.



The problem is clear in the graph above which looks at the approximate annual growth in LQHC net production required to balance the depleting conventional oil. You can see the growth rates needed are astronomical, even under the mild scenario. The problem is that when you have a really big production stream (conventional oil), and a little tiny production stream (LQHCs), it takes very large growth rates in the latter to compensate for even modest depletion rates in the former. Are these outlandish looking growth rates likely to be feasible?

This is why Hirsch thinks we needed to have started adapting twenty years prior to peak - to avoid having to grow LQHCs that fast (or experience the consequences of failing to do so). The problem ameliorates over time as the LQHCs become the dominant source of production and don't need to grow that fast to compensate for the depletion in the little remaining crude production.

In the second part of the series we'll look at physical restrictions on how fast poor-EROEI fuel production can grow, how the required rates compare to industry's current plans, and the CO_2 implications of using LQHCs.