The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

4%, 11%, Who the Hell Cares?

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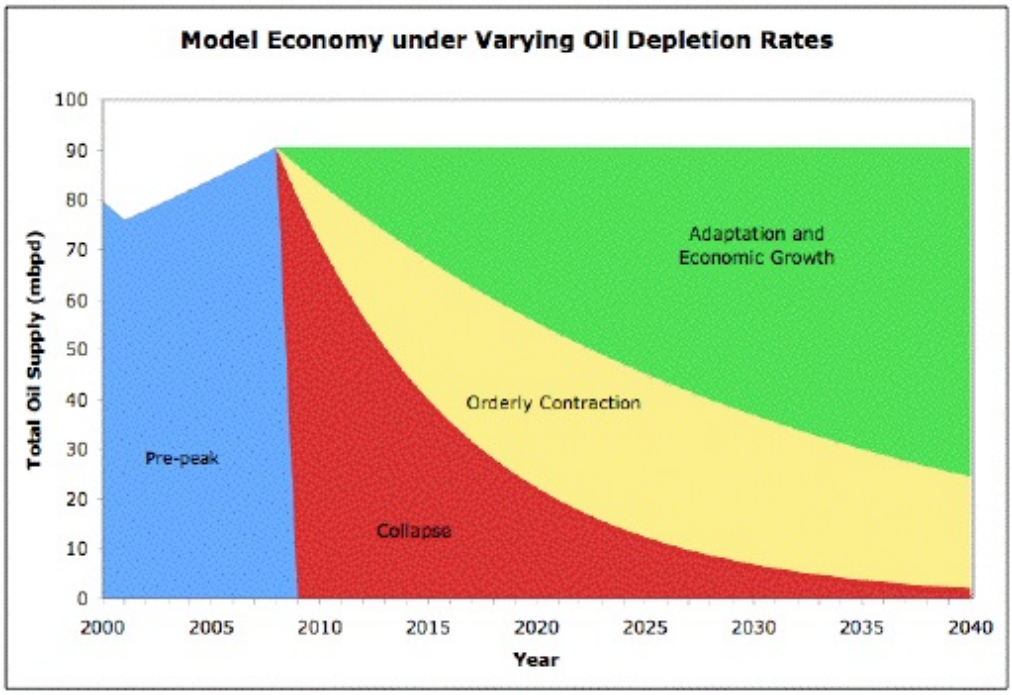
Who cares about the depletion rate? It's some small fussy number that we don't know, right? Peak Oil is PEAK OIL! Once we hit the peak *all bets are off*.

Wrong, I say. Once we are post-peak, the depletion rate is going to be the single most important variable by far. I argue it controls whether peak oil is minor unpleasantness, or Overshoot-style die-off. If we understand these issues, I think it can help to clarify exactly why one might choose to live at one or other end of the peak-oil spectrum - complacency or panic.



Technorati Tags: peak oil, oil

I'm going to argue that there are three rough regimes that we can distinguish. If the depletion rate is below the **contraction threshold**, then the economy can continue to grow despite depletion (green zone above). If depletion goes above this threshold, then we will have sustained economic contraction, but still in a mostly orderly manner (yellow zone). Finally, I argue there's a **collapse threshold** - if the depletion rate goes above *this* for a sustained period of time, then society will not be able to adjust and will go into collapse (red zone) until some new form of society can be constructed from the ashes of the old (much as happened to the Soviet Union, the Mayans, the Roman Empire, and Easter Island in various guises).

The picture assumes a near-term 2.5% annual growth in all-source, quality weighted, liquid

hydrocarbon supply. This culminates in a peak in 2008, for the sake of illustration, followed by various depletion regimes. The boundary between the green zone and the yellow zone is constant 4% depletion (my estimate of the US contraction threshold). The boundary between the yellow and the red is constant 11% depletion (my guess at the collapse threshold).

Of course, I'm not saying I know the date of peak oil, or that the true curve of supply is going to be neat and constant depletion as shown here. There could very well be a bumpy peak, and there's likely to be a somewhat fluctuating fall that starts off slow and then speeds up. It will probably be punctuated by various kinds of shocks induced by conflict, hurricane, or earthquake. Nor am I saying there are absolutely hard lines between the varying regimes of adaptation, contraction, and collapse. I don't exclude scenarios where society lives in one zone for a while and then crosses into another. What I'm proposing here is a a very idealized and simplified view, but I think it helps us gain greater insight into the basic dynamics of a post-peak economy.

The Contraction Threshold

As a rough approximation, good to 10% or so, the following things are true of the US economy:

- All transportation runs on oil
- The economy is entirely about the creation and use of material goods.
- All material goods are transported from creator to user via oil-powered transport
- Everyone gets to work by oil.
- Oil is not used to power making stuff, electricity is (ie coal, nuclear, hydro, natural gas).

Ok, ok, I'm simplifying - there's electric trains. There's software downloads. There's petrochemicals. There are natural gas powered vehical fleets. I'm sure some stores are right next to some factories. But basically, 2/3 of the economy is consumer spending and most households spend the great bulk of their budget on *stuff* - houses, cars, food, etc. Only a small portion is going into downloaded software, Internet service, and other primarily intangible goods. And the other third is businesses, and they're mainly buying tangible stuff too. And all that stuff is getting moved by oil, as Ianqui reminded us the other week. Not only that, the raw materials used to make the finished goods are also being moved by oil. And the labor to make the stuff is getting to work in oil powered vehicles.

So, since if goods can't be moved there's no point in making them, the simplest possible model of the oil economy is that GDP is directly proportional to oil usage. More GDP means more oil usage, and if oil supply shrinks, GDP shrinks proportionately. I think this model is probably correct to first order on short time scales (months to a year or two). If this model were absolutely true, then with an oil depletion rate of X%, we would have X% annual economic contraction.

However, by now, the free market economists are champing at the bit and Schumpeter is spinning in his grave. Adaptation, substitution, creative destruction, they cry. Yes, yes, and yes. Up to a point. We can replace oil with coal or natural gas. We can switch to plugin hybrids. But only so fast. And that switching speed is what sets the contraction threshold - which by definition is the amount of oil depletion required to make economic growth be zero.

The nice thing is, there's data that will allow us to get somewhere at estimating the contraction threshold, at least very roughly. The excellent Transportation Energy Data Book, on page 3 reveals that the average increase in the size of the US vehicle fleet is 3.6% from 1992 to 2002. Since this corresponds fairly well with the 3.2% average increase in real GDP over the same period, our approximate "GDP is proportional to oil usage" in the short term is not looking too

wrong.

Now page 9 reveals that the average age of a car on the road is 9 years, and a truck is 7.9 years. Let's split the difference and say the average age is 8.5 years, and thus about 70/8.5 = 8.2% per year of them per year are new - about 3.6% being growth, and about 4.6% being fleet replacement. I'm going to assume that in a somewhat but not horrendously stressed zero growth economy, people buy the same number of cars, but they buy smaller much more efficient vehicles. I'm going to assume the fleet stops growing, and the full 8.2% goes into replacement.

Now, what gets replaced with what? I'm going to assume that the best that can be done is to replace vehicles with ones that are twice as efficient. Eg, in the near term, that corresponds with replacing a 27.5mpg CAFE average passenger car, with a 55mpg Toyota Prius. In a decade or so, we'd need to be replacing Prius's with 110mpg plug-in hybrid hypercars, but that seems long enough for the auto companies to get with that program (or go out of business in some cases). Obviously, the factor 2 is an approximation. Hypercars might very well become available sooner, but also some people could afford to keep guzzling away in big conventional SUV's and would do exactly that. Let's assume those effects wash out to the factor 2 overall.

The situation with trucks is probably roughly similar. Semi-truck fuel efficiency can be about doubled by cleaning up their aerodynamics, and beyond that we'd be moving increasingly to railroads to get the next doubling in energy efficiency (which would require significant investment in the decayed railroad infrastructure).

There are a whole pile of second order effects which we will proceed to assume are smaller and roughly cancel each other out. These include:

- People might try to use their vehicles more efficiently. However, this basically requires rearranging the the building stock (or at least the use of it), which is extremely long lived (decades) and has been sprawling as average household size has gone down and population has gone up. We assume zero economic growth is only enough to arrest these trends, not reverse them.
- More economically inefficient uses of oil might be eliminated first. It's true that low income households (ie ones that don't create much value in an economic sense) will have to conserve more. However, it's also true that high income households use a lot of gasoline for purpose that have no economic significance and would not stop. We'll assume these effects cancel.
- Electricity might be substituted for oil to some degree. This can only happen slowly since the lifetime of the electricity generating equipment is extremely long (decades), and we assume it just helps us to make that factor of 2 average reduction when we replace a vehicle.
- People could telecommute. But telecommuting has been an option for a decade at least, and hasn't reached much penetration, presumably for good reason. I assume zero economic growth is not enough to radically change this picture.

So my rough estimate of the contraction threshold - the depletion rate in total liquid fuels that will result in zero economic growth is 8.2%/2, or **four percent**, to good enough precision here.

The Collapse Threshold

The reasoning about collapse is going to be a bit fuzzier. In fact my estimate of the collapse threshold is going to be what we scientists know by the technical term SWAG (scientific wild-

assed guess). But I think I have something to offer in the way of insight on the dynamics of collapse. I define the collapse threshold to be the depletion rate at which society collectively loses enough faith in the future that they are no longer willing to risk investments to preserve that future. This appears to be one of the fundamental characteristics in past societies that collapsed. The Easter Islanders gave up their intensive rock gardens, the Chaco Canyon people stopped building new Great Houses, the Mayans even stopped keeping track of their Long Calendar. (See Jared Diamond's excellent book *Collapse*, or Joseph Tainter's slightly more academic but also excellent *The Collapse of Complex Societies* for more detail.)

In our case, consider a potential investor in a company that is raising capital to open a lead mine to make batteries for anticipated future demand for plug-in hybrids. Let's say it takes five years to get the thing producing, and then the initial capital will take five more years to repay before it starts to really make money. So this investor has to believe society will hold together well enough over that time for his investment to really be worth it. Otherwise he's investing in gold instead (or vodka!).

Obviously, if our hypothetical investors do not feel enough confidence to make this investment, now society is in real trouble - the batteries needed to power the plugin hybrids are not going to be there when they are needed. And so on, across a thousand similar decisions across the economy.

Not only that, but the point at which wealthy investors are giving up hope about the future is also probably similar to the point at which the rest of society gives up hope too, and starts looking for alternative ways to survive. One of the leading effects of that is likely to be a loss of law-and-order. Things go downhill very rapidly from there as we have seen in the last week in New Orleans. We also know conflict was a major factor in the decline of Easter Island, Rome, and the Chaco Canyon Anasazi. Human beings can turn into bands of looters, and even cannibals (as at Chaco Canyon), with amazing speed once they lose faith in society.

I don't really know how to estimate this threshold with precision. But I note that each percentage point of depletion over and above the 4% contraction threshold results in a percentage point of annual economic contraction. By that reason, 11% oil depletion is 7% annual economic contraction which is halving the economy in a decade. That would sure scare the hell out of me from making any investments in anything except fruit trees and vegetable gardens. So my SWAG is the collapse threshold is **eleven percent** oil depletion.

Remember, I defined that depletion rate to be the depletion in all-source liquid fuels, quality-weighted (ie after we've included whatever can be gotten from slowly ramping up oil sands, coal-to-liquids, etc, but discounted by the increasing mix of less useful heavier sourer oils).

Summing It Up

I stress that I know all of this is a crude approximation. I'm not claiming my numbers are any more than rough guides to the general neighborhood. But I hope it helps us move the debate forward. I think the hoariest die-off proponent would have to agree that evil earth-destroying capitalism could probably adapt for quite some time if depletion was only 1% a year. I think even Julian Simon would have had a hard time arguing that human ingenuity could overcome 50% annual depletion in oil supply. I think since we've survived oil-shock induced recessions in the past, it's clear there must be some survivable middle zone of modest contraction.

So given the zones must exist, now we're just arguing about the numbers. The peak-oil-is-a-non-

issue crowd need to either argue that depletion will be slow (which is an argument that kind of needs to be based in geology and reservoir engineering), or that the contraction threshold is high (in which case they need to explain how the relevant infrastructure could be turned over much faster than today under conditions of economic stress.

Alternatively, die-off types need to explain either why the total depletion rate will be very high, or that the collapse threshold is low (society will lose the confidence to invest in the future even at depletion rates that are quite modest).

I'll offer my own best guesses for the depletion rate in a future post, but in the meantime, let the debate begin!