SUMMARY

Abstract

This paper discusses a range of serious issues on Energy availability and the efficiency of obtaining Energy resources. It questions whether declining efficiency in extracting Energy resources (EROEI) could present and Event Horizon where fossil fuels become a limit on how far the transition to Renewable Energy can go.

The Energy Predicament

Setting aside the 2012 oil price crisis, the Energy Predicament is a problem that has been ignored for too long. The world faces major energy challenges:

- The age of easy oil is is over - and many experts predict that oil production is about to reach a maximum, followed by inexorable decline, Peak Oil: *Expect a market failure, soon, where higher, volatile oil prices interact and become a ceiling on economic growth.*

- Competition, speculation or even conflict over the remaining energy resources needed to satisfy growth and rising standards of living in developing economies: *An increasing global scramble resources, first for for oil, in a market which may cease to operate freely.*

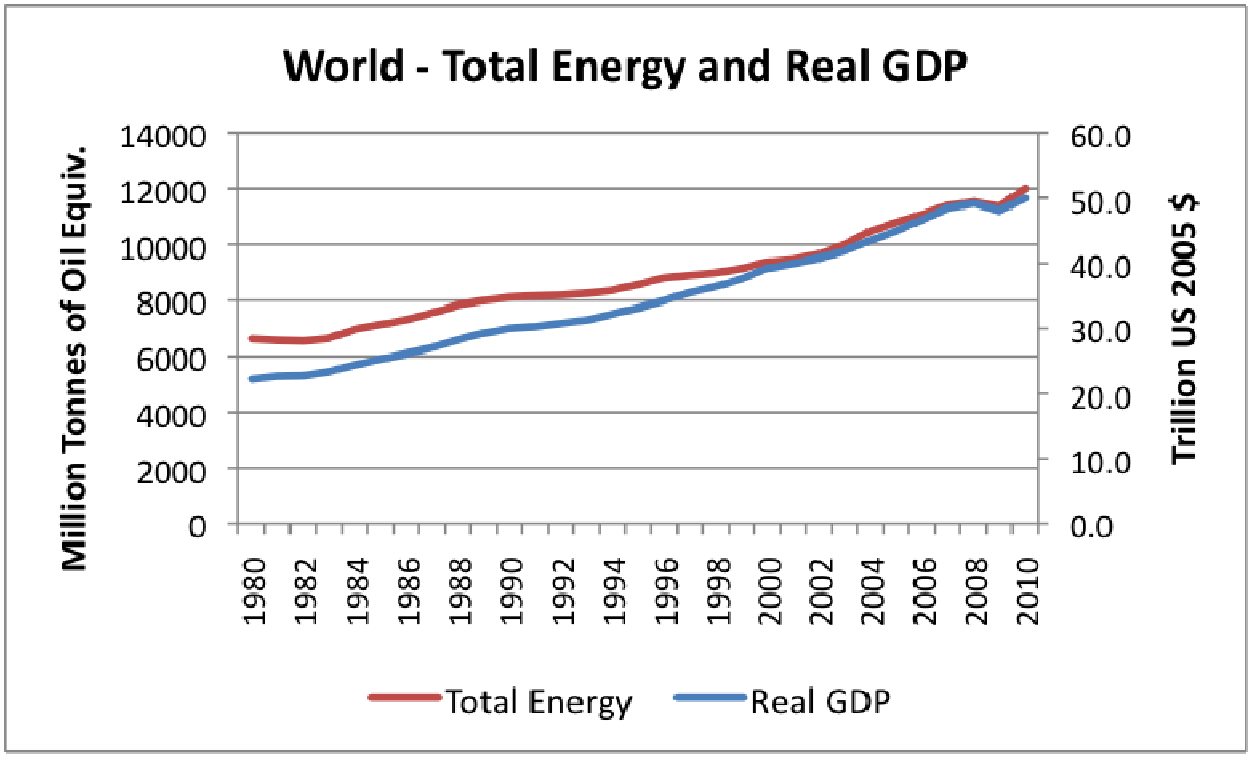
- Declining Energy Return on Energy Invested (EROEI), a critically important but little known problem; energy profits made by investing energy to gain energy are on a declining trend; substituting tar sands and biofuels for conventional oil will accelerate that decline in EROEI: *The trend is for energy operating costs to eat more and more into the energy profits from fossil fuels and the energy profits from biofuel substitutes are even lower; but our realisation of declining EROEI will likely be when energy resources cease to be economic.*

- The Event Horizon: the transition to Renewable Energy needs a front-end investment of real fossil energy to make it happen; the long-term thinking foresees that the Energy Transition could ultimately be limited by declining energy profits and restricted availability of fossil fuels: *We must quickly decide whether to burn off the remaining fossil resources trying to extend our current lifestyles and inefficiencies - and suffer the climate consequences - or invest them now in a resilient and sustainable energy system and accept a less profligate energy future.*

ENERGY

Energy Intensity

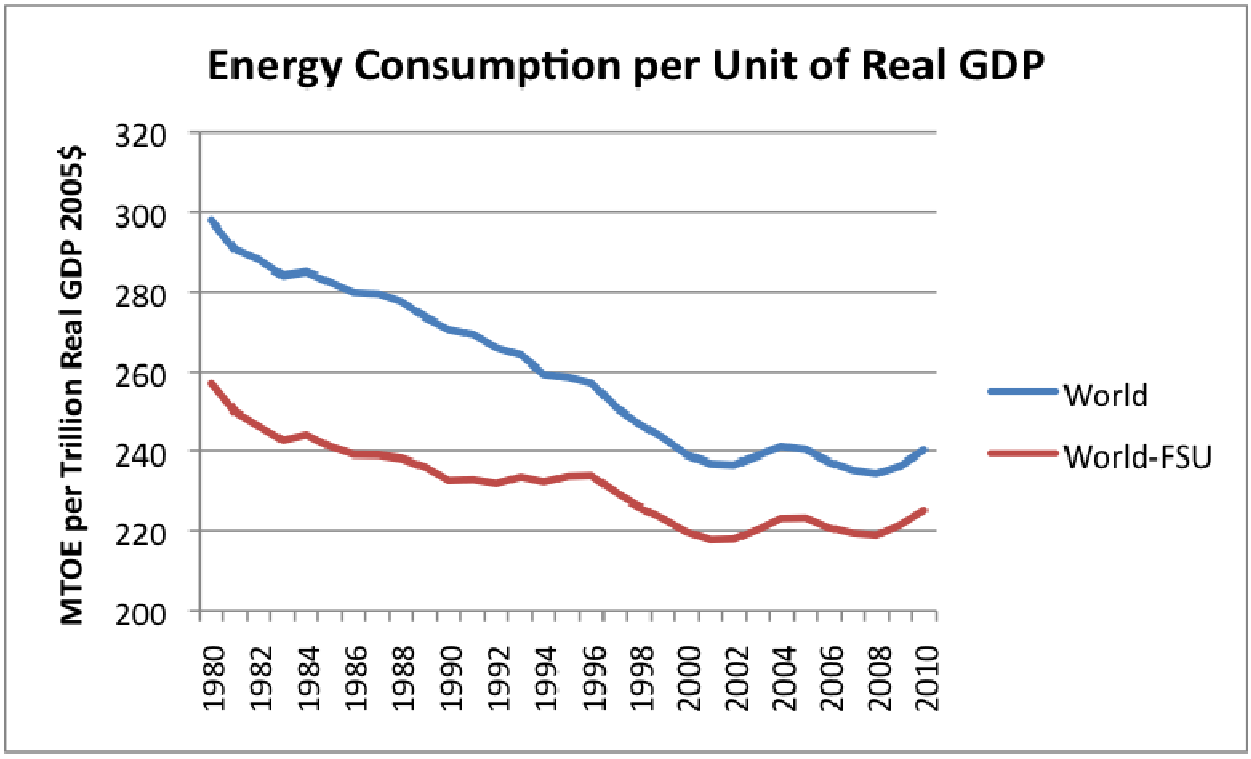
Global energy consumption has grown fairly steadily and consistently at 2.3% per year:



By express courtesy of Gail Tverberg (Our Finite World) published November 2011
Based upon USDA Economic Research Institute data. Other viewpoints are available.

In the modern technological world, we often reassure ourselves that the Energy Intensity of the global economy, the amount of energy needed for a unit of Gross Domestic Product (GDP) has been steadily reducing thanks to our ingenuity. Some well-known data argues that the global EIR is improving (reducing) and that the trend will continue.

But the data below from Our Finite World on a finer scale - especially look at the period after 2000 - suggests otherwise:



By express courtesy of Gail Tverberg (Our Finite World) published November 2011.
Energy Intensity of GDP by Area, based on BP Statistical Data regarding Energy Consumption in Barrels of Oil Equivalent, and USDA Economic Research Data regarding real GDP.

Notice the uptick after the Financial Crisis. How much further can efficiency gains reduce the amount of energy to produce a unit of GDP ? Or has the EIR of the global economy reached a limit in the last decade even though that period showed large growth in financialisation.

This question is not only significant for Climate Change policies; if there are there now diminishing returns in trying to reducing the global EIR, the availability of energy resources becomes even more important if economies are to continue to grow.

Not only that; energy resources must be gained profitably in energy terms as well as financial terms. The concept of energy in versus energy out is Energy Return on Energy Invested (EROEI).

Oil Depletion

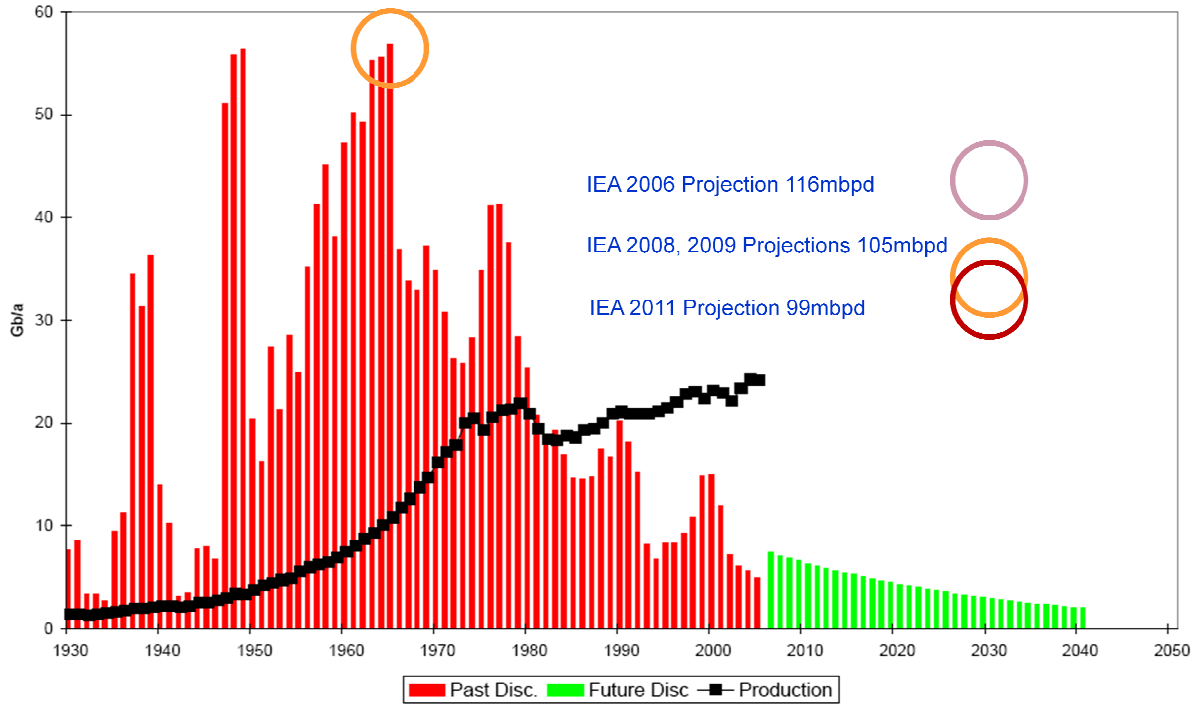
Oil is very special in the global economy and although it is only around 37% of global energy consumption fuels over 90% of transport and produces such a variety of other materials and goods that it is difficult to find a product that does not rely on oil.

Since it was discovered, even as early as 1919, there have been warnings that oil was about to run out. On the other hand as a finite resource, one day oil will become so scarce, difficult and expensive to extract that we will most likely out of convenience move on to something else.

This paper does not suggest that oil is about to run-out anytime soon.

But unfortunately the "running-out" message is often grasped by those wishing to utterly dismiss the concept of peaking: that global production could soon reach an all-time maximum and then decline gradually over many decades. This scenario is Peak Oil and it was first ventured by Shell geologist Marion King Hubbert in 1956.

As well as accurately predicting peak oil production nearly 20 years ahead for the bulk of the United States, Hubbert observed that a peak in oil discoveries would warn of the peak in oil production. This graph by Colin Campbell shows how global oil discoveries peaked in the 1960s and how global oil consumption has far outpaced discoveries since 1983:



Dr Colin Campbell, "Oil Crisis" ISBN 0906522 39 0, Figure 15-2
Courtesy of the Oil Depletion Analysis Centre (ODAC). With annotations.

Notice the general trend for oil discoveries towards lower numbers and smaller, more difficult fields.

The simple observation that oil discoveries peaked in the 1960's argues for a declining production trend some time ahead. Hubbert suggested 30-40 years ahead and estimated a peak for global production around 2000, but back in the 1970's he had very limited data on deep sea oil.

On the graph are forecasts of demand from the International Energy Agency (IEA). Because production from existing fields builds up and then declines, new resources have to brought on just to keep up with depletion. So to meet the IEA production forecasts on that graph the world will need the equivalent of six new Saudi Arabias by 2030, even if oil demand were to stand still. Many experts have questioned whether these IEA forecasts have been realistic.

Oil production is declining in two thirds of the oil-producing countries of the world. Over 80% of the world's largest, easiest - and usually the oldest - fields are in decline. The industry is on a treadmill to offset decline rates from existing fields while demand goes on increasing.

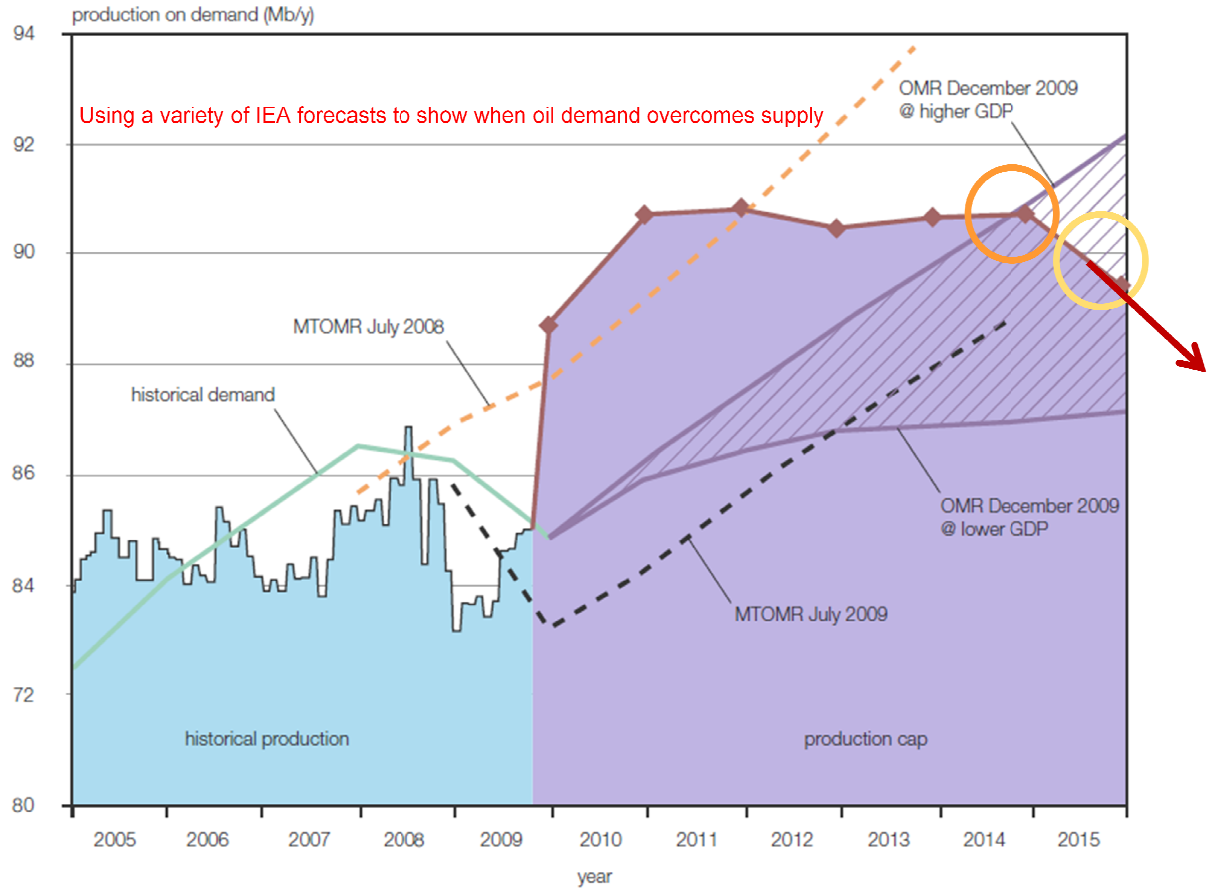
There is no dispute that there are large oil resources remaining and that higher oil prices bring on previously uneconomic fields; but this should in itself not justify dismissal of the concept of Peak Oil. New resources are more and more costly in money, energy and even political terms. The tar sands - a large but highly controversial non-conventional resource – are slow, relatively costly and difficult to scale up.

Significantly, the trend for these more difficult resources, and also the biofuels, is towards lower energy profits, more and more energy needs to be put in to gain a unit of energy output. It is widely accepted that the age of easy oil is over, but global demand continues to rise (even at 1% during recession).

Oil Supply Crunch by 2015 ?

In recent years the IEA - which has reassured governments about future supplies since the Oil Crisis of the 1970s – has shifted its confident position; warning of an Oil Supply Crunch before 2015.

The Industry Taskforce on Peak Oil and Energy Security (ITPOES) includes an airline. Below is a graph from ITPOES in 2010 which seeks to predict when oil demand will exceed oil supplies:



With annotations. Courtesy of the Industry Taskforce on Peak Oil and Energy Security (ITPOES)

ITPOES, like the IEA, predict a supply crunch sometime before 2015. It depends upon demand. The ITPOES analysis is right down-to-earth, based upon capacity from new projects coming on stream balanced against declining production from existing fields.

In fact, the inflexibility of project commitments to around 2016 is what gives this Megaprojects analysis higher certainty. This ceiling on oil production also tends to agree with the thoughts of the French oil and gas company, Total.

From 2008 the IEA gradually began to shift its position, acknowledging that the decline rate from existing fields had deteriorated from 3.7% to 6.7% and for the first time even discussing the idea of the beginning of a declining production trend: Peak Oil. The IEA's World Energy Outlook 2010 was also revealing in showing how much reliance the IEA placed on reserves yet to be developed or yet to be found in order to maintain its supply projections.

Peak Oil

We need to ask whether an Oil Supply Crunch – perhaps even the oil price crisis we are seeing in March 2012 - is in fact the advent of a plateau or the all-time peak in global oil production.

Peak Oil is all about flow. Oil is a finite resource, but this is not about “running-out of oil” tomorrow as some rush to suggest. This is a new era of increasing competition for global oil production and diminishing returns; an era where supplies start declining instead of growing every year.

Some experts say that more recently oil production capacity has been more closely planned against expected demand; but on the other hand, the oil markets are not transparent and may give little warning of when production is about peak.

Some investors have been planning rather publicly to exploit Peak Oil - early enough to avoid risks of government intervention in the markets. Economists at the St Louis Federal Reserve estimate that 15% of the oil price rise over the last decade was due to speculation, 40% of it due to increased demand. Speculation they say exaggerates price swings and operates against normal price expectations for supply and demand, but fundementals are clearly at work.

Analysis of increasing physical, economic and political constraints on oil supplies have convinced many experts that the peaking of global oil production will occur before 2020. Peak Oil will mean that after reaching a maximum flow to market, year-on-year there will be less and less oil available. Despite the large resources remaining, expert opinion is that they are unlikely to be brought on fast enough to affect the timing of Peak Oil.

In 2008, the IEA acknowledged that Global Conventional Oil (that’s easy crude oil) had peaked in 2006 and total oil production has been propped up since 2005 by biofuels and Gas-To-Liquids. Since 2005 global oil production has been flat, despite high oil prices usually expected to bring on supplies. Increasing concern is being expressed that while it has its own price expectations and has claimed very large resources, perhaps OPEC (Saudi Arabia in particular) does not really have the production capacity needed to bring down prices. Certainly the estimates of reserves within OPEC are controversial, secretive and have been questioned for several years. Another problem for policymakers is this lack of data transparency.

Meanwhile, economies are growing, living standards are improving, and they depend on an increasing supply of affordable oil. Because living standards and energy expectations in oil exporting countries are rising, so is internal demand for oil. The concept of the Export Land Model revolves around the double-squeeze where declining production capacity is further reduced by rising internal demand, leading to reduced oil exports. Some work on this suggests that Peak Oil Exports may have already occurred in 2007.

Even in advanced economies, decarbonising transport has hardly started and fleets have long lifetimes. We will need decades to move away from oil dependency, Peak Oil is urgent and global economies are vulnerable, not least because debt and financial instruments assume continued economic growth to redeem them.

The impacts of an early-then-expected decline in global oil production are extensive and even DECC acknowledge that the economic, social and environmental impacts are significant:

- Serious impacts on UK security of oil supply
- Generate possible geopolitical implications
- Impacts on UK security of oil supply
- Impacts on the prices for other fossil fuels such as gas and coal
- Cause disruption of the UK economy especially the transport sector, which would need several years or even decades of adjustment by government and the wider economy.
- Long term macroeconomic impacts (GDP, inflation etc) and impact on prices of other goods
- Possible impacts on UKG climate change goals
- Geopolitical implications.

Notice that DECC did not include in their list:

- Increasing internal pressures for Resource Nationalism, that is the moderation or withholding of oil export capacity once it becomes clear that Oil Depletion is an immediate global issue and that prices will go on increasing
- The risk of conflict
- Additional stress on a financial system and debt repayment, which are based upon future growth, and potential knock-on effects to investment in new resources
- Interactive disruption between oil and other commodity supplies due to speculation
- Social tensions that restricted oil availability and high fuel prices would cause
- Possible failure of essential services due to energy supply, social and financial disruption
- The economic impact of relying upon substitute energy supplies that aggravate the established decline in Energy Return on Energy Invested (which we discuss later in this paper)

How soon might oil supplies suddenly peak-out and go into decline ? One Chinese study has predicted Peak Oil as early as 2012, with many others expecting Peak Oil between 2013 to 2018. Importantly, it is not the date of Peak Oil, but the rate that production declines that is most influential on how rough a ride it will be.

Conversion of developed economies from oil dependency will take decades. In the United States, the 2005 US Department of Energy (Hirsch) Report “Peaking of World Oil Production: Impacts, Mitigation, and Risk Management” suggested these scenarios for the realisation and mitigation of Peak Oil:

- *“…Waiting until production peaks would leave the world with a liquid fuel deficit for 20 years.*
- *Initiating a crash program 10 years before peaking leaves a liquid fuels shortfall of a decade.*
- *Initiating a crash program 20 years before peaking could avoid a world liquid fuels shortfall.”*

But as we will see, complex interactions with the economy and markets mean that we are more likely to see spiking prices and a series of Oil Supply Crunches rather than the classic hump-backed peak. The Oil Price Crisis of 2012 may well mark the beginning of that period, just before decline sets in.

Peak Oil Demand

Here in 2012, notice the political pressure to release stockpiles in an entirely transient attempt to bring down high oil prices. Oil demand is poised to bounce back but stockpiles are very low and there are geopolitical threats to Iranian capacity. The middle oil price projection for 2030 by the Department of Energy and Climate Change (DECC) from 2011 has already been sustained this year. Countries are producing flat-out just like 2008 and net additions of capacity are extremely low. The 89mbpd forecasted by the IEA for 2012 is close to the 90-95mbpd absolute ceiling suggested by one oil company.

While many experts and some investors have questioned the potential for increased capacity and reserve estimates within OPEC, the IEA indicated in 2011 that more than 90% of global crude production growth over the next 20 years will need to come from Saudi Arabia, Iran, Iraq, Kuwait, Algeria and the United Arab Emirates. However, resource politics are also changing and the IEA also warned:

"...In some countries, oil investments have been diverted to social spending. Oil policies are taking on a more nationalistic tone, which means not to increase production as much as is needed in the world market."

Economic interactions and complexities of the oil markets have attracted much more attention recently. Modern thinking about Peak Oil has reflected upon the simple observation that oil discoveries have peaked, that oil prices have seen factor-three volatility through a period of flat production and that although new technology is not out-pacing the impact of declining fields, high prices might bring on poorer quality resources quickly enough to maintain the current plateau in production. Some experts have interpreted that these maxed-out fundementals mean we are already in the era of Peak Oil Demand.

Although the more positive aspects move on from a simple, geological basis for Peak Oil, many experts do not see oil production growing strongly in the future. Instead the question becomes whether economies have affordability limits for the more difficult oil. When physical and political supply constraints drive the oil price too high, these act as a brake on economies - a limit to growth.

As and when the thin margin of supply over demand disappears, we can expect more speculation and high, volatile oil prices that depress economic activity so the oil price falls. The cycle is repeated: this is a scenario of Peak Oil Demand. Some argue that even though speculation was an ingredient, this effect was seen in 2008 when oil reached $147/barrel. Fuel prices can only be hedged for so long against volatility, not against sustained high oil prices. In 2008, several airlines on razor-thin margins, simply folded.

Resource depletion should be a more persuasive argument for policymakers than Climate Change. But there are confusing signals for policymakers in complexities, speculation and lack of transparency in the oil markets; and recession, investment constraints, instability and conflict, and the deliberate withholding of production capacity to force up prices. These factors suggest a plateau of high and volatile oil prices, a series of Oil Crunches. They very likely mean that the peaking and decline of global oil production may only be apparent some years after the event.

UK Government Policy and Peak Oil

Oil and Energy Security are hardly mentioned in Government consultations for the expansion of UK airports. An assumption that the market will always ensure that demand is always met by supply would therefore appear to be the current basis of Government policy for continuing to plan airport expansion despite many warnings about Oil Depletion.

Many experts, including the UK Energy Research Council (UKERC), have already warned the Government that Oil Depletion has not been given enough attention in policymaking. This is from UKERC's 2010 report:

"…the probability and consequences of different outcomes (to the risks presented by physical depletion) has not been adequately assessed."

Responses to No.10 Petitions have suggested that official faith seems to remain that markets will continue to bring secure, affordable supplies of Energy. The same, reliable markets that traded Sub-Prime Mortgages. In 2010 the Government said:

"…With sufficient investment, the government does not believe that global oil production will peak between now and 2020 and consequently we do not have any contingency plans specific to a peak in oil production."

After a successful Freedom of Information request, we learned that the Department of Energy and Climate Change (DECC) was concerned enough about Oil Depletion to have studied it between 2007 and 2009. DECC's own range of Peak Oil scenarios lay between the immediate (around 2010) to the late 2030's: a remarkable timescale for something so important to policymaking.

However, Charles Hendry MP advised the House (Column 438W) in January 2011:

"…We have not estimated a date on which global production of crude oil will peak….In 2010, DECC's chief scientist sent out a call for evidence on the prospects for future oil supply to a range of experts. A number of responses received argue that a supply "crunch" (a tightness in the oil market), if not a peak in oil production, is very likely before 2020. We are very grateful for the excellent responses and will use the results to help ensure that our analysis is informed by all relevant factors and further develop energy policies that reduce the risks inherent in a resource constrained future."

At March 2012, no more has been heard from the Government about Peak Oil. But surely any obvious preparations would undermine confidence that a market-driven administration can influence a global market to deal with Oil Depletion, they could seriously disrupt financial markets and preparations would also dissolve a Government tenet for consumer choice.

One can only conclude that either the Government is no longer concerned about Oil Depletion; or avoiding public discussion; or that it is fully aware of the urgency but that there is no mileage for politicians in preparing for an Oil Crisis until one actually arrives.

In terms of it not being in anyone's immediate interest to say that the party is over, it is difficult to avoid parallels with the isolated but determined warnings about Sub-Prime.

Energy Return on Energy Invested

However, the issue discussed least of all is the growing challenge of declining energy profits: Energy Returned on Energy Invested (EROEI). Producing a unit of usable energy as liquid fuel is costing more and more in energy terms and increasing the use of biofuels will actually accelerate this trend.

EROEI is a simple concept, energy-in versus energy-out, but fraught with difficulties in determining the boundaries. Although caution should be applied in comparing EROEIs from different sources because those boundaries are likely to differ, here are some indicative EROEIs for liquid fuels:

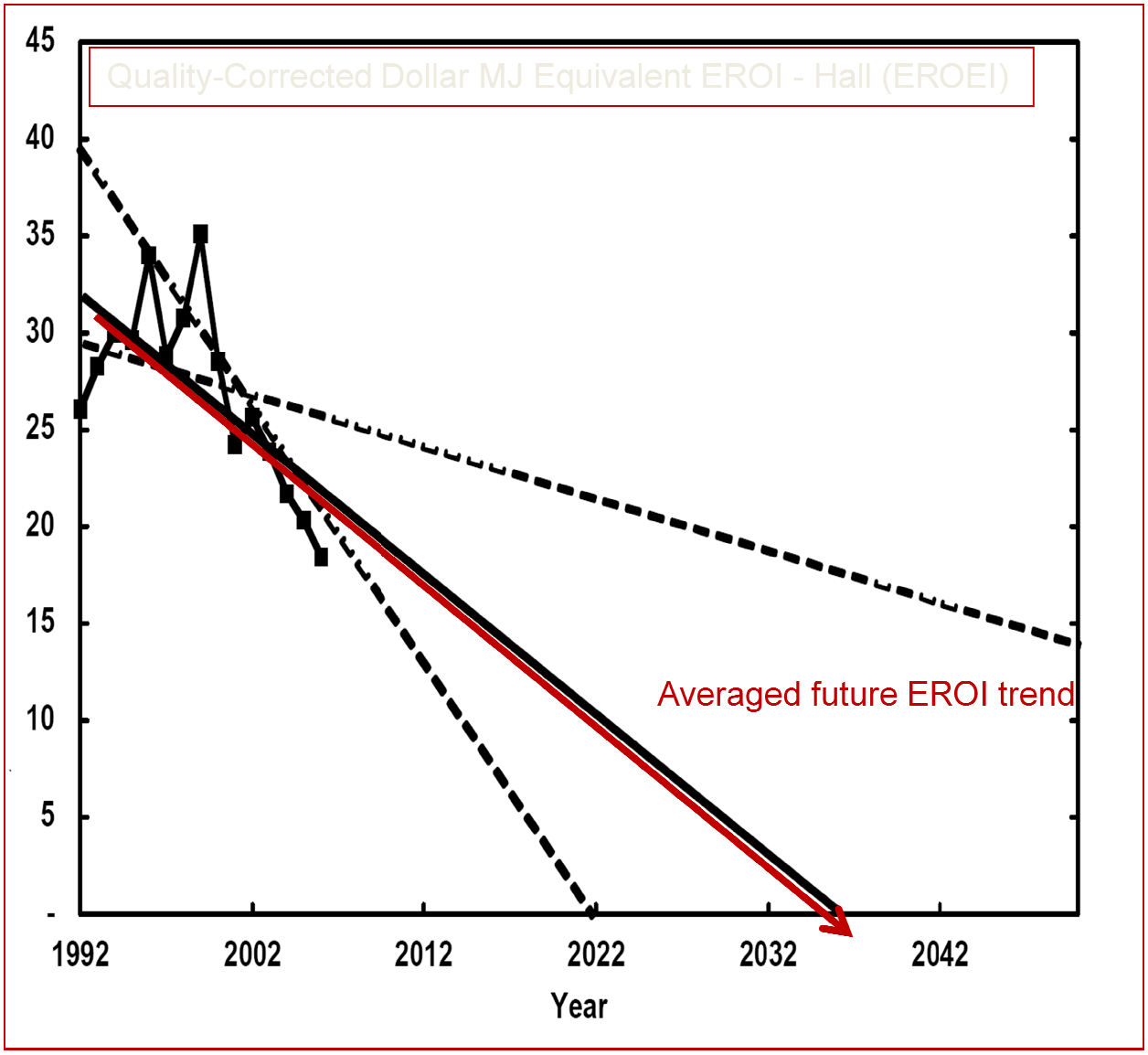
Global Oil (2006)	18	(Hall)
Oil (Tar Sands)	5.8*	(Hall)
Oil (Tar Sands)	3 - 4	(Shell)
Gasoline (2006)	10 -12	(Kaufman)
Bioethanol (sugarcane, Brazil)	9	(Localised, Macedo)
Biodiesel (rapeseed)	2.4 – 4.5	(Hall)
Biodiesel (soya)	3.2	(Sheehan, Shapouri)*
Bioethanol (corn)	1.6	(Shapouri)
Bioethanol (corn)	0.96 – 1.14	(Murphy)
Bioethanol (corn)	0.84 – 1.65	(Hammerschlag)
Hydrogen	Energy Sink (refining of renewable electricity)	

From these it is reasonable to expect that with current technology:

- The move towards biofuels is very likely to result in lower EROEIs
- That the EROEIs from Renewable Liquid Fuels are very sensitive to location and the level of technology used
- At the same time fossil liquid fuel EROEIs can be expected to also decline
- Substituting lower quality resources - such as biofuels, tar sands, oil shale - for conventional oil and the EROEI trend gets worse
- That substituting liquid fuels with lower EROEIs and expecting the same useful Net Energy output will increase global energy demand, likely at exactly the same time as Peak Oil restricts availability.

Therefore the challenge for global economies is that gains in energy efficiency need to outpace declines in EROEI as well as conserving liquid fuels.

This graph projects a suggested EROEI trend by Professor Charles Hall for global oil and gas:



Gagnon, N.; Hall, C.A.; Brinker, L. A Preliminary Investigation of Energy Return on Energy Investment for Global Oil and Gas Production. *Energies* 2009, *2*, 490-503. Open Access. Annotated.

But these projections by global experts in the field clearly show that incremental efficiency gains cannot outrun factorial declines in EROEI, especially for liquid fuels. Although policies are committed to increasing the proportion of biofuels - and the airlines have experimented with these - EROEI indications for biofuels are below those of low quality oil resources like the tar sands. In which case, liquid fuels, vital for global economies, are in serious trouble.

CONCLUSIONS

Peak Oil and the UK Government Position

Despite the evidence of many authoritative reports and having the rug pulled out by major shifts in the IEA's position since 2008, remarkably the Government has no published contingency plan and continues to make long-term policy decisions for an investment that is perhaps the most vulnerable of all to high oil prices, air travel.

Availability constraints on global oil production at Peak Oil will lead to economic, social and environmental impacts which are widespread and need to be fully considered in long-term policies. Oil Depletion (and EROEI) are issues that have not been adequately acknowledged in UKG policymaking – certainly not publicly. But then offering less and restricting more is a very difficult political outlook to present; whatever will happen to consumer choice ?

Peak Oil Demand

Apart from the increasingly urgent issue of Climate Change, the new era for liquid fuels is seen by many experts to be one of diminishing availability and diminishing energy returns which will impact on economies. In March 2012, Oil Futures trade at $200/barrel. Liquid fuel costs can be expected to keep rising and become an ever-increasing fraction of the whole economy. As the CEO of Shell said in the same month:

"...Longer term you will see [oil] demand rising and we will need all investments to cope with that demand. In the very long term we will see prices going up because of high demand and as it gets more expensive to get the resources out of the ground."

Even higher oil prices because the new resources are more difficult, and perhaps a scenario of Peak Oil Demand, where Economics take precedence over Energy in the debate. But this still reflects the increasing costs of extraction, the diminishing returns and declining energy profits.

An Event Horizon ?

Even in advanced countries like Germany which have made remarkable progress with Renewable Energy, the long-term thinking is increasingly worried about an Event Horizon: the point in the future when declining fossil fuel availability and declining energy profits become a limit on how far that Energy Transition can go.

One could also interpret the current policy vortex over Renewables - in particular over wind generation and the contentions over the relative subsidies lent to fossil fuels versus wind - as an indication that economic factors for an Event Horizon are already in play.

Surely this leads to policy decisions that are either based upon investing energy and resources in a precautionary manner for a resource-constrained future; or trying to extend our energy lifestyle in a fashion that is not sustainable, something that will in future look like a policy of burn-the-furniture ?

The Urgency of The Energy Challenge

So the real policymaking question from this paper is: Despite our technology, how fast can we convert today's economic models and infrastructure before Fossil Energy Profits are so badly reduced and so adversely affect all our resources that Energy Transition becomes impossible ?

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11 April 2012