Oil Peak – A Summary

There is increasing evidence that Oil will reach a production peak in the next few years rather than in 10's of years as has been indicated by oil companies and politicians. If this happens, it will have an enormous impact on the world economy.

This note summarises information gleaned from a number of sources. It is not intended to be definitive – but rather to bring the issue to individuals' attention and to indicate further potential reading. I have attempted to make the subject as relevant as possible to people without a background in oil or energy.

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http://www.powerswitch.org.uk/Downloads/pos.doc

Preface

Since the original version of this paper was written about a year ago little has changed in terms of the essential issue, although awareness has grown considerably. A few amendments are warranted.

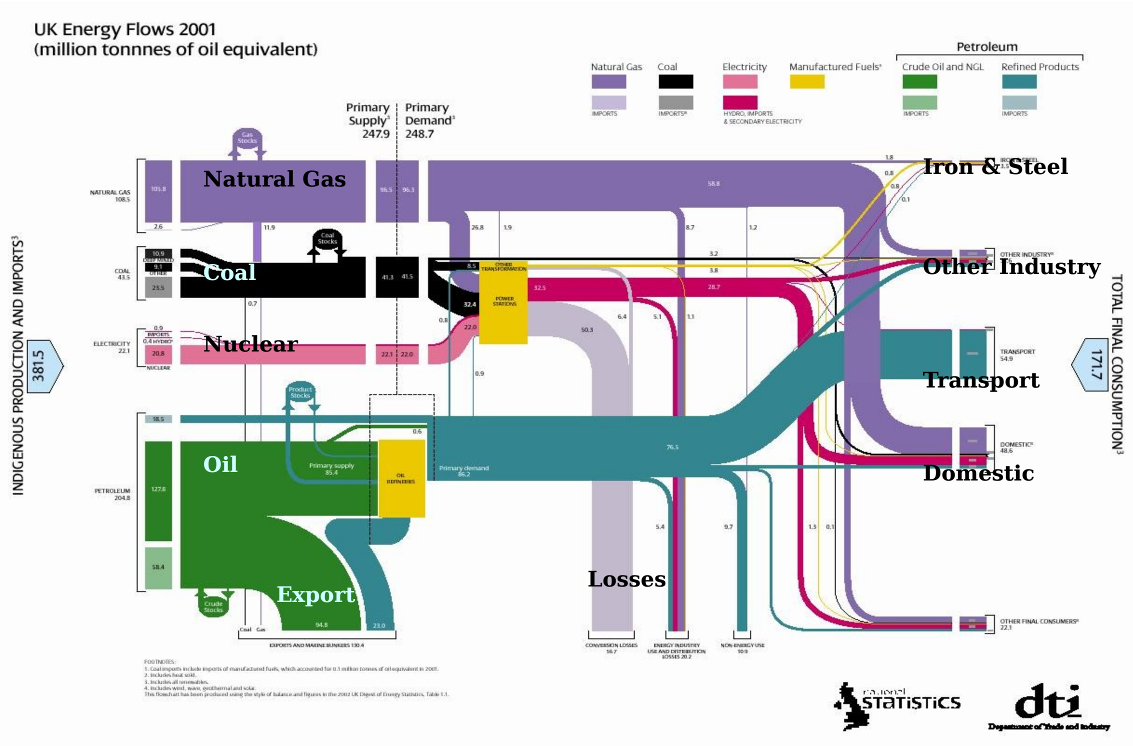
The main points are:

- Further reports have been issued that increase the weight of argument for peak oil being sooner rather than later. These include reports from Deutsche Bank Research and one produced for the US Department of Energy
- Global Warming now appears to be an increasingly urgent threat with reducing timescales and increasing potential impact. Peak Oil will primarily affect economies and life styles (as a minimum), but Global Warming will impact the entire ecosystem of the World. Both demand immediate action to minimise the effects, but whilst they will both impact Man, Global Warming is probably the greatest overall threat, however Peak Oil will still probably affect us first.
- Global Dimming has become more widely known – an effect that is masking some of the impacts of GHGs and thus probably delaying Global Warming. This supports the above point.
- Oil discoveries are falling below those predicted by the ASPO (Association for the Study of Peak Oil). Furthermore some of the Gas predictions by the ASPO have been held as optimistic. These assessments and results re-enforce the timing of 'Peak Oil' predicted by the ASPO.
- A more complete evaluation of the Economist Peter Odell's view of the future of Carbon Fuels has been carried out. He offers keen insights into the future response of Governments to the developing situation. However his assessment of when Carbon Fuels will peak and how they are formed is seriously at odds with those of many petroleum geologists.
- Financial advice from organisations such as Moneyweek and Hemscott is now flagging heavily the potential for an imminent peak in oil production. Goldman Sachs are predicting oil prices in the region of $100 per barrel.
- There has been a marked change in stance amongst some oil industry leaders and politicians. Whilst they are not openly stating that peak oil will arise in the next 10 years – they are now openly voicing concerns about security of supply and reserve limitations. The International Energy Agency, for the first time, acknowledged the concept of a peak in oil production. Their pitch is more on the level of investment required to meet energy needs.
- The IEA has also issued a report with recommendations of draconian measures to reduce oil consumption should demand outstrip supply
- Oil prices and oil futures are breaking records frequently reflecting the lack of production capacity
- OPEC has essentially lost control of the oil price with virtually no spare production capacity
- China has continued to establish deals to secure oil (Middle East, Venezuela and Canada)
- Demand for oil is growing at a higher rate than originally predicted and Energyfiles' projections based on a 2% per annum economic growth rate have been used in this summary place of the previous 1%.

Introduction

The Western World runs on energy. In very broad terms, the development of our industrial civilisation has been almost entirely possible due to the ability of Western societies to harness energy in order to develop and operate the technology that enables current cultures and lifestyles. The great bulk of this has been due to the abundance and use of highly concentrated energy sources in the form of fossil fuels.

Imagine having to make do with no oil, gas or coal. The following UK Department of Trade and Industry chart illustrates the use of different energy forms in the United Kingdom. Whilst countries vary – the overall message is largely the same.



Take away fossil fuels, and about 90% of all the energy that runs the UK today would disappear. Efforts are now being made to replace some power generation with wind turbines (perhaps 15% of electricity by 2015) and other renewables for environmental reasons. However this added generation will not even meet increasing overall energy demands. Furthermore with the current plan to phase out nuclear power over the same period we will still be 90% dependent on fossil fuels.[1]

Environmental issues aside – there is a lot of coal in the World although some have questioned how much longer it will be viable as an energy source. Also there is believed to be a fair amount of natural gas, although actual quantities are uncertain and much is located in distant parts of the globe. There should be no *medium term* problem maintaining electricity supplies if current fuel sources can be secured. That is a big if as we will increasingly depend on supplies of gas from sources that are highly exposed to political instability. Furthermore information on quantities of gas is even poorer than on oil. There are therefore issues on security of supply in the provision of gas for both heating and power generation.

[1] All stated figures in this note are approximate – however they are largely correct.

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These concerns on security of supply also apply to oil as that, too, comes from unstable parts of the world. However there is another threat – and that is the issue of oil reserves. Whilst subject to much debate, there are very strong arguments that we are close to the point where oil producers will soon not be able to meet demand. Even more worrying – the point where oil production will start to decline due to reserve depletion. When this happens it will have a major impact on the world economy.

There are alternatives to oil including coal, hydropower, geothermal, nuclear (fission, fusion, cold fusion), solar (thermal, photovoltaic, thermal power), wind, tidal, wave, biomass and bio-fuel. Much has been said of hydrogen, however hydrogen is a carrier not a source of energy. It has to be made. A summary of the state of these is included towards the end of this note together with their potential to fill the energy gap.

If you thought renewable energy was all to do with the environment, well Kyoto and the environment are the political drivers being used publicly by the UK government to support renewable energy development, and indeed may be their real justification. The environment is also critically affected by current power production methods and this is reason enough for investing in renewables. However the impact on Man of falling energy supplies could be even more dramatic than environmental change.

The purpose of this short document is to:

- Explain the current state of oil supplies
- Look at the potential impact of falling supplies on economies
- Consider the impact on lifestyles
- Consider what individuals, companies & governments could do

All this is much more comprehensively covered in a number of excellent books and sources on the internet – pointers to which are provided at the end. This is very much an introduction but contains the key points.

In Summary

Right now, the key issue is oil which provides over 95% of transportation energy and 40% of total energy. There is a very strong argument that we are going to be massively affected by declining oil supplies in the near future.

Keypoints:

- *The world economy runs on the principle of growth*
- *Industrial economic growth relies on increasing energy supplies*
- *Most current energy supply comes from fossil fuel sources*
- *Fossil fuels are extensive – but are now almost half depleted and production will peak sometime in the next 10 years*
- *Substitutes (such as non-conventional oil, gas & renewable energy) will not fill the gap fast enough*
- *This will have a substantial impact on the operation of economies and international affairs including:*
    - *Short term energy price shocks*
    - *World-wide economic recession*
    - *Increased international tension, & potentially wars*
    - *De-globalisation of economies*
    - *Food production*

For western economies it is likely to result in:

- *Increasing unemployment*
- *Collapse in investments (shares, pension funds….)*
- *Substantially increasing transport costs (both road, but especially air)*
- *Increasing energy and food costs (reductions in choice)*
- *A fundamental change in western lifestyles*

Oil Peak – A Summary

In looking at the issue of oil, it is important to note that this summary does not address the broader issue of sustainability or the environmental impact of using non-renewable energy sources. It simply focuses on the importance of oil (and other energy sources), the impact of falling supplies and the potential for alternative solutions.

No current modern economy is ultimately sustainable as all depend on the increasing supply of limited natural resources. The energy and materials we use from wood through to metals; animal and plant life; natural environments and even the land on which we grow food are all being used up or abused. Whilst some resources are so extensive as to be virtually inexhaustible, some are not, and oil shortage is going to be the first major one to bite.

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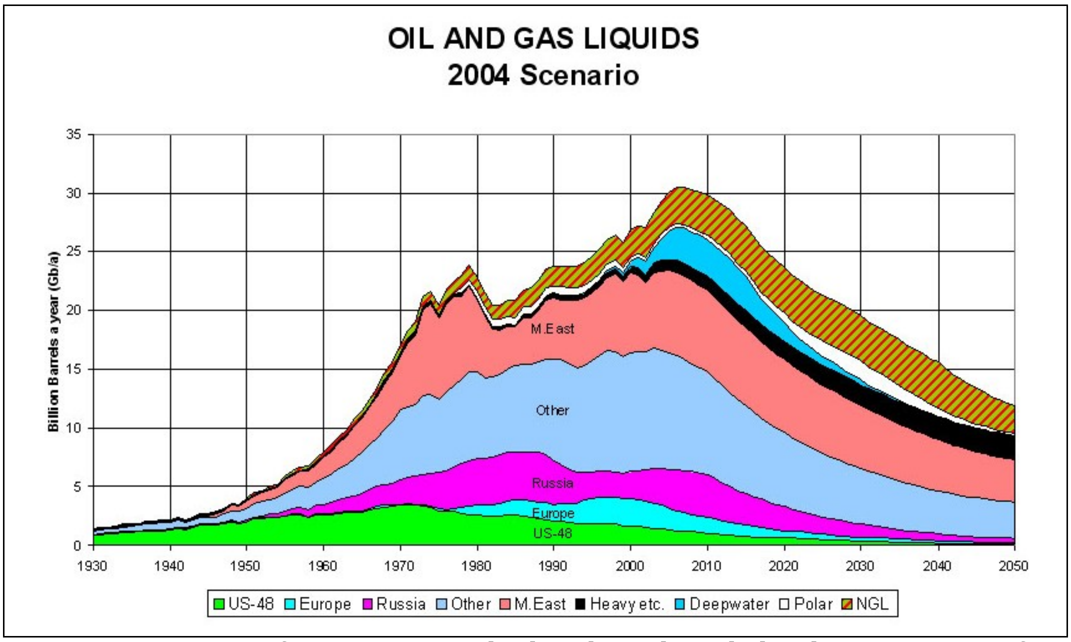
Oil Reserves

A respected American petroleum geologist, M. King Hubbert, studied the process of oil discovery and production, and correctly forecast a peak in US production would occur in the early 1970s. He realised that oil production had to mirror earlier discovery and that peak production would come when roughly half the total available had been consumed. Experts have applied his theory to other oil areas – and also to the world as a whole. Their conclusion can be summarised in



the current projection for conventional oil and gas liquids by the Association for the Study of Peak Oil & Gas (ASPO):

Governments and oil companies have repeatedly stated that there is enough oil for at least another 40 years. This is based on simply dividing remaining reserves by current production ignoring the obvious fact that the production rate from all oilfields declines towards exhaustion. The important issue is not that we are about to run out but that production is set to decline to eventual exhaustion in the distant future

it is not the point at which we run out of oil that matters – but the point at which we can no longer increase production

We are about half way through conventional oil reserves (i.e. excluding tar sands and oil shale).

The other half of the world's oil is still to be extracted. There is strong evidence that World oil production has nearly reached its peak. When the rate at which it can be extracted peaks – in other words we are unable to increase World supplies – we will have to make do with less year-on-year. From an environmental point of view this is a double edged sword as it may lead to increased use of even less desirable energy sources. However from an economic point of view it is potentially disastrous.

Over the years analytical techniques have improved enormously allowing prospective oil areas to be identified with a high degree of confidence. Petroleum geologists are largely agreed that about 90% of all the conventional oil ever to be found has now been found. Oil exploration is becoming more difficult and the number of new wells found is falling – as are their size.

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Discovery peaked in 1965, and in recent years we have consumed about four times as much oil per year as we have found in new reserves.

It is important to appreciate that whilst we are not ‘running on empty’ the entire world economy is based on continued economic growth, and continued growth requires continued increases in the use of oil. That is why consumption is increasing year on year. Recently Asia and China have entered a period of massive growth and are now seeking to secure oil and gas supplies to, literally, fuel that growth.

Surely Governments and Oil Companies are Aware of this?

The democratic system generally ensures that those wishing to get into or remain in power avoid spreading bad news – as their opposition will only use this to undermine them. It is not until there is a present, real and unequivocal threat that a democratic government will, or indeed can, act. However this does not mean they are unaware – nor that they actively discourage or suppress information – it is just that the system does not encourage the raising of strategic problems. Furthermore a democratic system doesn't support commitments that extend beyond the life of one term in office – so a long term energy strategy is very difficult to pursue without agreement between the leading political parties.

From a competitive point of view, governments cannot set policies that seriously disadvantage them in the World market. In theory it makes sense to suppress energy consumption and invest heavily in renewables. However if this were done without considering the effects on international competitiveness, the economy would run out of steam. Such a policy would therefore run into substantial public and business opposition.

Governments also take advice from experts – but those tied to government bodies are loath to present unpalatable information, so the supposedly august International Energy Agency and the USA's Energy Information Administration are both largely gagged by political affiliation. Equally energy analysts linked to the oil industry are unlikely to present problems as this has a negative impact on oil company share prices.

Meanwhile OPEC countries have continued to report high oil reserves in order to maintain their production quotas and/or secure World Bank loans. Financial institutions are also concerned about causing doubt and panic in the markets. It is simply not in any of these organisations' interest to express doubts over oil supplies. Obfuscation of the facts actually is in their interest.

This isn't a conspiracy theory, in fact arguably there are very good reasons why you would obscure this information as it avoids, quite possibly unnecessary, panic. However it also prevents reasoned strategic changes in direction that would reduce the medium and long term impacts of shortages.

Views from Other Informed Bodies

It is important to be aware that there are many highly intelligent and knowledgeable people in this area who disagree on the current state of affairs. Economists such as Peter Odell soundly deny any potential problem whilst oil geologists such as Dr Colin J. Campbell (who founded the ASPO) use oil resource information to show there is a problem.

There are many predictions of the amount of oil remaining – from organisations such as World Oil, Oil & Gas Journal, US Geological Survey (on whose analysis the IEA currently rely) and BP. These generally estimate a higher level of reserves – however they base their analyses on information provided by oil companies and countries, information that is inconsistent and highly questionable. By way of example, Saudi Arabia has been reporting 260 Giga barrels of oil reserves – but this has been unchanged for several years despite producing oil from these reserves (there have been no substantive new finds in this period). The ASPO estimate that slightly more than half that amount actually remains and the 260 Giga barrels is actually a measure of the original find.

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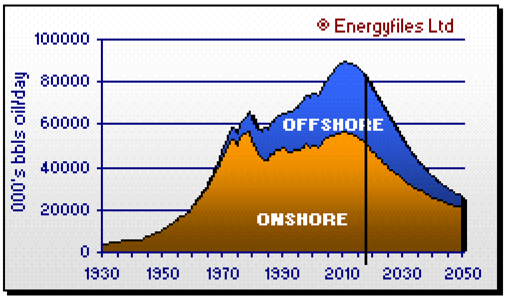


There are other independent analysts – for example Dr Michael R Smith from Energyfiles: "Any growth in global economic activity increases oil demand such that at 1% demand growth a production peak occurs in 2016, at 2% it occurs in 2012, and at 3% it occurs in 2008. "The world's known and estimated yet-to-find reserves and resources cannot satisfy even the present level of production of some 76 million barrels per day beyond 2020." These dates production and consumption is unfettered by political or terrorist events.

So there are really two schools of thought – those that believe we are nearing the peak of conventional oil supply – and those who don't. A peak in the production of oil has been predicted several times before – and been proven wrong. Why should energy sector investment bankers Simmons & Company International, Energyfiles and the ASPO's current prognosis be right?

There are global events that tend to support the early peak argument:

- *Major oil companies are finding it difficult to replace reserves and to backfill previous reserve over-estimates (Shell is the current example).*
- *Oil company consolidation is now happening – which hides reserve shortages by combining existing reserves*
- *Oil companies such as BP have resorted to replacing reserves through production agreements on old fields (such as those in Russia) rather than pure exploration*
- *Investment in exploration is falling*
- *Technical feedback from the state of major Saudi Arabian fields indicate a high level of depletion (essentially major wells are now producing a proportion of water than strongly indicates they are now at an advanced state of depletion)*
- *The USA's international policies are now increasingly overtly targeted at securing energy sources*
- *China and Asia are frantically scouring the world for gas and oil supplies to fuel economic growth*

How sure are we that we will have to make do with less energy year on year?

There are significant unknowns in this situation:

- *The actual size of conventional oil reserves is unknown*
- *It is possible, albeit unlikely, that a totally new clean source of energy will be found or developed*
- *Equally it is possible that new methods could be developed to use vast (but very poor quality) non-conventional oil reserves economically and in an environmentally friendly way*
- *International political efforts could lead to a coordinated and focused attempt to address the issue (so far we have made a stab at climate change – with some success)*
- *Human opportunism coupled with technological development may reduce demand and deliver new solutions faster than supplies fall*

Environmental issues started an increase in the development of renewable energy and there is a rapidly increasing number of people looking at alternative energy and steadily rising investment in them. Security of supply is now being voiced more and more at a senior level in government. We may be in a potential hole, but we may also be resourceful enough to find our way out….. it depends on how you view the likelihood of the above events, and the ability of nations throughout the world to cope with the challenge and inevitable changes.

So What is so Special About Oil?

Oil is comparatively easy to extract, transform, transport and distribute. Most people think of oil only in terms of its use for petrol and diesel. This is true, however it has a much wider and deeper usage within a modern industrialised society. Not only is it a highly concentrated, mobile energy source, it is also used as to produce an enormous range of materials used in making many of present day goods, the most obvious one being plastics, and is used as a vital source of fertilizer. It has therefore developed to become the single most flexible natural resource we have.

Currently oil is fantastically flexible and cheap. A UK gallon contains about 40kW hours of energy. The cost of extraction is roughly £7[2] for a barrel of oil (36 UK gallons or 42 US gallons).

Oil prices affect petrol and diesel prices. It also affects airlines and recent oil-price shocks have had a seriously negative effect on the share prices of airlines. It affects the cost of raw materials and increases in crude oil prices feeds through to reduced margins or increased prices for goods.

If you look graph of economic activity and oil consumption they are very closely correlated. One might argue that economic recession will lead to less oil consumption – true. However the recession in the late 1970s resulted from (politically created) oil shortages – not the other way around. It also doesn't take an economics degree to realise that, in the absence of cost-equivalent alternatives, removing a large proportion of the current energy supply and feedstock for fundamental manufacturing materials will impact economic activity.

By way of example, as the UK dti's diagram shows, crude oil supplies a large proportion of the energy used by an the UK (roughly 40%). It is mostly used for transportation which is crucial to industry, commerce and individual lives. Economists estimate that about 8% of the US economy is the cost of oil (probably a bit less in other countries as the US uses roughly twice as much oil per capita as the next nearest country).

Gas (a close cousin of oil) is increasingly being used to generate electricity, mostly to address Kyoto commitments – but also because it is a cheap, fast and flexible source of electricity.

Agriculture has been described as a process that converts petroleum into food. Natural gas in particular is an important source of synthetic nutrients on which crop yields depend. It is used to produce nitrates for fertilizers which are crucial to maintain the current level of food production, which is based on high yield crop varieties specifically developed to take advantage of high levels of artificial nutrient.

What About the Oil left in the Ground?

We can't get all the oil out of a reservoir – in fact about half the oil remains in the ground (and quite often more than half). This is due ultimately to the physics of the reservoir and the energy required to get the oil out (see 'Energy Economics' below). The practical limiting factors are technical and cost. At any one time the 'tipping point' at which production ceases depends on the price of oil and cost of

[2] Again numbers are indicative – however the current on-shore cost of producing a barrel of oil in Saudi Arabia is about $4. Offshore in the North Sea in the region of $10. A barrel=42 US gallons=36 UK gallons.

extraction. Improving oil extraction technology is allowing more of a reserve to be recovered. However there is no current indication that this is going to make a fundamental difference to total recoverable quantity. Ironically improving methods could make the situation worse as these techniques are good at holding production rates up – but when production starts to fall it goes down that much more steeply.

Oil companies refer to 'economically recoverable oil'. Oil is normally there in very profitable abundance or not there at all, so it differs from the extraction of minerals and coal where rising prices or falling costs allow more to be extracted. As production reaches the end of its natural cycle more costly techniques are used to extract it – for example water injection. With higher prices more can be economically recovered in such 'tail end' production.

At the margins if a barrel will sell for $40, it is worth extracting it at a cost of $30. Whilst this makes more of a reserve economically recoverable, even under very high prices, the quantities are small. Furthermore they have no material impact on the date of peak, which is much more important than eventually running out. If the market price is unstable and could drop to $25 oil companies are loath to make the investment in more advanced methods and can't sustain higher production costs – so the amount of 'economically recoverable oil' is less.

It is therefore important to appreciate that the total reserves from the point of view of an oil company to a degree depends on oil price. However this price factor doesn't greatly affect peak production or the total that is economically recoverable. Whilst the total amount of conventional oil recoverable is in principle limited, the energy equation, technical and market considerations will generally limit production first. The same cannot necessarily be said for non-conventional oil which has a much higher ratio of energy input.

Oil Alternatives

Are there alternatives? Well there are vast non-conventional sources - oil shale and tar sands deposits. The total amount estimated to be available is much greater than the total of conventional oil found. However there are huge environmental impacts of producing from these sources. The financial cost is high and the net energy gain low (see note below on 'energy economics'). To produce from these sources using current methods results in immense quantities of polluted water, and mining tailings. Current extraction techniques in Alberta require the use of natural gas to heat the tar sands to be able to both extract and to provide hydrogen to convert it into 'synthetic crude' . It also requires large volumes of water. Whilst more energy is recovered than expended it is questionable whether using clean[ish] natural gas to produce less clean oil is logical. Besides, the gas is fast running out and aquifers containing the water used in the process are being depleted.

Oil feedstock can be created from gas and coal. Again the energy efficiency is low and the cost high – but it is do-able. However there are now massively increasing demands on gas supplies (for power generation) and, more recently, on coal. New methods of extracting energy are being tried – for example setting fire to oil shale underground (also being tried with deep coal) with a view to extracting gas.

As 'conventional' oil becomes rarer and thus more expensive – these more costly energy sources will become increasingly viable. Companies will need to be able to justify the high level of investment required without a guaranteed return and to take on the potential commercial risks associated with the risk of environmental damage. However none of the above offers a high volume / low cost alternative to crude oil out of the ground. To scale them up to match the current rate of production of conventional oil would require an enormous investment. Even the rather [over]optimistic IEA predicts a maximum production rate of less than 10% of current world oil demand from non-conventional sources.

There are also ocean gas hydrates but no one has yet established how viable they are to recover and use – nor their extent. Current indications are that these deposits occur in disseminated granules and layers in deep ocean and polar regions (due to the need for low temperatures to form them). They are well described as the fuel of the future and likely to remain so.

Biofuels can be used in place of mineral oils. The energy equation still has to be applied to ensure the overall return on energy invested is positive – and there is some debate about this. It is, however, land intensive and even if there is a high rate of return using current methods we would need to employ the entire farmland of the UK to meet current UK demands if pure energy crops are used.

Other technologies are being developed. For example using high temperatures to decompose plant and animal material to form oil & gas (de-polymerisation or pyrolisis). Test plants show considerable promise in this area and claim a high 'EROEI' (see below).

In summary these sources are unlikely to be able to produce the high volumes rapidly enough to meet demand, and may not be able to meet overall needs completely. Current biofuel methods in the UK are unable to provide more than a few percent of the current crude oil supply due simply to production rate limitations and environmental impact (see 'UK 2025 Scenario' later in this paper)

A Small Lesson on Energy Economics

Energy economics is very similar to normal economics – but instead of accounting for money we account for energy. By investing some energy – we need to get more in return.

It is really very simple. We need to answer the following question whenever we 'produce' primary energy, be that coal, gas, oil, nuclear, wind energy…

How much energy do you put into a system and how much do you get out?

This is the Energy Return On Energy Invested – or EROEI.

If you use a gallon of oil, say, to build and run the equipment needed to get two gallons of oil out of the ground you are winning – this is an energy ***source***. If you use 1.5 gallons of oil to extract 1 gallon this is an energy ***sink***. This is a fundamental equation to consider in ***every*** energy source.

In theory this equation defines the ***ultimate*** limit on oil and gas extraction. In practice, as noted above, technical and financial (market) reasons generally stop production from a well.

An oil 'gusher' returns 30 times as much energy as you invest – or much more. But once you have to pump the oil out, inject gas and water etc, the return on energy invested starts to fall. There are occasions where an oil well (in the USA) has been kept in operation beyond the point where it used more energy than it delivered and became an energy sink.

Whilst technical and financial reasons usually limit oil and gas production before this point is reached, it is critical when considering, non-conventional oil, coal and renewable energy:

- Coal is more energy-costly to extract. Most of the sources with a high EROEI have now been exhausted and Gever (Beyond Oil) project that by 2030 the figure will be 1 – i.e. no net gain.
- Renewable energy solutions need to consider this also – by way of example a Wind Turbine will return at least 30 times the energy invested in it over its 25 year life.
- Bio-fuels (e.g. ethanol) or biomass (e.g. wood chip) require energy to plant, harvest and process. Different analyses indicate EROEI between 1 and 5.
- Nuclear power plants use a lot of oil energy to construct, to operate, and to handle the waste.

In none of these cases can you immediately conclude there isn't a net energy gain – you just have to be careful on your assumptions.

Note in making these assessments it is important to understand that we are comparing 'like for like' energy. Newton's laws tell us that we can't destroy energy as such – however when doing an EROEI calculation we need to assess the usefulness of the energy being invested. There may be the same amount of energy in a large body of warm water as there is in a barrel of oil – however we can't get the same amount of work out of the water that we can out of the oil.

There are always exceptions. Oil as a chemical feedstock may be more valuable that the energy needed to recover it. Also since oil is a dense and portable energy source, it may be viable to use a larger amount of energy from low intensity energy source to produce a smaller amount of oil. However we may as well just produce Hydrogen and avoid the pollution that goes with oil use.

Ultimately financial economics will regulate the viability of an energy source – for example the cost of operating an oil well simply gets too high. However this can be seriously distorted by market 'rules' (for example tax incentives), so is not as reliable as a direct energy calculation.

So How Will This Affect The Global Economy?

Well the honest answer is no one ***really*** knows although the projections from those that have looked at it are not overly optimistic (and that is a euphemism).

Current economic theory is based on growth and, ultimately, unlimited resources or substitutes for these resources. Traditional market economics assumes that if there is a shortage of something, the price increases until demand is dampened. However the increased price triggers more investment, which increases supply and thus prices fall. Things are thus kept in balance - so, in summary it has the view that:

economic 'stability' = economic growth = more energy each year.

However this assumes that you can produce more by investing more. This rule doesn't apply to limited natural resources as no amount of investment will deliver something that isn't there. Substitutes are also made. In terms of energy we have moved from wood, to coal and to oil and gas. Each step has forwarded industrialisation as it employs a more concentrated and flexible energy source. After oil and gas there isn't an obvious step, no clear alternative, unless one considers nuclear power. If there were a clear alternative to oil and gas then market economic theory would still apply. But there isn't as far as anyone can see – and many have looked – so this does bring into question the applicability of the current market economic model when presented with shrinking resources.

In practice much of the West (Europe in particular) have managed with modest energy consumption increases – whilst still raising GDP. The 'energy intensity' of the European economic activity has been falling. However this has largely been through the loss of high-energy industries (such as steel making) to emerging economies. The latter tend to be less energy efficient anyway and the overall effect is much the same in that global economic growth requires increasing energy consumption.

There are many people who are aware of this issue including university professors, senior petroleum geologists, commodity traders and energy experts. Some have done their own analysis on what will happen when oil production peaks. Broadly it is agreed that falling oil supply means economic recession. The other broad agreement is that it won't be a smooth ride. There are likely to be a number of 'oil crises' each creating a recession and reduction in demand, which will then be followed by falling prices leading to brief resurgence until supply limitations are hit again. Each oil crisis could be caused by terrorism, politics, war or production limitations. So, for a while the economic outlook will be rocky with no net growth or shrinkage then, once basic supplies really start to fall, largely downhill all the way, with brief ups as we go.

The broader consequences of this are so far-reaching that it is impossible to go into any depth here. A simple statement of the possible consequences sounds a bit like predicting the end of civilisation – something that can't really be done in a few sentences. Also, no one knows what will happen. There are a few observations one can make though, under the following headings:

- Globalised Economies
- Food production & costs
- Third World
- World domination & energy
- Transportation
- Money and Debt
- Financial systems
- Domestic resources
- Complexity

A **globalised economy** requires cheap transportation. Unless oil can be replaced rapidly as supplies decrease then globalisation will necessarily go into reverse. People and goods simply will move less. They have to. It isn't a price issue – there is simply less oil so there must be less transport. Increasing efficiencies and substitute energy will offset the decline to some degree, however to increase efficiency requires replacement of inefficient transportation – and the new transportation takes energy to create. So this won't be an overnight switch.

The current high-volume **food production** system employs oil and gas to farm, produce fertilizers and pesticides, irrigate and distribute. Calculations show that (in the USA) each kcal of food uses 10 kcals of fossil fuel energy to produce. Non-US production methods may be less intense but will follow a similar pattern. Clearly, with this dependency, without using oil or gas we can't sustain the current world population. Certainly increasing oil costs will push up food costs and result in less production. The hardest hit are likely to be **Third World** countries now dependent on cheap volume food from the USA. An increasing proportion of human effort and oil resources will need to be invested in food production, and food production will need to be increasingly local as transportation costs increase. More radical moves to organic based production would also reduce the amount of oil and gas required to produce the same amount of food.

Today **global domination** (currently by the USA) requires access to large amounts of energy – essentially to power and move around a large fighting force.

Furthermore the central position of oil in the operation of the international economy (especially as it affects the USA as oil is currently traded in $) means that reductions in supply – and changes in how it is traded – will have a significant impact on US global influence. There are all sorts of potential outcomes. For example, the USA could embark on an outright military takeover of key oil sources. US trade imbalances will only contribute to instability in the event oil production peaks and prices rise.

About 90% of all **transportation** is powered by oil. There are alternatives (bio-diesel, electric vehicles) and clearly many railways operate on electricity. Cars can be made a lot more efficient – especially in the USA. However there is a limit to how far you can go with efficiency and how fast the changeover can be made to more efficient vehicles. Production of bio-fuels is also limited. Calculations show that pretty much the entire agricultural land of the UK (irrespective of current use and suitability) would be needed to grow enough bio-diesel to meet just current UK diesel fuel needs. A similar calculation shows that we would need to build 50 nuclear power stations to produce enough hydrogen for UK transportation. Realistically, however, it would be possible to 'grow' enough fuel for 10% of current needs and generate enough hydrogen for another 10% - but nuclear power stations do take 10-15 years from inception to production. There is no obvious solution for air transport. In general then it seems highly likely that individual transport and air transport will become increasingly expensive and less common once oil supplies start to fall.

Based on reactions from economists it doesn't seem that there are any tools to manage a shrinking economy over the long term. The current primary economic tool, interest rates, is targeted at controlling **money supply** to manage inflation within an expanding economy. If inflation increases, the banks put up interest rates. However this works on the theory that banks need to match the amount of money in circulation to the size of the economy – and since the latter is growing modest inflation is acceptable and leads to a gradual increase the amount of money in circulation. But if the supply of a key primary resource starts to fall its price will increase leading to inflation and recession. It is likely that banks will be stuck between a rock and a hard place. Whilst raising interest rates will deflate the economy (by pumping money from those with loans to those with investments) it is also likely to worsen the recession and lead to deflation.

The World's **Financial Systems** rely on the issuance of currency against, essentially, a future 'promise to pay'. The USA is both central to World economy and typical in issuing government bonds – essentially loans. It is not clear that using money based on these loans will continue to be viable. At present oil, US Government Bonds, Dollars and Debt are on a sort of merry-go-round. As oil becomes scarce it increases in price in $ terms. This pumps more revenue out of the USA increasing its debt. This money is created by the US government issuing bonds that are bought by foreign national banks – and the US Dollars issued to the oil producers are re-invested in the USA. With spiralling oil prices this process cannot go on for ever. A failure to sell bonds would cause the World's reserve currency, the $, to collapse. The USA shows no signs of restraint and there appears to be no viable exit route from this cycle (which is more complex than this summary implies). If and when this does stop there could therefore be major international financial and economic disruptions – and any form of continuing economy will probably require a different mind-set and very different economic tools.

There is an overall trend throughout the world towards **globalisation** and increasingly complex economies and societies. Globalisation itself requires communication – both physical transportation of goods, cultures and ideas (through people movement) and information (mostly electronically). With low cost energy we can afford to have all this communication – and afford a huge diversity of solutions. Solution development also is aided by low cost access to a global market, which allows investment to be spread over a greater customer base. Increase the cost of and reduce access to energy, and the overall level of all forms of communication will fall – with the possible exception of electronic communication. It will also become more expensive to bring new ideas and solutions to market – so there will be fewer buyers – more losers and less diversity. Solutions will take longer to develop due to smaller markets and a longer return on investment. The overall upshot is **simpler solutions** an increased reliance on **domestic production**, **resources** and general communication – and a reduction in diversity and rate of change. Very simply it will be like going backwards in time in some ways.

When Will Oil Production Peak?

There are numerous unknowns in the situation – however as of early 2005 here are some factors that could drive things in the short to medium term:

- Oil refining capacity is currently at its limits – especially in the USA. It could be further increased but needs some investment (this is a simple economic issue)
- OPEC production appears to be at its limit. Again further investment is needed and time will tell whether they are able to raise production.
- In the USA, despite some recoveries, strategic oil stocks remain low following a cold winter. The next demand point is when the USA starts doing long distance trips in the summer.
- Both terrorist and US military activity are increasingly focused on oil production facilities in recognition of the developing scarcity of the resource and dependence on production facilities
- The International Energy Agency predicts increasing demand but there is no clear way to produce it
- Financial institutions are increasingly warning of long-term high oil prices

So it is likely that we will have an oil crisis by the end of 2005. However this is largely going to be driven by lack of production capacity or through terrorist activity rather than absolute resource limitations. On the other hand if major parts of the world go into economic recession then a production peak will be delayed or obscured.

The medium term is also not too rosy:

- The Association for the Study of Peak Oil (ASPO) now predicts peak production in 2008 (2005 for Regular Oil, 2007 for all liquids) – dates by which we will no longer be able to increase the amount of oil we can pump out of the ground.
- Energyfiles predicts a production peak in 2012 assuming a 2% annual growth in the world economy.

As noted above the key difference between these projections is the potential for increased production from the Middle East. Timing of world peak production thus depends on the accuracy of reports of Middle East reserves which, if accurate, would support an increase in production. Middle East oil is geologically concentrated with most of its oil in a few fields found long ago. Combining reserve reports and production figures the ASPO calculates that Saudi Arabia (for example) has only just more than half the amount it is reporting – an assessment recently corroborated by former Saudi Aramco Vice President. If so, most of any new production will thus be needed to offset natural decline in these old fields and will not add substantively to the total production from the region.

In general then the actual timing of any one individual crisis, and the start of overall decline, is impossible to predict as consumption will not continue smoothly up to a peak and then decline. Any economic / political / war / terrorist crisis will reduce consumption for a while and thus delay the actual peak, but really we are now talking in terms of a few years here or there rather than massive changes.

So in summary the total amount of oil available is largely known, even if reserves are falsely reported. Technology will make a higher percentage of conventional and non-conventional oil viable by financial, energy economic and environmentally acceptable measures. However, even taking these factors into consideration it is highly likely that production will peak in the next few years.

What Will It Mean To The Average Person in the West?

If the ASPO predictions are correct then we've probably got about ten years of international economic roller coaster before we go into a long decline. This initial period will be punctuated by a series of oil supply crises.

Each crisis will probably have some or all of the following effects common to our current form of economies:

- financial turmoil
- stock market crashes
- inflation will increase & therefore interest rates may increase – which could lead to deflation
- fuel prices will be highly unstable but, in general, become [much] more expensive
- energy in general (i.e. including power and gas) will become increasingly expensive
- economies will go into recession
- companies will go bust
- unemployment will increase
- food will become more expensive
- in the UK property prices will crash

Beyond the next few years, things get pretty hazy – but the prognosis is, as suggested above, pretty down-beat.

What Can Individuals, Groups, Companies, Administration Do?

The first thing is simply to inform yourself and make up your own mind on the above situation. The above is ***an*** analysis of the situation, but there are a lot of opinions! There are, for example, significant unknowns in both the timing and likelihood of events, so whether these are things to do today – or have in mind for the next five years or more no one really knows. It is better to be aware and forearmed.

Individuals

This is a short-term list:

- be prepared to move investments into funds less affected by an oil driven economic downturn

- (these might be raw commodities), and visa versa in the up turns (see The Oil Factor) [3].
- consider every option for reducing usage of any form of energy, in particular that derived from oil and gas (home insulation, low power lights, solar water heating…)
- plan a low-energy lifestyle / business operation (avoid a lifestyle that requires a lot of travel)
- minimise any loans – but preferably get rid of them
- aim to increase the local element of your lifestyle / business – reduce travel, use local resources and facilities
- minimise exposure to the property market
- look for business / personal opportunities that will arise from energy shortage
- implement energy saving policies
- maximise use of renewable energy
- make provisions for supply interruptions including power, food and water

Richard Heinberg's 'The Party's Over' proposes a much more comprehensive set of actions for individuals. 'The Oil Factor' addresses the potential for protecting investments during this unstable period.

Companies

There are both strategic and tactical issues companies should consider. Many of the points made for individuals apply, however in addition:

- assess supply chain sensitivity to energy costs (transportation, energy sensitivity of suppliers)
- assess customer (both business and individual) sensitivity to energy costs
- diversify business operations to build resilience by balancing energy-sensitive operations with less sensitive ones
- establish means of reducing inter-office travel
- reduce individual commuting
- establish an energy efficiency strategy and monitor progress

Governments & Administrations

Geller has addressed energy policies in considerable detail – however it is fair to say that this was against a backdrop of global warming rather than energy shortage. The main points for a large economic region are:

- set up the market to encourage the development of diverse energy supplies (including renewables, nuclear and clean-burn coal) – in particular from domestic sources
- actively disadvantage oil and gas or, at least, put renewables on a level playing field.
- focus heavily on energy efficiency – the return per $€£ invested is much greater than any other investment
- pro-actively drive research and development into new energy sources and energy conservation
- put in place policies that favour public transport and discourage individual transport
- educate the public & businesses - be open about the energy position
- re-align agricultural policies along low-fossil fuel input and sustainable lines
- avoid a proliferation of energy quangos and NGOs – but set up a clear set of energy focused departments within government operations
- lead by example – reduce administrative energy demands
- work closely with markets, banks and investment managers to handle the impact of fluctuations in global energy prices

[3] Note that it is essential to take financial advice. This is a hugely complex area. However if these predictions prove correct then 'traditional' investment policies are unlikely to provide financial protection.

- assess the impact of increased energy costs on the economy – for example reductions in holiday visitors – increases in the cost of importing and exporting goods.
- reduce dependence on long-distance economic activity – e.g. encourage domestic production
- collate information on energy resources – both nationally and internationally – collect systematic information on the true oil reserve situation
- establish policies to discourage population growth
- pro-actively work on international cooperation on energy resource management and energy solution development – e.g. sign and follow the 'Rimini Protocol' so as to cut imports to match world depletion rate

The Alternatives - is there a Magic Answer?

It is not beyond the realms of possibility that a miracle will happen. Whilst the immediate potential shortage is with oil – used for transportation etc - the key question is simply getting enough primary energy. Whilst there are variations in efficiency we can transform one form to another. For example go from electricity to hydrogen, methane or methanol.

At present most alternative energy research is focused on the production of electricity – generally with the objective of reducing the amount of CO_2 produced. Building alternative energy solutions (for example wind power) is currently not keeping pace with increases in electricity demand – so in practice we are not supplementing or replacing conventional power generation let alone making any energy provisions for transportation.

These are some potential alternatives but no magic bullets:

Bio-fuels (from energy crops)	i.e. converting vegetable oil, crops, food and agricultural waste to produce a form of diesel oil or alcohol. The energy economics are intensely debated due to the use of fossil-fuel derived fertilisers – but broadly speaking they are viable if managed the right way. However to produce just the UK consumption of diesel oil would require allocation of 100% of agricultural land to growing rape. Not all is suitable, we also need food .. .. Another alternative is growing algae which may be viable, but requires a lot of space (more viable in, say, the USA & Australia). Any of these methods will need considerable up-front investment.
Bio-mass	By which we mean burning wood, straw etc to generate electricity, These work – however they require a lot of land to produce a relatively small amount of energy. To generate the UK's current power needs from this source would require in excess of 100% use of agricultural land for biomass. … see comments for Bio-fuels….
Coal	In principle there is roughly 200 years proven reserves at current consumption rates although it is becoming increasingly energy intensive to mine. Gever has proposed that coal will become an energy sink by 2030. Coal is also environmentally damaging although clean burn (including carbon sequestration) is being researched. Coal can be converted into a synthetic crude oil. It is likely that coal will be used increasingly for power generation and become a source of transportation fuel despite the environmental impact.
Cold fusion	If this really became viable we could be home & dry. A staggering amount of [backroom] research has been conducted and experiments are becoming increasingly

	reproducible – but not 100%. Even if it becomes established science it will still take several years to move from laboratory to factory. The US DoE have opened the way for further research in this area.
Gas Hydrates	This is a form of 'natural gas' created under high pressure and low temperatures – typically deep in oceans. Reserves of gas hydrates are unknown but considered to be massive. Hydrates, however, are both highly variable in format, unpredictable in behaviour and not concentrated in the same way oil and gas are. Extraction of hydrates is subject to government research (note that oil companies are not themselves researching this). Whether or not hydrates can deliver a high-volume energy source is hotly debated. Gas hydrates would also contribute to global warming.
Hydro-electric	In industrialised countries many sources are already in use. Development of new ones is not quick (several years) and also has severe environmental impacts, and human impact due to displacement.
Hydrogen	Hydrogen is an energy carrier – not a source. Currently most of it is produced from natural gas. You can produce it using electricity – but where does the electricity come from? It has some practical limitations – for example hydrogen is not easy to store or transport. It has a low energy / volume density. Due to the energy losses through both the production of hydrogen via electrolysis and re-conversion to useable energy its use it does not make a practical means of employing renewable energy in transportation. However see also Solar & Nuclear.
Natural Gas	World wide there is still believed to be large gas reserves, although the data is much poorer than that for oil. In the UK gas supply is crashing. Demand is also growing at a tremendous rate and it, too, will peak in the near future (see ASPO graph). The end of gas comes fast because 80% of it can be recovered from a reservoir. Gas is now being used for power generation and could also used to supplement oil. As with coal, natural gas can be converted to a liquid – although this is very energy-inefficient and costly.
Nuclear fission	The cost of nuclear power is high at present and ERoEI disputed. Both mostly due to complex safety-related engineering and long term costs of waste management. New designs and technologies are being advanced that claim to substantially reduce costs. Uranium is not unlimited but breeder reactors are an option. A key issue is simply the time to get these into production. There are about 450 reactors in the world today. We would need ten times as many to substitute for oil. (High temperature nuclear fission can be used for thermal decomposition of water to produce hydrogen in volume). For all its down sides there are few proven alternatives and governments are already signalling their intent to re-invest in this form of energy.
Nuclear fusion	Current main-stream fusion research (the ITER project) focuses on a method that researchers believe will take 10s of years to turn into a viable energy solution. There are also some very fundamental engineering and process issues to overcome – such as the production of Tritium and handling of excess neutron production.
Nuclear fusion, Non – Conventional High	There are other potential fusion candidates – for example Dense Plasma Fusion. There is also research into high temperature generation when bubbles collapse which might also lead towards new ways of effecting fusion. These have

Temperature	yet to be proven scientifically and technologically before any reliance can be put on them – however it is possible these could deliver fusion more rapidly.
Pyrolisis / De-polymerisation	This is the use of high temperatures to decompose biological material – almost like using natures way of producing oil but in fast-time. It can be applied to virtually any animal, plant or mineral oil product. Plants operating in the USA demonstrate promising results – however it is early days. Clearly the volumes that can be produced depend on the volume of feedstock and this, in its own right, must be the ultimate limitation.
Solar Photo-Voltaic	This is the 'traditional' form of solar power – producing electricity directly from sun light. Financial costs for solar PV is currently high and the efficiency needs to improve for electricity (say about 15% at present) and hydrogen (about 8% at present). Research continues to increase efficiency and with high-volume production costs will come down.
Solar Hydrogen	This technology uses a sunlight to split water using a catalyst. Currently efficiencies are below 10% (i.e. less that 10% of the light energy is used to convert water to hydrogen). If efficiency can be raised this provides a highly desirable technology.
Solar Thermal	This takes many forms from direct heating of hot water to thermal power production. There also propositions for massive solar thermal solutions that would produce electricity. These are technically viable but will require substantial upfront investment and time to deliver energy in volume.
Tar sands, Oil Shale	There are absolutely massive reserves of this stuff. However extracting it and turning it into useable fuel using current techniques is environmentally damaging and also not energy efficient. (you have to invest, say, a barrel of oil of energy to get 2 barrels out, although energy efficiency will improve). There are logistical problems that severely limit extraction rates. Also we are back to carbon dioxide emissions again.
Wind, wave, tidal	Yes these are coming on – but wave and tidal are going to take a long while to get into production and all these will take even longer to match current electricity consumption needs, let alone produce the energy needed for transportation.

It is essential to appreciate the logistics and up-front investment required to make some of these a reality. To replace the energy we get from oil would require 100s of square kilometres of solar PV, Solar Hydrogen etc. The primary energy source (Sunlight) and space (desert) does exist – it will just take time, money and resources to make these happen.

When looking at these alternatives you also have to consider the energy invested in the alternative source. Even if a wind turbine returns, say, thirty times the original investment, you need that original energy available to create it. This means diverting current energy supplies in order to create tomorrow's energy sources – before we run out of today's….. For example if we choose to build enough wind farms for the entire UK's electricity demand we would have to use the equivalent of a whole year's worth of electricity to create them. About half the total energy used by a car is in its manufacture – and the other half in its use.

However all the above can contribute to a greater or lesser degree:

- Biofuels could address some of the requirement – but are limited by available land (see calculations below)
- Wind farms could contribute up to 20% of electricity needs

- Some estimates for wave and tidal indicate potential contributions from UK offshore sites equal to the total UK requirement – however others are vastly lower. This may depend on whether you calculate the total energy in tides and waves, or the total that could be extracted subject to the constraints of practicality and avoidance of environmental impacts.
- Nuclear power is a seriously thorny subject. Detractors say the EROEI is low and the environmental impact unacceptable. Supporters claim the cost and practicality has improved and that nuclear is the only real option. It has to be said that it is the only technology available today that could both produce the amount of energy required by current society – and avoid global warming.
- Pyrolisis of waste from farms (e.g. straw) the food industry and waste water treatment could provide a significant amount of oil and gas substitutes.
- Clean burn coal is do-able – although by the time emissions have been scrubbed and CO2 sequested the EROEI will be a lot lower than current plants.
- Oil from Coal. This process is well proven – and in use in South Africa. At current oil & coal prices it is still not economic, has low energy efficiency and results in high CO2 emissions. However as oil prices rise it will become more economic. In principle the CO2 can be captured and stored.
- Gas to Oil (often referred as GTL – Gas to Liquid). Again proven technology which will be economic if the difference between gas and oil prices increases.
- Solar solutions are emerging. Solar water heating is already well proven and, in some places, competitive with traditional forms of water heating. All these crucially depend on development and the fundamental parameters of cost, performance and EROEI. Solar Hydrogen could well be one of those 'wild card' technologies that make a crucial difference.

All these options, however, take time to get into operation. Nuclear power plants take fifteen years from inception. Wave and tidal schemes will take 5-10 years before even scratching the surface of current needs. There does not appear to be any solution in the wings that can be scaled up fast enough to replace the energy we obtain from oil.

The next section looks at two potential scenarios for the UK.

UK 2025 Scenario

Extrapolating the situation beyond the next 20 years is probably meaningless as there are so many variables. Two scenarios are considered for the position in 20 years time:

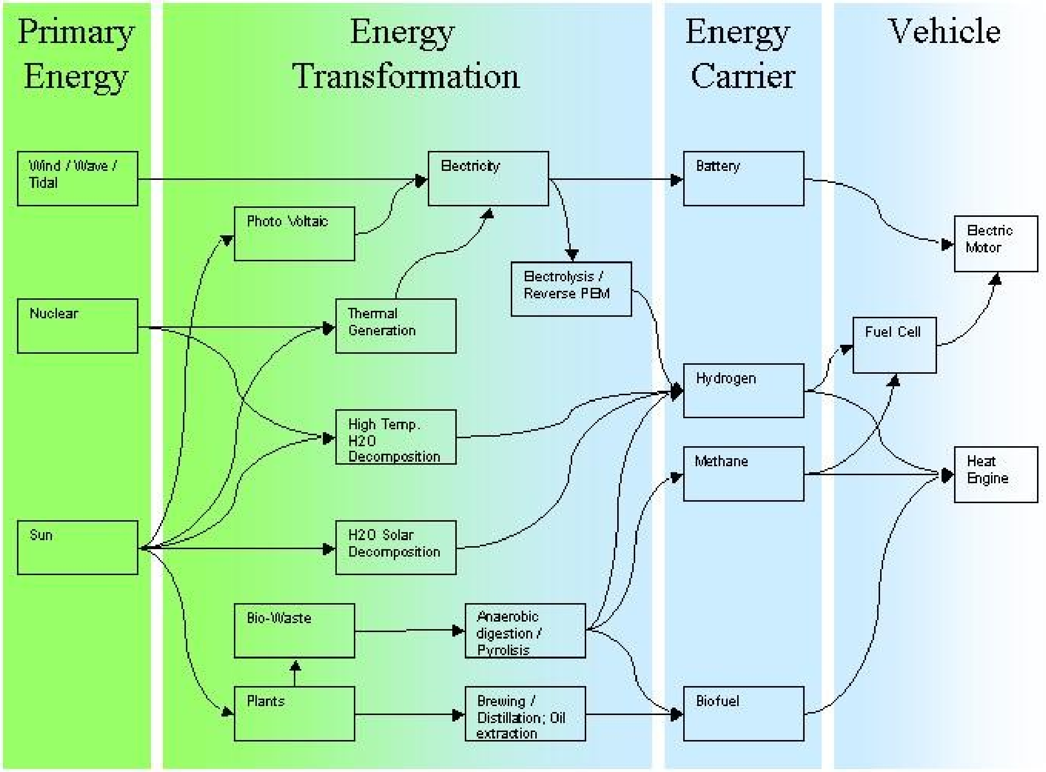
- The ASPO prediction on oil is correct.
- The EnergyFiles prediction on oil is correct.

We will assume, as a peak will result in recession, that either there is no net economic growth over this period – or that economic growth is achieved using the same energy demand but through greater efficiency.

Note that all calculations here are approximate – the purpose is to give an impression of the scale of the problem – not provide precise predictions.

The question is – come 2025 can we replace falls in fossil oil supplies with alternative fuels using technology that we have or know we an develop?

It takes 5-10 years to move a new technology into volume use – so the assumption here is that only technologies known today will be available to address this requirement in 20 years time. This assumption (know we can develop) separates the use of, say, biofuels and solar power from fusion (be it cold or hot). The latter may solve the energy problem – however we don't know if or when they will be deliverable. The diagram shows a very simplified picture of the options for alternative transportation energy looking at sources, transformation, transportation and usage. There are a number of other options and energy flows under consideration – these are the main ones.



Each brings different issues making them more or less viable. For example battery technology is gradually improving but energy densities are still far below that provided by (say) petrol. Fuel cell vehicles could run off 'traditional' fuels such as Methane (as in natural gas) or hydrogen. Both of these require substantial changes in the fuel / energy distribution infrastructure. Biofuels have the enormous advantage of requiring little change in infrastructure or transport technology – however there are limits on how much biofuel can be produced as it competes with other uses of the source materials (food, fertilizer).

Two technologies are considered:

- Biofuel production based on energy crops such as oilseed rape
- Thermal decomposition of water using heat from nuclear reactors to produce hydrogen

The following table provides a summary of UK energy consumption based on dti figures from 2001:

UK Annual Energy Figures (dti 2001)	**Primary input**	**Non-energy use**	**Converted to Electricity**	**Conversion losses etc**	**Energy Delivered**	**Energy Delivered**
	Mtoe	Mtoe	Mtoe	Mtoe	Mtoe	Twh
Total Primary Energy Consumed	248.7					
Total Energy Delivered to End User		10.9			171.7	2060.4
Total Losses & non-energy use				76.9		
natural gas	96.3	1.2	26.8	8.7	55.8	669.6
coal	41.5		32.4		3.2	38.4
electricity	0.9		0.9	61.8	28.7	344.4
hydro & renewable energy	0.4		0.4		0.4	4.8
nuclear fuel	20.8		20.8			
oil	86.2	9.7		5.4	**71.1**	**853.2**
other				1.1	3.8	45.6
TOTAL		10.9	81.3	77.0	163.0	1956.0

So in 2001 we used 71.1 Mtoe which is equivalent to 853.2 Twh.

We will assume that UK oil shortfall is the same proportion as World oil shortfall – to give an impression of how much oil we will need to replace in the UK. Looking at the ASPO and EnergyFile scenarios we can deduce the Worldwide oil shortfall in 2025 – and thus deduce the corresponding UK shortfall:

Future Oil Shortfall (2025)	**World Peak**	**World in 2025**	**Shortfall**	**UK Oil**	**UK Shortfall**	
	bbl / day	bbl / day	%	Mtoe	Mtoe	Twh
ASPO	85	60	29%	71	21	251
EnergyFiles (approx figures)	89	67	25%	71	18	211

What would be needed to replace this level of energy consumption with either biofuels from an energy crop – or hydrogen from thermally decomposed water?

Bio-Diesel

The bio diesel productivity is based on work done by Strathclyde University. It does not allow for EROEI – which could potentially more than double the land area required. This then provides the following in terms of usage of UK arable land to replace the shortfall

Potential Bio Diesel Production from Oil Seed Rape	**Potential Biofuel productivity**	**Quantity required**	**Land Required**	**Total UK arable land**	**Total UK Crop & Set Aside**	**% Crop Land Usage**
	toe per km^2	toe	km^2	km^2	km^2	%
ASPO	212	20,911,765	98,640	185,000	53000	186%
EnergyFiles	212	17,575,281	82,902	185,000	53000	156%

Clearly the above is unachievable. Whilst, in principle, it might be possible to release more of the UK's arable land (for example grassland) for energy crop production, we need food and not all land is suitable.

Hydrogen By Thermal Decomposition of Water

This process needs further development – however the basic physics and chemistry are well understood.

The assumptions are that:
- Fast breeder reactors would be used
- 50% of the thermal energy from the reactor is captured in producing hydrogen
- each reactor produces 3000 Mw of thermal power

Hydrogen Production		Efficiency*	Load Factor	Reactor Size	Annual Production	No. Reactors
	Twh	%	%	MW	TWh	
ASPO	251	50%	80%	3000	10.512	24
EnergyFiles	211	50%	80%	3000	10.512	20

Note that only about 35% of this heat would be converted to electricity in a current nuclear power station due to losses arising from the thermal efficiency of raising steam. This reactor equates roughly to that used at Sizewell B, which produces 1200Mw of power.

Summary

Production of any volume of bio diesel using energy crops can supplement current oil demands – but not replace even 20% of current oil requirements.

Nuclear power is clearly an option. However this requires considerable further development before it can be implemented. Furthermore it would require public support and development of both the infrastructure to distribute hydrogen and the in-vehicle technology to make use of it.

There are other potential methods for producing bio-fuels that would be more efficient, for example pyrolisis of animal / vegetable waste. The advantage of this approach is that it can use, for example, straw, sewage or offal as a feedstock thus leaving current land usage unaffected. Equally biofuels from algae would be more efficient as a larger proportion of the solar energy is captured by the algae. Calculations have shown that the entire US oil requirements could be provided for by 15,000 square miles of algal ponds – quite achievable in the USA.

End Note

The arguments supporting the imminence of a global energy problem are strong – and based on knowledge and observations from experienced people such as Dr Colin J. Campbell.

On the other hand economists such as Professor Peter Odell have a record of reliable predictions over many years. They put forward strong arguments that the scientists are ignoring economic realities.

Experts build reputations – and become thought leaders. Like all leaders, they are followed because they display certainty and conviction on a direction. This doesn't mean they are always right although being right helps a lot. Vacillation or change of direction is seen as a weakness in a leader undermining his argument. Perhaps of greater importance to the individuals, it can ruin their reputations.

Fortunately most of us are not experts and thus can more easily change our viewpoint. However we do need to make decisions on which of these two opposing views is right – as it may well drive individual decisions that will substantially affect our future well-being. So is it the economist or the scientist?

Economics is defined as: *'The social science that deals with the production, distribution, and consumption of goods and services and with the theory and management of economies or economic systems'.*

Economics is not a precise science. It is good at defining how economies work – however current economic theory has been developed during a period in which we have not suffered global limitations in resources, or if there were limitations, viable substitutes could be found. It is not a given, therefore, that current economic theory will be applicable in the future.

Equally it is possible to get tunnel visioned on one particular argument. As illustrated above there are numerous new ways of sourcing energy. Equally illustrated is that there are enormous logistical challenges with these.

There is no doubt that we are facing, at the very least, a major transition in the way in which we source and use energy. The world in 10 years time may be very different.

Further Reading

A very wide range of sources has been used. The following provide condensed and focused information and cover the ground most effectively:

Books:
Energy Systems and Sustainability (Open University Press)
Renewable Energy (Open University Press)
Energy Revolution – Howard Geller
The Coming Oil Crisis – Colin J. Campbell
The Oil Factor – Stephen Leeb
The Party's Over - Richard Heinberg
Why Carbon Fuels Will Dominate the 21st Century's Global Energy Economy - Peter Odell

Articles / Papers:
Oil Depletion – The Heart of the Matter (Campbell 2002)
Issue Spotlight: Oil & Gas Reserves – (Simmons & Co 2004)
Updating the Depletion Model (Campbell & Sivertsson Hydrocarbon Depletion Study Group, Uppsala University, Sweden)
UK Energy White Paper
Eating Fossil Fuels – Dale Allen Pfeiffer
The oil we eat: following the food chain back to Iraq – Richard Manning, Harper’s Magazine
Dti UK Energy Flows
UK Dti Energy Report 2004
Energy prospects after the petroleum age (Deutsch Bank Research)
Peaking Of World Oil Production: Impacts, Mitigation, & Risk Management (R Hirsch report for the US DOE)

Websites:
www.peakoil.net (ASPO)
http://news.bbc.co.uk/1/hi/business/3777413.stm
www.simmonsco-intl.com
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http://hubbert.mines.edu
www.energy21.org.uk
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www.opec.org
www.powerswitch.org.uk

Other Sources:
International Energy Agency Worldbook
BP Statistical Review of World Energy
US DoE Energy Information Administration
US Geological Survey
Energyfiles.com (subscription)

Glossary of Terms

ASPO	Association for the Study of Peak Oil
Bio-diesel	Modified vegetable or animal oils which can substitute directly for diesel oil.
Bio-Fuel	Generally a fuel derived entirely from a plant or animal source. Current examples are bio-diesel, which is from (typically) vegetable oils; ethanol which is produced from fermentation (say from sugar cane)
Bio-Mass	Plant material burnt to produce energy (for example wood-chip and straw burnt to drive a power plant); but also any plant or animal source used as a source of energy (chicken waste, dung)
BP	British Petroleum or Beyond Petroleum. Take your pick
Carbon sequestration	Separation and long term storage of carbon. When fossil fuels burn they produce carbon dioxide – which is contributing to global warming. Plants capture it and use it to grow creating complex hydrocarbons in the process. This is the natural process of sequestration but it can't keep up with the rate at which we are currently producing CO2. One option is to capture CO2 as it is produced from (say) a coal fired power station and store it long-term underground (e.g. in old oil and gas wells)
Clean Burn Coal	Burning coal produces all sorts of nasty products. Technology exists to remove sulphur. To achieve full clean burning of coal would require capture and storage or disposal of all combustion products including CO2
Cold Fusion	Apparently Nuclear Fusion – but at room temperature.
Conventional Oil	Essentially the sort of oil we all think about – liquid, flows.
Deep water oil	All the original oil wells were on land. However as these reserves have become less easy to locate exploration moved offshore – first to such places as the Mexican Gulf and the North Sea (in 10s to the low 100s of metres of water) and then to locations in 300 – 1000+ metres. The latter is 'Deep Water Oil'. The deeper you go the more costly, risky and difficult it gets to explore and produce oil.
Depletion	Using something up. Depletion of any irreplaceable resource starts the day you start using it.
EIA	US Energy Information Administration
EROEI	Energy Return On Energy Invested
Fission	Nuclear fission – energy generation through the splitting of heavy (typically Uranium or Plutonium) nuclei – the 'traditional' type of nuclear reactor
Fusion	Nuclear fusion – energy generation through the combination of light nuclei (for example hydrogen to form helium as occurs in the Sun). Current methods rely on extremely high temperatures. Inducing a fusion reaction, containing the fuel and fusion products, and extracting the energy are doable to a degree – however it will be 10s of years before this is a viable energy method
Gas Hydrate	Methane (generally) in a light chemical bonded. Effectively a material from which it is possible to extract methane comparatively easily.
IEA	International Energy Agency
Mtoe	Energy equivalent to a Million equivalent of crude oil
NGO	Non Government Organisation
Non-Conventional Oil	See oil shale and tar sands
Oil Shale	Really almost not oil at all – a stone-like form of material which holds an oil-like deposit
Peak [oil]	When oil production reaches a peak.
Pyrolisis	Using high temperatures to break organic material down producing oils, gases and carbon. The oldest application is in the production of charcoal – however this results in the loss of all the organic products.
Quango	Quasi-Autonomous NGO. Essentially partly government, partly private sector.
Solar Photovoltaic	Directly producing electricity from light – common in small electrical goods – but applicable on a larger scale. Currently a very costly way to produce power.
Sustainability	In the broadest sense a way of operating that does not use up or

	damage resources, environments, populations, animals, plants…. It is an approach that can be sustained indefinitely (within a human time-frame)
Tar Sands	Very heavy tarry oil in sand (pretty obvious from the name).
Thermal Solar	Using the sun's heat to generate electricity – for example by heating water to produce steam and driving a normal steam turbine and power generator. Also use of solar heat for heating water.
TWh	Terra Watt Hours
Toe	Tonnes of Oil Equivalent – in other words an amount of energy equivalent to that found in a tonne of oil