Six days

The future of global energy

Lorne Gifford

Today's World

The world of today is not defined by the banking crisis, credit crunch or the outrageous expenses of our members of parliament. Equally it's not defined by terrorism and conflict in Afghanistan, Iraq or Israel. It's not even defined by the good things that we often overlook, such as our unprecedented life expectancy, quality of living or social safety nets. Instead, today's world and all it provides us can be defined by a single number.

Here in Great Britain like most of Europe that number is 6. In North America and Australia it's 3, in China and India 30, and in the less touristy parts of Africa it's something over a thousand.

Six days is all it takes for the average British family to consume a barrel of petroleum.

Petroleum is crude oil and natural gas. Oil can handily be counted in barrels. Natural gas was formed in the same way as crude oil and comes from the same wells that are drilled and produced in exactly the same way. Being a gas, you can't count it in barrels, but you can count it as an equivalent number barrels of liquefied natural gas. Hence in the UK the average family burns its way through an equivalent barrel of crude oil and natural gas every 6 days.

A barrel of petroleum in less than a week? That's pretty amazing. It's easy to visualise a barrel and understand that it's quite a large amount, and the average family certainly don't spend all day and every day driving around in a V8 Range Rover to get through it.

The average British family, lets call them Tom and Sarah Jones and their children Connor and Emily, actually has a 4 cylinder Ford or Vauxhall that in six days will cover just under a hundred miles and in so doing use about 3 or 4 gallons of petrol (gasoline, one of the major things crude oil is refined into). Their dramatically high petroleum use comes not from the car, but from everything else that supports their life. It comes from the more obvious uses like central heating, the gas cooker and Thompson holiday flights to Spain, to the diesel the farmer uses in growing their food and natural gas the power station burns to generate their electricity, through to the less obvious like the nitrogen fertiliser and pesticides that support high crop yields and the bunker fuel needed to ship Tesco's economy bin bags from the factory in Thailand. Come to think of it, the bin bags themselves and every other piece of plastic packaging that forms such a large proportion of the Jones's weekly rubbish, as well as paint and ink, clothing, the 'rubber' tyres on their Ford Focus, diesel for the mining equipment used to dig out every other raw material, diesel for the lumber companies that supply Ikea with wooden flat packs, even our soaps and detergents. The list, of course, goes on and on, and we all vaguely remember the 'everything that's produced by oil & natural gas' diagrams from school.

What we don't remember from school is that back when Tom and Sarah Jones were sitting in the classroom little Connor and Emily now occupy, the world as a whole consumed about half as much petroleum as it does now. How come then, with all the talk of renewable energy and more efficient cars, do we use twice as much petroleum as we did only 25 years ago?

In this slim book I will explain how we got to a petroleum consumption number of 6, why it's as low as we're going to go and why it will soon be pushed out toward a month and beyond. I use the word pushed quite deliberately, as it's not something we have much choice in and not something we will willingly do. And by 'we' I mean quite literally you and me; us, those people alive today and not our children or their children. It's not something we can put off until our old age either, it's something that we will be doing in the very near future, and indeed may already have started on with today's financial and banking crisis merely being the opening salvo.

Of course we don't use oil and gas for all our energy needs. There are also all those new renewable energy sources as well as nuclear power, coal and a couple of others. Interestingly though, and despite everything you might believe, we rely on oil & gas for almost three quarters of our energy use here in Britain. All the rest of the fuel sources added together make up only one quarter of our energy mix. So regardless of whatever label you might want to give to our bright and shining technological world, it is still at its very core, the Petroleum Age.

I am going to concentrate on petroleum, with hardly a mention of coal, nuclear and renewables because of our overwhelming dependence on it and the unique way in which this highly concentrated energy source is easily moved around with us. It's that last feature, energy mobility, which has done more to create our modern world than all the politicians, armies and technology innovations put together. A cheap and mobile energy source is the driving force behind global markets, mass production, just in time inventories and every other facet that makes the modern world as productive and consumer orientated as it is.

I hope Mr and Mrs Jones find the time to read this book as doing so will help them in the choices they suggest to Connor and Emily when their children probably become the first of their line of Jones's that go onto university. Unlike previous recessions which saw a sharp decline in industrial and manufacturing jobs, this one has started a new trend for slashing service sector work. Indeed, in 2009 the only private sector employers looking for more graduates than the year before were in the energy, water and utilities bracket. As we will see, this is a telling indicator of how economic activity will re-align itself to the plateaux and then decline of the petroleum age.

The other reason this book is slim is because there isn't really that much to say. The end of our current way of life may already have begun so I am not about to pad it out with waffle, rhetoric and deliberately complex logic. It doesn't need it, simple facts will suffice.

Can we sustain our present oil consumption?

The petroleum age has been with us for over a century now. It started on a remote hill in south east Texas, known as Spindletop, on the 10th January 1901 with an oil strike that fundamentally changed a burgeoning new industry.

Having drilled to the unheard of depth of a thousand feet based on the theories of geologist Patillo Higgins, engineer and financier Anthony Lucas was partway through recovery and change out of the worn drill bit. As the weight of the drill string lifted off the bottom of the hole a loud crack echoed out, drawing immediate attention and concern from the rig crew. A broken drill string was the last thing they needed on the already horrendously expensive gamble of deep drilling. The crack was unusual though as the crew felt it through their feet as well as with their ears and it indicated something deep within the earth had just given way. Concern quickly turned to terror as the drill string started accelerating out of the hole all by itself. A thousand feet of drill pipe shot out of the hole, riding a wave of black crude that gushed several hundred feet into the sky. It was the classic image of an oil strike. The Lucas 1 well flowed at something over 100,000 barrels a day and had singlehandedly just doubled world oil production.

Before the end of the year, Lucas's well was joined shoulder to shoulder by hundreds of others, all fighting for space on Spindletop. Deep pits were dug and rapidly filled with lakes of crude as strike after strike produced gusher after gusher. Production soared and the modern oil boom was on. The gusher that heralded that first black gold rush created many of the companies that would come to dominate this new industry including Gulf (now part of Chevron), Amoco (part of BP) and Texaco.

You only need think for a minute about the practicalities of running a ship to see why the sudden influx of oil onto the world market led to a massive conversion from coal in industry as a whole and particularly in the transport sector. The coal fired boilers of the Titanic required 150 stokers to keep them fed and cleaned. Because coal is a relatively bulky and heavy fuel, a low density energy source, Titanic burned 10,000 tonnes of it in the 3,500 mile Atlantic crossing, or at least would have if she'd made it all the way to New York. Just one year after RMS Titanic sank on her maiden voyage, the new pride of the British Navy, the super dreadnought HMS Orion took to the oceans. The Orion had no need for stokers as her oil fired turbines were fed directly from storage tanks without shovelling or clearing of burned ash. And because of the much higher energy density of oil, she used just under 3,000 tonnes to cover 3,500 miles, so was less dependent on port calls and could spend more of her time hunting down and sinking the Kaisers' Imperial Navy. Burning oil instead of coal saved HMS Orion 15% in crew numbers, 50% in bunkerage and meant she had more powerful engines that bought her up to speed much quicker. For a similarly sized modern container ship operating on a crew of less than a dozen, the savings are altogether more significant.

Spindletop was incredibly important in the formation of today's world. Before it oil had been a scarce commodity used mainly for lamps and lubrication, but afterwards it was realised there was going to be so much available across the world and in such large volumes that it could become the fuel of choice. For the newly emerging aeroplane and automobile industries it was not only the fuel of choice, but thanks to its high energy density and the relatively small and light engines that burned it, it became the only choice. Steam engines and electric batteries rapidly gave way to the power of the internal combustion engine.

With Patillo Higgins' revelation that you could find oil simply by applying science to rocks and hills, geologists and engineers from the new oil companies set out across Texas, America and then the world to find and secure as many fields as they could.

The subsequent exploitation of the world's oil resources followed a remarkably similar pattern to game hunting in Africa. The game scouts, or trackers, (geologists in oil terms) headed off into the bush to track down the game. Not surprisingly they started with the nearest big prize animals like elephants and rhinos. Because of their sheer size the big animals left enough clues lying around that they were pretty easy to find. In hunting terms I guess the clues were big foot prints and enormous piles of dung. In the oil industry the clues that gave away the original elephants were unusual domed hills where there were no others and sometimes seepages of tar, pitch or crude. The hunters (our oil industry engineers) then followed, and again started with the highly prized and close by elephants, before working their way further from camp and down the game chain. Along the way a few elephants and rhinos were lucky enough to find themselves in newly established safe havens like the Masai Mara game reserve in Kenya (the Alaska National Petroleum Reserve, or Antarctic drilling treaty) and so avoided total annihilation.

As the oil hunt got into full swing, the price crude traded at fluctuated wildly as more and more elephants were found and more and more industries switched to oil, generating wild swings in supply and demand. The pattern continued until the 1960s, 1965 to be exact. By this time most of the world's oil provinces had been identified and global output levelled into the familiar pattern of a slow and inexorable climb as the engineers went about their business of bringing the new fields online. 1965 is a key year because up to that point the geologists found more new oil reserves each year than they had done the year before. After 1965 they found less and less new oil each year. In fact, the 45 year declining rate of oil finds since 1965 has been so stable that it has long been projected into the future to give a pretty accurate sum total of all the oil there is in the world.

Don't miss the importance of this statement; it's saying that we pretty much know exactly how much oil there is left to be discovered. The oil industry has scoured the globe several times looking for new fields and provinces. Areas you might think have not been investigated, like under the polar ice cap, actually have been. Underneath the polar ice cap there are both oil and gas reserves. Thanks to quirks of geology though, the oil though is generally on the Russian side with natural gas on the European and American side. The oil industry is so large and so global that it has long since disproved the classical economic theory that assumes there is always more of a raw material to be found if the price warrants further looking. We've looked further, into every nook and cranny and have discovered that oil supplies are finite, there is an end, and we know where that end is.

So the good news from projecting the find rate into the future is that the world has about 40 years of oil reserves left at the current production rate. For the sake of adding an impressive number, that's 84 million barrels per day, every day, for the next 40 years. You've probably heard mention of this 40 year number before as politicians, and the odd oil company CEO, use it to show that we can delay thinking about energy reserves for their term in office.

The bad news though, as we'll see, is that the politician's number doesn't really tell the truth because '40 years of oil reserves at current production rates', is physically impossible. To explain why, we first need to go back to our big game hunting analogy.

In the oil hunt it took until 1965 for our scouts to cover the whole world and log the herds of big animals; the elephants and rhinos. After 1965 the scouts turned around, went back over the ground they'd already covered and started logging the smaller animals; gorillas, impalas and suchlike. Having done that they once again turned around and started looking for the really small stuff, animals that were not only smaller but often lived in the more inaccessible and awkward places that had been skipped over before. Now, although the scouts were generally logging more animals each year, and still finding the odd elephant, the total tonnage of meat being noted was falling. It takes several springbok to add up to one gorilla and an awful lot of gorillas to make an elephant.

Organising a big game safari needs plenty of time and money, and so not surprisingly the tonnage of trophies our hunters bought back didn't peak in the same year the scouts peaked in finding it. There was a lag. Thanks to the likes of Teddy Roosevelt and Ernest Hemmingway, the African hunting lag was only a few years, but switching back to the oil industry the lag is somewhat longer.

Oilfields differ from elephants in one key respect. It's not a case of a single shot between the eyes with a 4 bore rifle, saw the tusks off and head back to camp for champagne and caviar. Oilfields are tricky beasts that take a lot of drilling with sometimes hundreds of wells, of which half may produce oil and the other half inject water, gas or a bunch of chemicals to maintain reservoir pressure and keep the oil flowing toward the producers. Once the geologist thinks he's found an elephant the engineers need to drill it, start producing, map the reservoir and then build the production rate up to the maximum the geology will allow. At the same time facilities need to be built to process the raw crude to a quality and stability sufficient for transport and of course install pipelines to take it to the nearest convenient shipping point.

Do this with enough elephants and rhinos, and spread them out around the world with widely differing political, geological and technical problems and you can begin to see that there's going to be a long lag between the peak finding date and the peak production date. Then add in to this that offshore and deep drilling technology has also been advancing, so that we've been able to replace dead elephants by shooting many more gorillas in ever shorter times. Unsporting as it may seam, but whereas your average game hunter still ventures forth with a single shot rifle, your average petroleum engineer now heads into the bush with the equivalent of several Maxim machine guns, a pocket full of grenades and a radio to call in an air-strike if he finds something worth killing really well.

Oil reservoirs, water injection and the geological limit to production

At this point it's probably worth explaining what an oil reservoir actually looks like and what the geological limit is all about.

Many people image an oil field to be a big empty cavern a couple of thousand feet below the ground that is full of a nice liquid black crude. All you have to do is drill a hole into it and suck up all the oil with a big straw.

An oil field or reservoir, the terms are interchangeable, really can be imagined as a nice big cavern. Instead of being full of crude though, it's actually packed full of sand or heavily fractured soft rock. The oil in the reservoir occupies all the tiny spaces between the sand particles or cracks in the rock. To get that oil to move towards a production well you've got to push it, which you do by injecting lots of high pressure water behind it, hence water injection.

The cavern itself is typically not that high, maybe about the height of St Paul's cathedral if you're really lucky. It can be very wide and long though, covering as much space as a good sized city.

So into this city sized reservoir, which these days is typically 3 or more miles below the surface of the ground with another mile or so of stormy ocean above it, you need to drill a lot of holes to get at all that oil. Like a city, the cavern will be broken up into separate parts, the districts and suburbs, each one needing at least one producing well and another water injection well. The holes, or wells, are not vertical anymore. They deviate away from the central drilling platform as they go deeper to spread out and capture as much area from a single drilling centre as possible. Offshore drilling platforms cost half a million dollars a day to run, so it pays to minimise how many you have. Once a well reaches into the cavern, 'pay dirt', it is deviated further, often to a completely horizontal hole so it can tap through as much of the reservoir as possible. Some of the wells that reach to distant suburbs can be up to 9 miles long and take a couple of months to drill.

Having drilled the wells, you then plumb all the drilling centres together with a mass of pipelines, chemical lines, water injection systems and control umbilicals, install a production rig or two, process equipment and export pipelines or mid ocean tanker loading points. Not forgetting of course that since we don't particularly want a subsea well blow out or loss of control of the system, we have an awful lot of safety features, monitoring equipment and redundancy down on the seabed. Finally, having spent several billion dollars of company money and having made the accountants really sweat, you can start producing oil. Drilling and development work continues long after oil is first produced with each suburb picking up several more wells to maximise the efficiency of extraction, so the expenditure is still high, but at least with oil flowing there is money coming in.

As a bit of a bonus, the first oil from a new field will often drive itself up to the production platform without much help. Crude oil normally has a degree of dissolved gas in it and given the chance, the gas will expand and in so doing drives the early oil up the wells. The Lucas 1 well back on Spindletop was such a gusher because it was a high gas content crude. Needless to say an uncontrolled gusher pumping 100,000 barrels a day of crude from the bottom sea of the is not what we aim to do in the 21st century, so there are monitoring and control systems and blow out preventers sitting on the seabed. If something on the surface goes wrong, like hurricane Rita, then the subsea systems take over and shut down production in a safe and controlled manner.

Within a couple of months of first production the natural gas drive will start to diminish and it’s time to begin water injection. Now, if you push too hard with the water injection then you’ll not only push oil into the producing wells, but you’ll also start pushing a lot of sand into it. This will clog up the well and make it less productive. So there’s a limit to how hard you can push and a limit to how much oil a well can flow. The limit is higher than it used to be, much higher thanks to a lot of technology such as acid fracturing, sand screens, down hole pumps, sand traps and smart geophysicists who will have studied the drill cuttings as the drill bit cut through the pay dirt and figured out what the limit is. The production limit is still there though, and if you go above it all you’ll do is clog up the wells and reduce the amount of oil coming out of the ground.

Push too hard with the water and you’ll also encourage it to find a single nice easy path that cuts right through the oil bearing formations and runs directly to the production well. This is not a good thing to do. You’ll have written off the costs of drilling the wells (which isn’t exactly insignificant) and you’ll have broken your suburb up into two smaller suburbs so will have to drill four more holes to get it back online.

Oil fields therefore have a production limit, a limit that is defined principally by the geology of the reservoir and a limit that it is not possible to go above.

The lag between finding and production

Getting back to 1965 and the best year ever for finding new oil reserves.

Because of all the factors associated with bringing oil fields on stream and building up the production rates to the geological limits, the lag between 1965’s peak finding year and the peak producing year has been calculated at anything between 40 and 55 years. Hopefully you can begin to understand why it's such a big lag, but crucially it indicates that global peak oil production will occur somewhere between 2005 and 2020.

Don't forget that we know how much oil there is in the world, including the stuff we haven't even found yet, we know how much has been produced, what the current production rate is, which new fields are coming online to offset depletion of older ones and can hence predict how the annual production rate will build, plateau or tail off. In a global game nothing is for certain, but these are as close to engineering certainties as you'll ever get.

The only uncertainty, and the cause of the 15 year spread on peak oil date, is how OPEC and in particular Saudi oil wells have been performing in recent years. I'll cover the reasons behind this uncertainty in a minute.

Once we reach peak oil supply, well there's only one way to go and it's not our politicians' belief of a level supply for 40 years and then fall off a vertical cliff when it all suddenly runs out. Remember I mentioned that we pump water into the reservoirs to push the oil to the wells and get the highest possible production rate? Well after you've been doing it for a while the reservoir becomes saturated and some of the water begins coming up those wells, a little bit at first and then more and more. The Forties oil field in the North Sea is a classic example of how water cut affects production.

Forties was one of our own home grown elephants. After coming on-stream in 1978, production rapidly rose until it was able to produce a quarter of Britain's oil through most of the 1980s, back when we were a world class exporter. That was half a million barrels a day all by itself. Then the inevitable happened, the water broke through and the water cut started increasing. Instead of pushing the oil to the wells, the injected water now washes it from all those tiny crevices. Forties didn't go from half a million barrels one day to zero the next when it ran out. In fact Forties is still producing, more than 20 years after passing its peak, only these days of the half million barrels a day of production fluid coming up the wells, 90% is water. Forties has gone from a giant oil field to a giant water processing facility as 450,000 barrels a day of water are separated from the oil and then pumped back into the reservoir.

Even though Forties passed peak production in the 1980s, it wasn't until 1999 that the North Sea as a whole peaked in output. That was thanks to all those gorillas we were machine gunning in the late 80s and 90s. Since the province as a whole peaked in 1999 though, its decline has been a textbook example of the power of water cut and predictive mathematics. The North Sea has given us an early run of exactly what is happening on a global scale. It's not alone either, as numerous oil provinces from Texas to Borneo have peaked and declined in exactly the same way.

Like Spindletop at the start of the 20th Century, water cut in the 21st Century is far more significant than you first think. The facts are very simple and very important, so important that I'll repeat myself for the one and only time and say them again, slowly;

Water injection leads to water cut, and water cut causes a declining production rate. It happens and there's absolutely nothing you can do about it.

And of the world's oil fields, fully 100%, as close to every single one as makes no odds, relies on water injection to maximise production rates. That means every single oil field will follow exactly the same mathematically predictable pattern of building to a peak production rate, plateauing and then declining. If you think you have a smart idea to get around the water cut problem, then patent it, tell the world and live the rest of your life richer than Bill Gates. Better still, tell me and we'll patent it together.

Although the world's oil industry supplies 84 million barrels of crude per day, we actually pump a lot more production fluid out of the ground. Globally the water cut from wells averages over 50%. So to get those 84 million barrels of crude we're actually pumping more than 170 million barrels of production fluid.

Those simple folk that think we have 40 years of oil left just don't get it; there is far more than 40 years of oil production left to go, but that's only because it is impossible to maintain the production rate once it reaches its peak. If our great grandchildren wanted too, then in a hundred years time they will still be able to pump 170 million barrels a day out of the world's oil wells, but by then they will be pumping nothing but oily water, not worth the energy needed to separate the oil and dispose of the water.

Oil, money and politics

Previous oil supply shocks happened in 1973 as a direct consequence of Israel's Yom Kippur war, 1979 when a revolution in Iran led to the disruption of exports from the world number two supplier, and 1991 when Saddam Hussein invaded Kuwait and annoyingly set fire to all the wells on his way back out. The most recent price spike occurred over the winter of 2007 to 2008 when the price of a barrel of crude oil came within a whisker of the $150 level.

Looking at the pattern of these spikes you could reasonably assume we get one every decade or so and that they are followed by a fall in prices and the resumption of our high consumption rates.

There was a subtle difference if the price spike of 2007/8 though. The previous three could all be attributed to sudden politically driven acts that reduced the supply of oil to the world market. But in 2007 there were no such problems.

Granted that Iraq was only at 2 million barrels a day, but it had been since the sanctions imposed after the first Gulf war and the hostilities since the end of the second. There were supply disruptions in the Nigerian Delta due to terrorist/separatist activity, but these were no more serious than in previous years. Traders have been blamed for generating a lot of the price increases due to speculation, but this subtly misses the point. The price spike of 2007/8 represented the end of an unprecedented five year run up in oil prices caused by increasing demand, which finally resulted in the global demand curve trying to go above the global supply curve. Put simply, more people were trying to buy oil than there was oil floating around.

And what happened then? Did Saudi and the rest of OPEC ramp up production to maximise on this unprecedentedly high price? Curiously they didn't. Global production hardly rose at all, and the rise that did occur can be largely attributed to non OPEC projects shifting over to an ultra fast track to get them on stream as early as possible. After the continuous increase in oil output year on year since Spindletop in 1901, global oil production actually hasn't changed at all since late 2005, instead it's levelled off into a plateau.

So why didn't OPEC increase production? Why did Saudi Arabia in particular allow oil to go to such an unsustainably high price that it triggered the deep global recession we are now in? For the last 30 years Saudi has talked of being the swing producer, the hand of reason that wouldn't allow oil prices to rise to levels that damage economies and trigger recessions. So why didn't they do it when oil was becoming so obviously expensive that the world began to slow down and stagnate? More to the point, why didn't they do it when they had seen 5 years of rising demand instead of a sudden political crisis and so could quite easily see what was happening and had all the time in the world to react? Could it be that in 2002 Saudi's production capability was quite a lot closer to the maximum than we realise, and that by 2005 they were at full capacity with no reserve left?

Incidentally, and as a sideline, if you think today's economic problems are due to the fall out from those risky mortgages sold to unemployed people in Middle America, then you are mistaken. It is now becoming clear that the current recession was due to the five fold run up of oil prices from 2002 to 2007 causing inflation in goods and food prices. This slowly bled away freely available credit as trillions of dollars from Western economies were diverted to the oil producing nations. As the available money supply tightened, interest rates inevitably rose, and that triggered the defaulting on toxic mortgages which led to the collapse of our financial markets. The bankers, of course, supplied the detonator to the credit bomb by selling the mortgages in the first place, so they're not entirely blame free.

Remember our Jones family and their consumption of a barrel of oil every six days? The five fold price hike since 2002 meant that instead of spending $5 a day on petroleum, by the end of 2007 they were spending $25 a day. For an average family that's a lot of money. And for an average economy that's a heck of a lot of cash disappearing overseas every day.

Of course, our economists and bankers have now figured out a solution to this problem; just print more money and spend it under a scientific sounding term like 'quantitative easing'. It was tried in Germany after World War 1, Argentina in the 1980s and more recently in Mugabe's Zimbabwe. Regardless of any short term gains, the downside is devaluation of the nation's savings and the very real possibility of run away inflation and a collapse of confidence in the currency.

Far more worrying though than Britain printing a couple of hundred billion new pounds, is that the United States has started printing trillions of new dollars under their own policy of quantitative easing. If the US gets this even slightly wrong then the ramifications will impact on all.

The dollar has long been the global currency of default. Most governments, banks and international companies hold large US dollar reserves because oil, along with most other commodities, is traded in it and the dollar has traditionally been seen as a safe and stable currency backed up by the largest and most profitable economy in the world. By printing dollars, the United States is not only devaluing the world's savings, but it is running the very serious risk that global markets will respond by moving to newer and more stable currencies, or possibly even back to gold. Those countries with significant surplus cash flow are certainly buying gold at an unprecedented rate and in so doing have driven the price up to record levels. China and India are just two examples of powerful economies with no natural ties to the US that are on a gold buying spree. If they decide to start offloading their US dollar reserves then the influx of dollars into a global economy that now see's them as a risky holding could well precipitate a total collapse in confidence and value of the currency. This would stall not just the US economy, but every other economy that ties its exchange rates to the greenback; essentially most of Central and South America, or has significant trading links with America; which is us in Britain.

Oil, money and politics are deeply intertwined. The oil industry understands money, politics and risk since these are fundamental parts of working in a global industry. Unfortunately though, it seems the world's politicians still don't understand the oil industry and still don't understand that 40 years of production at current rates simply isn't going to happen.

Are we at peak oil right now?

That the 2002 to 2007 run up in oil price wasn't cause by political events is obvious as there were no events in that period that caused any significant supply constraints.

In hindsight it now appears to have been driven by geological and engineering events. As global economies grew at unprecedented rates, peak oil supply was slowly being reached and the demand curve was getting ever closer to trying to exceed it. As the margins got smaller, then smaller events began to have a larger effects and it became easier for speculators to hedge against oil futures knowing they would turn a handsome short term profit.

The reason we didn't know we were reaching peak oil quite simple. The largest OPEC countries including Saudi Arabia, haven't changed their estimates of how much oil they have left in the ground since the Western companies withdrew or were thrown out from these territories in the aftermath of the 1973 Yom Kippur war. For 35 years their oil reserves have been closely guarded state secrets. We haven't been able to look into their reservoirs, had accurate data on water injection rates or reviewed their reservoir management programmes. Speculation and the odd titbit of information has leaked out, such that Saudi's Ghawar field, the mother of all oil fields who's 3,400 wells pump out fully half of Saudi's oil, are now running between 35 to 55% water cut. But not enough information has been available to accurately predict overall OPEC supply capacities. All we have to work with is the curves of the original oil finds and production profiles. From these, which incidentally are known as Hubbert curves after the American geologist Marion King Hubbert who first used them to accurately predict the rise and fall of Texas oil production, we have been predicting peak oil would be reached at sometime between 2005 and 2020.

Without better OPEC data that was as good as we could get and unfortunately the 15 year margin has been big enough for politicians to ignore that it might happen tomorrow, today, or as now seams quite possible in late 2007.

The recession has driven down oil demand in the same way all previous recessions have. We're buying less Chinese goods so there is less shipping demand, new car and truck sales have fallen through the floor, everyone is holidaying in Devon and Cornwall instead of Spain, and even food sales have become more focussed on the now cheaper local produce rather than those out of season delicacies flown in from the other side of the world.

As oil demand tapered off the price fell even more dramatically than it had risen. By early 2009 it bottomed out at a quarter of the previous years high. Oil price now appears to be incredibly sensitive to even the smallest changes in supply and demand. Demand dropped by only 3%, but the price spiralled down by 75%.

The only way we will know for certain if we are at peak oil is as our economies begin to recover. As the global market picks itself up and oil demand recovers we will either see additional capacity coming online from Saudi or we will see another spike in prices that will send us back into recession.

As it stands right now, the whole world is relying on the reassurances of a few men that their state secret is not going to broadside us. If it does then the next oil shock will happen in 2011; the year demand is expected to have recovered to the 2007 high.

Why are we using twice as much oil as our parents?

Just how did we come to be so dependent on oil in an age when we should have had the foresight to realise what was happening and do something about it? Well, just how the hell did we become so dependent on credit in an age when we made more money than ever before but never got around to just saving up for things like our parents did?

The answers to both these questions are because it was there, it was cheap and easy to get hold of, and we prefer to have things now rather than wait for them.

Back in 1973 a very brief and very minor war between a small country and its neighbours transformed the world energy scene and set in motion a series of events that has bought us blindly to a world on the edge of an unprecedented energy crisis.

The war was called Yom Kippur and it didn't even last for 3 weeks.

6th October 1973 was the Jewish day of atonement; the Yom Kippur public holiday in Israel. As always, Yom Kippur bought the country to a complete standstill, with even the moderate non-orthodox Jews turning the radio and TV off and spending the day at home with their families.

Seeking to regain territory lost in the even shorter 6 day war of 1967 a coalition of Egypt and Syria supported by Iraq and later Jordan capitalised on the reduced alertness of their neighbour and launched surprise attacks on the Northern and Southern Israeli boarders.

The heavily outnumbered Israeli Defence Force had only been partly caught by surprise though, Egyptian President Assad's earlier public declarations that he was going to wage war on Israel probably making up for any lack of attentiveness on that day. They gave little ground in the first day of battle and by the second had fought both invading armies to a standstill. Even so, by the 9th October, just the third day of fighting, the ferocity of battle had generated an attrition rate on soldiers and equipment that was so high the order was given for 'preparation for the end of the third temple'. This was for arming and loading Israel's 13 atomic weapons onto their launch aircraft. We have Mordechai Vanunu, the weapons scientist who blew the cover on Israel's atomic and nuclear bomb programmes in 1986, to thank for this nugget of information.

Knowing the level Israel was about to escalate the conflict too makes the US response now seem perfectly understandable. At the time though, it was seen as blatant support for the Jewish cause and an equally blatant undermining of the Muslim states.

To prevent the imminent atomic war (incidentally there's a big technology step from atomic to nuclear weapons, but that's not relevant here), President Nixon ordered the immediate supply of upwards of 50,000 tonnes of the most advanced military equipment direct from American bases to the Israeli front lines. The first of this equipment had been shipped half way around the world and pressed into service only 2 days later. It proved decisive in the battles and once again the tide of war turned against the Arabs.

The Arab anger at having victory so suddenly turned into yet another humiliating defeat was understandably very bitter. Even today I have Arab friends whose fathers curse the American tanks they suddenly came up against that had less mileage on them than the distance from Jerusalem and the still fresh paint of the Star of David covering the Stars & Stripes.

It was only one day after the first of these tanks were encountered that the Arab world responded with an immediate oil embargo against the USA and Netherlands, the Dutch having allowed their airports to be used for refuelling the US supply flights. The embargo triggered a four fold increase in crude prices and tipped the world into a decade long recession. More importantly though, the balance of power fundamentally changed from the oil companies to the oil producing nations as these nations took a firm control over their own resources.

The oil companies responded by pulling their engineers out of the Arabian deserts and sending them into the snowfields of Alaska, the stormy waters of the North Sea and any other province that wasn't OPEC controlled to develop new oil supplies. To use our big game analogy, the elephant hunt was over and gorilla meat was now firmly on the menu.

It took nearly a decade to bring the new provinces up to sufficient production to make enough of a dent into OPEC's cartel to bring oil prices back down to reasonable levels. But by 1981 non-OPEC production exceeded that from the OPEC countries and the cartels strangle hold on crude supplies began to relax.

Now, as the oil price began to fall you might think it would make sense to throttle back on both OPEC and the new non-OPEC production to try and support the price a little. But because of the global nature of the oil industry this didn't happen. The oil companies (the big multinationals like Shell, Exxon and BP) ran production as high as possible to make back the enormous investments the new provinces had cost them and keep shareholder dividends up. And in response the OPEC countries opened their taps to make up for the revenue they were losing because of a falling price and falling market share.

You must bear in mind that OPEC is far from a coherent organisation and at times it is able to make only the most general rules for its members, who in turn often ignore them. In the early 1980s OPEC spanned such different ideologies as ultra conservative Sunni-Muslim Saudi Arabia, Shiite-Sunni divided Iraq, Ayatollah Khomeini's strictly Shiite Iran, Christian Venezuela and multi-religious Indonesia. Two OPEC countries, Iraq and Iran were partway through an eight year war for dominance of the upper Persian Gulf and almost as soon as that was over Iraq invaded Kuwait on the pretext that Kuwait was quota busting and pinching Iraqi oil by directionally drilling under the boarder. Most of the OPEC countries at this time had no sources of wealth other than from the sale of oil, and over the previous decade they had come to rely on it for numerous social and not so social uses. Even Saudi Arabia, the great swing producer who was suppose to moderate its own supply to make up for quota busting by every one else, increased exports a little to give the multinationals 'a good sweating'. The predictable result was that the price of oil fell to single figures and the age of the oil glut came upon us.

The stagnation in consumer growth that had accompanied high crude prices began to reverse and we started to move toward the world as we currently know it.

Instead of technology advances leading to better mileage from cars and trucks, the automakers now used efficiency gains to add ever bigger and more powerful engines in ever bigger and heavier vehicles. Just take the medium sized executive car from

BMW as an example. As we went into the 1980s the most powerful version was the 528i. It sported 170 bhp and topped out at 129 mph, I know because my father had one and it was the quickest thing around. By the end of the 80s the BMW 5 series extended to a new M5 version that put out nearly double the power of the old 528i and reached an electronically limited 155 mph. Squandering efficiency gains has gone on right up to the present day. Despite increased use of lightweight composites and alloys, the latest M5 has a curb weight a third up on the 1980 car and carries a 5 litre V10 under the bonnet. At 500 bhp it has almost exactly 3 times the power output of my dad's old executive express. America, as always, went one step further and ditched the car altogether in favour of two and a half tonne SUVs.

The year on year supply of incredibly cheap oil through the late eighties and nineties led directly to the massive increase in global markets that we've all benefited from in the last two decades. Instead of manufacturing steel in Europe it became cheaper to ship the ore to China, have it turned into steel there and then have the finished steel shipped to us. Lamb joints began to come from New Zealand and coal from Australia instead of Wales, and everything from clothes to electronic components was soon made in low cost economies and transported across the world to markets. Like cars, the average speed of shipping increased with a typical container ship moving from a 12 knot cruise to 20 knots. Products were delivered to market faster and so the return on investment was quicker. With a single digit oil price, the vast increase in fuel use was insignificant compared to the economics of just in time inventory management.

It was only with airliners that we didn't see an increase in average speed, and this was solely due to the technological barrier posed by exceeding the speed of sound. At 600mph a typical airliner is flying at 80% of the speed of sound. To get above this and up to mach 1 requires a completely different set of aerodynamics that result in a much narrower and smaller passenger compartment. Flying above the speed of sound also creates sonic booms that are strong enough to break the windows of houses below. This is why the only supersonic airliner, the 100 seat Concorde, would accelerate above Mach 1 only when it was safely over the Atlantic. There was no point sending it on flights from London to India, Singapore or South Africa, because the whole journey was over land and so it would have to fly at the same speed as everyone else. Instead of increasing speed, the airline companies used cheap fuel and increasing efficiency to reduce ticket costs. The result was budget airlines with more and more people flying in larger and larger jets, and in the end a much greater use of aviation fuel than ever before.

The exporting of high labour cost industries to places like China and India meant the products came back a lot cheaper and so a consumer spending boom followed. We didn't spend less money on goods, we simply bought more of them. Mr and Mrs Jones's house went from one 24-inch television to a 38-inch energy intensive plasma screen in the lounge, a smaller one in the kitchen and a combined TV-DVD in each of the kids bedrooms. Computers began to appear in homes, along with countless chargers for cordless phones, iPods and the kid's remote control toys. Loft insulation and double glazing went in, but that simply meant the central heating was now left on for most of the winter to maintain a nice shirt sleeve temperature. Kitchen and bathroom lighting switched from a couple of 60 watt bulbs to a dozen 50 watt halogen down lighters. By the early part of this century the Jones's had even begun to buy patio heaters.

The moral is that energy efficiency and energy dependence are not related. You can increase efficiency all you like, but if the result is that engines, power stations and goods consumption simply becomes bigger, then total energy and hence oil and gas consumption will increase.

New Demand Growth

The 1980's also saw the start of a phenomenon that we don't often think about in the developed world. The less developed countries, handily known as non-OECD countries (that's OECD; Organisation for Economic Cooperation and Development, and not OPEC; Organisation of Petroleum Exporting Countries which I was using before), began a rapid industrialisation. Driven by increasing demand for goods on the global market, the low labour cost countries found themselves the ideal location for industries and factories moving out of high labour cost zones. The boom in their economies and rapid industrialisation led to an equally large surge in energy demand. Oil, being not only cheap, but also handily transportable and with that all important high energy density became their fuel of choice.

There are well over a billion people in China, just over a billion more in India and another billion or so in other industrialising non-OECD countries (Thailand, Vietnam, South America etc). Compare that to half a billion in North America and a little more in Europe. Individual average energy consumption might still be low in most non-OECD countries, but multiply that by the sheer numbers of people and you not surprisingly find that China is now the number two oil importer in the world, India is snapping at its heels and Indonesia has gone from OPEC oil exporter to non-OPEC importer.

You don't need to do an in depth analysis to figure out what's happening, you just need to look at the headline numbers; The 'first world' OECD countries add up to about a billion people, who because we are industrialised and maintain a high standard of living, use a little over half the world oil production. That leaves 5 billion other people who also occupy our planet, of whom 3 billion are in rapidly industrialising countries.

This non-OECD industrialisation really got into full drive in the 1990s and by 2000 had reached the point that a new middle class was emerging that was itself buying into the Western dream of cars, overseas holidays and gadget packed houses. To supply these new middle classes, two thirds of all the products from those Chinese factories are now being sold for non-OECD consumption. The 3 billion are becoming like us and that all adds up to a massive increase in energy use.

Make no mistake here, non-OECD countries are now bidding directly against us for oil resources, and since their typical family still uses a lot less than us and their countries often have significantly better balance of trade profiles that allow them to subsidise oil prices, they are also a lot less price sensitive. When Mr and Mrs Chan are only spending a couple of dollars a day on all the benefits oil is giving them, it's a lot easier and less painful to double that than it is for Mr and Mrs Jones to double a $25 daily expenditure to $50.

However you look at it, in a straight bidding war they are going to win.

The oil price in 10 years time

Interestingly it is quite possible by some very simple mathematics to work out the highest levels oil prices can possibly go to. The world's total GDP (Gross Domestic Product, otherwise known as the total value of all good and services we produce) at 2007's peak oil price was near enough $55 trillion a year. That's 55 with 12 zeros after it and a dollar sign in front. Divide that by the number of days in the year, 365, and it works out at $150 Billion a day. Now divide that by how much oil we use, 84 million barrels a day, and you come up with the price per barrel if we were to spend everything we earned on it of $1,786. Spending that much on oil would leave nothing left to buy or pay for anything else, so it is of course completely impossible. We know that with oil at $150 a barrel we still have enough money to run a society on, even if it does lead to a recession. Hence we can deduce that the maximum market value crude oil can go to must be somewhere between $150 and $1786.

That's a big range so let's see if we can apply a little more maths and basic logic to firm it up a little. To do this we need to look at a world with less oil supply and see how much the price needs to rise in order to remove sufficient people from the consumption side to balance supply and demand. I'll start with the Hubbert curve projected world supply for 10 years time; 70 million barrels a day. Because I'm an engineer and I know that the Hubbert curve has been produced by geologists who are more conservative than me, I think we'll actually be doing better than that, say 75 million barrels a day. That's just 12% less oil than we use now, and 10 years is short enough into the future that we can accept wide scale alternative energy use won't really have ramped up. Being a little general we can say that 12% less oil use is about what we get in a severe recession. It's actually a somewhat smaller reduction in oil use, but as before with my engineer's hat on I think that in 10 years time we will be sufficiently aware of oil supply problems that technology gains will have swung away from V10 powered BMW's and back to something more rational.

Now the key thing we know from the past 3 oil price shocks is that they all sent the price to a level that the world couldn't cope with. In other words, from history we know the prices of oil that caused enough economic recession to drive down demand. We also know that when demand goes down the price falls back rapidly before recovering to a new normal level that's less than the peak but about double the previous normal level. If you look up today's oil price I can guarantee it'll be about double the accepted normal of $30 to $40 that existed in the first part of this decade, which itself was about double the previous normal of $15 to $20 a barrel. In general it appears that oil price doesn't climb steadily, but instead goes up in saw tooth jumps.

For the next bit of maths I'm going to use 'dollars of the day'; that is amounts that are not adjusted for inflation. It's OK to do this with historical prices as I'm going to divide them into historical global gross domestic products. Since oil and GDP are both in dollars, dividing one into the other results in a simple ratio which cancels out the effect of inflation.

In 1973 the peak price oil reached was $12 a barrel and world GDP at the time was $5 trillion. This works out at about $2.4 of oil price per trillion dollars of GDP and it created a severe recession. In the 1979 Ayatollah Khomeini inspired oil shock the price went to $30 a barrel with world GDP at $11 trillion. This gives a ratio of about $2.7 per trillion dollars of GDP. Although we had only recently emerged from the previous recession this sent us straight back into crisis. The crisis wasn't helped by the following years Iran-Iraq war which drove the oil price a little higher. In 1990 to 91 when Saddam Hussain invaded Kuwait, the oil price briefly spiked at $39 per barrel, but the spike was so short lived and sufficiently far below the pain threshold that it only created a small and short lived downturn in our economies. At the time world GDP was $22 trillion, so the oil price ratio was $1.8 per trillion dollars of GDP.

However, in 2007 oil soared to $147 a barrel. GDP in our now global market orientated economies had reached $55 trillion, but even so $147 a barrel was enough to give an oil price ratio of about $2.7 per trillion dollars of GDP and create a very severe recession.

One thing that this ratio clearly shows is that oil is just as important to today's economy as it was back in the 1970s. Whatever you might have read or heard about having decoupled our industry and economies from oil price, I think you can agree that by some simple maths we can show it to be incorrect. It is important to remember that oil underpins all trade, transport and manufacturing, in just the same way that the service and financial sectors are underpinned by manufacturing and industry, and all are underpinned by farming. There's no point having an advertising industry if there are no manufactured goods to advertise, and there's no point having the latest blu-ray player and high definition TV if you haven't got enough to eat.

Back to the oil price to GDP ratio. It appears then that a ratio of 1.6 creates pain, but not a recession, a ratio of around 2.4 will cause a recession and a ratio of 2.7 will cause a severe recession.

Let's assume these figures hold true into the near future. Let's also assume that global GDP keeps rising along its curve so that in 2019 it is $100 trillion. By back working the calculation with the 'recession' ratio of 2.4 and a $100 trillion global economy we come up with a price for oil that will generate a recession in 10 years time of $240 a barrel. We can also use the 'painful' ratio of 1.6 to say that an oil price in 2019 of $160 a barrel will flatten economic growth but will still be manageable. Interestingly using the 1.6 painful ratio with the 2009/10 global GDP of about $61 trillion gives a current lower pain threshold of $98 a barrel. As long as the oil price remains below this value in 2010 then we can expect to have global economic growth.

So in 2009 we know that the maximum oil can go to is about $150 a barrel to trigger a drop in demand, and now we know that by 2019 it will need to go to about $240 a barrel to cause the same effect. The CEO of Russian energy giant Gazprom was right after all when he said oil would reach $250 a barrel, he was just 10 years too early.

$240 a barrel in 10 years time doesn't sound like the end of the world to me. Quite the opposite in fact, it reassuringly sounds like in the next decade or so at least, we will be able to cope with a restricting supply without overtly damaging our way of life. And as we have seen before, high oil prices stimulate activity on the renewable and alternative energy fronts.

It appears to me then that the start of the decline of the petroleum age will be far gentler than some of today's scare mongers predict. Coming off the peak oil plateau will not result in riots, civil disorder and a breakdown in society. Instead it will cause recession and flattening of economic growth.

Earlier I noted that we are reliant on the promise from OPEC that they were not really at full capacity in 2007. If they were, and if we again reach that limit, as is predicted, in 2011 then we can use our 2.7 ration with 2011's predicted global GDP of 68 trillion dollars to see how high oil will go. It works out at $184 a barrel.

2011 and $184 a barrel or 2019 and $240 a barrel, or some year and some price in between, the oil shocks will continue and will increase in frequency and severity over the next decade.

What does the longer term future hold?

I originally thought about calling this section 'What we need to do'. Unfortunately though, that would be a rather naive and misleading title. History tells us that what we should do in order to maximise our future wellbeing and what we will actually do are almost completely unrelated. What we will do is practically nothing.

Since this and the last chapter have moved away from geological and engineering certainties and into the realm of reasoned judgement, they will no doubt prove to be somewhat wide of the mark in future years. However, it is worth projecting what is likely to happen as oil and gas become increasingly sparse and expensive as it should help to allay some of the more dire threats I've read about the future of our civilisation.

Firstly, as we've seen in the last chapter, it's important to bear in mind that our civilisation isn't about to come to a sudden end and we are not the last generation living the high life. We do have a transition to go through though, and it some respects it will be far more painful than the near seamless transition I've indicated. I suspect though, that we will emerge from the other side looking broadly similar to today.

A sustained high oil price is quite a lot worse than it initially appears as it represents a very significant portion of our money supply that will no longer be kept within local economies but instead will head overseas. And with it unfortunately, will go the jobs and services that surplus money currently supports.

Transportation is perhaps the most visible industry that depends directly on oil price and availability. It's quite easy to see that with a reduced and more expensive oil supply the first thing that will happen is a reduction in the amount of goods and people that get transported around in our globalised economy. Local production will make a return as the transport costs for relatively heavy and cheap items begin to outweigh the labour savings found on the other side of the world.

Localisation in Britain will quite quickly extend from Welsh lamb and Cornish sardines to industries that we once thought had disappeared for ever from our shores such as furniture and clothes manufacture. Of course the fruits of these new localised industries will cost more when they are made by our own high wage labour. This higher cost, combined with the larger portion of our income that will now be disappearing to the oil producing nations, will leave us with less surplus purchasing power. Less disposable income will in turn cause a reduction in the service sector that supplies much of the nicer things in life, like weekend breaks, health clubs and interesting TV programmes. It also means less tax revenue to local and national government, which will invariably lead to a few more years of horrific budget deficits before we realise that the social services themselves need to be paired back.

Thus, speaking in very general terms, the initial fall out from reaching peak oil will be a reduction in the social and service sectors as more people find themselves moving back to primary industries and even a few to manual labour. The cheap jobs we exported will come home as globalisation is replaced by localisation.

The British economy in 2009 is divided into 76% service industries, 23% manufacturing and energy supply, and 1% farming. Essentially this means for every person growing food there are 23 making things, surprising but ever though we're a small country Britain is the 6th largest manufacturer and 5th largest economy in the world. And for every person making something there are another 3 that are providing him (or her) as well as themselves with some sort of service. Of those 3 providing services, 2 are in the private sector and 1 is publicly funded. These services range from the more useful, such as healthcare and emptying the rubbish bins, to perhaps the less useful like advertising, estate agents and independent financial advisers.

There was a great TV series I used to watch when I was young. It was called 'A Hitchhikers Guide to the Galaxy' and it ended with an advanced civilisation deciding to get rid of the entire useless third of its population by pretending their world was about to be destroyed and packing them all off in enormous spaceships. This useless third eventually (crash)landed on an uninhabited planet and promptly started making documentaries about themselves and selling each other trees with 'fabulous potential for conversion into spacious accommodation'. They did a few other funny things like make leaves their currency and then burn down all the trees when they discovered what hyper-inflation was. Needless to say, the two-thirds that remained back at home lived happy and prosperous lives until one day they were all wiped out by a virulent disease caught from a dirty telephone. Funny as it was, The Hitchhikers Guide to the Galaxy shows that whilst a lot of services are not really necessary there are still those that we really do need, such as telephone sanitizers (basic healthcare), to support the primary industries.

So if we don't need all of these services, then which are likely to disappear as our petroleum consumption number is pushed back to the lower levels that won't allow them to survive?

Back in 1977 when The Hitchhikers Guide to the Galaxy was being pitched to the BBC, British petroleum consumption was a little over 12% less than today. It can therefore be quite easy to assess in broad terms what the near term future British economy and lifestyle will be like by simply looking at our recent past.

1977 was the year of the Queens silver jubilee. It was a hot summer and what I remember most were the Jubilee street parties, the spiky pink and green hair of punks and Star Wars, the Movie. I flapped along in my ultra wide flared trousers (flapping was how you walked in them) with my equally flapping mates to see that summers blockbuster movie and left the cinema completely transformed from schoolboy into a wannabe Jedi knight. Although it didn't interest me in the slightest, the Alaska oilfields came on line that year and the North Sea had begun rapidly building Britain's own oil production. Saudi Arabia had also returned to full capacity following its post Yom Kippur war oil embargo. Oil prices had begun to slip and the outlook was bright. The good times heralded by that temporary oil glut would last all of 18 months before the Iranian revolution triggered the second oil shock and the winter of discontent.

The biggest difference between 1977 and 2009 was not how silly children's trousers were, you've just got to look at today's hoodies with trousers half way down their bums to realise kids will never learn. The biggest difference was in our economy. In 1977 the service sector made up half of GDP. That meant fully 50% of the British working population actually made things or grew the food we ate, and many of the services we now take for granted simply didn't exist. It's these recently developed service jobs that are the ones I think we'll lose first as our cheap manufacturing jobs come back home and the economy moves away from a services dominated matrix.

In some respects this list makes very happy reading. In 1977 estate agents (real estate agents) and independent financial advisers were far less prolific, and neither aspired to drive Aston Martin's. Credit companies, spin doctors and public relations departments didn't really exist, and many of the myriads of government and council services we now have also hadn't been thought of. Long term incapacity benefits were not part of the entitlements package and many of the less sexy jobs we have subsequently farmed out to imported labour were performed by our indigenous workforce. And, of course it was cold when you woke up on a winter's morning, hot in the car on a summer's day and the payroll department was called payroll and not Human Resources.

Because of the increased efficiency of machinery, transport and technology since 1977 our world in 10 years time won't be a complete return to the era of flappy trousers and nylon shirts. We'll still be able to buy things, do things and go places; it just won't be as much as we do now. Property, finance, leisure, media, marketing, pensions, customer services and many of the other new professionals may well find themselves looking at the jobs vacant section of the papers and wondering if a degree in Hotels & Catering really was such a good choice, but similarly a lot of perhaps less qualified mechanics, technicians, carpenters and agriculturalist will find themselves in unexpected demand. Hopefully the two Jones children will have opted for industry related degrees and will be joking with their mates about how misguided the older generation were to have thought History of Art or Marketing & Media was worth spending four years study on.

Future Energy

Looking further in the future to the time we reach a petroleum consumption number of 30 (a month) is altogether more difficult. The last time we were there was in the 1950s, back when no one had central heating, only a few could afford to run a car and we really did live off local and seasonal produce. The National Health Service had just got off the ground and the poor or unemployed lived a quite miserable life. A forcible return to 1950s Britain would see a return of what today is considered desperate poverty, hunger on the streets and a resurgence in diseases like TB and diphtheria that we currently have firmly under control.

History, however, is characterised by unexpected turns of events and by innovations overcoming seemingly insurmountable problems. I feel the chances are very good that we will have decoupled our productivity from petroleum consumption before we reach the one month milestone. It sounds a little unscientific, but something is almost bound to come along that will save us from a Britain of flat caps and rusty bicycles.

Perhaps the breakthrough will be in one of the technologies that are just becoming imaginable at the moment like second generation bio-fuels. With second generation bio-fuels the whole plant matter, rather than just the crop, is converted into a diesel or gasoline substitute.

Second generation bio-fuel thus has the potential to be an 'end game' technology. End game in that once you can convert the whole of a plant into energy then there are no more major breakthroughs you can make, the game is essentially over. Get it right and this end game technology can also be a 'killer application', to use a computer analogy. Why? Well it's quite simple really; bio-fuels can directly replace oil and gas, ramping up almost in a mirror image of the decline in petroleum production.

The current, first generation of bio-fuels use the sugars or oils, the crops, from plants like sugar cane and corn and thus are in direct competition for using these crops for foodstuffs. This has created a lot of adverse publicity and protests over 'fuel or food' as the land needed for them is the same agricultural land used to grow food. Second generation bio-fuels however, convert the whole plant, everything from the roots to the leaves and stems. The plants themselves therefore don't need to be traditional high yield food crops but instead they can be anything from trees to weeds. This means we can use plants that don't necessarily need good agricultural land to grow on and thus it allows second generation bio-fuels to exploit the world's vast acreages of sub-agricultural land.

Despite what you might think, there are still large amounts of unused land across much of Africa, Asia and the Americas. In some places, like Angola in central Africa, the land is unused because 3 decades of war has left it seeded with millions of landmines. Normally though, land is unused because it's marginal, with a climate or soils not good enough to support food production. If you just need to grow any plants though, and not an oil or sugar based crop, you can grow drought resistant plants in these areas.

Interestingly the basic method for developing and working large scale bio-fuel plantations on poor soils and in marginal climates with drought resistant plants is already in place from a rather unlikely source. Tobacco, from the nightshade family, is just such a drought resistant plant. The two dominant cigarette companies, BAT and Philip Morris don't actually own tobacco plantations, they just buy in the crop, make it into cigarettes and distribute it around the world. Significantly though, they have extremely good systems to provide farmers with the technical knowledge, equipment and loans to cultivate what would otherwise often be barren land. Tobacco is adapt at growing on very poor soils with relatively dry climates, so is ideal for otherwise uncultivated land.

The killer application that is going to make second generation bio-fuels work on an industrial scale is likely to be cellulosic ethanol. This is a ligno-cellulosic conversion process that has been shown to work very well in large scale pilot plants. You can forget the ligno-cellulosic portion of the last sentence because the important bit is that it has been shown to work very well in large scale pilot plants. In other words it is working at the factory level and not just the laboratory level. The technology is receiving substantial interest and funding from the oil majors as it now pushes towards full commercialisation. The first commercial scale test and operating plant is due to open in 2012.

If all goes well, then we're likely to see second generation bio-fuel refineries and plantations springing up sometime around the middle of the next decade, just when we're likely to be feeling the discomfort of higher oil prices again.

One of the most important things about cellulosic ethanol is that it can be used as a direct substitute for petrol (gasoline) and jet fuel with only minor modifications to engines. In other words, we can burn this new fuel in existing engines and don't need to replace every single car or aeroplane in the world with a hybrid or electric vehicle.

The forerunning cellulosic ethanol pilot plant has achieved a conversion rate of plant matter, in this case drought resistant switch grass, to ethanol of about 350 litres of ethanol per tonne of switch grass. From this starting point we can add a few more numbers to quickly assess if bio-fuels are a realistic solution to our energy supply future, and if so, what sort of impact it could have on our landscape.

Switch grass crop from an acre of poor land is typically 10 tonnes a year if it's grown in a warm or hot climate. With the normal vagrancies of commercial crop production, this is likely to fall by about 25%. Switch grass though, is just like tobacco in that it is very happy living off a low rainfall on poor soil.

Let's say then, that we use the skills of the tobacco companies to start cultivating many more of the marginal soils in sub-Sahara Africa. We'll also use the skills of our multinational oil companies in investing billions into politically unstable countries to build refineries and to distribute the ethanol around the world. Like the tobacco and oil companies, you'll have to ignore the politics of injecting vast amounts of money into regimes that might be less than squeaky clean. This is the real world we're talking about now, where 'what might be nice' plays second fiddle to what needs to be done.

Now, before I run the numbers it's important to note that what we have just defined is a direct replacement for petrol and aviation fuel that we know we can grow, refine, distribute and use without essentially any further technology development, management systems, changes in land ownership or governmental funding. In other words it's a real world replacement that we could use tomorrow. We just need to work out if we can get enough of it to start replacing some of those 84 million barrels a day of crude we're currently burning our way through.

So, 350 litres of bio-fuel per tonne of switch grass, 7.5 tonnes of switch grass per acre of land each year, 247 acres in a square kilometre, 161 litres make a barrel, the world uses 84 million barrels a day and there are 365 days in a year. How much land is needed to replace all the worlds' oil production with bio-fuel? The answer works out at a little over 7.5 million square kilometres (3 million square miles).

7.5 million square kilometres is a meaningless figure until you start to put it into some sort of context. Africa for example is 32 million square kilometres in size. About half of it is desert, semi desert, mountains, urban or otherwise non agricultural. This leaves 16 million square kilometres of land that is suitable for growing crops. Take away 5 million square kilometres of rain forest, since cutting that down would be somewhat bad publicity, and the 3 million square kilometres of good agricultural land that is already under food cultivation and you're left with about 8 million square kilometres - exactly what's needed.

It's easy to see then that Africa on its own could replace the whole world's oil production with a readily useable direct substitute. And it can be done by using the tobacco companies' methods of land cultivation, which means it can be done within the existing landownership and cultivation mechanisms. Biodiversity would obviously take something of a hit if a quarter of the continent was used to grow switch grass, and those marginally agricultural savannas that became game reserves to support the last of the real elephants and rhinos would also come under considerable pressure, so as always there are losers.

On the other hand though, our future could lie down an extended fossil fuel road whereby coal makes a comeback and the vast Canadian and Venezuelan tar sands are finally exploited.

Coal has actually been converted into a synthetic motor fuel on an industrial scale in the past. During WW2 the axis powers (principally Germany, Japan and Italy) had access to only 14% of the world's oil supplies. To make up for the crippling lack of diesel and aviation fuel on which the modern war machine runs, they started to process coal into a liquid substitute. It was a particularly energy intensive way of producing fuel substitutes, but their scientists and engineers showed it could be done, and crucially could be done on a big enough scale to make a major contribution to their war effort.

Similarly energy intensive in its exploitation are the tar sand regions of the Canadian North, Venezuela and a few other areas. Geologically speaking they are relatively newly formed petroleum deposits that haven't had the pressure and heat of overlying sediments to cook them into nice light liquid deposits. Instead the crude oil they contain is in a very heavy bitumen form. The problem of course, comes with how to separate the 3 barrel loads of sand that hold one barrel of very cold and sticky oil.

With shallow tar sand deposits it's possible to remove the upper vegetation and soil layers and then strip mine the sands. The sands are trucked to steam chambers where they are heated until the oil becomes less viscous and can be drained away. With deeper deposits, though, the large quantity of overburden from strip mining becomes too problematic to get rid of and so steam has to be injected directly into the reservoir formation to heat it up and thus release the entrapped oil.

Extended fossil fuel use through coal conversion or tar sand use is undoubtedly a very energy intensive way of generating new energy and something the environmentalists and climate change lobbies will oppose. As with the bio-fuels though, it can be done, and crucially it can be done on a big enough scale to make a difference and with known technology and known costs. Crude oil production from Canadian tar sands costs about $60 to $100 per barrel so it is eminently economic in a world of $240 crude. That's quite a lot of potential future profit between production and sale costs, so it's not surprising that most oil majors are heavily into tar sands.

Extended fossil fuels or second generation bio-fuels are the two best bets I have for near future energy sources. Only these two technologies have shown they have the scope to really pan out into the sort of industries that are large enough to supply millions of barrels of crude substitute a day, day in and day out. Despite all the press and publicity they get, the other technologies like wind, solar and even nuclear power simply aren't on the right scale to be anything other than bit players in tomorrows energy mix. They also don't produce energy in a form we can substitute directly for crude oil and so require a whole other level of technology and industrial effort to enable us to use them in electric and hydrogen transportation.

Britain in Numbers

I've deliberately not mentioned climate change in this book. Climate change is of course an enormous problem that the world as a whole will have to deal with.

Adapting the modern world to deal with the consequences of climate change is likely to cost use dearly. Those 2 billion people, the one third of our planets population that live at a subsistence level, the ones I missed out of my calculations because they don't really count in a modern world; they will be the least able as well as the first to pay the ultimate price of changing climate patterns.

Climate change, as we all know, is probably caused by our consumption of oil, gas and coal, the so called fossil fuels. I say probably, not because I'm an oil and gas engineer, but because I am sceptical of the underlying science and reasoning.

Look into it and you find that higher carbon dioxide levels promote much faster plant growth under drier conditions, just one self-governing mechanism that has been overlooked. Look a bit further and you begin to wonder why no-one is calling the climate scientists to better account. They might well be correct, but the rigour of challenging assumptions and deconstructing the computer models to see how much opinion has gone into those assumptions simply isn't there. The basic principles of the 'scientific method' don't appear to have been applied.

I'll give another example; carbon dioxide is actually a pretty poor greenhouse gas whose effects are significantly outweighed by those from water vapour. Water vapour doesn't appear in climate models though because it's too complex to mathematically model and slows down analytical run times by too great a degree. But if you look at the amount of land in the world that is being irrigated, and track that area back in time, you can see a clear correlation between irrigation and average global temperatures. So what, it's probably a meaningless correlation that has just occurred by chance. Maybe, but irrigating agricultural land means that water which would otherwise run out to sea in rivers instead goes to crops, from where most of it evaporates into the atmosphere. More water vapour in the atmosphere and more greenhouse effect?

What we appear to have in the global warming community is a lot of scientists trying to out-prove each other with similar predictions. Their predictions are similar because they are based on fundamentally the same assumptions, the same simplifications and the same mathematical modelling techniques. Then we have a lot of politicians, non-government organisations (NGOs) and media people making careers out of building empires around this and demonizing anyone that questions it.

I am not denying climate change is happening, so please don't demonize me as well. The climate is changing very rapidly and it's only logical to assume that it must be because of human activity. I'm also not saying I know why it's changing, because I don't. Ask me how to produce oil from a reservoir under a mile of water off the coast of Africa and I'll tell you how to do it with complete authority, ask me why the climate is changing and I'll tell you I don't know. But I will also say that I don't think anyone else really knows either. Carbon dioxide from fossil fuels? Increased water vapour because we irrigate far more land than we used to? Desertification from poor farming practices? Cleaner air from better particulate filtration?

Find the right criminal and we have a better chance of preventing climate change; carry on as we are and all we can do is adapt the world to deal with what is happening.

I'm going to make just one more observation and challenge to the accepted understanding of climate change before I leave it alone.

It could well be that increasing carbon dioxide levels actually turns out to be very beneficial to the human race. With more carbon dioxide in the atmosphere we would be able to grow lots more food and bio-fuels on lower rainfall levels and with less irrigation. This would allow us to support a higher level of global population to a better standard of health and prosperity.

Interestingly the rate at which plants grow actually increases by around 70% under higher carbon dioxide levels. This is why industrial greenhouses generate carbon dioxide to boost their atmospheric levels in the first place. So who knows, in a hundred years time our grandchildren might be deliberately releasing the carbon dioxide that we're currently planning on sequestering into old gas wells.

The reason I've not included climate change into a discussion on peak oil and future energy supplies is because it is a separate problem. Including it dilutes the fundamental problems of petroleum dependence and peak oil and introduces an area which I have shown can be used to undermined and de-rail the simple reality of oil supply.

Peak oil and climate change are completely separate issues. Peak oil is a clear and present issue that we have right now. Dealing with the wider effects of climate change is, I hope, an issue for Connor and Emily Jones to sort out.

There are many fine books and even better web sites which track global oil production and consumption. It's not a secret that we are at or very close to peak oil supply. And the mathematics behind it are far simpler and with much less scope for figure massaging to a convenient point of view than with global warming. It just appears that thanks to the 15 year spread on peak oil date it has never quite made it onto the short term radar that reports on today's problems.

For the year 2009/10:

UK Population = 61 million

UK oil consumption = 1.8 million barrels a day

UK gas consumption = 260 million cubic metres per day

Gas as equivalent barrels of oil = 1.7 millions barrels a day

1 equivalent barrel of petroleum (oil & gas) lasts the average person for 17 days

Or the average family of 2 adults and 2 school children for 6 days

6 as just a number is pretty small and insignificant. But six as the number of days the average British family goes through a barrel of petroleum is enormous and simply unsustainable.

The 2 billion that don't count

Incidentally, those 2 billion or so of the 6 billion people living on this planet that don’t count in our modern world; the ones that have an average daily income of less that $1.50 and live in places most of us have never been too. I see them a lot in the central African countries I’ve worked in.

My impressions are of smiling children carrying plastic chairs over their shoulders as they head towards improvised street schools, or of families of 5 or more perched onto a 50cc motor scooter giggling in their flip-flops and shorts as their father speeds along the only piece of tarmac road in town. They love it when you give them the Biro’s and note pads you’ve pinched from the office stationary cupboard and in general appear to be just as happy as my own children. A few obviously are in a poor state and you can see that the dollar you just rummaged out of your pocket means they get to eat that day.

Does it matter to us that these children die in droves from malaria, live on a diet of maize cooked over a wooden fire and will grow up to equally die in droves from Aids and Africa’s forgotten wars? I guess not, otherwise we would have done something about the 10 million under 5’s that die each year in our modern world. In tomorrows world we’ll think about them even less than we do today.

A career working in the international oil industry has taught me that we truly live in a brutal age, an age of staggering differences between those luckily enough to be born in the right country or to the right family and those that weren’t. But just perhaps some of those forgotten children will grow up to have the last laugh if Africa becomes the Saudi Arabia of a bio-fuelled future.

About the Author

Lorne Gifford is one of a handful of professional subsea engineers developing the worlds remaining offshore oil and gas fields. Starting on home territory in the North Sea, his work has taken him on a global journey from Trinidad to Thailand and from the Arctic to Africa. He is degree qualified, a Chartered Marine Engineer and one of less than a hundred Registered Subsea Engineers.

Lorne is the author of ‘the Andaman Express’, available from amazon.co.uk and Waterstones, and is also a part time lecturer in engineering and energy. He can be contacted on lornegifford@hotmail.com and booked for free energy career talks in Great Britain & Northern Ireland via http://www.engineersmakeithappen.co.uk/

He lives in London with his wife and two children and is currently working in Angola.