The Right Game

The Credit Crunch – Treating the disease rather than the symptoms.

By Andrew Lees
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Foreword

For several years I have been asked by clients to draw some of my thoughts together and publish a book. I have been reluctant – (some people might say lazy) – to do so, however with the credit crunch causing business volumes to decline, the time was suddenly made available. It also seemed the right time to tell this particular story. The credit crunch and the panic that it caused have offered the perfect opportunity to try and get both the public and business leaders worldwide to wake up and force politicians to take some very hard decisions and justify themselves.

The exercise has been hard work. Putting my thoughts down on paper is relatively easy, but then making them legible to the outside world has perhaps been more difficult. I hope I have achieved that, and would like to thank my colleague Henry Faire who has applied as much red-ink to my spelling and grammar as my English teachers used to 30 years earlier.

I work at a large investment bank on the broking side. I have been in the business since 1985 where my role has been to develop macro sales. The way I have interpreted that role is to look at, and try and `understand and question what's going on politically, economically and at sector level worldwide. Most analysts look at single companies, or look at economic data and express opinions on that. By looking at such a narrow set of information, they often miss the real story which I believe is the case now. Why has Japan for example stagnated for the last 20 years? They end up trading on noise and putting the system under greater and greater stress. Politicians reinforce and compound errors rather than enabling correct decisions to be made.

My clients have both rewarded me well, and more importantly acted as a great sounding board for ideas. They have pushed me to dig deeper and look wider to understand the real issues. There are various people I would like to thank who constantly ask questions and inspire different ways and different directions to think, but I'm not sure they would want me to mention them by name. Others have also offered their in-depth knowledge of the energy market, giving me access to a level of understanding that publicly available research alone cannot give.

I would also like to thank British Rail and its modern equivalent for making a 30 mile journey take almost an hour, giving me ample time to read literally hundreds of books that have given me inspiration and helped me do my job. It was either that or join the competition in the buffet car, which I must admit did have a certain draw.

Finally I want to acknowledge the various web sites that I use where individuals can express their thoughts and research, which perhaps the broader media and distribution channels only treat as minority sport. In particular I would like to thank the organisers and contributors to the web site www.theoildrum.com and www.energybulletin.com which carry a lot of well presented research and information, which most industry analysts either don't know or simply gloss over.

The reason I have not published this through a conventional publisher is several fold. Firstly the time taken to come to market is prohibitive, and I think making this freely available on the web will hopefully get access to more people. Secondly I see it as more of an investment to bring in more clients rather than a revenue generator per se.

Introduction.

Economists live in a world of abundance and plenty of anything real and yet a world of deficits and shortfall of bits of paper.

At the moment there is an understandable witch hunt against bankers. Politicians and the press are demonising the same bankers that a few years ago were facilitating economic growth and higher living standards for us all. The bankers certainly made major mistakes for which they must hold their hands up. Nevertheless we have to understand that the credit boom which extends back a lot further, and now the present credit crunch, is just the symptom of a much bigger story. The banking industry was just the outlet valve for surplus capital being created by demographics and the energy industry, a wave that the bankers chose to ride. The credit crunch simply reflected the turn in that energy and demographic tide. The purpose of this book is to try to map out where these structural forces will next be felt, and whether there is anything that can be done to mitigate them and just how far the tide will ebb.

Economic growth can be driven by one of two things; working longer which is referred to as factor mobilisation, or productivity growth. Factor mobilisation is the route taken by the former Soviet Union. It mobilised a greater and greater proportion of its population to work, and similarly deployed more and more of its resources. At stages this resulted in extremely fast economic growth, but by definition once all the factors of production had been deployed, expansion hit a brick wall. The second way is through productivity growth. Efficiency gains free up resources to be deployed in new industry, and in further advancement. Growth is only limited by the ability to innovate, subject to having available sufficient supplies of energy. Comparing the two different approaches, the factor mobilisation approach will always lose out in the end, something that Ronald Regan exploited by upping the Arms Race. To maintain the military status quo the Soviet Union had to divert a greater and greater proportion of its limited resources into supporting its military development, undermining other parts of the economy. The United States of America on the other hand, along with its economic partners in Europe and Asia, were able to more than match the Soviet Union's arms expansion from productivity growth. Western military expenditure rose relative to that of the Soviet Union, but it fell relative to the size of the western economy. By the mid to late 1980's the CIA estimated that Soviet military expenditure was around 17% of gross national product, more than twice the U.S. ratio.

To achieve productivity growth, you need an "energy subsidy". Human work needs to be replaced by work from machines and computers. At the moment the world's population is about 6.8 billion, but the machinery we use in terms of energy consumed, is the equivalent of deploying an additional 300bn virtual people or energy slaves 24 hours a day, 365 days a year. A single barrel of oil for example contains the equivalent of 25,000 man hours of labour in terms of calorific value. For the economy to achieve productivity gains and move forward, we need to deploy incrementally more energy, but that is where the rub comes in. The world economy appears to have gone through peak oil production in 2005. It went through peak onshore oil production in 1977, but that was compensated for by growing offshore production. That too has peaked, and over the last 10 years we have had to turn to something called gas liquids, tar sands, and ethanol to make up for the slowing conventional oil production and fill the gap against increasing demand. This "unconventional oil" now accounts for 6.5% of world oil output, up from 3.6% at the start of the decade. We have also compensated for slowing oil production with increased calls on coal, gas and nuclear. From the 1970's onwards, their contribution to energy production in the United States more than doubled, with oil becoming predominantly a fuel for the transport sector. Conventional oil has already gone through peak production. Coal and gas are not far behind.

Declining energy availability will result in declining productivity –(In 2008 the Wall Street Journal reported that the Indian construction industry was running out of labour. It was unable to afford gasoline or diesel for its earth-moving equipment and was having to replace them with men with picks & shovels). Alternative energies such as wind, solar and ethanol are quite frankly a joke in comparison with the scale of energy we require. According to Observ'ER and EDF Energy for example, as of the end of 2007 the U.S. was getting just 0.02% of its energy needs from solar and 0.7% from wind. It did get 1.3% of its energy from biomass, but the scalability of that is limited. The "low hanging fruit" of efficiency gains turns out to be nothing more than low quality analysis. Nuclear fission offers a potential bridge, but only for the short term and only if we invest now. Without a completely new source of energy, the human population will face a collapse far greater than at any period in history; far greater in severity than even the Great Plagues that wiped out about 1/3rd of the European population. Without a new source of energy, the world's carrying capacity would fall to about 15% of its present level, something that would happen from beginning to end within a period of 50 to perhaps 100 years from now. This is not a debatable science like global warming but is as certain as 2 + 2 = 4. We know that without energy just how bad the final conclusion will be, however what we do not know is how we will get there. It will not be a straight line, and will not be evenly spread around the world or across different industries. Demand for energy will be destroyed by price action, but where first? The western banking system was the weak link in 2008 which meant that Western demand was the first to crack, but where will be next, and when?

We will come out of the present credit crunch fairly quickly. The economy has overshot on the downside such that the resource constraints that put us here in the first place are not going to be an issue for the next couple of years. Indeed there is now a huge surplus of both labour and energy resources and other factors of production that can be deployed before the global economy hits its limits once again. Nevertheless without a new source of energy, the supply curve describing the factor inputs will steadily move to the left, capping any bounce. The global economy will gradually move down what is called the "thermodynamic equilibrium" to a much lower state of world order and economic freedom. It would be like the collapse of the Roman Empire, but on a very much faster scale. The fall won't be evenly distributed around the world or across different industries. Energy inefficient economies and companies will suffer faster than those that are efficient. The overly leveraged western banking system was the casualty in 2007/2008, but what will be next. Where and when will we see the next unwind in energy demand? Will there be a further lurch down in the developed world, or has Asia over extended itself? What industry is most at risk from high energy prices? Food prices will soar given their direct link to energy, so perhaps some of the poorer countries will be squeezed before the West? Will high energy prices restrict global shipping and transport, and what would this mean for economies of scale, and for specialisation. Would productivity fall?

Before you go and jump out of the nearest window, there is light at the end of the tunnel in the form of nuclear fusion, but at the moment it is a very long tunnel. It could be shortened in my opinion if our governments' started acting in the people's long term interests. Politicians must offer proper funding to nuclear fusion instead of leaving it to rely on what can only be described as garden shed budgets, after all it is arguably more important to the future of humanity than discovering the nuclear bomb was to ending the Second World War 65 years ago and to maintaining peace ever since. During WWII the United States spent 1.25% of GDP on the Manhattan Project to develop the nuclear bomb that destroyed Hiroshima and Nagasaki and ended the war. In today's money that would be around USD180bn, and yet since 1985 the world's leading powers have delayed and postponed the main development project ITER because of a USD10bn price tag. Worldwide spending is limited to a few hundred million dollars, with the United Kingdom spending more on "ring tones" for its mobile phones than it invests in fusion development. Nuclear fusion offers the potential of an unlimited energy source. We have managed to produce nuclear fusion in hydrogen bombs. We now need to learn to produce the energy in a contained environment for power generation. We have already managed to achieve fusion energy, but only on a very limited, and not yet sustained basis. It is vital that we do. The present time table for the development of fusion power is simply not good enough. Without achieving fusion in the near term, the very life that we know and love will soon disappear. The industrial revolution will gradually unwind. Quite literally, fusion is at the moment the only hope that humanity has. If we don't achieve it, the world's carrying capacity will collapse. If we do achieve it, then it should open up the possibility for an industrial revolution on a scale never dreamed of before. Surely it is worth more investment than a few hundred million dollars.

Chapter 1. The credit crunch

Whilst it is true you can't have a strong economy without a sound banking system, it is equally true that you can't have a strong economy with a rampant banking system.

Money is the mechanism for recording and controlling the factors of production, whilst credit is the risk associated with its transfer. It should be no surprise therefore that credit was the weak link when the supply of energy failed to keep up with demand and prices started to rise. People's earnings and income estimates, on which they had calculated their ability to finance their debt suddenly proved unrealistic. Creditors wanted out, but there was no market. As banks make their money by taking the credit risk between long term illiquid assets and short term liabilities, they were caught at the eye of the storm. Banks couldn't sell their assets whilst depositors withdrew their money; a classic run on the banking system.

Whilst banks were caught in the cross hairs, why had the debt been allowed to get to such ridiculous levels that this could become such a serious problem? At the end of 2007, the ratio of total U.S. debt to GDP (gross domestic product or size of the economy) was 475%. Debt was nearly 5 times the size of the economy. Some of the debt was financial sector, or inter-bank loans which economists had ignored, incorrectly assuming that because it was bank-to-bank loans, that it was double counting and that there was no credit risk involved. How wrong could they be? Even today a lot of analysts still don't take account of this debt, not realizing that it means twice as many people running for the exits when things go wrong and therefore a much sharper downturn.

U.S. debt growth started to accelerate aggressively from latter half of the 1980's onwards. Most people blame it on an the easy monetary policy pursued by Alan Greenspan as the credit growth coincided with his leadership of the Federal Reserve from 1987 to 2006. A second explanation is that the 1988 Basel Accord and the subsequent Basel II regulations that established minimum capital requirements for the banks were to blame, effectively allowing banks to increase the size of their balance sheets. Greenspan's willingness to cut interest rates at the drop of a hat meant that downside risk was to all intents and purposes underwritten by the Fed. It became so obvious that it was termed the "Greenspan put". When the actions of the Federal Reserve are so predictable that they are given a name, then you have to question the very purpose and the resolve of the central bank.

The Basel regulations were no better. Whilst having the best of intentions, banks found loopholes to exploit just as accountants do to reduce tax bills. This is known as "regulatory arbitrage". Banks use our deposits to buy large portfolios of assets, but have to bear the risk of those assets going sour with their own capital. Assets have to be weighted according to risk, and then sufficient capital provided to support that risk. On the asset side of the equation, financial engineering and derivatives were used to reclassify the risk to lower bands, whilst on the capital side shareholder capital was boosted by borrowing. The combined effect was to allow more assets to be held with less capital than the regulations intended. The rules required a minimum of 8% capital-to-asset ratio, allowing leverage of 12.5 times. This may sound a very flimsy number, but even that 8% capital is split into two bands. Shareholder equity is only required for Tier 1 capital, which only has to protect against 4% of assets, effectively allowing 25 times leverage. But that was not enough for the banks. Preferred shares, goodwill and other intangibles were classified as Tier 1. Certain banks entered into the credit crunch with leverage of 40 or 50 times, so when assets started to fall in value their equity cushion was wiped out very quickly.

The risk models deployed by the banks and hedge funds were self-deluding. Models were essentially basing their risk assumptions off a pyramid or ponzi scheme that relied on ever increasing amounts of debt. As the period of debt growth extended further and further from the mid 1980's onwards, the universe from which the data was collected became increasingly dominated by the pyramid itself. No matter how you analyse the data on a straight line, it will tell you that it is a straight line. The only prediction that you can usefully make with that data is that the straight line will continue. Amazing as it may sound, this is exactly what the so-called rocket scientists did, predicting that the straight line of rising asset prices would continue. I guess the only crumb of comfort is to thank God that they weren't allowed near a real rocket.

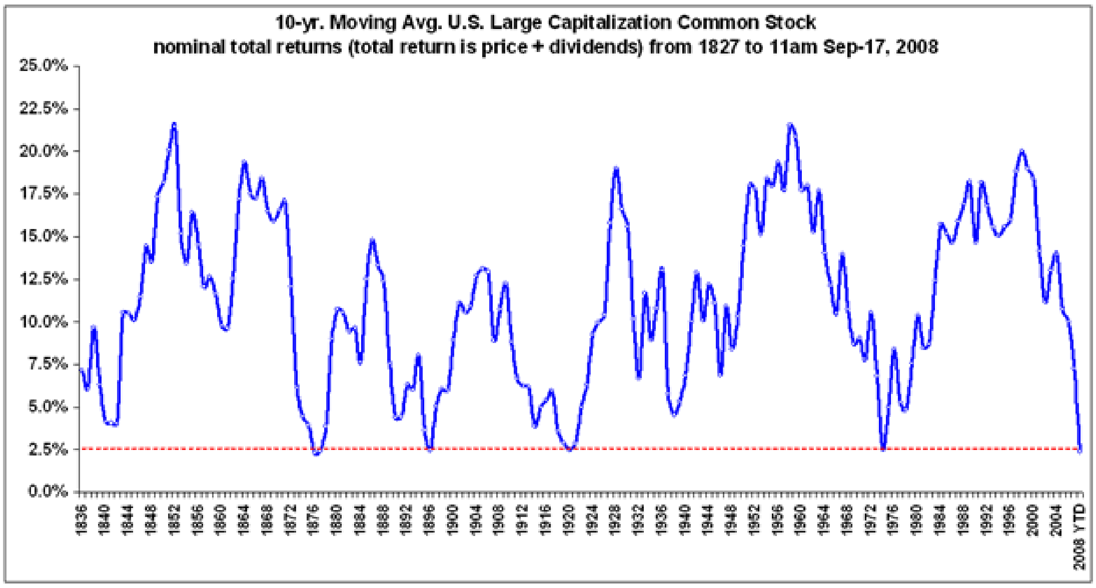
The delusion of lower risk fooled the banks to increase their balance sheets further and further. As more money chased assets, the return on those assets fell. At a macro level, U.S. economic growth per unit of additional debt fell continually from the mid 1980's onwards. At a micro level, banks' interest margins on loans fell to all time lows. They had no choice but to take on more risk to make any return, hence their foray into what became known as the "sub-prime" market. Of course the Basel risk-weighted rules should have stopped this happening, but for the regulatory arbitrage that classified it as low risk. As with any pyramid scheme, the crunch comes when there are no new participants. By the 18th January 2008, U.S. commercial bank cash levels had fallen to just 2.6% of their assets. They were effectively running out of cash, and the soaring oil prices turned off their supply of credit from Asia. If anyone wanted to take their money out of the banks, then the banks would have to sell assets, but to whom? At the same stage without more money going into the system, the income that the assets themselves were generating started to fall. If the banks couldn't afford to offer mortgages, then no more houses could be built, so construction workers and builders were laid off, starting a vicious spiral of job losses, rising default rates and lower asset prices.

Traditional firewalls that should have stopped debt growth and cleansed the economy were over-ruled. I mentioned the Greenspan put earlier, but there was a second moral hazard that his name was linked to; the so-called Greenspan dilemma. Banks traditionally borrow from you and me via our deposits, and then lend back to us through mortgages etc. As long as the interest rates they charge on the longer dated loans adjusted for the credit risk, are higher than the interest that they pay us on deposit, they will make money. This is described by the yield curve which would normally be upwards sloping. If it starts to flatten or invert, then bank lending becomes loss making. A flat or inverted curve has always managed to predict recessions for the simple reason that as the curve inverts, banks stop lending and credit growth slows. Despite the curve inverting at the end of 2005 and staying that way until mid 2007, bank lending continued to grow. The argument was that banks had turned themselves into a fee-based business rather than a credit business. They had arranged the mortgages, but then packaged them up and sold them to hedge funds and to off-balance sheet vehicles. What they didn't say or didn't realise, was that the banks were then having to lend to the hedge funds and to the off-balance sheet vehicles – (a way of reclassifying assets) - to facilitate their purchase, and that by definition that loan was therefore always going to be loss making.

Credit rating agencies added to the problem, classifying what was clearly junk as high quality AAA paper. Mortgages were offered way beyond people's realistic ability to pay, but after packaging them up and slicing the risk into different groups, the rating agencies gave a far higher rating to the paper than was deserved. If it was AAA paper, then adjusting for the assumed default risk, the curve was still theoretically positive sloping so what was wrong? The problem was that this paper should never have been classified as AAA, and the default rate was therefore going to be significantly higher than the rating implied. Even worse, the very fact that it was given AAA classification meant that the yield on it was far lower than it should normally have been; investors weren't getting rewarded for the risk they were taking. In a roundabout way, the cost of having this paper classified in such a manner as to meet the Basel rules, was a lower return and higher risk. You have to wonder whether it was the assets or the people that bought the assets that should have been labelled sub-prime, after all as one of my colleagues used to say, most people should be able to recognise that a pig wearing lipstick is still just a pig.

From the end of 2004 to the end of 2007 when the curve was basically flat, and therefore most banks' profits were "illusionary", cash levels at U.S. Commercial banks fell by about 2% to an all time low of just 2.5% of assets. With U.S. paper dollars in the economy only representing about 1.5% of all outstanding money, bank runs were almost inevitable. Three years of bank profits would have to be written off and at the same stage liquidity levels would have to go back to more conservative levels. The removal of credit or what became known as the credit crunch was inevitable as banks tried desperately to rebuild their balance sheets and atone for their sins of recent years.

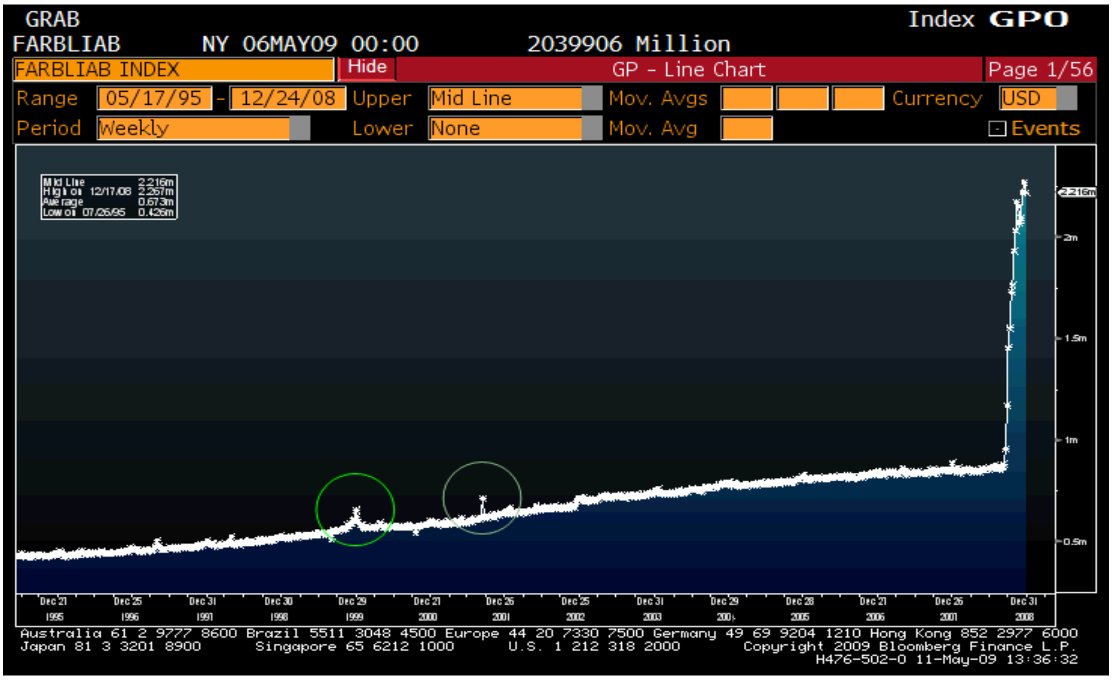
If the Federal Reserve, the regulators and the banks themselves either didn't understand what was going on, or chose to ignore it, then what about the shareholders. At the end of the day it was their money. Surely they wouldn't be willing to take undue risk for the returns they were getting? If you look at a chart of large capitalised stocks listed on the New York Stock Exchange, then even before the Lehman's collapse – (the main U.S. stock market index fell another 40% after its bankruptcy) – it had recorded its worst 10 year return for 200 years. Clearly that suggests that on a net basis a lot of people had taken their money out of the stock market. There could be numerous reasons for this. Perhaps they simply needed the money to live. Perhaps they put their money into foreign stock markets, after all the dollar fell heavily from 2002 until late 2008. Or perhaps those that sold the market realised that with such a large build-up of debt within the economy, future corporate earnings would be depressed for many years, and therefore the stock market was simply not worth investing in. Funnily enough, by far the largest buyers of the stock market in recent years were companies buying back their own shares and investing in the financial market rather than the real economy.



Even prior to the Lehman's collapse and the subsequent 40% fall, the US stock market had suffered its worst 10 year period for 200 years.

Putting to one side the failure of the systems, just how big was the problem? Are we realistically facing a 1929 style credit crunch or even worse, as economists and regulators now predict? As I said at the outset, the level of U.S. debt had grown to 475% of GDP at the end of 2007. If you treat the economy as your own personal balance sheet and cash flow statement, most people would recognise that supporting debt nearly 5 times their gross income would be a near impossibility. That kind of anchor would drag almost anyone down. Expenditure would fall to the barest minimum as you desperately try to meet your debt obligations. That is all very well at an individual level, but if society as a whole has the scale of debt we are talking about, then cutting expenditure to meet interest bills would send the economy into a nose-dive. Unemployment would soar, making the servicing of the debt even more difficult. Those that had taken on the debt in the belief that their wage growth would be sufficient to outgrow it, would suddenly be left with very little light at the end of the tunnel.

As the market and the economy collectively realised some of the over-indulgence of recent years, there was always going to be a knee jerk reaction the opposite way. I had expected a major correction, but I must admit I was taken aback by just how quickly and how deeply a state of utter desperation fell over people. I shouldn't have been. During the bubble, high pay reinforced people's belief in their own self-importance, so the credit crunch was a rude awakening. A lot of people had to come to terms with the reality that their job and career had just been another aspect of the bubble. People couldn't see any hope. In a 2 week period my trains were delayed by 4 suicides. The same economists who denied that there had been any problem when the debt was building up, now offered no hope for any solution. Monetary growth and other data that were pointing to a bottoming economy was dismissed as "high frequency data which confuses the picture". The expansion of the Fed's balance sheet - (see below with circles highlighting Y2k and 9/11 for comparison. Notice also the flat line during the Asian financial crisis in 1997 and through the Russian debt default in 1998) - was used as evidence of just how large the banks' problems were rather than as an indicator that a new financial system was being established. Economists said the money wouldn't get into the system. They ignored near record levels of mortgage refinancing and dismissed the fiscal stimulus as too small. They said that the monetary expansion in China could not possibly lift the global economy, even though its cheap exports to the United States over the preceding 5 years was commonly thought of as the main reason for growth during that period. And most importantly of all, the stimulus from oil prices collapsing from just under 10% of world GDP to about 2.5% was treated with as much contempt as it was when oil prices were rising and economists simply stripped the impact from their models by using "ex food and energy" data. If only we could all have ignored the massive impact of the price change of food and energy on our ability to service our debts as easily as economists did. Their naivety was frightening.



Federal Reserve Balance Sheet

The comparisons with 1929 are valid as far as the level of debt goes, but beyond that it is not a fair reflection of the situation. Huge policy mistakes were made in the run-up to the 1930's depression and the subsequent aftermath, that quite frankly made not only the depression inevitable but were also major contributory factors to WWII. After the First World War, America emerged as the world's only major creditor nation. All the gold which the world used to finance international trade had ended up in U.S. vaults. Quite rightly, the United States insisted on debts being repaid, but by imposing tariffs equivalent to roughly 38% of the U.S. cost of producing similar goods, it made payment impossible. With no gold to pay their debts, and no way to sell goods into the States to earn gold, the depression was inevitable. America overwhelmingly failed to recycle inter-governmental debt receipts into the purchase of European goods, a move that was further exacerbated by its abandonment of the Gold Standard. Germany, Japan and France were starved of raw materials, and whilst the U.K. could get access to them via its Empire, it effectively taxed the Empire to collapse. People say that WWII ended the Depression. This is not the case. It simply put the U.S. gold back into the system via military spending etc, but immediately after the war, the U.S. economy quickly nose-dived. It was not until the Marshall Plan in 1949 that the U.S. effectively lifted the barriers and started to recycle its gold reserves back into the system.

By comparison, U.S. debt today is denominated in its own currency; the U.S. dollar. This makes a huge difference. It can effectively just turn to the printing presses if it so wishes. The currency would fall, lowering the international value of U.S. wages and therefore allowing it to export goods to the rest of the world to meet its obligations. There is no wall or barrier up to prevent that happening as there was in the Great Depression. Secondly, the world's largest creditor China, has not waited for a war to pump money into the system but tried to compensate for the U.S. slowdown immediately. It not only announced major domestic stimulus packages, but has also presented the world with its own version of the Marshall Plan, offering major swap lines or loans around the world to get people to buy its goods. It also removed export taxes and offered cheap financing to these countries to ensure that its international trade continues to grow. The International Monetary Fund has offered credit lines to various countries, and most of the World Development Banks have raised capital to inject funds into the developing world. Clearly the private banking industry did initially withdraw credit from the global economy, but unlike the 1930's, the world's governments and central banks have done everything in their power to offset it with their own credit growth and their alternative banking systems.

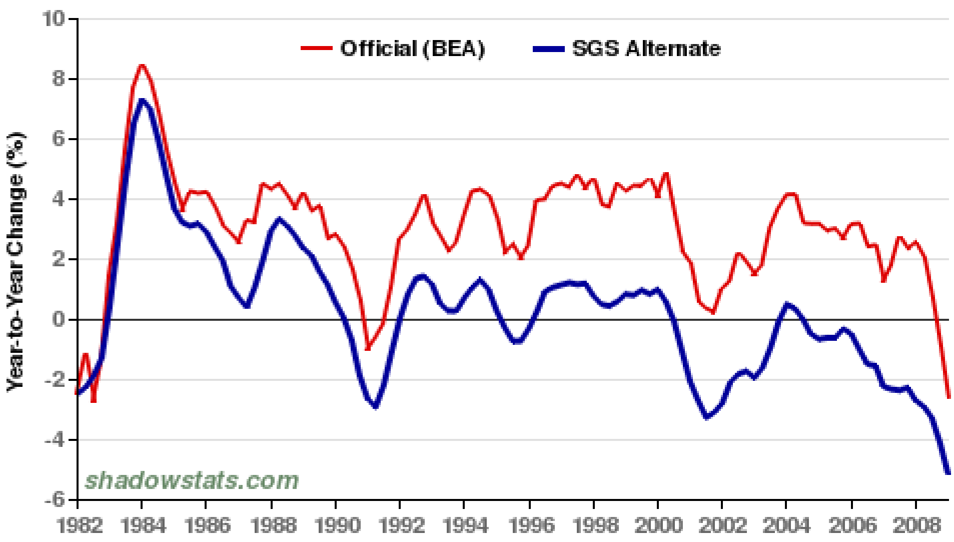
Post the Lehman's collapse, the stock market fell an additional 40%. Rather than writing off debt over a long period of time which would have kept earnings depressed for many years, the collapse triggered this to happen much quicker, which should result in a much more favourable outlook for the economy and stock market than if the debt had been an anchor chain around the economy for years. To a greater or lesser extent, the equity supporting the debt was wiped out forcing the banks to sell the debt at whatever price they could get. The debt was transferred at much lower prices into new hands, both private and public. The lower price paid for the debt allows for a higher default rate, or a reduction in the servicing costs. Most of the assets behind it are still around. Houses and machines are still there, and so the ability to service the debt should have improved. A lot of debt will have been replaced with equity which means that the new owner has bought the assets at very depressed levels and will now participate fully in any recovery. Overall the market has cleared or transferred the marginal debt into new hands, that believe rightly or wrongly, that they will make a positive return on it. For the moment, I would have to think that is correct. The economy will recover fairly quickly.

The gross incompetence that I have described only explains how the debt bubble was facilitated. It does not address the much more important question of why it happened, and why therefore it was just the weakest link in a much bigger story. Until people understand and accept the reason behind it, the solutions that they offer are just treating the symptoms. Unfortunately by doing so they are aggravating the real structural issues. Governments have been panicked into spending trillions of dollars of tax payers money trying to compensate for the credit crunch. Their spending is perpetuating the same unsustainable pyramid, just as the Greenspan put or the regulatory arbitrage did over the last 20 years. By not understanding what caused the debt bubble, they are directing the money into areas that the economy will not be able to afford. The money will be wasted. The economy will recover over the next couple of years, but without addressing the real issues it will be a recovery built on sand.

Chapter 2. Why borrow?

Most of what is written describes the way the markets ought to be, but remember what ought to be may be totally different from what is, and it is what is that moves the market.

Whilst the debt bubble and credit crunch is now fairly obvious for all to see, what is not so clear is why we needed to borrow so much money in the first place, and if debt was growing so aggressively then how was it financed? Since the mid 1980's, U.S. economic growth per unit of additional debt has fallen. Throughout the 1950's, 60's and 70's, the U.S. was able to achieve around 60% - 70% return per unit of additional debt. The economy was growing and debt was coincidental. From then onwards however it has collapsed. Published data suggests that economic growth per unit of additional debt slowed to about 15 - 20% over the last 10 years, but using the traditional methods of calculating the size of economic activity - (since 1991 the U.S. has ignored the cost of servicing external debt) – the data is even less complementary, suggesting that the U.S. economy has not grown at all over the last 10 years, and not faired any better than Japan over the last 2 decades.



U.S. Annual GDP growth – Official vs Shadow Government Statistics (SGS)
The difference is the cost of servicing external debt.
www.shadowstats.com

U.S. real wages have been flat for more than 20 years. The median real wage has actually declined. Employee compensation has fallen steadily from 60% of National Income in the early 1980's to about 56% in 2008. Professor Paul Krugman wrote an excellent book about this entitled "The Age of Diminished Expectations". The reality in my opinion is not that the U.S. household reduced its expectations, but rather something else has gone on. Indeed to maintain the illusion of earnings, the U.S. household steadily reduced its savings ratio - (see below) - from around 10% of GDP in the 1970's and early 1980's into negative territory in recent years. Houses were re-mortgaged and equity withdrawn from property to such an extent that owners' equity fell from 70% of the household real estate market in 1985 to just 45% today. Shares were also sold, and pension assets left to fall. To maintain the illusion of a rising standard of living, the U.S. household had to take on ever increasing amounts of debt. It mortgaged its future. The asset price inflation that became a major part of household income was dependent on ever increasing amounts of debt; the pyramid scheme that we now recognise. The real question therefore is not why borrow, but rather why were earnings flat, and what had gone wrong with the economy?

U.S. Personal Savings Rate as a Percentage of Disposable Personal Income

The Japanese household savings ratio also fell steadily from the mid 1980's onwards although by the end of 2007 was still just in positive territory at 2.2%. It was not yet having to borrow, but was saving less and less. Government debt soared as companies lowered their spending. Japan remained in surplus with its external partners, but internally it has played out the same situation as the United States except for one fact; that household spending and borrowing was replaced by government spending and borrowing, which is now also happening in the United States.

From the mid 1980's onwards, the western business model started to break down. Something had happened that made it uncompetitive. As I will describe in later chapters, changes to the demographic profile of the countries, the price of energy, and finally productivity all moved against the West and in favour initially of the Asian Tigers and then of China and India. Demographics meant that fewer workers were entering the western labour forces whilst Asian demographics and land reforms meant that there was a flood of very cheap surplus labour in the East. A collapse in oil prices from 1986 onwards as Saudi Arabia flooded the world, turned business on its head. High western wages were premised on high productivity, but with energy now basically being given away, this business model was undercut with the low wage but low productivity models of Asia. China for example was still using hugely energy inefficient cement kilns that Europe had faded out more than 200 years earlier, but with energy almost free and labour just a fraction of the cost of the West, that 200 year old technology out competed its modern counterpart. Western capital poured in chasing high returns. Pairing cheap Asian labour with modern Western equipment and technology was far easier and cheaper to achieve productivity gains than to invest in technological advancement.

Economic growth boomed in the East and collapsed in the West. Jobs and revenue were generated in Asia, supporting incredibly high capital spending; in China's case as high as 50% GDP. The West was left with repatriating the profits from Asian production and the need to borrow from Asia to maintain its standard of living. U.S. capital spending fell steadily from the mid 1980's onwards. With the exception of a brief recovery in the late 1990's as companies invested in the Internet, U.S non residential capital investment fell to around 10% GDP. After adjusting for depreciation, capital spending was basically non-existent and according to General Electric's chairman and CEO Jeffrey Immelt, U.S. research and development spending fell to an all time low of just 2% GDP. Companies bought back their own shares rather than invest in the real economy. Economists said it wasn't a problem; America was investing in "intellectual" capital although with hindsight I don't think they would be so quite so comfortable using that term to describe the high wages of the banking industry. America was living off past investments and Asian handouts. The massive growth in the banking industry was essential to keep the illusion going.

Banking is a necessary control mechanism or layer of management on the economy. Its function is to allocate available capital to those businesses and individuals that can pay the highest returns given the risks that they are taking. By doing this it enables the economy to generate the best possible sustainable growth. Risky investments or new ideas need to prove their viability by paying higher returns, such that only those ideas that people really believe in get funding. The banking industry is not productive in itself. It is a cost base or layer of management around the economy. In some ways it is similar to government in that they both allocate an economy's resources, although with different end motives. If the banks allocate capital efficiently, then it should lift the overall potential of the economy, but if its costs are too high or it allocates the capital to the wrong industry or to the wrong consumer, then it will just be another expense for the productive resources of the economy to support. Just as I think most of us agree that Big Government is a waste of resources, so too is a financial industry that is out of all proportion to the underlying economy.

In recent years the U.S. financial industry produced nearly a third of all U.S. profits, allowing it to pay high wages and drain a lot of talent from the rest of industry. The domestic economy could not possibly have supported that kind of cost base, but it was sustained by foreign capital. Loan growth was dominated by financing end household consumption and facilitating the U.S. trade deficit. If the goods were produced in the States it wouldn't have been a problem. Manufacturers would have generated sufficient revenue to invest in maintaining and growing output. Domestic wages would have risen, and debt would have kept in line with the size of the economy. As it was the consumer bought cheap goods from China which experienced the wage growth. U.S. household spending was not matched by domestic income; instead it was supported by borrowing from abroad. China was throwing off so much surplus capital that it could finance this loan growth and support a U.S. banking system that was disproportionately large to its economy. China needed an end buyer of its goods and the U.S. consumer obliged.

By having end consumption in one country and production in another, default was always likely. Greenspan could have choked off the U.S. consumer by putting up rates, but if China was willing to take on the U.S. credit risk, then why do so? China's demographics meant that it had a structural surplus of capital. Its dependency ratio – (the ratio of dependents to workers) – was collapsing such that end demand could not keep up with potential economic output. China's motive was not profit but employment. This was even reflected in an anti-bankruptcy policy that meant cheap funding was given to companies whether or not they were profitable. By pegging its currency to the dollar, China's huge domestic investment programme had an end market for its output, but in the longer term it would mean that the capacity that China was building was never going to make money. China's business model was reliant on the U.S. consumer being able to finance an ever larger pool of debt with lower income, which was clearly unsustainable.

Whilst default was inevitable, China seems to have ring fenced itself to some degree. Rather than lending directly to the U.S. consumer or the U.S. banking system, China lent to the U.S. government by buying Treasuries. This freed up domestic capital within the United States which the banks then lent to the households. To date, it has been the banks that suffered. China has remained immunised with its credit risk limited to the dollar; however the only reason that hasn't yet fallen is because China hasn't asked for its money back. When it does, the dollar will fall and China's investments will be revealed as heavily loss making. In the meantime however China is trying to keep the illusion going by replacing the lost demand from the States with demand from the emerging markets. It is offering cheap credit to numerous other countries with the hope of finding an end buyer for its goods. The one major difference is that it is trying to finance these exports with Renminbi loans rather than dollars, making it far harder for the countries to default than through a simple currency devaluation.

We should not forget that in recent years America has had to finance two wars. Whilst on a completely different scale, it is worth remembering that in order to finance WWII the U.S. completely restructured its economy for the production of military goods, banning domestic consumption of things such as cars and halting residential and highway construction. Britain had to go one stage further. Even basic food consumption was rationed. It had to sell down its last international assets – (including effectively its Empire) - and then mortgage itself up to the hilt with the USA. After WWII the U.S. economy was the most powerful economy in the world, but by the early 1950's the cost of the Korean War meant it was having to sell down its gold reserves to finance the war. By 1971 the cumulative cost of the Vietnam War had depleted U.S. gold reserves to such an extent that the USA defaulted on its international debts. It should be no surprise therefore that post 9/11 U.S. international borrowing, as measured by its current account deficit – (chart below) - went up from USD80bn a quarter to in excess of USD200bn a quarter. To maintain its standard of living and pay for the Afghan and Iraq wars, the U.S. had to borrow ever increasing amounts from abroad. Marry that up with China's structural need to export capital, and a great partnership evolved.

U.S. Current Account Balance in Billions of Dollars
Chart provided by Bloomberg

This explains the acceleration of U.S. debt over the last ten years which should be rectified to some extent as the cost of the war falls, however it does not explain the much longer term trend for the U.S. to borrow. Throughout the 1950's and 1960's the U.S. was running a trade deficit although this was financed by gradually selling down its gold reserves rather than having to turn to borrowing, hence the flat current account. Post its default, it took more than 10 years and aggressive monetary tightening by Federal Reserve governor Paul Volcker before international creditors were willing to allow the U.S. to borrow again, but from the early 1980's onwards the U.S. has been running a deficit.

The world financial systems operate on what is referred to as the dollar standard. World trade is transacted almost exclusively in the dollar. This means that the US must run a current account deficit. If it ran a surplus, it would suck all the dollars out of the system leaving nothing to transact in, a paradox known as the Triffin Dilemma that explains the common saying that *when the US sneezes, the rest of the world catches a cold*. This has been a side effect of the present credit crunch. As U.S. investors and banks repatriated their assets from abroad to plug their domestic finances, there were dramatically fewer dollars available for international trade, hence its almost complete collapse. The reason often cited of why the U.S. is allowed to get away with running this deficit is that it is seen as the cost of being the global policeman and providing the rest of the world with a military umbrella. The cost of that role is huge and yet the world in its totality benefits from it, so this seems reasonable. As the funding of the deficit has shifted from Europe and Japan to China, and then increasingly the Middle East and Russia, there has been a certain reluctance from some countries to support U.S. military spending. Russia for example, which earns most of its foreign exchange in dollars through oil and gas sales, has reduced its dollar reserves to just 41.5% of its total reserves, leaving private capital to pickup the balance.

This logic only works however if the creditors don't expect to be repaid and the debt is defaulted on, perhaps by a continued fall in the currency. The dollar index, which measures the general international value of the dollar against major world currencies, has fallen by an average of about 1.1% a year since 1971. Its fall against the Japanese Yen, until recently its main creditor, has averaged 3.5% pa over the period. Of course if the creditors asked for their money back, then the dollar would fall much more heavily. Selling these dollar liabilities from one counterparty to another does continually happen, but actually redeeming the dollars would mean either the U.S. running a current account surplus, which it hasn't been able to achieve for years, or selling down any international assets it has. This leaves the U.S. in a position of having an ever increasing pool of debt, which whilst necessary for the reasons mentioned above, also means that the economy will structurally under perform its potential. As the Austrian economist Friedrich Hayek said; "The economy in its entirety must continue to decline as more is being consumed than produced, and some part of consumption therefore takes place at the expense of existing capital stock".

Historically the world traded on the Gold Standard; a creditor system as oppose to the present dollar or debtor system. All foreign trade had to eventually be settled in gold. If a country had become uncompetitive, its gold reserves would gradually be lost to the more efficient economy. The country would then have to lower domestic wages or devalue its currency to realign its competitiveness and gradually earn back its gold. This way debt was not allowed to get out of control. Economies would restructure and be all the more dynamic for so doing. Under the present international system, this firewall has been removed and replaced by a system that has allowed debt to accumulate to unsustainable levels. The debtor has all the cards. China cannot possibly sell any of its Treasuries without the value of its remaining position collapsing, but more importantly if the United States decides to print more money, then either China has to buy the dollars or watch the value of its existing reserves collapse. It is like someone with an overdraft going to his bank and telling them that unless they lend him more money then he will default on his existing loan. Because the U.S. has been allowed to borrow ever more money, it has not been forced to restructure and invest in productivity gains. Instead, consumer spending has increased at the expense of capital spending. It explains the declining state of the U.S. capital stock, the declining real wages, and need for households to withdraw equity from their mortgages. Literally the dollar standard has not only allowed, but actually required the U.S. to become lazy.

The huge cost of the wars in Iraq and Afghanistan put a spot-light on the scale of U.S. debt, and most importantly the accelerated pace that it was accumulating. Even if it wanted to, Asia simply couldn't afford to throw good money after bad to the extent it was being asked to do, as higher energy prices meant that its own trade surplus was collapsing and the energy exporters were becoming the big creditor countries. It is much easier for a late comer to the party to pull the punch bowl away than it is for someone who has been there from the start. With Asia only able to support a small fraction of the U.S. trade deficit, the call came on the energy surplus countries, but why should they be willing to lend to the United States when it already had such a mountain of debt. Instead Russia diversified its reserves. Of the dollar reserves that it earned through selling oil and gas, it sold 58.5% of them, forcing the dollar down. Private capital had to step in and take the risk. Similarly the Middle East deposited its dollars with British banks leaving them to deploy them on their own books, but eventually the risks became too big for private capital to bear. The point is that something is wrong with the system if firewalls can continually be over-ruled, and zombie companies, and even worse, zombie economies kept alive. The need to borrow and the failure to restructure are commensurate with governments and central banks over ruling the natural order of markets. Keynesian and monetary stimulus cannot continually be used as single edged sword. The failure of the Gold Standard in the 1920's and the Gold-Backed Standard in the 1960's was precisely because the natural balance was overruled by governments, turning the system from a creditor system to a debtor system.

There is a saying that socialism collapsed because it did not allow the market to tell the economic truth. In recent years, the overruling of the firewalls that I have mentioned, and the increased roll of government in allocating spending, has been akin to forcing the market to tell a lie.

The reality goes a lot deeper. The return on college tuition has fallen in the States since 1998 such that the wage differential that the higher education affords has fallen relative to the cost of attaining the education. Some of this may be due to a declining quality of education, but since the Internet boom, it may also been due to job growth being concentrated in the construction industry as banks misallocated capital into housing rather than productive industries. The other area of job growth has been healthcare, where again there has been a poor return on investment. Drug productivity has declined both in terms of the number of new drugs per unit of spending on research and development, and in terms of economic return as measured by the drug sector's share prices, which have stagnated since the mid 1990's. Similarly medical spending overall has failed to pay for itself. The cost of extending life expectancy has far outweighed the benefit that could be achieved by an equal extension of the working age. Whilst both higher education and improved life expectancy are aspirational, unless they can generate a positive return, they rank alongside any other form of consumption and are therefore at risk of having to be scaled back, as we will later find out happened in the former Soviet Union. Unless the US can start to generate a positive return from its investment through better innovation, then its ability to continue attracting money from abroad will gradually disappear. Without a better allocation of resources leading to innovation, the US would eventually sell down its technology to other parts of the world, lifting their relative consumption and starving the US of capital.

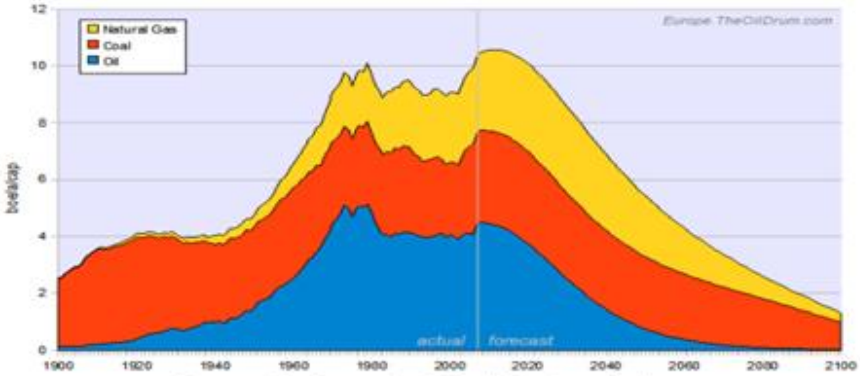
Chapter 3. A fair day's pay.

Ideas beget ideas. Words inspire thought. No one person has a monopoly on valuable information or insight.

My father always used to say that the most important invention ever was the wheel. Others may say fire or perhaps the plough. In all sciences and industries, the biggest and easiest advances happen at the outset. From there onwards there are declining marginal productivity improvements. To achieve efficiency gains takes more and more research and development. With every advance in science, the difficulty of the task is increased. To maintain a smooth productivity growth therefore, the amount of research and development needs to grow exponentially.

If we want to achieve steadily expanding productivity gains, then by definition we must divert an increasing number of resources to achieve that gain. More and more man hours and computer hours will need to be diverted to attaining these scientific advances. That means that there are less and less resources available for simply maintaining the status quo. We therefore need to find substitute resources. Manual work has to be replaced by machines and mental work by computers, both of which require fuel to operate. This is known as the "energy subsidy". At the moment the world's population is 6.8bn people, but our energy use is the equivalent of having an additional 300bn people working 24 hours a day for 365 days a year. Over the last 100 years energy consumption per capita has gone up 5-fold, although it has been fairly flat since 1980 - (see Olduvaie curve below). If you take those first 80 years therefore, energy consumption per capita rose by 2.03% per annum on average, but has since been roughly flat until the turn of the century. Combine this energy subsidy with population growth, and overall economic growth can be explained almost perfectly.

Conventional Fossil Fuel Consumption per Capita



Forecast for Conventional Fossil Fuels per Capita.
Sources: UN for Population model, Jean Laherrère [pdf!] for Natural Gas, Energy Watch Group for Coal and The Oil Drum - Khebab for Oil. Click for large version.

The energy subsidy is necessary to achieve productivity growth. Without it we are simply reliant on working the population that much harder; what is termed factor mobilisation. But there is a limit to this. There are only so many hours in a day, and the Earth can only provide food and water for a certain number of people without increasing plant and soil productivity. This limit to growth without productivity was described by Thomas Malthus, and effectively explains what happened to China 500 years ago and to the Soviet Union over the last 100 years; their demand for resources outstripped the country's ability to provide them.

To obtain real wage growth, productivity needs to rise. If someone can produce twice as much this year as they did last year, then their effective real wages will have doubled. To achieve that productivity growth, it is likely that more machines, or more advanced machines and computers were needed. To design and build that technology means sacrificing final consumption and redirecting the resources that would otherwise have been consumed. To keep advancing the economy needs to direct more and more resources away from final consumption and into education, and research and development. More and more technology is therefore necessary to make up for this shortfall. Ofcourse this all relies on energy, and explains why the energy subsidy is so vital to economic growth. The U.S. has not seen any real wage growth since the early 1980's. Neither has it seen its energy consumption per capita rise. It would seem therefore that the U.S. has not seen the 2% per annum productivity growth over the last 20 years that government statistics claim.

Some people will no doubt say that my logic is wrong. Why is a U.S. car that burns twice as much gas as a European car an indication of productivity advancement? By itself it is not, but the very fact that the economy as a whole is able to produce sufficient fuel for people to drive these gas guzzling cars is an indication of the level of overall productivity. The U.S. economy has sufficient economic power that it can support this level of fuel inefficiency if that is their preference.

Energy Consumption Per Capita.
http://globalis.gvu.unu.edu/indicator_detail.cfm?country=KR&indicatorid=146

Random sample only

	1980	2000	% Increase
Zambia	318	111.00	-65.09
Mozambique	174	61.00	-64.94
Albania	905	341.00	-62.32
Afghanistan	33	15.00	-54.55
Romania	3112	1477.00	-52.54
Russia (only available since 1995, so used oil production as a proxy)	12.7	6.50	-48.82
Cameroon	151	84.00	-44.37
Poland (all the fall happened before 1990)	3479	2234.00	-35.79
Zimbabwe	413	340.00	-17.68
Bulgaria	2639	2229.00	-15.54
Canada	7777	7862.00	1.09
Algeria	924	946.00	2.38
United States	7321	7725.00	5.52
Belgium	4789	5099.00	6.47
United Kingdom	3483	3864.00	10.94
South Africa	2390	2654.00	11.05
France	3360	4131.00	22.95
Italy	2379	2933.00	23.29
Argentina	1238	1600.00	29.24
Brazil	531	717.00	35.03
Japan	2662	3766.00	41.47
China	389	556.00	42.93
Spain	1659	2773.00	67.15
India	142	318.00	123.94
Indonesia	167	385.00	130.54
South Korea	960	3284.00	242.08
Thailand	258	970.00	275.97
Germany (data only available since 1995			

Productivity growth has instead happened in Asia. First the Asian Tigers and then China. It is obvious that their standards of living have improved dramatically over the last 20 years; they are clearly narrowing the gap with the West. As you can see from the previous table, energy consumption per capita rose by just 5% in the United States between 1980 and 2000. In France it rose by 23% and Spain by 67%, but in South Korea it rose by 242% and Thailand by 276%. The fact is that it is much easier to obtain productivity growth from a low base, particularly when the science has already been developed and it can simply be bought in. It is far easier and cheaper to teach your children basic literacy and numeracy that will enable them to operate modern equipment and press a few buttons, than it is to push education to the next level that potentially might result in major new scientific advancement. The U.S. could therefore achieve a far greater energy subsidy by outsourcing production to the massive potential labour forces of Asia, than by trying to achieve productivity growth on its own.

Unfortunately whilst the U.S. has outsourced its basic production, it has failed miserably to achieve any major technological advancements. Rather than directing the freed up resources that outsourcing allowed into Research and Development, the U.S. seems to have simply rested on its laurels. In fact it has actually lagged behind other parts of the world in rolling out the Internet and mobile phone technology. Consumption has become too large a part of the economy leaving insufficient resources available for economic advancement. Not only has the U.S. household been borrowing from abroad, but of its own domestic output, very little has been spent on innovation or even maintaining existing levels of investment. It has slipped down the league of patent applications. The United States needs to address this. If the free market cannot make this adjustment by itself, then it should take notes from Germany and raise the consumption tax whilst lowering corporate tax. It needs to step up funding of research and development. People say that the biggest leaps forward happen during war time. The reason is simply that the allocation of resources is shifted to obtaining that scientific advancement; the capital:labour ratio rises. If the redirection of resources achieves productivity gains, then the size of the whole economy expands. Household consumption may achieve a smaller percentage of the whole economy, but it will nevertheless be bigger in absolute terms than without these productivity advancements.

Unfortunately at the moment, government policy has been aimed at stopping the natural processes of the credit crunch happening by trying to support existing consumption. This is understandable as it will cushion the short term pain from the restructuring, but it will leave the economy with a bigger pile of debt and little in the way of productivity reward. Instead it should embrace the restructuring that is needed by directing capital into big new projects that will improve productivity just as it would during a war. In the 1930s for example, one of the projects was the Hoover Dam which continues to contribute to US power generation 80 years on. During WWII the Allied governments directed resources into jet engines that led to the modern airline industry. There was investment in the first computers and ofcourse during the Cold War there was investments in the Space Race that led to satellites and modern communication systems. All of these investments led to huge productivity gains and were behind a lot of the growth of the last half century. Similar thinking is needed by the governments of today.

Asia’s economy has expanded aggressively compared with the West. Their standard of living has improved dramatically. Household consumption rates as a percentage of the economy are just a fraction of their U.S. equivalent. The Chinese savings ratio is 50% - (household savings ratio is 25%). This allows Asia to obtain productivity gains dramatically faster than the West, although it is only achieving these gains by pairing off cheap Asian labour with existing Western technology. It is not pushing the boundary or achieving any new scientific advancement.

As Asia’s increased energy subsidy drives productivity advancements its wages naturally rise. If it is able to produce twice as much today as it did yesterday, then its wages will double. As its wages rise, its energy consumption per capita will also rise. If it is able to produce twice as much today as it did yesterday, and the West is unable to produce anything more, then Asia’s wages will rise relative to those of the West, and its consumption of energy will also rise relative to that of the West. The Chinese new car market for example has already overtaken the presently depressed levels of the U.S., and with vehicle sales expected to exceed 11 million units in 2009 it will be within 25% of the record set by the States in 2000. If China’s economy continues to expand at the present pace of about 10% per annum, then the number of workers that will move into the threshold of being able to afford a car will rise exponentially every year.

China’s energy consumption is presently running neck and neck with the U.S. By 2010 it will have become the world’s largest consumer of energy, and yet its economy is still only a fraction of the size of the States and not expected to equate with it until 2030 at the earliest. Chinese economic growth lifted world energy prices to record ever levels in 2008, even after adjusting for inflation. If the size of its economy were to match America’s over the next 20 years, then what would that mean? Its energy consumption has grown about 5% per annum faster than its economic growth over the recent years, but assuming that the two were to achieve parity, then its energy demand would have to grow 6.7 fold between now and 2030 for the size of the economy to equate with the U.S. Without a new source of energy, this would be impossible to facilitate. As we will find out in later chapters, the productivity of energy is itself collapsing. More and more resources have to be directed into maintaining existing fuel production leaving fewer resources available for the consumption of that energy.

China is extremely energy inefficient, consuming more than 10 times the energy per unit of GDP than Japan. People therefore expect it to be able to achieve efficiency gains, allowing its economy to grow vastly faster than its energy consumption. Their logic runs along the lines that China will move from a heavy engineering economy to a much more diversified economy that is less energy intensive. The problem with this logic is productivity itself, or a particular branch of it called the Jevons Paradox. Increased energy efficiency lowers the effective price of the energy when it is measured in terms of the work that it can achieve, and as we all know when something becomes cheaper we demand more of it. Indeed it is the very fact that the price of energy from 1986 until recently had been at an all time low that China's energy consumption has been able to soar. If energy prices had remained high then almost no matter how low Chinese wages had gone, its economy simply would not have been able to compete.

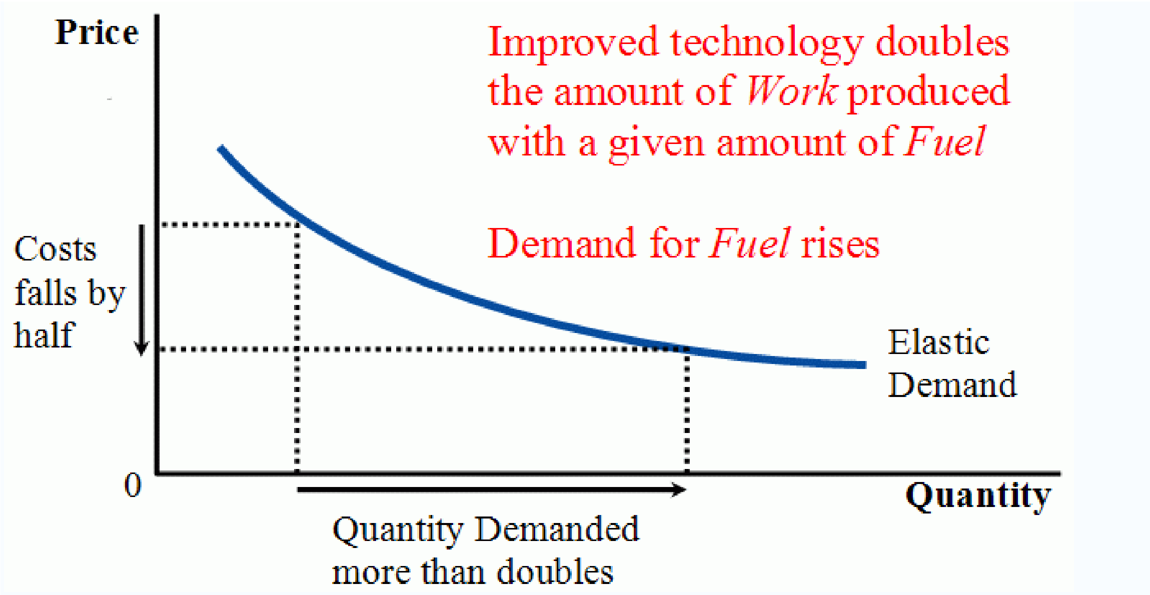
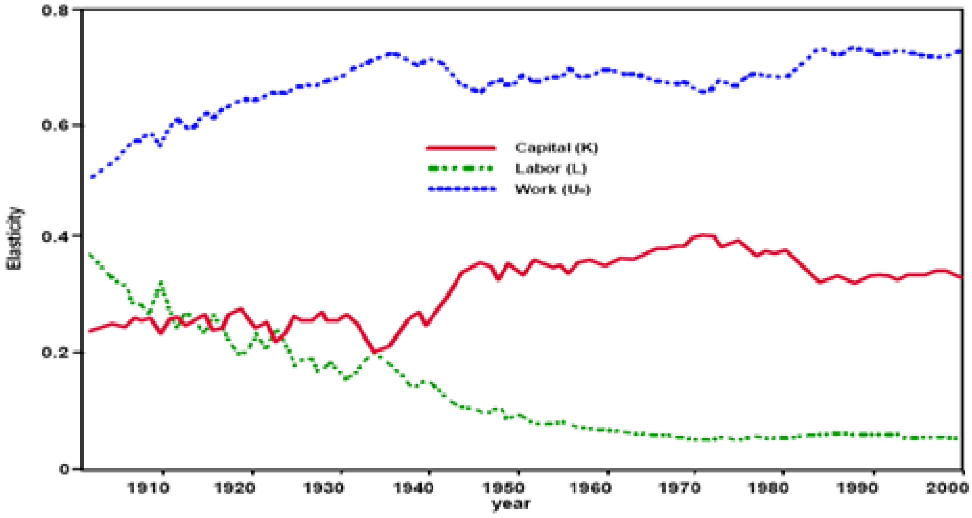


Chart Provided by Wikipedia

The question therefore is not whether China's economic growth would be accompanied by rising energy consumption, but rather whether its economy can grow at someone else's expense. Given that China is now the world's largest energy consumer, it seems reasonable to ask the question whether it can out- compete the United States for the available energy? To answer this we need to know why China is so energy inefficient. The problem is not that it is reliant on particularly heavy industry. In fact it consumes about 3 times as much energy per capita as its neighbour South Korea which competes with China in a lot of the heavy engineering industries. The problem is much more basic than that; it is the scale of its population. China's land and water supplies simply cannot support the population even to its present standard of living. Beijing and the surrounding area are consuming 75% more water than sustainable via natural rainfall and rivers. Aquifers are being pumped dry to meet demand. Some of them are over 100 metres deep, which is the height of the Victoria Falls. Imagine the energy required to lift the water this height. Most people know that the Italian city of Venice is sinking at a fraction of an inch every year, but parts of Beijing are sinking by up to eight inches - (20 centimetres) - a year as the world's largest cone of depression – (underground hole created by depleted water table) - measuring over 40,000 square kilometres has been formed by the exploitation of these aquifers. It should be no surprise that the world's second largest cone of depression measuring over 8,000 square kilometres is located around Shanghai. Major rivers are increasingly failing to reach the sea, but despite this China's water consumption per capita is still just a fraction of that of the West. If China's economy is to grow, its water consumption will need to rise. Not only do all the new houses need modern plumbing, but industry also uses vast quantities of water for cooling and cleaning etc. To meet these needs, the scale of desalination that would be required would be vast. Some estimates suggest that by 2020, industry will need to get about 20% of its all its water requirements from desalination, which would lift Chinese energy consumption onto a different plane. The second area of inefficiency is in food production. Over exploitation of the land is rapidly turning it into desert. The removal of forests to meet land needs has resulted in top soil literally being washed away. In WWII Japan invaded Manchuria for its resources. Seventy years later, double and triple cropping most years has resulted in a complete collapse in its carrying capacity. Top soil has been washed or blown away such that it is unlikely to be able to support the existing scale of crop production for much longer. To compensate for mineral depletion and the sterility of the soil, China uses three to four times as much fertilizer per acre of land than is used in the West, and yet its yields are only about 90% - 95% of those achieved in the West. Fertilizer production is the 4th largest consumer of coal in China, behind power generation, steel and cement.

It seems likely therefore that Chinese energy consumption will continue to grow at least in line with GDP. In fact as its water and soil resources become ever depleted, it will require a larger and larger energy subsidy just to stand still. Even if you put this to one side, its marginal productivity of capital has fallen consistently since 1990; it is getting less growth for each new bit of capital or energy it employs. Rather than productivity improvements going into higher wages and a better standard of living, it will go into finding fuel. China will be running faster just to stand still. This is already evident in 2009 as China increasingly has to turn to imports of coal, iron ore and steel as the embedded energy is cheaper than if it is produced at home.

The efficiency or productivity of an economy is traditionally measured as economic output per capita. There is no mention of energy in that calculation, and yet the energy is perhaps the most important factor in allowing an economy to grow. All aspects of economic output are dependent on energy input to a greater or lesser extent. If I think about my average day, I consume food which is one of the heaviest users of fuel to plough, fertilize, pesticide and harvest the fields. Grains then need to be washed, heated and dried, then transported from farms to processing centres where they will be ground, mixed with other ingredients, cooked and packaged, all of which requires more energy. It is then transported to shops and from there on to our homes where it is either stored in a fridge or cooked or eaten straight away. Washing up and maintaining hygiene then takes as much energy again. I then drive to the station in a car, get on a train and read a newspaper. Not only does the car and train use energy, but both them, and the newspaper required energy in the initial manufacturing process. I then walk to the office along the pavement that has been made with burning tar. The office is made of steel, bricks and glass, and furnished with fibres that even if they are organic have been turned into a useable product by energy. I then need the lights on to read the computers. The more powerful the computer, the more energy it consumes. I have a cup of tea where the water I use has been pumped many miles and up at least 3 flights of stairs to the tea machine which then boils the water. My colleague has a can of coke where the aluminium packaging is almost pure energy. Every single aspect of modern life is reliant on energy in one form or another.



Marginal productivity (elasticity) of each factor of production in the USA 1900 – 1998
(Accounting for Growth: The Role of Physical Work by Ayres and Warr)
http://www.iea.org/Textbase/work/2004/eewp/Ayres-paper1.pdf

Economic output and economic growth is dependent on how much energy we can deploy efficiently. The marginal productivity of energy equates to more than twice the combined marginal productivity of capital and labour. Economists will say that the capital equipment is far more important than energy because it contains the accumulation of knowledge that allows us to achieve the latest advancement. That knowledge is however based on trial and error and everything that has gone before it. In other words it is based on our cumulative use of energy. A modern car is faster, more efficient and safer than its predecessors, yet the equipment advances that have achieved this have only been discovered by the funding that has come from selling the older car, ie from the accumulated use of energy. To achieve productivity gains, existing capital equipment needs to be replaced with more modern equipment. People often highlight the 7.6 miles per gallon improvement in energy efficiency that American cars achieved during the 1970’s and 1980’s oil crisis, however this improvement, which happened between 1977 and 1985 was only for a new car. It took another 15 years to achieve it for the fleet as a whole. Even this is somewhat of an exaggeration of the advances in innovation as the U.S. manufacturers were simply buying existing, more fuel efficient technology off Europe and Japan.

The U.S. car fleet remains about 45% less efficient than Europe’s. It has aged from about 6 years in the early 1990’s to about 10 years today. On average a car loses 1% fuel efficiency every year that passes. Seals go and engines lose horsepower. Barings grind. Drive chains and gears wear down and become less efficient. As it ages it also has to spend far more time in a garage, consuming more and more man-power and parts. In the short term this deterioration in efficiency is more than offset by reduced energy demand from turning over the fleet less frequently - (When adjusting for the energy loss through power plants etc, it takes the energy equivalent of about 50 barrels of oil to make a car) - giving a false impression of fuel savings. Over the longer term however, more money and resources are wasted on the car by the loss of fuel efficiency and the mechanical maintenance that it requires than making a new car. Productivity gains are only achieved by turning over the capital stock which consumes vast quantities of energy.

The fact that U.S. energy consumption per capita has not increased since 1980 is not indicative of efficiency gains, otherwise real wages would have increased. Instead it is due to underinvestment in capital equipment and infrastructure etc. In some cases U.S. capital equipment is vastly beyond its efficient lifespan, perhaps best emphasized by the score card that its own American Society of Civil Engineers have given the country. Without heavy investment in new equipment, the U.S. risks productivity falling and therefore a lower standard of living. This is known as the Thermodynamic Equilibrium. If you imagine a motorcycle going around a wall of death at a circus, then to get to a higher plane the motorcycle needs to open the throttle and consume more energy. If it reduces its throttle and consumes less energy, then the momentum it still has will only keep it at that height for a short period of time before it starts to slide to a lower level. For an economy to obtain a higher level of productivity a greater amount of energy needs to be consumed, and to maintain that level of productivity the capital stock needs to be continually turned over and updated, consuming energy. With US capital equipment now beyond its useful life, if it is to avoid a falling standard of living, it will have no choice but to increase investment and therefore increase its energy consumption.

In the previous chapter I made a rather facetious remark about the term intellectual capital being applied to the banking industry. Intellectual capital cannot however be dismissed so lightly. Education is the single most important investment that we can make, opening up doors to everything else. Medical advances that could cure diseases and reduce the amount of days people have off sick each year can dramatically lift economic growth, probably more so than repairing antiquated infrastructure. I think most people would agree that intellectual capital is what causes advancement. Where it is misunderstood however is the importance of energy in that advancement. If you take the Human Genome Project for example, this was completed in 2003 after 13 years of work. The project was coordinated by the US Department of Energy and the National Institute of Health, with major investment from the Wellcome Trust, Japan, France Germany and China. First of all the resources to invest in this project would only have been freed by the overall energy subsidy. Secondly vast amounts of computing power will have been used to determine, store and analyse the DNA sequences. The press have recently highlighted that performing 2 Internet searches from a desktop computer can generate about the same amount of carbon dioxide as boiling a kettle for a cup of tea. Think how much energy would have been consumed by the world's most powerful computers doing this 13 year analysis, and all the energy consumed in the spin-off projects. As I said earlier, with every advance in science the difficulty of the task is increased. More data needs to be analysed and manipulated. Computers need to be more powerful. The existing capital stock of computers needs to be upgraded requiring vast amounts of energy in just the same way as turning over the U.S. car fleet would absorb huge amounts of energy. The IT industry now generates as much carbon dioxide (CO_2) as the world's airlines and it is growing exponentially. More powerful computers require ever more energy to operate. Productivity growth in all of its forms is concomitant with greater energy demand.

In the last few months of 2008 and the first quarter of 2009 as the credit crunch deepened and people lost their jobs, one of the things that become all too obvious was that there had been a huge amount of fat in the system. Take those high paid bankers for example. If they are salesmen they would probably be paid about 2% or 3% of the revenue that they generate. Assuming that similar amounts went to analysts and traders etc, then around ninety percent is supporting admin, management and other overheads. Some of this may be necessary, but 90%? Those bankers then pay taxes. Rather than all being collected at source, the tax men decide to collect it through numerous different means, justifying a huge workforce. In the United States 16% of GDP is spent on healthcare, twice as much as in northern Europe or Japan where the life expectancy, the ultimate arbiter of healthcare efficiency, is much longer. Have you ever sat down and thought what proportion of workers within the economy, actually produce something useful? If we all produced something, the size of the economy could be many times the present size. The nation's standard of living could go up dramatically. Taxes could be lowered to just a fraction of the present rate but still bring in more revenue. Productivity and economic advancement could soar. There are two problems with this. The first is the scale of energy subsidy that would be required to support such a workforce would be huge. Moving some of China's workforce up the very first steps of the productivity ladder lifted its economy from nowhere to the third largest in the world, but also lifted world energy prices from record lows to record highs. The second problem is how much of the same product do you want?

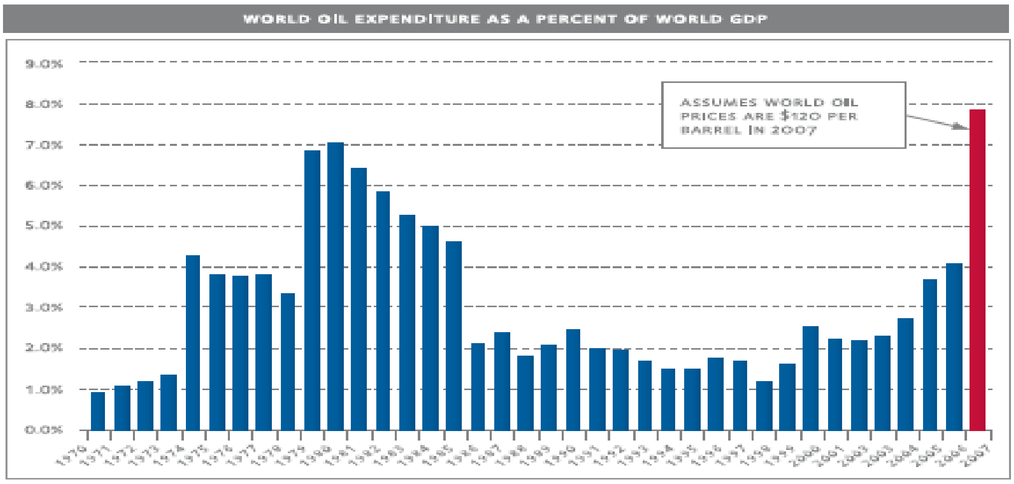


Chart provided by www.theoildrum.com

As I will explain later in the book, there is not the fuel availability at the moment to lift world productivity, so resource allocation will have to be determined by relative productivity. Any increase in energy consumption by one country or industry must come at the expense of a decline by someone else. The rapid rise in energy prices in recent years and the resultant credit crunch is this process happening. The United States is seeing its economy contract whilst China appears to be winning out in what is effectively a resource war, expecting to see 8% economic growth in 2009. Looked at from a different perspective however, we know that the U.S. economy cannot presently compete. The huge restructuring of the U.S. workforce is extremely painful, but if you can remove yourself from the personal hardship it may cause, in the end it could put the U.S. in a good position. Firstly by shedding some fat it will increase the capital to labour ratio of the remaining staff and therefore lift their productivity. It will result in a large pool of cheap well educated labour that if deployed efficiently, should see the overall economic potential of the economy increased. It is how those resources are deployed that is vital to the long term outlook. Government transfer payments can get people back into work, but if it is not productive work then it will not help the U.S. compete for resources. Hopefully the credit crunch is the wakeup call that the U.S. needs.

On the other hand China appears to be the victor at the moment. It is offering cheap loans and funding to any country that will buy its goods. This may sound generous and will sustain its economy in the short term, but looked at in a more objective manner; China's exports are not competitive. That may sound strange given that it is winning market share globally with its products, but the point is it has to lend money to the international community to enable them to afford to buy them. Without that cheap capital it would undoubtedly have a much lower market share. If it hadn't lent over USD2trn to the United States over the last few years, how many goods would it have actually sold? By maintaining this false market it is investing in capacity that in the long term cannot possibly compete. By simply applying existing Western technology to its workforce China is producing capacity way in excess of economic demand.

Whilst the United States has fallen to 4th in the world annual league of innovation and patent applications, China is 54th. It seems that it is almost literally true that the last great invention China made was gun powder. Without innovation, China's economic growth is to the detriment of the world as it starves other countries of the capital that they need for research and development, and therefore for innovation. New sustainable markets are not found by selling more and more products at cheaper and cheaper rates, but by designing new products to sell and tempt the public as per the mobile phone or the Internet. Cheap Chinese labour has sucked in capital from the rest of the world offering it a greater return, but without innovation the world's overall return on capital will fall. U.S. companies such as General Electric and Intel are recognising this. They say that U.S. growth over the last 25 years has been about household borrowing, but now, for that growth to continue the companies have to go back to basics and invest in research and development to create new products and new markets. Unfortunately 500 years of history and a Socialist regime suggest that China does not have the mindset for innovation, relegating it in the longer term to nothing more than a cheap labour force and only when energy prices are low.

As the next few chapters will hopefully explain, today's problems are far more serious than even this would suggest. Both energy output and the human workforce itself are set to become less productive with major implications not only for the relative performance of economies, but more importantly for absolute performances.

Chapter 4. Tightening the old age purse strings

When a man's vision is fixed on one thing, he might as well be blind.

One fact of life that unfortunately no one can deny is that we are all ageing. Normally however this is a transition within a population; with the age of the population itself remaining static as new children are born. In most of the developed world, this is no longer the case; the population itself is ageing with major consequences. As an individual person ages, they go from being a net consumer of goods to a producer and then back again to a large consumer. Now whole countries are following the same path.

Demographics in the United States, Europe, Japan and particularly parts of Asia, now face similar problems to those that were instrumental in the collapse of the Soviet Union. Each has taken their fertility rates down at different speeds. Those that took them down the most aggressively saw the biggest demographic dividend on the back of it, but are now ageing much more rapidly. Whereas the U.S. is ageing by 1 month for every year that passes, other countries are ageing by 5 or 6 months. As the dependency ratio collapsed, capital over and beyond consumption was freed up, allowing for big increases in investment and the productivity improvements that came with it.

Those countries that took their time to bring their dependency ratio down were able to build up capital over a sustained period by investing in research and development and lifting the world's overall level of advancement, whereas those that brought their dependency ratios down very quickly, and are now ageing rapidly, have not been able to afford this luxury. As much as they may have wished to deploy their surplus capital at home, it has been far easier and cheaper for them to simply buy existing off-the-shelf technology and education rather than just reinventing the wheel. It will not be until the cost of labour and thereby productivity, has risen to developed country standards, that it would be more efficient to invest in innovation. A large proportion of their savings will therefore continue to be deployed externally. The question for these economies is just how far their productivity will improve and what standard of living they will reach before they become old.

The U.S. old-age dependency ratio fell from 39% at the end of the 1940's down to 20% in the early 1970's where it has remained ever since. It now starts to rise fairly linearly as the baby boomers retire. By 2030 it will be back to 36%, an increase of almost 1% per annum. Assuming a retired person consumes just 50% of what he consumed when he was a net producer, this will mean an additional 8% - (1/2 * (36 - 20)) - of total output will have to be directed to these non producing assets. Under any circumstance, that is a huge cost for the economy to bear, and just to show that I am not exaggerating the cost, the Trustees to the Social Security Fund say an immediate 2% increase in payroll taxes are needed just to bring the state pension fund into actuarial balance, let alone the private sector. Without the increase, the fund will turn cash flow negative in 2016, but even ignoring this deficit, the government has already borrowed from the scheme so will have to redirect tax revenues just to repay the loan.

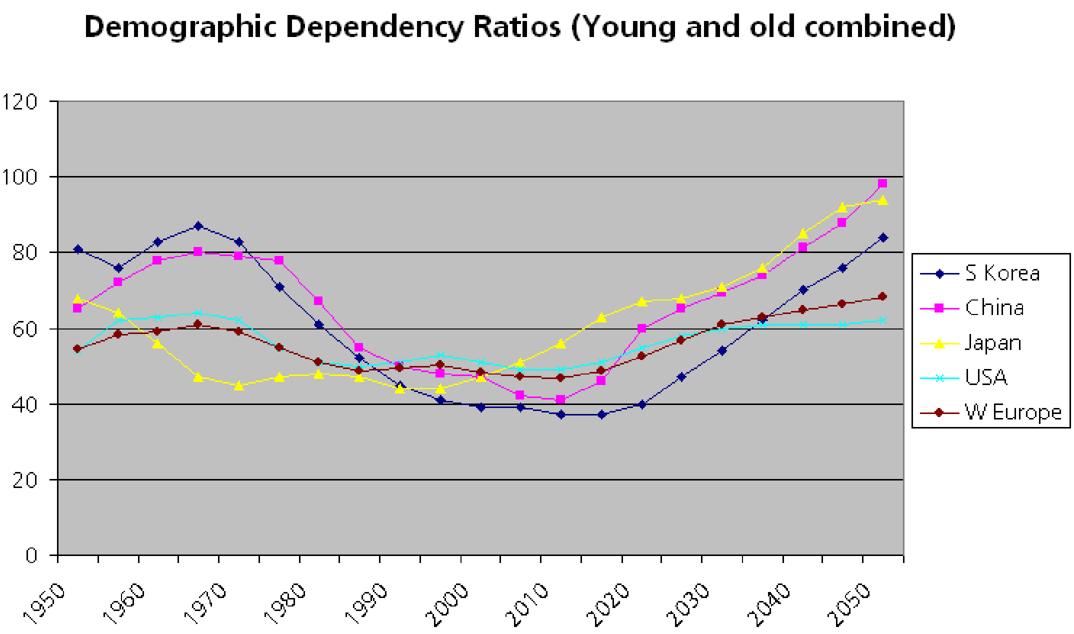
Unfortunately the story gets worse. As we know the U.S. has been running a large current account deficit for many years. It has been living beyond its own means, borrowing off the rest of the world. As its dependency ratio rises, it will need to borrow increasing amounts just to sustain its existing standard of living. The creditor nations however face a demographic bust at least as bad, if not in some cases substantially worse than the States. They will no longer be in a position to continue exporting savings, but will rather be recalling existing loans and if the chance arises, looking to borrow to support their own economy. It will no longer be a case of just the U.S. facing a capital shortfall, but almost all of the world's main economic powers. Despite the pain, the reality of the present credit crunch is that the U.S. has continued to borrow, although at a much reduced rate. When these loans are eventually called in, it will be yet another effective tax on the U.S. economy; however unlike the present situation where increased spending from China and other countries is trying to offset the contraction from the United States, it will be a situation where global production as a whole is being squeezed.

Piling on the bad news, as the U.S. ages, the demands on its healthcare system will soar. In 2007 Federal Reserve governor Fisher warned that the present value of future liabilities was USD83.9trn – (about 6 years worth of US economic output). In April 2009 the Medicare Trustees issued their third consecutive "Funding Warning". The Medicare Hospital Insurance Fund (HI) started to see negative cash flow in 2008. The Trustees suggest that it could be brought back into actuarial balance by an immediate 134% increase in the allotted payroll tax from 2.9% to 6.78%, or an immediate 53% reduction in program outlays, or some combination of the two. Rapidly rising doctors' bills and outpatient expenses will lift the Supplementary Medical Insurance (SMI) projected funding needs from 1.3% of GDP in 2008 to 4.7%, however this is over the next 70 years. Assuming a linear increase, this would require an immediate 1.7% tax increase to meet this payment. Overall therefore, without a default on its Medicare commitments, the U.S. would have to raise its payroll taxes by just over 5.5%.

As you start to see, the costs involved in the demographic problem are huge, completely dwarfing the scale of the present credit crunch. The cost however is only half of the problem. As the economy directs more resources to pensioners for final consumption, or abroad to pay off external debts, there would be less capital available for industry. Productivity will go through the floor setting off a vicious spiral. Rather than attracting the best brains into the country, the increased tax burden would surely result in a massive brain drain, pushing the economy to a lower level of value added output. The U.S. has to increase the percentage of resources going into economic output and reduce those going into final consumption. Whilst the increasing "Grey vote" will make this difficult, the U.S. will have no alternative but to default on its healthcare and pension programmes.

Germany is achieving this default by raising the consumption tax and lowering corporate tax. By increasing the consumption tax it will lower the effective purchasing power of the pension, whilst lowering corporate tax will allow greater investment in plant and machinery and therefore support productivity and wages. Pensions would be a smaller percentage of output, but it would hopefully be bigger in absolute terms as the economy as a whole would be bigger. Thirty years ago the U.S. had the lowest corporate taxes of any of the major industrialised countries, whereas now it is the second highest. This has to be lowered, which means using taxes to rebalance the economy from household consumption to domestic production. The burden of the hugely inefficient healthcare system also has to be cut.

The chart below shows the total – (childhood and old age combined) **-** dependency ratio of some of the major economies. As you can see, West Europe and the United States have shallower curves than the Asian economies. Had it not been for the baby boom immediately after the war, their curves would have been flatter still. Asia has had the biggest demographic dividend, and because it was mandated by government and the one-child policy in certain countries, it happened in an incredibly short period of time. South Korea for example will take just over 15 years to move from an aging society in which 7% of its population is over 65 to an aged society where 14% of its population is over 65, something that took Western Europe about 100 – 150 years to achieve. The positive consequence was that the Asian Tigers and China saw their workforces rise about 4 times faster than their dependent populations, freeing up a huge amount of productive workforce over and above final consumption, resulting in the surge in exports and the build-up of capital that we now associate with their economies. Unfortunately as more people now start to leave the workforce than enter it, this demographic dividend will reverse.



Typically a retired person is only expected to be able to sustain a pay cut of 25% - 30% of their final salary. Even if their pension was to fall to 50% of their previous salary as I assumed in my earlier calculation, that will be a huge cost to bear. U.S. Federal spending on those aged 65 or over is 10 times Federal spending on children. Using these parameters to define a "weighted" dependency ratio, you can start to understand the difficulty that countries now face. The rating agency Standard & Poors warned in its June 2006 Greying Country Report, that South Korean government debt would sink to "speculative grade" by 2020 without a fundamental reform of its pension system. Faced with a massive shortfall of capital at home, these countries will turn from net exporters of capital to net importers.

The two largest U.S. creditors are Japan and China. Seven million Japanese were born between 1947 and 1949, entering the workforce 15 – 20 years later and helping drive Japan's economic miracle. Those same baby boomers will retire over the next few years, reducing the workforce by a net 3%, but a reduction in the fertility ratio (number of children per woman) below replacement means that by 2030 Japan's working population is expected to shrink by 12.9% as insufficient children enter the labour market to replace those retiring. The elderly dependency ratio will increase by 8% in the next 5 years alone. As more and more Japanese output is directed into consumption by non-productive assets, ie pensioners, there will be less capital available for plant and equipment. Productivity will fall and with it wages. The only way around this is to direct a greater proportion of economic output into capital equipment and productivity gains. Domestic assets have to compensate private capital to stay at home. Japan's economy has achieved this to some extent, by real wages falling by just over 0.5% per annum since 1996, offering capital a higher rate of return. Government monetary and fiscal policy aimed at countering the slowdown has in all reality slowed the adjustment process, but despite this there are clear signs of the capital coming back into the country. Toyota for example have said that it will not expand or build any more U.S. car plants, as the logistics of producing more cars in the United States doesn't work given that Japanese wages are now lower. Instead it is building its first new car plant in Japan for 17 years. Japan's rising dependency ratio means that it will only be able to maintain its standard of living by increasing its capital to labour ratio and replacing man hours with machine hours and an increased energy subsidy. Over time Japan will have no choice but to sell down its foreign exchange reserves, and indeed in June 2009, the Japanese Government Pension Investment Fund, the world's largest pension fund with 120 trillion yen (1.2 trillion dollars) of assets, announced that it will now become a net seller of assets to meet its liabilities.

Of course the biggest exporter of capital to the States in recent years has been China. Unfortunately it faces the biggest demographic bust of them all. China's economic boom has been extremely powerful, but it has also been built on extremely poor foundations. China officially adopted the one-child policy in 1979 although the fertility rate had already fallen heavily to levels below replacement in the ten years beforehand. The workforce is thought to have peaked in 2008 with the old age dependency ratio at 16%. As the last of the parents from before the one-child policy was implemented now start to retire, there are going to be fewer workers replacing them. Through just two generations, from grandparent to grandchild, the number of children being born would fall by 75%. Imagine when those grandchildren become the main workforce, the huge cost that they would have to support. Western economists who have wished for an increase in domestic Chinese consumption and reduced exports are likely to get more than they bargained for. The reality is that the economy would collapse under the weight. Over the last 15 years, China's industrial workforce expanded by well over 100m people – (the entire U.S. workforce is only 155 million) - but over the next 15 years it will shrink by 80m people due to demographics.

China's problems go even deeper. It faces a gender imbalance due to hepatitis that goes all the way through the population to those in their 50's. The male population is roughly 10% larger than the female population, so the reality of a one-child policy is slightly less than one child. As I will explain in a later chapter, with declining agricultural productivity, the migration from the countryside into town will also reverse putting the industrial workforce under even greater pressure. China's ability to continue exporting capital will reverse. Its loans to the U.S. and other countries will be called in.

The last 30 years or so have seen dependency ratios collapse globally. Surplus capital soared, and like anything else, when there is an increase in supply, the cost of that capital became cheaper. Bond yields fell and the yield premium demanded by equity investors over bonds inverted as the traditional yield gap became the reverse yield gap. The growth in the financial system was undoubtedly driven to some extent by the excess capital resulting from the falling dependency ratio. Would the so-called "secondary banking system" of hedge funds have ever happened without this excess capital? Would banks have taken their provisioning levels down to record lows? As the dependency ratios across the world's developed economies start to rise, it is logical to expect the cost of capital also to increase. Not only will sub-prime mortgages no longer receive credit, but over time only those projects offering the highest returns on investment will be financed. Equity investors will again be able to demand a yield premium over bonds for taking the additional risk. If there is less capital to allocate, the banking industry itself will shrink. With credit growth slowing, or possibly even falling, the outlook for the economy is very bleak. Repayment of loans made when the economy could conservatively assume 3% per annum growth will start to look much less secure.

In May 2007 Federal Reserve governor Frederic Mishkin stated that Federal Reserve economists now believe that the maximum sustainable growth rate of the economy is slowing with the slowing population growth. Similar comments have been made by Canadian and Japanese politicians. An IMF working paper highlighted that in a world of falling labour forces, it is important to focus on per capita variables rather than aggregate variables. Monetary growth per capita will slow because of capital depletion and falling wages. How do you create economic growth in an environment of lower real wages? If monetary growth per capita is weaker, then overall monetary growth will be a lot weaker. This would be a disaster for banks. In the last 30 years as the global dependency ratio collapsed, making a 30 year loan was a great trade as economic growth caused by the falling dependency ratio would have assured the repayment. At the moment the dependency ratio is bottoming and turning higher. The rate of change is clearly very high, and banks had not anticipated this change, hence the collapse in the banking system that we have seen. But over the next 30 years, life becomes much more difficult. If the rising dependency ratio means that economic growth will slow, or more likely that the economy will slow, then 30 year loans need to factor in a much higher rate of default than overnight loans. Whether that default is through inflation or through non payment of capital, the yield curve will have to steepen heavily. The availability of capital for anything beyond the shortest duration will dry up.

As Japan is finding out, no amount of monetary or fiscal stimulus can counter this trend. Immigration is also not feasible on the scale that is required. The number of immigrants coming into the economy would have to be huge. To maintain the present dependency ratio in the United States for example would require around 5 million immigrants every year. Given that we are not generally talking about the populations shrinking for the time being, but rather that shape of the age structure changing, there simply wouldn't be the available homes or infrastructure to support the numbers required. The immigrants would therefore have to build their own support structure, leaving a negligible net contribution to the economy beyond what they are consuming themselves. Similarly trying to lift the fertility rate will not solve the problem, at least not without a lead time of at least 15 – 20 years to educate the children. In the meantime this would increase the childhood dependency ratio and remove women from the workforce, making the immediate problems that much worse. To highlight the importance of women to the workforce, between 1950 and 2000, 60% of all the new entrants into the U.S. labour force were women. The female participation rate is almost at parity with the male participation rate, so reversing even a small proportion of this would have a major impact on growth. For countries like China that have taken their fertility ratios down so heavily, reversing this would take several generations.

If a rising dependency ratio is going to cripple the economy, then the simple answer is to default on the pensions. Targeting tax on pensioners is one way to achieve this, and this is already happening in Germany. Realistically though the tax would have to be very substantial to take pensions down to a level that the workforce can support. The alternative therefore is to delay retirement and extend the working age through cutting the pension. My calculations suggest that a combination of an additional 5 years in work plus a reduction in the pension from 75% of final salary to 50% would go most of the way to sorting out the problem, although in Japan the government has already extended the retirement age from 60 to 65 and is now pushing for it to be taken to 70. In normal circumstances governments are not very good at taking hard decisions, and indeed it has taken Japan 20 years of stagnation before taking these measures. With an increased percentage of the political vote that will come from people in, or nearing retirement, voting through this default will be extremely difficult. It seems likely therefore that rather than the government making the decision, market forces will have to impose the change on us, which means more pain.

The benefit of a larger workforce from raising the pension age is offset to some extent by a natural pattern of decay in productivity and innovation beyond the mid 40's as captured so famously by the 1970's BBC television series Dad's Army.

The demographic dividend that Asia experienced in recent years needed an energy subsidy. The excess labour that it produced would have been of little use in competing with the Western economies unless it could have been married up with modern technology. As the dependency ratio rises, we will need ever greater amounts of energy to compensate. Unfortunately the availability and productivity of extracting fossil fuels is falling. Rather than being able to compensate for the declining dependency ratio with more energy, we now face the situation where the energy subsidy has stopped rising and is set to fall.

Chapter 5. The Extinction of Fossil Fuels

Petronius. "Mundus vult decipi, ergo decapiatur". If the world wants to be deceived, so let it be deceived.

As if the demographic problem was not bad enough by itself, it converges with a much bigger energy problem. I cannot emphasise too much, just how dependent modern life is on fossil fuel energy. Whilst humans have built up intellectual capital to manipulate energy to do our bidding, the scale of the work it is doing is quite frankly breathtaking. Imagine having a servant working for you. He works flat out for 24 hours a day with no days off for holiday. Now imagine every person on Earth having 50 slaves working flat out 24 hours a day for 365 days a year. That is the scale of fossil fuel energy that we use. We now face a situation where the availability of that energy is going to collapse.

There is some argument over the precise timing of this problem. A lot of technical experts believe that we have already gone beyond what is termed peak oil, ie the maximum production of oil. I am in this camp, although quite frankly I would still be worried if I was one of the optimists as they can only see oil production rising until perhaps 2020 before output starts to decline. A lot of the difference is in definitions. Oil is no longer called oil, but rather liquids. Conventional on-shore oil production peaked in the 1970's. Combined onshore and offshore oil production appears to have peaked in 2005, with the exception of one month in 2008. For the last 10 years the main growth has been in gas liquids, tar sands and ethanol, which are significantly more expensive to produce than conventional oil and now account for about 6.5% of all liquid fuels.

Gas liquids are themselves an indication of an ageing oil field. As reservoir pressure declines, the gas within the field begins to separate from the oil, creating "gas caps". This wet gas then has to be processed by putting it through a centrifuge to collect all the tiny oil droplets. Not only is this expensive, but it is also indicative of ageing fields. Imagine a bottle of fizzy drink. When you release the lid, the drink will explode out of the bottle driven by gases. By the time the bottle is only about half full, most of the gas has seperated from the drink leaving the rest flat. Some gas does still come out of the bottle, but it is insufficient to lift the rest of the drink with it. Within an oil field, as the pressure falls, the remaining gas seperates and floats to the top of the oil field, forming a gap between the well and the oil. Either the well needs to be put further down into the field and pumps used to lift the remaining oil, or water needs to be pumped into the field on which to float the oil to the surface, but in this case the gas will act as a barrier unless it is also removed. That gas is collected and put through a Gas Oil Seperation Plant to collect all the droplets of oil. As you can imagine this is an energy intensive process, but over the last 10 years it has accounted for an ever greater proportion of global oil production.

The Canadian Tar Sands are vast, however the net energy from the sands is minimal. Twenty percent of the tar can be surface mined whereas the eighty percent balance needs to be mined by steam injection. Two holes are drilled deep into the ground next to each other. Steam is pumped into one hole under pressure to melt the tar and lift it up with the vented steam via the second hole. As yet this has not been achieved economically, and neither has it been achieved safely. Steam under pressure can effectively be a bomb, and in May 2006, Total's Joslyn oil sands project in Canada blew up, blasting a crater 20 metres wide. The surface mined tar is produced commercially. The tar has to be mined, and then cleaned in huge washing machines that are effectively set on the hot spin cycle, consuming vast amounts of water and energy. The finished product still needs hydrogen to be added to lift the quality to a combustible level. Once you take account of this, there is almost no net energy produced by the tar sands. The estimates vary from them being a drain on energy, to producing a net 5% - 10%, to some estimates as high as producing 150% more energy than is put in, ie a range of EROIE (energy return on invested energy) estimates of below 0 to perhaps as high as 1.5. For the 80% of the tar that would require steam injection, the EROIE will clearly be lower still. Even taking the optimistic end of estimates however, it is clearly not going to be a viable substitute for declining oil production.

Putting aside concerns over the environmental impact, the quantities of water required as the cleaning agent, and the amount of gas input that is required to supply the energy to melt and clean the tar, it is thought that the maximum oil output from the tar sands will peak at about 3m barrels per day by 2015 - 2020, before then starting to tail off. Even at this relatively low level, it will mean diverting water, and therefore writing off vast quantities of land that could otherwise be used for agricultural purposes or livestock. It would also mean consuming about 16% - 20% of Canada's natural gas output, a quantity that is simply not going to be available. Because the cost of production is so dependent on the availability and cost of water and gas, the economics are not as clear cut as people think. Whilst companies are looking into the feasibility of building nuclear reactors on site to provide the energy and steam required, what is clearly apparent is that the tar sands should not be viewed as a fuel source in themselves. The tar sands are simply a storage medium for fuel in exactly the same way as a battery. Because the world's transport runs on gasoline, it is preferable to use natural gas or even nuclear fuel to turn the tar sands into gasoline. A premium is effectively paid for energy in gasoline form than for the same quantity of energy in gas or electrical form.

The net addition of energy from tar sands is minimal. There is no question however of a massive net loss of energy from "Coal to Liquids" technology. Starved of oil in WWII, Germany invented a way to turn coal into oil and gasoline to power its war effort. The technology was continued by South Africa under Apartheid, and is now being looked at by America and China. The technology essentially uses high temperatures and high pressures to extract gases from coal which is then condensed back into liquid fuels. Further refining processes are then required to achieve high grade fuel characteristics. The U.S. National Coal Council has been pushing for government incentives to help build plants to generate 2.6 million barrels per day by 2025, the equivalent of 10% of its oil needs. The scale of energy loss however is horrific at around 60%, even before carbon capture and sequestration. To meet 10% of the U.S. present oil consumption from the technology would require 40% of present U.S. coal production. Environmentalists describe the technology as a carbon dioxide factory that produces energy on the side. China had been somewhat further along the process of adopting the technology with various test plants now in operation, but in October 2008 the government announced that it had officially halted all of its coal-to-liquids projects due to environmental and economic reasons. Given the loss of energy from this process, gasoline would have to trade at a significant premium over coal to possibly justify the technology. The very fact that this is being discussed in the United States highlights the concerns the U.S. has over its energy future.

Another potential medium to carry energy is Shale or Kerogen. It is not oil, although if you come back in a few million years time, then subject to the right pressures and temperatures, it would turn into oil. Human ingenuity can speed up the process, but again it is hugely energy intensive. The giant European oil company Royal Dutch Shell has been working on technology which would require the insertion of electric heaters hundreds of feet into the ground to heat the oil shale to between 650 and 700 degrees Celsius for more than 2 years. At the same stage, to prevent seepage and environmental contamination, it would create an underground wall around its site by freezing ground water to a depth of 2000 feet. The net energy loss would be huge.

If peak oil is not a problem, why have marginal fuels like tar sands, natural gas liquids and ethanol become such a large proportion of supply? Why is there any consideration being given to tar sands and shale oil, which consume almost as much energy as they produce. Whilst there is a general campaign of denial of peak oil, the very actions of the oil companies validate the theory.

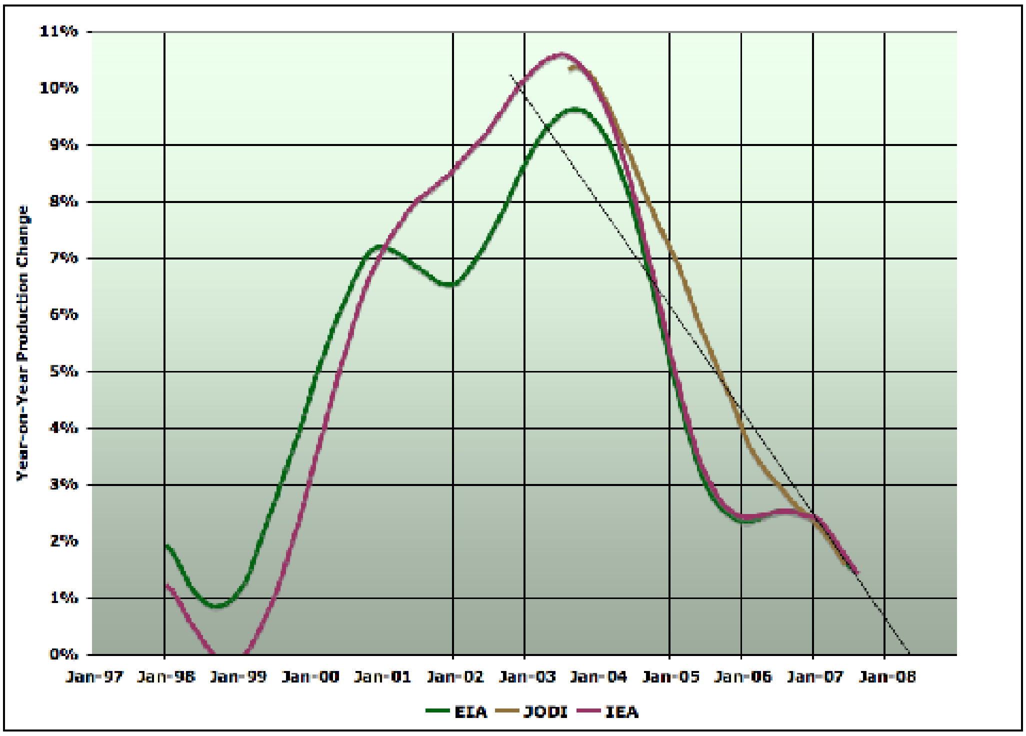
World discoveries of oil peaked in 1965, and have gradually declined ever since. Every year since 1984 the world has consumed more oil than it has found. In the late 1990's, the books I was reading on the subject were basing the optimists view of peak oil not until about 2020 off finding around 24bn barrels of oil every year between 1995 and 2020. This has been undershot by about 170bn barrels, logically reducing their estimate by about 5.5 years to around 2014/2015. Modern seismic technology enables high quality geological maps of the remaining oil fields to be drawn without the need for drilling. Exploration is much cheaper than historically. If there was oil to be found, then surely it would have been found by now. The idea that we found enough oil in the 1960's such that we haven't needed to look any further, is rubbished by the very fact that we are increasingly having to turn to the marginal fuels mentioned above. The fact is that there is now very little of the Earth that has not been explored. It is highly unlikely that we have missed any sizeable fields, although recent discoveries off the coast of Brazil will still provide some people with hope.

The biggest oil field in the world, Saudi Arabia's Ghawar, was discovered in 1948. It is now debatable whether this field has gone past peak production or not. Saudi Arabia's oil production has fallen since 2005. It suggests that the decline has been voluntary whilst others say that time has finally caught up with the field and that output is now in a terminal decline. Certainly between 2005 and 2007 well productivity deteriorated by about 25%, reducing the average daily production from each well to around 4,500 bpd (barrels per day) from around 6,000 bpd where it had been for the previous 10 years or so. Given that this decline was whilst world oil prices were making new all time highs in both nominal and real terms, if this decline was voluntary then it would be no less political than the so-called "oil sword" that Saudi Arabia swung over the world in the 1970's. Putting this to one side however, there is no debate that the 2nd, 3rd and 4th largest fields ever found – (Kuwait's Burgan field, Mexico's Cantrell and China's Daqing) - are all now beyond peak production. Twenty years ago, more than 14 fields worldwide produced more than 1 million barrels per day. Now it is down to just 2, Ghawar and Burgan. Since 1980, only one field has been discovered globally that can produce upwards of 500,000 barrels per day.

The United States of America was the first major oil producer to go through peak production in December 1970 when oil was fluctuating between $1 and $2 bbl (barrel). The first oil shock lifted the price to $12bbl in 1973. It then continued on upwards to $17 bbl in 1978 and $40bbl after the Iranian revolution and the start of the Iran/Iraq war. This price rise was necessary to allow such projects as Alaskan oil and North Sea oil to become viable and to offset the declines from the "Lower 48 States" and from Iran and Iraq. Twenty five years later, production from both the North Sea and Alaska are now in terminal decline. Falling output from Alaksa's primary field Prudhoe Bay cannot be offset with increases in the surrounding fields. As it stands production has been falling significantly below the expected decline path which has caused some concern at The United States Department of Revenue. The British half of the North Sea production has declined by 44% from its 1999 high of 2.9m bpd despite a surge in spending back to the highs of the 1980's. The Norwegian half of the North Sea experienced peak production in 2001at 3.4mbpd and is now down 25%.

Mexico's Cantrell field also helped to cushion the world from the 1980's oil crisis. Discovered in 1976, the world's 3rd largest field started production in 1981 and saw production peak in 2003. Despite warnings from peak oil experts, the scale of the subsequent decline took a lot of people by surprise. In January 2005 Mexico's state oil company Pemex warned that Cantrell had gone past peak production, and that its output would decline smoothly at about 6% per annum. At that stage Mexico was producing 3.4m bpd, with the Cantrell field accounting for 60% (or 2.1m bpd) of the total. Just 4 years later Pemex has warned that Cantrell's 2009 output will fall to just 700,000 bpd, down 66% from its highs. Like many producers, in order to maintain maximum output and revenue Mexico had used technology to maintain high levels of output beyond the natural decay rate. From the late 1990's it had pumped nitrogen into the fields to force the oil out more quickly. Whilst this had supported the flow rate, the consequence was that the field was exhausted that much more quickly, and the eventual pace of decline was much more aggressive than people had expected. As a result Mexico's overall production fell 9% in 2008 to 2.8m bpd, and is now down 27% from its highs.

What is really frightening is that since 2005 when conventional oil production seems to have peaked, the main increase offsetting the declines in Saudi Arabia, Norway, the USA, Mexico and Nigeria etc have come from Russia and the former Soviet Union, ie countries that we know have gone beyond peak production. Russian production fell for the first time in a decade in 2008. Both the vice president of Lukoil and the former head of TNK-BP warned to now expect a steady decline in output. The government had to grant tax breaks to producers to encourage development in remote areas to try and offset the declines from the aging giant fields as the marginal return on investment was collapsing. At the height of the post-Soviet revival of production, Russia was getting 10,000 bpd per additional rig. It has now fallen to just 200bpd per additional rig. Most of the production gain was associated with replacing the old failing Soviet pumps and getting the very last reserves out of the ground, but now the system has been modernised, any additional gains have collapsed as per the below chart. Third generation fields are now having to be drilled to maintain output, but the average field size is just 15 million barrels with the median field at just 7 million, highlighting just how expensive production is becoming. Even Rosneft warned that the Sakhalin-1 oil field, which had been an area of hope, had seen production peak in 2007 and that output would now fall by 25%. Like the U.S., Russia is now thought to have consumed down around 85% of its reserves.



www.theoildrum.com Year on year change in Russian oil production according to 3 data sources. The black line is an extrapolation of the current trend.

Areas that had been protected from drilling for environmental reasons such as the United States Outer Continental Shelf, are also somewhat of a misnomer. The U.S. government body, The National Petroleum Council (NPC), estimates that there is 60 billion barrels of undiscovered but “technically recoverable” reserves in the lower 48 States, the Atlantic and Pacific Seaboards, the Eastern Gulf of Mexico and off the shores of Alaska. Of these undiscovered reserves however, only 19bn are in areas that have been subject to moratoria and therefore precluded by law from leasing and development. The other 41bn barrels are in areas that are, and have been, open to leasing and development. Even if these estimates of undiscovered reserves prove to be correct, the resultant impact on oil production would be marginal. The NPC itself suggests that at best it may add 1 million barrels per day to U.S. production by 2025. Ironically, given the lack of drilling ships, a major search programme for this yet-to-be-found oil may actually lift oil prices in the short term. In 2006, total U.S. crude oil reserves fell by 4% to just under 21 billion barrels, which at a present U.S. consumption rate, would last it just over two and a half years without imports.

As the evidence of peak oil has mounted, some of the more optimistic fraternity have comforted themselves with a notion of peak "cheap" oil. They have decided that there is still plenty of oil available, but at a higher price. Unfortunately this mounts to the same thing. Paper money simply controls the factors of production. If we are allocating more of them to maintain energy production, then we are effectively allocating less to producing consumer goods and the like. The energy subsidy for the rest of the economy is falling and we are becoming servants to energy rather than the other way around. In the first days of the oil market, a prospector could effectively put a straw in the ground and oil would come up from the field below. The return from the field was about 100 times the amount of energy that went in. The field had a net energy return or EROIE - (Energy Return on Invested Energy) - of 100. As fields have aged, more energy has to be put into the fields to maintain output. Water or gas has to be pumped in to flush the oil out. More wells need to be dug within the field. Electric pumps need to be installed. The oil then needs to be separated from the water, all of which consumes energy. We may see this as the price of oil rising, but all of these additional expenses gradually lower the EROIE rate, and somewhere along the line the EROIE dips below zero. Although there are more reserves in the field, there is a net loss of energy in getting that remaining oil out of the ground. At that stage there would be no point exploiting the field. It would be abandoned. Globally the EROIE rate is thought to be between 12 and 20.

At the same stage that existing fields are maturing and the EROIE declining, so new fields have to be deployed. It is estimated that upwards of 5% of global production from existing fields is being exhausted each year. The natural rate of decay is actually nearer 10% but applying the latest technology has managed to limit the decline and lift the overall recovery from the field. There are some forecasts that are significantly higher. This has to be replaced with new fields and new wells. Fields are exploited in order of size and cost. Outwards of the giant fields, the size of remaining fields follow a log normal distribution. The size of the fields falls by a factor of about 8, and outwards of those by a further 8. At the moment the EROIE on new replacement production is as low as 3, meaning that for every one unit of energy input, only three additional units of energy output are delivered. The productivity of oil production itself is falling. The figures are measured at the well-head, but because the output from each well is that much smaller, the amount of infrastructure to deliver the oil to market needs to be that much bigger, which further adds to the cost of oil production.

There are two problems therefore. The EROIE from existing fields is declining due to age and field depletion, whilst at the same stage the EROIE of any new fields coming on stream is much lower than the overall EROIE mix because the fields are much smaller and more expensive to exploit. As you can imagine, trying to replace the output of an ageing giant field like Cantrell with the new smaller fields, means those new fields will be exploited that much faster. Between December 2008 and June 2009 Cantrell's output is expected to fall by 110,000 bpd. That decline would completely exhaust the average new Russian field - (average size 15 million barrels) – in just over 3 months, which would then presumably have to be replaced by an even smaller field. Unfortunately it is more complicated than this as the production profile of these smaller fields is no different to the larger fields, ie as the fields get depleted it takes more effort and more technology to pump out the residual oil. The EROIE that started life at about 3 or 4, declines even further.

As the overall EROIE rate declines, then to simply maintain the net energy availability for the rest of the economy, we would have to dramatically increase the amount of gross energy consumed. If the EROIE rate halved, then to maintain existing energy supplies for the rest of the economy, the amount of resources devoted to the energy industry would have to double. Unfortunately this results in a feedback loop. The greater the gross consumption of energy, the faster the rate of decline of EROIE would be. Energy is not the only resource needed to maintain the flow of oil from these ageing fields. In recent years the steel and engineering industry couldn't keep pace with the demand for oil rigs and specialist ships. Similarly the supply of skilled labour and even manual labour hasn't been able to keep up with demands, hence the wage growth in the industry. A greater proportion of all factors of production were being consumed in maintaining oil output, leaving less available for all other industries; ie a lower energy subsidy.

A simple look at the maths of the EROIE calculation reveals some very worrying implications about the cost to the global economy, and the impact of moving to an economy powered by a low EROIE alternative energy. An EROIE of 20 would describe a situation where 1 unit of energy is being used to extract an additional 20 free units. In this case the gross consumption of energy is 21 units. If the EROIE halved to 10, then to obtain the same net energy subsidy for the rest of the economy, the gross economy would have to grow by 4.7% to 22 units. The size of the energy network would double. It would represent 9.1% of the gross economy (22 units) or 10% of the net economy (20 units), squeezing all other industries.

At this stage it would be remiss of me not to mention the huge Brazil find. In November 2007 the Brazilian state oil company Petrobras announced the discovery of a 5bn – 8bn barrel field off the coast of Rio. This would turn out to be just part of a much larger complex, the Santos Basin, perhaps as big as 50bn barrels which would be huge by any measure. First of all, how come such a large complex has just been found, and does this offer the promise of other big discoveries around the world? New seismic technology allowed the oil to be found beneath deep salt beds that had historically been impenetrable for traditional seismology, so perhaps this does offer some hope, however when you look at the complex in more details it is nothing more than a sticking plaster. The depth of the Brazilian finds are 32,000 feet or 10 kilometres below the ocean surface. At these depths, the temperature is so high that the reserves would normally be gas rather than oil which only forms in a limited range of temperatures and pressures, so this is very unusual. Assuming that the difficulties of drilling and extracting oil can be overcome, the EROIE rate is likely to be no better than an average deepwater well of around 5. That would reduce the net energy from the complex by around 20% to about 40bn barrels, enough to cover global demand for just 15 months. Of course we do not need to replace 100% of oil output today, however assuming production from existing fields falls by about 5% per annum, then just making up the shortfall with these fields would exhaust the entire complex within 6 years.

Putting to one side the engineering obstacles of developing the fields, Petrobras may also face difficulties funding the development. The credit rating agency Standard & Poors downgraded Petrobras to BBB- or just one grade above junk classification, which will raise its cost of funding. When the Gulf of Mexico was developed, the cost of new cutting edge technology was huge. America therefore made it a free-for-all to attract the scale of funding needed. Brazil has done the opposite. In the next 5 years alone Petrobras has a USD174.4bn capital spending plan. Standard & Poors downgrade implies that there is insufficient equity behind the deal. This would be a huge cost even for the government to bear. If the project was shared across a large number of the major oil companies, then the costs would be easier to afford. Without a change in the equity or ownership structure, the development is likely to be even slower than Petrobras itself suggests, with major implications for the price of oil globally. This is yet another example of insufficient investment into the world's energy infrastructure.

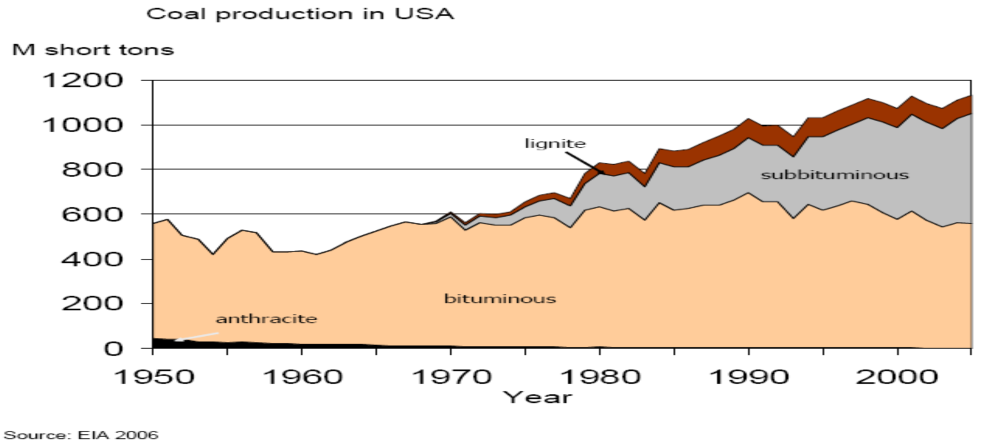
If oil production has peaked and is starting to decline, then what about coal, after all in the 20 years after the second oil shock, the U.S. electricity generating sector reduced its oil consumption by about 70%, replacing it with a near doubling of its coal and natural gas consumption. In 2006 U.S. President George W Bush made one of his characteristic blunders. Touting U.S. energy independence, he boasted "Do you realise we have 250 million years worth of coal". Of course he meant 250 years. The reality is more like 25 years. The U.S. Energy Information Administration data he was referring to was based off a 1974 survey by just one person, Paul Averitt, which itself was based off data provided in a 1909 survey by two geologists. Much more recent (mid 1980's) and detailed surveys by the USGS (United States Geological Survey) had concluded that only about 30% of the reserve base would be potentially mineable. A 1989 survey by the U.S. Bureau of Mines warned that only 5% - 20% of the original coal reserves were available economically. Between 2002 and 2009 the USGS downgraded the coal reserves of the Gilette fields in Wyoming, accounting for 37% of total U.S. production, from 20.87bn metric tons to just 9.16bn.

The sad reality is that the United States went through peak coal production in terms of energy in 1998 at 598.4 Mtoe (million tonnes of oil equivalent) according to http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf . Whilst total coal production has been steadily rising by about 20 million tons per annum since 1960, the higher energy content Anthracite and Bituminous coals peaked in 1950 and 1990 respectively.

The high grade coals have increasingly had to be compensated for with lower quality subbituminous and low quality lignite coals. The volumes that need to be burned to generate the same heat value are 20% and 50% more respectively. That means 20% and 50% more needs to be mined and transported. When adjusting for the costs of making and running the trains, the net energy subsidy from the coal falls still further. Whilst U.S. coal exports have been fairly consistent on a tonnage basis, on a net energy basis they are down by almost 90% from 1980. With 40 new coal power plants coming on stream in the next few years, the likelihood is that the U.S. will soon have to become a net importer of coal. The idea that the U.S. could divert 40% of its coal output to coal-to-liquid technology to produce just 10% of its oil needs is quite frankly laughable.

Energy Watch Group

http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf



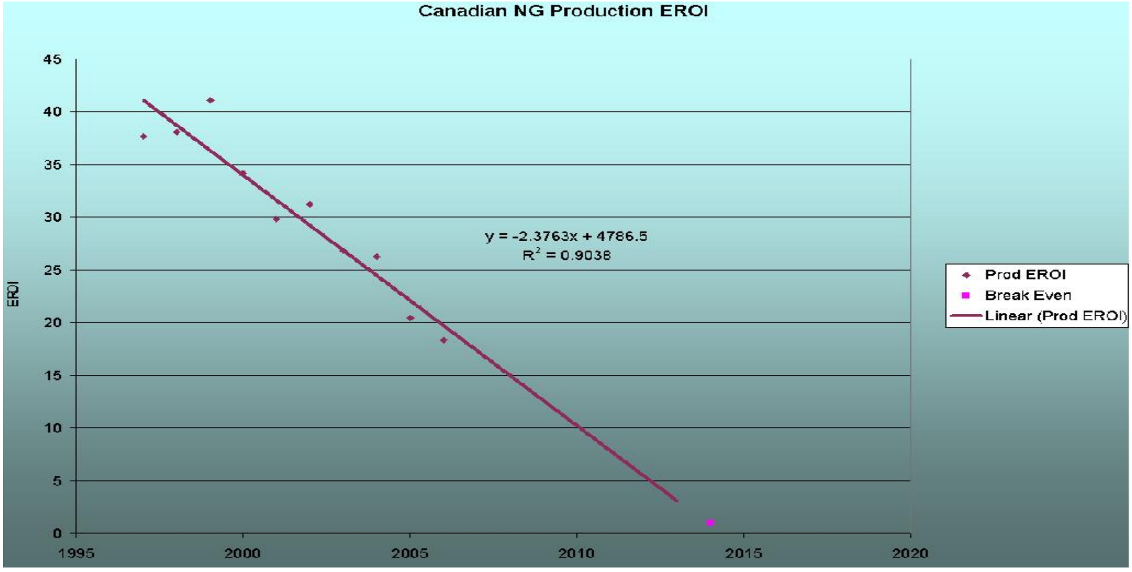
The average heat value of Bituminous Coal is 12,750 Btu's per pound, some 21% higher than Sub-Bituminous (10500 Btu/lb), which is itself, 75% higher energy content than Lignite (6,000 Btu/lb). Anthracite has by far the most energy content, in some cases higher than oil.

China is the world's largest producer and consumer of coal, equating to about 40% of world production. It produces more than twice as much coal as the second largest producer, the USA which itself produces more than twice as much as the third largest producer, Australia. The makeup of China's coal has started to shift from 100% bituminous & subbituminous to about 90% bituminous & subbituminous and 10% lignite. Whilst the international energy agencies forecast for Chinese coal production is for a peak of about 2.5bn tons per annum around 2015 and subsequent decline, the more optimistic scenario forecast by China's Ministry of Land and Resources on the 8th January 2009 is for production to rise to 3.3bn tons by 2015 and continue on upwards to 3.5bn tons by 2020. Taking these figures at face value, its production would grow at an annualised rate of 8% per annum from 2007 to 2010, slowing to 4.8% per annum through to 2015 before collapsing back to just 1.01% per annum growth to 2020. If this were the case, then either its economic growth rate would collapse, or its imports would have to soar. Realistically the picture is likely to be dramatically worse as the only way its coal production could reach the volumes it suggests is if the makeup of its coal shifted increasingly to low energy lignite.

By early 2010 China's energy consumption is expected to exceed that of the United States. The size of its economy is not however expected to equate with the size of the U.S. economy until 2030 based on a growth differential of about 7% per annum - (Chinese economic growth of about 10% per annum vs U.S. growth of about 3% per annum). Given that this is one of the key assumptions being made by the global leadership, where is the energy going to come from to drive this growth? China produces and consumes about 40% of world coal production. The U.S. produces and consumes about 20%. It seems highly unlikely that any other country will be able to make up for their shortfall. Australia and India each produce about 7% of world coal, so the 4 countries combined account for 74% of world production. India is presently a small net importer, but is expected to see coal imports rise to 28% of its hard coal needs by 2030. Australia is the world's largest exporter, but even if it exported 100% of its coal output, that would only be sufficient to support the growth in Chinese fuel consumption for about 2 years. At the moment the largest exporter to China is Vietnam, but it has started to scale that back and has said that it will gradually eliminate exports altogether to ensure domestic security of supply. Indonesia is the world's second largest exporter, but its exports only account for about 2% of world production, and given that it has gone through peak oil its coal exports are now facing competing demand from the domestic economy. Germany is the world's largest importer of coal, having already gone through peak production of both hard coal and lignite. Canada has also gone through peak coal production. As far as the former Soviet Union is concerned, it does export a similar amount to Indonesia, but the problem is most of its reserves are lignite which, because of its low energy content, is not economic to transport over long distances.

Whether from detailed field analysis or fitting curves to production profile data, estimates for coal production now centre on a peak around 2015/2025 and then plateau until about 2040 before declining. As with oil however, the easiest and most economic coal will be mined and burned first, resulting in a declining EROIE rate. The added problem is that the energy content of coal falls from 30MJ/kg for Anthracite down to just 5MJ/kg for low quality lignite. Some mining is on the surface whereas other mining is deep under ground. The cost structure will change enormously, and so therefore will the need for resource allocation to maintain output and support this plateau. The net energy from coal production will decline.

In terms of natural gas, the story is no different. In fact just after I wrote the paragraph on the Tar sands, the Calgary Herald reported that the production of natural gas had peaked in 2001 at 14bn cubic feet a day and had now fallen to just 12bn cubic feet a day in 2008. That figure is expected to fall as much as 1bn more this year. The decline can be offset to some extent via an ever increased number of drilling rigs, however the reality of that is that the EROIE will continue to decline. As it is, the rate of decline of EROIE has been following a linear path, as depicted in the chart below. If the trend continues the EROIE rate will fall through the X-axis by 2014, at which stage it will cost as much in energy to extract the gas as the energy obtained from the gas. In effect Canada would have exhausted its gas supplies. Not only would Canada have to become a net importer of gas rather than exporter, but it would also not be able to produce the tar sands without an external source of fuel, helping to explain why there is talk to use nuclear power to extract the tar sands. In the mean time, as the EROIE falls, the cost of gas production will soar, lifting the cost of the tar sands. Given that oil prices are theoretically set by the cost of the marginal barrel, this could lift oil prices dramatically higher.



www.theoildrum.com. *The EROIE of natural gas production in Canada*

One of the differences between the mining of natural gas and oil is that once the hole is drilled, then gas should flow freely out of the field. As long as the pressure in the field is greater than the pressure on the surface, the gas will want to escape. Once the field has gone through peak production, the eventual decline will be much more rapid than with oil. The U.S. is thought to have already gone through peak "conventional" gas production. Overall the annual number of gas wells drilled has risen almost 4-fold from 9,000 at the turn of the century to 33,000 in 2008, but supplies have essentially been flat all the way back to 1994. The extraction of gas from Shale has recently lifted production. The shale fields have been known about for years, but the problem has been about how to exploit the gas on a large scale, which has been solved with horizontal drilling. Compared to drilling for conventional gas, it requires more drilling and also hydraulic fracturing, both of which lowers the EROIE. The well's exhaustion comes very quickly, with around 70% of the ultimately recoverable reserves coming in the first year and the balance in the second year, such that the trajectory of the EROIE collapse is that much steeper than with conventional gas fields.

Natural gas provides about 35% of Europe and Eurasia's primary energy supplies. Output from every West European nation is now in decline, such that West Europe (European Union) relies on imports for 60% of its entire gas needs, or 290 billion cubic metres, just over half of which come from the former Soviet Union. In 2007, production in the former USSR increased by 1.3%, with growth in Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan offsetting a small decline in Russian output which accounts for 77% the total. The big Russian fields Yamburg, Urengoy and Medvezhye that provide the bulk of Russian production and exports to Western Europe are in decline. Russia consumes just over 70% of its production. Taking account of the decline rate from its existing fields, the lack of investment in new fields, and assuming a moderate 2% per annum increase in domestic consumption, Russia will stop exporting gas within 10 years. There are even suggestions that the annual Ukraine dispute at the peak of winter may actually reflect the inability for Russian production to meet peak demand. In order to free up production for exports, the Russian government has approved a long range plan to gradually switch its electricity generation away from gas, but the supplies are likely to fall well short of West European needs.

Europe, like the States will increasingly have to turn to the LNG, or liquid natural gas market. As the name implies, this involves cooling natural gas until it turns into a liquid that can then be shipped in special ocean going tankers. To liquefy the gas, it needs to be cooled down to -260 degrees Fahrenheit (-162 degrees Celsius) and then kept at that temperature on board ship. Depending on how long the gas needs to be kept frozen, ie how long the transport route is, this process will reduce the net energy of the gas by around 20% – 25% before taking account of the energy consumed in building the necessary infrastructure – (import and export terminals, storage facilities and tankers etc) – to handle the gas. Indonesia had been the world's largest producer of LNG for 3 decades, but a 10% decline in domestic gas production over the last 4 years and greater domestic needs because of peak oil, meant that in 2006 it failed to meet its commitments to Japan, South Korea and Taiwan, with sales falling 19%. Heavy investment from Qatar has promoted it to the world's main player, but with its total exports at just 39.3bn cubic metres for export, it will hardly make a dent in the West's shortfalls, particularly now that the Gulf Cooperation Council member states face a gas shortfall, with Saudi Arabia for example now turning a net importer. Domestic demand growth from North Africa will also limit any exports from the region.

As I described earlier, China faces a domestic coal crisis, the scale of which is impossible to meet by imports. When China's coal production peaks, world coal production will peak. It also faces a imminent peak in domestic oil production. China's Ministry of Land and Resources warned in January 2009 that between 2010 and 2015 domestic oil production would peak at 200m tons. Given that is just 5.8% higher than the 2008 level, the peak seems imminent and indeed in March 2009 China's oil giant CNPC confirmed that its oil output had already started to fall, with production at certain fields as much as 10% - 20% below previous targets. The Ministry of Land and Resources said it sees no big breakthroughs in the years ahead, and that consequently it will increasingly have to rely on imports. According to China's National Energy Administration, its oil imports will soar to 60% of its needs by 2015. Domestic gas production is minimal accounting for just 3% of its energy mix, but it has stated that it intends to use LNG imports to lift this to 10% of its energy mix by 2010.

Over recent years, some of the biggest growth areas for oil consumption have been from the Middle East and North Africa. As oil prices soared, so did their income and therefore their spending power, lifting domestic oil consumption. Imagine the energy that it has taken to drive the construction boom in Dubai where 25% of the world's cranes are now deployed. Saudi Arabia forecasts that its own oil consumption will rise by 7% in 2009 or 150,000 barrels per day. Without a comparable increase in output, exports will get squeezed. In 2005 & 2006 world net exports showed a small fall, led by a 3.3% fall in net exports from the top 3 producers, Saudi Arabia, Russia and Norway. When a country goes past peak production, unless there is a comparable fall in domestic demand, exports will take the brunt of the pain; they will collapse. Countries that were exporters soon become net importers as happened with Britain and Indonesia in recent years, and is thought likely to happen with Mexico over the next few years. In 2008 Mexican oil production fell 9.2%, but exports fell 16.8%, and according to Mexico's finance ministry exports will fall another 18% in 2009.

Whichever way you look at it, fossil fuels are on the verge of extinction. Oil production is declining and neither gas nor coal substitution can continue to make up for the shortfall as they have for many years. As the supply of energy fails to meet demand, the price will start to move to a user value basis from a cost basis. This will price out energy inefficient consumers; however politics will also determine where it goes, at least in the short term. Soviet politics for example determined that Soviet oil supply went mainly to domestic industry, however the fact that the Soviet machine was so energy inefficient, resulted in its eventual collapse. In the end, the flow of energy eventually went to the more efficient industry of the West. At the moment the credit crunch is allowing China to sign up long term contracts to try and secure its own energy future, but in the end if China's inefficient consumption of energy fails to make an adequate return, then these contracts will be broken. By the end of 2009 Russia will have constructed a gas pipeline to Asia. Until now Russia's threat to switch energy supplies from Europe to Asia had been empty, but now it is a real possibility. Clearly politics will determine where that gas is distributed in the short term, but in the longer term the economics of consumption will be the final arbiter.

The increased energy subsidy that the world desperately needs to lift productivity and to pay for the rising dependency ratio, is simply not going to happen. Not only do we face a declining supply of energy, but the productivity of extracting that energy will itself fall. With a declining energy subsidy, global productivity will fall, and with it our standard of living. All aspects of modern life are dependent on this energy subsidy to a greater or lesser extent, including food production. Finding a new cheap source of fuel is therefore essential not only for the quality of life but also for life itself.

Chapter 7. Green is no Alternative

Charles McKay "Men, it has been well said, think in herds; it will be seen that they go mad in herds while they recover their senses slowly and one by one".

In the introduction I scoffed at the idea of alternative energy. We must understand that we have always used this so-called alternative energy. It has simply been marginalised by fossil fuels because of cost and available quantity. The percentage of our energy usage from these alternatives has gradually fallen, and now represents the lowest percentage it has for over 200 years. Reversing this trend is going to be extremely difficult, not only in terms of making the alternative energy as cheap as we have been used to with fossil fuels, but also to make sufficient quantities available to both offset the shortfall from fossil fuel itself, and also to grow the overall output of energy, which will be necessary if the world economy is to achieve economic growth.

	Fossil	Nuclear	Hydro	Waste	Solar	Biomass	Wind	Geothermal
Middle East	96.8	3.2	0	0	0	0	0	0
Australia	91.4	0	6.7	0	0	0.7	1.1	0
Ireland	89.4	0	3.6	0	0	0.5	6.6	0
Indonesia	88.3	0	6.9	0	0	0	0	4.8
Netherlands	86.9	4.3	0.1	1.4	0	3.8	3.4	0
China	83.5	2	14.2	0	0	0.1	0.2	0
Italy	82.1	0	12.5	0.6	0	1.7	1.3	1.8
Mexico	81.7	3.8	10.6	0	0	1	0.1	2.9
India	80.4	2.6	15.2	0	0	0.2	1.6	0
South Asia	78.7	2.4	17.4	0	0	0.2	1.3	0
East & Southeast Asia	78.3	9.3	11.2	0.1	0	0.5	0.2	0.4
Taiwan	78	17.1	3.4	0.6	0	0.8	0.2	0
United Kingdom	76.8	15.6	2.3	1.2	0	2.8	1.3	0
United States	71.7	19.1	6.3	0.3	0	1.3	0.7	0.4
Denmark	71	0	0.1	1.1	0	9.6	18.3	0
Central Europe	69.7	17.5	11	0.2	0	1.4	0.2	0
World	67.8	13.8	15.9	0.2	0	1.1	0.9	0.3
North America	65.9	18.5	12.9	0.3	0	1.3	0.7	0.3
Japan	65.6	24.2	7.5	0.2	0.2	1.5	0.2	0.3
South Korea	65.5	33.2	1.2	0	0	0.1	0.1	0
Germany	62.3	21.9	4.3	0.7	0.5	4.1	6.2	0
Argentina	61.9	6.3	30.5	0	0	1.3	0.1	0
Spain	61.7	17.8	9.6	0.5	0	1.2	8.8	0
European Union	55.7	27.7	10.1	0.6	0.1	2.7	3.1	0.2
West Europe	51.3	26.2	15.7	0.6	0.1	2.5	3.1	0.3
Finland	40.6	28.8	17.4	0.2	0	12.7	0.2	0
New Zealand	34.2	0	54.4	0	0	1.3	2.2	8
Austria	33.6	0	57.9	0.9	0	4.4	3.2	0
Canada	25.7	14.5	57.9	0	0	1.5	0.5	0
South America	23.4	2.2	72.1	0	0	2.3	0.1	0
France	9.9	77	11.3	0.3	0	0.7	0.7	0
Brazil	9.3	2.8	83.9	0	0	3.9	0.1	0
Sweden	3.9	44.7	44.7	0.6	0	5.1	1	0
Switzerland	1.5	41	53.9	1.8	0	1.7	0	0
Norway	1.2	0	97.8	0	0	0.3	0.7	0
Iceland	0	0	69.2	0	0	0	0	30.8

2007 Worldwide Electricity Production (Observ'ER and EDF)

Between 1950 and 2000 global energy consumption rose by around 400%, or about 2.8% per annum on average. From the late 1970's, that pace slowed to about 2% per annum. If the world economy is to continue to grow, it will need a new source of fuel. In order to achieve the kind of economic growth rates the world is used to, will need 2% more fuel every year. After ten years that would cumulate up to an additional annual consumption of 22%. Even assuming that fossil fuel production remains static rather than declining, the call on other sources of fuel will become immense. As I will explain later, nuclear fission has its own supply problems and therefore can only be a short-term bridge at best. The third major source of energy, hydro also has its limitations. Most of the world's major rivers have already been dammed, some in several places such that the potential growth rate is minimal. With silt build-up reducing the efficiency every year, and with higher returns from other uses of the land and water, parts of the world are now actually pulling down dams. In the last thirty years or so, the United States for example has pulled down over 600 dams freeing up land and water for other uses. Given that these three sources of energy account for 97.5% of worldwide energy consumption, how are the other sources going to possibly provide for the growth that we require.

The solutions being put forward are bio fuels, wind & solar, and then tidal and wave energies. Bio fuels should be written off straight away. First of all food production these days is net energy consuming. More calories are consumed in growing grains - (from fossil fuel based fertilizers and irrigation) - than end up on our table in terms of food. Modern high yielding grains also manage to convert more than 50% of the photosynthesis energy into the seeds. The idea therefore that most of the energy is lost in terms of the rest of the plant material, simply doesn't stack up. Even if it did, that plant material needs to be recycled back into the earth to maintain a level of nutrients to help support future crops. Without this the soil becomes sterile and requires ever greater amounts of fertilizer to compensate.

"Top soil mining" is another consequence of over-exploitation. Not only do the minerals disappear, but without a layer of protection from plant cover, the soil gets washed and blown away. Over the last 50 years the U.S. state of Iowa has lost 8 inches of top soil leaving just 10 inches. Grains need 6 inches of top soil for their roots to form properly. The rate of erosion is 20 times faster than the rate that top soil can be formed by natural processes. The introduction of no-till farming in the United States has to a greater or lesser extent eliminated this erosion, but the need for double and triple cropping in much of Asia to feed their huge populations has meant top soil continuing to erode. At the present rate of erosion, the Chinese province of Manchuria, which Japan invaded in WWII for its natural resources, will be bare rock within 10 years. Deserts cover 20% of China and are spreading. This has created a vicious circle whereby reduced land availability has meant increased intensity of farming resulting in greater top-soil mining. It has had to abandon agriculture for industrial uses, and its Ministry of Agriculture has even warned that China will struggle to meet its own grain needs due to the deteriorating quality of its agricultural land. On the 24th June 2009 China's Ministry of Land and Resources said that marginal farmland will no longer be allowed to return to woodland as it calculates that land available for agriculture is now just 1.4% in excess of the 1.8bn mu (120m hectares) needed to feed its population.

Increased use of Bio fuels would be a hugely retrograde step. It is neither sustainable nor renewable either on a pure acreage basis or from the point of view of irrigation. Whilst the distillation process only takes between 4 & 7 gallons of water for every gallon of ethanol, it first takes 780 gallons of irrigated water to produce the grain. Current water withdrawals from the Ogallala aquifer, which provides 1/3rd of the U.S. nation's underground water needs, is already greater than the aquifer's recharge rate. In Nebraska for example there has been a 190 foot decline in the water table over the last 50 years compared with a recharge rate of 0.02 – 0.05 feet a year. Globally, 70% of all water used is for agricultural irrigation, leaving 22% – 23% for industry, and just 7% – 8% for domestic use.

Genetically modified (GM) crops seem unlikely to bridge either the water or land gap. The International Assessment of Agricultural Science and Technology for Development has questioned any yield pickup from GM crops, stating that results were "highly variable" and that in certain areas "yields declined". Instead it is increasingly recognised that GM, along with industrial agriculture in its entirety, is just another beneficiary of the energy subsidy. GM built its reputation on the increased yields of pest-resistant crops; however the reality is that they are not pest resilient but rather pesticide resilient. Given that pesticides are just a derivative of fossil fuels, the GM revolution has been dependent on fossil fuels in just the same way as the Green Revolution before it. It is simply is not feasible for bio fuels to be anything but a curiosity for the world as a whole, or a political tool. The world's population is about 6.8bn people, but we use the equivalent energy of having 300 billion people working 24 hours a day. Manufacturing that scale of energy through food production is simply pie in the sky, and indeed over the longer term, without some sort of energy subsidy to support agricultural production, yields will collapse.

We are therefore left with wind, geothermal and solar energy to meet these requirements. The sheer scale of fossil fuel usage makes solar energy the only real viable "green" alternative. Only 2% of the sun's energy that hits the surface of the Earth is converted into wind, so for the scale of energy we need to capture, wind is to some extent just a sideshow although at the moment it has been adopted most widely, accounting for 0.9% of world electricity production. Government statistics are based off "installed capacity", but on average, wind turbines only operate at just 27% of installed capacity due to the variability of winds etc. Over the last 10 years the growth in installed capacity has averaged 29.6% per annum, but even continuing at that pace it would still only represent 3.2% of present electricity capacity by 2015. Assuming our energy demands continue to grow at 2%, wind would still only represent 2.9% of our needs by 2015, and only just account for 50% of new capacity additions by 2017.

Because of the variability of wind energy, conventional power stations have to be on immediate standby, reducing the overall efficiency. Either that or additional capacity needs to be installed in different parts of the country to minimise the risk of insufficient wind. Even if it was part of a diversified portfolio of energy sources, there would still need to be sufficient additional capacity to cater for all eventualities. The turbines are said to be 40 times more efficient than their old pre-industrial revolution wooden mills, and that better blades and higher and cheaper towers, will increase efficiency still further, but wind is still an extremely low density source of energy. If Britain was to rely on wind farms to replace our existing electricity needs for example, it has been reported that we would need to increase our wind farms 300-fold, covering an area twice the size of Wales. Whilst that may be theoretically possible, it could only be achieved at the expense of other uses of the land. Offshore farms would be significantly more expensive to construct and maintain. A 3 Mega Watt turbine with 90 metre diameter blades for example weighs 250 tons, and even in shallow waters, requires a further 250 tons of steel and concrete foundations to support it, all of which requires huge amounts of energy in the first place to produce, transport and then erect and maintain. There are experiments with tethered autogiros to capture wind energy from the jet-stream where the wind is much more constant and powerful level, but the complications involved mean this is unlikely to be anything but a curiosity. Wind power will reach 2% or 3% of our energy needs and therefore serve an important role, but it not going to be a replacement for fossil fuel.

To highlight the inefficiency of wind and the importance of energy density, Samsung Heavy Industries recently launched the Xin Los Angeles ship which is capable of carrying 9,200 twenty foot containers and needs a crew of just 19 people. By contrast the famous Cutty Sark tea clipper that was used to ship coal from Australia to China, and then tea from China to England, needed a crew of about 30 to control 32,000 square feet of canvas sails. Its cargo was limited to just 600 tons and took about 100 days to sail from China to England – (different sources give slightly different figures).

If we therefore accept that solar is the most likely large scale system, just how feasible is it? Contrary to popular opinion, there has not been much improvement in solar power efficiency since the 1950's when solar (or photovoltaic) cells were first built. Efficiency improvements have been in the production process rather than in actual conversion of solar energy. The ratio of electric power to light incident on the cell is governed by laws of physics, which give a theoretical maximum of about 26% for single spectrum cells. Solar cells are effectively just LED's - (light emitting diodes) - run in reverse. Just as an LED will only emit one colour of visible light when exposed to an electric charge depending on the material used in the semiconductor, so a solar cell will only collect energy from one part of the light spectrum depending on the material used. Silicon based cells for example could theoretically convert 26% of the light spectrum into electricity, although for the moment the most efficient cells operate at about 22% conversion.

More complex solar cells that effectively sandwich together semiconductors made of silicon, gallium arsenide, zinc manganese and other materials, do give access to a greater proportion of the spectrum, however these only give about 40% efficiency and are extremely costly to produce, limiting their use at the moment to spaceflight applications where outside the Earth's atmosphere the solar density is about 8 times that on the planets surface. In the 1970's and again now, NASA and others studied the prospects of putting solar arrays into space and then beaming this higher energy content down to Earth either by microwaves or via lasers. It is estimated that we would require 800 arrays, each the size of Manhattan, to be placed in space to replace the energy we presently get from fossil fuels. The cost is seen as multiples higher than Earth based solutions, so I think we will leave that to science fiction for the moment.

A common misconception seems to be the assumption that Moore's Law can be applied to photovoltaic cells. This is not the case. The laws of thermodynamics are not so generous. As an aside, it should also be noted that Moore's Law states that the processing power of new semiconductors doubles every 18 months, not that its processing power doubles per unit of energy applied. A modern computer processor for example will consume about 160 watts of power, 15 times as much power as its early – mid 1990's equivalent. As computers become more powerful, they are fast becoming the biggest energy consumers on the planet. The so-called server farms that support the Internet, consume more energy than aluminium smelters. The introduction of "cloud cover", or industrial storage centres for computer data, and the introduction of video on demand, which requires exponentially larger computer storage capacity, means that the demands on energy will continue to rise with any economic advancement. The reality of this "cloud cover" service for the computer companies themselves is that profit margins are extremely low and that the main differentiating factor is the cost of the energy input, which explains why several companies have been in discussions to locate some of their server farms in Iceland.

Industry estimates suggest that once Google's server farm in Dalles Oregon is operating at full capacity in 2011, it will require as much as 103 MW of power to run, enough to supply every home in Newcastle England (population 260,000) or 6% of the energy from the local hydroelectric station which is comparable to the Hoover Dam, or about 9% of the U.K.'s Sizewell B nuclear reactor. The server farm was located here to take advantage of the cheap electricity. Google has at least 12 of these large scale data centres in the United States, and at least 35 worldwide, and Google is just one of many. Google's latest plant is in Finland, where again it will be positioned with access to cheap power in mind, replacing an old Stora Enso paper mill

Solar power's dependence on daylight would mean having far more solar capture capacity during the day time as it would be needed to power high capacity batteries, or to produce hydrogen, to cover our energy needs during the evening and the night. Alternatively, super conductivity cabling would mean that we could follow the Sun around the Earth – (I should probably say the Earth around the Sun), however that would still need sufficient capacity to be built in say Australia to power not only Australia's day time needs, but also to power say Britain's night time needs. The best conductivity cables also leak 3% - 5% of the energy passing through them every 1000 kilometres, whereas the best batteries lose about 14% of energy on charge. Either way we are effectively talking of doubling up the solar collective capacity to compensate for the energy we use outside daylight hours. The energy intensity of the sun hitting a solar cell is not just binary; it changes throughout the day as the Earth rotates, being most powerful as the sun is directly overhead. The energy from a solar cell therefore changes throughout the day, which means the power available from the grid would also vary. The energy would therefore have to be supplemented with some other more stable source of energy. To maximise solar efficiency rates, the solar cells would have to track the sun across the sky, a process that would consume energy and therefore further reduce the effective net solar conversion rate.

To complicate things still further, the fact that we would need sufficient capacity not only to meet our present energy needs, but also to build replacement solar cells when the existing ones come to the end of their useful life – (ie breeder cells) - would dramatically add to capacity issues. Based on the cells not reaching energy breakeven for 5 years - (the average of 16 different surveys is 4.92 years) - and probably having a useful life of no more than 15 - 20 years, we are probably talking about an additional 33% - 50% capacity being required. Similarly if we are going to grow our energy consumption over time, we would need additional breeder cells to be dedicated to this expansion. As you can imagine, the figures start to add up. The size of the network required to cater for all these inefficiencies would dwarf our present fossil fuel network. This would also be the case with wind farms, and brings me to the nub of the problem. The name alternative energy implies a system for making energy that can be viewed as an alternative to fossil fuel. This is incorrect. The manufacture of solar cells or wind turbines is very energy intensive in the first place.

Most of the energy required to create solar cells is consumed in the manufacture of the raw silicon itself. Once the raw material has been mined and transported, it requires heating to temperatures in excess of 2000 degrees Celsius, and then upgrading to the necessary quality. At the moment the scale of the solar cell industry is so tiny - (the U.S. gets just 0.02% of its electricity from solar cells, and from what I have read, nearly 20% of all solar cells worldwide are used to power calculators and or road signs) - that it can use silicon scraps left over from the computer chip industry. If solar power is to expand significantly, then other dedicated sources of silicon must be generated. There would effectively have to be a scaling up of the silicon operation globally into something of similar size to the oil industry, which would mean huge mining and transport operations as well as smelters etc. If we were to attempt to build out photovoltaic cells on any proper scale, it could result in major material shortages. Gallium arsenide for example is the material of choice for doping silicon. The principal source is a residual from aluminium mining and purification. But if the industry were to increase just by a factor of 10, other sources would have to be found, and presumably the cost would rise dramatically.

Solar cells cannot be viewed in isolation from fossil fuels. Whilst the idea of alternative energy is very attractive, the reality is that it will need a vast amount of fossil fuel energy to be consumed in the building of this new energy system. The figures are huge. Assuming we only used solar cells during the day time and did not need to create some kind of storage system for the evening or for those times when there was cloud cover etc, then based off a simple energy breakeven, it would take a minimum of 5 years worth of our existing fossil fuel output simply to build this new energy system. This ignores losses of energy in the burning of the fossil fuels, which are as high as 70% between the theoretical energy content and the energy actually converted into electricity by power stations. A major redirection of fossil fuel usage, away from final consumption and towards building the alternative energy system, would be essential.

If we assumed that fossil fuel production is going to start falling at 5% per annum for illustrative purposes, then based off the 5 years required to achieve energy breakeven, that would require a transfer equal to 25% of a single years fossil fuel production, into making sufficient solar cells to make up for this annual shortfall. Exactly the same would need to happen in year 2 and so on. After a period of years the additional solar energy would start to kick in, but as you can see from the below table, even after 20 years the energy available for the rest of the economy has still not returned to energy parity with year 1, losing slightly more than an accumulated 3 years worth of GDP. In fact under this basis, the energy available for the rest of the economy would not reach 100% of year one's level until year 37, however the accumulated loss of energy in those 17 years is slightly less than half a year's worth of GDP. It should be remembered that this is the optimistic view in that it ignores the need to build out extra capacity for use in the night time, it ignores the need for what I have called breeder cells, and it ignores the fact that the cells useful life is only around 15 - 20 years.

Year	AVAILABLE FOSSIL FUEL ASSUMING 5% PA DECAY	FOSSIL FUEL INVESTED IN SOLAR	NET FOSSIL FUEL AVAILABLE FOR REST OF ECONOMY	ENERGY FROM SOLAR CELLS	AVAILABLE ENERGY FOR REST OF ECONOMY	RATE OF GROWTH OF ENERGY FOR REST OF ECONOMY	LOSS OF ENERGY / GDP REST OF ECONOMY
1	100.0	25.0	75.0	0.0	75.0	-25.0%	25.0
2	95.0	25.0	70.0	5.0	75.0	0.0%	25.0
3	90.3	23.8	66.5	10.0	76.5	2.0%	23.5
4	85.7	22.6	63.2	14.8	77.9	1.9%	22.1
5	81.5	21.4	60.0	19.3	79.3	1.7%	20.7
6	77.4	20.4	57.0	23.5	80.6	1.6%	19.4
7	73.5	19.3	54.2	27.6	81.8	1.5%	18.2
8	69.8	18.4	51.5	31.5	82.9	1.4%	17.1
9	66.3	17.5	48.9	35.2	84.0	1.3%	16.0
10	63.0	16.6	46.4	38.7	85.1	1.2%	14.9
11	59.9	15.8	44.1	42.0	86.1	1.2%	13.9
12	56.9	15.0	41.9	45.1	87.0	1.1%	13.0
13	54.0	14.2	39.8	48.1	87.9	1.0%	12.1
14	51.3	13.5	37.8	51.0	88.8	1.0%	11.2
15	48.8	12.8	35.9	53.7	89.6	0.9%	10.4
16	46.3	12.2	34.1	56.2	90.4	0.9%	9.6
17	44.0	11.6	32.4	58.7	91.1	0.8%	8.9
18	41.8	11.0	30.8	61.0	91.8	0.8%	8.2
19	39.7	10.5	29.3	63.2	92.5	0.7%	7.5
20	37.7	9.9	27.8	65.3	93.1	0.7%	6.9
						TOTAL	303.6

The scale of the fossil fuel depletion will ultimately determine the maximum period over which the pain can be spread; however government policy – (I do not believe that the market will be able to allocate resources) - will need to determine the resource allocations between investing in the new energy platform, and the amount of capital available for the existing economy. We cannot simply divert expenditure from oil production into the alternative energy industry. If we did, the rate of decline of fossil fuel production would accelerate dramatically. From 2005 to 2008 for example, as previously highlighted, Saudi Arabia's well productivity fell by 25%. It had to divert 25% more resources into maintaining output. In order to keep fossil fuel production at the highest possible level will need more resources, not less. Expenditure on fossil fuels will have to accelerate - (The International Energy Agency for example believes that USD22trn will need to be invested by the oil industry between now and 2030, although the leading industry expert Matt Simmons suggests it is closer to USD100trn as a lot of the infrastructure is way beyond its design life) - just to fight the natural rate of decay. Governments cannot simply raise taxes on fossil fuel production to pay for alternative energies. Instead they need to lower taxes on fossil fuel production and raise it on fossil fuel consumption, exactly the opposite of what governments are presently doing.

As you can see from the simple modelling above, there would be an initial whack to the economy, and then a gradual build on growth from the lower level. This is not an actual loss of GDP, but rather a switch from consumer goods to energy capturing goods. It would certainly be felt as a huge hit to everyone's standard of living, but the output of the economy would not suffer. It would simply produce different goods. The scale is unprecedented. The cost of the Vietnam War to the United States of America peaked at 9% of GDP, and that of the Korean War at 14%, whereas I am effectively talking a cost of around 25% GDP as calculated a little later, up from the present 4.7% GDP. World War II did peak at 38% of U.S. GDP, but these costs only lasted for a matter of 2 or 3 years, whereas the duration of this transfer is permanent. Of course we would get used to the lower disposable income so after a few years it wouldn't be an issue. The real problem however would be financing today's debts with this much lower disposable income. Financing for the present economy would be crowded out by financing for the alternative energy system. Asset prices would be destroyed (at least in real terms), putting the entire banking system under huge stress, and lifting the cost of capital. This would be bad enough in isolation, but remember that rising dependency ratios from demographics will also be squeezing the amount of free capital. The shock that we will face is totally unprecedented.

Using the same 5 year energy breakeven and a useful lifespan of 20 years, it would take 13 years of deploying 100% of the energy generated from the present wind and solar capacity to add an additional 1% to total capacity, and 18 years before it would add 2% to world capacity. Any real growth in alternative energy capacity therefore will be totally dependent on the availability of fossil fuel to power the manufacture of the wind turbines or the solar cells.

Whilst this may sound an incredibly negative story, I believe I am actually putting the positive spin on the true depth of the problem. My figures only look at replacing fossil fuels, but as I will explain in the next chapter, Hidden Energy**,** we face shortfalls of other forms of energy. Building a completely self-sustaining alternative energy system using just 5 years worth of fossil fuels would be an incredibly good investment, but unfortunately the reality is much more difficult. Wind and solar power are extremely low energy density. Massive arrays or windmills need to be used to turn that low grade energy into something sufficiently powerful to form any useful task. This wouldn't be a problem if these arrays could have a much extended lifespan, such that the low energy density was made up for by the system being able to produce the energy uninterrupted and at low maintenance for many years. The reality is that it can't. If we assumed a 5 year energy pay back from a solar cell, a lifespan of 20 years and no maintenance or cleaning, then that would mean you get 3 times as much energy out of the system as you put into it in the first place, giving an EROIE (energy return on invested energy) of 3. Existing fossil fuels on the other hand have an EROIE many times higher. The only way to effectively advance ourselves is to use an energy source that has an EROIE at least as high, if not higher than we have been using. Otherwise we will be diverting an ever greater proportion of our available resources to extracting that energy, leaving less of an energy subsidy for the rest of the economy. Given that the size of the economy is directly linked to the size of energy subsidy, which is itself determined by the overall EROIE rate, if we are to maintain our standard of living we will have to find a high energy density alternative.

Running through some calculations, if the EROIE of our entire energy infrastructure declined to 3, then to continue to get a net energy subsidy of 20 as suggested on page 35**,** would need the gross economy to expand by 27%. The size of the energy market would rise from 4.7% of the economy to a massive 25% of the economy. Not only would this lift relative wages in the sector relative to the broader economy, but it would also throw up questions about the availability of other resources. Will the new-look economy require the same resources as it presently consumes such that it will just be a case of retooling certain industries and re-training staff like in a war mobilisation, or will completely new industries need to be built? Do we have the necessary raw materials such as Gallium Arsenide? Will the new economy have large excesses of certain products and deficits in others? Given that the supply of fossil fuels is coming under pressure, it might be more realistic to turn the above calculation on its head and suggest that in order for the gross energy to remain unchanged, the size of the rest of the economy would have to contract by 21.25% to just 75% of the gross economy.

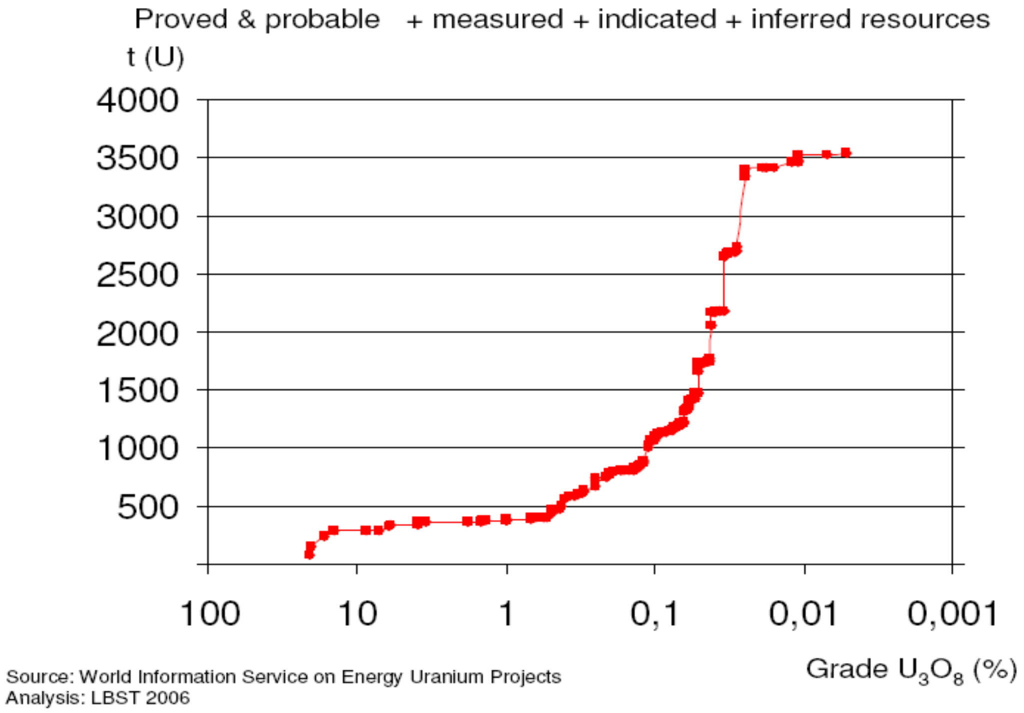
It should be noted that the estimate of an EROIE of 3 is from surveys that focus on the immediate input-output ratios, however when research starts including the “long tail” inputs then the numbers can change dramatically. Rather than simply accounting for the energy cost of making the solar panel itself, if we include the energy cost of making the machine that makes solar panels then that will add to the cost. What about the factory in which that machine is located? Should we also include the energy consumed by the machine that made that machine? Or some proportion of the energy cost of building the road on which the goods were transported? If we take this to the ultimate conclusion, do we actually get any net energy from the solar cell? Given that fossil fuels are presently used as the energy source to make the infrastructure to make the solar cells, these calculations cannot be accurately addressed, however we can conclude with certainty that the EROIE rates will be lower than the optimistic figures I have assumed, and perhaps significantly lower.

There are certain green projects that make sense. Harnessing the power of the Severn Bore in Britain for example would make perfect sense. The estuary has the second highest tidal range in the world. Putting a barrage across the mouth of the river and only allowing the water to flow through turbines could produce around 8% of the U.K.'s electricity needs for generations. It would certainly be expensive, but the lifespan of the barrage would make up for a low energy density. The problem is that it would flood certain mud flats, and therefore anger conservationists. At some stage however, people will have to make a choice. Over the long term, it is literally a matter of life and death. Do we want to protect a picnic area for a few birds, or do we want to be able to produce sufficient energy to fertilize and irrigate our crops, and thus feed ourselves. In the midst of the present credit crunch, the British government should be investing in projects like the Severn Barrage. It would employ thousands of engineers and construction workers, and would take advantage of the cheap cost of energy at the moment because of the credit crunch, to invest in our future. This kind of direction of capital is exactly what is required of the government, however so far government has had its head firmly in the sand and is directing capital into increased household spending via cuts in consumption tax, effectively fighting what needs to be done rather than embracing change.

If low energy density is the problem, then what about Nuclear Fission? Whilst it does tick this box, it has several major problems. Putting to one side the fears over safety and storage of spent fuel, as of 2005 no new nuclear plant has been ordered in the United States of America without subsequent cancellation since 1979. There is no skill-set therefore to build out the scale of plants we would need to the safety standards that we would require. It is estimated that we would require 10,000 new single Gigawatt plants to balance our present energy needs. Educating the number of engineers to the desired level, and then trying to build out power plants, is just not feasible in anything but the medium to long term. Government policy has clearly failed us over the last 30 years, such that we cannot look to fission in the short term. In fact with most of the operating reactors in the United States of America and in countries such as Germany and Italy fast approaching the end of their useful lives, it seems that fission may add to the problem of depleting fossil fuels rather than offset it.

Most nuclear plants use the specific isotope Uranium 235 as their fuel source. Less than 1% of the world's uranium is U235. Discovered reserves would only be sufficient to support the existing industry for another 20 - 30 years. Only Canada can boast reserves where the ore grade is greater than 1%. This means having to dig, crush and extract through various processes 100 tonnes of rock to get just 1 tonne of U235. More than two thirds of the uranium stock has ore grades of less than 0.1%. This will result in a declining net energy return to fission up to about 2030 when the remaining ore grades fall below 0.02% and the EROIE falls below breakeven. Uranium 238 is much more abundant. Breeder reactors using U235 can enrich (or irradiate) U238 with neutrons into Plutonium 239, which then becomes the power source within the reactor. Such breeder reactors would increase the availability of the fuel for reactors about 10 fold, but even this scale of increase would only be sufficient to extend our existing nuclear mix into the medium term. It would not be sufficient to offset the decline in fossil fuel. Given that only Japan, Russia and India have existing breeder reactor programs anyway, it is somewhat academic as the U235 would be exhausted before breeder reactors could be built to extend its effective lifespan. In the first few months of 2009, China, Japan and South Korea got their cheque books out and have been investing heavily in uranium mines in Kazakhstan, tying up 20% of world reserves, as well as taking large stakes in private companies to secure supplies from Canada and Australia.

The chart below shows the world's cumulative uranium resources by ore grade (without China, India and Russia) in thousands of tons. At the present rate of consumption of 67,000 tons a year, the reserves yielding a net supply of energy would only last 20 – 30 years. Between 2015 and 2030 a uranium supply gap is likely.



http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Uranium_3-12-2006ms.pdf

Fast breeder reactors (FBR) could extend the life of the world's uranium reserves, however only 4 of the existing 439 reactors are of this kind, and there is no way that sufficient could be built before U235 stocks are exhausted. FBR's have not gained market share because of the dangers involved. Not only would the P239 create an almost impossible disposal problem, but also within the reactor water cannot be used as a coolant. Instead liquid sodium must be used, which as anyone that has done basic chemistry will know, reacts explosively in air and water adding to the risks associated with this kind of reactor.

I would love to be saying here that these alternative energies are feasible. I do not want to be throwing a bucket of cold water over them; however they are simply not realistic other than meeting very marginal electricity needs. If we view them in that light, then there is a position for them, and indeed that is where the argument seems to be progressing. The U.S. Energy Information Administration for example estimates that by 2030 the U.S.A.'s solar energy mix will equate to just 1.5% of the energy it gets from coal compared to its present 0.02%. Whilst it may not sound much, even this small scale would require an annualised growth rate of 24% according to my calculations, which would make solar companies potentially a great investment. In no way though does it even start to address the problems of fossil fuel depletion let alone our need for ever more fuel.

Two hundred years ago, before the industrial revolution, the world was fuelled by wood or biomass, wind, water, solar and even ethanol, after all from an economic perspective, a horse is nothing more than a tractor with its own on-board ethanol refinery. Coal then powered the industrial revolution, with oil and nuclear energy taking things to higher levels. Each progression needed not only more energy, but also a greater density of energy as recognised by Winston Churchill. Whilst he is known most famously for leading Britain during WWII, in 1911 as First Lord of the Admiralty, he ordered the Royal Navy to move from coal to oil propulsion. It would "raise the whole power and efficiency of the Navy to a definite higher level; battleships, better crews, higher economies, more intense forms of War power". "Mastery itself" he emphasized "was the prize of the venture". Higher density oil would occupy much less space and would require fewer people to stoke the boilers etc. Not only does productivity rely on energy consumption, but also the density of the energy. The idea therefore that the world can support its present level of complexity and output on pre-industrial revolution energy sources is ill-conceived. What is more, the adoption of these alternatives would remove vast swathes of land and water from more productive uses. It would also reduce the effective workforce over and beyond the fall due to demographics, as more people would be required to manage this vastly less efficient source of energy.

Chapter 8. Hidden energy

"Just as the market moves with the marginal buyer or seller, it is often an incremental bit of information, which added to all the slumbering bits of information in the fund managers mind, suddenly makes the picture whole"

I am not an environmentalist. I live in the countryside and am not far from the seaside, and do not want to see them ruined, but I believe the global warming debate lacks any substance. To say the science is not conclusive would be an understatement. The absorption frequencies of CO_2 are saturated such that the atmosphere already captures close to 100% of the radiation at the relevant frequencies, limiting the amount of warming from further carbon dioxide emissions. Temperatures have been cooling now for about 10 years as per the solar cycle, and the 30 year Pacific Decadal Oscillator, which describes the temperatures far better than atmospheric carbon concentrations, now suggests that we are at the start of a 30 year downward cycle of temperatures. Even if the link to carbon emissions is genuine, which as I say it looks very flimsy at best, then it is fairly irrelevant anyway because peak fossil fuels means that the release of carbon into the atmosphere is going to slow aggressively over the next few years. Why therefore worry about carbon concentrations soaring if we know that we are rapidly running out of carbon fuels that we can release.

Nevertheless whilst I am not worried about carbon emissions, I am concerned. There is a natural energy subsidy from the environment that is rapidly disappearing around the world. As we all know, fossil fuel is effectively fossilised solar power. It takes millions of years to produce in what I would describe as a "long cycle". This is not however the only source of energy we consume. There are at least two other solar energy cycles that we rely even more heavily on. Let's call them the "slow" and "fast" cycles. The fast cycle is the direct use of solar power for such things as growing grains, and the energy required to drive the water cycle – (rainfall or precipitation is nothing more than a cycle that first of all desalinates water and then transports it inland). The slow cycle on the other hand involves the storage of these fast cycle energies in terms of aquifers and icebergs that lock the rain away for later use, or that lock decaying plant matter away in terms of top-soil, processes that can take hundreds or thousands of years. Not only are certain parts of the world (predominantly Asia) now consuming way in excess of the energy that can be provided by the "fast cycle" just to survive, but they have now almost completely exhausted the energy stored away from the "slow" cycle in terms of aquifer and top soil depletion. They are increasingly reliant on stored solar energy from the "long" cycle (fossil fuels) just to feed and water themselves.

There is no actual shortfall of water, but there is increasingly a shortfall of fresh water, and particularly fresh water in the right location. The scale is huge and only going to get worse as global consumption of water doubles every 20 years, more than twice the rate of human population growth. It may surprise you to know that it takes 140 litres of water to grow sufficient coffee beans to make a single cup of coffee. For every teaspoon of sugar you have in your coffee, it takes another 30 litres of water. To make a cotton shirt takes 2,700 litres of water, and to make every kilogram of beef takes 15,500 litres of water. This concept is known as "embedded or virtual" water, and can be applied to everything we consume from agricultural products to industrial products, although it is agricultural products which are the biggest consumers of water. As parts of the world are consuming beyond their sustainable levels of water, effectively consuming down their capital rather than simply living off their income, they have to turn elsewhere. Water increasingly needs to be either transferred from one location to another via vast engineering works, produced via desalination or reverse osmosis, or imported in its embedded or virtual state. All of these will require vast amounts of energy adding to the burden we have already discussed.

The so-called Green Revolution that lifted crop yields in recent years, enabling the world to feed itself, was totally reliant on increased fertilizer and water input. Yield per acre may have risen, but yield per "effective" acre has fallen. Despite all the talk of genetically modified plants, we have not been able to fundamentally alter the basic process of photosynthesis. Additional yields are based on more water and more fertilizers, both of which are dependent on increased energy input. Increased crop demand for water means increased demand for irrigation. The world grows twice as much food as it did a generation ago but extracts three times as much water, rapidly depleting rivers and aquifers. Whilst overall cropland loss due to degradation is a major problem, the U.N. warns that on at least $1/3^{rd}$ of the world's fields today, "water rather than land is the binding constraint". What is worse is that the marginal return on both fertilizers and water is now shrinking, so unless there is some major technological breakthrough, the demands for water and fertilizer will grow exponentially with our increased demand for food – (the global population is expanding by about 70 million per annum).

The Middle East is consuming down all of its water reserves very quickly. Jordan, Israel, Oman, Yemen, Qatar, Bahrain, Saudi Arabia, United Arab Emirates and Kuwait are all withdrawing and consuming more water than they are getting from their annual rainfall. Kuwait is consuming 22 times its annual rainfall for example. These countries are increasingly reliant on either desalination or importing virtual water in terms of grains. In 2008 for example, Saudi Arabia announced that it will scale down its agricultural production and become 100% reliant on food imports by 2016. It will export energy in the form of oil and then re-import it in food. Despite this, it will have exhausted its aquifers within 10 years or so, and will therefore increasingly have to turn to desalination. If you then consider the huge construction work in places like Dubai, where it now takes over a year after the buildings are complete to connect them up to water and electricity supplies, you have to think that the energy demand growth of recent years is going to continue.

Despite their oil reserves, the Financial Times ran an article in July 2008 suggesting that the Middle East "faces an acute shortage of gas and power". The region has failed to adequately invest in oil's poorer brother, natural gas such that analysts estimate that the six countries that make up the Gulf Cooperation Council (Saudi Arabia, Kuwait, Qatar, Bahrain, Oman and the United Arab Emirates) face a shortfall of gas of at least 7trn cubic feet by 2015, equivalent to 41% of the UK's entire remaining proven gas reserves. This shortage will profoundly affect their ability to meet the rising power demand for desalinated water for both their growing populations and their growing industry. In recent years the Middle East and North Africa saw larger energy growth than China. Its exhaustion of fresh water and its increasing calls on that water, combined with insufficient gas to meet its power needs, will mean that its oil exports continue to fall – (exports from the top 5 oil exporting nations have fallen in each of the last 3 years). This will act as a feedback loop, with lower oil exports lifting overall oil prices, which themselves will lift the Middle East's living standard and by definition its consumption of water.

Libya consumes more than 7 times its sustainable supplies. Whilst it may sound strange, the largest aquifer in the world lies under the Sahara desert. The Nubian aquifer contains 150,000 cubic kilometres of fresh water. General Gadafi has used Libyan oil reserves for the last 20 years to pump water along a 10 day journey from the aquifer to farms. The plans are to increase the infrastructure and increase the transfer by 150% to 2 cubic kilometres a year. What will that mean to the available energy for export? What would happen if say China decided to help other African countries develop this vast source of water to meet some of China's growing food, and therefore, water needs? Perhaps the power of the sun on the Sahara could be converted into energy for pumping this water, but as we know to build out the vast scale of solar cells that are required would take huge amounts of fossil fuel in the first place.

Pakistan and all the other Stan's are all using between 50% and 100% of annual rainfall. Pakistan abstracts 5 times the water per head than does Ireland. Of 180 cubic kilometres of water entering the River Indus, 170 cubic kilometres are used for irrigation. Add to that demand for drinking and washing as well as industrial demand, and the giant Indus no longer reaches the sea, making both the water that is available and the land that it irrigates, increasingly saline. Overall 96% of available water in Pakistan is used for agriculture according to the CIA. Crop yields are falling and vast swathes of land have to be abandoned each year to the desert. With the population growing rapidly, either Pakistan will increasingly have to turn to imports, or will have to desalinate the water within the Indus itself, as well as find another source of fresh water. No wonder it is becoming a failed state. What would happen if India turned the water off to Pakistan?

The former Soviet states, Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan and Kyrgyzstan, are following a similar trajectory. On average 91.8% of the water the region consumes goes on agriculture according to the CIA. Diverted water into cotton fields and other agriculture has reduced the Aral Sea, the world's 4th largest inland body of water just 40 years ago, into a huge desert. Crop yields have halved due to salinisation. The scale and cost of desalination is prohibitive. The world's most efficient desalination or reverse osmosis plant takes 4.1kWh of electricity to produce 1 cubic metre of water, which I calculate as equivalent to 0.38 cubic metres of natural gas per cubic metre of water. Instead there has been talk of resurrecting a Soviet plan to transfer 27 cubic kilometres of water a year from Russian rivers 2500 kilometres away.

Whilst the countries discussed so far have been the worst hit, they have to some extent been the obvious countries where the problems should be well understood. But what about the larger countries like China and India with their large populations? On the face of it they are not too bad. Ten year old data has India consuming 33.85% of sustainable water and China 19.43%. Even ignoring the fact that their economies have more than doubled in the interim period and therefore made the situation significantly tighter, the problem is that the rainfall is neither distributed evenly geographically, nor through the course of the year. Eighty percent of the run-off (percentage of the rainfall that ends up returning to the sea) across Asia is concentrated in the monsoon season, so these statistics heavily underestimate the severity of the problem. According to The World Business Council, the lack of fresh clean water could stop China and India's economic growth.

India uses over 20 million water pumps to tap underground reserves, which are now extracting about 250 cubic kilometres of water a year from the aquifers, more than 2.5 times the replacement. This irrigates over 2/3rds of India's crops. There are more than 1m new pumps added every year and as the wells get deeper, the energy cost of pumping the water rises The wells are upwards of 100m deep, with wells in India now around 400m deep on average and some close to a mile deep. For comparative purposes, the annual flow over the Niagara Falls in North America is about 59 cubic kilometres a year and its height is just 52 metres. Some simple maths will tell you that the energy consumed by India alone, in lifting 250 cubic kilometres of water 400 metres out of the ground, is the equivalent to the energy in 208m barrels of oil. As the wells become more depleted and it eventually has to turn to desalination, the energy consumption will rise on very conservative assumptions to 783m barrels of oil or 2.46% of present annual oil production globally. It should be no wonder therefore that China is the world's second largest consumer of electricity and India is 5th.

Non-renewable ground water beneath the North China Plains is expected to be completely exhausted within 10 years. The scale of the water transfer plans in China is now 45 cubic kilometres a year from the Yangtze to the north. The plans are several-fold, part of which involves using nuclear explosions to drill under the Himalayas to divert water from Tibet back into mainland China. In India the scale of the water transfer projects are almost 50 cubic kilometres. To give you a feel on just how much water this is, the 600 km reservoir behind the Three Gorges Dam, the world's largest hydroelectric power station, contains just 22 cubic kilometres of water when it is full.

Adding together the Russian, Indian Chinese and a 10 cubic kilometre Australian project, equates to 129bn cubic kilometres of water that official sources suggest need to be transferred just to meet existing agricultural needs. Given that it takes about 1000 tons of water to produce 1 ton of grain, this would suggest that if these transfers are not made, the 4 countries would be consuming 129m tons of grain per annum above levels sustainable from their existing water geography. That equates to 49.8% of world trade in grains. Whether the canals and storage – (storage capacity behind dams is disappearing at over 1% pa due to silt and salt build-up) – are actually built, or whether the countries increasingly turn to imports of virtual water from the States and Latin America, the energy that is going to be required to offset this natural water shortfall will be vast. Food mileage is set to rise, not fall. If China was to desalinate sea water to meet the shortfall it will face around Beijing for example, it would consume 3% of world oil production.

China also faces huge problems to do with the quality of water. Its own statistics agency says that 40% of China's water is only fit for agricultural and industrial use. Most people think these figures significantly underestimate the problems, but nevertheless taking them at face value China itself says that it will have to build thousands of water treatment plants, all of which will deploy energy. In fact the quality of some of the water is so bad in parts of China that no level of treatment can purify the water to levels that would be acceptable for human consumption, not even for the Chinese population itself. India's government says that 75% of its water is contaminated.

China is beginning to explore desalination as a source of coastal water supply. Large facilities have been proposed for the county of Xiangshan in eastern Zhejiang Province, and in the northern China city of Tianjin. Xiangshan suffers severe water shortages. The plant proposed for Xiangshan will have a production capacity of 100,000 cubic metres a day. It will use the heat from an existing power plant. The cost will be around CNY6 (USD0.87) per cubic metre, but it will be blended with local supplies and sold for CNY2.5 with the government bearing the cost of the subsidy. In March 2007 China announced that it would build a 600 kilometre pipe of toughened glass to transfer 1 million tons of sea-water a day, to Xilinhot in Inner Mongolia. The water is needed to both try and slow advancing deserts, and also to help coal production. The water will be desalinated at its point of destination with the coal that it is helping to mine. I wonder just how low the net energy from that coal will be once you adjust for the energy consumed in pumping and desalinating the sea water.

In Los Angeles, construction workers are digging a 30 foot wide 600 foot shaft next to Lake Mead. The 110 mile long reservoir has dropped by 1% pa since 1999. By 2012 it is likely that the water level is below the existing pipe that delivers 40% of the city's water. Patricia Mulroy, manager of the Southern Nevada Water Authority is planning a 327 mile underground pipe to tap aquifers beneath valleys north east of the city. Californian farmers now sell water rights to each other. The Dean of the Kellogg School of Management said that "Water is going to be more important than oil in the next 20 years". This is a commonly held view, but the reality is that the only way the water shortfall can be rectified is through the use of more energy. The decaying natural energy subsidy was not considered a problem when the supply of fossil fuel was growing, and there was enough energy to meet all our requirements, but now the world is suddenly waking up to a peak in fossil fuel production, hard choices have to be made over how that energy is used. A timely analogy might be the decline of General Motors. Its loss of market share was ignored year after year as the overall market was continuing to grow, but once that turned down, people realised just what a mess General Motors was in.

Water is not only important to life itself, but also to the quality of life. If China and India want a Western standard of living, then they needs access to a certain amount of water that they simply do not have.

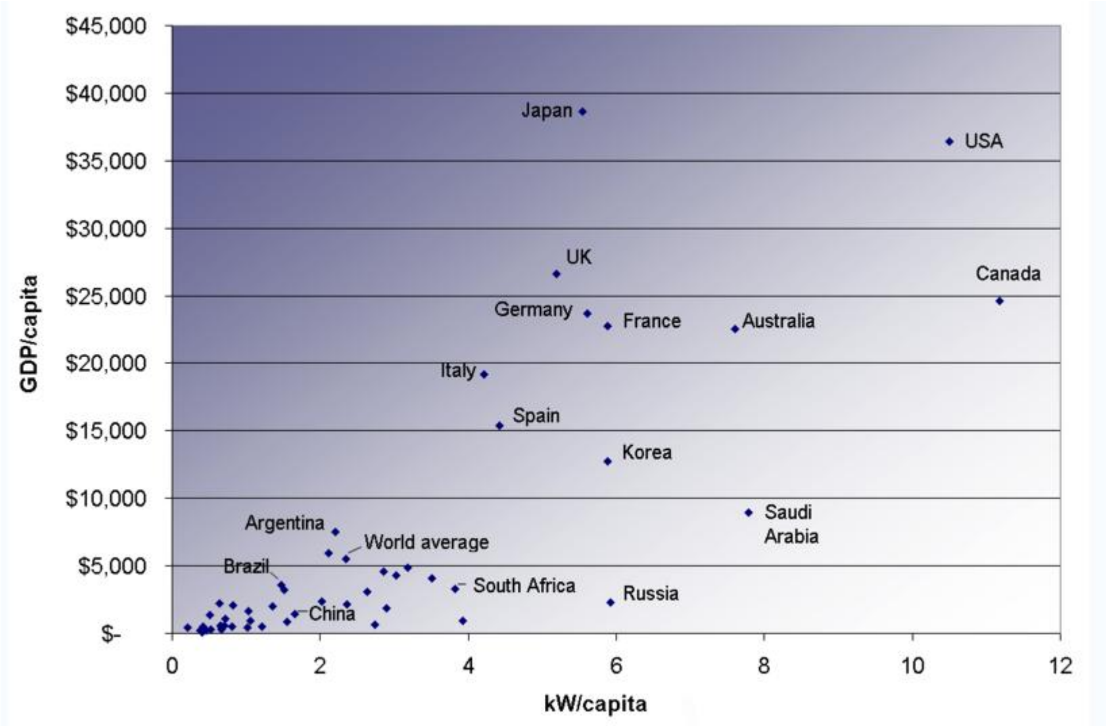
Another huge natural energy subsidy that is ignored is the earth itself. Soil is created via several processes that involve rocks being gradually eroded by weathering (heat, rain, cold, wind etc) and by the roots of plants, as well as decaying plant material and bacteria and various biological processes. It is effectively the result of an energy cycle that takes hundreds of years to produce. The world is now consuming soil faster than it is created, and is therefore mortgaging its future. Twenty four billion tons of soil are lost every year, equivalent to 4 tons per person. Mechanised farming has depleted nutrients and made the soil sterile, such that it can only support crop production with massive inputs of these nutrients via fossil fuel based fertilizers. The removal of plant cover, particularly forests or grassland, has removed the ability of the soil to store water. Rainfall then simply washes away the nutrients. Without applying fertilizers, crops have nothing to feed on and die, turning the soil gradually to desert.

Because of the population density, the removal of top soil has predominantly occurred in Asia. Land is cropped and harvested 2 or 3 times a year. China has to use 4 times as much fertilizer per acre as the world on average to get just 90% of its yield. Fertilizer production is now China's 4th largest consumer of coal, accounting for 7.1% as much coal as the entire power generating industry. Deforestation continues to remove natural catchment areas. Water that was held in the soil and supported underground aquifers now just drains away, washing soil away with it. China's Yellow

River gets its name for this very reason. The river disperses 3 times as much sediment as does the Nile, Mississippi and Amazon combined. Because too much water is now being drained off the river for irrigation, there is not enough flow to wash the sediment out to sea. The river bed then turns to sand and gets blown across the country leading to huge sand storms. The water that is drained for irrigation also becomes saline, reducing the natural fertility. During the Great Leap Forward, China's forests were chopped down to power the growth. During a 15 year period the central province of Sichuan saw its forest cover fall from 40% to 12%. By 1995 it had fallen to 8%, and is now almost non-existent as the country continues to exploit its resources. Fifty years ago the soils under the forests could hold 400 cubic kilometres of water, which was a huge natural asset. Now the soil is just washed away turning the Yangtze into a similar mess as the Yellow River.

The silting up, damming and general exploitation of China's rivers has restricted their use for transport. Unlike the United States which has the largest network of navigable rivers in the world, China increasingly has to turn to rail for the transportation of goods. It should be no wonder that the industrial growth has all been around coastal ports. If it is to drive this growth inland, then the transport networks will have to be enhanced, which means huge amounts of energy to construct and maintain them, as well as to utilise them. This has been highlighted recently by the construction of the 1800 kilometre Kunming-Bangkok Road that links China with the countries of the Greater Mekong Sub-region (Thailand, Laos, Vietnam, Myanmar and Cambodia). Whilst the Mekong River is the world's 10th largest river, and the 7th longest in Asia, the extreme seasonal variation in flow and the presence of rapids and waterfalls has made navigation extremely difficult, but as China increasingly has to turn to this region for agriculture, timber, oils and fishing, it is having to establish major road and rail networks. At the moment bureaucracy means that a 2 or 3 day journey is taking more than a month to complete, but once systems are in place, trade with this region will develop rapidly.

The natural energy subsidy helps to explain some of the huge divergence of energy efficiency across different countries. If you draw a diagonal line on the below chart from the bottom left hand corner to the top right hand corner, then you can see which countries get the most GDP out of their energy consumption. Countries that are above the line are the most efficient and those below it, the most inefficient. Japan stands out head and shoulders above all other countries, with Northern Europe and North America next. Brazil and Argentina don't consume much energy as their economies have not yet developed, but they get a similar level of economic output per unit of energy input, as either Spain or the USA. Russia and Saudi Arabia are both large exporters of energy, but they are inefficient users of it. Some of this can be explained by the fact that their energy is very cheap and therefore they can waste it, but I think the real reason is the very low natural energy subsidy. Saudi Arabia for example has historically had to use desalinated water to irrigate crops, and whilst Russia has vast areas of land and water, most of the land is inhospitable and its water resources have been in the wrong part of the country. It also has no warm-water ports so trade and development has been limited. China's inefficiency is several-fold. Not only does it not have the water, land or forest resources that can naturally support its consumption, nor the natural water transport network to spread wealth internally – (its 3 great rivers do not interconnect), but it also has a huge population for those natural resources to support. No wonder China is overtaking the United States as the world's largest consumer of fossil fuels despite its economy only being a fraction of the size.



Graph produced from 2006 Key World Energy Statistics from the IEA
by Frank van Mierlo and available on Wikipedia.

Increased use of fossil fuels has allowed the world to ignore these declining natural energy subsidies, but with fossil fuel production now peaking, it will become increasingly obvious. The small scale adoption of ethanol by the USA in 2007 and 2008 highlighted this dilemma. By diverting some of the U.S. natural energy subsidy into ethanol production, it sent world food prices through the roof. The scale of move was helped by yet another energy cycle; world food stocks themselves were at a record low. Increasingly the world will start to price these natural energy subsidies more in line with fossil fuels. Analysing a country's energy balance sheet will shift from just coal and oil reserves per capita to forest cover per capita, water supply per capita, and quantity and fertility of soil per capita etc,. This will favour the West and Latin America and hurt Asia which has benefited from record low energy prices for the last 20 years. Relative prices and terms of trade will change. Asia's trade surplus is likely to become a deficit.

Unless the world is prepared to suffer a collapse in its standard of living, it is going to have to replace and enhance its existing energy subsidy.

Chapter 9. The Low Hanging Fruit.

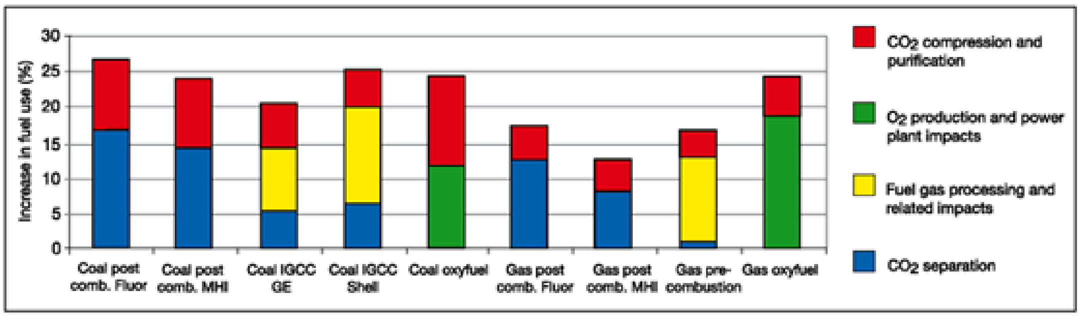
Freud. In a crowd the sentiment of responsibility always disappears. When an individual becomes a member of a crowd they "descend several rungs in the order of civilisation". The mind of a crowd is not an average but a common denominator.

As it has become increasingly obvious that we are exhausting our traditional fossil fuels, and that existing alternative energies are unlikely to be able to make up for the shortfall, research has moved to the elimination of waste and efficiency savings. In 2007 the U.S. National Academy of Sciences and National Academy of Engineering initiated a major study, "America's Energy Future: Technology Opportunities, Risks and Tradeoffs", which offered very little optimism. It even asked "Are we up to the challenge?" concluding "There is no reason to be particularly optimistic, but time will tell". Instead it adopted the all too familiar line that "Maximising energy efficiency and decreasing energy use will remain the lowest hanging fruit for the next several decades".

Eliminating waste and increasing energy efficiency are becoming the consensual solution to the forthcoming energy problem. Historically the global economy has grown by a real 3.3% per annum (pa) since 1983, whereas the use of energy has risen by about 2% each year. The energy efficiency gain therefore has been around 1.3% pa. If the supply of energy follows a "normal curve" as commentators think, rather than rising by 2% pa, the supply of energy will fall by 2% pa. Even taking an optimistic scenario that the availability of energy will be constant, an increasing proportion of it will be directed away from existing production within the economy and towards building out alternative sources of energy or compensating for the declining EROIE. It is very difficult therefore to construct a realistic scenario where the supply of energy to the world economy will be anything but falling. Nevertheless assuming that energy supply remains constant, would it be possible to achieve

3.3% pa economic growth by reducing the energy intensity of the economy? Could we lift the energy efficiency gains from 1.3% pa to 3.3% pa?

The laws of physics limit the absolute levels of efficiency, but there is ample scope for big gains to be made before we reach those physical limits. Whilst efficiency gains can be made through the entire energy consumption chain, the biggest savings are likely to be made at the source, or upstream end, as they will be reflected all the way through the chain. Unfortunately as we know, the efficiency of accessing fossil fuels is itself declining, so we have to go one step further away from the source to get the next largest potential gain, the power station, the refinery or the internal combustion engine. If for example we could increase the efficiency of power stations from the present 30% level to 40%, then that would have far more impact than increasing the efficiency of say light bulbs by the same 10%. Unfortunately the world's obsession with green energy is set to negatively impact the efficiency of power generators. Carbon capture or sequestration is energy intensive. The flue gas has to be re-heated to temperatures of about 140 degrees Celsius to allow solvents to separate the carbon dioxide from other gases. Steam then needs to be applied to remove it from the solvent. It then needs to be pumped to wherever it is going to be stored and then compressed to a manageable size. Overall the process reduces the net energy by between 14% and 26% depending on the source of fuel used, where in the burning process it is extracted, and of course the distance of the power station from the place of storage. The timescale for coal depletion will accelerate depending on how widely this technology is adopted.



www.theoildrum.com Percentage increase in fuel use per kWh of electricity due to CO2 capture compared to the same plant without capture.

The next most important upstream use of energy will be in mining. I have already described how over-exploitation of land and water resources has reduced the natural energy subsidy for farming, and how this has had to be replaced with the increased use of fossil fuels; the so-called Green Revolution. The same situation is evident in mining. The profitability of an ore body will be dependent on ore grade, depth and location, access to cheap labour and other resources, as well as transport infrastructure and distance to the market. As the higher quality ores are consumed, the marginal cost of production will rise. In April 2008 Rio warned that it had to extend the life of mines - (Kennecott Utah Copper mine from 2020 to 2036, and the South African Palabora Mine by 5 to 7 years) - and exploit lower quality ores, to maintain output. In September 2008 BHP said that output from its Escondida copper mine, the world's largest, would fall by 15% over the next two years because of declining ore grades and insufficient power supplies to compensate. It submitted plans to build a USD3.5bn desalination plant and a 180km (112 mile) pipeline to provide sufficient water to maintain copper production. According to Codelco, the world's largest copper producer, within a decade all of Chile's copper production will have to rely on desalination plants rather than groundwater. Twenty six percent of the copper stock in use globally is already recycled, but with new and expanded roles, the demand for copper in the developed Western economies continues to rise. For the fast developing economies such as China to enjoy a Western standard of living, it is estimated that its copper consumption would have to rise 7-fold. Unless the global economy's demand for resources is going to fall, and it seems highly unlikely that it is, then the energy subsidy required to mine, extract and process that ore, will have to increase. Far from improving, the efficiency of the upstream part of the energy consumption chain is declining and the depletion of ore grades means it will continue to decline.

Looking at the mid-stream and down-stream part of the energy consumption chain, efficiency gains are achieved by technological improvements. These can be either add-on improvements or by complete replacement. A modern house for example will be more energy efficient than an old house, but it is unlikely that it would make sense to tear down an old house and replace it with a brand new one, just for the efficiency gains. It would certainly seem far fetched to imagine pulling down the entire capital stock of houses every few years and replacing them with more efficient houses. Instead new windows or insulation materials may be applied, gradually replacing and improving the efficiency. All of this consumes energy, which has to be factored in to any measure of efficiency gains. As much energy is consumed in the manufacture of an average American car for example as is takes to drive it 63,000 miles at 30 miles per gallon. Replacing cars or houses more frequently will improve the efficiency of the car fleet or housing stock, but won't improve the efficiency of the car industry, or housing industry as a whole.

There is a payoff between energy efficiency and energy consumption that is reflected in the cost of running and maintaining a car, or replacing it with a new one. There are other variables in making that decision which means that it won't necessarily be replaced at the optimum time. In fact if you take the example of a car that loses about 1% energy efficiency every year, then the initial owner will replace it far too early, but given that it is then used in the second hand market it should continue to be used until the economics of running and maintaining it no longer make sense. Manufacturers will build in life expectancies and tolerances that are commensurate with how quickly efficiency gains are likely to be achieved. Similarly consumers update their goods when they feel the uplift in efficiency or value is worth the price paid to that person. Between manufacturers and consumers, the market already upgrades its capital stock at an optimum time for the perceived gains, making somewhat of a mockery of the fuel efficiency logic of governments' "cash for clunkers" schemes. If companies fail to optimally upgrade their capital, competition will force them out of business. It is true that this process has not happened in recent years as it should do, because China has been subsidising its inefficient business model with an artificially low currency. But even this obstacle could not last indefinitely. The cost of the subsidy – (rising energy prices) - became prohibitively expensive for the Chinese, and indeed the world economy, to bear. The credit crunch and the resultant job losses that we are now seeing is just this restructuring and efficiency process happening. Unfortunately because this subsidy has been very large for a number of years, the scale of the required restructuring is just too painful, and explains why it is being fought rather than embraced.

Rather than adopting new, more efficient equipment more quickly, can't we achieve bigger leaps forward by increasing the level of research and development? As I described earlier in the book, in order to increase R&D, we either need an increased energy subsidy or we need to deploy existing resources differently, away from final consumption and into additional R&D. If we chose the latter route, then we are becoming slaves to energy rather than energy being our slave. Energy efficiency and productivity of energy are one in the same, and therefore must be described by the same set of rules. The thermodynamic equilibrium tells us that in order to move to a higher level of productivity, we must consume more energy. Unfortunately there is no way around this.

As you can see by the chart below, energy conversion efficiencies have been fairly flat for both mechanical work and electric power and distribution for the last 40 years, suggesting either that we are approaching the physical limits to energy efficiency or that we have simply not been investing sufficiently in achieving efficiency gains. The big advance in electric power generation and distribution was achieved over the period when electricity was initially adopted. The efficiency gains over the last 40 years have been minimal. Mechanical work such as the internal combustion engine has also seen little in the way of efficiency gains over the last 60 years or so. There is some improvement, but it is small and it takes many years to lift the efficiency of the whole fleet; the cost of that efficiency gain is very high. There are steady improvements in the energy efficiency for heat processes for both industry and for washing and cooking, as well as for lighting. Some of this gain has been in the actual delivery of the energy as gas and electricity networks have replaced oil and coal.

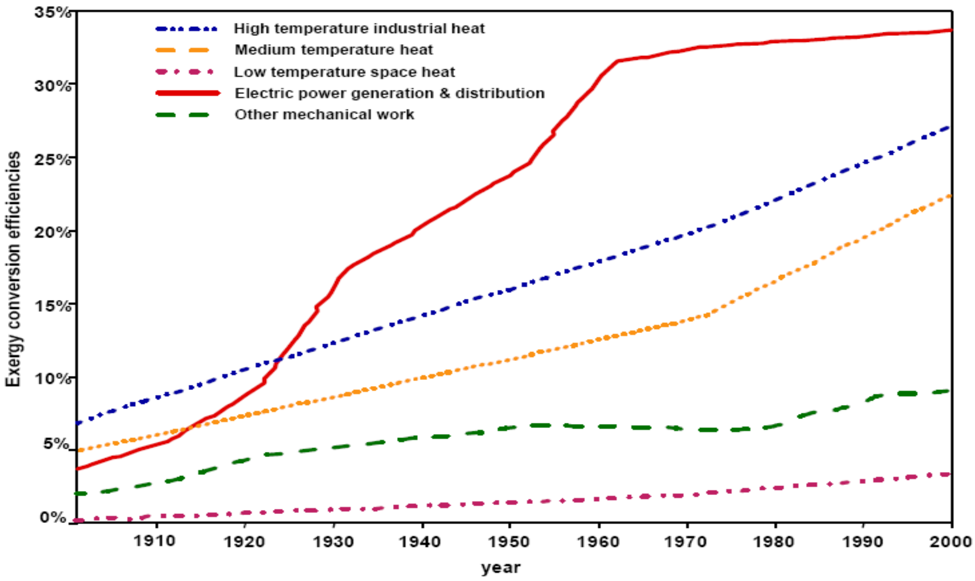


Figure 1: Energy (exergy) conversion efficiencies, USA 1900-1998
(Accounting for Growth: The Role of Physical Work by Ayres and Warr)
http://www.iea.org/Textbase/work/2004/eewp/Ayres-paper1.pdf

One of the most widely discussed potential efficiency gains at the moment is in transforming the car industry from internal combustion engines to battery power. The so-called hybrids are only more fuel efficient in short stop-and-start journeys and similar efficiency gains can be achieved by simply adopting a smoother driving style with a traditional car. A full switch to electric cars is also not as clear cut as the above chart would suggest. If the electricity is provided by fuel cells, then adjusting for the energy lost in charge, in storage, in having to carry a large weight around to counter the lower energy density, and for the loss of efficiency in the electric motors themselves, around 80% of the electric energy is lost. Adjusting for this, a hydrogen powered car would presently be a retrograde step. As far as battery powered cars are concerned, the most efficient batteries lose about 14% of the energy on charge and a further 5% to 10% is lost by the electric motors. A further drawback is the continual leakage of power. If you fill up the tank of an internal combustion engine with gasoline, the gasoline is unlikely to go off unless you leave it for years. A battery will lose all of its power within a few weeks. Because of the inability to stop at a gasoline station and charge the battery instantaneously, people will always run battery cars with a large excess charge in just the same way that they keep their mobile phones fully charged. If they don’t use their car for another week or so, then a lot of the charge will be lost through leakage. Driving to the shops could become very expensive. Adjusting for these peculiarities, the efficiency gains are not as clear cut as we are led to believe, but even putting these problems to one side and assuming we had the right technology, it would take 10 – 20 years to roll it out across the economy as a whole, and an energy subsidy that we simply don’t have.

Whilst further technology improvements will be made, charging batteries will always lose a certain amount of available or useful energy. I specifically use the word useful energy because it relates to the laws of thermodynamics, one of the most powerful laws of physics. Most of us know and understand that energy can neither be created nor destroyed, but rather can be transferred from one form to another. The second part of the law however, which is responsible for pretty much everything we do such as how an engine works, is that energy naturally moves from a higher plain to a lower plain. Heat for example goes from hot to cold or a ball rolls down hill and not up hill losing its potential energy. Overcoming this is possible, but it takes energy, or at least it takes useful energy. In fact whilst we are alive, our very bodies do this all the time, fighting the natural decay by consuming energy. Other examples often quoted are fridges or air conditioning units which fight the natural order. Charging a battery or increasing energy density will always lose a certain amount of available energy. With fossil fuels, that work has already been done by nature over millions of years, which is why replacing fossil fuels with lower energy density alternatives, simply makes no sense. It is theoretically possible, but the scale of the network of systems we would have to deploy to get the same energy subsidy would be mind blowing.

Other areas of potential efficiency gains that are often discussed include the replacement of cars and trucks with trains, and secondly the localisation of food production. A train can be more efficient in transporting a large number of people to one specific location, but it wouldn’t be as efficient at transporting them all to different locations. Producing food locally may well save on food miles, but it would also require a redirection of labour. It may also require changes to the way the land is used, additional irrigation and even glass houses and heating. Transport and distribution routes would also be affected, perhaps requiring more roads and railways to be built. Whilst a train can be more efficient than a car depending on its load factor, and local food production may reduce food mileage, the reality is that the modern economy is more efficient with cars than without, and it is more efficient importing food than producing it at the point of end consumption. The world has achieved its 3.3% pa economic growth and its 1.3% pa energy efficiency gains by building up different layers of complexity. That complexity is just another name for the energy subsidy. It is what supports the present overall level of economic output. If we removed layers of complexity, then whilst specific industries may become more efficient, the economy as a whole would suffer. The thermodynamic equilibrium would fall. The harsh reality is that a declining energy subsidy will result in falling productivity, reduced efficiency, and most importantly a lower standard of living. Changing the definition of productivity from economic output per capita, to economic output per unit of energy, would have major negative implications for us all.

The elimination of waste is another often cited area that could save fuel. If instead of one person driving himself to work he took a few of his colleagues, then it would save gasoline. It would also mean fewer cars are needed and less steel needs to be produced, and even less repair work on the roads etc. It would therefore mean less economic output. There has been a fuel saving, but so what. The economy has shrunk, and therefore the population’s standard of living has fallen. If the car workers found new jobs in different industries, then their energy consumption would rise again. The elimination of waste in this sense is not actually elimination at all, but a preference of how the energy subsidy is used. The credit crunch is the process of this happening. As the world economy shrank, energy consumption fell. A lot of so-called waste was removed, but with it our standard of living also fell. With the reduced energy subsidy, people were literally thrown on the proverbial scrap heap. Their jobs were effectively classified as a waste of energy. In reality however, redundancy cheques and government transfer payments softened the blow to the individuals, meaning that there was a reduced benefit to those that continued to work. Rather than eliminating waste, the economy simply fell to a lower plain, where some of its productive potential such as its workers, were simply left idle.

A recent energy awareness campaign suggested that recycling a single 1 litre plastic bottle could save enough energy to run a computer for 25 minutes. If I accepted that at face value, I would need to drink 19.2 litres of bottled water every day just to keep one of the computers I use switched on for 8 hours. Given that I have 4 screens and two computers that would increase to lets say 50 litres a day. I also access the web, and run both Reuters and Bloomberg on my computers, all of which will use massive server power to support the service. The saving therefore is minimal. I would also question what the true EROIE - (energy return on invested energy) - is when all costs are taken into account. Given that the laws of thermodynamics state that without an external source, energy always moves from a higher level to a lower level, the EROIE of the plastic bottle will clearly be below that of its initial feedstock oil, and given that the dominant amount of energy will have been consumed in the initial process of making the plastic bottle, the net energy available from recycling will be minimal. Whilst I certainly don’t want to discourage recycling, the laws of physics mean that it will only ever be marginal, and in some cases simply not worthwhile at all. The obvious example is the recycling of our own waste. In the previous chapter I mentioned a process called top-soil mining and how over exploitation has reduced the natural fertility of our soils. If we could return or recycle more of our natural waste to the soils, then this would help to improve fertility, but the energy costs of pumping this waste around the country would be far too high for the additional nutrients and fertility it provides. Instead the nutrients have to be provided by fossil fuel based fertilizers in a more concentrated form. If this energy subsidy ran out, then the land would simply not be able to support the present population either in absolute numbers or in the distribution between the urban and rural mix.

The term “low hanging fruit” to describe the elimination of waste or accelerated efficiency gains rolls off the tongue very easily. The reality however is very different, and this head-in-the-sand attitude is making things much more dangerous. We can change our preferences, and use our energy subsidy to build different goods, but achieving efficiency gains and growing the economy as a whole is dependent on an increased energy subsidy. The fact that fossil fuel production appears to be peaking and is set to fall, means that without some sort of alternative fuel, the world economy will collapse. This is the reality, and unfortunately as I will explain in the next chapter, it is imminent. In 2008 the world found itself in a situation where the energy subsidy was simply insufficient to meet the global demand.

Chapter 10. Blackout

A dress manufacturer once said that stocks were no different from dresses, to be sold at a profit if possible, but marked down and sold regardless before the end of the season.

In recent years, a reduced energy subsidy has become all too apparent. From the peak of oil production in 2005 - (other than a marginal increase at the start of 2008) – to the peak in price in 2008, oil prices jumped from $50 a barrel to almost $150 a barrel. If supply had kept pace with demand, then prices would have remained unchanged. Instead the tripling in prices reflected unfilled demand. Prices rose to squeeze out the marginal consumer. Had prices not risen, it is estimated that there would have been demand for an additional 5m barrels per day. For the world economy as a whole, that loss of 5m barrels per day, and whatever the equivalent on coal and gas was, would have been an opportunity cost. Within the wider economy however, there will have been some major changes in the mix of that consumption, both geographically, within different industries and at the consumer level itself. Trying to understand these may help to give an understanding of what the next weak link in the unfolding energy story may be.

The political and economic collapse that has been Pakistan in recent years is not just down to the Taliban. You can argue about cause and effect, but at the end of the day Pakistan has simply not been able to afford the energy to lift or maintain its standard of living. In 2007 and 2008 power shortages were running at rates of 20% and upwards. Load shedding was 18 hours a day, causing huge losses and forcing industrialists to lay-off workers. In March 2008, the state utility company had switched off all power to Karachi, the biggest and most industrial city due to unpaid bills. By mid 2008, unannounced load shedding meant that 200,000 electric tube-wells across the country could not operate, negatively affecting the agricultural sector, which was rather a problem given that 60% of its exports were cotton. Even the harvesting and processing of its food staple, rice was negatively affected. The rolling blackouts not only hurt the domestic economy, but squeezed exports, which had been the source of payment for importing oil. The energy supply chain collapsed, leaving Pakistan having to turn to Saudi Arabia for debt forgiveness on existing loans and to extend cheap oil to it. We in the West laughed when we heard that the power shortages meant that the Pakistani people couldn't see the President's resignation on television or hear it on the radio, but the reality was that energy shortages were rapidly making Pakistan a failed state, something that no one should want to see, not least because it would mean the U.S. having to commit more military resources to the region.

How many men with picks and shovels does it take to replace one man with a Caterpillar truck? Whilst that sounds like a joke, it is a question that India had to find an answer to. Unfortunately the answer was more men than even India had available. In early 2008 the Wall Street Journal ran an article highlighting that India's construction industry was seeing a shortfall of workers. High oil prices had resulted in it having to idle its big earth moving equipment and replace Caterpillar trucks with men with picks and shovels. It simply did not have enough workers to make up for the shortfall.

India's energy shortfall was not just limited to the construction sector. It was widespread. Throughout 2008 the southern provinces of India, accounting for 1/3rd of the country's textile production were seeing huge shortages. Despite paying a 40% premium to independent generators to try and get what available power there was, the shortfalls were still described as "unprecedented" according to the Southern India Mills Association, resulting in "a huge setback to productivity". Unless companies in the province of Tamil Nadu agreed to take zero power from the grid between 6pm & 10pm from October 9th 2008 onwards, in addition to the 5 to 8 hours a day of unscheduled load shedding, they were threatened with disconnection from the grid. The spinning industry saw power shortages of 40% – 50%. With the country as a whole in deficit, the industry was unable to tap other parts of the national grid. The food industry couldn't run its fridges and freezers, negatively affecting exports. Even the country's prize technology industry, which had been guaranteed power supplies for a certain price, ended up suffering the same power shortfalls as other industries. The Indian Power Secretary warned that the shortages threatened to undermine the country's growth. It had been unable to allocate coal to new power plants that were meant to generate 60 Giga-watts of additional electricity as Coal India Limited had only been able to import 30% of its targeted needs. Second quarter power generation rose by 2.3% vs the government target of 12%.

Even China's strong economic growth was below potential due to energy shortages. Power shortages in Guangdong, China's manufacturing hub reached 10% of installed capacity causing brownouts and the staggering of power consumption. Guangxi, Guizhou and Yunnan had to shut 6.2% of capacity in late 2007 / early 2008. Domestic coal production couldn't keep pace with domestic demand. Competition for imports from Australia resulted in queues of ships as many as 80 long having to wait for loading. Cargoes of LNG destined for the United States and other areas within the Atlantic basin had to be diverted to Asia – (China, India and Japan) - causing large inventory draws. Supplies to U.S. terminals fell as much as 47%, with pressures only eventually being alleviated by the resultant demand destruction that we presently attribute to the credit crunch. In 2008, China's power output growth fell heavily. The collapse however started from January and continued throughout the year, while oil and coal prices continued to rise by 47% and 77% respectively before peaking out in July. Demand was destroyed before prices eventually fell.

There was also the direct effect on food prices and therefore household budgets. Grain prices soared as the U.S., accounting for 44% of world grain exports, diverted land to produce ethanol as a gasoline substitute. Europe similarly introduced government policy to scale in the adoption of bio-diesel. Food prices soared globally as inventories collapsed to their lowest levels since records began in 1960, causing scares over food availability. Even the U.S.A. saw runs on rice and some other staples. As food prices soared, so too did land and fertilizer prices. Some countries such as the Philippines had to abandon their fertilizer subsidies, resulting in less acreage being sown, the effects of which we are likely to see in 2009 and 2010. China had to abandon its ethanol policy and scale right down its industrial use of agriculture, while countries such as South Korea which rely heavily on imports, had to pay up aggressively for food, sending its overall trade data into heavy deficit, and forcing households to change their spending habits. Economists argued that food price inflation was irrelevant, but that was nonsense. The household budget had to change away from discretionary goods to consumer staples. It is debatable whether the U.S. ethanol policy is net energy accretive. Instead it is thought that because the U.S. controls 44% of world grain exports, by diverting a small proportion of this into ethanol production, it was able to lift prices and maintain its oil buying power in the international markets, just as countries such as Brazil have historically dumped coffee crops into the sea to support prices. By doing this the USA changed the “terms of trade” and effectively tried to divert the energy crunch away from its shores and towards the grain importing countries.

According to the United Nations, the world’s hungry grew by 100 million people in 2008 to 1 billion. That is almost one in every six people on the planet. The U.N. attributes the deterioration on the financial meltdown, but look beneath the surface and these 100 million people became hungry because of insufficient fossil fuels. Poorer countries could no longer afford fertilizer to support domestic crop yields, and they were priced out of the international markets by the richer countries. Industrial demand for water also meant that a lot of the farmers in India could make more money selling their water to industry rather than irrigating the land for agricultural production. People rioted over food shortages in over 100 countries in 2008, most notably in Haiti in the Caribbean where the prime minister was overthrown. Even a year later in June 2009, fertilizer prices had still not fallen sufficiently to guarantee the additional food production that is needed.

The shortfall in energy also had more subtle effects. The age of the U.S. car fleet has extended from 6 ½ years in the early 1990’s to 10 years in the middle of 2008. With U.S. vehicle sales now down 52% from their 2000 high, it will have aged further. The 2009 American Society of Civil Engineers latest report-card on the state of U.S. infrastructure has one C+, one C, two C-‘s, one D+, five D’s and five D –‘s. This encompasses aviation, bridges, dams, drinking water, the power grid, navigable waterways, rail & roads, and schools etc. Car manufacturing, construction and civil engineering projects are all extremely energy intensive. The U.S. can delay the replacement or maintenance of this capital equipment, but over time it will become less efficient. Road works will cause traffic jams and a huge number of wasted hours. Bridges will have to be closed diverting traffic huge distances further. Power grids will start to fail causing blackouts and forcing industry to run at lower capacity utilisation rates, or worse still, close altogether as happened in South Africa where the intermittency of power output meant that it was too dangerous to operate the mines. Americans now spend 3.5bn hours a year stuck in traffic jams, which effectively reduces the U.S. workforce by around 1m people. The annual shortfall of expenditure on the U.S. water system is at least 11billion dollars and 131.3 billion dollars annually on roads, bridges and transit. Just to bring the nation’s schools into good repair would cost 322 billion dollars according to the National Education Association. Whilst the accounting for this shortfall is expressed in U.S. dollars, it could equally be expressed in joules of energy or barrels of oil. If the under-investment continues, then either the economy is left to slip to a lower level of output, or more energy would be used to maintain the existing output.

U.S. problems were not limited to the long term underinvestment. In fact it was potentially on the verge of a much more immediate actual physical shortage. As oil prices rose the U.S. ran down its non-strategic reserves, i.e. those in the private sector. By December 2007 inventories had fallen to such a low level that the whole integrity and efficiency of the pipeline network that transports fuel across the country was starting to come into question. Had reserves been allowed to fall much further, the pumping stations would increasingly have become a series of lock gates to steer oil around the pipeline rather than just to keep oil pressure within the network. This would undoubtedly resulted in inefficiencies and shortages in different parts of the country.

Clearly there have been some major winners from the energy shortfalls. High energy prices put the Russian economy back on its feet, and drove strong growth in the Middle East. In fact the Middle East and North African oil demand growth has been stronger than China's, and from a higher base, accounting for 30.5% of the world growth of oil consumption in 2007. Even here however there has been insufficient energy to meet demand. In Russia, more than 5 years of economic expansion above 5% per annum have fuelled big increases in demand for electricity, which was not backed up by investment. A string of blackouts and emergency Kremlin intervention starting in 2006 forced the government to accept the need for a 100 billion dollar investment programme in the sector by 2010, although the credit crunch has sidelined this.

Even the Middle East itself had a greater demand for energy than it could meet. It is thought that due to underinvestment, the member states of the Gulf Cooperation Council – (Saudi Arabia, Bahrain, Kuwait, Oman, Qatar and the United Arab Emirates) – will increasingly need to import natural gas despite its production almost tripling since 1990. In 2008 the world mining giant Rio Tinto had to abandon plans for a 3 billion dollar aluminium smelter in Abu Dhabi due to the power deficits. New developments in the regional construction boom had to wait upwards of a year after construction had been completed to be connected to power and water. Desalination plants, literally a matter of life and death, not only for the growing population, but also for the evolving industry, have yet to be built. Saudi Arabia's gas initiatives have not led to any increase in proven reserves. In fact last year the French oil giant Total abandoned its exploration projects within the country as a lost cause saying it was consistently coming up dry. Saudi Aramco explored the area in the 1970's and had come up with the same conclusion, but reserves are so short worldwide that fields are being re-explored. Qatar cannot supply the sheer magnitude of gas that will be needed to meet the lower Gulf's demand for power generation, aluminium smelting, water desalination, petrochemicals and iron ore industries. The Middle East's petrochemical industry has become very important to world fertilizer production, so this will have major ramifications worldwide.

Latin America suffered heavily from underinvestment. Subsidised energy consumption in Mexico, Venezuela and Bolivia meant the oil and gas industry had insufficient funds for reinvestment. In 2008 gas supply contracts couldn't be honoured. Supplies from Bolivia to both Brazil and Argentina fell heavily short of contract, and onward exports to northern Chile fell to zero. Production at the all important Chilean copper mines was not severely interrupted, but only because the mining companies had to subsidise the electricity companies for using much more expensive diesel as their fuel, helping to add to the rising metals prices.

Despite rising prices, parts of the energy industry itself were starved of the very fuel it needed to maintain output. On the 21st February 2008 shares in Santos (Australia's 3rd largest oil and gas producer) and in Iluka Resources (mining, concentration and separation of mineral sands) fell the most in 20 years and 14 years respectively, as soaring costs forced both companies to cut future development expenditure. Exactly the same situation happened in Venezuela where, despite record oil prices, the oil sector GDP shrank by 5.3% in 2007, extending a decline of 14.7% since Chavez first gained power in 1998. It would be fair to argue that this shortfall is because Chavez's policies starved the domestic oil industry of capital, instead using the money to buy the support of the populace. But that same argument means that there is insufficient energy being produced to both support domestic consumption at its present levels and at the same stage to maintain oil output, let alone grow it. In other words, the opportunity cost of Venezuelan consumption was the loss of future Venezuela oil production. The same story can be said of Mexico where oil revenues account for 40% of government revenues. Even in the Middle East, with prices right at their highs, the oil industry was unable to invest enough money to support production. It was estimated that the Middle East needed an extra 100,000 engineers and 600,000 labourers and construction workers just to maintain production over the next 5 years. Even the private oil companies could not get access to sufficient drill rigs and equipment to meet their demand, so once again final consumption of energy was being borrowed from under investment in future energy supplies.

When you realise just how large the energy deficit was, you start to understand why the economy burnt itself out. It was simply running too fast. I said at the outset that it is estimated that the shortfall of oil against demand was 5m bpd. That is a 6% deficit. The "oil sword" that was waved over the global economy in 1973 was just 5% of Middle Eastern, not world, output. In fact it was not even that large as Iran and Iraq did not reduce output. Clearly something had to give, and as we have discussed sub-prime assets and credit was the weakest link. Quite frankly it is remarkable the economic boom didn't burn itself out far earlier. What it does mean now is that the cap on the upside to the global economy is going to remain low. It also means that a major shift in the make up of growth still needs to happen out of consumption and into energy resources in whatever form that may be, completely the opposite to most government policy at the moment of taxing energy production and subsidising energy consumption.

With oil production from existing wells now thought to be falling at about 4% per annum due to geology, even for the global economy just to sustain the present depressed levels of economic output beyond the short term, investment within the energy industry will have to increase. As yet, higher energy prices have not managed to dramatically lift investment. A seventy percent increase in spending by the oil industry between 2000 and 2005 was essentially absorbed by higher equipment cost. Adjusted for inflation, investment rose by just 5%. With the world's remaining reserves increasingly located in the Middle East and Russia which severely restrict foreign investment, or in high tax countries, the percentage of free cash flow being reinvested by the oil industry in exploration and production is just 40% compared to 80% in the late 1970's & early 1980's. With nowhere to invest, the Western majors are effectively liquidating themselves. BP - (formerly British Petroleum) - for example, has bought back and retired 60% of its shares since 2000, while Exxon has been buying back about 30 billion dollars of shares each year. The under-investment is also in staff, as more than half of all oil field professionals reach retirement age by 2015. According to a 2007 report by the International Energy Agency, the result of the underinvestment will be a shortfall of oil production of 12.5 million barrels per day (or about 15%) by 2015, which would infer that over the next few years the shortfall is going to become increasingly real for most of us.

Chapter 11. Back in the USSR

The Money Game. "A growth stock is like a beautiful woman. The market will give it a premium for its growth (good looks), but as they mature they lose their growth (beauty). For a long time the market will continue to keep them at a premium; the memory of the beauty will be so strong that the gentlemen who were first struck by the beauty cannot see the lines and sags creeping in. As new gentlemen come in though, there are new beauties to greet them, and memory is not enough to keep the matrons popular".

"We will bury you" was the translation of the words used in a famous speech given by the former Soviet leader Nikita Khrushchev to Western ambassadors at a Polish reception in 1956, referring to the relative performance of the economy compared to that of the United States. At the time this seemed a realistic possibility as Soviet economic growth was consistently around 8% - 9% per annum, about 3 times that of the West. In a 1957 Foreign Affairs article Calvin Hoover projected that the Soviet economy might outstrip that of the United States by the early 1970's just as analysts now predict that China will outstrip the United States by 2030. The reality turned out somewhat different. It was the West that buried the Soviet Union. So what went wrong? Why did the Soviet Union collapse? And can this give us any clues about our own future?

The Soviet story was a microcosm of the problem we now face. The fertility rate fell from about 7.5 children per woman in 1900 to 6.5 in 1923. It then collapsed to 2.8 children per woman by 1943, and continued to fall thereafter. At the time this was below the replacement rate. The number of children being born would not be sufficient to replace their parents, however until the parents started to retire and more people left the workforce than entered it, this was a huge boost to the economy. As the number of dependent children fell, so the cost of supporting them also fell. Women were freed up to work, and indeed the Soviet Union led the world in women entering the workforce. Between 1950 and 1968 the female participation rate doubled from 19m workers to over 40m, with women able to work in all industries and in high profile jobs. The combined effect of the falling childhood dependency ratio and the increased workforce meant there was a huge boost to the free, or unallocated, capital. Marrying that up with an increased supply of energy, the economy experienced far superior growth to the United States of America. Khrushchev's threat seemed well founded.

Unfortunately the demographic dividend only lasted for a certain amount of time and then started to reverse. As the parents' generation started to retire, and fewer people entered the workforce than left it, the boost the economy initially had from the childhood dependency ratio falling, started to reverse. With elderly people generally consuming far more than children – (an elderly person for example may have his or her own house whereas a child will normally share a house with at least two other people) – this reversal is quite severe. The excess capital that the Soviet economy was producing over and above final consumption, fell, and with it the productivity and output of the economy. Most of us remember the Soviet Union in its days of decline; huge bread queues, the grey and damp buildings, antiquated machinery, and of course the Soviet car. We forget that at one stage there seemed a very real threat that the Soviet Union would become the dominant world power.

To some extent Soviet isolation and capital controls limited the flight of capital abroad so the decline in the capital:labour ratio was less than we can imagine happening in the West. Within the country however it was a different matter. Capital was allocated according to central control, resulting in excess investment in certain areas and big shortages elsewhere. One of the consequences was that the rise in the dependency ratio wasn't evenly spread. Millions of people were encouraged (if that's the right word) to move from the large farms into the industrial cities, but the result was an ever higher dependency ratio within the rural community, and insufficient people to operate the farm machinery. The rural community was bled dry and agricultural yields collapsed. By the late 1960's however the geographical shortage had become an outright shortage.

"Cradle to grave socialism" meant a modern pension system. Retired workers received between 50% and 100% of their best year of salary depending on strategic importance of their jobs, however with a declining workforce there was no way to support this. Even forcing pensioners back to work achieved very little and by 1990, with 20% of Russians reliant on a pension, all funds were exhausted. It had to default. Hyper inflation took pensions down to just a few dollars a month. The unfortunate consequence was that the life expectancy absolutely collapsed, falling from 65 in 1987 to 57 less than 10 years later. It may sound harsh and impersonal, but early death lowered the dependency ratio until the workforce could once again produce enough for itself, and for the dependents to survive, although it must be said the quality of life was still pretty poor.

Could the Soviet Union not have faired better if it had saved more in advance of this demographic bust? However they are accumulated, savings are nothing more than a claim on the factors of production. If there are no factors of production, the savings are worthless. The Soviet Union clearly failed to invest in sufficient human capital as its fertility rate fell below replacement, and the fact that it was isolated from the majority of the rest of the world meant that it could not pair up any other forms of capital with the growing human population from another part of the world. The Cold War, and in particular the U.S. policies to block communist expansion – (Eisenhower feared country after country falling to Communism in what he described as the Domino theory) - may actually have had a far bigger impact than we now credit, in that the associated wars not only stopped Communist expansion but also the ability for the Soviet Union to deploy its capital with these workforces. Along the same lines, we shouldn't underestimate the importance of the growing networks that China is presently trying to establish with its present surplus of capital, and the potential reverberations and impact that this could have on the Western economies.

The Soviet Union's growth was not just built on demographics. Its aggressive adoption of oil and gas was at least as important. Oil production soared from just over 1/2m bpd in 1945 to a peak of 12.4m bpd 40 years later, making it the most important producer in the world. That equates to an annual growth rate of 8.35%, easily explaining economic growth. The rapid growth of oil production was initially sufficient to cushion the demographic bust that was starting to happen, however the constraints of geology and peak production would soon undermine the oil industry. The 1970's world oil crisis was a god-send, giving the Soviet oil industry a new lease of life. Between 1970 and 1981 Soviet oil production rose from 16% of world production to 21%. It was able to compensate for failing domestic harvests with massive grain imports from the USA, paid for with oil exports; part of the so-called Détente. The oil revenues were essential to hide the true state of the economy, helping to extend the life of the Soviet Union.

For a short time the USSR was able to compensate for declining domestic productivity by selling its high cost oil abroad, however every year from 1974 onwards, oil production fell short of target. Production growth slowed to 6.8% pa from 1971 – 1975. It then slowed further to 4.2% pa from 1976 – 1980, before flat lining for the next 5 years. Rising domestic consumption meant that exports fell, but that was compensated to some extent by high prices and a change in the terms of trade. Then in 1986 when Saudi Arabia lifted oil production and world prices tumbled, the high cost Soviet oil industry literally collapsed. Oil output halved revealing the antiquated economy beneath it. Without the West subsidising the Soviet oil industry, the Soviet economy imploded.

Analysis of the Soviet oil fields also gives clues as to what the rest of the world may now experience. The Volga Ural basin saw production peak in 1976. West Siberia was no better. Fields are exploited in order of size and of cost of production. As the larger fields become exhausted, technology such as water injection - (pumping water in to the oil field to float the oil and keep the field under pressure) - has to be used. This lifts the cost of production and lowers the net energy available from the well. Outwards of the large fields, the size of smaller fields' drops log-normally. The cost of production from a small field is dramatically higher than from a giant field, and because the output is so much smaller, far more fields need to be exploited. The cost goes up and the EROIE (energy return on invested energy) or net energy, goes down. The fields get exhausted leaving a greater reliance on ever smaller, less efficient fields. To maintain oil production, more of the economy's capital and labour had to be directed at the oil industry, leaving less available for other industries. The declining EROIE rate was no different to the rising dependency ratio. Both acted as a massive tax on the rest of the economy, starving it of capital and thereby lowering its productivity. Energy price rises are having exactly the same effect on Western economies today.

Declining energy productivity results in declining or slowing industrial productivity. Détente was successful because it paired the much more efficient western economies with high priced Soviet oil; the West could afford the high priced Soviet oil whereas the Soviet Union itself couldn't. As global oil production slows and prices become more and more expensive, the global market will once again marry up the more efficient energy consuming economies with the available supplies.

Greenspan attributed the collapse in inflation in the West to the entry of former Soviet workers into our workforce. This is undoubtedly one reason for wage disinflation, however as so often seems to be the case with economists and politicians; it is far too simplistic an explanation. The demise of the Soviet Union was due to a collapse of cheap available energy. Where a country sees a fall in the energy consumption per capita as was the case in the Soviet Union, it invariably becomes a failed state. Without the cheap energy, productivity, and therefore wages collapse. If a worker is only able to produce half as many goods as he did the previous year, his wages will halve. Greenspan viewed this as a disinflationary wage force entering the Western economy. It was, but it was also the absolute collapse of the Soviet wage and standard of living that caused it. The break-up of the Soviet Union and then the 1998 default by Russia and its 90% currency devaluation, was just the final stage in the process of abandoning its inefficient industries.

Soviet workers were skilled and educated, so once the political walls came down, Western capital could exploit this now extremely cheap labour. Had the political walls taken longer to come down, Russian education may have failed, making it a much less valuable resource to exploit as per some African countries. The press highlight the vast productivity gains now coming from these eastern bloc countries, but again the reality is that cheap workers are just being matched with western technology. Until eastern wages equate with western wages, it will continue to exert a disinfaltionary force on western wages.

An interesting question to think about is that in the late 1950's and early 1960's people were expecting the Soviet Union to take over from the United States as the leading world economic power. If that had been the case, then Soviet wages would have been higher than U.S. wages. Greenspan's disinflation from the entry of cheap Eastern bloc labour only happened because Soviet industry collapsed, wiping out livelihoods. Western access to Soviet oil was the consequence of high costs of production undermining the rest of the economy; the source of funding for the oil industry. If Soviet workers hadn't seen this complete collapse in wages, if they hadn't effectively been willing to take a huge pay cut and therefore reduce their consumption of goods, what would have happened to our living standards in the West? Where would we have got our energy from? The reality is that global energy consumption per capita initially peaked in 1980, and after a couple of years of falling in the early 1980's, it has been flat until the last 5 or 6 years when it has just got back to its 1980's high before starting to fall again. During this period the Western and Asian economies benefited from expansion of energy consumption per capita, but this was at the expense of collapses in the former Soviet Union and Africa. The West benefited from the misfortune of the USSR.

The more widely known problems that helped bring the Soviet Union to its knees are also very visible in China today. In order to match its industrial growth with agricultural output, the USSR applied the industrial mindset to farming. Agriculture was mechanised. One hundred million acres of marginal land was ploughed into production, needing vast quantities of fertilizers, pesticides and irrigation. Resources were in the wrong parts of the Union so rivers were diverted and canals dug to transport water thousands of kilometres to areas that needed it. Within just a few years soil erosion had started to smash yields. Soils became saline, requiring ever greater amounts of water to support crops. Seas dried up and turned to salt beds, the most famous being the Aral Sea. Fishing industries were destroyed. Dust bowls were created and whole countries literally turned into deserts. It was a disaster. More importantly it was a costly disaster. As food productivity fell, a greater proportion of Soviet resources had to be directed to maintaining food production. In the end the USSR had to turn to America. Through Détente, it imported up to 25% of the U.S. harvest in the early 1970's, paid for with Soviet oil. World food prices soared. As I said earlier, the first oil shock in the 1970's was a god-send, effectively allowing the Soviet Union to feed itself for a few extra years, but at the same stage starving its own industry of oil and therefore investment needed to maintain productivity.

Conventional thinking is that the Soviet Union's demise was down to state control undermining the efficient allocation of capital, and that the economy was stressed even further by Reagan upping the Arms Race. The real misallocation of capital however was structural; under-investment in replacing the human population, in sustainable agricultural production and in finding and exploiting oil efficiently. The rapid Soviet growth was because it consumed its resources very quickly rather than investing sufficiently in replacement. The relatively small size of the USSR and the fact that through the Cold War the West stopped the spread of Soviet Capital (as well as Soviet ideology) beyond its borders meant that it couldn't share the cost of technological advancement and productivity gains; in just the same way that economists believe that trade protectionism would undermine most economies today.

Soviet oil production fell from 12.5 million barrels per day in 1987 to just over 6 million by 1995. With Russian wages collapsing – (the currency remains down about 90% from its pre-1998 level and down about 96% from its 1993 level) – and fresh capital coming in from the West, Russia has managed to get production back towards its highs, however at least 85% of its oil production is coming from fields that have gone beyond peak production. Soviet oil technology was the best in the world. Whilst this postponed declines in production, it meant the cost soared. Some of the biggest fields have to pump nine times as much water as the oil that is eventually recovered. Others rely on underground electrical pumps, meaning vast amounts of electricity are used to lift the oil. West Siberian production has to be pumped vast distances which adds to the energy cost of production. There is no getting away from the fact that Soviet production is reaching a secondary peak, and that the cost of producing the remaining oil will continue to rise. The question is at what stage this becomes too much of a drain on the global economy , and secondly is it really sensible for China, a hugely energy inefficient consumer, to be tying its future energy needs to a hugely inefficient energy producer?

Communism and the centrally planned or command economy, doesn’t work. It removes incentives and allocates capital and resources in an inefficient and wasteful manner. The spread of this ideology is what the West fought so heavily against. Why therefore are we allowing our economies to become increasingly state controlled? Why have we allowed government to become an ever larger part of the economy? Eisenhower’s domino theory was that if allowed to go unchecked, then communism would quickly spread from China to the rest of mainland Asia and then to the West, but the reality seems to have been that by allowing it to peg its currency to the dollar, the West has undermined its own industry and ended up increasingly replacing free markets with government capital and control; its policies have ended up tilting it towards communism in everything but name. America must break itself away from the shackles that this has imposed.

Chapter 11. As the Crow Flies

Playing the stock market is effectively the same as Old Maid. You need to stay in the game as long as possible but must have passed the Old Maid to someone else before the game is over.

The positive trends that drove global growth over recent decades are now turning in on themselves. The growth in the factors of production that allowed the economy to expand is reversing. The demographic pyramid that financed long and comfortable retirements is inverting and the dependency ratio is rising. The energy subsidy has started to fall, and therefore productivity growth, which has centred on broadening the deployment of existing technology rather than expanding the technological advancement, is also falling. And finally the so-called green revolution that has allowed the urbanisation of Asia is becoming barren. Soils are turning to desert and wells are turning dry. The consequence will be a deterioration in output and a falling global standard of living. There are potential solutions, but none of them can solve the problem in the short term, and indeed will add to the interim pain. The question is just how far the global economy will slide before innovation eventually comes to its aid, and what path the breakdown of the economy will follow. Will it be a straight line as the proverbial crow flies, or as I suggest a more staggered decline?

The credit crunch is the second casualty. The first was the rapidly rising food and energy prices as demand initially failed to respond to tighter supplies. Parts of the developing world suffered brown outs as capital was redirected into the energy industry, resulting in shortfalls elsewhere and finally the credit crunch. At the same stage the excess capital thrown off in recent decades as the global dependency ratio collapsed, started to top-out and reverse, negatively impacting the ability to support outstanding debt. In the short term, the recession has been far more severe than the reversal of the factors of production required. A lack of understanding, poor management and economists, and press predicting the end of the world, has resulted in banks running for the exit and credit collapsing more than it needed to. Unemployment has needlessly soared. The third stage therefore has been the return of sanity to the markets as a result of the central banks printing of money. This will be followed by the realisation that for the moment at least, the economy is running significantly below potential and that in the short term there is a huge amount of spare capacity in terms of both labour and energy that can be exploited. The very fact that most commentators have not yet understood the structural reasons behind the credit crunch means that they are incorrectly responding to different signals, making the moves much more extreme than they need to be. More capital will be wasted as governments' re-inflate the same old bubble, addressing the symptoms rather than disease

The factors of production are no longer a constraint to economic output in the short term. The credit crunch has increased the availability of oil and coal above presently depressed consumption rates, and significantly increased the availability of cheap labour, whilst the central banks are now providing adequate liquidity. With no constraints, the global economy should return to growth, driven initially by those countries whose finances remain relatively robust and have benefited most from the fall in food and energy prices, ie China and other parts of Asia. Not only are their balance sheets stronger than in a lot of the West, but so too are their income statements, as measured by their trade surplus.

In the medium term however, perhaps 18 – 24 months down the line, the factors of production will become restrictive once again, and it is this area that I want to focus on. Clearly there is not enough of either of these factors of production to lift global output and growth back to where it was, but there is enough to take it back to somewhat higher levels than at present before energy becomes a constraint once again. Understanding that the credit crunch has just been the weak link in this bigger structural story should give investors a much better idea of what sort of rebound should be expected and how the duration of it may be very small. Investing for a 2 year rally may be very sensible, but investments that require a positive 10 year outlook may not be. Insuring that there is an exit strategy therefore will be extremely important for any longer term investments. For the huge government investment and nationalisation programmes, the only possible exit strategy will be inflation.

Understanding where risk is located is hugely important. Who is the counterparty to a trade? Will a fall in price result in forced selling and risk reduction? Similarly, will shareholders punish underperformance on the way up? The U.S. credit bubble for example was just the opposite side of Asia's export of savings, and yet when U.S. credit blew up, the value of Asia's savings went up rather than down. At the time Asia's main counterparty risk was to the dollar and to the U.S. government. From 2002 to 2007 the net official inflows into the States only financed 47% of its current account deficit, leaving the credit risk increasingly in private sector hands. Mortgage counterparty risk was held by the banks, both directly and indirectly. As the credit crunch bit, this counterparty risk forced the banks to repatriate assets back home to cover domestic shortfalls. When the resource constraint starts to bite again however, counterparty risk may well have changed. By protecting and socialising large parts of the banks' assets, and by the government taking on the roll of borrower of last resort, the weak link is increasingly being transferred to the dollar itself. In the end this is exactly what needs to happen as the imbalance between the United States and Asia needs to unwind. The question is how and when this happens. Clearly it is not in the creditors' best interest to see its assets default, but equally it is not very sensible to keep buying an asset and reinforcing the imbalance.

China has been diversifying a small proportion of its new dollar earnings into natural resources, leaving the private sector to take the risk. It has kept itself pegged to the dollar, but the consequence has been that the two currencies, the dollar and the renminbi, have declined against the world's other main currencies and against commodities. China is therefore compounding the eventual problem by adding to its dollar reserves, but has once again introduced the private sector into this risk. For the moment therefore I would suggest that the weak link is still with the private sector, however given that its balance sheets have already been severely damaged, I would suggest the scale of the private sector risk that builds up will be relatively small before the next part of the credit crunch happens. With the governments and central banks also much more alert to the problems, and with unutilised central bank facilities, the ability to socialise the risk and transmit it back to the dollar should happen much more quickly and seamlessly than in 2008. Nevertheless, for the moment the weak link remains with the private sector. When the second part of the credit crunch happens therefore it is likely that the dollar will initially rebound, but not to the extent it did in the second half of 2008. Similarly the scale of the economic hit, and the demand destruction to fossil fuels will be much less severe. The fall in energy prices will be relatively small and short lived, meaning that Asia's export of savings are swallowed up by the Middle East. It will not have the ability to continue supporting its imbalance with the United States. The dollar will then finally fall allowing the U.S. to restructure, whilst a stronger Chinese currency will reveal the inefficiencies of the Chinese economy.

I have been liberal with my definitions, interchanging Asia and China. It should be noted that in 2007 and 2008 when food and energy prices last soared, and the terms of trade moved against manufacturing countries, China did remain in surplus throughout the period although at a much reduced level. Other Asian countries however like South Korea, India, Hong Kong, the Philippines and Thailand all swung heavily into deficit. Malaysia, South Korea and Singapore all have very large trade deficits relative to the size of their economies in both food and energy, whilst Thailand and India have large deficits in energy, so when the price of these imports soar, their economies simply cannot finance them. Some of these countries do have a cushion in terms of foreign exchange reserves, but of course if they sell them then the dollar will fall and so too therefore, U.S. demand for their exports, resulting in an even bigger deficit; the so-called prisoners dilemma. This will not all happen in one go. Certain countries are more exposed than others, and of course as one falls then their demand for resources will fall. As they withdraw their credit from the US, the austerity that it imposes will also act to weaken the demand as per the existing credit crunch, pushing prices lower. In other words there is a natural balance in the system. As long as the energy supply curve continues to move to the left however, the only way this can be balanced is by demand destruction, so one country, or one industry will fall after another. It is also worth remembering that as the world economy deteriorates, there will be less capital available to invest in energy extraction, and so the leftward shift in the supply curve will accelerate. Again that has been amply demonstrated in recent months as the oil industry cut back investment in new wells by over USD150bn as the credit crunch hit the world economy.

The impact on the U.S. consumer would be imposed austerity, but the US household has already taken a large part of the pain. It has already cut back expenditure aggressively and therefore is less exposed to the export of Asia's savings. In the first part of the credit crunch, the risk was internalised to the U.S. to a large extent. Asia only had exposure to the dollar and to Treasuries whereas domestic banks had the household counterparty risk. Now that the Federal Reserve and government have nationalised some of the problem debt, the counterparty risk has changed to the dollar itself. When the default eventually happens therefore, U.S. industry should benefit from the weaker currency. Imports will be priced out of the market and prices will rise. The hit to U.S. living standards will be achieved through inflation, but the increased competitiveness will limit the loss of employment.

In recent years the U.S. banking system has failed abysmally to allocate money in a productive manner. Rather than allocating capital to sustainable growth, it has focussed on asset price appreciation; it has constructed a ponzi scheme. Companies have bought back shares rather than invest in research and development, whilst banks, accountants and regulators have bent and changed rules to allow households to continue to spend over and beyond their income. Why therefore should we expect them to restructure now? The answer is that it has been China's manipulated exchange rate that has forced the U.S. to consume capital rather than invest it. The credit crunch and the failure of the banks is a symptom of the problem rather than the problem itself, and so once the currency peg is broken then the US economy should be able to rapidly restructure. Until the default happens however, the growth that we see will just be another form of unsustainable asset bubble. Paul Volcker's planned regulations to clean up the financial system have been put on the back-burner, whilst accounting regulators have backtracked and allowed controversial methods to be used to value certain assets. Rather than investing in productivity gains and improving the sustainability and quality of earnings, regulators have opted for the easy option and seem to once again be encouraging the manipulation of asset prices to give the impression of earnings and economic strength. Nevertheless it is an asset bubble where the counterparty risk is increasingly the government and the dollar rather than the household. It is still worth trading given the present overhang of energy and labour in the market, but in the longer term, accounting gimmickry will not get the U.S. access to the world's declining energy output and therefore it is an unsustainable bubble and must be viewed in that context.

As energy prices rise, the world's surplus savings will increasingly shift to the oil exporting nations. Their growth is likely to rise aggressively, but nevertheless they are likely to generate significant savings that will need to be exported. Russia has a limited interest in keeping its savings in the dollar. It has gradually reduced the weighting of its dollar reserves since 2002 to just 41% and has recently suggested that it will remove all exposure over the next 2 – 3 years, stating that it will not roll over its maturing Treasury bonds. This means that private capital will have to step in and offset this. The Middle East will also only hold its dollars off-shore to avoid the possibility that the U.S. freezes its assets, instead holding them on deposit with U.K. banks, which then have to deploy them on their own books. As long as the U.K. banks hold them in Treasury notes they should be able to take a small turn without taking any undue risk, supporting sterling in the short term. If instead the UK banks deploy these savings more aggressively to make a better return, then the credit risk will once again shift to their balance sheets as it did in 2007/2008. Any rebound in sterling will only be temporary. At the moment the U.K. is benefiting from the rebound in its U.S. mortgage assets etc, but given that we know that the U.S. has to eventually default, this will bring the pound down again unless it can remove its dollar exposure before this happens. Longer term however the U.K. faces far larger structural problems. The new lease of life that the U.K. was given in the 1980's was only partly due to Margaret Thatcher's reforms. The real driver was the discovery and exploitation of North Sea oil which is now in terminal decline. The second of its major industries that is likely to be scaled down dramatically is international banking. Not only are international capital flows set to slow and reverse with the falling energy subsidy, but with a competing renminbi bloc, the UK's control over the capital flows will also fall. On the other hand it seems likely that Hong Kong will become the financial centre for administering trade and capital flows within the renminbi bloc, offering some short-term opportunities for investments in the banks servicing that bloc.

If the story I describe is correct, then surely governments will take decisions to counter, or soften the blow. Whilst I am personally as critical of George W Bush as the next person, if I judge the former U.S. President by his actions, then I must conclude that at least he understood the issues that the world now faces. I would question the policies that he implemented, particularly with regards to the invasion of Iraq, but whether it was increasing the Strategic Petroleum Reserves, putting in place the Ethanol policy, opening up the Outer Continental Shelf, or policies that got around the Clean Air Act and allowed traditional coal power stations to continue operating, the fact is that his policies could be interpreted as addressing the energy problem. People may say that his blundering ended up sending food and energy prices higher, and therefore the policies didn't work. I would argue that any policy that tries to make an aggressive expansion into alternative energy or to secure existing sources of supply, would have a similar effect, causing fuel prices to soar as they would be diverting a huge amount of existing fossil fuel use to building these alternative energy systems. President Bush's policies however were aimed at securing future energy resources via force; either taking them from Iraq or by linking grain prices, where the U.S. controls the world's surplus, to oil prices. Other countries are trying to secure the remaining resources via different routes, which again may offer different directions of how the next part of the energy and credit crunch plays out.

For the moment the surplus savings has shifted back to Asia. To a large extent that is because the terms of trade have changed; the price of its imports such as food and energy have collapsed more than the price of its exports. The following table highlights for example, that South Korea's economy has benefited by 4.27% from 2008 to the first quarter of 2009 simply due to oil prices falling by USD55bbl over that period. Unfortunately accurate data is not readily available to repeat the exercise with grains, however given that the land and water availability per capita is very low across Asia due to the high population density; we know that the food situation will increasingly reinforce this picture.

World Bank.
Terms of trade improvement for oil between early 2009 and average of 2008 expressed as a percentage of GDP

Iran	-26.78	Albania	0.86
Saudi Arabia	-25.36	Netherlands	0.96
Algeria	-22.04	Italy	1.02
Angola	-21.42	Spain	1.03
Kuwait	-21.36	Greece	1.08
Kazakhstan	-16.89	Hong Kong	1.16
Bahrain	-11.13	Ireland	1.18
Venezuela	-10.07	Poland	1.18
Norway	-9.34	Belgium	1.26
Russia	-6.93	Switzerland	1.28
Argentina	-4.79	Czech Repub	1.45
Australia	-3.38	Belarus	1.48
South Africa	-1.95	Japan	1.54
Mexico	-1.12	Bangladesh	1.68
Canada	-1.06	Croatia	1.70
Brazil	-0.61	Bulgaria	1.83
Denmark	-0.39	China	1.97
Indonesia	-0.14	Israel	2.27
UK	0.03	Pakistan	2.37
Singapore	0.11	Antigua & Bar	2.63
Iceland	0.32	Philippines	2.78
Malaysia	0.42	India	2.85
United States	0.52	Taiwan	2.89
Sweden	0.66	Dominican Re	2.92
Austria	0.67	Thailand	3.07
Germany	0.78	South Korea	4.27
France	0.84	Cambodia	4.96
		Lebanon	5.28

Mexico, the UK, China and India will become increasingly dependent on imports in the near term, whilst Brazil will be more self-sufficient.
***(Add in coal and perhaps food and the movement will even larger*)**.

To maintain growth rates, China has stated that it will continue to rely on a policy of strong domestic growth and strong export growth. The State Administration of Foreign Exchange has said that it will regulate the renminbi by balancing the capital flows. In other words it will continue for the moment to keep its currency pegged to the dollar. At the same stage however, by transacting its trade with Hong Kong, Macao, the South East Asian nations, Russia and Brazil in the Chinese renminbi, it is reducing the importance of the dollar to world trade. At the moment the scale is negligible, but it is likely to grow quickly, which will encourage broader acceptance of the currency. It has also offered large Renminbi swap lines to parts of Latin America and several of the former members of the Soviet

Union, and signed up several long term oil and gas deals in its currency. With China's economy booming, and its exports taking a greater and greater slice of world trade, it seems only logical that this trade will gradually migrate away from the dollar and towards the renminbi. China's huge dollar reserves also add to the legitimacy of the currency. It was able to offer cheap dollar financing and loans to various countries around the world in recent months that were unable to access the dollar in the international markets; effectively acting as a lender of last resort in the U.S. dollar to these countries. Whilst this is all small scale, the greater the acceptance of China's currency in the world markets, and the greater amount of world trade that is transacted in it, the greater will be China's ability to access the world's energy resources. As we know from the Triffin Dilemma however, this only works if China runs a trade deficit. Exactly 60 years after the U.S. Marshall Plan gave dollar loans to Europe and Japan to help establish the dollar bloc, China appears to be following similar policies to build a competing currency bloc. If we imagine in 18 months time the food and energy markets are tightening again, then Asia's trade surplus will collapse, and it will have to start selling its dollar reserves. If in the meantime China has managed to find enough countries to trade in the renminbi, then it will be able to simply print money to finance its deficit just as the U.S. does today. It will effectively be able to give paper money or IOU's to the Middle East and Russia in exchange for their oil.

China is playing its cards very well. It gives the impression of strength, but dig a little deeper and the inference of what it is doing would appear to confirm the longer term food, energy and demographic problems that the world and China in particular faces. Its trade surplus remains extremely high, but rather than simply buying U.S. Treasury bonds and indirectly subsidising the U.S. consumer it is gradually diversifying away from the dollar into acquiring future supplies of energy and other raw materials. At the same stage China has very gently been undermining the dollar by sowing the seeds of doubt in people's minds about the very future of the dollar standard. It has been increasing the rhetoric about how unfair the system is, whilst at the same stage being careful not to actually knock the currency too hard and be seen as the aggressor. More recently it has been putting in place the ground work for a Renminbi standard, and suggesting that the dollar be replaced as the world currency, perhaps with one based on Special drawing Rights.

As I suggested in the previous chapter, one of the reasons that the Soviet Union failed was that it was a relatively small isolated bloc. Through the Cold War the U.S. had stopped its expansion, which limited its access to wider technology, resources and therefore limited its energy subsidy. The U.S. effectively stopped the Soviet bloc gaining critical mass, and just like any network – (telecom, electricity, computer etc) - it is the size and take-up of that network that matters. If you think along those lines, and think that there are not enough available resources for the world's two largest energy consumers to continue to grow, then it is in the interests of both countries to sign up as many other countries to their network as possible, even if these are energy importers. The network not only brings size, but it also brings efficiency, and therefore competitive advantage to buy the depleting energy resources.

As well as transacting regional trade in the renminbi – (note the renminbi and the yuan are interchangeable in just the same way as pound and sterling are both used to describe the U.K. currency. One is the measurement of the other) - and establishing swap lines with numerous countries that can only be settled in Chinese goods, China is allowing foreign listings of shares and bonds in Shanghai, and actively pursuing the expansion of trade around the world, particularly across Asia inclusive of Japan, and all of the resource regions, Latin America, Africa, the Middle East and Eurasia. On the 28th April 2009 China's State Information Centre said that "substantive efforts should be made to step up the process of China's renminbi as an international currency for oil trading". China now consumes 9% of world oil production and more than 40% of world coal production. As domestic demand starts to fall and its energy needs rise, it cannot afford the foreign exchange risk associated with paying for these imports in U.S. dollars. "China should try to step up and expand yuan denominated trade with neighbouring countries to expedite the process of the yuan toward becoming a regional reserve and settlement currency. This is the first and inalienable step to develop yuan into an international currency". It said "the creation of a diversified oil pricing system and transaction currency will be irreversible in the future".

The very fact that China is setting up a renminbi standard would imply that it believes that it is going to become a debtor nation, at least with the participating countries. Rather than running a trade surplus, China is setting itself up to run a deficit. In the U.S. that deficit is seen as the cost of being the global policeman, but in China's case what is the quid-pro-quo? One global policeman provides stability, but two would pose a threat. How would the world cope with its largest creditor suddenly swinging into deficit? China's foreign exchange reserves have been questioned over the years, but their sheer size gives China the legitimacy in people's eyes to set up its own currency bloc. If China is going to be swinging to a debtor nation over the medium term, then what better way of convincing people to start buying its paper than to have a huge pile of strategic reserves. And perhaps 18 months down the line, when China's economy may be starting to struggle due to the resource constraint, then it can sell some of its reserves undermining the dollar and supporting the domestic economy. It would give the impression of domestic strength allowing it to attract capital flows, but realistically it would be indicative of problems. A growing and strengthening renminbi bloc would help cushion China's exposure to the defaulting dollar.

We know from both the energy, demographic and food situation that China will increasingly have to rely on imports to maintain its standard of living. As food and energy prices soared in late 2007 / early 2008, China's trade surplus fell heavily although it did remain in surplus. Several Asian countries weren't so lucky, seeing big swings into deficit purely because of the scale of food and energy that they needed to import. China's own forecasts for domestic coal and oil production infer that imports will have to soar aggressively. Worse still, the cost of Chinese coal production is starting to rise as mines become depleted and deeper shafts have to be dug. Increasingly the cost of Chinese economic growth will be determined by international coal prices rather than the price of domestic coal. This differential had given Chinese industry an effective subsidy of up to USD250bn (2.5bn tons @ USD100 a ton price differential) a year by some estimates in 2007/2008, more-or-less accounting for its entire trade surplus. China uses as much energy as does the United States, yet its economy is still only about 20% of the size. Its low wage, low productivity business model has out-competed the much higher wage models of the West, but as its energy prices start to be set by the international market, it will not be able to compete. China's growth has been driven by factor mobilisation; deploying vast quantities of cheap labour and cheap energy. It has not been about efficiency or productivity. As both of these factor inputs start to reverse and become more expensive, so China's economy will rapidly be priced out of the world market, with obvious implications.

China is presently marking the twentieth anniversary of the Tiananmen Square crisis where tanks were turned against its own people. In 1989 the Chinese economy was booming and foreign capital was piling in, but under investment in energy production, poor harvests and attempts to remove price controls resulted in inflation of more than 50%. There was also food hoarding. The situation was rescued in the end by the economy. A record harvest that year and then an even bigger harvest in 1990, together with tighter controls over credit growth, brought inflation back down to 3% by 1990 and consigned the uprising to history. In the 1930's as the global economy went into depression, China's boom turned to bust. Civil strife turned into hyperinflation, and the eventual rise of communism. The reality is that the Chinese economy is one poor harvest, or one small drop in energy subsidy away from collapse, and so will do everything it can to stop this eventuality.

China's undermining of the dollar and its establishment of the renminbi bloc, as well as its diversification of foreign exchange reserves into energy security, all makes perfect sense when looked at from this strategic point of view. Its vast foreign exchange reserves will act to cushion its economy in the short to medium term. When resources become constrained again therefore, China is likely to once again point the finger at the United States and try and attract international capital into China. At that stage I would expect it to start selling down its foreign exchange reserves to support the domestic economy, increasing the pressure on America. Rather than the two economies slugging it out for the resources directly, the battles are likely to be fought elsewhere just as the Cold War was fought indirectly in countries such as Afghanistan, Korea and Vietnam rather than directly between the two protagonists. I am not necessarily talking about military conflict, but rather economic conflict. China for example could determine to some extent how and when the U.S. default happens. By taking payment gradually in grains, the default would happen through higher food prices that would squeeze certain other economies more rapidly than China's. Its policy of buying up international energy companies, and offering lines of credit in exchange for long term contracts that has lifted oil prices aggressively from its lows could equally be interpreted as directing which economy is priced out of the market, and therefore suffers from the US default.

Whilst China's USD2.13trn (June 2009) of foreign exchange reserves does give it the upper hand in the short term, the U.S. has already started to rebalance its economy, with its non oil trade deficit falling from USD43.25bn a month at its worst to USD15.6bn on average in the first 4 months of 2009. By socialising a lot of the debt, the U.S. has also transferred a lot of the risk back to the dollar and China, so the impact on the economy is likely to be less severe than in 2008/2009. Nevertheless the weak link will still be the U.S. economy when resource constraint bites once again and China has to start selling down its reserves. This will however mark the end of the Chinese boom. Once it has sold down its foreign reserves, and once it has been realised that China is a major importer of food and energy, but does not have the productivity to give the same return on those resources as does the West, then I am afraid its days will be numbered. At that stage I would think China will rapidly collapse as there is no way that its energy needs could possibly be met by imports. The U.S. on the other hand will go through another recession in a couple of years time, but hopefully its superior energy efficiency will end up returning the U.S. to a trade surplus, sucking capital back into the States. Politicians are obviously the wild card, but history has told us that eventually, after enough pain, the electorate will vote through the medicine that it needs.

Britain now faces a situation where its oil and gas reserves are rapidly running out, its international banking industry is in severe decline, and government policy is doing its best to alienate capital flows. With an increasing energy deficit, Britain faces a stark choice; either to become a low wage economy like Eastern Europe such that it might be used as an outpost for cheap labour intensive manufacturing, or to invest in technological advancement and productivity gains, however that would require pools of expertise and scientific knowledge that Britain's tax structure does not encourage. Unfortunately as a nation, Britain has invested almost nothing in alternative energy and so is at a significant disadvantage to the rest of Western Europe. It has also consistently underinvested in transport infrastructure so its ability to deploy labour effectively in different parts of the country is severely hampered. And finally the government's commitment to the vast number of civil servants and other non-jobs that are nothing more than a huge tax on economic production means that Britain will never have the capital to invest in productivity gains. The present government clearly doesn't have any understanding of the economy, and is implementing policies that seem almost certain to push the country closer to the scrap heap. Unfortunately British society is probably going to have to go through the same kind of pain as the 1970's - (the three-day week, the blackouts, strikes, the winter of discontent, and mass rioting) - just to get some kind of leadership, both at a political level and at a company level. That said, these very problems make it a geared play on the present recovery.

Northern Europe on the other hand should be relatively well placed. Europe's trade position is balanced. It is not reliant on capital inflows to support its economy. It is far better positioned for the energy crisis than any other major economy, and continues to put more emphasis on alternative energy than anywhere else. It is certainly not immune from rising fossil fuel prices, but with 6 of its economies getting anywhere from 37% (Switzerland) to 72% (Iceland) of their primary energy from non fossil fuel sources, the impact on its economy will be relatively less severe than in the States or Asia. Europe has not only invested heavily in alternative energies, but it has also invested very heavily in capital equipment such that it is second only to Japan in terms of energy efficiency. Theoretically speaking, it would be far more sensible for Russia or the Middle East to sell their oil to Europe than to Asia for the simple reason that Europe could produce far more goods with it, and therefore support a higher combined standard of living. Europe's higher wages and higher standard of living than China, also means that it has much greater flexibility to realign its end consumption mix, to pay for the higher cost of the oil. Its higher standard of living could be cut into without affecting its ability to live beyond subsistence, so whilst it may cause a lot of hardship it won't cause the kind of revolution that is likely in China. As it presently stands however, China is the one signing up long term energy contracts with places like Russia. Whilst this makes perfect sense to Russia now that energy prices are low and its finances look in a mess, the reality of tying itself to one of the most energy inefficient consuming nations means that as the energy market starts to tighten once again, the logic of these contracts will come into question. Pressures within Russian society are likely to result in the contracts being broken; economics will eventually overcome politics as Russia should know all too well from the collapse and break-up of the USSR, and the 1998 Russian debt default. Once again therefore you have a situation where China is playing its cards very well in the short term, but the longer term favours Europe.

Food production is another critical area of stress that is likely to decide who gets access to the world's energy resources. Global food production has only managed to meet population needs with the help of vast quantities of fertilizer and irrigation, the so-called Green Revolution; however the division of that subsidy is heavily skewed towards Asia. The United States and Latin America have much better natural productivity of the land, and have invested heavily in their soils over the last 20 years or so through no-till farming methods. Europe has some of the richest soils in the world because of glacial action, but it is the United States and Latin America that have the ability to export vast quantities of grains to meet some of the world's needs. With mineral resources and the giant new Brazilian oil field, Latin America looks too tempting for China to resist. Capital will pour into the region and into Brazil in particular. Not only will it benefit from the up-cycle, but should also be an area of relative calm into the corrections because of the long-term importance of its output to other economies around the world. Of the so-called BRICs, Brazil is the only country with the necessary mix of factors of production to support analysts' long term growth targets. I would also see Brazil as a shrewd player. It will open itself up to benefit from China's present growth, but it will not tie itself exclusively to China. It knows that in the longer term its prospects are probably with the United States, but it will position itself to benefit either way. Other parts of the continent such as Venezuela and Argentina are much more politically challenging, and thus whilst they do have some resources that the world will need, investments are likely to be much more volatile and therefore subject to shorter term timings.

When things are looked at from a structural point of view, there is a whole new layer of understanding. Given the importance of the Middle East to the future of the global economy, the Iranian nuclear policy makes perfect sense. Iran says it needs to develop nuclear energy. The U.S. says that Iran is developing nuclear weapons, and must be stopped. The truth is that Iran will need alternative energy just as the rest of the world, but it is also going to need nuclear weapons to give itself a level of security. Whether decided politically, economically, or militarily, the Middle East is going to be the prize. Either the countries will have to come under the military umbrella of one of the competing powers, or they will have to build a sufficient deterrent to be too much of a threat. The U.S. is unlikely therefore to allow Iran to build nuclear weapons as that could become a major risk to any U.S. energy policy within the region. The only enticement that the U.S. could possibly give in my opinion to stop the development, would be for the U.S. to actually offer its own military umbrella as it clearly does to Saudi Arabia, and presumably now offers to Iraq. From an Iranian perspective however, accepting either umbrella would limit it to selling its oil to that one country or bloc when resources become constrained; if it had its own nuclear threat then it would be able to sell to whichever economy was willing to pay the higher price. The Middle East also needs to import grains, which the U.S. is in a far better position to provide than is China, however a Chinese bloc may be able to meet its food needs.

In the short term the region can benefit from capital inflows from China, and there is no reason why it can't sign up to its free trade area or even eventually transact some of its trade in the renminbi, but at some stage it will have to make a decision on which side its bread is buttered. Even then the decision may be imposed upon it by military means. Could we be saying in a few years time that the cost of the Iraq war was actually very cheap as it resulted in Iraq's oil flowing to the States? I have grouped the region together as just one player, but of course that is not the case and different allegiances mean major divisions within the region. Whilst the Middle East will be vital in determining the direction of the competing parts of the world economy, it is clearly going to be far too political to voice any sensible opinions other than to say that the region will be increasingly volatile.

The Cold War I have described will be played out via partnerships and networks. Japan may be a vital link in that network, bringing its economy in out of the cold. From the 1950's through the 1980's, Japan achieved significantly better economic growth than the United States. Even after 10 years of stagnation, its growth rate for the second half of the 20th century was more than double that of the United States. It was going to take over the world, and quite frankly the U.S. didn't like the economic threat that it was posing. Japan's growth was driven by productivity advancement that far exceeded anything in the West. The government targeted specific industries with credit growth and at the same stage protected the domestic market from imports. Consequently it ran a massive current account surplus which prompted repeated U.S. intervention in the currency markets. Eventually in 1986 Japan had to agree to the Structural Impediments Initiative which required the restructuring and redirection of the Japanese economy to rely increasingly on domestic demand for growth rather than exports to the U.S. With high wages, domestic demand was already very strong. Policies were put in place to try and lift demand further but there is a limit to just how many cars etc people wanted.

Under pressure from the West, Japan abandoned the policies of window guidance that had served it so well. Rather than invest in the domestic economy, companies invested directly in their export markets. Toyota built huge car plants in North America, whilst none were built in Japan for 17 years. With the Japanese economy increasingly having to rely on profits from overseas sales rather than revenues from creating the product at home and then exporting it, economic growth slowed. Capital spending increasingly came from the government trying to offset the slowdown from industry, but being non productive spending it resulted in very high government debt levels and a big collapse in the household savings rate. Domestic industry faced a second problem. With energy prices collapsing from 1986 until recently, its high wage high productivity business model couldn't compete with the low wage economies of East Asia and China. Wages gradually adjusted downwards, which combined with the higher energy prices of recent years, drove Japan's longest period of uninterrupted growth on record. Toyota also started to invest back at home as the high cost of production elsewhere could no longer be justified. Assuming that Japan has finally abandoned its Structural Impediments Initiative, and that economics will start to drive investment once again, then Japan could be a very interesting play. The fact that its demographic pyramid is very poor means that it needs to invest aggressively in productivity gains. Rather than sending capital abroad as it has been for many years, if Japan is to avoid a collapse in its standard of living, it has no choice but to maintain or lift its domestic capital:labour ratio.

Having a strong Japan in your currency bloc, working with you rather than against you, would be extremely important. Its strength is in manufacturing efficiency and technology, but its weakness is food and energy, which would seem to better complement the US economy than China's. If the Japanese government got its act together, then it could build out a dominant roll in the world production of alternative energy technology just as it historically did in the car and electronics industry. Not only is it one of the world leaders in nuclear fission and solar technology, but its extremely fuel efficient industrial economy should be able to deliver the best standard of living possible for the currency bloc it is in. From the position of a solid domestic base, the Japanese car industry took over the world. There is no reason why Japan cannot do the same again with alternative energy systems.

Whilst the United States was scared of losing its leadership to Japan in the 1980's, the reality is that a partnership with Japan is now going to be much more in its interests than a challenge from China. If the United States is willing to allow itself to become a market for Japanese exports once again, then Japanese industry can start to invest in domestic productivity and efficiency gains, meeting its own need of lifting the capital:labour ratio and therefore offsetting its own demographic problem. China has recently been trying to court Japan. It realises that the Renminbi bloc will not be able to challenge for the world's resources without the support of some of the other major global economies, but the logic of such a partnership simply does not stack up for Japan. Bad land management and over exploitation from its huge population, means that the natural resources Japan invaded China for in 1937, are no longer there. The recent overtures by the United States to enhance its protective nuclear umbrella over Japan, suggest that it recognises the strategic importance of this relationship. Indeed you could argue that North Korea's sabre rattling has played into the United States hands, helping reinforce the alliance with Japan.

South Korea is to some extent in a similar position, with both China and the United States falling over themselves to ensure adequate lines of financing, but I do not see it in quite such a pivotal role as Japan. As the table above highlighted, its economy is one of the most adversely affected by a rise in energy prices, and would similarly be hit by rising food prices. Its international trade fell heavily into deficit for example in 2008 when food and energy prices rose, and for an economy that competes across most industries with Japan, it uses about 3 times as much energy per unit of GDP. Supporting South Korea would therefore start to become quite expensive once energy prices start to rise.

South Korea itself subsidises North Korea, providing it with 10% of all its food needs and 2/3rds of its fertilizer needs, so any support from the West is indirect support to the North. The cost of maintaining peace is only going to get bigger as North Korea's economy continues to collapse. During the Cold War, the North Korean economy only survived thanks to Soviet subsidies. In the few years immediately after Moscow discontinued aid in 1990, industrial output fell by 50%. The average monthly salary is only sufficient to buy just 4 kg of rice, making private economic activity the only way to survive. In late 2007 a report prepared for the budget committee of the South Korean National Assembly estimated that the expense of unification would be between 800 billion dollars and 1.3 trillion dollars just to bring North Korea's average income to half the level of the South's. It is thought that a full German style reunification would be a mortal blow to South Korea as the income differential is far larger than it was between East and West Germany. Even putting to one side these potential costs, South Korea's demographic ageing is one of the worst worldwide, so whilst the South Korean economy is important for both the renminbi and dollar blocs in the short term, in the longer term it seems likely to become very expensive to support. Given the problems it will face, the area could actually become a destabilising force.

India throws up some conflicting signals. On the face of it India is in a real mess. It is living beyond sustainable food production, which is going to be further compromised by its expanding demographic. Its agriculture is heavily reliant on pumping water for irrigation, which has taken it to the verge of being the 4th largest energy consumer worldwide. It has continual power deficits, is having to open previously abandoned coal mines to try and keep up domestic production, and is expected to increase its coal imports by 150% over the next 3 years alone. It sits in the middle of the world's energy resources, sucking in energy imports from all over the Indian Ocean. Its oil imports come from the Persian Gulf, with coal coming from countries such as Mozambique, South Africa, Indonesia and Australia, and LNG from Qatar, Malaysia and Indonesia. Its ability to afford this is however very limited. It already runs a sizeable trade deficit, and very poor infrastructure - (ports, transport and power) - has left it with very low productivity, such that when the availability of energy starts to tighten again, it is likely to be one of the first losers as was the case in 2007/2008. On the face of it therefore India seems likely to be written off as somewhat of a basket case, however its very location and size means that the United States may be able to use India as a counterweight to China's expansion, limiting its resource grab. The United States reversal of its nuclear non-proliferation policy with India is an example of the two countries may work together. More than half of the world's container traffic and more than 70% of traffic in petroleum products passes through the Indian Ocean, so control over the region is vital to world security.

Beyond the major power game, there are a few countries which offer little for either side. Mexico for example will soon become a net energy importer rather than exporter, dramatically affecting the country's finances as the government relies on oil taxation for 40% of its revenue. It already imports its grains from the United States, and it has a widening structural water shortage. Mexico relies heavily on transfer payments from Mexicans living and working in the United States which will undoubtedly fall as the U.S. has to economise. From an economic perspective, the outlook is bleak and according to a 2009 U.S. Joint Operations Command report, Mexico (and Pakistan) is now in danger of sudden collapse. That said it may be better for the US to have access to cheap local labour, particularly given the increased security cost of controlling the border if the economy were to fail.

The world's policy on productivity growth has changed in recent years from one based on technological advancement to one based on broadening the use of existing technology across a much wider workforce. Resource constraint means that this globalisation must reverse. There is simply not enough fossil fuels for us all to have the standard of living that we would wish. The decline in the world economy is not going to be evenly spread. Some countries are going to suffer far more aggressively than others, and it is this that world politicians should be positioning for. Given that China's economy already consumes as much energy as the significantly larger U.S. economy, it makes no economic sense for the vast majority of countries that China wins the battle for the resources as it would lower world living standards for far more people than if the U.S. won. Nevertheless for the moment I would suggest that the pendulum will move one step further against the West, imposing further economic hardship, before finally coming back and aiming squarely at Asia.

The United States has a far higher standard of living than does China. Like Europe, it can cut non-vital consumption far more deeply before it causes real hardship, and therefore it can afford a much higher oil price. This austerity or adjustment process still has further to go and is why the U.S. and in particular the dollar is likely to be the weak link when resources start to tighten once again. Once the US is forced to make the readjustment and start running a trade surplus, it will gradually suck dollars out of the system, leaving international trade with a shrinking monetary base and reduced credit with which to facilitate trade. The US adjustment would impose a credit crunch on international trade, severely hurting the Asian countries that are most exposed to industrial exports.

The backbone of the United States wealth is the productivity of its natural resources - (food, water, transport and security) - which is dramatically higher and far more sustainable than for China. This has meant that a much higher percentage of its workforce has been freed to produce goods beyond the necessities. China on the other hand has only been able to free up its workforce since the land reforms of the late 1970's and early 1980's. Even now the rural and mining workforce still accounts for the dominant part of the population, and over exploitation of these natural resources means that their productivity is falling, effectively taxing people back to the countryside. Together with the demographic problem, this will reduce China's supply of industrial labour.

U.S. food productivity is vital to other parts of the world, accounting for nearly half of world grain exports. As the supply of fossil fuels become tighter and the green revolution starts to reverse, food prices will soar as we saw in 2007/2008. The terms of trade will move in favour of food production and away from manufactured goods. To a greater or lesser extent, the terms of trade between grains and energy will be balanced as we saw in the 1970's when the Soviet Union and the United States simply bartered food for oil and the two moved in tandem.

On a structural basis, it is far more important from the world's perspective outside of China, for the U.S. to win the rights to the remaining energy resources than it is for China. That said, China is giving the appearance of strength and is trying to buy a better hand of cards via the network it is trying to create. Unfortunately it is unlikely to be able to get a winning hand in the allotted time. Nevertheless it still has a massive monthly trade surplus and vast foreign exchange reserves. Whatever the longer term result, investors should position themselves to benefit from how and where these funds are used, like how China will use the funds to access more of the natural food and natural resources from the Greater Mekong Sub region. Clearly if a country is important to China's ambitions, then it will also be important to the U.S. like the South Korean example mentioned above. China has also shown itself willing to deal with leaders that the West would not chose to deal with, for example giving billions of dollars of military assistance to the Burmese junta in return for building a pipeline and roads across the country from the Bay of Bengal into the southern Chinese province of Yunnan**.**

Productivity should win out in the end, but politics will mean that the path is not smooth, and not necessarily the obvious one. Investing at a sector level however should benefit from the knowledge that the supply curve of energy is going to move steadily to the left. The fact that the demand curve will be volatile due to politics, the required payback period for investments, poor management and lack of understanding etc, should mean that there are great opportunities to trade in and out of the marginal oil producers. Exactly the same opportunities will be available in credit markets as the volatility between the energy demand and supply curves creates large contractions and expansions in economic growth and therefore in financial balance sheets. Liquidity however should always be a major consideration as you do not want to be left stuck with something that you cannot get out of later so I would favour trading the banks themselves rather than the paper that they are holding.

Whether I have correctly described the short term cyclical path or not, only time will tell. All we can be certain of is the structural end game if the energy subsidy continues to fall. The story I describe offers little hope. It may take longer for us in the West to really be squeezed than other less wealthy parts of the world, but nevertheless it will eventually happen. Why therefore am I actually very optimistic? As I will explain in the next chapter, I believe with a little investment, the world could be on the verge of accessing an almost unlimited amount of high density energy that could make the industrial revolution look like child's play.

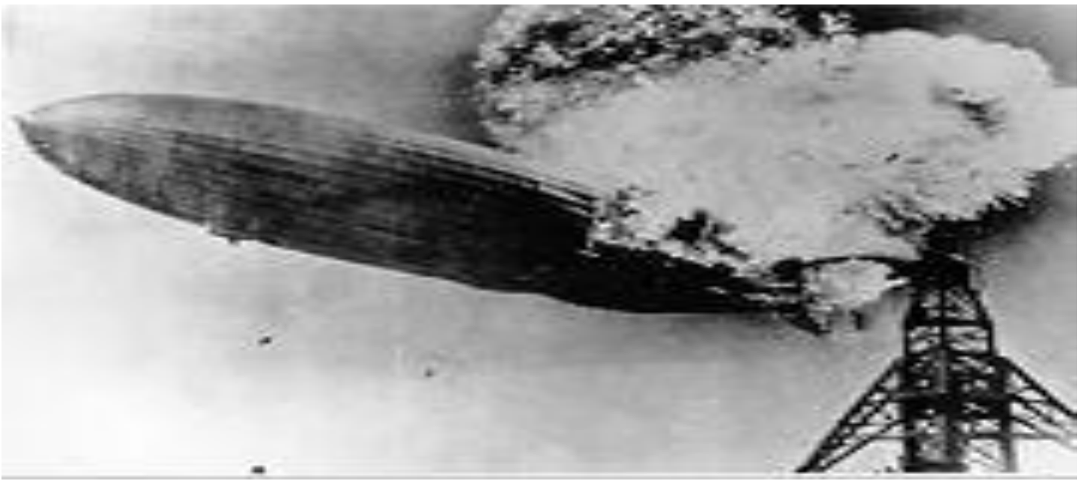
Chapter 12. Going critical

Charles Darwin: Those species which are best adapted to changes in the environment are most likely to survive.

The world is living way beyond sustainable levels of water. Surface water now supplies less than 60% of the water used in irrigation globally, with the rest relying on external sources of energy to pump out aquifers and desalinate sea water. Available farmland and rangeland is falling by 1/3% every year due to wind erosion, water erosion and salination. Thirty six percent of the world's cropland is experiencing decreased output and reduced productivity from top soil mining, leaving fossil fuel based fertilizers to support yields. Grain inventories have fallen for 40 years and crop production now consumes as much fossil fuel energy as the calorific energy that we eat. There should be no doubts that we are living beyond the income and short term capital of the sun, at least using our present methods of harvesting the sun's energy. We are also consuming down the sun's long term capital in terms of fossil fuels at an accelerating pace; in the 20 years since 1989 for example, the human race has consumed 50% of all the oil that it has consumed in its entire history. The world needs a new energy source.

Nuclear fusion seems to be the answer. Whilst there are the obvious fears associated with anything nuclear, the reality is somewhat different. The fusion process of releasing energy via combining the nuclei of light atoms is far more powerful than the fission process of releasing energy by splitting apart the nuclei of heavy atoms, but the risk of going critical is simply not there. Similarly radioactive waste is not an issue. The waste product is helium gas, which is neither toxic nor radioactive. The materials used in the reactor will become highly radioactive, however that will decay within 50 to 100 years, leaving it no more radioactive than a coal power plant. New materials are also likely to reduce that problem still further. Fusion is not only less environmentally damaging than any fossil fuel, but it is also less damaging to the environment than any of the so-called green alternative energies that are being discussed. There are now even reports that nuclear fusion could be used to turn 99% of fission reactors' waste into useful energy and that therefore underground stockpiles of nuclear waste could actually become a valuable asset. In a fission bomb a runaway reaction burns through most of the fuel, but in power plants it is controlled to stop it going critical, which leads to most of the fuel becoming highly radioactive waste. Neutron bombardment from a fusion engine would have ample energy to fission this sludge whilst controlling it within the bounds of the reactor.

The amount of energy released from the fusion of hydrogen to form helium is about 10 million times as much as the chemical energy released by burning hydrogen or using a fuel cell. Given that water consists of 2 hydrogen atoms attached to a single oxygen atom, the world's oceans effectively become the source of fuel. Releasing energy through fusion can be achieved at lower temperatures with deuterium or heavy hydrogen – (obtained from heavy water) – which is also easily obtainable in vast quantities. Unlike a fission power station which contains a large amount of the fuel within the reactor, a fusion engine would be much more like an internal combustion engine, injecting tiny quantities of the fuel between each firing, eliminating the possibility of a run-away reaction. Whilst hydrogen itself is highly combustible as evidenced by the Hindenburg disaster below, the quantities of fuel required are tiny and this should be able to be stored extremely easily just in the same way that anyone with a car stores gasoline in a tank. A nuclear fusion power plant should be intrinsically safe.



The 1937 Hindenburg tragedy shows the chemical energy released from burning hydrogen. The nuclear energy released from the fusion of hydrogen is 10 million times as great.

Fusion is far more powerful than fission, converting larger percentages of the mass within an atom into energy. It is achieved by heating a fuel to extremely high temperatures and giving the atoms enough energy to overcome a natural repulsion, to collide into each other and to fuse. The problem is that the hotter the material becomes, the more the fuel expands and the atoms move away from each other, resulting in less atomic collisions and the fusion snuffing itself out. The Sun gets around this containment problem by gravitational force, however even then it is a balancing act between the two forces; gravity trying to pull the atoms together and heat trying to force them apart. This acts to regulate the pace at which the fuel can be consumed, and therefore allows physicists to work out the age and the life expectancy of the Sun by comparing the mass of the fuel and the pace at which it is being consumed.

Fusion bombs overcome these two opposing forces of needing both extremely high heat and close vicinity of the atoms by effectively squashing the hydrogen between two exploding fission bombs. Even then the fusion reaction only lasts a fraction of a second before it has snuffed itself out, but in that time huge amounts of energy are released. The largest ever bomb to be detonated was the 50 megaton Tsar Bomba, nearly 3,500 times as powerful as the bombs of Hiroshima and Nagasaki, however this is towards the theoretical limits of fusion bombs.

The idea of harnessing nuclear fusion for power stations only really started in 1951. At the temperatures necessary to overcome the repulsive forces between nuclei and therefore to achieve fusion, any container made of steel, concrete and glass would simply vaporize, so some other form of container was necessary. Within just a few months western scientists had worked out 3 different methods by which fusion could possibly be achieved. There are 4 states of materials; solids, liquids, gases and then at extremely high temperatures needed to create fusion, there is plasma; “a gas of positive ions and free electrons with little or no overall electric charge”. At these temperatures electrons become unconnected from the nuclei, but they are still attracted to them. Physicists realised that these electrons could be controlled by magnetic fields, offering a way to make a virtual containment field. The problem with this “magnetic confinement” is that it is not complete. If you create a magnetic field in a tube or cylinder shape then the plasma will rush out of the end, and if you join the ends of the magnetic tube together and form a donut shape, then the magnetic field is weaker on the outside of the donut and the plasma escapes out of the sides. Either way there is plasma leakage, making it near impossible to get the plasma hot and dense enough to achieve fusion. This leakage or confinement efficiency determines how large the system needs to be to create more energy from the fusion than is lost in heating the plasma. The third way was to use a pinch system which simply sent a very strong electric current through the plasma. Just as if you send a current down a copper wire it creates a magnetic field, so too does it by sending a current through the plasma. This then acts to squeeze or "pinch" the plasma, creating both the heat and the density to achieve fusion. The theory was there, but the reality of achieving fusion would take somewhat longer.

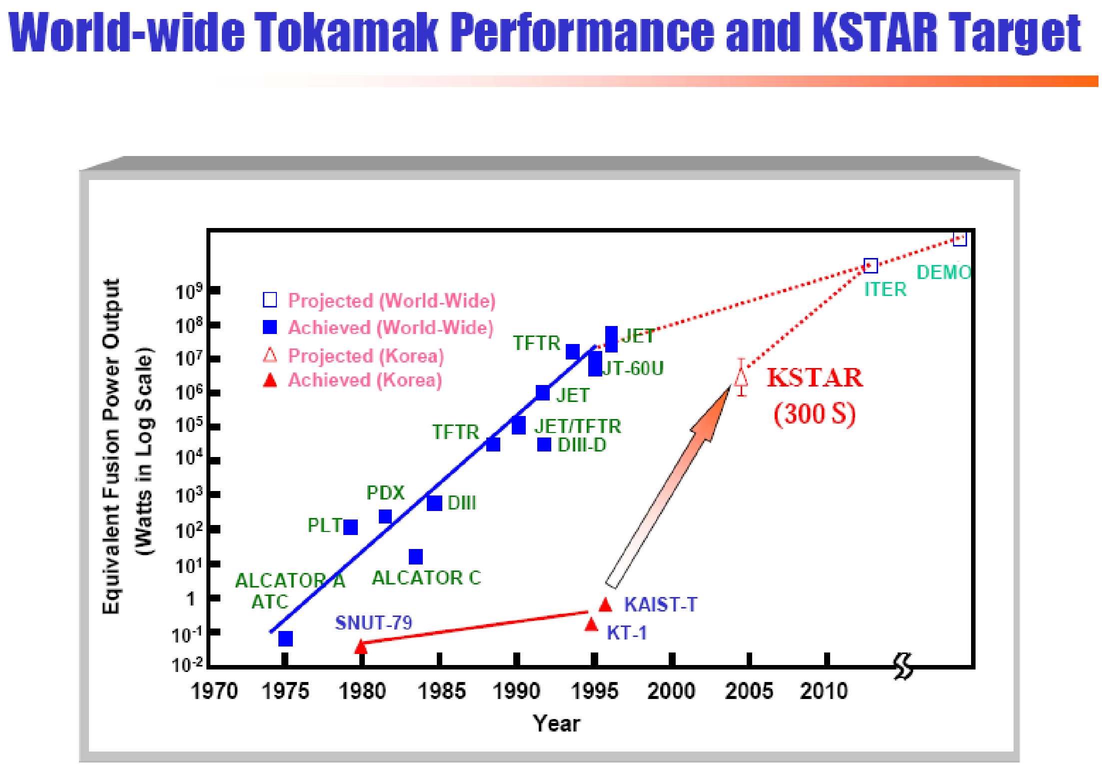
Over the next 10 years the U.S. spent just USD10m on trying to iron out various problems associated with these different methods. The next leap forward came from the Soviet Union, which in 1968 announced that it had combined the magnetic donut shape together with the pinch system to create the Tokamak. The pinch took a huge amount of energy to create the fusion but then when it released it the magnetic field from the donut could effectively keep the energy from dissipating. Now the system could both create enormous heat and density, but also keep it contained sufficiently long to allow the fusion reaction to generate energy before the plasma escaped and snuffed itself out. This machine could achieve temperatures and maintain fusion many times longer than the systems individually, although it was still only for tiny fractions of a second. Then in 1974 the U.S. proposed another way of achieving fusion, by using an array of lasers to both contain and heat the plasma. By bombarding the hydrogen instantaneously from every possible angle, it could contain the plasma whilst achieving sufficient temperatures to achieve fusion. Again there were many complications with this inertial confinement research, but fusion was achieved.

By the time Jimmy Carter had left office, the budget had temporarily got up to USD200m and things were starting to be achieved, but then with partial core meltdown at Three Mile Island nuclear fission plant in 1979 and the availability of North Sea and Alaskan oil, Reagan abandoned nuclear altogether, and this is quite frankly how it has been ever since. The last fission plant to be commissioned in America was in 1978. The availability of cheap oil from the mid 1980's onwards meant that the high capital cost of nuclear fission made it more expensive than traditional fossil fuel power, pushing it out of favour with the utilities. There was neither the political support nor commercial support for nuclear power of any form. The Chernobyl accident in 1986 was the final nail in the coffin. Nuclear power became a pariah and in the public mind; fusion was tarred with the same brush.

In 1985 as relations with the Soviet Union were starting to ease, Soviet President Gorbachev proposed collaboration, the International Thermonuclear Experimental Reactor or ITER. The U.S. signed up to the USD10bn project with several other countries, but then with Chernobyl accident, the collapse of the Soviet Union, the Japanese recession and little support from U.S. scientists, ITER was postponed and postponed. It is still 9 years away and its aims and ambitions have been significantly watered down. ITER is now expected to be completed by 2018 and has the aim of producing 10 times as much power as it consumes for a period of an hour at a time. This is still not achieving a self sustaining reaction, but it would be the final stepping stone before achieving it. Despite the push backs to ITER and the lack of funding, the smaller European, Japanese and U.S. reactors have been closing in on sustained fusion.

Budgets over the last 20 or 30 years did not allow much more than experimentation in the garden shed.

On a recent BBC documentary for example, it was claimed that the UK spends more on ring tones for mobile phones than it does on research. Nevertheless fusion has advanced dramatically. JET (Joint European Torus) achieved 60% energy output in 1997 and in April 2004 Sandia National Laboratories announced that it had managed to use "pinch" fusion to create temperatures of 2bn degrees Kelvin and energy output as much as 4 times the energy input. The French Tore Supra's use of perpendicular magnetic fields has produced and held plasmas over sustained periods – (the longest has been 6 minutes and 30 seconds) - allowing more detailed studies to follow, whilst the use of superconducting material for the magnets allowed it to achieve energy breakeven. The latest progression of tokamaks is South Korea's KSTAR engine which expects to advance research to high performance steady state operation.



Projected path from South Korea's National Fusion R&D Center

Perhaps the most impressive recent advancement has again come from Russian scientists in collaboration with Sandia – (a Lockheed Martin company working for the US Department of Energy's National Nuclear Security Administration with responsibility for all US energy technologies). Earlier I described how a fusion engine operates like an internal combustion engine in a car whereby a small amount of fuel is injected into the reactor, it is burnt and exhausted and then a fraction of a second later more fuel is put in. Until recently the fusion reactors were still like the very first steam engines which effectively only had one stroke (using steam to push a cylinder) and then someone had to come and turn a valve and exhaust the steam and all the energy; completely impractical. With inertial confinement reactors the lasers had to spend several hours cooling down between each firing. Again completely useless, but the Russians recently invented what is called a Linear Transformation Driver (LTD) which can fire sufficiently strong lasers bursts every 10.2 seconds. A test machine has fired without flaw for more than 13,000 fires which on my calculations is 36 hours. According to Sandia's web site, this would be "enough (theoretically) to generate high yield nuclear fusion within the parameters necessary to run a power plant". They describe it as "revolutionary" and closing the gap with magnetic confinement.

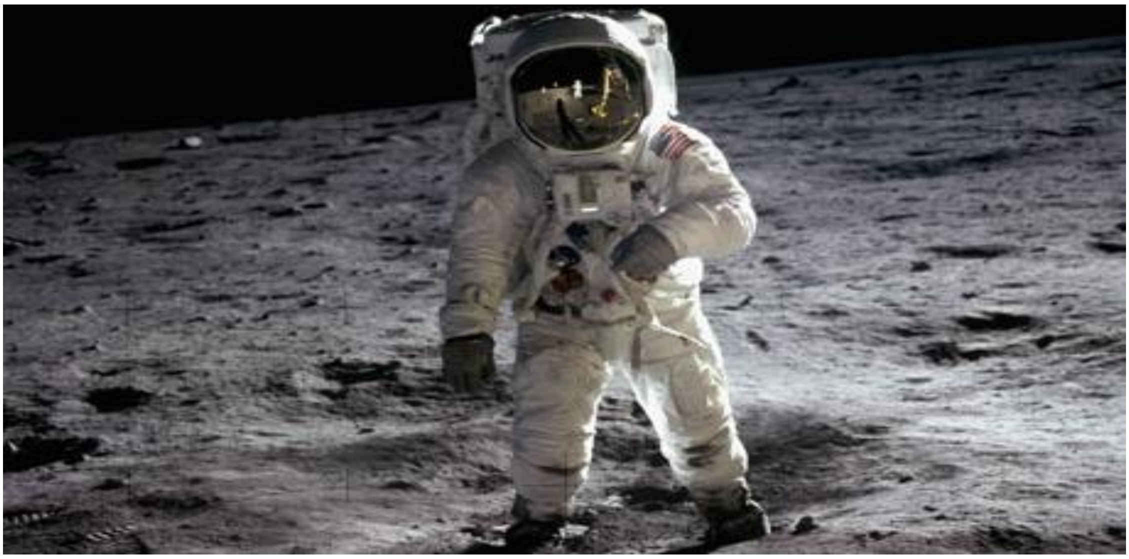
Whilst this sounds promising, once again it is not being treated seriously. Ever since the U.S. signed the nuclear non-proliferation treaty with Russia which stopped the testing of nuclear weapons nearly 20 years ago, the US fusion budget has been spent simulating conditions created by nuclear weapons to ensure that its nuclear arsenal remains effective, and that its nuclear scientists maintain and develop their knowledge. It is a DOE NNSA Defence budget and the advancement in inertial confinement for fusion power has just been incidental.

The development of fusion power would fit perfectly with the declining profile of fossil fuels. The EROIE of the first fusion experiments consumed as much as 100 times the energy that was created. It has now achieved breakeven and ITER is expected to lift the EROIE to 10. The positive trajectory should continue to advance as our knowledge develops. More efficient containers will reduce leakage giving higher fusion rates, and a much higher energy subsidy. The EROIE of our existing fossil fuels is declining and marrying that up with the present so-called green alternatives would reinforce the problem, limiting the size of the economy. Adopting fusion technology on the other hand would initially soften the declining energy subsidy from fossil fuel, and then gradually lift the economy to a higher plain. As the EROIE of fusion advances, so the growth rate of the economy as a whole could advance. Imagine the growth rate that would be possible if the EROIE improved from 20 to 100. Literally the size of the energy subsidy would go up fivefold, lifting the potential size of the non energy economy from 20 times the size of the energy market to 100 times. As the EROIE rises so more resources would be freed up, allowing for greater productivity growth. Contrast this with the adoption of a wind or solar based system where the EROIE would collapse, limiting the size of non energy economy to just 2 or 3 times the investment in energy infrastructure.

It is worth remembering that when oil was at its 2008 highs, the world was spending just under 10% of GDP on oil, and presumably almost as much again on other fossil fuels etc. The costs of peak energy cannot be overstated. Forget comparisons with 1929; the world would simply not be able to support its present population. We would be flung back into the dark ages. Despite what is realistically a shoestring budget, we do seem to be closing in on self-sustaining harnessed nuclear fusion. Given the energy outlook without achieving nuclear fusion, governments have to start treating fusion seriously. The Manhattan Project during WWII to create nuclear bombs cost 1.25% of US GDP, which in today’s money is about USD180bn. We have pushed back the ITER project for 30 years because governments worldwide wouldn’t spend USD10bn collectively. The excuse that we are in a recession at the moment is also somewhat feeble as government deficits are not of the same order of magnitude as in WWII when U.S. military spending peaked at 38% GDP; there is absolutely no comparison with the squeeze that happened on people’s standard of living at the time.

With the electric revolution, there was huge spin offs beyond consumer goods etc. “Without high speed tools and the finer steels which they brought about, there could be nothing of what we call modern industry” according to Henry Ford. A typical plasma temperature is 100 million degrees Kelvin but the Inertial Confinement lasers have achieved temperatures as high as 2bn degrees Kelvin. The heating of the hydrogen at these temperatures causes something called ablation whereby the atoms on the surface of the hydrogen evaporate so quickly that it creates an opposite force that is 100 times as powerful as the thrust of the space shuttle at launch, and can generate pressures about 100 million times greater than atmospheric pressure. At the other end of the spectrum, the super conductivity magnets operate at almost zero degrees Kelvin. This will undoubtedly lead to new directions; new qualities and new industries. Another comparison might be the indirect spin-offs from the space race which gave us access to satellites and therefore such things as the mobile phone. .

The reality of nuclear fusion is that if we can achieve it, then we can have a virtually unlimited supply of cheap fuel. The energy subsidy that this would bring would be similar to that brought by coal, commonly referred to as the industrial revolution. I said in a previous chapter that productivity gains are best described by the term punctuated equilibrium. The big leaps forward have come with the harnessing of coal via the steam engine, initially the beam engine and then the turbine. The next big jump came in the form of the internal combustion engine and later in the jet engine, then electricity and the electric motor, and of course rocket fuel and satellites that I mentioned above. If we had an unlimited source of energy, opportunities would open up everywhere. Rather than people being forced into non jobs that so many people are these days, they could be deployed productively. Our standards of living could go through the roof, huge amounts of jobs would be created and tax rates would collapse. There would even be sufficient energy to provide fresh water and irrigation across Africa and lift hundreds of millions of people out of poverty. China could end its one-child policy. If we so wished, we could clean up the atmosphere. The opportunities would be endless.



In May 1961 John F Kennedy gave one of the most famous speeches of the last century. *"First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him back safely to the Earth. No single space project in this period will be more impressive to mankind or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish". He continued "No nation which expects to be the leader of other nations can expect to stay behind in this race for space" and of course "We choose to go to the Moon in this decade and do other things, not because they are easy, but because they are hard".* If ever such a commitment was necessary, then it is now. When he made his speech most of the relevant scientists did not think it was possible. Now most do believe that with the commitment of funds, fusion power is within our grasp.

Conclusion

"Everybody still doesn't believe any word that comes out of Washington; they still don't believe we'll ever get out of Vietnam, and they certainly don't believe half of the earnings that are reported. But when prices go up enough, everybody believes something; even if it is only that everybody else is about to believe".

Given the benefit of hindsight, most economists link the credit crunch with the scale of US debt. They recognise the imbalance between Asia's excess savings and the West's excess consumption, and suggest that the credit crunch was inevitable, and therefore see the debt having to be worked off before the world economy can recover. If 450% debt:GDP was sustainable however, then why not 475%? As long as China's excess savings are continuing to rise, and it is in its best interests to export them, then there is no reason that the level of debt can't go higher. China may have decided it wanted to reduce counterparty risk, hence its diversification away from the dollar and the dollar's fall from 2002 to 2008, but because of its low dependency ratio it was still producing a surplus of capital that needed to find a home. As long as global trade was transacted in the dollar, this surplus of capital was ending up in the United States, albeit for a cost as private capital was increasingly forced to take the risk.

The scale of U.S. debt is a function of the global financial architecture which requires the U.S. to run a current account deficit, and therefore requires the United States to under invest at home and undermine its own competitiveness. Natural arbitrage should have rebalanced the system. Capital should have flown out of the U.S. forcing up the cost of capital and forcing companies to restructure, but as was the case in the 1920's and the 1960's, politicians thought it was not in their best interests to allow this to happen. The U.S. changed the definitions of data to give a much more generous picture of the state of the economy than reality on the ground would suggest, to support private capital inflows, whilst China and other Asian nations sterilised any capital outflows from the U.S. by recycling it into buying huge quantities of U.S. Treasury bonds.

It is not the dollar standard per-se that is to blame, but rather the fact that politicians over-ruled the natural firewalls. In the 1920's the gold standard should have raised wages in America and lowered them in Europe, allowing the repayment of war debts. As Keynes said at the time, "Ultimately...there must be a readjustment of the balance of exports and imports. America must buy more and must sell less. Either American prices must rise faster than European (which they will if the Federal Reserve Board allows the gold influx to produce its natural consequences), or failing this, the same result must be brought about by a further depreciation of the European exchanges". What he also realised however was that none of this was likely to occur, so he predicted that "America will not carry through to a conclusion the collection of the Allied debt, anymore than the Allies will carry through the collection of their present reparation demands" on Germany, in just the same way that today it is not in China's best interests to call in its dollar loans. Just as China has intervened in the currency markets to stop them performing their natural balancing function, so too in the 1920's the U.S. sterilised gold inflows by selling securities. In the 1960's, again exactly the same situation happened. U.S. debt was allowed to accumulate from the early 1950's Korean War onwards. Throughout the 1960's, Europe and Japan operated the Gold Pool to support the dollar and therefore sterilise and recycle funds back into the United States. On both of these occasions however, the bubble became too big for the creditor countries to physically support. In 1928 and 1929 the U.S. stock market bubble sucked in so much capital from the rest of the world that the U.S. could no longer sterilise or recycle it back to Europe. In the 1970's, with the costs of the Vietnam War getting out of control and the U.S. going through peak oil production, Europe and Japan could no longer afford to recycle the funds, leaving the US to default.

The 2008 credit crunch was no different. The supply of energy couldn't keep pace with demand; there was a shortfall of about 5m bpd against that required to support the size and complexity of the global economy. World oil prices peaked in 2008 at around 9.5% of world GDP, starving the rest of industry of capital. Initially some of the smaller and poorer countries were squeezed out, whilst the richer countries reduced some of their waste – (what a lot of economists call the low hanging fruit). With each reduction, the size of the global economy shrank, and therefore the size of debt that it could support fell. The reduced energy subsidy resulted in less capital being created and therefore an implosion of the bubble.

The reality is that whether there was any debt in the economy or not, if the energy subsidy fell then the level of activity in the economy would also have fallen. Debt was only relevant in helping to direct where that contraction happened. Even then, debt is not as important as counterparty risk. Historically people have compared the US level of debt with that of a "banana republic", but the reality was that with an extremely high standard of living, its ability to trim its own consumption and therefore support its debt, remained extremely high. Its counter party risk was therefore rightly seen as second to none.

The fact that the US economy was one of the first to plunge into recession whilst other less efficient economies continued a little while longer, can again be described by counterparty risk. The US consumer bears the market price of oil and has to adjust his spending accordingly. It is each individual person's finances that determine his consumption of oil and therefore the level of activity and output of the economy. In a lot of the less efficient economies however, energy consumption is heavily subsidised, so the transmission mechanism is somewhat different. Rather than being determined by the counterparty risk of each individual person, it is determined by the counterparty risk of the average of the population, or the country as a whole which means that inefficient consumption can continue much longer as the rich subsidise the poor. When eventually it collapses, it will be that much bigger and widespread.

In an article in the Financial Times (June 26th 2009) the former Federal Reserve governor Allen Greenspan suggested that as the global stock market recovers, the improvement that it would bring to both bank and household balance sheets, will lift the economy once again. He suggested that the stock market is not merely a leading indicator of global economic activity, but rather it is a major contributor to that activity, operating primarily through balance sheets. If you compare and contrast that view with his predecessor, Paul Volcker that this problem goes back to the 1980's and the present credit crunch gives America an opportunity to once again invest in the fabric of the economy rather than in asset prices, then I think you start to understand the reality of the last 30 years. Alan Greenspan is clearly happy to reignite the same debt bubble and allow the real median U.S. wage to continue to decline with productivity, and replace that loss of competitiveness with increased borrowing from abroad. Paul Volcker on the other hand wants to invest back in the U.S. economy and lift both productivity and real wages. Whilst in the short term Greenspan's reflation of the debt bubble will support the economy, it is only Volcker's restructuring and reinvestment that will repair U.S. counterparty risk and therefore allow it to support its present mountain of debt. For the moment, the world's governments are pursuing the Greenspan or Keynesian approach, which will work until we hit the ceiling of resource constraint once again. At that stage, credit risk will again determine where the pain is allocated.

Efficiency and productivity gains are best described as a "punctuated equilibrium" with the occasional technological leap. On average the world economy expands by about 1% per annum faster than its energy consumption; but the real efficiency gains come with the energy itself and the way it is distributed. Even the efficiency gains that Henry Ford's production line so famously achieved, and on which all modern production processes are now modelled, was only made possible by electricity. Henry himself attributes the success of his production line to the use of electricity, allowing "machinery to be arranged according to the sequence of work" which "probably doubled the efficiency of industry, for it cut out a tremendous amount of useless handling and hauling". It was impossible to make traditional line shafts long enough and strong enough for modern production lines. Trying to run the required number of pulleys and belts off the line shaft would be like trying to build a modern sky-scraper with bricks. To support the mass of bricks at the top, the walls at the bottom would simply have to be far too thick to make the building of any use. Similarly a line shaft that was both strong enough and long enough to give Ford its production line would have required an engine so big that it would have made a mockery of the efficiency gains. The electricity revolution, and the energy subsidy that it brought, also made domestic chores such as washing clothes, ironing and vacuuming that much easier, freeing up millions and millions of people to move into external employment. Even the entertainment industry benefited from this energy subsidy as whole countries could now be entertained by very small numbers of people through the television and radio networks. Whilst it is very simple to explain these advances as innovation and technological gains, we must not forget the reality is that they are just additional energy subsidies. Even the latest video on demand or delayed and halted transmission systems are just another form of energy subsidy.

Most of us recognise that the industrial revolution was powered by coal, but I don't think we attribute enough of the subsequent expansions and contractions of the global economy to the availability of energy, and in particular the energy subsidy. Looking over the last 40 or 50 years, the energy subsidy can explain both the long term structural advances and also the shorter term cyclical expansions and contractions. Just as the USSR's collapse can be put down to the fall in its energy subsidy, the same can be said of the stagnating US and British economies in the 1970's. When U.S. oil production peaked in 1970, the spotlight was put firmly on the U.S. current account deficit and the inability of the U.S. to honour its international debt obligations. As U.S. oil production started to decline, the competition for the Middle East's oil intensified. Coal miners in Britain held the country to ransom, causing blackouts and forcing the country to adopt a 3 day week. Commodity prices rose worldwide squeezing the industrial economy, but at the same stage giving countries such as the Middle East and the former Soviet Union, renewed vigour. Japan's energy efficiency enabled it to out compete, becoming the dominant industrial power of the day.

In 1979 the Iranian Revolution lifted prices to new highs, squeezing the less efficient industrial economies still further. The political revolution that then followed in Britain and the United States was attributed to Margaret Thatcher and Ronald Reagan's economic reforms, but the reality was that the discovery and exploitation of oil in the North Sea, Alaska and the Gulf of Mexico, was the real driver. The decadence of the 1980's and songs such as The Pet Shop Boys *Lets Make Lots of Money* was driven by this energy subsidy. Margaret Thatcher's easy access to oil meant that although oil prices remained high in the early 1980's, the striking coal miners were little more than an annoyance and were eventually defeated.

During the 1980's the Iran/Iraq war left both economies weakened. Saudi Arabia had kept oil production very low during that period, ensuring high oil prices and effectively funding both countries destruction of each other. Then in 1986 after both economies had torn each other apart, it ramped up production aggressively. It sent oil prices through the floor and effectively ended the war. The consequence for the wider world was a massive boom. Initially Japan was the biggest beneficiary. Being the world's industrial engine, the collapse in fuel prices gave it a sudden sea-change in profit levels. Money flowed both internally into the property and stock market, and to a lesser extent externally. This sudden one off boost to Japan's profit margins lifted asset prices worldwide. The main Japanese stock index rose to a high that is still more than 4 times today's levels, 20 years later. At the same stage however, the low energy prices undermined the whole Japanese business model which was built on high efficiency and therefore high wages. With energy now being almost given away, low wage low productivity countries such as China could out-compete Japan. It took a few years to get critical mass, but once it did, it strangled the Japanese economy. Neither Japanese stock nor property prices could be sustained with industry now under pressure from the rest of Asia. Wages would have to adjust downward causing the subsequent disinflation that we now define Japan's economy by. To compensate for the economic bust back home, Japan had to dump its international investments and repatriate funds just as US banks did in the second half of 2008. US and UK commercial real estate was particularly hard hit, helping to cause the banking crisis in those countries. .

Prior to Iraq's invasion of Kuwait in 1990, it had pleaded with Kuwait to reduce its flow of oil, to lift world prices, and thereby help repair Iraq's economy. Because Kuwait's oil revenues are so large in comparison with its economy, it had built a major international portfolio of investments which had become its dominant income stream when oil prices were low. It was no longer just a Rentier economy and had no reason therefore to comply. Iraq had thought that the Iran/Iraq war was fought with the U.S. blessing, and miscommunication or misunderstanding gave it the impression that its invasion of Kuwait also had U.S. sponsorship. Clearly it didn't. The higher oil prices it caused hit Western economies, but more importantly, by combining Iraq and Kuwait's oil reserves, Saddam had control of the world's largest reserves. If his tanks continued to advance, he could also potentially have taken control of Saudi Arabia's oil fields, leaving the world's industrial powers at his mercy. Clearly that had to be stopped.

At the same stage, Japan's imploding asset bubble was sucking capital out of the rest of the world, pushing the U.S. and Europe back into recession in the early 1990's. The 1997 Asian financial crisis was not dissimilar to today's problems. Private capital flows into the developing economies had risen exponentially in the preceding years to 256 billion dollars, but eventually the expansion of credit became self-limiting, taking oil prices up more than 50% from January 1996 to January 1997. As the bubble began to unwind it was realised that implicit government guarantees were worthless, leading to a flight of capital and the Asian financial crisis. As the economies collapsed, so the price of oil fell to its lowest real level since January 1971, resulting in the 1998 Russian debt default and the demise of the hedge fund Long Term Capital Management. Even the extent of the Internet and mobile telecom's bubble can be traced back to the cheap capital that the collapsed oil price afforded. When energy prices finally started to rise consistently in the middle part of this decade, it should be no surprise that Japan started to recover, registering its longest period of uninterrupted growth on record. Whilst some of these may seem spurious connections, when you consider that ever since U.S. domestic oil production peaked in 1970, every subsequent US recession coincided either with oil prices exceeding 4% GDP or the oil price rising aggressively in the preceding months, then the connection becomes very real and very obvious.

The direct link between energy and the size of the economy can be understood by analysing what is meant by gross domestic product. Whilst it is defined as the total market value of all the final goods and services produced in an economy in a given year, it can equally be described as a measure of the level of activity and the value that we decide to attribute to that activity. The energy subsidy encompasses not only final energy consumption but also the conversion efficiency of the embedded energy within capital equipment. A lorry for example does a huge amount of final work, but that lorry is itself just the result of previous work done by energy to build the lorry. Even the value that we attribute to a good is directly related to the energy subsidy. Theoretically it is determined by the marginal utility of the product, but that is itself based off the complexity and support structure of the underlying economy, in other words the energy subsidy. An artist's painting for example may be worth ten million dollars today because the global economy is able to provide the buyer with the necessities of life and give him the ability to afford that kind of money, but if there was a genuine collapse in the economy and food shortages, then the marginal utility of that painting may be worth less than a tin of baked beans. Similarly the cumulative knowledge that has gone into the design and construction of the lorry in the previous example is the result of a previous energy subsidy. Unfortunately as economies and societies have become more and more complex, and value added has become more service related rather than industrial, these links have become less visible and less understood. Over the next few years I would expect people to start remembering their basic laws of thermodynamics and just how pivotal the energy subsidy is to everything that we do.

A deteriorating demographic situation means that without increasing the age of retirement, our standard of living will fall. In normal circumstances this would be bad enough, but the world now faces the situation where the energy subsidy is set to fall. The supply of fossil fuels is peaking and the EROIE is falling. Building out an alternative energy system would further reduce the available fuel to support our existing standard of living. Its reliance on low density energy would mean a network of generators, transmission systems and storage vastly bigger than today's to produce the same end supply. If the EROIE halves, the size of the network will have to double to get the same net energy, severely affecting its green credentials. The price of raw materials would rise as they are increasingly consumed by the energy sector, squeezing end household consumption and reducing our standard of living. Asset prices would be destroyed (at least in real terms), putting the entire banking system under huge stress, and lifting the cost of capital. It may be possible to get 5% to 10% of our energy from alternative sources and therefore have some cushion against peak fossil fuels, but the cost of a full scale switch would be prohibitively expensive. The energy subsidy would fall so far that whilst we would not become slaves to energy, we would pretty much become an equal with it.

Nuclear fusion is the only solution. It is within our grasp. A proper commitment from governments worldwide to different programmes should be able to make it possible and turn what would otherwise be the worst disaster to face the modern world into the biggest growth opportunity of all time. We need to increase the pace of fusion development to a timetable at least commensurate with the decline of fossil fuels. Until this happens, the energy subsidy, and resultant productivity and credit tide will continue to ebb. Globalisation will reverse and industries will completely change. Understanding the disease and embracing the change will open up huge opportunities whilst those that try to fight the change will end up with nothing. Fortunes of entire nations will be made and lost over the next 20 years.

I understand that a lot of people will dismiss this book as an exercise in negativity, just as they pilloried anyone who warned about the unsustainable debt bubble in recent years. This head in the sand attitude is very dangerous. It has already resulted in policy error and much more severe pain than was necessary. It has also resulted in the problems being reinforced as governments have fought the symptoms with their allocation of resources, rather than the disease. I hope that this book will be a wakeup call to governments and policy makers, and that they will embrace the change that needs to happen, but I fear the reality is that if the credit crunch and the pain that it has inflicted has failed to make them understand the problems that we face, then I am probably being too optimistic to assume that my book will get their attention.

Governments should take heed. If you don’t keep the lights on, you will lose power.

Background Reading. A few introductory reads.

1. Michael Hudson. **Super Imperialism**. The history of the dollar standard. Why it came into being and what it has meant.
2. Michael Hudson. **Global Fracture**. The last time the global financial architecture was tested in the late 1960's and 1970's.
3. John Perkins. **Confessions of an Economic Hit man**. How the US used the dollar standard to influence the world.
4. Peter Warburton. Debt and Delusion. The growth implications of carrying large amounts of debt. Other similar books include Empire of Debt and the Demise of the dollar

5. Paul Krugman. **The Age of Diminished Expectations.** An introduction to productivity.

6. Diana Choyleva. **The Bill from the China Shop**. China's export of capital
7. Joe Studwell. **The China Dream.** Backround information on the Chinese economy.

8. Thomas Homer-Dixon. **The Upside of Down.** The collapse of the Roman Empire due to overstretch.
9. Jeremy Rifkin. **The Hydrogen Economy.** A very basic introduction to peak energy. (other books with a similar story although all from different angles. Addicted to Oil, America's Energy Future, Gusher of Lies, Half Gone, Oil and Islam, Winning the Oil Endgame, Out of Gas, Profit from Peak, Russian Oil Supply, The Final Energy Crisis, Twilight in the Desert and Big Coal.
10. US Department of Energy. **Wind Power in America's Future**
11. Bradford & Travis. **The Solar Revolution**.

12. Charles Seife. **The Sun in a Bottle**. An introduction to nuclear fusion
13. Garry McCracken. **Fusion**. A reference book/text book on all aspects of fusion.

14. Jun Ma. **China's Water Crisis**. The most frightening book you will ever read.
15. Fred Pearce. **When the Rivers Run Dry.** Great background reading of the world's water problems
16. Mostafa Dolatyar. **Water Politics in the Middle East.** The water issues behind the Israeli conflicts.
17. Peter Gleick. **The World's Water**. A biannual reference book.

18. DR Montgomery. **Dirt.** What a cool title. The importance of soil to civilisations.
19. Dale Pfeiffer. **Eating Fossil Fuels.** The green revolution

20. Phillip Longman. The Empty Cradle. An excellent introduction to demographics
21. Nicholas Eberstadt. **Europe's Coming Demographic Challenge**. The balance between Europe's worse demographic than the US but much better health system.
22. LJ Kotlikoff. The Coming Generational Storm. Another great introduction.

23. A Auerbach. **Generational Accounting around the World**. Detailed inter temporal accounting.
24. G Magnus. **The Age of Aging.** Written by our own George Magnus.