Peak Oil, the Decline of the North Sea and Britain's Energy Future

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Britain faces a series of problematic choices in order to re-negotiate our lifestyle within the biophysical limits that will assert themselves over the next few decades. These problems cannot be avoided, and they are complex because they affect so many aspects of our economic, social and material well-being today. For that reason they are innately political, and thus require the political parties of Britain to engage with these issues in order to map out a means of dealing with the crises these changes will generate.

We are so often told about the problems of climate change by the various political parties in Britain, but in fact the changing climate is just one of a number of factors that we will have to manage over the course of this century. If we take an ecological or biophysical perspective[1] then we see that society faces a far wider set of problems to resolve as it adapts to the reality that growth within a finite environment has its limits. Such limits are not theoretical[2], and are being played out within our lives today under the guide of phenomena such as global food shortages, resource depletion or climate change.

These are global issues; in many cases they will require global solutions in order to create a satisfactory outcome for everyone on the planet. However, Britain has its own domestic problems related to the "ecology" of our past history in these islands: Britain was one of the first countries to industrialise, and we mined many of our natural resources as part of this effort; during the early 19th Century we were the "Saudi Arabia of coal", exporting British coal around the world[3]; more recently Britain has exploited the oil and gas reserves of the North Sea, and this has inarguably contributed the the well-being of our economy for the past three decades. Today, this 250 year arc of economic and technical development has reached its zenith; the accelerating depletion of North Sea oil and gas production marks the point at which we must plan for the "downside" – and the inevitable decline in the easy availability of energy and material wealth that is the inevitable result of this transition. What's important is to ensure that as part of this process the "decline" of our ability to generate economic wealth from our material resources does not translate in a more general crisis in British society; we must learn to reap the benefits of our human assets rather than the geographic chance of possessing abundant natural resources.

A holistic view of energy and the economy

When I talk of a "holistic" view of energy and the economy I mean an analysis of our energy problems that goes beyond the simple economics or geopolitics of supply and demand. Energy, and the supply of energy and mineral resources within our own geographic boundaries, has shaped the history of Britain and led us to the point we are at today. How we will adapt to restrictions on the availability of energy resources, and the price of that energy, is inextricably bound up with the way in which we have developed in the past and how this influences our ability to create new ways of living in the future.

The extent to which we can relate this analysis of energy and its relationship to the wider economy stretches well beyond the field of energy economics. For example, we can look at the energy and economic relationships within our food supply, the general consumption of goods, and even the operation of the regulatory system around issues such as house construction, to see how the assumptions at the heart of the high growth/high consumption liberalised economy skew national policy in certain directions. However, for the purposes of this presentation I will limit the scope to the relationship between energy consumption and the operation of the national economy.

There has been much debate in recent years about the decline of our indigenous energy production, led by the disparate insights of BBC docu-dramas[4] or expert energy groups[5]. Much of this debate relates to the issue of energy security[6] and the difficulties of finding secure supplies of energy to "keep the lights on"[7]. In fact the energy issue is far more complex, and isn't just related to the availability of fuel. Energy consumption has specific economic impacts across the whole economy, and is related to both economic productivity and growth.

The standard explanation of the origins of economic growth – from Adam Smith, Thomas Malthus, David Ricardo and Karl Marx until the late Twentieth Century – is that it is created by applying capital (money) and labour (people working) to extract added value[8] from

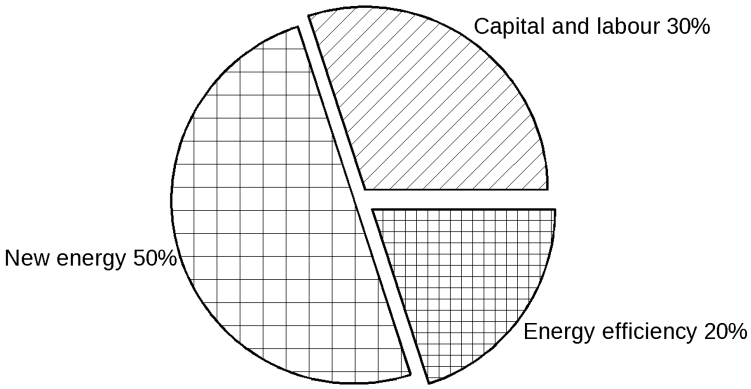

Figure 1. The sources of economic growth

the production of goods and hence profits. It was believed (e.g. under the Cobb-Douglas production function[9]) that every 1% of additional labour produced 0.7% of growth, and every 1% of additional capital produced another 0.3% of growth. Then, in the 1950s, the US economist Robert Solow found that this view could only explain about a third of the observed growth in the economy. Something else (later called the Solow residual[10]) was driving the value of economic growth. More recent research – for example by Professor Reiner Kümmel[11] or Professor Robert Ayres[12] have identified the source of this residual growth (see figure 1): The majority of the value of growth is due to the actual increase in energy consumption in the economy, where each 1% of energy growth produces around 0.5% of economic growth; another significant contribution is made by the improving levels of energy efficiency, because improving the utilisation of energy in the economy overall allows more work to be done with the same amount of energy, and this adds around another 0.2% to average economic growth; and, capital and labour together, as observed by Solow, then make up the other 0.3%.

One of the most important trends within the Technological Revolution has been the replacement of human labour with more highly automated machines, and so we should expect that energy utilisation would have an impact upon growth in lieu of human labour. For example, the energy contained in one barrel of oil[13] represents the equivalent of 25,000 hours of human labour – that's equivalent to 12 people working 40 hours a week for an entire year. Increasing the level of energy in the economy represents the equivalent of adding more labour to the economy, but at a vastly cheaper rate than real human labour, and so the economy becomes more productive as a result. At the time of writing a barrel of oil costs roughly $76 – which at an exchange rate of £1:$1.65 is about £46. The human labour equivalent to the energy in that barrel of oil, even assuming a low rate of pay such as £5.80/hour (minimum wage), would cost £145,000 – or re-valuing that barrel of oil in human terms, about $239,250/barrel! In other words, 99.97% of the equivalent labour value of oil is “free”, and so our use of energy can be seen as constituting the labour of many energy slaves[14] who serve our needs[15].

This seemingly magical role of energy in the economy makes sense because, in terms of the thermodynamic principles, adding energy is like adding more labour but at a vastly cheaper rate; put simply, burning more energy allows you to do/make more “stuff”. In turn this means that the exergy efficiency[16] (the overall efficiency of systems, not just of elements within the systems) of these processes is also important when we evaluate the effects of energy on the economy as it increases the level of “work” delivered[17], and the increased productivity this represents also increases the value of economic growth. The difficulty in communicating this issue is that it's not a straightforward matter to disentangle energy and growth. For example, in 2007/8 did higher energy prices cut energy consumption and then initiate a recession, or did the recession cut the use of energy?; the theory would say it is the former, but the popular economic debate would say it is the latter.

Over the Twentieth Century economists have sought to improve the economic efficiency of society in order to increase growth, but within this the role of energy was largely ignored because it was generally cheap. This problem first became apparent during the 1970s. As the cost of energy rose following the 1973 oil crisis[18] the effect was to make the economy less productive; prices rose, then inflation rose, profits fell, and in turn this reduced the real value of economic growth. For example, at 2008 inflation adjusted prices, over the fifty years from 1924 to 1973 the price of oil averaged $14.78/barrel, and $13.64/barrel in the boom period between 1949 and 1973. Over the twenty-five years from 1974 to 1998 (before the current upswing in prices) oil prices averaged $45.48/barrel – *over three times higher*; and the average over the ten years from 1999 to 2008 was $49.96/barrel, with the average in 2008 rising to $97.26.

The effects of changing energy prices were internalised within the economic system over the decade or so that followed the sharp price rises in 1973. Arguably the early 1980s recession was the readjustment that internalised the new prices – resolving the problem through the greater efficiencies of off-shoring the manufacturing industries of the developed states, allowing the economy recover and began to grow strongly again. However, the recent trend of rising prices and the constraints this places on production invalidate this process, and once again raises the importance of energy to the overall economy. To a certain extent, higher energy prices invalidate many of the higher economic efficiencies of systems such as off-shore manufacturing, just-in-time delivery and the outsourcing of services that solved the economic woes of the 1970s and 1980s by holding commodity prices down.

Recent research has suggested that the present-day economic crisis was not ultimately due to “sub-prime mortgages”, but rather the rise in oil prices[19] and other resource costs. As in the early 1970s, 1980s and 1990s, the high energy prices of the last three years have once again generated an economic recession. Although it might be blamed upon the “sub-prime crisis”[20], and the role of banking liabilities in the sever-

ity of the resultant crash, it was initiated by the inflationary effects of high energy prices in the economy as a whole; not least the high fuel and food prices hitting the domestic budget of those who held sub-prime mortgages, causing them to default.

Obviously if at least half of economic growth is energy-related then such a relationship between the price of energy, economic productivity/efficiency and growth is not surprising. Other research suggests that, once the world begins to grow again at the end of the present recession, oil prices could rise once more[21] and repeat the recessionary cycle far more quickly than governments might anticipate; the arguable effect of a constraint in energy supply will be to shortening of the business cycle[22] as demand grows, creating a price spike, following each successive downturn. There is absolutely no reason why this accelerating cycle of price rises and recessionary cuts in energy consumption should not begin again as the world "recovers" from the present recession – in terms of the classical economic outlook it's merely the "invisible hand"[23] of the economy balancing the shortage of energy against the growth in demand.

More problematically, the situation today is worse than at the beginning of the present recession, and certainly compared to the recessions of the 1970s and 1980s, because the investment that was due to bring new sources of energy on stream has been deferred. This means that, when the world wants to begin using more energy in 2010, it will not be available in the required quantities and prices will rise again sharply. In the longer term, following the peak in global oil production, unless we are able to find an alternative economic model to contract the economy ahead of the depletion curve the time between recessions will progressively shorten into a more protracted decline. Following the peak in global gas production, and the absolute ceiling on human energy use that this transition will mark, the decline will be constant unless we find a new way of satisfying our needs sustainably within the limits that are likely to prevail at that time.

Energy and the general economy

If we unpack this rather complex relationship between energy and the economy then what we find is that energy means much more than the acquisition of fuel supplies – as noted above, there is an direct relationship between the utilisation of energy and economic growth.

There are three aspects to the analysis of the role of energy in the general economy (see figure 2):

- The possession of energy resources represents a value in terms of an ***asset*** – with this comes both the appearance of national wealth, the potential for external loans that can be secured against the value of such assets, and the inward investment that can support the wider economy in order to exploit these assets;
- The exploitation of energy resources brings with it a general boost to ***economic activity*** – in turn this activity creates confidence in the wider economy, it stimulates investment in other sectors, and from this cycle greater wealth and monetary flows are created; and finally
- The availability of indigenous energy resources generates easily accessible ***fuel sources*** – this creates both security of supply, but perhaps more importantly the easy availability of fuel reduces the need for stockpiling and other forms of intervention trading, this in turn creates greater supply chain efficiencies and thus cheaper fuel, and this again boosts national productivity.

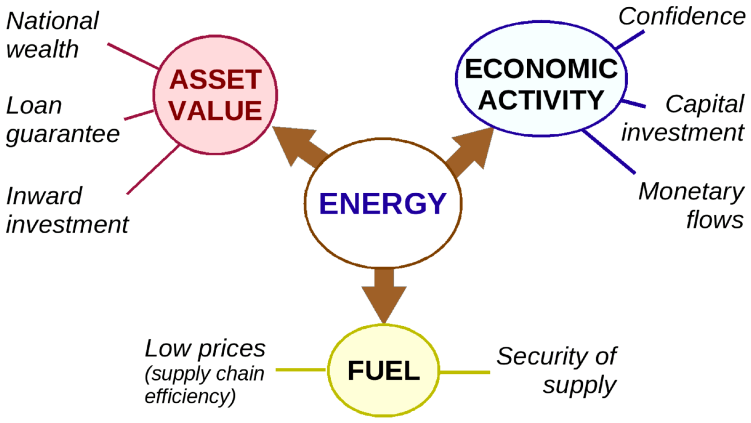

Figure 2. An holistic view of energy and the economy

Over the last three decades the British economy has benefited from the trends described above. The depletion of the North Sea represents not just a diminution of these effects, but as we approach the point where the majority of our energy is being imported we will see the reversal of them. Our ability to adapt to this new set of circumstances will define how well or badly we will make the transition to a materially less intensive economy that must inevitably follow from these restrictions.

To understand how the depletion of the North Sea (and the depletion of our general resource base over the last 300 years) will affect the economy in the future we need to look at our use of energy and other resources over the period in which our economy has grown and intensified. Britain has throughout its history, at least until the last half of the Twentieth Century, been largely self-sufficient in energy resources. Britain's ability to industrialise was dependent upon the easy availability of energy and mineral resources in these islands, not just the social and political trends of the Seventeenth and Eighteenth Centuries that gave rise to the Industrial Revolution. Of course the counter-trend to this process has been that Britain has utilised much of its resource base, and now that we are reaching the physical limits of production we must reconsider how we will operate our economy in the future.

Let's begin with oil.

If you travel west from Edinburgh Waverley station towards Falkirk, shortly before reaching Linlithgow, you can see large brown heaps of spoil that are locally called "The Bings"[24]. These are the remains of the oil shale processing industry that operated in this area from the 1850s until the 1960s. Long before North Sea

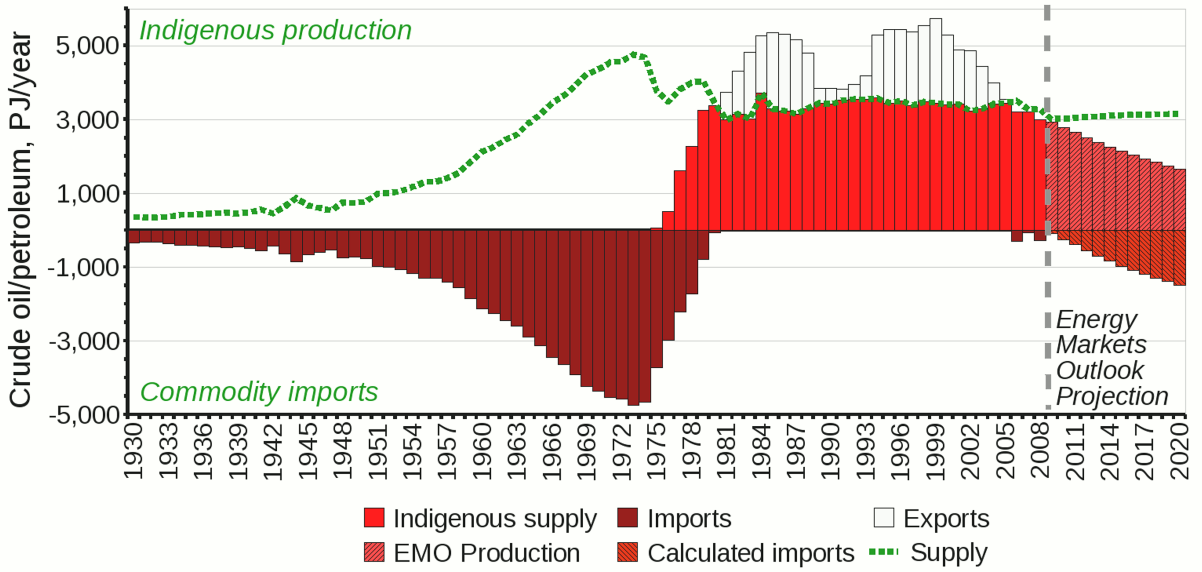

Figure 3. UK petroleum production/import balance, 1930 to 2008 and projections to 2020

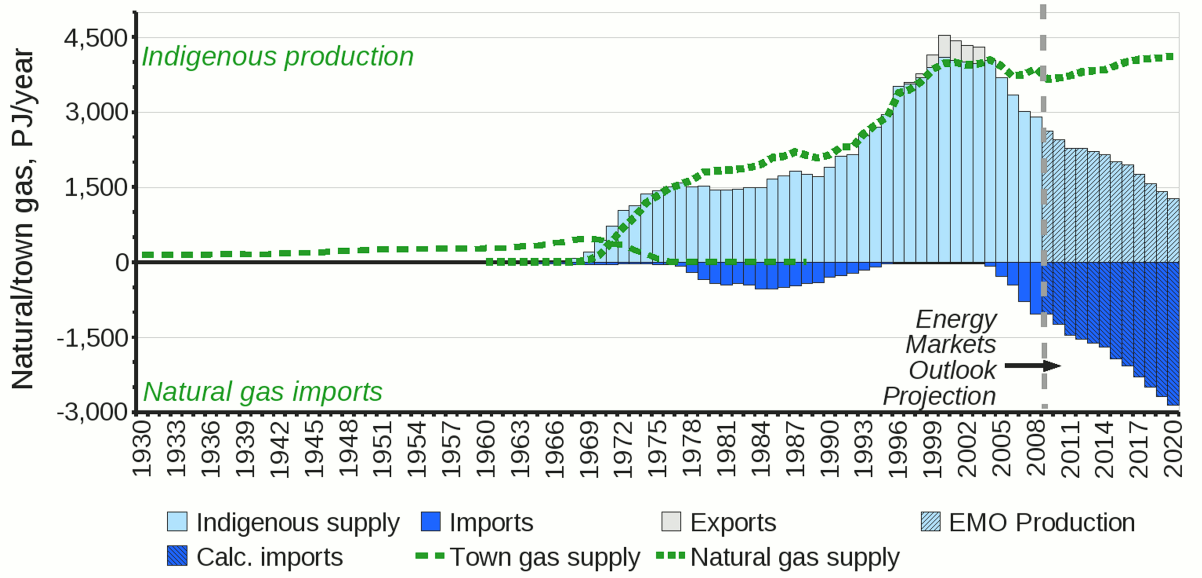

Figure 4. UK natural gas production/import balance, 1930 to 2008 and projections to 2020

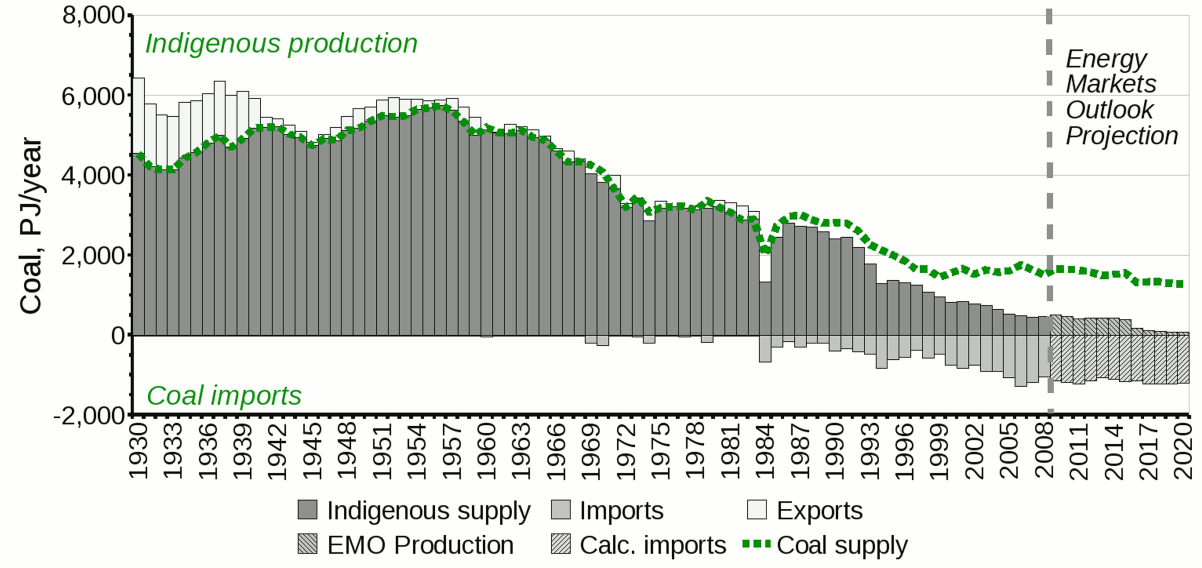

Figure 5. UK coal production/import balance, 1930 to 2008 and projections to 2020

oil began to reshape the coastline of the Firth of Forth, this area was the leading producer of petroleum products in Western Europe – and it is now worked out. Britain then went abroad to find oil, first in central Asia around the Caspian, but then in Iran through the Anglo-Persian oil company – the antecedent to British Petroleum. This process of developing expertise and technical capabilities ultimately reaches a peak with the development of the North Sea, which at the global level broke new boundaries in the fields of off-shore exploration and drilling.

The Department of Energy and Climate Change (DECC) has petroleum consumption data that stretches back to 1890[25]. In the UK quarter of the consumption of oil over this period has taken place since 1994, a half since 1979, and nine-tenths since 1955 – as shown graphically in figure 3. In all the graphs presented here the data is presented as a net value: Where imports exceed exports then the imports figure has the value of exports subtracted from it, and vice versa; this means that what you see is the balance of indigenous energy production to the flow of the commodity in or out of the country. The dotted line shows the overall level of supply. When there is sufficient indigenous supply the line coincides with the top of the indigenous production column and exports appear above it; but when there is insufficient indigenous supply the line floats free and you'll see the value of imported energy ad the difference between the line and the top of the indigenous production column.

Before we started producing oil from the North Sea most of our petroleum demand was imported – and it was the first time in the history of Britain that an essential component of our energy economy had been sourced from outside the UK. Then, from the early 1980s, along came North Sea production[26] and we ceased to be one of the worlds major oil importers and instead become one of its major producers. Apart from the period from 1989 to 1993, when the Piper Alpha disaster shut down much of our export capacity, Britain was a net exporter of oil to the global market from 1981 until 2005. However, in 1999 production in the British sector of the North Sea peaked, and since that date it has been falling. Even the opening of the new Buzzard oil field in 2005 only halted this declining trend for a few months.

If we look forward in time, there are various projections for how Britain will source its energy in the future. Until its dissolution in 2006, this role was carried out officially on behalf of the Government by the Joint Energy Security of Supply (or JESS) Committee[27]. After various problems with the production of their reports, in 2007 the Government took back control for its forecasting, and now jointly produces (with Ofgem) the *Energy Markets Outlook* (EMO) report[28]. In the petroleum graph (and the graphs that follow) I've used the EMO base/central projections of future production and demand in order to show how our use of petroleum will change in the future. I've summarised the data, by fuel source, in the statistical appendix[29] that accompanies this report.

On the most recent set of data, the *Digest of UK Energy Statistics 2009*[30], Britain was importing just under a tenth of its petroleum requirements; by 2020, EMO forecasts that this could rise to just under a half[31]. The important variable in this calculation is the depletion rate of North Sea production; EMO estimates the depletion rate at an average 5¼% per year – lower than the estimates by other analysts, some of whom quote 7.7%[32], which would mean that just over half of demand would be imported by 2020.

If we look at gas production then we see a similar picture. The data in these graphs represents the value of primary energy – the energy value of raw fuel used within Britain; there is no data before 1960 on the gas graph because before that date gas was a “secondary” product manufactured from coal rather than a primary fuel that was mined or imported. Before 1960 the gas being consumed was “town gas”[33]. Initially developed as a form of lighting[34] for the industrial mills of Birmingham in the 1790s, through thousands of small local gasworks it later became a source of light and heat around Britain until the introduction of natural gas and the national gas grid from the 1960s. The first natural gas was imported into Britain in liquefied form from Algeria, and was stored at Canvey Island[35] in the Thames Estuary (the first time that gas had been transported in this way). At the very end of the 1960s gas began to flow from the southern North Sea. Due to the large potential for supply the national gas grid was extended and, by 1989, the supply of town gas for public use had ceased.

Natural gas not only supplanted the previous role of town gas for domestic uses, it also created a market within industry because it was cheaper and cleaner than using oil. At the same time the Government promoted the use of natural gas for power generation. This created the “dash for gas” – the use of coal and oil diminished as industry and the newly privatised power generators switched fuels, significantly increasing the efficiency of power generation and heating. This not only cut carbon emissions significantly, it also boosted the productivity of the economy. Again, DECC has a database of gas supply data going back to 1882[36], and on these figures a quarter of all the town and natural gas supplied over that period has been used since 2001, a half since 1994, and nine-tenths since 1966 (see figure 4).

Britain's natural gas production increased in the late 1970s, but during the 1980s our demand increased faster than production and so we began importing gas from the Norwegian sector of the North Sea. Then in the 1990s production exceeded demand and, from 1997 until 2003, Britain became a gas exporter. The end of gas exports coincided with the peak of natural gas production in the British sector of the North Sea in 2003 – and in fact the early peak took the industry by surprise, as the new importation infrastructure that it had planned was not due for completion until 2005 to 2010[37].

The problems with declining gas production are far more serious than those of oil production. As with oil, the EMO report projects the likely future production and demand for natural gas until 2020[38], and the view

it provides is even more problematic than that for oil. In 2008, Britain imported a quarter of its consumption; by 2020 it is predicted we will be importing just over two-thirds (or more – again there is an issue about depletion rates). At the moment there are various proposals for increasing Britain's gas storage, but this still does not avoid the root of the problem – *we are systemically reliant upon the use of natural gas, and without gas our increasingly technological society cannot function*. Just as our own production peaked, so the production of gas in Russia and other sources of piped or liquefied gas is likely to peak within two or three decades – especially if the global peak in oil productions leads to the accelerated use of natural gas to produce oil substitutes[39], or the use of compressed natural gas[40] in the transport sector.

If we look at the data on energy use within the economy in 2008[41]:

- Three quarters of Britain's petroleum supply goes into the transport sector as a whole, and half of it goes into road transport – in a supply crisis we can significantly cut oil demand through reductions in non-essential travel and increasing the use of the available public transport infrastructure; but conversely,
- A third of Britain's gas supply goes into power generation, and another third goes directly into domestic properties for heating and cooking – in a supply crisis, especially as it is likely to take place during the Winter when gas demand across Europe is at its highest, we would face a significant social crisis; and
- The reliance upon natural gas for power generation is significant because, since the privatisation of the major utilities and with the increasing use of telecommunications-linked "just in time" delivery systems, a disruption of the electricity supply would both shut down a large part of the logistics business as well as putting the increasingly centralised (due to the increased use of electrically pumped pipelines) water supply and sewage systems at risk of failure – even if we had the oil available for the transport sector (to operate the transport system/the logistics industry) it is the reliance of our electricity grid upon natural gas that reduces the general resilience of British society.

The gas supply need not be completely cut to create a more general economic crisis; it only needs to be reduced by a moderate amount, just 10% to 15% below the level of demand, to trigger a national crisis as the shortfall causes the many public and private organisation with interruptible supply contracts to have their gas supplies cut. The failure to replace the demand for coal fired power plants (with alternative options to avoid consumption, not just replacing the physical power generation capacity) adds to this problem because we will be unable to fuel switch from gas to coal in order to reduce the burden upon gas supplies (as happened during the previous supply crisis in December 2005).

Next, let's consider coal. Coal has been used in Britain for many centuries[42], and by the 13th Century its use became more organised with the first dedicated mines. It wasn't until the Industrial Revolution, and more especially the development of the canal network to allow the transportation of coal across much of the country, that the use of coal became widespread outside of those areas where it naturally outcrops at the surface.

DECC produced a dataset of coal production and consumption dating back to 1853[43], and over this period the bulk of coal consumption was during the the Twentieth Century, first from the consumption and exportation of coal, and latterly from the large-scale importation of coal. Based upon these statistics a quarter of all coal consumption has taken place since 1960, a half since 1932, and nine-tenths since 1878 (see figure 5). Although arguably this is an incomplete set of data, as it doesn't begin until 1853 after the widespread use of coal began, the statistically significant use of coal probably dates back to around 1810 to 1820[44].

Due to its much earlier period of use, British coal production peaked around the mid-1920s, at which point we were exporting nearly half of our coal production. Today coal production is at about 7% of the peak level of the 1920s, and we now import 70% of our consumption. Irrespective of the ecological issues around coal burning, in terms of an indigenous energy supply coal is no longer an option – we have no sizeable coal reserves left, and the idea that there are "200 years" of coal under Britain are a myth. The reserves that remain are marginal, and whether they are developed or not will depend to a great extent upon what happens in the world coal market – they require a high global price to make production viable. For this reason the EMO report has a wide variation in its projections[45] for both coal use (given the uncertainty about future coal-fired power plants) and coal production (due the investment required to develop marginal resources). In reality coal production in Britain only has a decade or two left, and by 2020 it is predicted that we will be importing almost all our coal.

The only other mainstream options to produce more energy are nuclear power and renewable energy. Presently the policy for both these options is mired in controversy for much the same reasons as the general problems with the energy economy as a whole – *an inability to face up to the biophysical limitations on our future development*.

Nuclear power, today and in the past, makes little difference to the energy economy overall. That's because it only generates electricity, and so does little to address the wider complexity of energy supply and the structural dependency on certain fuels. In 2008 nuclear power represented 14% of the electricity generated by the major power producers[46]; in the same year electricity consumption represented 18% of final energy consumption[41]; therefore the contribution of nuclear energy to the energy consumption overall is just 2.5% – arguably if households were to lower their thermostat by one degree we would eliminate roughly the same amount of energy as is provided by nuclear power. Whether or not Britain builds new nuclear power plants is in many ways a distraction from the debate over energy security, for two main reasons:

- Firstly, it's unlikely that any plants will be completed before Britain has to import a significant proportion of its energy supply, and even then the amount produced will not significantly alter the quantities of energy that we will have to import in the form of oil, gas or coal; and
- Secondly, this whole debate is ignoring the more important energy-related issue as to the globally available uranium resource[47] – arguably there's no more than 60 years of production at current levels of consumption, it is likely that global production will peak well before that date[48], and in any case if the world tried to go down the nuclear route to abate carbon emissions then the global reserve of uranium could be exhausted in just one to two decades[49].

This second point, regarding the availability of uranium resources, is important because at the moment DECC, through the *Energy Markets Outlook* report, is being disingenuous regarding Britain's uranium reserves. Britain does not have uranium "resource", it has a large "stock" of the left-over material from the production and reprocessing of nuclear fuel. The report states that[50], "*the inventory held by the NDA could be used to fuel up to three modern 1000MW* (or 1GW) *PWR reactors over a period of 60 years.*" The difficulty with this statement is that it relates to just the 5,100 tonnes of fissile uranium and plutonium[51] described in the report – the other 54,900 tonnes of depleted uranium mentioned in the report is not usable within any conventional form of nuclear reactor. The plutonium component of the fuel is also no straightforward because the use of "mixed oxide" fuels can be problematic in terms of safety, and so is only suitable for certain modern reactor designs with a higher quality of secondary containment. In any case, given that we are due to lose up to 20GW of generating capacity over the next decade or so, we would need at least twenty such nuclear plants to address the shortfall in generating capacity – meaning that the projected "60 years" would reduce to just nine years.

Britain does not have the type of geology to produce uranium either. Although, as highlighted by certain environmentalists such as James Lovelock[52], Britain could theoretically extract uranium from rocks such as granite the energy required to do this would exceed the energy produced[53] from the resultant fuel when it is placed in a reactor. Consequently, in my projections I class the energy value of nuclear power as "imported" energy. I also assume that no new plants will be producing power until after 2020, and so for the purposes of the projections up until 2020 I'm assuming that the existing timetable for nuclear plant closures goes ahead as planned.

Renewable energy is another issue where the rhetoric doesn't match up to the practical reality. Recent studies, such as the Centre for Alternative Technology's *Zero Carbon Britain*[54], or David MacKay's *Sustainable Energy Without the Hot Air*[55], map out various options for changing Britain's energy supply. Either of these studies have their good and bad points, but both try and describe the potential future energy supply within the context of today's energy system (albeit both reports take the starting point as being the problem with carbon emissions rather than a more general biophysical perspective). The Government's policy, expressed in the recent *Renewable Energy Strategy*[56] does not take a clear view of the existing energy supply in framing future strategy. Instead it expresses the future energy mix in terms of "what's possible" to meet various targets for renewable energy production or the reduction of carbon emissions. As a result the strategy fails to encompass the wider ecological and resource restrictions on both our use of energy and resources – which will impinge upon the large-scale technologies selected within the strategy – and the affect that changing the structure of Britain's energy supply will have upon the operation of the economy in general. Within the Government's strategy the approach is that one unit of renewable energy is equivalent to one unit of fossil energy – arguably this is not the case because each has specific physical and economic characteristics that have implications for the utilisation of resources and the operation of the national economy.

The renewable energy chapter[57] of the *Energy Markets Outlook* report was produced before the recent Renewable Energy Strategy, and in any case contains very little detail as to the future structure of renewable energy production in Britain. Rather than enter into a protracted examination of the viability of the various strategies for renewable energy in Britain (such as the net energy or carbon related to each strategy – a significant factor in saving energy/reducing carbon emissions when considering imported renewable fuels or waste incineration) I've taken a general target figure as the level of energy production from renewable sources in 2020 – 15% of the energy supply is produced from renewable energy sources. I then assume that one fifth of this figure is imported, although on recent evidence it is likely that a far higher level of this energy may be imported[58].

A view of our energy future

Each of the graphs for oil, gas and coal provides a description for how our use of these fuels has changed in the past, and how they are projected to change in the future. What's more valuable is to combine these sets of data, along with the data for nuclear and renewable sources, into a single projection of our past and future energy supply – as shown in figure 6. By combining all the data on production, importation and consumption we can get a picture of how our past energy economy has affected the general economy, and then use this insight to try and frame a projection for what happens when we become dependent upon energy imports. The complication with this is that the total supply figure represents a balance of various commodity imports and production: Where the exports columns reach above the line then Britain is a net energy exporter – *we are producing more than we consume*; where the exports falls below the supply line then we are net energy importer – we are producing less then we consume and so must import energy.

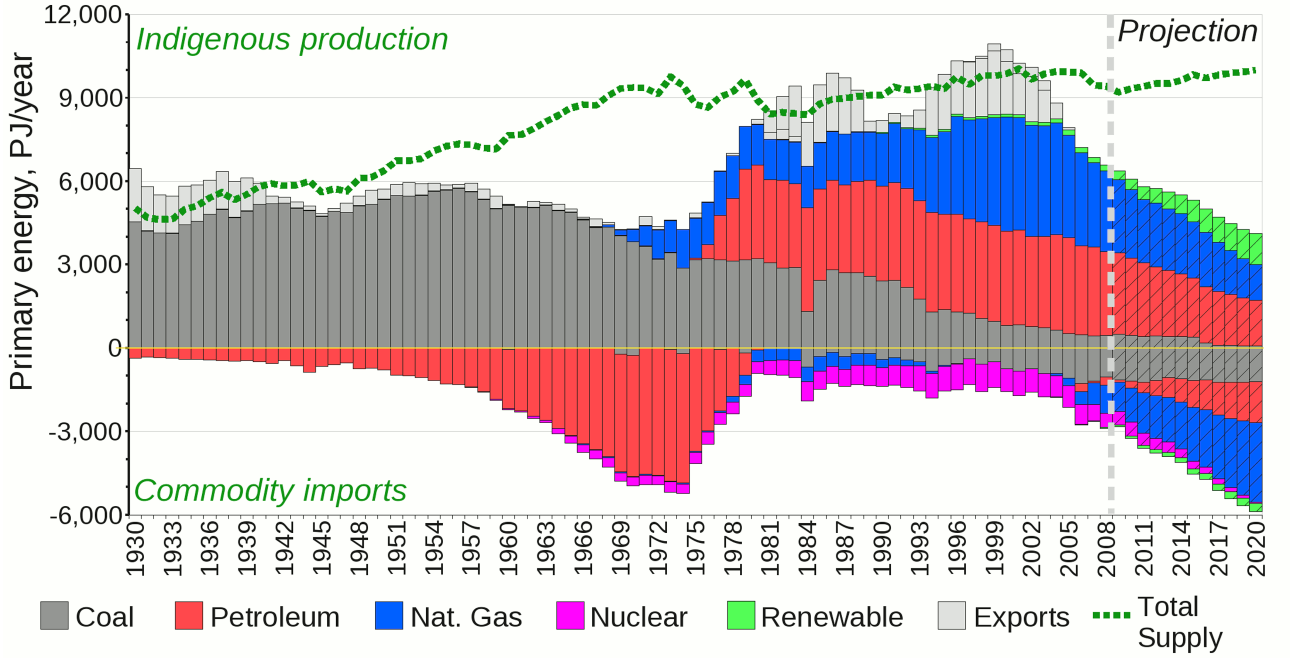

Figure 6. UK primary energy supply production/import balance, 1930 to 2008 with projections to 2020

Although the historic datasets have various starting points, for this analysis I've chosen to start at 1930 – just after the peak of coal production, but more importantly just before the adoption of "consumerism"[59] within mass culture and the transition from using mostly coal, to oil and then finally gas. There are various observations we can make on this graph:

- From its low point following the Great Depression in 1929 until 2008, energy consumption in Britain has increased at an average 1% per year, and from 2009 until 2020 it is forecast to grow at 0.5% per year;
- If you look at the graph then it would appear than in the latter half of the Twentieth Century we were using about 1½ times the primary energy that was used in the first half of the Century, but this is not a valid measure of the productivity of that energy – as the efficiency of utilisation today is at least two to three times higher than in the 1920s the amount of useful work extracted will be a factor of three to five times greater, and as a result the economic productivity of society is greater too;
- Coal, which made up 90% of the primary energy supply in 1930 (imported oil made up a large proportion of the rest), has shrunk in significance and now only makes up 16% of primary energy supply – and this has brought with it a large increase in the economic efficiency of the energy system that has benefited the wider economy, especially the displacement of coal by natural gas (as outlined earlier);
- The value of oil in the economy, although it grew from 8% of the energy supply in the 1930s to 49% in 1973, has reduced with the large-scale use of natural gas and now only contributes 35% of primary energy supply – predominantly in the transport sector;
- Natural gas has been the transformative agent within the energy economy, now providing just over 40% of our primary energy supply – the higher efficiency and lower cost of natural gas has provided a significant boost to the economy over the last two decades;
- Nuclear power, which at its peak in the mid-90s provided 5¼% of the primary energy supply, has declined with the closure of the older nuclear plants, and even if revived is unlikely to provide a timely nor significant solution to the problems of energy supply and importation because it can only solve the problem of electricity, and electricity is a minority of energy consumption overall;
- Renewable energy too, as present and future projects are skewed towards the generation of electricity, only plays a minor role in the energy economy – and even with a large expansion in capacity it cannot off-set the increase in imports that is being driven by the decline in oil, gas and coal production;
- The most important change depicted in this graph is the shift from being an energy exporter to being an energy importer, which has happened twice over the last century – from exporting more than 50% of the value of our primary energy supply in early 1920s to importing 55% by 1974, and from exporting 26% of our primary energy supply in 1999 to importing 30% in 2008, and a forecast of importing 59% by 2020;
- The driving force in energy policy from 1999 onwards is the depletion of our indigenous energy resources – on the EMO projections, from 2009 to 2020 indigenous energy production declines by an average 6% per year, and offsetting this decline is well beyond any proposals for the development of new nuclear or renewable capacity.

In short, within the British economy "peak energy" is

not a theory, it is a hard, quantifiable fact.

The effects of the contraction of indigenous energy sources, and the commensurate increase in energy importation, are the key to understanding how Britain's future economy will be shaped by the changing structure of the energy supply system. We already have an illustration of the potential changes in the economic effects of the last time this happened, in the 1960s and 1970s. At that time we were approaching the 50% level of importation, driven by the growing demand for oil in the economy as a result of the "consumer boom". This progressively took more capital out of the economy, and economic activity slowly declined as a result. The real difficulties emerged following the 1973 oil crisis, when higher prices exacerbated this trend. However, the arrival of North Sea production, and the transition from being an energy importer to being an energy exporter reversed this trend – as noted by Andrew Marr in his recent *History of Modern Britain*[60]:

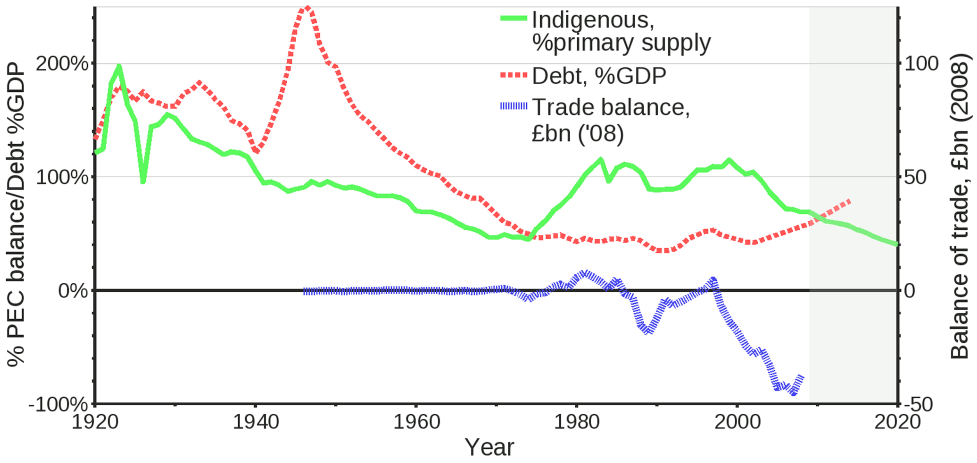

Figure 7. UK indigenous energy production, balance of trade and national debt

> Its impact on the politics and public finances of Britain... can hardly be exaggerated. It helped bank-roll Thatcherism... Some economists... have argued that without it the Thatcher experiment would have collapsed during 1981-2. One observer says: 'The Industrial shake-out of the early eighties, of which unemployment above three million was the consequence, was indeed financed with the considerable help of the oil revenues'. So there, to start with, is an irony. A great new source of national wealth helped to produce mass unemployment, or at least make it politically possible.

Speculating as to what the imminent decline in indigenous production means for the economy in the future is rather difficult; the British economy of the 1960s and 1970s operated on a wholly different basis to the present day economy. Before the neo-liberal reforms of the 1980s Britain was a manufacturing economy, geared towards export production, and which operated on the need to maintain a healthy trade balance; following the 1980s Britain has become a service economy, geared towards importing much of its material needs and creating the required foreign exchange through the global trade in services. How the changing energy situation will affect the vitality of the economy is therefore defined by two factors: the level of trade, but more importantly the relative level of capital flowing out of the economy; and, related to the outflow of capital, the level of national debt.

If we look at the level of indigenous energy production as a proportion of energy supply, the national debt since the 1920s[61], and the balance of trade since the late 1940s[62], we can see a trend emerging that distinguishes the energy-related economic problems of the 1970s from the potential future changes that declining indigenous energy production will create – as shown in figure 7. Britain's overall level of debt was dominated during the Twentieth Century by the cost of fighting two major wars. However, from the 1950s to the 1980s, in part because the changing value of the pound and inflation eroded the value of that debt, Britain was able to reduce its national debt from 250% of GDP to around 40% of GDP. That situation has now changed due to the recent economic crisis; Britain's level of national debt is set to increase from 59% today to a project 79% of GDP by 2014[63]. At the same time the trade balance, due to the shift in the nature of the economy, has moved from floating at around a parity level towards, over the course of the 1990s, a large deficit.

What has kept Britain's economy afloat over the last ten to fifteen years is the surplus produced from the foreign trade in financial services. If we look at the Office for National Statistics "Pink Book"[64], over the last decade the contribution of finance-related services has roughly equalled the overall value of the trade deficit – averaging about £25 billion per year. However, the value of the trade in financial services has been dominated by the trade in hedge fund and debt-related assets that have been called into question as a result of the credit crunch. The first two quarters of 2009 saw a decline in earnings as a result of the credit crunch, but the collapse in earnings from the City of London has been balanced by the collapse in general consumer imports as a result of the recession, and so at present the trade picture in no worse[65] (and in fact, it has improved as a result in the fall of energy prices and the reduction in energy consumption during 2007 and 2008). How this changes when the economy begins to grow again depends upon whether the City can produce large profits without the trade in high-risk financial instruments that created the recent crisis, and the Government bailout that has strongly driven national debt.

Whilst we were an energy exporter the sale of oil and gas contributed between £4 billion and £7 billion to the value of the trade balance each year. Now that we

have become an energy importer this trend has started to drive the value of the trade deficit – as you can see from the graph there's a rough correlation between the value of the trade balance and our level of indigenous energy production (the actual relationship is more complex because it's dependent upon the level of imports, energy prices and the value of the pound). In 2000 the export of energy created a surplus of £7 billion; in 2008 the importation of energy created a deficit of £9 billion – a quarter of the value of the deficit in that year. If we project the surplus forward, assuming that all other factors stay the same but the increasing level of energy imports continues to drive the trade deficit, then by 2020 the deficit might be £10 billion to £20 billion higher, more if prices rise and consumption is not cut.

The economic crises at the end of the 1970s, when Britain had to get a loan from the International Monetary Fund, was the result in a general lack of confidence in the economy. As noted earlier, the possession of energy resources represents both an asset with which to secure loans, and a more general measure of confidence in the status of the economy in general. The risk over the next decade is that once again the outflow of capital from the economy, driven by the rising level of energy imports, and the rising level of national debt, will again create doubt about the viability of the economy. The risk is that if this outflow of capital becomes too great, and the economy suffers as a result, then the doubt about the economy will devalue the pound. Then, as both energy and a sizeable proportion of our national debt is traded in foreign exchange, this increases both the relative value of the debt and the cost of our energy supply (e.g., the recent rise in fuel prices has been driven by the falling value of the pound – wholesale oil prices have largely been static over the course of the past six months). If this were to become a self-reinforcing process then it could trigger a major economic crisis and, as in the late 1970s, we would have to seek help from the IMF in order to secure the foreign exchange required to continue to import energy, food (a large proportion of our food supply is imported) and consumer goods.

Prognosis: *Unknown*

This is uncharted territory. As noted above, in some ways the present situation is very like that of the 1960s and 1970s – relatively the levels of debt and energy importation are mirror of those in the 1960s/1970s. The significant difference today is that we have a high trade deficit For these reasons we can't draw direct comparisons because this changes the dynamics of the relationship between the global and the national economy. I believe that only one thing is certain: *A general decline, and ultimately a crisis within our national economy is likely if we try and proceed as if nothing had changed – that is, we keep importing a sizeable proportion of our energy, food and other material goods*.

If we proceed as if nothing had changed then we have to import energy – *there is no other option*. The only way we can change this outcome is to completely redefine the purpose and structures of the energy industry in Britain, but in turn this would lead to a conflict with the “hands off” approach that has been the policy since the liberalisation on the energy industry in the late 1980s – and which the three major political parties still support. If we want to reduce the deficit, and reduce the value of debt, then this means that as a nation we will have to buy less, and cut-back on existing consumption, all of which would run counter to the consumer-oriented focus of the economy – falling consumer spending would involve a prolonged contraction in economic activity that both the business and the political world will not countenance within their existing economic philosophy. Such an approach is even (in my view, perversely, since growth is not possible within a finite environment) contrary to the Government's stated aim[66] in the UK Sustainable Development Strategy of the, “*maintenance of high and stable levels of economic growth and employment*”.

We cannot change the nature of Britain's energy system without changing the fundamental economic performance of the economy as a whole. Whether we try and go for a renewable energy led approach, or we opt for a more ecologically realistic contraction of economic activity to levels that we can both afford financially and be able to support with a larger proportion of indigenous energy, any change in the energy system must be mirrored by a change in the economy as a whole. The past two decades of economic growth and high-levels of material consumption have been the result of a long process of change, the key to which has been the use of higher quality, more “energy dense”, and thus more efficient sources of energy – the transition to natural gas being the last phase in this process. Renewable energy sources are generally not only less thermodynamically efficient, they are less energy dense and thus the return on investment is less, and so economic efficiency of these systems is lower. A largely renewable energy system, and a system that contracts to use the least amount of energy and resources in order to reduce the demand for imported energy and resources, is therefore an economy that does not grow in the same way – it is an economy of “economic maintenance” rather than an economy of “economic growth”[67].

The greatest difficulty we have today is that no one, either at the top of the political or business world, is willing to hold this debate in public – and in general the views that are represented in the mass media are those that support the culture of the consumer lifestyle and economic growth rather than that of lifestyle simplicity and economic contraction. Within Government there has been a general resistance to entering any debate on the issue of energy depletion, and the economic effects of a more import dependent energy system. Instead the Government's response has been to pledge faith[68] to the International Energy Agency's increasingly doubtful forecasts[69] for future energy supply[70], and to adopt the orthodoxy that the energy market will be able to solve any problems that might arise.

A good example the Government's myopic ap-

proach to the restrictions on future energy supplies is the recent report[71] by the former energy minster Malcolm Wicks. It dismisses the resource depletion issue because it does not accord to the IEA's position, and continues to trumpet the case for markets and innovation as the solution to the problem of energy security. One of the best non-technical analyses of the report came from the Oil Depletion Analysis Centre[72] – "*The Wicks Report rightly contends that energy security should be a 'national priority', but its claim that 'there is no crisis' suggests an alarming complacency at the heart of British energy policy. A more egregious case of famous last words would be hard to find.*". Unless we have an open debate on these matters, where evidence is openly assessed rather than being dismissed because it does not accord to the "business as usual" conception of the liberalised energy markets, then not only will we not make progress, but, rather like the credit crunch and the unheeded warnings in the years leading up to it[73], when the reality of our situation can no longer be avoided the national crisis will be far more serious.

If we look forward, taking into account the biophysical restrictions[74], a major change in the nature of our economy is certain – if only because the reality of our situation dictates that it can't stay the same. That is the political issue that British society must reconcile itself to. For the two decades we have been living a lifestyle that has been sustained by the wealth and power created by indigenous energy resources. That cannot continue, and the process of moving from an economy that has no limits to one that must operate within more tightly constrained limits is going to be a difficult re-adjustment for many: For the political class it means redefining what it is society represents, and what its aspirations should be; for the business community it means redefining what the term "business as usual" really means; and for the public it means reassessing their own material aspirations, and perhaps a return to a far less energetic lifestyle that in terms of energy and material consumption is likely to be similar to the levels which existed in the 1950s or 1960s.

Promoting such a message may not, in terms of today's policy framework, be a realistic proposal for any leading politician. The fact that these truths are ultimately unavoidable, and will have to be addressed at some time in the near future, means that public opinion may be even more adverse when the energy problem spills over into the wider economy; it's therefore a matter of political judgement as to whether the lesser of two evils would be to have this troubling debate today, or to put it off until the resultant crisis requires far more unpleasant action.

Britain is, in microcosm, an example of the transition the entire globe must make in order to adapt to the global peaks in energy and resource production over the course of this century. Potentially we could be the state that leads the way. Just as we were the first to industrialise in the Eighteenth Century, and develop the systems of the modern urban industrial city in the Nineteenth Century, so we can lead the way in managing the inevitable decline of the growth economy and the transition to a less energetic, smaller-scale economic paradigm during the Twenty-First Century.

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Please note that you can find a PDF version of this paper, with click-able links to the various web references, on-line at http://www.fraw.org.uk/mobbsey/papers/appgopo_presentation-20091124.pdf.

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Postscript

Many thanks to the All Party Group on Peak Oil for the invitation to make this presentation.

The graphs, statistical data and information from the presentation, including click-able sources and links detailed in this hand-out, are available on-line from my “work” web site – http://www.fraw.org.uk/mei/

See also my book, *Energy Beyond Oil* (Matador Books, 2005 – paperback, ISBN 9781-9052-3700-5, £15.99) – it outlines the basic principles of how the UK energy economy works, the problems that peak energy will create, and the some of the alternative options for energy supply we adopt. I hope to have the sequel out in 2010... *honest!*

Further information is available free from the Free Range Energy Beyond Oil Project – http://www.fraw.org.uk/ebo/

In the Spring and early Summer of 2010 I'll once again be undertaking a workshop tour of Britain – details available from the tour website, http://www.fraw.org.uk/tour/ (*from early December 2009*). If you'd like to get in touch to arrange a workshop or presentation then please email me – mei@fraw.org.uk

Many thanks to the various Free Rangers who have to put up with my inveterate requests for reality checks and read-throughs, and assisting with work on the issue of energy and human ecology for the last eight years.

Finally, this presentation is taking place just over ten years after the presentation by Colin Campbell to an All Party Parliamentary Group [*The imminent Peak of World Oil Production*, presentation to a House of Commons All-Party Committee, C.J. Campbell, July 7th 1999 – http://www.hubbertpeak.com/campbell/commons.htm], rekindling the resource debate in Britain – *doesn't time fly!* My thanks to Colin (and the other trail blazers) for laying the path that I now follow.

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