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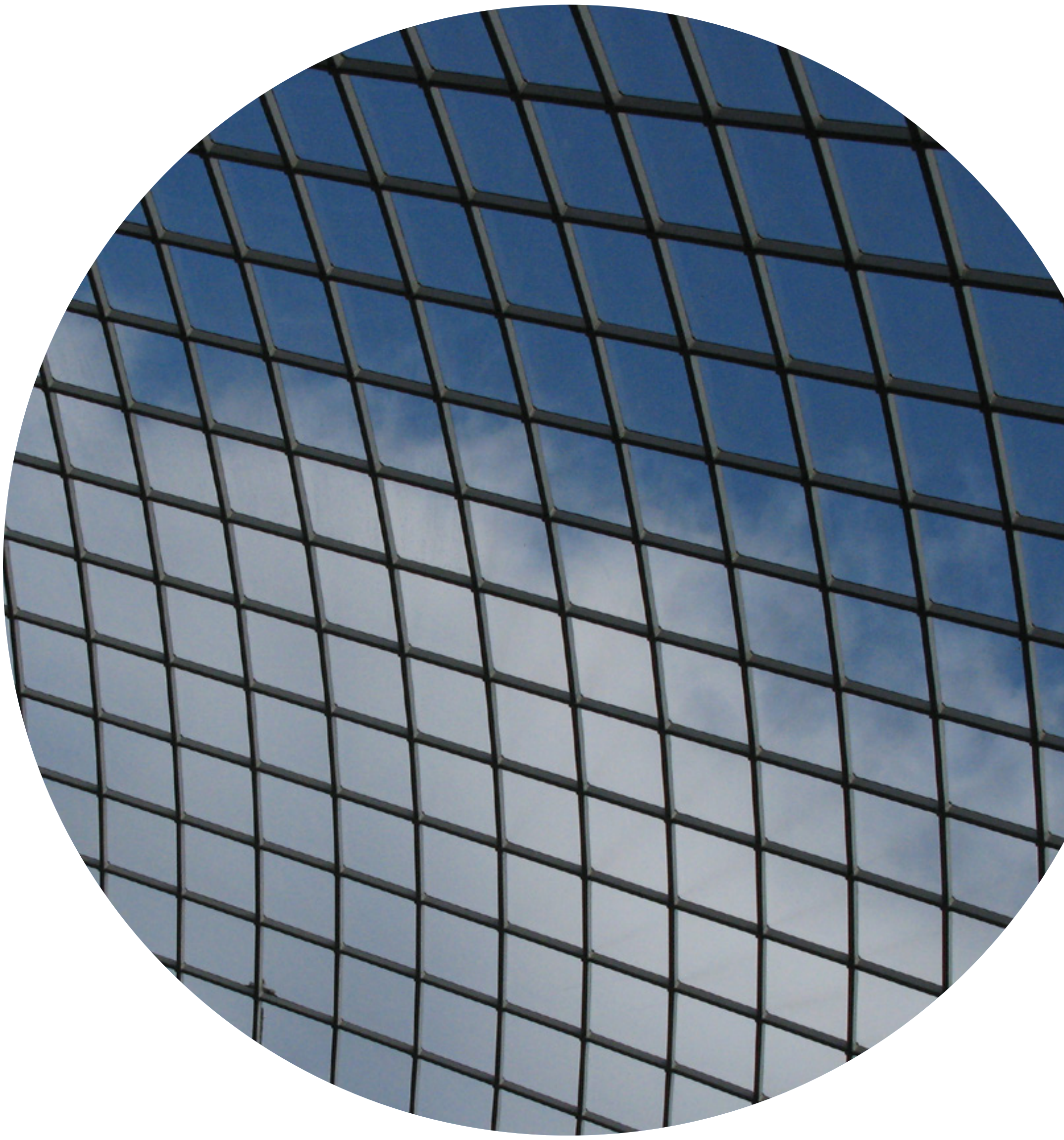

The economics of oil dependence: A glass ceiling to recovery

Why the oil industry today is like banking was in 2006

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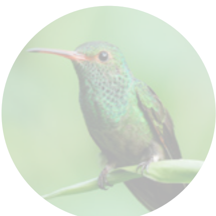
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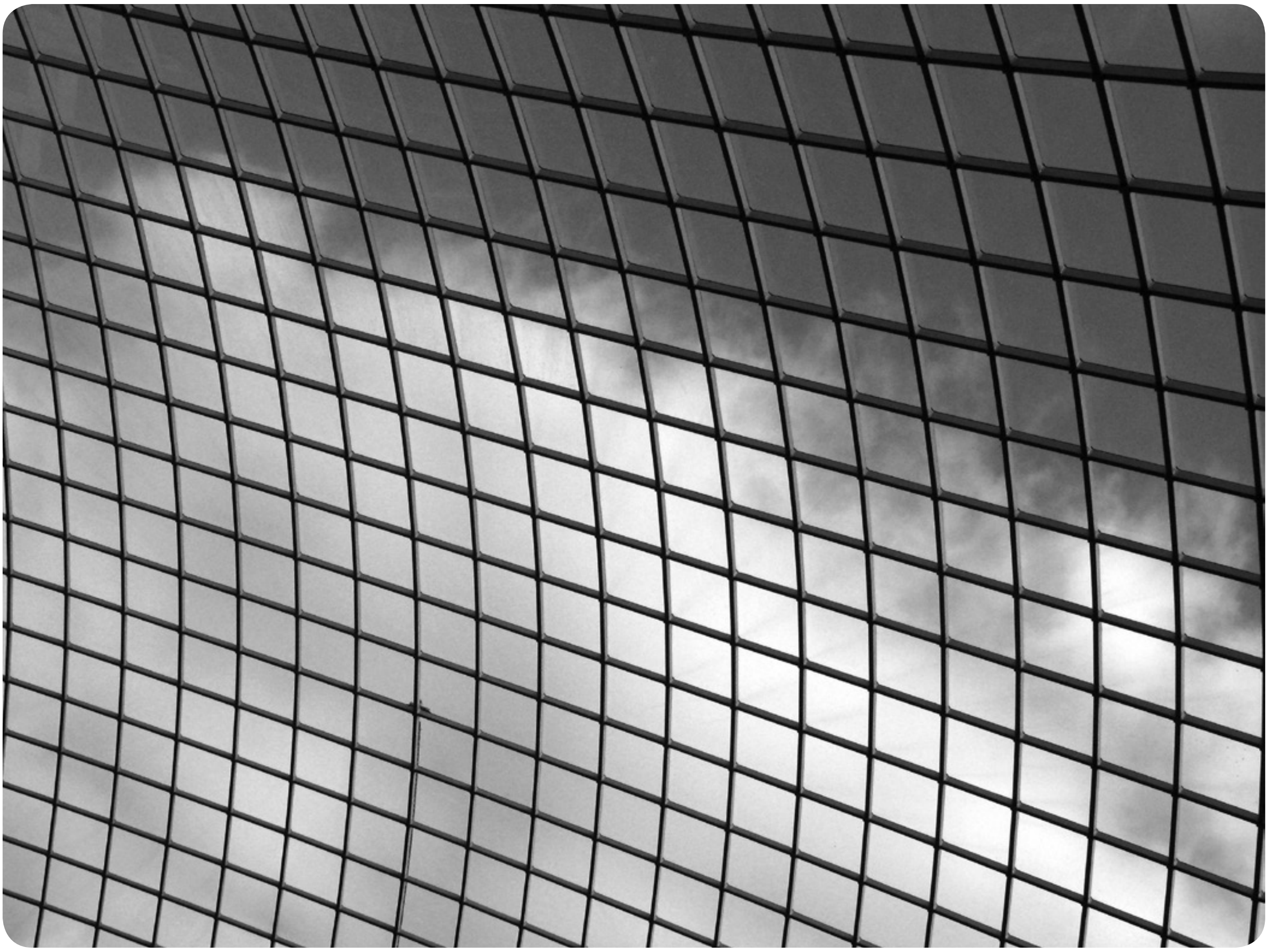


Contents

Executive summary

The current high oil prices have the potential to strangle the economic recovery in many countries.

Fatih Birol (2011) Chief Economist, International Energy Agency, 14 December

As growth in oil production slows and global demand continues to rise, sustained high oil prices and price spikes will have a significant impact on the economy, in effect placing a glass ceiling on recovery of the economy.

The analysis presented in this report shows that this threat is as real and as imminent as was the banking crisis in the middle of the past decade. Without bold and imaginative action, the consequences will cast a shadow on generations to come. Unemployment, underfunded essential services, recession, and depressed and crippled economies provide daily reminders of what the future will hold.

Oil prices and the Great Recession

In the last year, the International Energy Agency (IEA), the International Monetary Fund (IMF), and the G7 have warned that high oil prices have likely been constraining economic recovery from the Great Recession.

Slowing the rate of decrease in oil production can only be achieved by a potential doubling of the price of oil over the next decade. This is likely to usher in the phenomenon of 'economic peak oil'. In this report, we define this as:

> *…the point at which the cost of incremental supply exceeds the price economies can pay without significantly disrupting economic activity at a given point in time.*

Beyond this 'pain barrier', the level of oil prices will have a dramatic effect on a nation's people and its economy, threatening stagnation and hardship.

Using this definition of economic peak oil, our analysis provides a new method for determining the likely timing of peak oil, compared to the more common method of simply looking at new capacity, subtracting depletion, and balancing that against the most likely trajectory for growth.

We find that both approaches seem to point to 2014/2015 as a crunch period.

A crisis of the cost and availability of transport fuels

In this report we argue that the current economic crisis is neither an oil crisis nor an energy crisis, but a crisis related to the cost and availability of transport fuels – gasoline, diesel, jet kerosene, and ship bunker fuel. These liquid fuels account for up to 80 per cent of all oil usage.

Transport fuels link all elements of the economy. If every linkage costs more due to sustained high oil prices, all costs will increase, the economy will slow, and inflation will rise.

The vulnerability of oil-importing economies

Nations that are increasingly dependent on oil imports face two threats over which they have very little control.

First is the increasing consumption of oil in the producers' own countries. Saudi Arabia, traditionally the largest oil exporter in the world, exported less oil in 2011 than it did in 2005 or even 1985. This is despite large increases in production in recent years.

Second, some importing countries may be better able to accept higher prices for oil. In mature high-consuming economies like the USA, oil prices greater than $90 per barrel will have a significant economic impact. However, industrialising economies, such as China, are thought to be able to tolerate prices in the $100–110 per barrel range.

Softening the impact of high oil prices

Softening the impact of high oil prices can only come from three sources: greater supplies of low-cost oil, greater efficiency in use of oil, or a transition to a low-carbon economy.

New sources of low-cost oil: No new sources of low-cost supplies are known. For example, optimism about shale oil fails to recognise that the additional supplies represent a higher cost. As oil is priced by the cost of incremental supply and this is a high cost, significant falls in oil prices can only occur if there is a major recession or depression, similar to that seen in the second half of 2008.

Improved efficiency in oil use: Greater efficiency in use occurs continuously, but it is relatively slow, occurring at a rate of just 2–3 per cent a year. A major drive to increase efficiency in use could be achieved through government incentives and regulation, but demand management would be necessary to avoid increases in efficiency leading to growth in demand – the so-called rebound effect.

Transition to a low carbon economy: The transition to low-carbon economies will reduce the impact of high oil prices. Yet despite the need to and the knowledge of how to make this transition, the policies to manage the economy in this way remain mostly absent and slow to progress.

Supporting the transition to a low carbon economy

The only option to soften the impact of high oil prices that is likely to meet the magnitude of the challenge is a transition to a low-carbon economy. But this will require political leadership and policy certainty to create a long-term, sufficient and consistent incentive structure for renewable energy.

We recommend the government employs available and new mechanisms for public sector finance, such as a Green Investment Bank to change investor behaviour in favour of new, low carbon sectors.

Adaptive responses such as investment into mass public transit systems, more efficient vehicles, people travelling less due to home working, and cheaper, low carbon energy alternatives will also all help.

The urgent need for government contingency planning

In addition to issues of security and sustainability, the impact of economic peak oil is another important reason to reduce an economy's energy intensity and dependence on oil.

Historical evidence shows that shocks lie in wait for unprepared nations. Well-prepared economies, however, should still prosper.

Because of this, we recommend urgently that:

- The government make public any assessment it has made on scenarios for economic peak oil and its likely impact on the UK economy and population.
- The government make public what, if any, permanent institutional mechanism, beyond the current Civil Contingencies Committee (COBRA), has a remit to assess the overarching implications of economic peak oil for the UK.
- The government make public which major spending departments have contingency plans for peak oil, and what the assumptions behind any such plans are.
- Should any major UK economic sector lack official contingency planning for economic peak oil, the government should explain why, and with what confidence such plans are absent.

Introduction

Today, we are so dependent on oil, and oil is so embedded in our daily doings, that we hardly stop to comprehend its pervasive significance. It is oil that makes possible where we live, how we live, how we commute to work, how we travel – even where we conduct our courtships. It is the lifeblood of suburban communities.

Daniel Yergin (1991) The Prize[1]

In summary
We have now reached a stage in our exploitation of fossil fuel resources where economic growth, as we have known it over the past century, has come to an end.

The cost of continuing to increase our supplies of oil and gas has reached a level where recession has become endemic. Each time the economy begins to recover from recession, the price of oil will increase and send the economy back into recession.

The only possible response to this situation is very clear. It is the same response that is needed to combat climate change – end our dependence on fossil fuels.

The year is 2006. Gordon Brown has just boasted about the UK's successful 'light touch' financial regulation in his Mansion House Speech.[2] He is proud of spurning the 'siren voices' that called for a regulatory crackdown. The following spring he will boldly announce the end of 'boom and bust'. Huge profits are being made in the City, confidence is high, and the economic tide is rising. The banks, politicians, and regulators think that innovation has designed risk out of the financial system.

What could go wrong? Now we know. Right across the political spectrum, a financial mirage had held commentators in the media, the market itself and the regulators, whose job it was to oversee the banks, spellbound. Any voices that warned to the contrary – and there were such voices, including ours– were derided or ignored.[3]

Now, as the economy stands in 2012, without bold and imaginative action, the consequences of complacency over the banking system will cast a shadow on generations to come. Unemployment, underfunded essential services, recession, and depressed and crippled economies provide daily reminders.

Contrary to recent reassurances that the world faces no problem in terms of its continuing dependence on, and use of, fossil fuels, especially oil, we are in danger of repeating the catastrophic complacency that characterised the banking sector up until 2006.

Living in the Oil Age

We are living in the Oil Age. Since the beginning of the Industrial Revolution, the world has experienced a period of rapid economic growth. Over 97 per cent of humanity's financial wealth has been created in just 0.01 per cent of human history.[4] The driver behind this phenomenal expansion is a complex combination of abundant cheap fossil fuel energy that is relatively easy to extract, in addition to the spread of transport and communication technologies, the accumulation of knowledge, the evolution of science, the increase in population, and rising levels of personal consumption.

Although some experts forecast that oil would remain cheap and plentiful until at least the middle of this century, in the past five years the situation has changed dramatically. Consumption of oil has risen to nearly 33 billion barrels a year (some

90 million barrels per day) but the price has rocketed from $10 a barrel at the start of the millennium to over $100 today. A key driver of this dramatic increase is because sources of cheap 'easy' oil are dwindling rapidly.

We have now become accustomed to the assumption that the world economy will continue to grow indefinitely, providing us with an endless increase in the supply of products and services, most notably of food and transport. But, this cannot last forever.

As Charles Hall and Kent Klitgaard argue in their book *Energy and the Wealth of the Nations*:

> *…if oil, the most important energy source to fuel the economy, goes through the inevitable path of growth, plateau and decline (i.e. peak oil) and the financial market is built on the assumption of unfettered growth, then something has to give. Eventually the aspirations and assumptions of indefinite growth in assets, production, and consumption must collide with the reality of an ever-constricted source of energy that fuels real growth.*[5]

Peak oil concerns the complex economic impact of what happens after the world reaches the point of peak affordable oil production – when rates of flow part company with demand in such a way that there is a major impact on price. Beyond that point, obviously there will still be oil (and other fossil fuels) but the dynamics, cost, and energy needed for increasingly difficult and polluting production change significantly.

If demand continues to rise over the coming decade and beyond, this will act to intensify the impact of peak oil on the economy. So, while there will still be oil, the key question will be whether it will be affordable for our economies. If not, what will the economic, social, and environmental consequences be, and what can governments do to reduce the economic threats they pose?

With the development of unconventional fossil fuels such as shale oil and gas,[6] there is febrile speculation that our oil-dependent economies have been given a 'get out of jail free' card. Opinions are divided, however, mainly by whether this means a new boom time: 'It's unbelievable, the opportunity', the *New York Times* reported one former coal miner saying in Washington County.[7] Or, a complete disaster – if climate change is to be limited to below 2 °C, less than 20 per cent of the available, and economically recoverable, fossil fuel reserves can still be burned between today (2012) and 2050.[8]

Over the past decade, awareness of peak oil has slowly gained ground. However, there are signals that the debate is changing again. A new oil and gas rush has brought both fear and delight that the end of the oil age is not in sight after all. Or, at least, not such that we need worry for the economy.[9,10,11]

Either way, the belief that peak oil is an important issue in its own right for the economy and our livelihoods, appears to have receded into the distance. Such a conclusion ranks in terms of complacency with the over-confident thinking in 2006 on banking and finance. But, partly this is to do with popular confusion about what peak oil actually is, and what the societal costs are.

This report presents a new analysis of the threat of high and sustained oil prices to economic growth and recovery from the current Great Recession in the UK. Strategies for decoupling the economy from fossil fuel use and dependence are well understood, but insufficiently acted upon. Less well known or understood is the state of national contingency planning for, and awareness of, economic peak oil. In the concluding section of this report, we make a series of recommendations to government to ensure that the UK is well equipped to respond to future sustained high oil prices.

Unless nations prepare to break the relationship between fossil fuels and their economy, this will prolong or prevent recovery from the current economic crisis, in effect, placing a glass ceiling on our recovery.

The relationship between oil and the economy

From a physical point of view, industrial production is not possible without energy or more specifically the performance of physical work (including the transportation of goods) and associated information processing. Taking this view, energy or *exergy* – the energy available to do useful work – is a key factor in modern industrial economies. Logically, therefore, the economy should be extremely sensitive to prices and restrictions on use.

Currently energy only features as a minor component in orthodox theories of economic growth, if at all. Most macroeconomic models seem to be blind to energy constraints. Yet there is a growing body of evidence that demonstrates exergy plays a dominant role in the economic prosperity of industrial economies.[12,13,14]

In July 2008, the price of Brent Crude spiked at $147 per barrel after sustained increases since the turn of the millennium, and faster increases since the start of 2007 when the price more than doubled. This helped to push up the price of other commodities including food. This period also overlaps with a dramatic rise in the volume of complex financial instruments that later proved to be central to the financial crisis.[15] A similarly dramatic increase in income inequality occurred over the same period.[16] The latter saw a negative spiral of poverty and debt reinforced by the high cost of housing, food, and energy.

Commodity prices have a major impact on the global economy and people's livelihoods. In the autumn of 2008, spurred by the oil price, speculation, and crop failures, the rising cost of food forced around 75 million additional people below the hunger threshold.[17] Some economists went as far as to suggest that the oil-price spike triggered the sub-prime debt crisis in the USA, as the knock-on effect on other prices pushed hard-up, low-income families with subprime mortgages into defaulting on their loan payments.[18,19]

The UK and other states in the OECD are currently facing falling real incomes, rising unemployment, falling economic growth, and rising inflation.[20] Yet, the measures in the UK's 2011 budget that grabbed attention were a 1p cut in fuel duty and other policies to soften the impact of volatile oil prices on consumers. A powerful lobby, including well-supported e-petitions on the official government website, to stop the proposed longer-term increases in fuel duty was successful. In June 2012, the Chancellor, George Osborne, scrapped a proposed 3p increase in duty.

Compared to the relative importance economists might ascribe to incremental changes in fuel tax, politically they are contentious and given much more weight than they merit. This might also reflect an overly sanguine attitude towards resource scarcity issues held more generally in conventional economic circles.

All this implies that the price of oil is more fundamental to the economy than is generally recognised in economic policy-making, and that price spikes or sustained high oil prices have severe impacts on western economies.

During 2011, oil traded in the range of $100–$125 per barrel with the price at the pumps being over 130p per litre. The high proportion of fuel duty in the final price to the consumer (70p including VAT) has the effect of insulating pump prices, up to a point, from the volatility of the price of crude oil. Looking forward, however, one investment bank, Goldman Sachs, that forecast prices increases in 2007/2008, predicted that prices would rise again to $130 in 2013. It highlighted the repeated risks:

We continue to view the crude oil market as navigating between the currently tight physical oil markets and the threat that the European debt crisis could trigger a global economic recession in the near future, which would lead to a sharp drop in oil demand.[21]

This statement warrants closer examination. It points out that oil demand is dependent on economic growth. But to what extent is economic growth dependent on oil supply, or to be more precise, oil supply at an affordable price? The statement could be re-ordered as follows:

We view the economy as vulnerable to tight physical oil markets and the threat that the inevitable price increases required to bring demand into balance could trigger a global economic recession in the near future, which would compound the European debt crisis.

The impact of oil prices on the economy goes beyond the immediately apparent effect on UK consumers. Indirect impacts and feedbacks come into play.[22] These include:

- The UK's main export markets may suffer a squeeze on aggregate consumer demand and business investment, adversely affecting trade in invisibles, such as financial services, as well as manufactured goods.

- The rapid run down in UK sector oil, gas, and to a lesser extent coal production is producing a balance of payments pressure that is likely to result in further depreciation of sterling over time, with a resulting reduction in the purchasing

Box 1. Energy return on investment

Energy return on investment (EROI) is a measure of the efficiency with which energy is used to extract energy resources from the environment. In other words, it provides a measure of how much energy is left over after correcting for how much of that energy is required to generate (extract, grow) a unit of the energy in question.[23] It can be used as a proxy to estimate generally whether the cost of production of a particular resource will be high or low, or perhaps even to estimate energy costs themselves.

As ecological systems with a large energy surplus have a competitive advantage, so too does the economy. Indeed, the huge growth in the global economy can be attributed to the switch from low EROI wood (30:1) to coal (80:1) and finally to oil (100:1). Our economy thrives on high EROI energy sources.

Not only is the growth rate in production of oil falling, oil production is experiencing diminishing returns. This is clearly illustrated by the evolution of EROI for oil in the USA over time:[24]

1930s, EROI = 100:1

1970s, EROI = 25:1

1990s, EROI = 11–18:1

One study found that the global average EROI for oil in the first half of the 2000s was approximately 20:1. And, if current trends continue the ratio will change to 1:1 in the next 20–30 years.[25] In other words, at this point oil will cease to be a net source of energy.

While many estimates suggest that resources of unconventional oil may well exceed those of conventional oil, increasing amounts of energy, and therefore capital, will be required to extract the resource. Unconventional oil is estimated to have an EROI of around 3:1, bearing in mind that once an EROI approaches 2:1, the oil might as well be left in the ground, given the additional energy required to refine it into a useful fuel.[26]

The concept of EROI is a useful tool for explaining why oil prices – particularly from new, unconventional sources – are unlikely to resolve the challenges posed by economic peak oil.

While techno-optimists argue that technological advances will ensure a continuous supply of cheap energy, energy expert Charles Hall, who developed the EROI concept, argues that there is little or no evidence that technology is winning over time because the EROI keeps falling.[27]

power of the UK consumer in relation to imported consumer goods.

Those who put faith in the dynamic nature of markets are more sanguine. As supply tightens, they argue, the oil price rises, which in turn triggers:

- increased supply becoming viable at the higher price;
- substitution of oil for alternative products; and
- a fall in oil demand.

In this framework, a belief in efficient markets suggests that any policy intervention to curb oil use is unnecessary or worse, counter-productive. Price is meant to be the magic wand that rebalances energy markets. Yet, in the UK, most easy adaptations in terms of fuel switching were done in the 1980s, when North Sea gas spurred the 'Dash for Gas'.

Further adaptation will run into the same challenge as new oil production capacity – incremental changes will be progressively more expensive and the right investments may be economically unaffordable (Box 1). Even if further adaptation and fuel switching happens, negative impacts will still be felt if it does not happen quickly enough.

Adaptation at the aggregate scale may hide many problems at the micro-economic level. For example, what will the effect of asymmetric adaptation be among households in different income brackets, and among civil society, public, and private sectors? In spite of what is known about the poor suffering first and worst when energy prices go up (Box 2), insufficient analysis has been done on the distributional impacts of higher oil prices. Different demographic groups – according to age, income, being rural or urban, living alone or with family – all have different capacities to change their behaviour, and different degrees of vulnerability.[28]

Vitally, successful adaptation at the level of the whole economy cannot, by any means, be taken for granted. Debt problems, already dramatically worsened by bank failures and the financial crisis, which passed immense costs onto the public purse, combine with balance of payments problems to affect energy-importing nations like the UK. Indeed, links between deficits, oil prices, and the euro crisis in southern Europe have been drawn.[29]

Box 2. The societal impacts of peak oil

Because energy costs account for a disproportionately high share of the incomes of poor households, rising oil prices will have a disproportionate impact on people in poverty.

In the UK, average household spending on energy in the home (electricity, cooking, and space heating) is around 5 per cent of household income when rescaled to take into account different household size and composition.[30] Households living in fuel poverty, however, spend 10 per cent or more of their income to maintain adequate warmth.[31] This is typically due to low income, poorly insulated accommodation and old or inefficient central heating. The UK's ageing and poorly insulated housing stock explains why fuel poverty here is worse than in other European countries

Schemes such as Warm Front that aimed to reduce fuel poverty led to improvements in energy efficiency in fuel-poor households. However, since 2004, these improvements have tended to be offset by rising prices. This means that more households on the margins of poverty have been pushed below the income threshold by increased energy costs.

In 2010 there were 3.5 million fuel-poor households in England alone, almost three times the number at the decade's low point of 2003.[32] Around one in six British households were fuel poor, in spite of a government target at the time to eradicate the problem.

There is extensive epidemiological evidence showing that fuel poverty has a severe impact on physical and mental well-being.[33,34,35] Older people, children, and those who are disabled or have long-term illnesses are particularly vulnerable. Fuel poverty is most common in private, rented accommodation and in single-person households, whose share of the overall housing market has increased.[36] Rural areas are also more vulnerable than urban ones.[37] For those who live in fuel poverty, tough decisions have to be made, such as sacrificing heat and warmth for food.

Economic peak oil

Peak oil is defined as the point at which production of cheap, conventional oil peaks, plateaus, and begins a long-term decline relative to continuing demand. As Robert Hirsch, former advisor to the US Department of Energy has argued, it is not about energy in general, but about liquid fuels in particular.[38] This matters because liquid fuels are particularly critical to our economies.

Transport depends on liquid fuels to link all parts of our economies: from farm fields to food processors to shops, from mines to mineral processors, factories and end users, and from homes to workplaces, high streets, and shopping and leisure destinations. The various products made from oil dominate all forms of transport and transit. If oil becomes too expensive, economic activity slows and inflation rises.

Hirsch's analysis illustrates that the world currently has $50 trillion to $100 trillion of capital equipment designed to run on liquid fuels which cannot easily, quickly, or at all, be adapted to a different fuel source.[39] For example, while there are tens of thousands of electric vehicles and 14 million gas-fuelled vehicles on the road today, this is dwarfed by approximately 930 million vehicles that run on gasoline and diesel. All but one aircraft runs on kerosene, and almost all ships are fuelled by oil. The scale of the challenge to transition towards alternative transport links is clear, and raises questions about the long-term sustainability of our interdependent world and global supply chains.

Divergent perspectives on peak oil

Geologists explain peak oil as an inevitable geological phenomenon. Oil was created in a process taking millions of years, and reserves are not being added to. Although the precise scale of total recoverable reserves is hard to know, their finite nature is certain.

Many economists, however, look at the issue quite differently. They are less concerned with physical limits. Instead, they argue that scarcity in supply drives prices up, sending a signal to the market. Sources, previously considered uneconomic because of the cost and difficulty of their extraction become attractive, as does the development of other forms of liquid fuels, such as biofuels. In this view, peak oil is not a wall or a cliff, but merely a road junction.

Both points of view are part of the picture.

Economic peak oil

In this report we make the case that peak oil is largely an economically driven phenomenon caused when the cost of incremental supply exceeds the price economies can pay without significantly disrupting economic activity at a given point in time. In other words, while hard to pinpoint, there is an oil price, beyond which economies begin to experience severe negative impacts depressing economic activity and causing extreme social hardships. Key industries suffer with major knock-on effects on disposable incomes.

In a recent International Monetary Fund (IMF) study, a new model of the world oil market was developed to reconcile both the geological view – focused on physical limits – and the economists' view – focused on the influence of the price effect, such as spurring further technological innovation.[40] The authors of the study tested the model against others by looking back at actual events. The new model consistently outperformed existing models in forecasting oil prices and oil output, producing a much closer fit to the real economic impacts of dynamics in the oil sector than models from either, separate viewpoint.

Overall, the study implied that incremental increases in oil supply are set to slow, and any further increases in world oil production will come at the expense of a near doubling in 'real' terms over the next decade. The report concludes:

> *We suspect that there must be a pain barrier, a level of oil prices above which the effects on GDP becomes nonlinear, convex. We also suspect that the assumption that technology is independent of the availability of fossil fuels may be inappropriate, so that a lack of availability of oil may have aspects of a negative technology shock. In that case the macroeconomic effects of binding resource constraints could be much larger, more persistent, and they would extend well beyond the oil sector.*[41]

Their conclusions are supported by a growing suspicion that low levels of economic activity seen in most western economies in 2011 and 2012 are already due to the inhibiting effect of oil prices.[42] Over the past 18 months, for example, the International Energy Agency (IEA) has repeatedly warned that the price of oil is acting as a barrier to recovery from the banking and financial crisis of 2007/2008.[43]

Peak oil: real or not?

The technology to extract difficult, harder to access, 'unconventional' oil reserves has developed quicker than previously expected.[44] At the same time, optimistic reports about the potential for a new boom in oil production are attracting considerable attention.[45,46,47]

The main arguments of this new boom are, however, flawed and based on generous assumptions relating to:

1. the rate of decline of production from existing oil fields and the potential production capacity of oil fields in Saudi Arabia and Iraq;
2. assessments of the level and duration of flow from new, unconventional sources; and
3. the costs of new production capacity.

One such report, its presentation and the discussions it provoked, became a microcosm of debate on the broader issues surrounding peak oil. Written by former executive of Italian oil company Eni, Leonardo Maugeri, and funded by the oil company BP, the report argues that the industry has a bright future.[48]

1 Decline of production and potential production capacity

Using a decline rate that is less than half the size of the IEA's estimates, Maugeri argues that new production capacity will soar to 110 million barrels per day (bpd) by 2020, compared to the 93 million bpd the IEA expects to be produced this year.

Maugeri and others have also taken on trust the production capacity Saudi Arabia claims, but has yet to prove. He is similarly optimistic about a large, long-promised, and yet to be delivered growth in production from Iraq.[49]

Not everyone in the industry itself shares this level of confidence, however. Yves-Louis Darricarrere, president of Total's oil and gas exploration division, has a different view. In early 2012, he publicly stated: 'We think it will be difficult to produce more than 95 to 97 million barrels per day in the foreseeable future.' To meet demand and compensate for declining fields, Darricarrere argued that two new Saudi Arabias would be needed by 2030 to produce an extra 25–45 million bpd.[50]

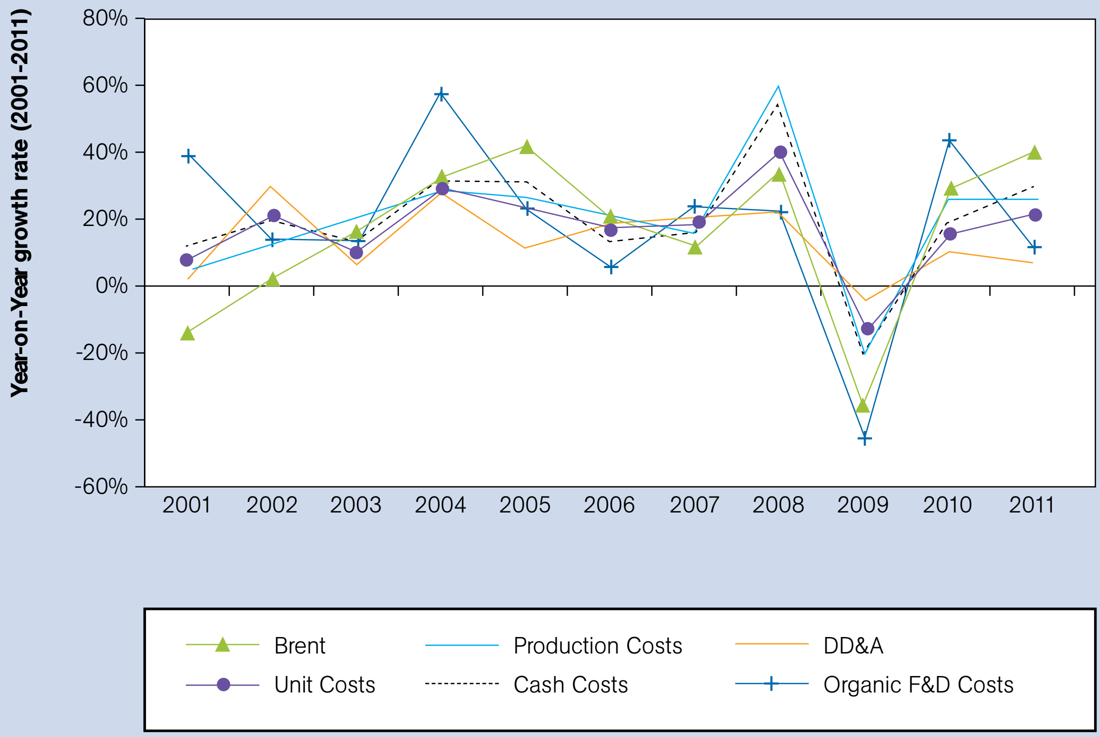
2 Potential of new, unconventional sources

Another crucial error often made is the assumption that the potential of unconventional oil sources like shale and tar sands, represent like-for-like replacements for the 'easy oil' of, for example, Saudi Arabia's volume in the last century. Extracting oil from Saudi oil fields requires very little energy compared to that needed to extract shale oil.

The IEA concedes that the production of conventional 'easy' oil peaked in 2006; this means that any further growth has to come from unconventional sources.[51] However, extracting unconventional shale oil from, for example, the large and much discussed shale deposits of the Bakken formation in North Dakota, is not the game changer for peak oil that some would like it to be.

The Bakken formation has been known about for decades; oil was first produced there 50 years ago. Yet, optimism about the performance and endurance of wells dug into the formation are belied by North Dakota's own Department of Mineral

Figure 1. Relationship between Brent oil price and the marginal cost of production, cash costs, production costs, unit costs and finding and developing (F&D) costs.[55]



Resources. Its figures show wells undergoing a much faster rate of decline in production.[52]

This also highlights the tendency to minimise the bad news and play up the good. Production from North Dakota, for example, is rising fast, but output from Alaska is steadily declining. Put the two together and production is fairly constant.

3 The costs of new production capacity

Former industry executive Colin Campbell points out that Maugeri also assumes that new capacity can be developed at a cost of around $70 per barrel.[53] Based on recent trends published by Bernstein Research, however, the actual production costs for the 50 biggest listed oil producers – at $92 per barrel in 2011 – are likely to rise to $100 per barrel during 2012.[54] Their report concludes: 'The longer term outlook for higher oil prices continues to be supported by the rising costs of production.'

The importance of the focus on production costs is that they exert a very strong influence on the actual price of oil. This is illustrated in Figure 1 which shows the strong correlation between the growth in the marginal cost of production, cash costs, production costs, unit costs, and finding and developing (F&D) costs. According to Bernstein Energy, over the past 10 years, these costs have grown at between 10–20 per cent Compound Annual Growth Rate (CAGR) in line with oil prices which have increased at about 16 per cent CAGR in the past decade.

A charge of 'crying-wolf,' levelled at environmentalists since the 1970s, is similarly laid at the feet of those who raise the peak oil issue. Richard Heinberg, US energy analyst, highlights the irony of the oil optimists' own track record:

Around 1998, when the modern peak oil discussion was just hatching, the International Energy Agency, the US Department of Energy [DOE], and the US Geological Survey [USGS] all issued forecasts that world oil production would grow steadily to achieve 120 million barrels per day by 2020, while prices would remain at the level of $20 per barrel (in 1998 dollars) even beyond that date. In 2004, when it was already clear that those forecasts had no chance of being realized, Daniel Yergin declared that oil prices would stay at $40 per barrel for the next 15 years. Neither the IEA, nor the DOE, nor the USGS, nor Daniel Yergin foresaw a situation in which crude oil production would flat-line for seven years beginning in 2005, or in which prices would whipsaw to record highs of up to $147 a barrel as they did in 2008.[56]

Onwards from M King Hubbert who, decades ahead of anyone else, predicted the peak of North American oil production to an astonishing degree of accuracy, those alerting the world to the likely impact of peak oil, argues Heinberg, have the better, and more useful track record.

Taking account of both economic and geological views, as the IMF report did, means sustained increases in oil prices – described by the authors of the IMF paper as 'uncharted territory for the world economy' will be very different to past experiences when prices have spiked and remained at very high levels for a few months.[57] The authors also allow for worse outcomes in which the 'lack of availability of oil may have aspects of a negative technology shock', leading to 'macroeconomic effects of binding resource constraints which could be much larger, and more persistent'.[58]

The IMF's caution is a valuable antidote to all those who casually talk of $200 per barrel of oil without asking themselves what the economic impact will be when every transport linkage in our economies costs significantly more.

Reconciling geologists with economists: A new approach

Conventional cost curves show incremental development costs ranging from $45 per barrel for Saudi oil, to $90 per barrel for Canadian tar sands and Venezuelan Orinoco heavy oil (Table1). Most of the new, incremental deep-water sources fall in the $70–80 per barrel range.

Actual costs on average for the world's 50 biggest producers already appear to have strayed beyond this range of costs for new production capacity. Costs estimates can, of course, vary greatly depending on what is included and how finances, profits, and overheads are treated. These are estimates of the prices needed to justify a new, large development.

The need to balance income and expenditure by OPEC producers

For most OPEC producers, oil and gas revenues are their principal source of income and government revenue. When oil prices rise, producer government expenditure tends to rise to match income, absorbing most if not all gains quickly. In exceptional circumstances, such as the OPEC events of the 1970s, it can trigger other major impacts. Then, the recycling of surplus petrodollars laid the foundations for the debt crisis that subsequently hit much of Africa and other poor countries that became heavily indebted. The sudden rise in fuel prices also triggered recessions in wealthy countries including the UK and the USA.

The so-called Arab Spring has added a further twist to this process. Governments in a number of OPEC countries and some non-OPEC producers have dramatically boosted government spending on their security apparatus and on social hand-outs, to reduce the risk of losing power through upheaval.

Saudi Arabia dramatically illustrates this phenomenon. On the latest budget projections Saudi needs an oil price of $90–100 per barrel in order to balance its revenues and expenditures; otherwise it will run deficits and consume financial reserves. Many other OPEC members rely on a comparable oil price to balance income and expenditure (Figure 2). Keeping prices at a high plateau is therefore in their interests. Even if circumstances conspire to force prices down, the unintended consequence could be greater instability in producer countries, and therefore greater insecurity in oil supplies.

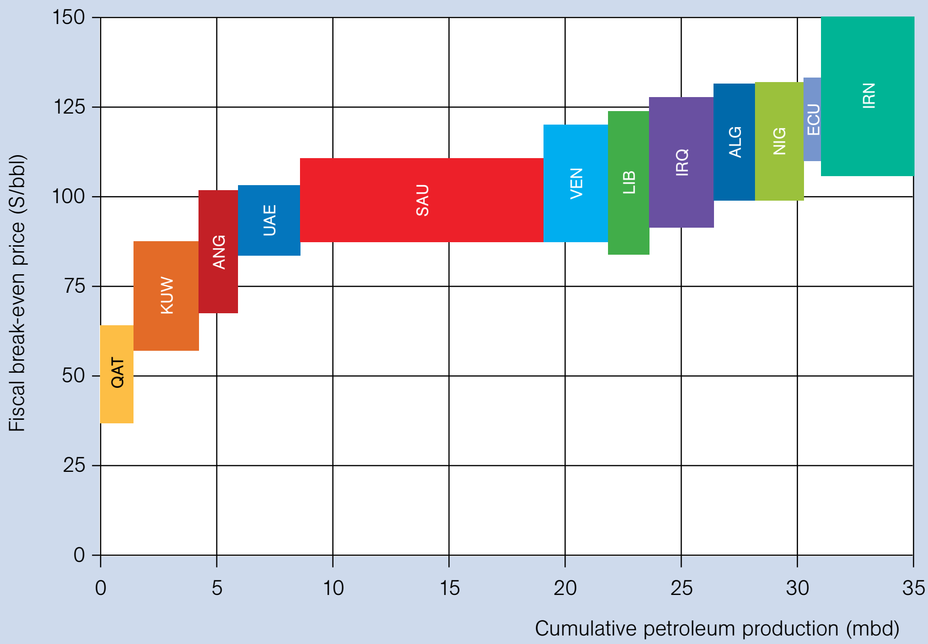
The role of Saudi Arabia

As Saudi Arabia is the only oil producer with significant reported spare capacity, its policies effectively set the world selling price for oil. Yet other factors complicate the picture. Saudi Arabia has major domestic infrastructure developments planned and

Table 1. Incremental development costs

Type of oil	*Cost ($/ barrel)*
Saudi	45
Canadian tar sands	90
Venezuelan Orinoco heavy oil	90
Deep-water sources	70-80

Figure 2. OPEC fiscal cost curve for 2011. Bar width indicates the country's production, while bar heights show break-even prices in order to balance income and expenditure.[59]



in progress. The energy demands of those projects are likely to be met by Saudi oil. So, even if Saudi can deliver on its claimed spare capacity, there is no guarantee it can be wholly relied upon by the international community.

All other suppliers are effectively price-takers and will sell at the highest price available to them. Producers other than Saudi Arabia have the power to drive prices higher by reducing production. But there are few, if any, prepared to forgo current income in the hope of greater income at a later date.

Effective incremental oil supply curve

The effective incremental oil supply curve (EIOSC) describes how the price of oil sits within a band. The lower threshold is set by the cost of production, and the upper by the point at which demand is destroyed, i.e. people stop wanting to pay for it.[60] In reality, this band is surprisingly flat, somewhere in the $80–$110 per barrel range. For the immediate future this is the most likely range for oil prices. A recession can drive prices down to the $40–60 per barrel range but this is likely to be relatively short-lived where economic revival, triggered by the lower oil price, drives oil prices higher again.

As described, the cost of developing new productive capacity is going up, and is likely to continue to do so. New 'easy' oil production has largely gone. As of the first quarter of 2011, the IHS/CERA Upstream Capital Costs Index (UCCI) – a commercial measure of cost rises in the industry – went up to 218 from a 2009 low of 200. It is now on trend to pass the third-quarter 2008 peak of 230.

Higher government spending by oil producers tends also to push up the EIOSC. The rise is driven by the dynamic of depletion of the low-cost, easily exploitable oil and its temporary replacement by less accessible and higher-cost oil. For this reason, any significant and sustained price fall, barring a major global depression, is remote.

In the short term, it is possible to see a ladder of costs for what it will take for non-OPEC countries to increase supplies incrementally from a range of fuel sources. For the short term, looking over the period 2011–2016, and starting with the lowest, comparative costs rise in this order: biofuels (various sources such as maize and

Box 3. The environmental cost of unconventional fossil fuel resources

As fossil fuel firms scramble to increase their proven reserves, they are venturing into ever riskier environments, using increasingly experimental technology. The impact of these riskier activities was observed following the Deepwater Horizon catastrophe in the Gulf of Mexico in 2010.

Development of the Macondo well was a technically demanding endeavour. The source of the spill was below 5000 ft of water and a further 3000 ft beneath the ocean floor itself. At such depths, direct human intervention is simply not possible.

The impact of the oil spill had huge consequences for marine and coastal ecosystems. The US government counted significant numbers of dead animals: 6,104 birds, 609 sea turtles, and 100 marine mammals. But these figures only include animals collected.[61] Actual mortality is likely to be much higher: scientists estimate that the carcasses gathered so far represent a fifth of the actual mortality figure for turtles, and at most 6 per cent of cetaceans.[62]

Closer to the shore, the spill wiped out salt marsh plants 15 to 30 ft from the Louisiana shoreline. The plant die-off led to a more-than-doubled rate of erosion along the marsh edge and subsequent permanent marsh habitat loss.[63]

More recently attention has switched to exploitation of oil and gas resources in the Arctic. In September 2012, a group of MPs from the Environmental Audit Committee called for a moratorium on oil and gas drilling in the pristine environment until the highest environmental standards are employed and the currently inadequate oil-spill clean-up technology can catch up with demands of the inhospitable conditions of the polar latitudes.[64]

soybean, but the cost is unpredictable as price has been frequently affected by serious crop failures), shale oils (USA now, and China later), natural gas liquids (NGLs; various sources), Brazil (deep-water drilling), USA (offshore), Canada (tar sands), and with smaller gains from generally lower cost Colombia (onshore) and Kazakhstan (onshore and offshore).

For OPEC to increase supply incrementally over 2011–2016 they are likely to depend on current spare capacity, largely held by Saudi Arabia, or from new capacity. Caveats include the confidence attached to Saudi claims and the call of domestic demand. Only three other OPEC members have at-all plausible plans to expand capacity. The largest of those is Iraq, with Angola and the UAE offering smaller gains. Table 2 shows the size and likely cost of these incremental supplies.

The economic impact of peak oil, then, can be clearly seen to be the result of shifting cost structures within the industry, in relation to the difficulty of exploiting ever-more difficult new sources, rather than being due to an absolute shortage of oil resources. This indicates that there is a fundamental difference in meaning between the two concepts of economic and geological peak oil respectively.

Table 2. The main oil and NGLs production gains anticipated for 2011–2016 and their likely development costs.

Country	***Production gain (million bpd)***	***Incremental oil cost ($/barrel)***	***Sources and possible threats.***
Non-OPEC			
Canada	1.0–1.2	70–90	Tar sands
Brazil	0.9–1.1	60–80	All deep-water
NGLs	0.5–0.7	50–80	Various sources
US offshore	0.2–0.3	70–80	
US shale oil	1.2–1.5*	50–70	Bakken and others
Colombia	0.2–0.4	40–60	
Kazakhstan offshore	0.1–0.2	70–80	Multiple delays
Kazakhstan onshore	0.1–0.2	50–70	Delays
Other non- OPEC	0.2–0.3	40–70	Mostly Africa
OPEC			
Iraq	1.1–1.3	40–60	Security concerns
Angola	0.6–0.8	70–80	Deepwater
UAE	0.4–0.5	50–70	Redevelopments
OPEC NGLs	1.4–1.6	40–60	
Other OPEC	0.5–1.0	40–80	Rises and declines

*Bank of America/Merrill Lynch

Identifying the pain barrier of economic peak oil

A lack of data makes it hard to identify the exact price point at which orthodox GDP growth is stopped. However, the price of $147 per barrel in mid-2008 we believe helped to trigger the Great Recession, although the global economy was weakening from late 2007.

The oil price rising to around $120 per barrel in the second quarter of 2011 brought growth to a near halt in a number of European economies (and elsewhere), several of which had not recovered from the 2008 recession. Again, in 2012, high oil prices in the first quarter appear to have slowed growth.

On analysing the past 37 years of US crude oil expenditures and GDP, energy consultants Douglas-Westwood concluded in every case when oil consumption reached 4 per cent of GDP, as seen in 2011, the US has suffered a recession.[65] The authors go on to suggest that in mature economies like the USA, oil prices greater than $90 per barrel result in a significant economic impact, while industrialising economies, such as China are thought to be able to tolerate prices in the $100–110 range.[66]

The low oil prices of late 2008 and early 2009 helped stimulate economic recovery, but also a rapid recovery in oil demand – effectively a catch-22 situation.

The USA gives the clearest illustration of rising oil prices suppressing economic activity, which is probably a function of low taxes on oil and related products. Changes in the price of oil therefore feed directly into the economy. The relationship is slightly weaker in European economies where taxes on oil products are higher, and particularly so for gasoline and diesel.

Fuel subsidies may cushion the impact of oil prices, but only to the point that the cost of higher government expenditure and inefficient fuel use is felt. Venezuela and much of the Middle East demonstrate the point. Elsewhere in this context, rapid oil price rises either hit national budgets or fuel shortages appear; this has been the experience of both Iran and Pakistan.

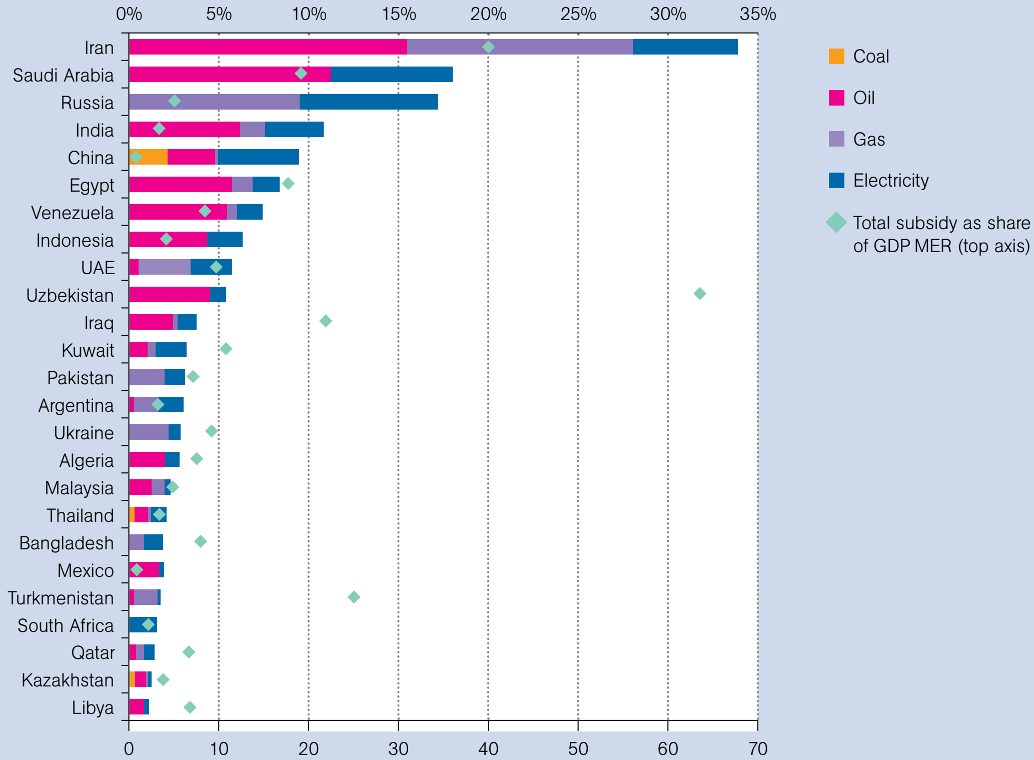
According to the IEA's *World Energy Outlook 2010*, countries giving the biggest consumption subsidies as a percentage of price in 2009 were, in descending order: Iran (since reduced), Saudi Arabia, India, Egypt, Venezuela, Indonesia, Iraq, China, and Algeria (Figure 3).[67]

China's economic peak oil

China is so large and influential that it tends to distort most studies. In presenting statistical pictures of global trends it is common to do so with China both present and exempt to allow for its unique effect. The countries in Figure 2, for example, are all ultimately hostage to Chinese demand. On its own, China accounts for about half of the growth in demand for most commodities, including oil, in a typical year. The Middle Eastern economies and commodity suppliers like Brazil, various African countries, and Australia and Canada, largely depend on China's growth for their own. If China's demand fell, for example, Brazil's mining and oil sectors would weaken, and with them, the Brazilian economy as a whole.

What price, then, can China bear? The historical record shows tremendous volatility, but in general, it would appear the country can afford to spend between 6.3 and 6.7 per cent of its GDP on crude oil, or approximately around $100–$110 per barrel. Above this level, China's oil consumption and GDP growth tend to fall. This is substantially higher than the $90 per barrel estimate for the price that the USA and Europe can bear.

Figure 3. Economic value of fossil-fuel consumption subsidies by country and type, 2009. [68]



Note: MER = market exchange rates.

China's tolerance is higher because the value of oil is higher there. The economic benefit of the first car in a family, for example, is much greater than that of the third. Similarly the productivity gain from the first truck in a commercial fleet is greater than that of the twentieth. Industrialising economies such as China and India, therefore, have a higher marginal productivity from an extra barrel of oil than in more developed economies.

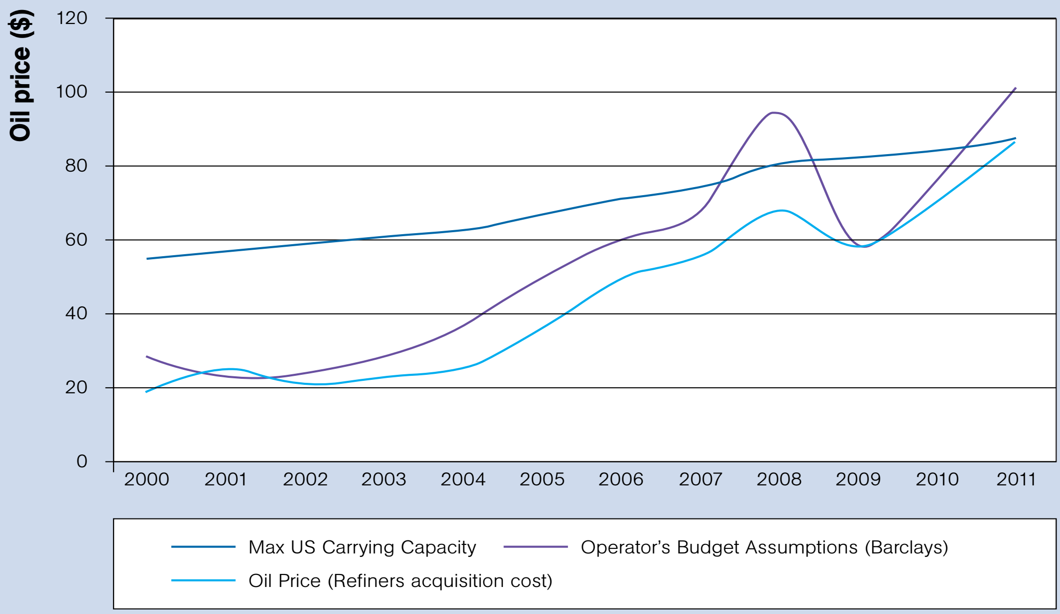
The higher price tolerance of developing economies suggests that by paying above the comfort level of richer nations for oil, they could render those richer economies stagnant.

Determining the likely timing of peak oil

Historically, prices used by oil companies as a basis to approve projects for new production capacity, were well below what the US economy could afford to pay for the resulting oil. In 2004, for example, operators approved projects based on a $20 per barrel oil price, when the US economy was capable, theoretically, of handling a price near $60 per barrel. In its most recent survey, however, Barclays Capital indicates that operators' assumed a price of average West Texas Intermediate crude oil price of $87 a barrel and an average Brent price of $98 budgeting purposes.[69] This is right around the ceiling level that the US and many European economies can tolerate. On current trends, then, oil companies will be approving and developing new production capacity that delivers oil at prices effectively unaffordable to advanced economies, without serious negative consequences. This can be seen in Figure 4.

Reality would, of course, be more complicated. Economic activity in emerging economies also stimulates activity elsewhere. China's rapid growth has created a huge pool of capital. The USA saw a double shock in 2008, due to the low cost of capital and the high price of oil. But expanding emerging economies create export markets, and low-cost capital can aid investment in new domestic infrastructure that advanced economies can benefit from, as they seek to adapt and reduce their energy dependence.

Figure 4. Oil prices: Refiners' acquisition costs, maximum US tolerance levels, and operators' budget assumptions for project approval.[70]



The transition to low-carbon economies will reduce the impact of high oil prices. Adaptive responses such as mass public transit systems, more efficient vehicles, people travelling less due to home working, and cheaper, low carbon, energy alternatives will all help.

History holds out promise that rapid adaptation can happen.[71,72,73] If this adaptation is fast and at a large enough scale, oil prices might be broadly stable. But they haven't been. Instead there has been a weak, and sometimes retroactive response by governments with regard to fossil fuel dependence during the period when prices have risen from $25 to around $100 per barrel in the eight years between 2003 and 2012.[74]

The efficiency gain for oil use is a good measure of adaptive responses. This looks at the degree to which oil is used more efficiently, or ceases to be used for lower value-added purposes, or has other fuels substituted for it. Either response shows up as improved efficiency in terms of oil use per unit of GDP. The efficiency gain has run typically at around two per cent per year, although some believe 1.2 per cent to be a more accurate figure. The IEA, however, now quotes three per cent, indicating that it believes the process is speeding up.

Between 2003 and 2008, oil prices rose by $10 per year. Figure 5 illustrates this trend in both West Texas Intermediate (WTI) and Brent Crude oil prices. Figure 5 also shows the lower (danger) and upper (crisis) thresholds for 'economic peak oil' based on current estimates.

Figure 6 shows real and projected Brent oil prices rising at $10 per barrel per year, and a price that allows economic growth at three per cent per year to reflect an increasing adaptive response. The crossover point gives the economically determined peak oil when sustained growth becomes impossible. Price increases, driven by depletion, outrun the adaptive responses that higher prices induce. The lines cross in 2014, indicating a possible timing for an economically determined peak, the point at which the oil price is economically destructive and cannot be sustained for any length of time.

This analysis gives an alternative method of determining the likely timing of peak oil, compared to looking at new capacity minus depletion, and balancing that against the most likely trajectory for growth.

Figure 5. Development of oil prices illustrating the $10/year trend (red line).

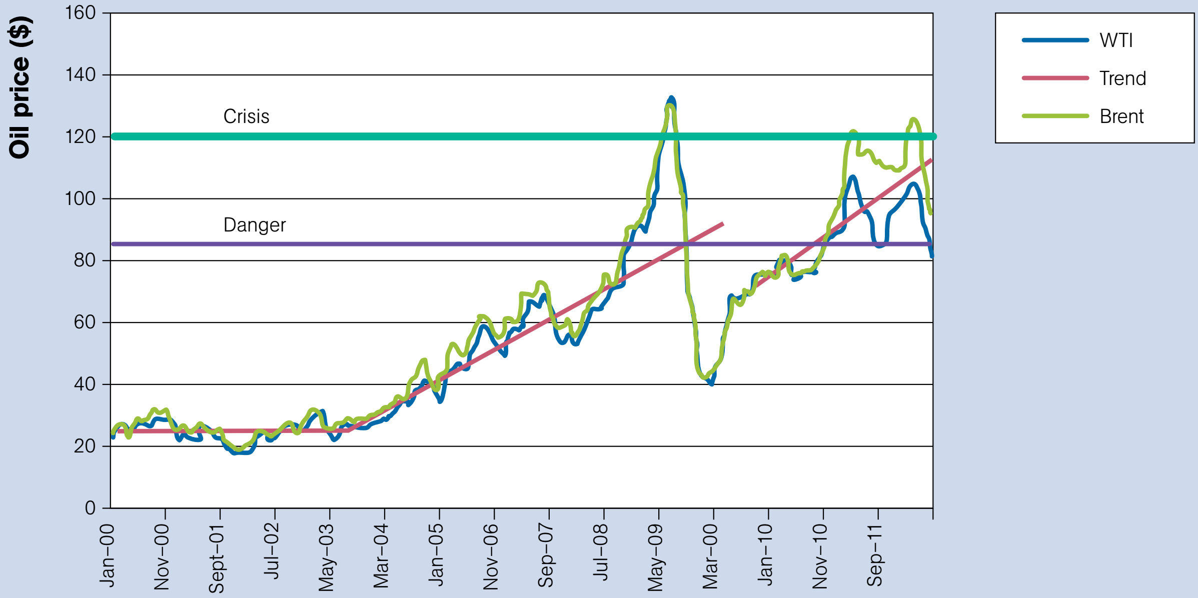
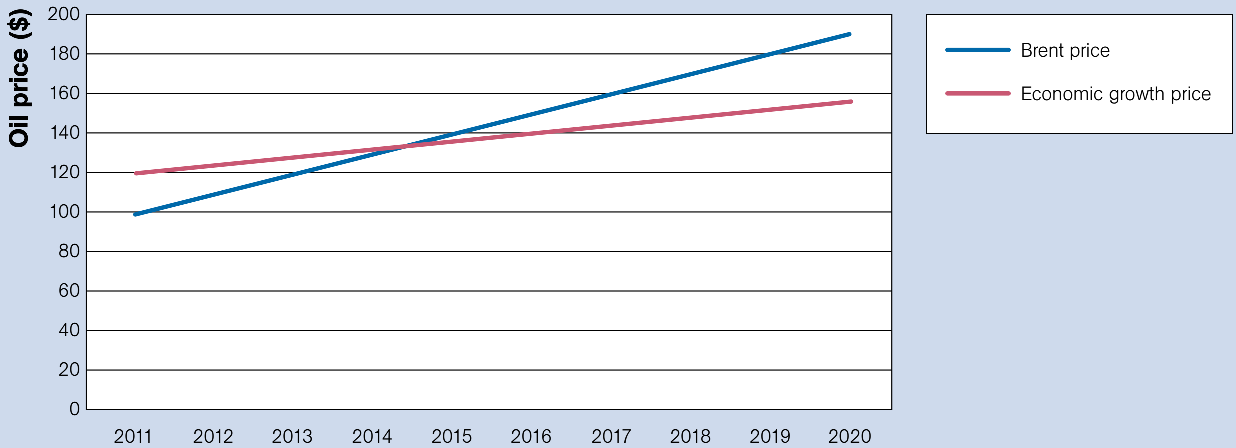


Figure 6. Brent oil prices rising at $10/year (blue line) and a price that allows economic growth growing at 3 per cent year to reflect an increasing adaptive response (red line).



Both approaches, however, seem to point to 2014/ 2015 as a crunch period. The coincidence is not surprising, because most of the remaining future oil development projects are high-cost, for example in deepwater fields, tar sands and the Arctic (Table 1).

The peak point may also be brought forward by a self-reinforcing dynamic. Rapidly changing prices likely to be associated with peaking tend to inhibit the kind of investment needed to better manage remaining oil resources, and indeed to escape oil dependence.

Adaptive responses to high oil prices

The key adaptive response to high oil prices, at least initially, is fuel substitution. In the 1970s around 25 per cent of all oil used in power generation was heavy fuel oil. This has dropped to just 4 per cent and is still falling. The substitutes have been coal, gas, and nuclear generation. Oil used for space heating (gas oil/furnace oil) is also in decline, largely displaced by gas. Better efficiency and insulation have also played a part.[75]

Gas to liquids (GTL), coal to liquids (CTL), biomass to liquids (BTL) and enhanced oil recovery (EOR) all have the potential to increase liquid fuel, as does algal oil. At present, however, only GTL costs are economically viable, and only with a guaranteed supply of low-cost gas. According to the IEA, the lowest cost of these potential incremental supplies is currently EOR using CO_2[76] then GTL, other EOR, BTL, and CTL.

A crisis of the cost and availability of transport fuels

Given that globally around 80 per cent of oil is used by transport, and in the USA it is 80–85 per cent, how can this be substituted?

Switching to electricity for vehicles is not yet economic, and is only really applicable alternative for surface transport. Biofuels are actively promoted, but only really function as 'fuel extenders' making orthodox fossil fuels go further. Also there is a zero-sum conflict over whether finite agricultural land should grow crops for food or for fuel.[77] So-called second- and third-generation biofuels offer a partial solution, but are not yet economic. The use of natural gas for transport in places like Pakistan, India, Brazil, Iran, and other emerging economies is becoming widespread. All such transitions, however, take significant time and investment.

Meanwhile, transport demand is growing strongly, particularly in Asia, Africa, and South America. There is an existing global fleet of over 930 million vehicles that run on gasoline and diesel. In short, there is little scope and ability to quickly substitute oil-derived transport fuels. The relatively straightforward substitution of heavy fuel oil and heating oils has already been mostly done while the hard task of substituting transport fuels has barely begun.

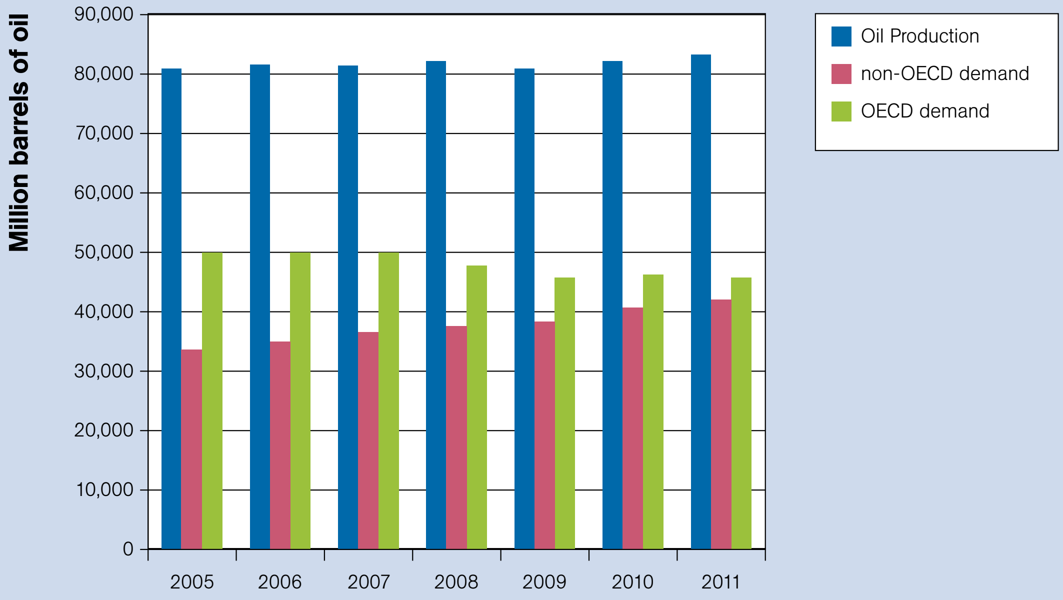
Where high added-value uses of oil are concerned, such as insolvents and lubricants, they will be more able to withstand higher oil prices and efficiency will likely improve. Petrochemical feedstocks have seen a move away from petrochemical naphtha to natural gas liquids (NGLs) such as ethane, propane, and butane.

The limits to adaptive responses

Overall, adaptive responses have done nothing to restore oil prices to the lower levels that the industry believed possible at the start of the new millennium.

The conclusion seems to be that adaptation to lessen oil dependence needs to be large scale and fast to constrain the upward trend of oil prices. As long as that fails to happen, the main, involuntary adaptive response is likely to be periodic economic crashes big enough to lower the consumption of oil and its price. These will result in a general shift of consumption from richer consumers in wealthier economies to new consumers in developing countries.

Figure 7. Global oil production compared to OECD and non-OECD demand



This happened in during the most recent recession (Figure 7). Between its start in January 2007 and its hiatus in the first quarter of 2011, demand rose by 4.3 million bpd in the non-OECD area and fell by 4 million bpd in the OECD area. Figure 7 also shows that between 2005 and 2011 non-OECD consumption grew by 8 million bpd but oil production/supply grew by only 4 million bpd.

Why gas will not provide the answer

For the UK, gas is the dominant fuel accounting for 40.4 per cent of primary energy consumption in 2010, significantly ahead of oil's 35.2 per cent. This dominance of gas in the UK energy mix means that the UK is one of, if not the most 'gassy' of the major economies, well ahead of the global average of 23.8 per cent or the EU average of 25.6 per cent of primary energy demand.

In fact, the only economies that are more 'gassy' than the UK are major gas producers such as Russia, Algeria, the UAE, Kuwait, Qatar, Malaysia, Argentina, Pakistan, and Turkmenistan. Other key gas producers such as the USA, the Netherlands, Saudi Arabia, Australia, and Indonesia are all rather less 'gassy' than the UK.[78]

However, the UK's North Sea gas supplies are running down fast and after peaking at 108.4 billion m^3, in 2000 were down to 45.2 billion m^3 in 2011 and are continuing to fall.[79] Latest indications are that by the third quarter of 2011 gas imports were accounting for over 50 per cent of consumption. In less than a decade, the UK has moved from being a small (11 billion m^3) exporter to a major importer.

Unlike oil, gas has only a limited number of applications. Its most valuable and lucrative market is for home heating and cooking followed by the rather larger market for space heating in commercial and industrial premises. The industrial market for uses such as kiln-firing and metal working has been undermined by the relocation of many of these energy-intensive processes to the Far East and notably to China. The market for gas as a generating fuel is the most competitive market as coal and nuclear energy are viable options restraining the price that can be charged for gas in this use.

Gas as a transport fuel?

Although gas can be used as a transport fuel, there are real constraints on its use. The conversion of gas to liquids consumes up to 40 per cent of the gas in the conversion and so this capital-intensive process is only viable where there are large volumes of low-priced gas with no other outlet. More widely viable is the use of compressed natural gas (CNG) in vehicles. The key constraint is the heavy and bulky containment system for the gas. This means it can work well for heavy vehicles operating limited distances from a base. Buses and public service vehicles like dust carts (garbage trucks) are obvious examples. CNG also works well for taxis and cars if the loss of boot space to the fuel tank is not an issue.

The challenge comes with longer distances and the need for refuelling stations. In the UK, and in most of Europe and North America, the forecourts are effectively controlled by the oil companies. To date these have been reluctant to add a competing fuel while the gas companies have been reluctant to build a fuelling network. It is notable that in the countries that have developed a gas-fuelling infrastructure, there are major powerful gas companies. Russia, Pakistan, and Egypt are good examples.

The 'Dash for Gas'

The UK's infamous 'Dash for Gas' in power generation was largely driven by the arrival of significant volumes of gas from the North Sea that had no other outlet than UK use; it could not be exported until the Interconnector pipeline was completed in 1998. The Interconnector allows gas flows both to and from Zeebrugge in Belgium to Bacton in Norfolk. From 1998 to 2004, the UK was a net exporter. From 2005 to date, it has been a net importer.

The Interconnector also had the effect of connecting UK and continental gas prices. Since 2005, when significant gas imports started, the UK has had to pay international gas prices to secure supplies. The rapid increase in UK gas prices since 2005 means that it seems unlikely that gas can take a larger share of UK primary energy supply; in fact, it is quite likely to see its share reduced.

Only in North America are gas prices fully de-linked from oil prices. In the Far East all imported gas is sold at oil-linked prices, while in Europe a strong link to oil prices remains although it has weakened somewhat as gas markets move towards full deregulation like the USA and the UK.

There has been much recent publicity about a shale gas discovery near Blackpool in Lancashire and the way this could potentially reverse the fortunes of the UK gas industry and give the UK the sort of low gas prices currently seen in the USA. Natural gas prices in the USA are under half of European levels and a third of Far Eastern levels.

Shale gas: A cautionary note

Great caution should be applied to shale gas hopes for a number of reasons. By its very nature, shale gas is expensive to develop as it requires horizontal drilling and hydraulic fracturing of the shale beds, both of which are expensive. The subsurface mineral resources are owned by the landowners in the USA and Canada but in virtually every other country on Earth the mineral rights are owned by the state.

In the USA, the low gas prices are largely the result of landowners rushing to develop their gas resources and producing a glut of gas that has depressed gas prices to below properly accounted development costs. The mechanism is that the landowners issue fixed-term development leases which contain obligations to drill a number of wells within the term of the lease, typically five years, with extension provisions.

The gas company owning and operating the lease massively increases the value of the acreage they have leased by proving that it is productive by drilling up and producing gas. They then have the option of selling the gas and/or selling part or the entire lease. It is reported that a combination of gas sales, lease sales, and money raising has allowed the US shale gas industry to cope with real costs that are around $7–8 per million BTU[80] while sales prices are $3.5–4 per million BTU. The expectation is that US gas prices will return to rather higher prices in a few years' time making shale gas a truly economic proposition and shale leases well worth hanging onto.

There remain a number of key unknowns about shale gas, the most important of which is its decline profile. Whereas conventional gas fields decline relatively slowly and predictably, shale gas production declines very rapidly as pressure within the earth closes up the fissures produced by the hydrofracturing (or fracking). Critics claim wells have an economic life of as little as five years or less. The companies claim much longer lives and higher residual values for their wells. This in turn feeds into claims of profitability or non-profitability.

Recent work has shown that shale beds, which may extend over multiple US states, actually have more productive 'sweet spots' which the companies have concentrated on developing and that the earlier assumption that the whole bed is equally productive is wrong. It is this new understanding that has led to a recent 80 per cent downward revision of the undiscovered, technically recoverable reserves of the Marcellus shale in eastern North America - the largest of the US shale beds.[81]

Similar bad news has come from the first two shale gas wells drilled in the highly rated Polish shales. According to Bernstein Research, the flows from the wells in the Baltic basin were well below US flow rates. Their analysis concluded, '… data from Poland's shale gas wells validate our concerns about European shale gas: poor flow rates in over-pressured, hard-to-develop shales'.[82] If Europe's shale is less productive, this will add to concerns about water supply, proximity of population centres, water contamination, ownership and leasing concerns, and broadly based environmental concerns.

Unless and until rich and productive gas-bearing shales are found, the European shale gas boom is at imminent risk of collapsing before it has even started, regardless of the enormous environmental implications[83] were it successful.

Policy recommendations

In this report we have argued that complacency on economic peak oil could be more reckless than the failure of banking oversight.

There are many reasons to reduce an economy's energy intensity and dependence on oil. The impact of economic peak oil is yet another, very important one. Multiple shocks lie in wait for nations who are unprepared. Sudden or steady, consistent rises in oil prices can bring an economy to a standstill, create unemployment, and deepen poverty and social hardship. A well-prepared economy, however, could prosper regardless.

1 Supporting a transition to a low-carbon economy

Strategies for decoupling the economy from fossil fuel use and dependence are covered substantially elsewhere and repeating these is not the purpose of this report. However, it is enough to point out that the only option to soften the impact of high oil prices that is likely to meet the magnitude of the challenge is a transition to a low-carbon economy. But this will require political leadership and policy certainty to create a long-term, sufficient and consistent incentive structure for renewable energy.

The economic approach of a Green New Deal can help break the bonds of fossil fuel dependence, insulate against the impacts of economic peak oil, create employment, tackle fuel poverty in particular, generate jobs, and promote a dynamic, modern, low-carbon economy. Of course, it also means an effective approach to tackling climate change.[84]

- We, therefore, recommend the government employs available and new mechanisms for public sector finance, such as a Green Investment Bank to change investor behaviour in favour of new, low carbon sectors.
- Adaptive responses such as investment into mass public transit systems, more efficient vehicles, people travelling less due to home working, and cheaper energy alternatives will also all help.

2 The urgent need for government contingency planning

Less well known or understood than what to do to bring about a low-carbon transition, is the state of national contingency planning for, and awareness of economic peak oil. Because of that, we recommend that:

- The government make public any assessment it has made on scenarios for economic peak oil and its likely impact on the UK economy and population.
- The government make public what, if any, permanent institutional mechanism, beyond the current Civil Contingencies Committee (Cobra), has a remit to assess the overarching implications of economic peak oil for the UK.
- The government make public which major spending departments have contingency plans for peak oil, and what the assumptions behind any such plans are.
- Should any major UK economic sector lack official contingency planning for economic peak oil, the government should explain why, and with what confidence such plans are absent.

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