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Peak Oil

The Implications for Planning Policy

A Discussion Paper published by the RTPI Development Planning Network and RTPI-TPS Transport Planning Network

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DISCLAIMER

PURPOSE OF THIS DISCUSSION DOCUMENT

This discussion paper sets out the findings of a study undertaken into the issue of Peak Oil and the implications for spatial planning. It aims to promote discussion, raise awareness among transport and spatial planners of the issues around peak oil and suggest an agenda for action by professionals. It is intended as an introduction and primer to the issue; further work will be necessary to develop a greater understanding of any of the facets of Peak Oil covered in this paper, and to develop the responses that UK planning professionals should be making to ensure that the concept is properly taken into account in future planning.

This paper refers to planning processes and procedures under the English system. However, the issues raised here are relevant across UK nations. Reference only to English examples should not be taken to mean that the implications for other nations have been ignored.

While the issue of Peak Oil impacts on all aspect of spatial planning, this document has a strong focus on transport, however we welcome discussion and comments on other areas of planning that it impacts upon.

All comments should be forwarded by e-mail to transport@rtpi.org.uk.

CONTENTS

SUMMARY

The summary of this discussion document is set out in a separate document and can be accessed at http://www.rtpi.org.uk/transport_planning_network/

1 BACKGROUND

Introduction

Oil is a finite resource. It will become exhausted at some point in the future, and before this the level of production will peak and then decline. **Peak Oil** is the point of maximum oil production, after which this decline happens. This point usually occurs when around half the oil in an oilfield has been extracted, with half remaining. The timing of Peak Oil varies for each individual oil field, but production profiles can be aggregated to give a similar picture of global oil production and the peak for this. The timing of that global peak is a key issue. Opinions on this range from the view that the peak has already been reached to that the peak is decades away.

As demand for oil continues to grow, the impact of a peak of oil production and the following decline will have profound implications for the availability and the price of oil, and of all its derived products. All scarce non-renewable resources are subject to the same peak phenomena (e.g. natural gas, coal, platinum, copper and rare earth). Nevertheless, Peak Oil is clearly a pressing issue, and the focus of this paper. However, it must be recognized and borne in mind that similar peak phenomena will be repeated with other resources.

In terms of spatial planning responses to Peak Oil, we shall be constrained by the form and nature of the built environment that exists at present. In adapting spatial planning policies to reflect the consequences of Peak Oil, the key challenge will be to flexibly use that built environment to reduce energy consumption in general, and of oil in particular. This may require some recently-developed behaviours to change back to the ways that things were done formerly (e.g. a greater use of local shops and services). However, with technologies now available, particularly in terms of communications technology and vehicle design, many novel responses will also be possible.

As this paper was being prepared, news emerged of civil unrest in several Middle Eastern countries, and damage to nuclear power stations in Japan as a result of an earthquake and tsunami. This reinforces the need to think seriously about the security of energy supplies and the way in which we use energy. Taking on board the consequence of peak oil is a key part of this.

This Paper

The discussion document is based on a desk study of the issue, primarily through use of internet searches. As ever, the range of information and opinions is vast, but use here has been limited to those sources considered credible, with all source references listed. The study behind it has comprised comprise three elements:

- A literature review, focusing on why Peak Oil is important for planning;
- A critical evaluation of the scenarios and implications of Peak Oil for spatial and transport planning identified in the literature, and discussion of the shortcomings of present approaches in this respect; and
- Developing recommendations for discussion by planners with the aim of taking better account of peak oil in developing planning policies and proposals in the future.

The authors' intent was that this paper should provide a usable and relevant document which provides the starting point of an initiative to encourage greater awareness of Peak Oil among planners, and to develop responses to this within the profession.

At various places, the paper refers to planning processes and procedures under the English system. However, the issues raised here are relevant across all the nations within the United Kingdom. Reference only to English examples should not be taken to mean that the implications for other nations have been ignored.

The content of this paper covers various aspects associated with Peak Oil as follows:

- **Chapter 2** sets out what Peak Oil is about, with a select range of evidence to describe the issue;
- The current state of understanding and policy influence within UK Government is described in **Chapter 3**;
- **Chapter 4** discusses the potential travel demand impacts of Peak Oil, firstly in terms of the range of possible responses and then the potential scale of demand change using a simple elasticity model;
- Possible policy and technological responses, and the policy implications of Peak Oil are set out in **Chapter 5**;
- **Chapter 6** draws conclusions from the present study, and suggests an agenda for discussion by planning professionals.

The RTPI Networks encourage readers to get in touch with us with their views and ideas for how this debate can be widened and incorporated into the planning agenda. All comments should be e-mailed to transport@rtpi.org.uk.

2 THE CONCEPT OF PEAK OIL

Peak Oil theory dates from the 1940's. Typical profiles of oil discovery and production follow a bell-shaped curve. Peak Oil is when production reaches its maximum before it declines irreversibly. This point undoubtedly has already been reached for some oilfields, and some observers say it has already been reached globally. Others suggest it will be another 20 years away. However, there are reservations around the level of quoted reserves on which such estimates are based

The key effect of Peak Oil will be not just that oil simply ceases to be available, but also that availability declines year on year. The demand/supply gap quickly widens even with static production. Increases in price and price volatility are the inevitable result. There are also likely to be impacts on wider economic activity, such as high inflation and lower economic growth.

A global oil crisis seems inevitable sometime within this century. Increased oil demands from emerging economies will more than offset decline in consumption in developed countries. This means it is unlikely that production will be increasing quickly enough to make up for shortfalls in supply.

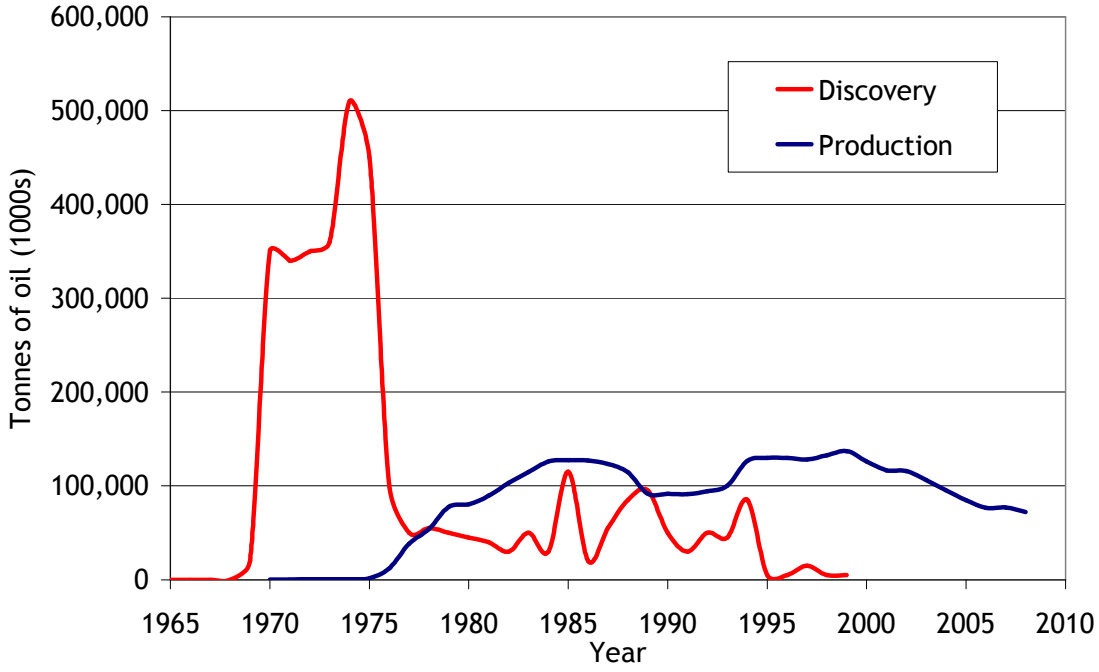
Introduction

Peak Oil theory was postulated by M. K. Hubbert in the late 1940's[1], and subsequently developed in a paper to the American Petroleum Institute in 1956[2]. Hubbert predicted a peak in US oil production (excluding Alaska and Hawaii) in the period 1965-1970; the actual peak occurred in 1971. The paper also predicted a global peak around 50 years later, in around 2015 – 2020.

The theory of Peak Oil is based on the typical profile of discovery and production. When an oil field is discovered, there is a lag before oil production starts. The rate of production increases to a maximum and then declines as oil wells are added and then removed, and also because of the physics involved. Not all the oil in a field is actually recovered, the typical rate currently being 35%, although this can be increased to up to 70% through enhanced oil recovery (EOR) techniques. It is commonly accepted that the output of oil (crude oil) from any reservoir follows a bell-shaped curve. Peak Oil refers to the moment when the daily global oil production reaches its maximum ('peak'). After reaching its 'peak', the amount of oil that can be extracted will level ('plateau') before it declines irreversibly.

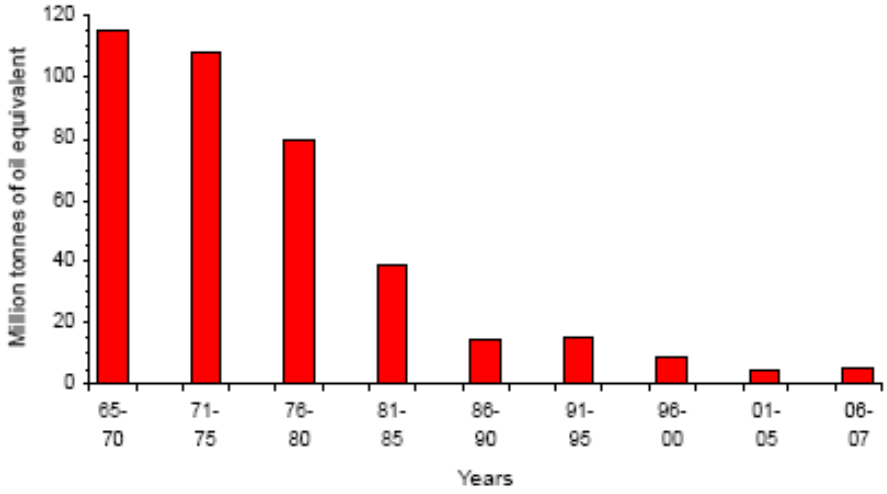
This can be illustrated through the experience of the North Sea; the profile of discovery and production is shown in **Figure 2.1**[3].

FIGURE 2.1 NORTH SEA OIL DISCOVERY AND PRODUCTION



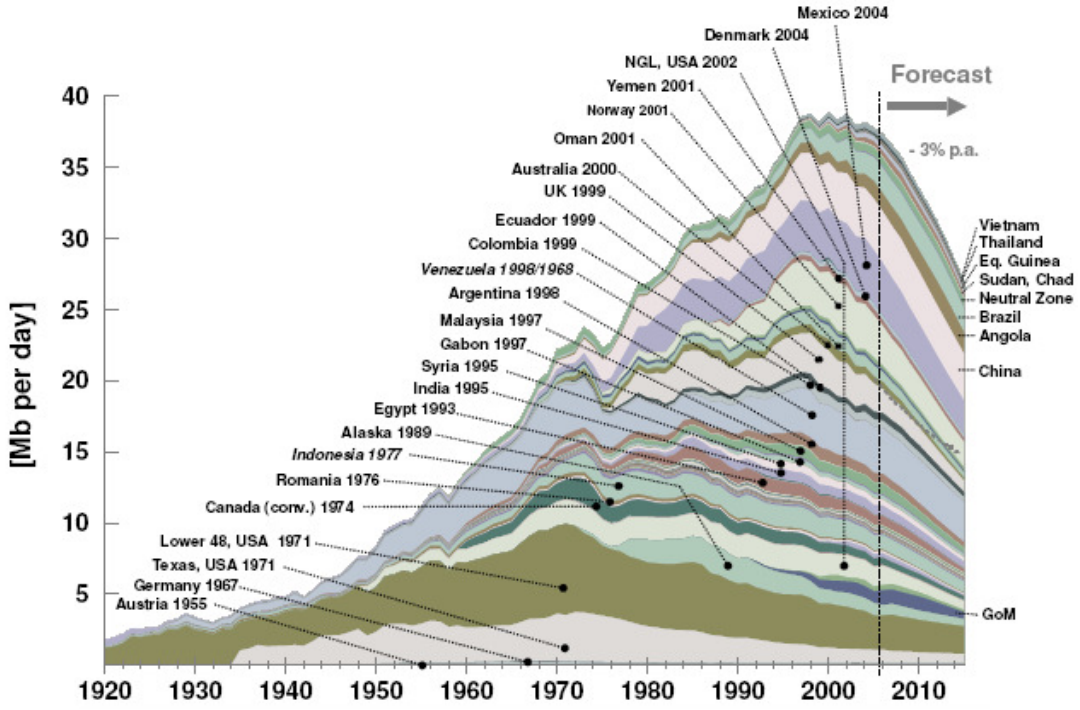
The peak of discoveries came in the early 1970s, but production did not start until the late 1970s. Production increased through the 1980s, peaking in 1999 and has nearly halved since. Whilst new fields continue to be discovered, these are small in comparison to earlier finds and are quickly exhausted. This is another key element in the concept of Peak Oil; that all the big fields are discovered first. **Figure 2.2**[4] shows the average size of discoveries in the North Sea from the mid 1960s onwards; the largest fields were discovered in the decade between 1965 and 1975, since when the average field size has diminished rapidly to barely 10% of the earlier fields.

FIGURE 2.2: NORTH SEA OIL FIELDS AVERAGE SIZE



Many countries, albeit minor producers, have also peaked; this is illustrated in **Figure 2.3**[5]:

FIGURE 2.3 OIL PRODUCING COUNTRIES PAST "PEAK OIL"



There is no agreed date as to when Peak Oil globally will be reached or when we will run out of oil. Some estimated there could be an energy crunch from 2012. The UK Industry Taskforce on Peak Oil and Energy Security (ITPOES) believes that Peak Oil will arrive in 2015. Other suggestions range between now[6] and 2030[7] . The recent view of the International Energy Agency is that *"although global oil production in total is not expected to peak before 2030, production of conventional oil ... is projected to level off towards the end of the projection period"*[8]. Unconventional oil, such as the tar sands of Alberta, Canada, are expected to make up an increasing amount of production, although such sources are relatively expensive and will have significant environmental impacts.

However, it must be acknowledged that while the underlying concept of Peak Oil is quite a simple one, the debates around it are complex and often fiercely contested. For example, there are many definitions of what "oil" is and a wide range of factors that affect oil production. The Peak Oil debate tends to focus on conventional oil production and often excludes natural gas liquids (NGLs) and other unconventional sources such as oil sands, and oil shales. Secondly, the fundamental constraint on production is typically considered to be the geological scarcity of oil, leaving out other important factors such as technological progress, future demand for oil and its link to the oil price, access to and investment in the development of existing resources, and political instability or resource nationalism that limits the amount of recoverable oil. The UK Government's Energy Security Review[9], for example set out the view that current proven reserves are equal to over 40 years of current production. However, the immediate risk to oil production is not the level of resources and reserves, but the world's ability to convert these into production now and in the long run, which is essential for the UK's security of supply.

World oil supply and demand

World oil reserves are estimated to be some 1,258 billion barrels[10]. At 2007 production levels (i.e. around 82 million barrels/day, or 30 billion barrels/year), reserves would last around 40 years. However, given world population growth and continued economic development, particularly in China and India, demand for oil is expected to increase by some 1% annually[11], meaning that current oil reserves may last less than 35 years.

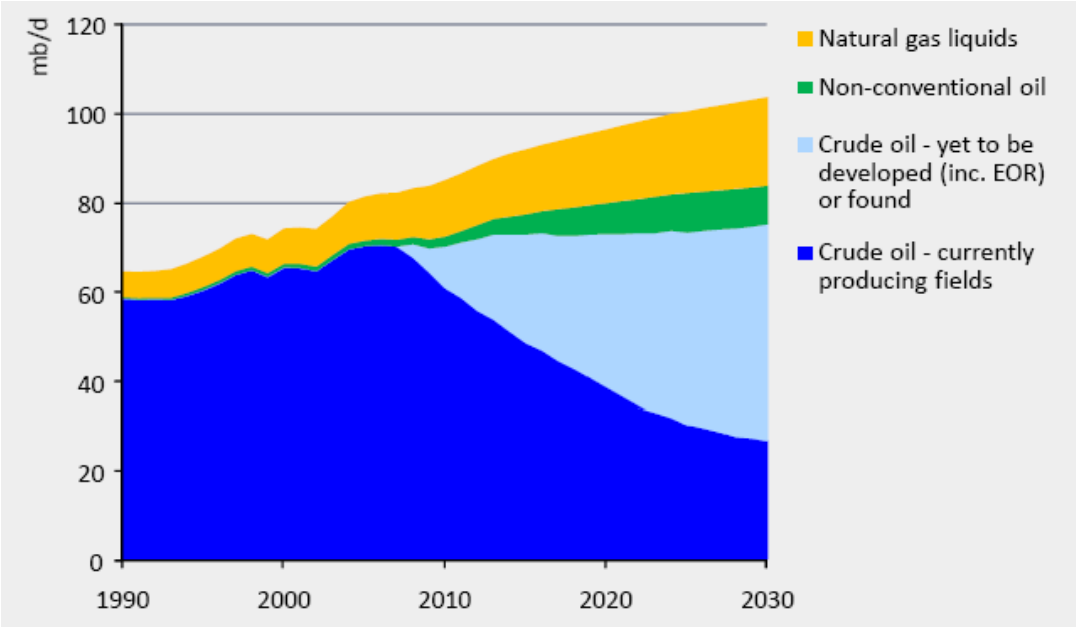
Simply increasing supply to meet this increasing demand is of itself challenging, with production capacity equal to 80% of current capacity needing to be built worldwide by 2030 to offset the effect of oilfield decline and to meet demand growth[12]. The current financial crisis is limiting investment and concerns over the ability to meet total investment needs are growing.

However, there are reservations around the level of quoted reserves, particularly in the Organization of the Petroleum Exporting Countries (OPEC) nations. Proved reserves in the Middle East essentially doubled during the 1980s[13], as the OPEC nations linked production quotas to the level of reserves. For example, Kuwait, had around 67 billion barrels of reserves from 1980 to 1983, wherein they jumped to 93 billion and have increased further to reach 101 billion by 2006. Interestingly, this period saw production from Kuwait total 17 billion barrels. Similarly Saudi Arabia has reported reserves consistently around 260 billion barrels since 1989 and yet has produced 60 billion barrels over the same period.

The data for Kuwait has been challenged following a report from the Kuwait Oil Company in 2006 and seen by Petroleum Intelligence Weekly[14] . This reported (for 2001) reserves of just 48 billion barrels, less than half of that publicly reported. In May 2007, the Oil Minister Sheik Ali admitted[15] that reserves were the lower figure of 48 billion barrels, although probable reserves of three times that (150 billion barrels) were also announced. Overall, Sadad Ibrahim Al Husseni, former Executive Vice President at Saudi Aramco, Saudi Arabia's national oil company, considers world reserves to be overestimated by some 300 billion barrels[16].

Finally, supply growth is predicated in part on development of oil fields yet to be found, as shown in **Figure 2.4**[17] . Of note, it suggests an imminent peaking of oil production from existing fields (the base dark blue area).

FIGURE 2.4 WORLD OIL PRODUCTION BY SOURCE

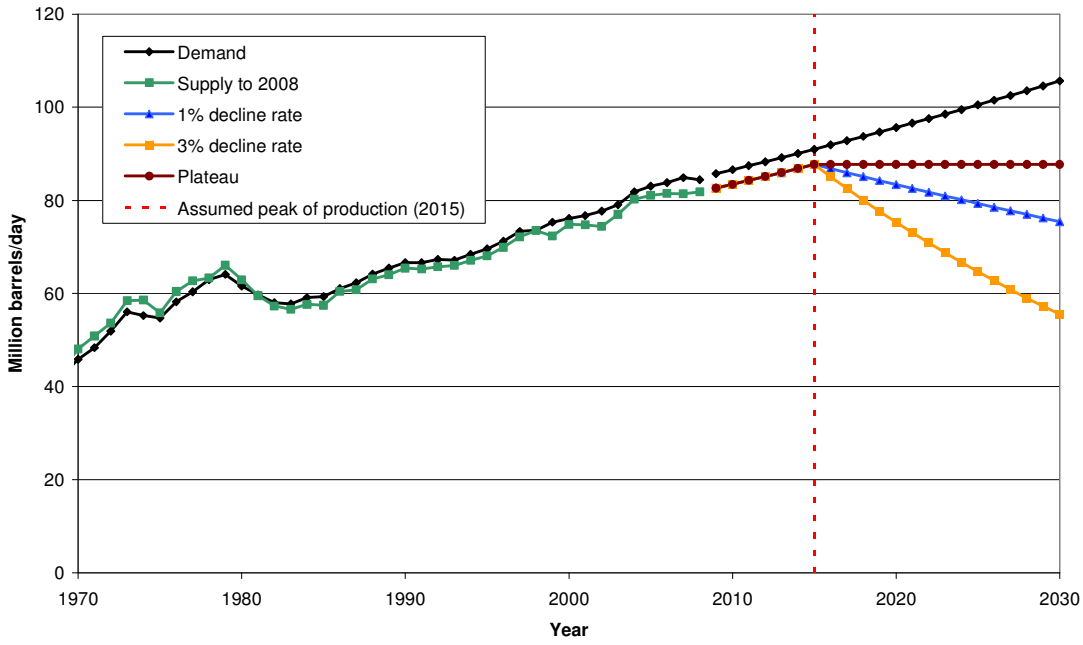


The impact of Peak Oil

The key effect of Peak Oil is not that oil simply ceases to be available; rather the availability of oil declines year on year. Notwithstanding the uncertainty of the date of Peak Oil (which will really only be clear well after the event), the impact of even a plateau of output will quickly become apparent. **Figure 2.5**[18] shows

how the demand supply gap quickly widens even with static production (the plateau) or low rates of production decline (assuming a peak in 2015).

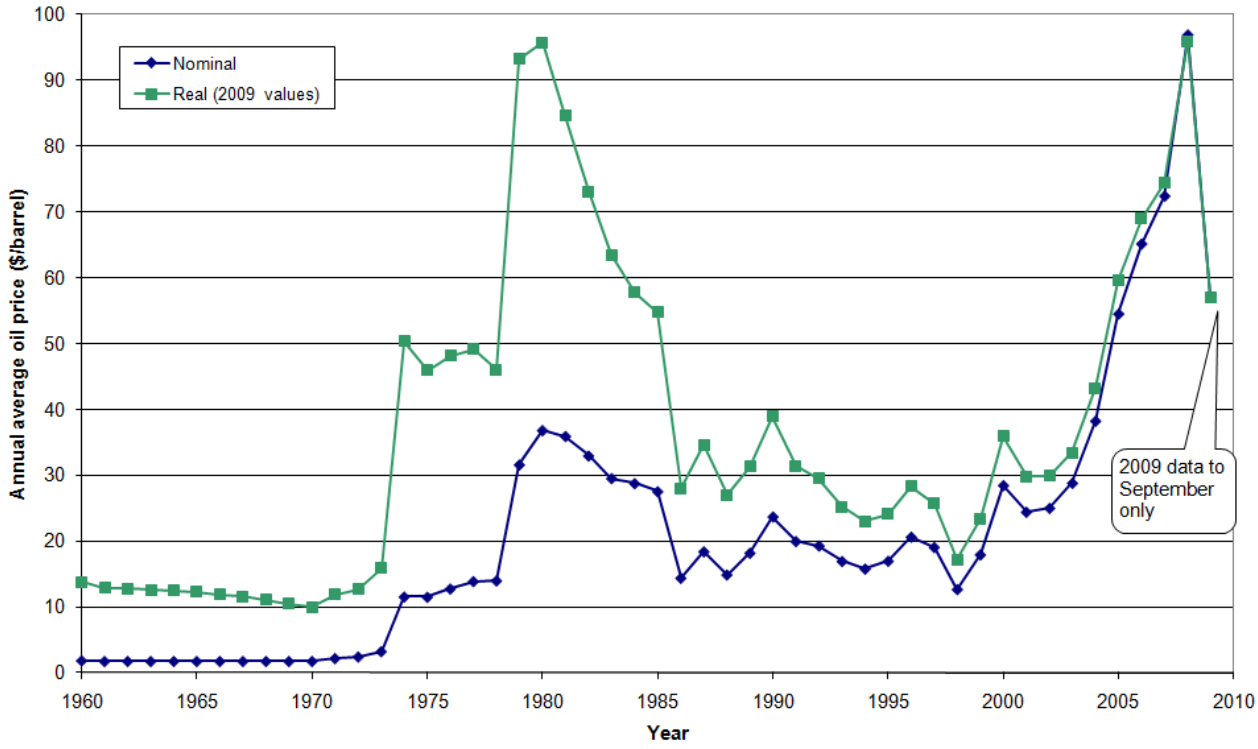
FIGURE 2.5 DEMAND - SUPPLY IMPACT OF PEAK OIL



The consequence of this is that there becomes a widening gap between supply and demand with a resultant increases in price and price volatility. Recent oil price volatility has been very extreme, with the oil price reaching a high during July 2008 of over $140/barrel, before falling back to barely $40 barrel just 6 months later, with a modest recovery to around $70-75/barrel by August 2009. However, as illustrated in **Figure 2.6**[19], oil prices have been increasing since the early 2000s, after a period when they had been relatively constant for the previous 20 years, and this increase reflects the lack of any material growth in output during this period (growth in output since 2004 has only been 2%). The recent declines reflect the softening of oil demand as a result of the economic recession.

Increases in the oil price will of course lead to changes in demand levels over the longer term which will mitigate the effects of Peak Oil to some degree, leading to some equilibrium position where oil prices rise but not as far as would be the case where demand is more inelastic. In essence, whilst oil demand is relatively inelastic in the short to medium term, the longer term demand may be more price elastic as consumers seek alternatives and reduce demand in a number of ways, assisted by technological development spurred by Peak Oil. Also, governments and business can already take measures[20] to reduce exposure to price volatility and these may be extended under Peak Oil. However, the net impact over the medium to long term will still be price levels and price volatility higher than that experienced in the past and this will become more pronounced and permanent as the effects of Peak Oil take effect.

FIGURE 2.6 OIL PRICES SINCE 1960

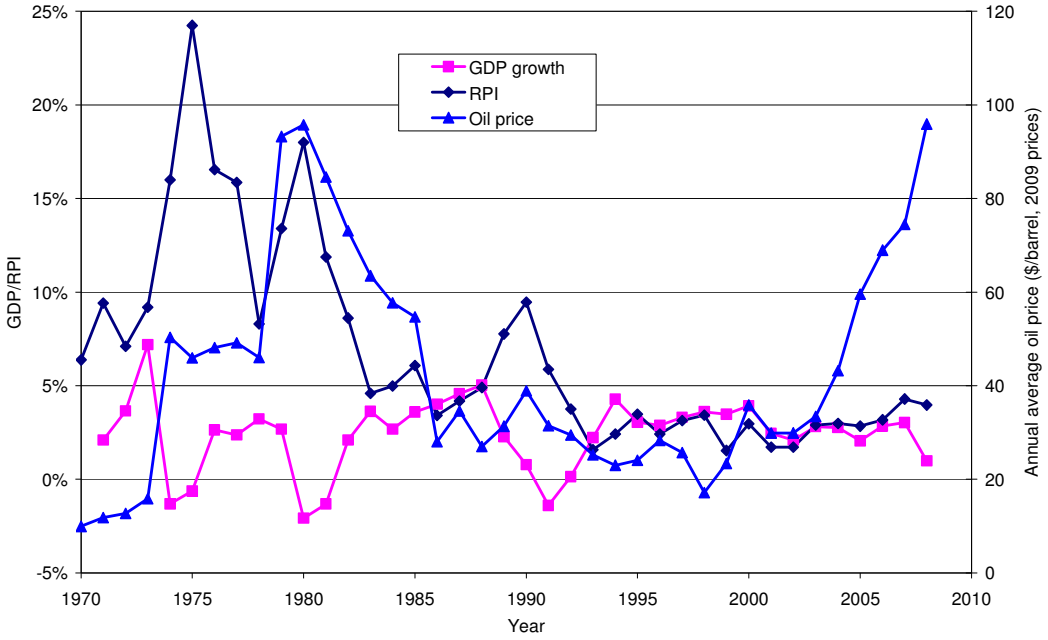


Forecasting oil prices is prone to large uncertainties, more so under Peak Oil. Some commentators have predicted prices will reach $200[21] or $300[22] a barrel. Such impacts will likely have a profound impact on transport, where for road and air, oil will continue to be the dominant energy source for the foreseeable future. Air is particularly vulnerable given the strong link to the direct cost of oil due to aviation fuel being untaxed and the virtual absence of alternatives to oil based fuels at the present time.

Oil price rises might make the exploitation of other forms of fossil energy (e.g. shale gas) more economic, and encourage faster development of engine technology to use alternative fuels derived from gas, adapting technology already used for oil exploitation and use. There is already some availability of liquid petroleum gas to fuel land transport, for example. However, the ability to exploit the reserves is as yet uncertain, and the environmental implications are potentially severe.

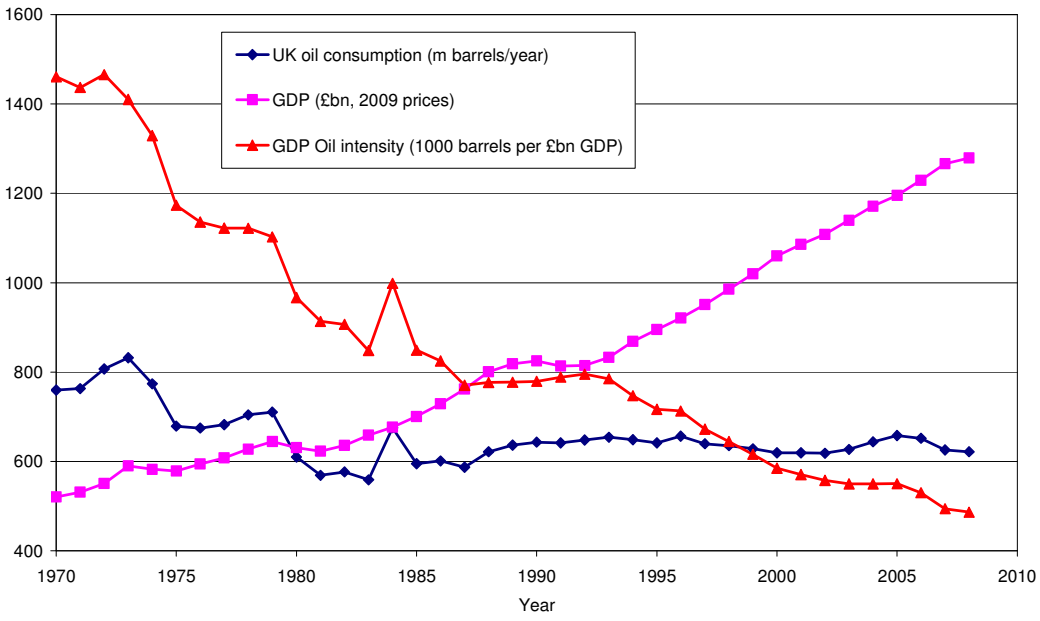
Peak Oil may also have an impact on wider economic activity. As illustrated in **Figure 2.7**[23], large changes in the oil price coincided with periods of high inflation and lower economic growth, particularly in the 1970s and early 1980s. Oil prices tripled between 1973 and 1974, ushering in a period of inflation coupled with poor economic performance, a similar pattern occurring around 1979-1980. However, the oil price increase since the early 2000s does not appear to have a material impact on GDP or inflation.

FIGURE 2.7 OIL PRICES AND UK ECONOMIC GROWTH AND INFLATION SINCE 1970



Through this period, total oil consumption declined from a peak in 1973 of around 830 million barrels per year to around 650 million barrels per year for the last 20 years or so. Given economic growth in that period, the GDP oil intensity has fallen sharply, as illustrated in **Figure 2.8**[24]. This may explain the minimal impact the recent oil price increases have had on UK economic growth. In essence UK GDP growth may be decoupling from oil prices as the economy becomes less dependent on oil and hence more resilient to Peak Oil.

FIGURE 2.8 UK OIL CONSUMPTION, GDP AND GDP OIL INTENSITY SINCE 1970



However, any substantive increase in oil prices would still have an impact; oil consumption accounts for some 1-2% of GDP, with this proportion spiking to 2.5% in 2008 as the oil prices spiked. In early 2008, it was estimated[25] that sustained high prices ($100/barrel) could cost the UK economy £18bn, losing up to 1.5% of GDP.

In terms of supply to the market, oil companies tend to exploit the largest (and most accessible) fields first. This means that the giant oil fields that are currently in production, are old and already at or near their maximum capacity. With no recent discovery of large and easily developed (and therefore low cost) oil reserves, it is reported that 8 of the world's 10 largest oil companies are struggling to maintain their current production level[26].

An oil crisis will occur when the rate of oil extraction starts slowing down, this becoming increasingly unable to meet the rising demand for oil. Unless some giant and low cost oil fields are found quickly, Industry Taskforce on Peak Oil and Energy Security (ITPOES) believes that the global oil supply will not exceed 91-92mb/d in 2015[27]. By 2030, the global oil supply is forecasted at about 106mb/d[28], against a global demand of about 105mb/d[29] .

Many analysts believe that a global oil crisis is inevitable sometime within this century. By that time, most of the oil demand will come from the emerging economies of countries like China and India, so even a decline in oil consumption from the developed countries[30] would not resolve the global supply-demand imbalance. With global supply unable to meet demand, oil prices will rise and remain volatile. There is a long lead time for oil projects and inadequate investment in the industry over recent years. Consequently, even if new oil fields are found, it is unlikely that production could be increased quickly enough to make up for the shortfall in supply that is currently projected.

3 INFLUENCES ON POLICY DEVELOPMENT

UK economic growth is linked to global oil supply. We have been importing oil since 2005, and are used to relatively easy, reliable and cheap supplies. Oil provides one-third of the UK energy consumption and 95% of transport energy used. Changes to the supply and price of oil due to Peak Oil will affect all travel and transport of goods. It will also affect the supply of electricity, and could lead to rising prices for goods and services in general.

Spatial policy concerns that may arise from Peak Oil will include food production, housing, waste management and recycling, economic development and the whole basis of spatial planning.

In terms of energy policy, oil prices are projected at around $70/barrel through to 2025, with a range around this down to $45 and up to $150. However, there is no apparent or explicit acknowledgement of the effects of Peak Oil, other than to note that maintaining energy supplies after North Sea oil and gas production has peaked is a key challenge going forward. The conventional wisdom appears to be that global oil and gas reserves are sufficient to sustain economic growth for the foreseeable future.

Similarly, Peak Oil is not recognized in spatial planning typically. Current changes to the planning system will provide a new strategic context for local policy development that is localist in its approach. It remains to be seen if and how this will deal with issues relating to the implications of Peak Oil.

Transport policy also has recently been reviewed at the national level, but remains resolutely silent on the issue of Peak Oil. Technical approaches to transport policy development and the planning of major schemes reflect the oil price forecasts mentioned above. Other recent reviews, such as the Stern Review on the Economics of Climate Change and The Eddington Transport Study maintained similarly optimistic views.

There are a few examples of Peak Oil being explicitly considered in policy development, including research by the Welsh Assembly Government and the Local Government Association. At a local level Bristol City Council has done good work in this area, and there is some limited experience from overseas.

Concerns arising from Peak Oil

In the UK, our economic growth has been linked to the level of global oil supply. Our society is oil dependent. However, the discovery of North Sea Oil in the post war period allowed the UK to reduce its dependence on imports. We have been importing (crude) oil since 2005. We are also used to getting fuel easily. The decline of global oil supply is a serious issue, but more critical is our ability to continue to import oil. With limited exports to pay for imports, our economy will struggle with the balance of payments which could be further compounded by rising oil prices.

In the UK, oil (petroleum) was one-third of the total primary energy consumption in 2009, but it accounted for nearly 95% of the transport energy used in the same year[31]. Transport, particularly car transport, will be the first to be hit in an oil crisis. Our cars are predominantly run on conventional oil-based fuel. Any changes to the supply and price of oil will affect our journeys to work, school, shops, as well as other services and activities. A possible outcome of our oil insecurity could be fuel rationing at the petrol station forecourts.

Oil is also required for fueling vehicles to deliver raw materials, food, as well as other goods and materials. In 2008, HGVs and LGVs together consumed over 12 million tonnes of fuel[32], representing the second largest road transport energy user group after private cars. Any gaps in oil supply will disrupt business operations, and create further indirect effects that will ripple from one economic sector to others. Companies that have long complex supply chains, operate a ‘just in time’ business strategy, and/or rely on foreign markets will be particularly vulnerable to fuel supply uncertainty and price volatility.

Although oil-fired power stations play a relatively small role in our energy supply, oil (including diesel fuel) is used in the construction, maintenance and repair of the various electricity infrastructure (generating stations, substations, transformers, transmission lines etc). Furthermore, due the need to meet the EU regulations on large combustion plants, many of our power stations and oil refineries could face closure by 2020. Electricity companies will be under increasing pressure to maintain services against rising energy prices. Unless non-oil based fuel substitutes and energy supply from other renewable sources are well in place to meet our increasing demand, the result could be the introduction of controlled power cuts in order to minimize our energy consumption. Any substitution of electricity for oil in road transport (as presently is being encouraged by the government) would exacerbate this.

Fuel shortages could also lead to rising prices for goods and services in general. The fear of food and fuel shortages could be accompanied by panic buying. This, together with the difficulty of maintaining essential services (including the police, healthcare, and fire services) and any likelihood of enforced power cuts, could result in communities becoming isolated and people being left stranded. It is likely that the most vulnerable and socially deprived members of our society will be the ones hit the hardest.

In terms of spatial policy, there are a number of concerns that may arise from the Peak Oil phenomenon and its likely effects. These will include:

- **Economic development:** Increasing resource costs will raise obvious issues of the availability and costs of energy needed for machinery, production, keeping factories and offices warm/cool. However, there also will be broader, and perhaps more significant issues about supply of materials (e.g. plastics) and changes in the sort of products and services we will need in the future. Also, if the balance between the cost of labour and the cost of transport changes are we may see a return to more local production. For example, plants that moved to low cost developing countries may start to return to the UK, with implications for the economies of both developing countries and the UK. Will there be a move away from Just-in-time back to wholesale distribution, warehousing and freight consolidation. For products which have a long shelf-life, not time critical then there could be a return to water transport as well as rail freight, although there are capacity issues with the current infrastructure.

- **Housing:** The availability and cost of keeping homes warm in winter and cool in summers will throw into sharp contrast the issue of fuel poverty and will alter the economics of housing provision. The way in which refurbishment of existing houses will be affected, and standards for new houses will need to be set to ensure that they have much greater energy efficiency that at present. The way in which building materials are reused will also need to change. The savings from providing more energy-efficient homes will more than offset the additional costs due to the increased cost of fuel.

- **Waste management and recycling:** The changes in resource costs due to Peak Oil will in the future will change the economic basis of resource winning and recover. This is likely to prompt a greater need to look at how we can recover materials and energy from existing land fill sites (even closed ones). It will also raise planning issues about creating the infrastructure for greater reuse and recycling and for recovery of materials and energy from waste.

- **Food production:** Fuel shortages and price increases will not just affect fuel used for transport, but also where it is used for farm machinery, food processing, manufacture, storage and refrigeration. Fossil fuels are also basis of much pesticides and fertilisers (and so impact on farm productivity) and plastics for food packaging.

- **Spatial Planning:** For the last 40 - 50 years, proximity to motorway junctions and/or international airports has been drivers of development and growth. If rail and waterways become more important and if travel to work journeys become a lot shorter or more focused on mass transport then we could see a very different geography locally, regionally and nationally.

Within the scope of the present study, it has not been possible to examine all these issues in detail. Our focus has been to examine some of the implications that have already influenced energy policy, and then to turn to consider some of the specific concerns relating to spatial planning and transport planning.

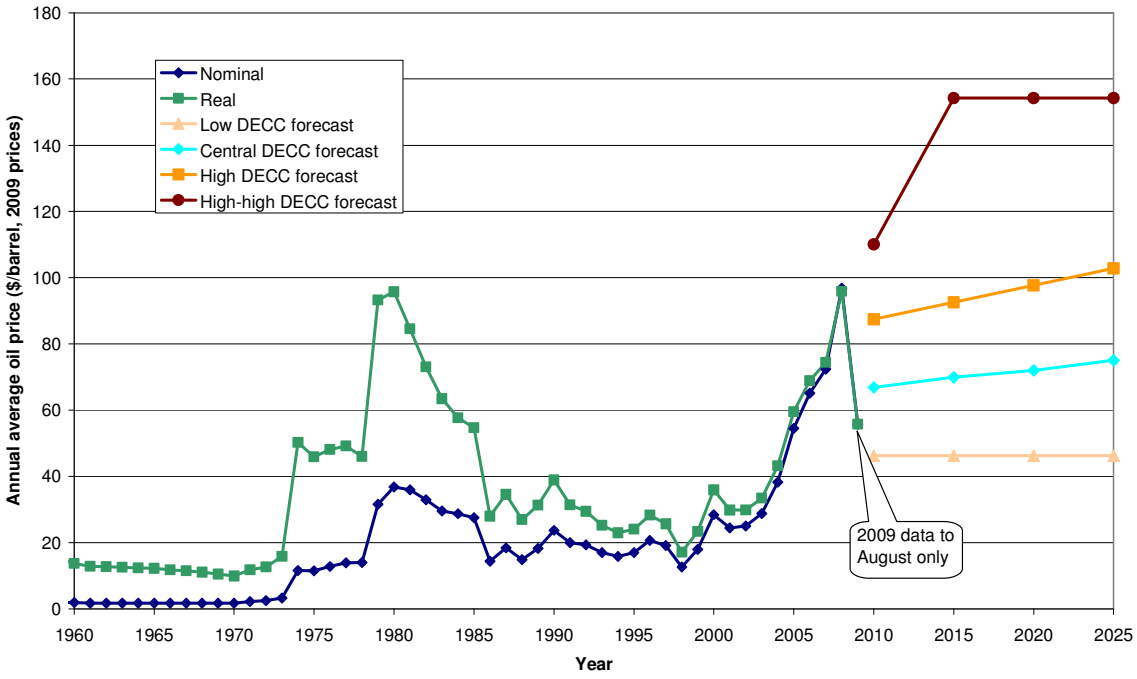
Energy policy

Department of Energy and Climate Change

The Department of Energy and Climate Change (DECC) was established in October 2008 bringing together energy policy (previously with BERR - the Department for Business, Enterprise and Regulatory Reform) with climate change mitigation policy (previously with Defra - the Department for Environment, Food and Rural Affairs). The merging of these reflects the fact that climate change and energy policies are strongly interconnected.

As previously noted, DECC produces forecasts of oil prices. The central case forecast has an oil price around $70/barrel (2007 prices) through to 2025, with a range around this down to $45 and up to $150; the forecasts are shown in **Figure 3.1** [33]. Comparison with historical prices shows that the Central Forecast reflects the typical value over the last 3-4 years, with the high being more typical of the 2008 peak. The high-high value broadly sees the recent trend extrapolated to 2015 and then plateauing at $150/barrel.

FIGURE 3.1 DECC OIL PRICE FORECASTS (2009 PRICES)



Reviews of the literature undertaken for this study revealed no apparent published information or consideration explicitly by DECC concerning Peak Oil, with the exception of the acknowledgement that a key challenge facing DECC is to ensure energy supplies after North Sea oil and gas production has peaked.

2007 Energy White Paper

The 2007 Energy White Paper[34] did not raise the issue of Peak Oil, citing an IEA report[35] that concluded that global oil and gas reserves are sufficient to sustain economic growth for the foreseeable future. Indeed, the term Peak Oil does not even appear in the White Paper.

The focus of the White Paper is energy security and reducing carbon emissions. To do this, it emphasizes a need to save energy, develop cleaner energy supplies and secure reliable energy supplies at prices set in competitive markets. Key elements of the strategy set out in the White Paper were to:

- Establish an international framework to tackle climate change, including a shared vision for stabilising the concentration of greenhouse gases in the atmosphere.
- Provide legally binding carbon targets for the whole UK economy, progressively reducing emissions.
- Encourage more energy saving through better information, incentives and regulation.
- Provide more support for low carbon technologies such as wind, tidal, solar and nuclear power.

Of themselves, the goals of energy efficiency and use of renewable energy sources clearly will help counter some of the potentially adverse impacts of Peak Oil. However, tackling this issue is not an explicit policy goal of the White Paper.

Spatial policy and planning

Peak Oil is not well recognized in spatial planning although some direct effects of Peak Oil will be experienced in the UK within the time horizon of national and local plans. There is inevitably a time lag between the realisation that a subject is important and its appearance in spatial plans. For example, most plans are only now including some reference to health issues although the issues (the inter-relationships between the environment and obesity, deprivation, air pollution and life expectancy) were already known and being explored in the later 20th Century in some parts of the country, appearing for example in the Mayors' first London Plan[36].

Peak Oil potentially affects spatial policies in terms of:

- **Energy efficiency concerns:** Typically, policies regarding the spatial distribution of development, the setting of densities for development and the types of buildings that are permitted have not taken the need to use energy in the most efficient ways into account. Similarly, the resulting demands for travel and infrastructure investment to meet those needs have not considered explicitly the constraints that energy shortages might place on longer-term returns on investment.
- **Security of energy supply:** This has most often been reflected in spatial policies in terms of providing necessary infrastructure to match supply of energy with demand, typically by ensuring that supply, generation and transmission capacity is provided to support planned industrial and domestic development. More recently, there has been a recognition that specific policy responses are required to help ensure that the particular needs relating to the development of renewable energy sources are required (e.g. land for growing biomass; sites for biomass incinerators; siting of windfarms, solar panel arrays, hydroelectric and wave generation technologies etc.).

The fact that spatial plans have been hierarchical – based on statements of national planning policy and (until 2010 in England outside London) on regional plans – has had two effects:

- if the subject is not explicitly mentioned in at the national level, it is liable to be considered not significant for local plan preparation; and
- if a policy is mentioned in higher level plans, then policy is not to be repeated in local plans unless there are specific local issues, as is required by Planning Policy Statement(PPS12).

The Localism Bill proceeding through Parliament at the time of writing will rescind Regional Spatial Strategies[37], and at the same time the consultation has recently closed on the consolidation of policy

statements, circulars and guidance documents into a single National Planning Policy Framework[38]. While this will provide the strategic context for local policy development in the future, the responsible minister has indicated that the new Framework will be localist in its approach, with local communities to decide what is right for them. It remains to be seen how this framework will deal with issues such as development of a capability to provide renewable energy, construction standards to make new homes and other buildings more energy-efficient and the infrastructure needs to encourage the use of alternative fuels for transport. However, the indications are that the framework is intended to be brief, and it seems likely that it may be silent specifically on issues relating to the implications of Peak Oil.

Also, although development plan documents are supposed to have a clear vision for the future, and may be based on a pen picture of the area and its opportunities and problems, in practice most are limited to a few objectives, largely based on the good intentions of the Community Strategy, a desire for everywhere to be a "world class" place with excellent facilities and community satisfaction, together with more specific concerns about the location of housing, major economic development (or redevelopment) and the protection of the environment. Hard-hitting issues that might upset this consensus are largely avoided – indeed the location of housing and the competing claims of centres within the authority are usually contentious enough.

The advent of neighbourhood plans in the Bill may satisfy demands for more community concerns to be reflected in planning decisions, but runs the risk of reinforcing a negative conservative approach to the area, based on current preferences and behaviours. One only has to observe the outcry in local communities whenever parking charges are imposed or increased, and the near hysteria generated when petrol process rise – together with calls for government subsidy to the motorist in the form of reduced taxation of fuel. Short-termism and emphasis on purely local concerns may make preparing for Peak Oil more difficult without strong strategic leadership from the development plan, local transport plan and sub-regional partnerships.

The abolition of regional strategies in effect may remove the ability for spatial plans to address wider questions, such as the future structure of an area in relation to the severe constraints exerted by flooding and coastal erosion, congestion, the looming crisis of waste disposal, and the lack of infrastructure to meet foreseen demands. However, the need for an "evidence base" and the essentially short term nature of economic analysis has resulted in show-stopping issues largely being left to national professional and commercial interests and research bodies.

Some recent development plans do incorporate climate change issues, which represent policies generally relevant to Peak Oil but which do not address the issues comprehensively. Most development plans now will include specific reference to climate change issues, as presently required by Planning Policy Statement 1 (PPS1) and Supplement. The policies proposed are generally compatible with those that would be necessary to confront the shortage of hydrocarbons in the future. However, there is an incomplete understanding:

- Issues relating to the provision of infrastructure to generate and deliver renewable energy typically relate to the direct environmental consequences of that infrastructure itself. Clearly, the potential locations of facilities to generate renewable energy are limited to those where the right topographic and/or meteorological conditions exist, and these are often sensitive locations in environmental terms. Also, there is often a need for such developments to be remote from residential areas, which again tends to focus such proposals in sensitive areas. While appropriate policies to protect important and vulnerable environmental resources are important, there is a suspicion that some proposals for vital renewable generating capacity have been blocked through "NIMBYism".

- Consideration of issues relating to mitigation of, and adaption to, climate change is often limited (and indeed government advice by the Planning Advisory Service in the "Plan Making Manual" reinforces

this view[39]) to considerations of the energy use of buildings and the more obvious adaptations needed for expected increased flooding probabilities. The establishment of stricter Building Code Levels and requirements for renewable energy components are common features. This would be a valuable component of dealing with Peak Oil, even if not sufficient. However, some plans still see energy as being a demand to be met by utility suppliers.

- Transport – following PPG13 – pays attention to travel choice and alternatives to the private car. Attempts are made to secure development locations where travel demands can be reduced or met by more sustainable modes, but there is often no certainly that alternatives will be delivered. The history of development planning in most of the UK suggests that good intentions are rarely fulfilled in execution, and the drift to car-dependence continues. The development of communities that are not dependent on motorised travel, or only on transport that in the longer term can continue to be sourced from renewable energy, would overcome many Peak Oil issues in this sector. We are far from this, however, and some plans concede that the car will continue to be the dominant form of transport.

- The area that is almost completely ignored in development plans is that of food security. One of the effects of Peal Oil will be to put pressure on the productivity of farmland which is currently only sustained by intense fertiliser input (using hydrocarbon products), and serviced by a distribution sector mainly reliant on oil. Perhaps because agriculture was excluded from the definition of "development" in the Town and Country Planning Acts, the sector is not considered in plans. Rural policies concentrate on rural diversification (for economic reasons, often irrespective of transport issues), the preservation of existing habitats or landscapes, and the hierarchy of settlements (to meet housing demands more generally and maintain some viability in smaller communities).

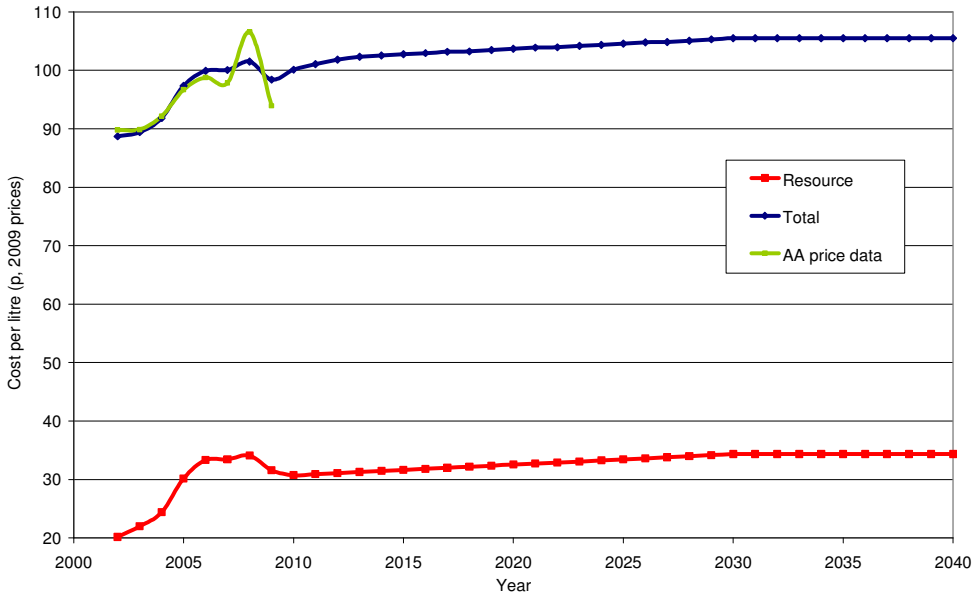
Transport policy and planning

Transport policy has recently been reviewed at the national level, and a new White Paper[40] now sets the context for local policy development and transport planning at the local level. However, this document remains resolutely silent on the issue of Peak Oil, although it sets out the intention to support wider goals of promoting economic growth and reducing carbon emissions. While the White Paper emphasises the key role of developing sustainable travel in delivering the Government's key objectives for local transport, at the same time it underlines the importance of travel by car and rail for longer-distance journeys, and stresses the role of local communities in identifying transport needs and shaping transport responses in their own areas. The extent to which the implications and effects of Peak Oil in the longer term (e.g. in terms of the cost of fuel and travel) might restrict choices in this respect is not explicitly considered.

At the technical level, the most widely-adopted approach to transport policy development and the planning of major schemes in Britain is set out in the UK Government's Transport Analysis Guidance[41]. This provides detailed guidance on the appraisal of transport projects and wider advice on scoping and carrying out transport studies.

A key unit offered within the system is TAG Unit 3.5.6, Values of Time and Operating Costs. This sets out monetary values of time and vehicle operating costs for the forecasting and economic appraisal of transport schemes. The values, illustrated in **Figure 3.1**[42], show the resource and total cost (including taxes) for a litre of petrol (note that whilst the data is from 2002, it is forecast from 2008 onwards and hence fails to reflect the impacts of the high prices experienced in that year). The resource cost peaks at 34.1p/litre in 2008 before falling back and is then forecast to grow slowly to reach 34.4 p/litre by 2030, remaining flat thereafter: essentially, the forecast is for constant (in real terms) cost. The total cost line shows some increase, driven by assumed changes in fuel duty. Overall, no material change to long term fuel price is assumed. The values are based on the oil price forecasts issued by the Department of Energy and Climate Change (see above).

FIGURE 3.2 WEBTAG PETROL PRICES (2009 PRICES)



Stern Review on the Economics of Climate Change

The Stern Review[43] was announced by the Chancellor of the Exchequer in July 2005. The Review set out to provide a report to the Prime Minister and Chancellor by Autumn 2006 assessing the nature of the economic challenges of climate change and how they can be met, both in the UK and globally.

The Review assumed that the transport sector is still likely to be largely oil based by 2050. Reviewing the supply of fossil fuels, including oil, the Review stated that *"there is enough fossil fuel in the ground to meet world consumption demand at reasonable cost until at least 2050"*. Focusing on oil, the Review, quoting International Energy Agency (IEA) data, opined that this cost could be less than $30/barrel.

The Eddington Transport Study

The Eddington study[44] was jointly commissioned by the Chancellor of the Exchequer and the Secretary of State for Transport to examine the long-term links between transport and the UK's economic productivity, growth and stability, within the context of the Government's broader commitment to sustainable development. The Study was announced in Budget 2005 and reported on 1 December 2006 to accompany the 2006 Pre-Budget Report.

The study undertook modelling analysis, using a range of tools, to inform its work. A key assumption within this was the oil price in 2025. The central estimate is that oil will be $35/barrel (2004 prices), with high and low values tested respectively of $50 and $20. Additionally an extreme value of $100 was modelled. These forecasts were based on the then Department for Trade & Industry (DTI) forecasts of oil prices. The central case assumption equates to around $40/barrel at current (2009) prices, a level that was rarely exceeded during the period between the mid 1980s and the early 2000s. However, the average since the early 2000s has consistently exceeded this, as demonstrated in **Figure 2.6**. Based on recent experience and the likely impacts of Peak Oil on prices, the high or even the extreme oil price assumption is likely to be more realistic.

Experience of Peak Oil Influences on Policy Development

Experience from the UK

As noted previously, in the UK there are few examples of the Peak Oil concept being explicitly considered in policy development.

In 2008, the Welsh Government produced a research paper for members[45] that examined the theory of Peak Oil, and considered the implications for oil users of the impending peak. This recognized that at some point, global oil production will reach a peak, and beyond this the oil that remains will be more difficult and costly to extract. While noting that the UK Government believed that the world's oil and gas resources are sufficient to sustain economic growth for the foreseeable future, it observed that the UK's oil production peaked in 1999, and the UK became a net importer of oil in 2006 and that imports will form an increasing proportion of oil consumption in the UK.

While authorities in the south Wales valleys tend to have a relatively low per capita use of fuel for personal road transport; rural authorities tend to have higher per capita use. One of the manifestations of Peak Oil will be a rapid escalation in oil price. Oil prices are currently the highest they have ever been, even accounting for inflation. In July 2008, the Deputy First Minister for Wales wrote to HM Treasury to raise concern over the impact of increasing fuel costs on businesses and consumers in Wales. The paper concluded that there is broad agreement that Peak Oil will have profound economic impacts, and that these will in turn have social repercussions. There is also a consensus that those countries that do plan and prepare for Peak Oil will have an advantage over those that make no preparation. Sweden is the only country that has an explicit government commitment to breaking its dependence on oil.

Another 2008 report by the LGA[46] took as a jumping off point the recent high volatility of oil prices. Considering whether the high peaks in prices were temporary, or if we need to prepare for an era of higher oil and energy prices, this report attempted to frame this trend against the challenges posed also to responding to the threat of climate change. It concluded that in the future all sectors of the economy are likely to be affected to some extent by the end of the era of cheap oil. However, it identified the effect on the transport sector as potentially the greatest because it is so heavily reliant on liquid fuels. The report concluded that increasing demand, particularly from developing economies, combined with a declining supply of easy and cheap oil is likely to mean greater price uncertainty in the long term. It also recommended to local authorities practical steps they can take to help households and businesses adapt and offered some practical examples of action being taken now by local authorities and communities to prepare for challenges of diminishing energy supplies and climate change. Finally, the report suggested what central government needs to do to help local councils, with a view to helping all local authorities in demonstrate leadership and stimulate innovations on this most vital of issues.

In Bristol, the City Council recognized that the city's development and fortunes are closely linked to changes in the nature and supply of energy. Bristol's historical success as a trading city exploited the wind to power our ships and our modern city is based on the use of fossil fuels, in particular oil. In the face of warning from an increasing number of experts that the era of cheap oil is over and that an oil "crunch" is likely in the near future, Bristol City Council and the Green Capital Momentum Group of the Bristol Partnership commissioned a study of the implications of Peak Oil[47]. This reviewed the issue and made a number of recommendations for action across a range of policy fields, including social cohesion, emergency planning, transport and accessibility, food, healthcare, public services, the economy, power and utilities. This was intended as the first step in making the city more resilient to the shocks of an oil crunch and to help identify new opportunities created by a move from oil and fossil fuels to more sustainable and local energy.

Experience from other countries

Within the scope of the present study, it has not been possible to review experience of where peak oil concerns have influenced planning policy in countries other than the UK. We are aware that there are examples, such as:

- In February 2006, Sweden announced that it would try to wean itself off oil completely by 2020[48]. This was in response to concerns over climate change and the impact of Peak Oil and the associated price increases.
- Ireland undertook a study[49] to consider the impact of Peak Oil, given its dependence on imported oil. It recommended that a national strategy be developed to mitigate the impacts of Peak Oil, encompassing an EU wide energy policy that sets out a common co-operative approach to dealing with oil peaking alongside a national policy focusing on the specific challenges to be faced by Ireland. The latter included reducing the consumption of oil in transport, improving energy security, developing alternatives to oil, improving energy efficiency and reducing the need to travel through strong spatial planning policy.

We would welcome contributions from readers indicating other examples which could inform the development of policies in the UK in this respect.

4 IMPLICATIONS OF PEAK OIL FOR TRAVEL

The impact on travel of higher oil prices due to Peak Oil will be most likely broadly to reduce demand on all modes, except for rail travel, which will show a slight increase. If oil prices hit $200/barrel, car travel will return to 2008 levels and fall to nearly 10% below 2008 levels at $300/barrel. Even at the higher price, air travel demand will remain above 2008 levels, albeit marginally.

Such changes in the patterns of demand for travel could have important implications for transport investment. In particular, highway capacity enhancement schemes would provide fewer benefits due to reduced congestion relief and time savings, whilst the case for similar schemes on the railway network would be strengthened.

One clear implication of this is that investment priorities made on this basis would differ from those based on current assumptions. In particular, the returns on investment in measures to promote active travel (i.e. walking and cycling) and smarter choices (such as home-working, tele-commuting, greater use of public transport, lift-sharing, and car clubs etc.) may also be more attractive in economic and environmental policy terms. This is wholly consistent with the policy positions set out in the most recent Transport White Paper.

However, the different outcomes that might result from pursuing the same policy goals based on alternative economic assumptions and analyses of this type need to be recognized in land use and transport policy-making more explicitly.

Travel Responses to Peak Oil

The response to Peak Oil in relation to travel will be varied and include both mitigation strategies to reduce the direct cost impact of Peak Oil, along with changes to travel demand.

Market based responses will include development of more efficient vehicles and vehicles powered by alternative fuels. Mitigation strategies will tend to focus on improving the energy efficiency of powered travel. In particular, drivers may buy more fuel efficient vehicles in the same vehicle class, smaller vehicles, or vehicles powered by alternative fuels. Driving techniques and style can be improved to reduce consumption. Similar strategies can be employed by other modes, although for aviation and rail the rate of change will be much slower given the typical lifetime of much of the vehicle fleet and associated infrastructure.

Even with such mitigating strategies, the cost of travel will still increase and travel demands will change. The exact change will depend on such issues as current mode, the journey purpose, income and existence of alternatives. The short to medium impact on car travel will arguably be greatest since energy dominates the perceived marginal cost of travel; conversely energy is just one component (up to 20%) of fares on rail, bus and air. Possible demand changes include:

- **Trip frequency:** the frequency of travel could reduce, either directly (simply making that journey less frequently, for example visiting family and friends) or indirectly (through increased home working for example).
- **Tour arrangements:** trip making, say during a week, can be rearranged to undertake the same activities with fewer (return) trips by linking them better
- **Change of origin and/or destination:** essentially relocating the journey ends to reduce the length of the trip. This would most likely involve changes in destination, for example working closer to home,

shopping more locally etc. Some change might involve relocating the home end closer to the workplace.

- **Mode choice:** this might be independent of or in conjunction with a change in trip origin and/or destination. Assuming the trip is unchanged, it would simply mean changing the mode of travel, such as car to bus or rail for longer trips, or to walking and cycling for shorter trips. It could be done simultaneously with a change in origin and/or destination, for example moving house or employment location to be able to use rail for commuting rather than car.

- **Route choice:** this will have a marginal impact on fuel consumption, but some (car) journeys may reroute to reflect the greater emphasis on fuel consumption relative to journey time.

- **Car ownership and car use:** car ownership is a material influence on the level of transport demand and is an obvious influence on mode choice and trip destination. The impacts of Peak Oil may make car ownership and use a less attractive proposition and with lower car ownership, travel demand will change. This may be mitigated through membership of a car club as an alternative to ownership, where a car is available but at a direct cost and with restrictions on availability. Similarly, consumers may switch to more efficient or alternative vehicles (such as Smart or G-Wiz) for city use but these are less multi-purpose and less suitable for longer distance travel.

- **Land use change:** in the medium to longer term, patterns of land use and economic activity may change sufficiently in response to Peak Oil to reduce the dependence on oil based transport.

Potential travel demand impact

As part of the research conducted for this study, a simple elasticity model has been used to forecast the potential impact on travel demand, expressed as total passenger kms, with the range of oil prices outlined previously. The model was originally developed by transport consultancy Steer Davies Gleave to research the impact of pricing policy on transport carbon emissions as part of a study for the Campaign for Better Transport[50].

The model uses current long term forecasts of demand by mode and applies industry standard elasticities to understand how price changes will affect demand. The use of standard elasticities may not reflect the potential for paradigm shifts in travel behaviour, nor the mitigating strategies adopted by travellers in the more extreme scenarios tested (such as use of alternative fuel vehicles). However, it is not intended to produce accurate forecasts of demand under different oil price scenarios, rather to illustrate the potential demand impact of varying motoring costs and public transport fares arising from Peak Oil. More detail on the model can be found in the **Appendix** to this paper.

Fuel prices

The relationships between oil prices and petrol prices encapsulated in WebTAG Unit 3.5.6 have been used in the model to derive estimates of UK petrol prices given differing levels of oil prices. The range considered covers the Department of Energy & Climate Change (DECC) forecasts and the higher forecasts of $200 and $300 per barrel (see **Figures 2.6** and **2.7** above. The resultant petrol prices (in pence per litre) are set out in **Table 4.1** below.

TABLE 4.1 FORECAST UK PETROL PRICES (P/LITRE, 2009 PRICES)

Year	DECC Low	DECC Central	DECC High	DECC High-High	Goldman Sachs	Matt Simmons
2010	89	100	111	123	172	226
2015	90	103	115	148	172	225
2020	90	104	117	147	172	225

Year	DECC Low	DECC Central	DECC High	DECC High-High	Goldman Sachs	Matt Simmons
2025	89	105	119	146	170	222
% change from DECC Central (used as basis for WebTAG values)						
2010	-11%	0%	11%	23%	72%	126%
2015	-12%	0%	12%	44%	67%	119%
2020	-13%	0%	13%	42%	66%	117%
2025	-14%	0%	14%	40%	63%	113%

The DECC Central oil price forecasts produce petrol price forecasts of 100 to 105 p/litre; as noted, these are the values within the WebTAG guidance in Unit 3.5.6. The DECC low forecast is typically around 90 p/litre, the high up to 119 p/litre, with the high-high forecast producing petrol prices of around 147 p/litre by the middle of the next decade, some 40% higher than the central forecast. The higher oil price forecasts of Goldman Sachs and Matthew Simmons produce petrol prices materially higher than this, at around 172 p/litre and 225 p/litre respectively, or some 70% and 120% above the DECC central forecast.

Price Scenarios

A range of scenarios were developed for use with the model, with % changes in car fuel prices and fares for rail, bus and air, based on the proportion of industry costs typically spent on fuel as follows:

- Air 20%;
- Bus 12%; and
- Rail 5%.

These are based on rates identified by Steer Davies Gleave, with the rail proportion being taken from a research study by the Rail Safety and Standards Board[51].

Since the model can only utilise a single temporal price variance, the DECC forecasts for 2020 have been employed, along with the $200 and $300 per barrel forecasts previously quoted. **Table 4.2** sets out the oil price forecasts and the associated change from the DECC central forecast (see also **Figure 2.7** above) which is assumed to be the basis for the demand forecasts.

TABLE 4.2 FUEL PRICE SCENARIOS IN 2020

Scenario	Oil Price ($/barrel)	% change from DECC Central
DECC Central	70	n/a
DECC High	95	36%
DECC High-High	150	114%
Goldman Sachs	200	186%
Matthew Simmons	300	328%

Allowance has been made for improvements in fuel efficiency. Data for car[52] has been taken from WebTAG Unit 3.5.6, with bus assumed to have the same rate of improvement. Air efficiency growth, at 1.6% p.a. to 2020, is consistent with Department for Transport (DfT) forecast assumptions[53]. No change in fuel (energy) efficiency is assumed for rail[54]. The resultant impact on highway fuel prices and public transport fares is set out in **Table 4.3**.

TABLE 4.3 SCENARIOS OF CHANGES IN FARE AND FUEL COSTS

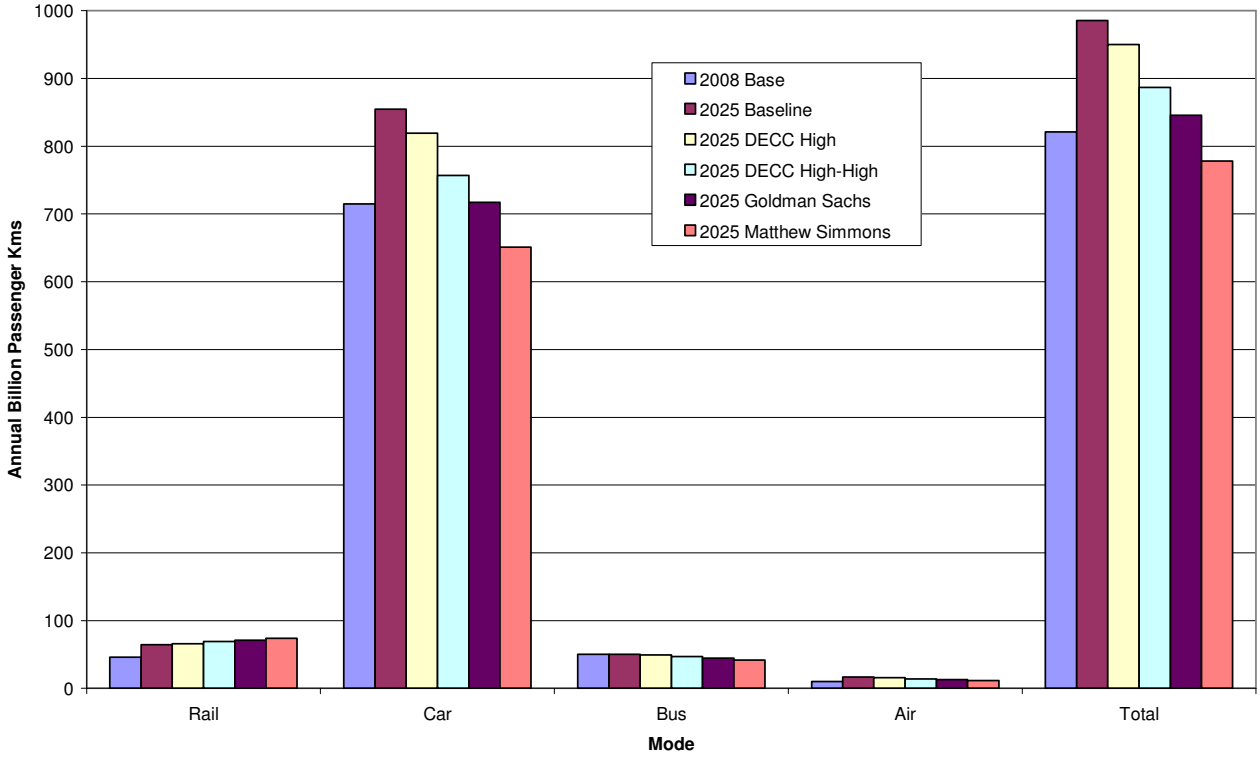
Scenario	Car	Bus	Rail	Air
DECC Central	0%	0%	0%	0%
DECC High	11%	4%	2%	6%
DECC High-High	37%	12%	6%	19%

Goldman Sachs	57%	19%	9%	32%
Matthew Simmons	102%	34%	16%	56%

Demand Impacts

The demand impacts predicted by the model are illustrated in **Figure 4.1**[55]. This shows the 2008 Base and 2025 Baseline demand based on the DECC Central oil price forecasts, with then the impact of the various oil price scenarios. Of note, car is the dominant transport mode, with 87% of total UK passenger km in 2008; air has the lowest share at just 1%. Growth is forecast through to 2025 for all modes, with the exception of bus; air is the fastest growing at 65%, followed by rail (40%) and car (20%). However, it should be noted that the model does not take into account supply uncertainties and the risk of interruptions or greater price volatility.

FIGURE 4.1 2025 DEMAND IMPACT BY OIL PRICE SCENARIO



5 SPATIAL AND TRANSPORT POLICY RESPONSES TO PEAK OIL

Peak Oil will affect everyone unless appropriate steps are taken soon. Possible responses by the planning profession could include an emergency energy supply plan; co-ordinated policies on Peak Oil and climate change, and raising public energy awareness. Adoption of the Oil Depletion Protocol, joint Peak Oil task forces, and partnerships with community-led initiatives are among the options open to organizations.

There is already available a wealth of advice on urban design and sustainable travel, which is providing more clarity in statistical terms and the right focus for meeting desired goals in terms of Peak Oil and climate change. Key themes include settlement size and the strategic location of development, the strategic transport network, development density and so on.

These examples of existing initiatives, often not specifically focused on the Peak Oil issue, nevertheless provide pointers as to the way forward for planners. These include approaches developed by the Design Council Cabe, the Independent Commission on Transport, the Low Carbon Communities Network, the Low Emissions Strategies partnership, the Centre for Alternative Technology and the Transition Towns Network among others.

Specifically in relation to transport policies, there are also a range of current responses that could be better co-ordinated and harnessed to address issues relating to the implications of Peak Oil, such as energy efficiency, use of alternative fuels, pro-active management of fuel prices, smarter car use, encouraging modal shift and other changes in travel behavior, and speed management. Initiatives by the present Government focus on encouraging walking and cycling for shorter local journeys to support its wider goals of promoting economic growth and reducing carbon. However, the importance of travel by car and rail for longer-distance journeys is highlighted.

More explicit consideration of Peak Oil will have mixed impacts on policy goals for transport. The concept of Peak Oil must be better integrated into policy making, as climate change currently is, and the synergies between them recognised. One means of achieving this is to better integrate Peak Oil considerations into existing appraisal techniques for spatial planning and transport policies.

None of this is new, and are not exclusive to cities, as often is held. Work by the Government Office for the South East or the Joseph Rowntree Foundation, for example, indicate this. Most measures to secure low carbon living patterns of development are entirely compatible with preparing for Peak Oil. However, there does need to be a greater imperative for their successful implementation.

Towards a response to Peak Oil

The effects of Peak Oil will affect everyone unless appropriate steps are taken sooner rather than later. The literature review undertaken as part of this research project has identified a list of possible actions that could be followed by the planning profession. The list is not exhaustive and the emphasis should be on developing as many realistic options as possible to prepare our society for the effects of Peak Oil. At a national/strategic level, policy responses could include:

- Developing a emergency energy supply plan;
- Co-ordinating policies on Peak Oil and climate change; and
- Increasing public energy awareness.

At a local level, some responses could be to:

- Adopting the Oil Depletion Protocol (www.oildepletionprotocol.org);

- Setting up joint Peak Oil task forces as partnerships of local authorities and other stakeholders;
- Developing close partnerships with existing community-led initiatives (e.g. the Transition Network - http://www.transitionnetwork.org);
- Promoting policies that support the local sourcing of food and materials;
- Adopting a more strategic approach to energy, heating and cooling;
- Reducing overall transport demand within the built environment through the planning process;
- Adopting policies and incentives to enable a major shift from private to public transport, cycling and walking; and
- Promoting policies that support local production of non-fossil transport fuels, and developing energy from renewable sources, including energy-from-waste projects.

Very many planning and transport strategies contain common proposals for more sustainable living. There is a consensus amongst most built and rural environmental professionals on the measures that need to be taken. These have not necessarily started from Peak Oil (although energy supplies in the context of global warming have often been a concern). One useful summary of the approach was provided by the Design Council Cabe (formerly CABE)[56], which starts from the premise that the urban environment needs to become a better place to live, noting that *"a place that improves health, well-being and economic resilience while simultaneously – and dramatically - reducing greenhouse gas emissions"*.

The priorities are listed as:

- **Energy:** Develop a low carbon and renewable energy portfolio and reduce energy demand;
- **Waste:** Plan for sustainable waste management and turn waste into energy;
- **Water:** Manage surface water and flood risk and encourage sustainable water use;
- **Transport:** Encourage public transport, walking and cycling, reduce car use and improve the carbon efficiency of vehicles;
- **Green infrastructure:** Integrate green infrastructure into urban areas and help wildlife adapt to climate change;
- **Public space:** Adapt public space to climate change and maximise the potential of public space

There is often synergy between the measures needed to create a good environment (in general planning terms) and to deal explicitly with Peak Oil. Conversely, the looming crisis of Peak Oil should assist in establishing planning good practice measures that are either somewhat controversial (at least to some sections of the public and politicians) or given lip service to but not seriously implemented. Many non-car transport policies and attitudes to decentralised energy fall into these categories.

Similarly, the links between transport and land use have always been an important element of spatial planning, and continue to be so. The most recent Transport White Paper states that *"it is vital that transport planning has early and proactive engagement with the development plan preparation process and also with applications that have significant transport impacts"*[57]. The "predict and provide" approach to road planning early gave rise to opposition to transport policy that sought to facilitate car mobility. Concern about urban deprivation led to questions about the quality of urban spaces, whilst concern about the countryside and land lost to development have long been drivers for designations of countryside and policy to contain urban sprawl (green belts). Two examples are work on transport in the 1970s and on

environmental strategies, leading to the White Paper -This Common Inheritance, Cm1200 in 1990, which explicitly included global warming and energy efficiency. More recently, the 1999 Report of the Urban Task Force "Towards an Urban Renaissance" advocated measures to regenerate urban areas, including one recommendation to commit a minimum of 65% of transport public expenditure on walking, cycling and public transport, and another to discourage low density development.

An example of how policy directions may be changed is provided by the Independent Commission on Transport (ITC) was set up by Hugh Montifore in 1973 as a response to the concerns over traffic growth, including the government position in supporting the growth of personal mobility in the years after the 1963 Buchanan Report "Traffic in Towns". The Commission's 1974 report "Changing Directions" examined transport, suggested criteria for national policies and made recommendations. One of its chapters concerned the resource costs of transport, including energy consumption; oil reserves and security of supply (the Arab oil export embargoes were under way at the time); and alternatives to oil. It concluded that there should be immediate implementation of policies to limit the consumption of energy and especially oil. This, it was recommended, should be achieved by:

- Reducing the amount of travel;
- Encouraging walking and cycling;
- Encouraging the use of more energy-efficient motorised transport modes and discourage the use of less efficient modes for both people and goods;
- Encouraging more efficient use of all modes, but particularly of the one which uses most oil (i.e. cars);
- Encouraging changes in vehicle and engine design;
- Reducing road speed limits; and
- Encouraging greater use of electric transport.

These principles could almost be the objectives of low carbon policies today, and indeed do appear in many strategies aimed at reducing carbon emissions from transport. In the intervening period, some progress has been made on the efficiency of vehicles, but hardly any on really encouraging energy efficient modes. Nevertheless, their impact has been limited, and congestion and car dependence has continued to rise, and public transport, walking and cycling is often unpopular or extremely hazardous in many areas.

Interestingly, the ITC report also considered the land lost to transport uses, lost in the production of aggregates, and indirectly via the pattern of urban development, contrasting Milton Keynes (planned around the car) with older areas planned before the car. It concluded *"The loss of land taken directly and indirectly by transport is clearly a cause of concern. No account at all is taken, when the cost of transport is calculated, of the indirect effects of transport policy in promoting patterns of urbanisation which cause higher losses of agricultural land than would otherwise be necessary. The direct costs do, of course, appear in the road programme, but it is doubtful whether the market price of agricultural land fully reflects the long term requirements of food production or the environmental and recreational costs involved"*. [para.3.80]

Spatial Planning Policy Responses

It has been observed that "the best transportation plan is a good land use plan."[58] . The pattern of land use has a material influence on the level of travel demand and the modal choice of travel. Low density, mixed use sprawl is largely dependent on oil based car travel and serving such low volume dispersed travel patterns with efficient public transport is very problematic. The resulting distances also make walking and cycling difficult.

Whilst the timescales are long, future spatial planning policy should focus on developing patterns of land use that are conducive to reducing the need to travel and to maximising the viability of public transport, walking and cycling as credible travel choices.

It is recognised that although spatial planning policy can help, it is very difficult for this to counter the trends for globalisation. Increasing specialisation and trade as an engine of economic growth has been recognised since Adam Smith (economist). Although there is scope for reducing the need for travel, there is an inevitable increase in demand for movement due to these economic trends that cannot be easily avoided. It should also be noted that as an economic factor of production, transport is relatively cheap compared with land, raw materials and labour. Therefore, it is often substituted for these (e.g. having one depot distributing to a large area is cheaper than two smaller ones because it is cheaper to transport the goods around than to buy two plots of land). The overall effect of countering these trends will be to raise the costs of production, which has an (often unrecognised) impact on the economy. However, if Peak Oil raises transport costs relative to land and labour then this balance may change.)

There has been a proliferation of alliances on various aspects of low carbon living, all of which make a valuable contribution to the debate on climate change and by extension to resource use (though not necessarily explicitly). Examples are authorities signed up to Low Emissions Strategies, and Low Carbon Communities. Many local action groups are involved in promoting sustainable or "one planet" living. Generally, however, there seem largely detached from spatial planning. Low Emissions Strategies take PPG13 as a starting point, but in execution are more concerned with vehicle emissions than fundamentally changing the pattern of travel and development.

The Low Carbon Communities Network was formed to link, network and support the rapidly growing movement of climate change groups that are forming at a local and community level. Its aims are to:

- Work alongside and communities and organisations in the UK and across the world to halt global warming as far as is possible;
- Encourage the adoption of low carbon and zero carbon policies, technologies and lifestyles through local action, and to enable groups engaged in this action to be as effective and efficient as possible;
- Support greater community awareness of the urgency of action required on climate change, and offer clear pathways to identify high impact, positive and achievable local solutions; and to
- Enable those active at a local level to positively influence UK national and local government policy and practice.

A choice is presented between low carbon living and an insecure future, as illustrated in **Figure 5.1**[59] below:

FIGURE 5.1: LOW CARBON COMMUNITIES NETWORK: WHERE ARE WE GOING?

The Low Emissions Strategies (LES) partnership[60] supports the wider adoption of LES by planning authorities and encourages the use of well established and innovative measures. LES's have as the primary aim to accelerate the uptake of low emission fuels and technologies in and around a development site. LES can be achievable and effective when planners and environmental practitioners work together and can contribute to achieving Local Area Agreements. The LES partnership aims to show and share best practice and support networking and cross communication between partners, peers, local authorities and practitioners

Zero Carbon Britain is an initiative from the Centre for Alternative Technology. In its second report[61], it recommends political and economic solutions to the urgent challenges raised by the climate science, outlining how the UK might be transformed into an efficient, clean, prosperous zero-carbon society. In particular, the report notes that *"the great transition to a zero-carbon Britain is not only the most pressing challenge of our time, it is also entirely possible. The solutions needed to create a low-carbon and high-wellbeing future for all exist, what has been missing to date, is the political will to implement them".* The context for this is climate science, energy security and equity, and proposals are given for transport, the built environment, land use and agriculture and renewable energy.

The Transition Towns Network's role is to inspire, encourage, connect, support and train communities as they self-organise around the transition model, creating initiatives that rebuild resilience and reduce CO2 emissions. A small collection of motivated individuals within a community can come together with a shared concern: how can our community respond to the challenges, and opportunities, of Peak Oil and Climate Change? They begin by forming an initiating group and then adopt the Transition Model with the intention of engaging a significant proportion of the people in their community to kick off a Transition Initiative, a community working together to look Peak Oil and Climate Change squarely in the eye and address the question *"…for all those aspects of life that this community needs in order to sustain itself and thrive, how do we significantly increase resilience (to mitigate the effects of Peak Oil) and drastically reduce carbon emissions (to mitigate the effects of Climate Change)?".* Such approaches, where 'bottom up' activism develops local solutions would very much resonate with the present Government's localism agenda.

There are other more focused initiatives, for example the "Twenty's Plenty" campaign to reduce speed limits in residential areas, which would also contribute to the overall objectives.

However, although these initiatives raise the profile of Peak Oil, and discuss issues related to it, they appear to derive from individual initiatives or places (Totnes in the case of Transition Towns), and seem to derive advice and support (if any) from different government departments – not usually CLG - responsible for planning. Integrating them into strategic thinking embracing spatial planning, transport investment and urban and rural spatial planning policy would seem essential.

One web-based compendia of information about the relations between land use and transportation[62] notes that the latest research on this topic is providing more clarity in statistical terms than earlier studies, with *"a focus on multi-variate analysis and some assessment of the more difficult empirical issues, such as co-linearity (variables are inter-related), causality (impacts may be two-way) and attitudinal/self selection issues (whether particular urban forms are associated with certain travel behaviours, or whether people with particular types of attitude are attracted to certain urban forms)"*.

It also notes that *"The wide ranging potential of urban structure – including issues of density, settlement size, regional structure and accessibility, provision and mix of land use, jobs-housing balance, location, local street layout and neighbourhood design – covers interventions at a range of scales. It is clear that there are significant associations between the built environment and travel behaviour, even when socio-economic characteristics and attitudes have been accounted for. Trip lengths and mode share are the most likely of the travel variables to be affected by the form of the built environment"*. The main themes relating to this are identified as:

- Settlement Size;
- Strategic Development Location;
- Strategic Transport Network;
- Density;
- Jobs-Housing Balance;
- Accessibility of Key Facilities;
- Development Site Location;
- Mix of Uses;
- Neighbourhood Design and Street Layout;
- Traffic Demand Management; and
- Parking.

A planning checklist is provided for each theme. For example, under "Strategic Transport Network", the following is noted:

- Develop sub-regional and city-regional governance structures (e.g. Multi-Area Agreements) that support an effective process for achieving integration in transport and urban planning.
- Develop key public transport linkages and networks between cities and towns and within larger conurbations (in collaboration with national government) and locate development adjacent to nodes to make use of capacity.

- Improve the efficiency of the strategic transport network by increasing integration between modes, for example at important urban and edge-of-town interchanges and park-and-ride sites.
- Prioritise public transport infrastructure investments that support desired development patterns.
- Make more efficient use of available road capacity through traffic demand management measures and road space reallocation to more sustainable modes

Similarly, the Government's Homes and Communities Agency site providing advice on placemaking[63] sets out a series of aspirations for the main themes of:

- Environment;
- Governance;
- Economy;
- Transport and Connectivity;
- Services;
- Social and Cultural; and
- Equity.

These highlight issues such as integration, access to information, design, the commitment to reducing car travel and the development of sustainable travel modes. Links are given to sites such as the Manual for Streets; Act on CO_2; and the Code for Sustainable Homes.

Also Design Commission Cabe's resource information includes the report Hallmarks of a sustainable city, linking to the website www.sustainablecities.org.uk. The common themes are identified as:

- Energy - Sustainable energy planning and management reduces our energy consumption and increases our use of low carbon or renewable energy.
- Waste - We have been consuming natural resources at an unsustainable rate and producing too much waste – we can do more to reduce waste in the first place, and make better use of waste materials.
- Water - The ability to engineer water for irrigation was the foundation of civilisation. A safe supply of drinking water and the clean disposal of foul water are essential to modern life.
- Transport - In many towns and cities outside London, we have come to associate our freedom to move conveniently between work, home and shops with use of a private car.
- Green infrastructure - the living network of green spaces, water and environmental systems in, around and beyond urban areas.
- Public space - public space includes streets, squares and parks, which are open and accessible to everyone.

The section on transport highlights the fact that transport accounts for around a quarter of the UK's carbon emissions and rising. With road transport responsible for 86 per cent of that, sustainable transport planning is fundamental to meeting carbon reduction targets. Coupled with spatial planning, transport planning can also improve health, the economy and quality of life.

There are four ways to reduce transport carbon emissions, and all need to be pursued:

- fewer trips;
- shorter trips;
- using more sustainable modes of transport; and
- increasing vehicle efficiency and occupancy.

Linking transport and urban planning can greatly enhance the effectiveness of policies to achieve the first three objectives – for example by thinking strategically about:

- appropriate sites for urban extensions;
- the ability to connect to existing settlements;
- the location and connectivity of homes, businesses, schools, hospitals, leisure facilities and green spaces; and
- the role of street patterns and design in making it easier to walk, cycle or take public transport to school, work, leisure or shopping, rather than drive.

The benefits of sustainable transport planning also include a healthier environment through less air pollution. There are fewer road traffic accidents and the growing restrictions placed on children's lives and movement can begin to be eased. There is a more resilient local economy through increased footfall, a positive effect on property values and reduced costs from traffic congestion. There is improved social cohesiveness with open and public spaces all more inviting to go to and linger in with less traffic. People have better journeys, by whichever mode, with fewer cars on the road.

None of this is particularly new. Previous planning guidance from the government – from the original PPG 13 onwards – has highlighted the need to provide alternatives to the car. The shift from "Urban Traffic Engineering Techniques" through Design Bulletin 32 to the Manual for Streets has also reflected the growing realisation of the need for a different approach to traffic management and movement. In London, the work on "Sustainable Urban Quality" undertaken by Llewelwyn-Davies for the London Planning Advisory Committee around 2000 to inform strategic planning guidance for London identified the potential to significantly increase residential densities and at the same time improve the environmental quality of new residential development. Key to this was ensuring that the amount of space required for roads and car parking is kept to the minimum necessary taking account of non-car accessibility. This need not imply high rise development (as many have feared) and creates the density of people able to better support a high level of accessibility to public transport, facilities and services. In turn, more intense public transport becomes viable.

Moreover, the approaches outlined here are not the exclusive realm of more intensively developed inner areas. Sustainable Residential Quality principles were applied in the wider South East during the development of the regional planning guidance for the area (Sustainable Residential Quality in the South East for the Government Office for the South East, 1998). Patterns of development and transport were identified as becoming unsustainable and measures needed to be taken to make more use of local facilities and grow and urban renaissance on the basis of the many centres existing in the south east of England. A planning and transport policy framework was needed that developed existing centres and integrated them with their catchments, rather than developing stand-alone centres. Public transport needed to be improved and integrated with centres and the planned pattern of development.

A more wide-ranging report for the Joseph Rowntree Foundation, the Civic Trust and Ove Arup examined the sustainable renewal of suburban areas (1998). Local centres, community facilities, housing renewal and adaptation (based on the SRQ model above), and transport integration were all seen as key to

improving the quality and performance of the suburbs. On transport, the historic pattern of radial routes needed to be adapted to provide alternatives to the car. This would involve both modest but integrated improvements to bus, cycle and pedestrian routes and in some places transit-oriented development around high capacity systems on the Continental model.

Most of the measures set out in the reports and advice and directed at securing more sustainable low carbon living patterns of development are entirely compatible with preparing for Peak Oil. Many are identical. The fact that so much is known, but so little progress has been made – to the extent that car-dependence is growing except in a few places with high quality (electric) rapid transport systems – shows a marked inability to take more than a short term and politically expedient approach to the issue. The more that the necessary measures are deferred, the more will be the disruption to lifestyles and the economy at the first symptoms of energy shortages, and the greater the unnecessary degradation of local environments by car dominance and the loss of greenspace and local facilities. This cannot be said to be a resilient approach to the high risk of exposure to fuel shortages.

Transport Policy Responses

Of itself, the energy price impacts of Peak Oil will change the choices travellers make. The aim therefore is to:

- develop a transport system that is resilient to Peak Oil (and use the opportunity to develop a transport policy that is more sustainable); and
- mitigate the adverse impacts of Peak Oil.

The policy and (market driven) technological responses to Peak Oil are concerned with:

- maximising the efficient use of oil based fuels;
- encouraging modal shift to more efficient modes; and
- minimising the need and desire to travel.

Energy efficiency

According to the DfT, vehicle efficiency is expected to increase at around 1.5% per annum through to 2020. This reflects the mix of petrol and diesel cars changing, the latter being more efficient. However, this assumes that the same range of vehicles continues to be purchased and that there is no general movement to more efficient cars per se. Fuel consumption rates for given vehicle classes varies by a factor of around 3, so a general move to the most fuel efficient vehicles will have a material impact on overall consumption.

Recent changes to the Vehicle Excise Duty regime, with high emitting vehicles taxed more than low emitting vehicles, were undertaken to encourage the purchase of vehicles with lower emissions and given the close correlation with fuel consumption and emissions, the scheme could be modified to target fuel consumption in a similar way.

In the same way that EU regulations are being considered to mandate emissions standards, a similar and complementary scheme could be adopted to enforce minimum fuel efficiency standards[64].

Alternative fuels

Non-oil based fuels provide a complementary opportunity to mitigate the impacts of Peak Oil, with the proviso that the alternative fuel is not itself subject to potential declines.

Initially, much potential was placed on biofuels, but questions have recently been raised about their long term sustainability, notably the impact on food production and wider environmental impacts. Whilst the UK has achieved the target of 2.5% of road fuels being biofuel[65] , the EU has diluted the original 10% target of the biofuels share[66] in recognition of the concerns raised, with the aim that 40% of that target should be met by more sustainable sources than traditional biofuel (this share would include hydrogen, electricity and "second-generation" biofuels, made from waste or algae, for example).

Electric road vehicles offer great potential, subject to improvements in battery technology securing acceptable cost, lifetime and performance criteria. Supply issues also need to be resolved. Electrification of the rail network is well within current technologies and straightforward to implement (the DfT have announced electrification of the Great Western Main Line and the Liverpool-Manchester line[67]).

Conversely, development of alternatives to oil based aviation fuel is in its infancy. Developing an energy and propulsion system that can provide equivalent power output whilst remaining within acceptable weight and size constraints will be a formidable challenge.

Pro-active management of fuel prices

Tax is the largest element of fuel prices in the UK and the rest of Europe (around 70%). It is therefore possible to use variable tax rates to:

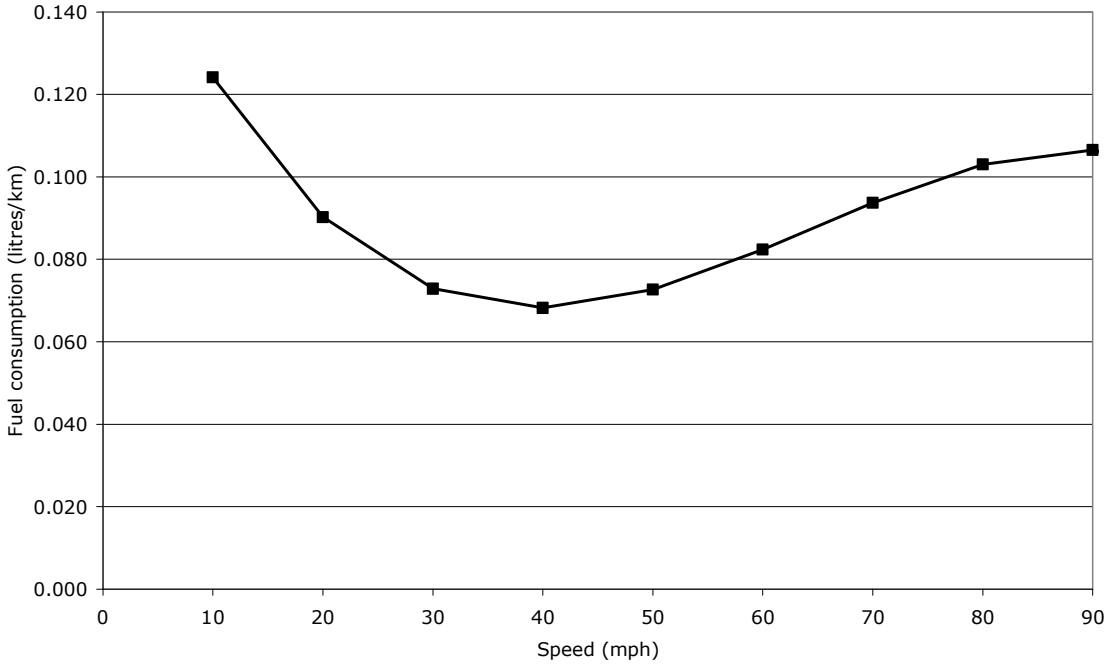
- smooth the volatility in oil and fuel prices that Peak Oil will engender; and
- to pro-actively manage a smooth transition to higher fuel prices in the longer term as Peak Oil takes effect.

Such use of tax rates may necessitate tax changes elsewhere and changes in the mix of tax receipts, but could be designed to be revenue neutral over the medium to long term. Any such management of fuel prices may be coordinated with other mitigation measures and with other countries in Europe.

Smarter car use

Simply using cars more effectively and efficiently will reduce demand for fuel. Smarter driving techniques, improving driving style, can offer significant savings and are achieved at essentially no monetary cost. Reducing speed limits can have an appreciable impact on fuel consumption. According to WebTAG, the optimal speed is around 40mph (65kph), as shown in **Figure 5.1**[68]. Reducing the limit from 70mph to 60mph could reduce fuel consumption by 13%. In 2008, Spain announced a raft of measures[69] including speed limit reductions to reduce the dependence on oil imports. Even enforcement of existing limits would yield some fuel savings.

FIGURE 5.1 FUEL CONSUMPTION AND SPEED



Encouraging modal shift

Modal shift away from car offers the possibility of major reductions in fuel consumption. Rail and coach offers options for long distance trips, whilst buses, walking and cycling can replace the shorter distance car trips (23% of car trips are less than 2 miles, with a further 34% between 2 and 5 miles).

Changes in travel behaviour

Peak Oil will encourage people to reappraise their travel and lifestyle choices beyond the direct cost impacts of Peak Oil and policy should be developed to manage and facilitate this and to encourage a permanent change to travel habits. (For example, the 2008 surge in oil prices led to large increases in US public transport demand which have not been reversed following the subsequent drop in prices in late 2008[70].)

This could consider more than just direct travel behaviour and encompass alternatives to travel and lifestyle. For example, more use of virtual communications (such as video conferencing) could reduce the need to travel. Peak Oil may strengthen the idea of 'travel less and see more', analogous to the slow food movement. It will encourage greater emphasis in local communities, promoting 'localism' rather than the global virtual village. The current economic recession has shown that animal spirits, sentiment, trends, envy and emotions are very influential in consumer and investment trends and there is scope to embrace these to influence smarter travel. An obvious analogy is the recent explosion in cycling in London, in part driven by congestion and crowding on the public transport system, but also by it becoming more mainstream and socially acceptable.

Speed Management

In prescribing speed limits for traffic, the disadvantages are often perceived as inhibiting motorists' freedom, having revenue costs in terms of enforcement, and reducing economic benefits (as conventionally measured) by making car and lorry journey times longer. However, an appraisal based on sustainability appraisal concepts could demonstrate a number of synergies:

- Reduced fuel consumption;
- Greater road safely, leading to:
    - Lower accident costs and human costs,
    - Safer conditions for other users, encouraging use of streets for other modes and social interaction;
- Greater time advantages to other modes (where good alternative mode networks are available);
- Reductions in car use, leading to:
    - Greater localism in supply and community facilities (as catchment areas of time travelled by road reduce),
    - Increased health (from greater walking and cycling and less air pollution from vehicles)
    - Increased greenspace (if roadspace reallocated)
    - More economical use of land for urban uses from higher densities without loss of greenspace and lower traffic design speeds.

Clearly, the details would depend on individual circumstances and the ability to deliver a full planed package – the above might not apply if access standards for pedestrians and cyclists were not improved, or if effective public transport was not provided for a sufficiently extended "day" due to narrow commercial reasons.

Much information is already buried in evidence for Local Development Frameworks and Local transport Plans, and needs to be articulated to stimulate rapid policy change.

The election of the present coalition Government in May 2010 has heralded changes in approaches to land use and transport policy. At the time of writing, there is still much uncertainty about the detail of policies and proposals which are still emerging.

Nevertheless, coalition Government has said it *"…believes that a modern transport infrastructure is essential for a dynamic and entrepreneurial economy, as well as to improve well-being and quality of life. We need to make the transport sector greener and more sustainable, with tougher emission standards and support for new transport technologies"*[71]. On this basis, the key policies on transport that have been articulated by the coalition Government include:

- Mandating a national recharging network for electric and plug-in hybrid vehicles.
- Granting longer rail franchises in order to give operators the incentive to invest in the improvements passengers want – like better services, better stations, longer trains and better rolling stock.
- Reforming the way decisions are made on which transport projects to prioritise, so that the benefits of low carbon proposals (including light rail schemes) are fully recognised.

- Establishing a high speed rail network as part of our programme of measures to fulfill our joint ambitions for creating a low carbon economy. Our vision is of a truly national high speed rail network for the whole of Britain. Given financial constraints, we will have to achieve this in phases.
- Support for Crossrail and further electrification of the rail network.
- Supporting sustainable travel initiatives, including the promotion of cycling and walking, and will encourage joint working between bus operators and local authorities.
- A commitment to fair pricing for rail travel.
- Introduction of a new system of HGV road user charging to ensure a fairer arrangement for UK hauliers.

As noted above, the most recent Transport White Paper, published January 2011, brings together these aspects of policy on local transport. The White Paper sets the Government's approach to shorter local journeys (so, trips of five miles or less) with the intention to support its wider goals of promoting economic growth and reducing carbon. A lot of weight is given to immediate gains from local interventions, especially when it comes to job creation. It brings together the announcements and initiatives on local transport governance and funding since the May 2010 elections and emphasises the key role of developing sustainable travel in delivering the Government's key objectives for Local Transport. However, it underlines the importance of travel by car and rail for longer-distance journeys, while stressing the role of local communities in identifying transport needs and shaping transport responses in their own areas.

More generally, it is clear that the coalition will continue the former Labour Government's policy emphasis for transport of supporting competitiveness and economic growth following the recommendations of the Eddington Report, and honouring the UK's commitments on reducing carbon emissions to avoid the harmful consequences of climate change. Policy positions on providing safe ways to travel and improving the health and quality of life of people through their travel choices are also key themes. The impacts and synergies of Peak Oil on these goals are discussed in the following sections.

Supporting national economic competitiveness and growth

Higher fuel prices brought about by Peak Oil will directly undermine this objective, through increases in the cost of transport. However, the scale of the impact on competitiveness will be dependent on the relative mitigation measures put in place by the UK and other countries in response and the pre-existing proportion of transport costs in economic output (for example the UK is less of a manufacturing nation than say Germany and hence may be less affected by increases in transport costs).

However, some mitigation would likely arise from the reduction of congestion and unreliability on the transport network as highway demand in particular is suppressed.

Reducing emissions of carbon dioxide from transport

The coalition Government appears generally to be retaining the last Labour Government's policies to reduce greenhouse gas emissions from transport through a combination of policies on land use, energy production, new technology, behavioural measures and price signals[72]. This should reduce dependence on oil, but it is by no means clear at this stage to what extent.

More directly, the peaking and subsequent reductions in oil supply will of itself reduce emissions. Any associated price signals would promote more efficient use of oil for transport and encourage the development of alternative technologies and planning regimes. However, there is a need to ensure that replacement technologies and fuels in response to Peak Oil do not replace or exceed those that would

have come from oil. The findings from the Julia King review of low-carbon cars[73] will assist in this area and also assist in the mitigation of the impacts of Peak Oil.

Contributing to better safety, security and health

Peak Oil will have marginal, but likely positive, effects on safety. Transfer to public transport from car will improve safety; conversely, transfers to cycling may reduce safety. Less travel per se should improve safety (in absolute terms, not necessarily on a unit rate basis i.e. deaths/106 kms travelled). Traffic speeds may drop in response to higher fuel costs, improving safety levels marginally.

General health benefits will arise from less use of car for travel, with any increase in walking and cycling as a substitute for car use.

Improving quality of life

Peak Oil may marginally reduce the environmental impact of transport (such as noise and vibration), through stabilising or reducing traffic levels and speeds and reducing the need to increase capacity with its attendant land take and environmental impacts.

However, Peak Oil may adversely impact on the diffuse positives that transport brings: the range of goods on supermarket shelves, the ability to visit friends and relatives, enjoyment of the countryside and seeing the world. This may be mitigated through a change in behaviour and outlook that focuses enjoyment on other and/or more local activities (localism).

The impact of Peak Oil and the higher associated fuel costs may entrench and likely worsen existing levels of inequality, since those with higher incomes and wealth will be less affected by the increase in transport costs. Enhanced provision of public transport and better facilities for walking and cycling will mitigate this to some extent.

A new policy framework for Peak Oil

As set out above, Peak Oil has mixed impacts on the current UK policy goals for transport. There are some synergies between the climate change related goal and those required to mitigate against Peak Oil, where actions to reduce emissions should have direct correlation with reducing the demand for oil based fuels. The impact of Peak Oil on the other policy goals is likely to be marginal at best and often counter to them.

Given that Peak Oil will happen at some point, albeit with uncertain timing, and the possible profound and severe impacts that it could engender, integrating Peak Oil mitigation into transport policy is imperative. As with climate change, early and substantive action will minimise the impacts and provide the greatest scope for mitigating interventions.

On that basis, the concept of Peak Oil must be better integrated into policy making, as climate change currently is, and the synergies between them recognised. These should be given due prominence in future development of both spatial plans and transport strategies. Cross-cutting government policy also should be developed to reflect Peak Oil, as has happened with climate change, in such areas as spatial planning policy, energy supply security, industrial development and taxation.

As one means of achieving this, it is clear that Peak Oil considerations should be integrated into existing appraisal techniques that are used to evaluate and inform both spatial planning and transport policies, as well as policy in other sectors such supply of energy, water resources etc. Good practice in techniques such as Appraisal of Sustainability of National Policy Statements, Sustainability Assessments and/or Strategic Environmental Assessments of other policies and programmes, and Environmental Impact Assessment of development projects so that policies/proposals should include an explicit assessment of

their impacts on oil consumption and of the implications of Peak Oil on their future operation and decommissioning as appropriate. This should apply not just to spatial and transport policies, but also to other key aspects for oil security, such as industrial and domestic use. This is discussed further in the following section.

Implications of Peak Oil on Environmental Assessment and Sustainability Appraisal

Since the introduction of the European Union Directive on Environmental Impact Assessment[74], the requirements to carry out environmental assessment for certain projects prior to their development has been transposed into UK regulations. Similarly, the EU Strategic Environmental Assessment Directive[75] has been translated into legislations for a number of years, resulting in the consideration of strategic environmental effects (including impacts on sustainability) being integrated into our plan making process.

Under the Planning and Compulsory Purchase Act 2004, planning authorities are required to perform Sustainability Assessments on their Local Development Documents (LDDs). The 2004 planning reform coincided with the entry into force of the SEA Directive. To incorporate the SEA Directive requirements into a wider SA process for LDDs, new guidance[76] was published in November 2005 which was based on the (then) Office of the Deputy Prime Minister (ODPM) guidance to the SEA Directive[77] .

There are 5 key stages in the SEA/SA process and their implications in respect of Peak Oil are illustrated in **Figure 6.1**[78]:

FIGURE 6.1: LEGISLATIVE REQUIREMENTS OF SEA/SA AND THEIR IMPLICATIONS ON PEAK OIL ISSUES

SEA/SA Key Stages	Key Tasks Under Each Stage	Key Implications of Peak Oil Issues
Stage A: Set the context, objectives, establish the baseline, decide on the scope	Identify relevant plans, programmes and environmental protection/sustainable development objectives Collect relevant baseline information Identify environmental/sustainability issues Develop SEA/SA objectives Consult on the scope of the SEA/SA	1. Under the three pillars of sustainable development (social, economical and environmental), finite resources (including oil) could be considered under 'environmental'. But this is not the norm and requires clear policy guidance 2. In the absence of clear Government direction, there are no environmental limits/targets on oil consumption 3. Peak Oil issues are only partially covered by general environmental protection/ sustainable objectives (e.g. reduced/low carbon emission, renewable energy, waste minimisation, encouraging modal shift and non-car reliance, social inclusion) 4. The prediction/evaluation of Peak Oil effects as a result of plan/programme implementation is inhibited by items (1) to (3) above.

SEA/SA Key Stages	Key Tasks Under Each Stage	Key Implications of Peak Oil Issues
Stage B: Develop and refine alternatives, and assess effects	Test the plan/programme objectives against the SEA objectives Develop strategic alternatives Predict the effects of the plan/programme, including alternatives Evaluate the effects of the plan/programme, including the alternatives Consider ways to mitigate adverse effects Propose measures to monitor the significant environmental effects of plan/programme implementation	5. The identification of strategic alternatives and consideration of mitigations could assist in the promotion of non oil-based fuel energy sources 6. The development of effective measures to monitor the effects of plan/programme implementation on Peak Oil would be restricted given items (1) to (4) above.
Stage C: Prepare the Environmental Report (ER) or SA Report	Prepare the ER (or SA Report) for public consultation and use by decision-makers	
Stage D: Consult on the draft plan/programme and the ER (or SA Report)	Consult on the draft plan/programme and the ER (or SA Report) Assess significant changes Make decisions on the final form of the plan/ programme to be adopted, and providing information on how the ER (or SA Report) and consultation opinions were taken into account	The general lack of understanding of Peak Oil may affect the quality of consultation responses and the extent of changes to the draft plan/programme. The SEA/SA process has been criticised[79] for its lack of influence in the direction of the plan/programme and in bringing about changes in the decision-making process. In this case, even if Peak Oil issues are considered in the SEA/SA, it may amount to no more than a 'box-ticking' exercise.
Stage E: Monitor Plan/Programme	Develop aims and method for monitoring Prepare appropriate responses where adverse effects are identified	

*

The SEA/SA provides an audit trail and ensures that environmental/sustainability issues are considered during the preparation of a plan/programme. However, in its current assessment approach and in the absence of any environmental targets/limits that are specific to Peak Oil, the effectiveness of the SEA/SA in dealing with Peak Oil is very restricted.

The SEA/SA process provides for opportunities to change the plan/programmes through the production of an Environmental (or Sustainable Appraisal) Report. However, some have argued that reporting is primarily concerned with legal compliance and only results in minor 'tweaking' of wordings which has no real influence on effecting change in the plan/programme direction. If this criticism is justified, then unless the SEA/SA process is improved to address this deficiency, the identification and assessment of any

significant environmental and sustainability issues, including Peak Oil, would represent no more than a 'box-ticking' exercise.

The environmental topics that are required to be assessed in an EIA include: population, fauna, flora, soil, water, air, climatic factors, material assets, including the architectural and archaeological heritage, landscape and the inter-relationship between these factors. As far as Peak Oil is concerned, oil (fuel) storage and the provision of other oil-related infrastructure would come under 'material assets'.

Additionally, an EIA development (i.e. development deemed to require assessment under the terms of the EIA regulations) is also required to be assessed against policies/objectives at all levels. Although many of the policies have been formulated with other (environmental, transport, social, economical) objectives in mind, they could have some impact on Peak Oil, including:

- Reduce climate change effects through a number of ways including: reduced carbon emission to meet national targets; energy saving/efficiency; renewable energy including energy from waste;
- Reduce car reliance, and encourage modal shift to public transport, walking and cycling;
- Encourage social inclusion and tackle multiple deprivation;
- Encourage sustainable development;
- Discouraging out of town development; and
- Encourage rural diversification.

However, Peak Oil effects are not limited to the above. Without the support of clear policy guidance, some of the key effects of Peak Oil could be omitted from the EIA process. Some of the Peak Oil issues that are currently not in the forefront of planning include:

- Fuel/energy security;
- Consumption of finite resources including oil/fuel;
- Food security – encourage local/regional sufficiency; and
- Agriculture - reduce reliance on petrochemical products through less use of chemical fertilizers.

In the absence of a clear Government guidance and specific targets/objectives to address Peak Oil, individual authorities are left to their own devices on how to deal with Peak Oil. Ultimately, the extent to which research documents are translated into meaningful policies and objectives would affect the effectiveness of the EIA process in dealing with Peak Oil issues.

As in the case of SEA/SA, unless there is clear guidance and strong policy statement concerning the use of finite resources (including oil), Peak Oil effects would not be assessed in a coherent and consistent manner in the EIA process.

Spatial planning has a vital role to play in addressing Peak Oil. Our plans and policies should also support emergency planning through appropriate provision of relevant infrastructure/facilities, which will require co-ordination from all fronts and across technical disciplines.

Unless there is clear provision in our policy documents, the SEA/SA and EIA processes would not be able to assess effectively the impacts of a plan/programme/development on Peak Oil or during an energy crisis.

6 TOWARDS AN AGENDA FOR ADDRESSING PEAK OIL

Conclusions

Acceptance of the concept of Peak Oil means not only will oil supplies eventually become exhausted, but after passing the point of maximum oil production, stocks will dwindle and prices rise significantly and consistently. Some observers say this peak has already occurred, while others hold that it is up to 40 years away. There may be unpredictable interruptions of oil supply and greater price volatility well before this.

In the UK, Government policies on transport, energy policy and land use have consistently ignored or played down the Peak Oil phenomenon. Nevertheless, the potential impact of Peak Oil is profound. Frequency and patterns of travel will change, and current patterns and trends in land use will become ever less sustainable than at present.

Policy and technological responses that focus on maximising fuel efficiency, encouraging the use of more efficient modes and minimising the need and desire to travel are required. The price effects of Peak Oil will encourage such responses, and these can be supported by appropriate policy measures to guide this transition to a lower carbon transport system and land use policies that maintain lifestyle choices with less need to travel.

Within the planning process, Peak Oil will have serious implications for the demand forecasting and decisions on investment priorities. Alternative scenarios need to be explicitly considered. Also, existing modelling tools and techniques will require fundamental re-evaluation given the potential for Peak Oil to radically change choice behaviour, exogenous demand drivers, land use and trip patterns.

Spatial planning also needs to more explicitly take on board the implications of Peak Oil, both in terms of how changing travel patterns affect the feasibility of traditional land use patterns, but also what proactive measures are needed to maintain economic activities and lifestyle choices in a post-oil economy.

Recommendations

The implications of Peak Oil must be recognized in the development of national policies on energy economic development, spatial planning, transport and investment in infrastructure. While it is recognized that there is a great deal of uncertainty and debate about these implications, the adoption of scenario-based approaches to evaluation may help decision-makers to understand the alternative outcomes of “business as usual” policies in a post-Peak Oil world.

In order to facilitate this, spatial planners, transport planners and other built-environment professionals need to develop an understanding and shape appropriate responses to the following:

- Energy-efficient spatial patterns, and how development may be planned to reduce energy consumption by reducing the need to travel, and providing critical mass for the promotion of mass public transport, local energy generation and distribution networks and combined heat and power networks.
- Better understanding of the policy responses necessary to ensure that existing and new buildings, both commercial and residential, are energy-efficient and/or may be used on a low-energy basis. This should include, among other things, aspects of design, density and specification of materials and services.
- The good work done over the past 20 years on reducing the need to travel be revisited and consolidated to provide clear and acceptable policies that lead people to travel less. Changes in technology have made home-working, tele-commuting and video-conference much more realistic and

workable alternatives to traditional commuting patterns, but their full potential is far from realized. The revolution in delivering more accurate, up-to-date and accessible travel information to drivers and for users of public transport needs to be capitalized upon.

- Changes in travel behaviour should be actively sought to reduce travel by unsustainable modes. The increasing use of motivational methods and techniques developed in market research, adverting and the treatment of various addictions to encourage changes in travel behavior needs to be much better understood and consistently applied.
- Ensuring that the most energy-efficient means of travel are encouraged, and where each mode of travel is best in this respect. This would include, depending on the circumstances, car clubs, lift-sharing schemes, priorities for high-occupancy vehicles and vehicles using alternative fuels as well as high-occupancy public transport.
- Understanding the energy needs of essential travel that cannot be met in other ways. In this way, energy budgets that prioritise essential travel can be developed as a basis for policy discussions.
- The polices required to support the generation, supply and distribution of alternative energy sources and fuels, particularly in respect of renewable energy sources, need to be put in place. However, this must be balanced with other appropriate environmental concerns such as protecting the quality of the landscape in remote areas and balancing requirements for food and biomass production.
- Incorporating Peak Oil related concerns into policy and project evaluations through amendment of requirements and guidance such as the Strategic and project Environmental Impact Assessment regulations, and the Government's Transport Analysis Guidance.

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Further reading

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APPENDIX: IMPLICATIONS FOR FORECASTING TRAVEL DEMAND AND JUSTIFYING TRANSPORT INVESTMENT

Demand forecasting under Peak Oil

The potential impact of Peak Oil on fuel prices and hence on choice behaviour is such that the ability of traditional modelling tools to forecast the impact of such impacts will be severely stretched and (possibly) likely to underestimate the effects of Peak Oil. Furthermore, assumptions about how demand will grow due to exogenous factors, notably car ownership, will need to be reviewed. Conversely, assumptions about how cost drivers change into the future (such as vehicle fuel efficiency) may underestimate the contribution these make to mitigating the impacts of Peak Oil. The overall net impact will be unclear and highlights one likely outcome of forecasting under Peak Oil: medium and longer term forecasts will be prone to a much wider degree of uncertainty than hitherto.

The other key issue (noted above) is whether traditional models will be able to properly deal with the scale of cost change and attendant demand change that Peak Oil may engender. It is possible that Peak Oil will bring a major paradigm shift in the choice behaviour of travellers, making existing tools unsuitable and requiring a similar paradigm shift in modelling to get the right analysis and policy responses.

Travel costs and choice behaviour

Demand forecasting will usually include both the temporal and monetary costs of travel. On that basis, the impact of changes in fuel prices on travel demand and patterns can be forecast through existing tools. However, the models used in the forecasting process have two key implicit assumptions:

- That travel costs do not materially change through time; and
- Choice behaviour, reflected through the parameters in choice models, is constant through time.

Travel costs

Typical network based 4-stage demand models use a combination of journey time and monetary cost to reflect the overall (generalised cost) of making a journey. To replicate the actual choices being made, additional costs are often added to reflect the intangible preferences that travellers have, notably between modes (such as car and bus). Across the model area, cross-sectional data and analysis is used to derive the most appropriate model structure and parameters. When used to forecast into the future, such costs usually only change marginally, for example through highway congestion and public transport crowding in terms of travel time, and through real changes in monetary costs (usually only 1-2% per year in real terms). Negating the latter though are increases in the value of time, meaning the trade off between time and money usually becomes less important.

However, the impact of Peak Oil could have a much more profound impact on the monetary cost of travel and hence the overall generalised costs than normally experienced. The extent to which this occurs in practice will be dependent on the mitigation strategies adopted (as set out above) to minimise the direct costs of travel before changes in travel demand take place. Car users might migrate to more fuel efficient vehicles or adopt alternative fuelled vehicles, smarter driving techniques may be adopted to reduce fuel consumption and travel patterns and land use patterns might change. The net impact is uncertain.

In summary, current models are not well suited to forecast a future with a high degree of change and uncertainty; they are designed for a forecastable future that is not too different from the present. On that basis, it is possible that demand modelling may not robustly forecast the impact of Peak Oil and will likely underestimate its impacts.

Making Travel Choices

An associated issue is that Peak Oil may bring about a change in choice behaviour beyond that simply ascribed to the change in tangible travel costs. This may arise indirectly through such initiatives as smarter choices programme introduced as a way to mitigate the impacts of Peak Oil. The modelling of smarter choices is recognised by the DfT as an area for development and to this end the DfT initiated a research programme to consider the issue and provide guidance for inclusion in WebTAG, but this has yet to be issued in any form.

Another possibility is that Peak Oil may be the trigger for a reappraisal of travel choices, breaking habits built up over time. Recent research suggests that 'it is only when circumstances change that people will reconsider their behaviours'[79] ; whilst this is in the context of personal circumstances, a major trigger caused by an event such as Peak Oil, albeit over a longer timeframe, may have the same effect.

Exogenous growth and car ownership

In the UK, exogenous growth is usually taken from TEMPRO, a DfT program that provides projections of growth over time for use in local and regional transport models. It presents projections of growth in planning data, car ownership, and resultant growth in trip-making by different modes of transport under a constant-cost assumption. Car ownership within TEMPRO is determined by a combination of:

- Demography (household structure, age, etc);
- Income and the national economic background;
- Type of area; and
- Other car-related factors (i.e. license holding, prevalence of car clubs, rates of company car ownership, etc).

The income effects of Peak Oil will impact on car use rates directly and may influence car ownership rates as well, with second order effects on transport demand.

Model structure

Most transport models typically segment demand by journey purpose, time period and mode (highway and public transport). This is considered the most appropriate segmentation for the majority of project requirements in the UK. However, for schemes involving pricing then 'some additional segmentation by willingness-to-pay or income….may be required' [79] to reflect the fact that choice behaviour will differ between such segments. Given the possible price impacts of Peak Oil, then at a minimum, such an approach to modelling will be required.

An issue associated with income segmentation is forecasting how exogenous factors impact on the growth of income and the relative change between the segments. For example, a simple approach would be to assume that the distribution of income growth is uniform across the segments; more complex approaches could be adopted to reflect the likely change in incomes across professions, skill levels, educational attainment, socio-economic groupings etc. In any event, the income effect of Peak Oil may depress real income growth in addition to the actual transport cost impact. Again this may differ by income group, with the result that, for example, the lower income groups grow faster than the overall average; consequently, the impact of Peak Oil will be to shift the behavioural response focus to that of the lower income groups.

More fundamentally, a move to tour and activity based models rather than the current (WebTAG) trip based modelling may be required to reflect properly the travel cost budget limitations that Peak Oil will engender. This may also better reflect the income effect of Peak Oil reducing the overall level of activities entered into and the associated reduction in travel demand.

Perhaps the best approach to model the effects of Peak Oil is to move to a system dynamics approach in recognition that Peak Oil may change the course of demand levels and patterns over the forecasting and Business Case horizon. For example, the short to medium term could be influenced by a business as usual scenario, with Peak Oil effects becoming apparent in the longer term. Clearly, the impact of Peak Oil will be dependent not only on policies to address it at that time but also the sequence of events prior. Such an approach is better suited to understanding how economic development, transport and land use interact through time and provide a more robust approach to planning and Business Case development.

Justifying Transport Investment

The 'mechanics' of developing a business case for transport investments is likely to be largely unaffected by Peak Oil; rather the issue is one of recognising the impacts of Peak Oil over the period covered by the business case. Such impacts will be present in the Do-Minimum as well as the Do-Something, but the differential that drives any Business case will be materially affected by the impacts. An obvious example is airport expansion, where the high proportion of airline costs accounted for by fuel may result in a material demand impact arising from Peak Oil in the latter period of any Business Case forecast (for example, the DfT air travel forecasts are for 2015 and 2030 and the later year has the greater potential for Peak Oil impacts).

The business case needs to recognise and reflect issues that stem from the potential for:

- Greater change over the period covered;
- Greater uncertainty; and

- Greater change over the period covered.

Typically, a Business Case is based on forecasts for the opening (or a nearby) year and a year perhaps 10-15 years later. However, such timescales may not allow the full impacts of Peak Oil to be fully felt and hence may distort decision making where the latter years of the Business Case may have a material impact on the case overall.

On that basis, the forecasting and associated Business Case analysis should consider later forecast years than is typically the case, either additionally or with the second forecast year later than is typical. Any such approach will be prone to more uncertainty, but this is an area where the Business Case will need to be developed.

Greater uncertainty

Peak Oil will bring a new area of uncertainty to the forecasting and Business Case development of transport schemes in a range of different areas:

- The impact of Peak Oil on oil and fuel prices;
- The associated impact on the pricing of alternatives, notably public transport;
- Levels of car ownership and use and exogenous demand growth;
- Income levels and values of time;
- Behavioural change;
- Market response (more fuel efficient vehicles, electric vehicles etc) and
- Adoption and success of mitigation strategies.

Such uncertainty may lend itself to the use of scenarios in Business Case analysis, rather than the usual central case forecast and sensitivities around this.

Transport Model Used in the Study

Overview

In order to illustrate the potential impact of price changes implied by the results of this research, we have constructed a simple model to calculate changes in demand and carbon emissions between 2008 and 2025. This is not intended to produce accurate forecasts of demand under different pricing scenarios, rather to illustrate the potential scope for achieving a significant change in travel behaviour through changes in both motoring costs and public transport fares.

The model is based on the following key elements:

- We have taken Department for Transport (DfT) demand forecasts, expressed in terms of passenger-km, as representing the likely base case outcome in the event that existing relativities between motoring costs and public transport fare levels are maintained. In practice, DfT's forecasts are arguably more consistent with a continuing relative decline in overall motoring costs. However, since the focus of the analysis is on identifying

possible changes in demand and emissions rather than on producing accurate forecasts, we consider that this representation of the base case, assuming constant real prices and fares over time, is reasonable.

- Price changes are applied as a percentage change to the average price of a given mode. In the case of car travel, the model distinguishes between a change in the total lifetime costs, for example following a change in Vehicle Excise Duty, and a change in the price of motoring fuel. Except in the case of a reapplication of the Fuel Duty Escalator, price changes are treated as one-off events occurring in 2008, with relative price differentials maintained over the remainder of the forecasting period.

- In order to estimate pricing impacts, we have applied estimates of the elasticity of demand for different modes sourced from the research summarised above. In order to simplify the model, we have not sought to include all of the elasticity estimates reviewed (in particular the elasticities by income level and journey purpose shown in Table 5.1). In the case of car travel, the model estimates the impact of changes in both overall motoring costs, based on an estimate of the purchase price elasticity, and in fuel prices using fuel price elasticities for the short, medium and long term. In the case of rail demand, the model distinguishes between London and Southeastern, long distance and regional services, while bus services within and outside London are also modelled separately. In addition, separate short, medium and long term elasticities for both main public transport modes are included.

- We have applied own price elasticities in preference to the cross price elasticities in modelling the effects of price changes on demand. This is partly because cross price elasticities are less well understood, and partly to ensure greater transparency and clarity of modelled outcomes.

- Hence, the allocation of passenger-km between modes following a price change is based on a trip generation and abstraction matrix. This contains assumptions about the percentage of traffic that is "priced off" as a result of a price increase and the percentage transferring to each of the other possible modes. These assumptions were primarily sourced from The White Book, although we have made modifications in order to ensure that the model generates plausible results.

- We have estimated carbon emissions on the basis of the values of emissions per passenger-km for each mode reported in Figure 4.2. As noted above, these values were sourced from guidelines produced by DEFRA.

We have simplified the analysis considerably in order to focus on the impact on demand and mode share of changing prices. As a result, the model has a number of limitations that must be borne in mind when interpreting the results. In particular:

- It takes no account of income, employment or other factors that could change the demand for travel;

- It assumes that there are no capacity constraints on the ability of any given mode to accommodate increases in demand, although in specifying assumptions for the generation and abstraction matrix we have sought to ensure that transfers of traffic from car to public transport are plausible;

- Load factors for each mode are assumed to be fixed such that changes in passenger journeys are proportionate to changes in total passenger-km, although in practice price changes could be expected to result in significant changes in capacity utilisation, particularly in the case of public transport;

- It calculates the impact of a one-off price change in 2008 as a percentage change from the base case forecast in each year thereafter, using the relevant modal elasticity and ignoring possible lags and more complex dynamic effects;

- While including short, medium and long term elasticities, it takes each time horizon as a defined number of years, with the short term represented as the first three years, the medium term the subsequent four years and the long term the remainder of the forecasting period;
- In terms of cross elasticity effects, the model does not consider what proportion of, say, car trips are susceptible to modal shift and to which mode in particular; and
- It ignores technological changes that might affect real transport costs over time (although fuel efficiency changes have been accounted for in the analysis presented in this Peak Oil report).

These are clearly strong assumptions that substantially reduce the model's ability produce reliable forecasts of absolute levels of traffic. However, it can be used to investigate the changes in traffic that might arise from a change in the relative prices of different transport modes and hence help to inform price-based policy initiatives.