MAKING SENSE OF THE BIG ISSUES –
CLIMATE CHANGE AND PEAK OIL

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1. INTRODUCTION

As transport professionals, we find ourselves at the centre of an increasingly complex range of policy issues. The profession has evolved over the years from working in the relative simplicity of the 'predict and provide' era to the present day, multidimensional context. The policy context has rapidly expanded to cover local environment issues, wider policy integration and social inclusion issues, to name a few. We are now apparently faced with two truly global issues in the form of climate change and peak oil, both of which have the potential to fundamentally impact on peoples' travel options and hence travel choices and behaviour. How well prepared are we to engage with these issues in a coherent, rational and proportionate way?

Almost daily, there are new media reports relating to aspects of climate change. Yet in this welter of information, the basic facts, figures and context can easily be missed. The purpose of this paper is to provide a digestible overview of the basic context of the climate change and peak oil debates.

To a large extent, present methodologies for developing transport strategies and investment programmes, including approaches to appraisal, are still fundamentally based on a 'business as usual' assumption. The paper also attempts to raise some questions as to the appropriateness of this approach, in the light of climate change and peak oil.

2. CLIMATE CHANGE

The recognition of the existence of Climate Change resulting from human activities, is a relatively recent phenomenon. The relationship between increased greenhouse gas (GHG) emissions and global temperature was first mooted in earnest in the 1980s and it has taken a number of years to move from the scientific fringe to the relative mainstream of policymaker and public consciousness where we are today.

2.1 IPCC

In response to the emerging debate, the Inter-Governmental Panel on Climate Change (IPCC) was set up in 1988. The IPCC consists of an international panel of scientists, tasked with providing objective advice to policymakers on the risks of climate change. Central to this has been the four IPCC Assessment Reports published in 1990, 1995, 2001 and 2007. As time has passed, the degree of scientific consensus has strengthened and the level of certainty expressed by the IPCC has increased. The First Assessment Report admitted to **considerable uncertainty**, but we see a general strengthening of the view that human activity is contributing to climate change to the point that, by the Fourth Assessment Report, this view is deemed **undeniable**.

The progression of scientific opinion on climate change can clearly be seen in the Fourth Assessment Report, which points out that '**warming of the climate system is unequivocal**'. The report indicates that 'carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values'. The IPCC clearly presents the argument that the **burning of fossil fuels is responsible for the rising levels of carbon dioxide in the atmosphere**, although land-use changes and other factors also have an effect.[1]

The quantity of GHGs present in the atmosphere is measured in terms of its concentration, parts per million (ppm). In 2005, the global atmospheric concentration of CO_2 was 379ppm (430ppm for total GHGs), compared to pre-industrial levels of around 280ppm. The average annual increase in CO_2 concentrations has risen from around 0.9ppm/year during the 1960s to around 1.9ppm/year since 2000, so is increasing in line with emissions. Records from ice core samples suggest that present day CO_2 levels exceed by far the natural range over the last 650,000 years. The speed of change is also unprecedented.

The Fourth Assessment concludes that, in the absence of new climate change policies, by 2095, global temperatures will be between 1.1C and 6.4C higher than in 1990, with corresponding sea level rises of 0.18m-0.59m. These changes would continue well beyond 2100. To give this some perspective, the planet is currently around 5C warmer than at the time of the last ice age.

The IPCC does not make specific recommendations regarding the level of cuts in emissions. Instead, it lays out a series of scenarios regarding (a) the level at which atmospheric GHGs stabilise in the atmosphere, (b) the year in which CO_2 emissions peak, and (c) the level of emissions in 2050, compared to 2000. The consequences are expressed in terms of average temperature rise, compared to pre-industrial level and average, resulting sea level rise. A consensus has emerged that global temperature must be kept at less than 2C above pre-industrial levels to avoid runaway climate change.

The IPCC concludes that CO_2 concentrations must peak at 350ppm-400ppm (379ppm in 2005), with emissions peaking then reducing between 2000 and 2015. In the longer term, this would require CO_2 emissions in 2050 to be between 50% and 85% lower globally than in 2000.

IPCC 4th Assessment Summary

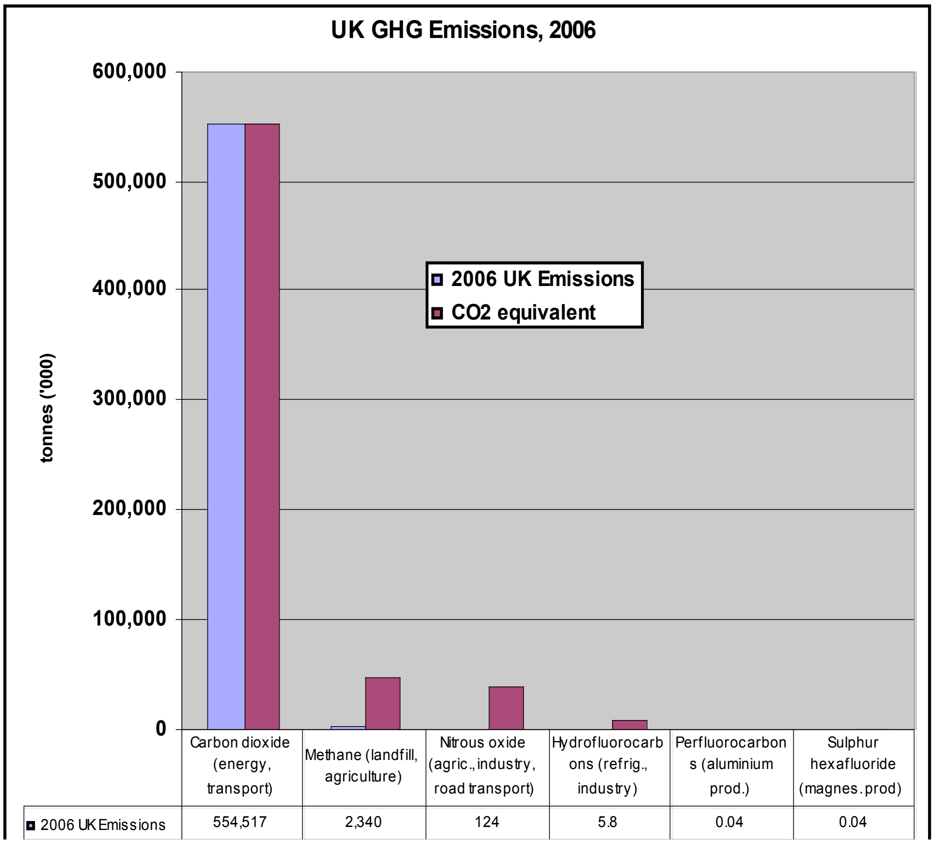
- Warming of the climate is unequivocal – air / sea temps, melting of snow and ice, rising sea level;
    - 1906-2005, +0.74C, rate is increasing
    - 1900-2005, +250mm, rate is increasing

- Natural systems are being affected by climate change;
- Global GHG emissions due to human activities have increased by 70% between 1970 and 2004;
- Observed temperature increases are 'very likely' (90%+) to have been caused by anthropogenic (ie derived from human activity) GHG emissions;
- With current policies, global GHG emissions will continue to grow in the coming decades;
- Continuing increases in GHG emissions will cause further warming and greater climate impacts than seen so far;
- Anthropogenic warming and sea level rises will continue for centuries, due to the time scales associated with climate processes and feedbacks, even if GHG emissions were stabilised;
- Anthropogenic warming could lead to abrupt or irreversible impacts, depending upon the rate and magnitude of climate change;
- Many impacts can be reduced, delayed, or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels.

In short, the effect of the publication of the 4th IPCC report was final widespread acceptance that Climate Change is real, and is caused by human activity.

2.2 What are the Greenhouse Gases?

There are a range of GHGs which contribute to climate change; the main ones are shown in the bar chart below. This shows UK 2006 emission levels in pure tonnes, together with the CO_2 equivalent ie the 'global warming potential' of each gas (eg 1 tonne of methane is equivalent to 21 tonnes of CO_2 in global warming terms). These figures are based on the accounting method used by DEFRA for reporting to UNFCCC (United Nations Framework Convention on Climate Change).[2]

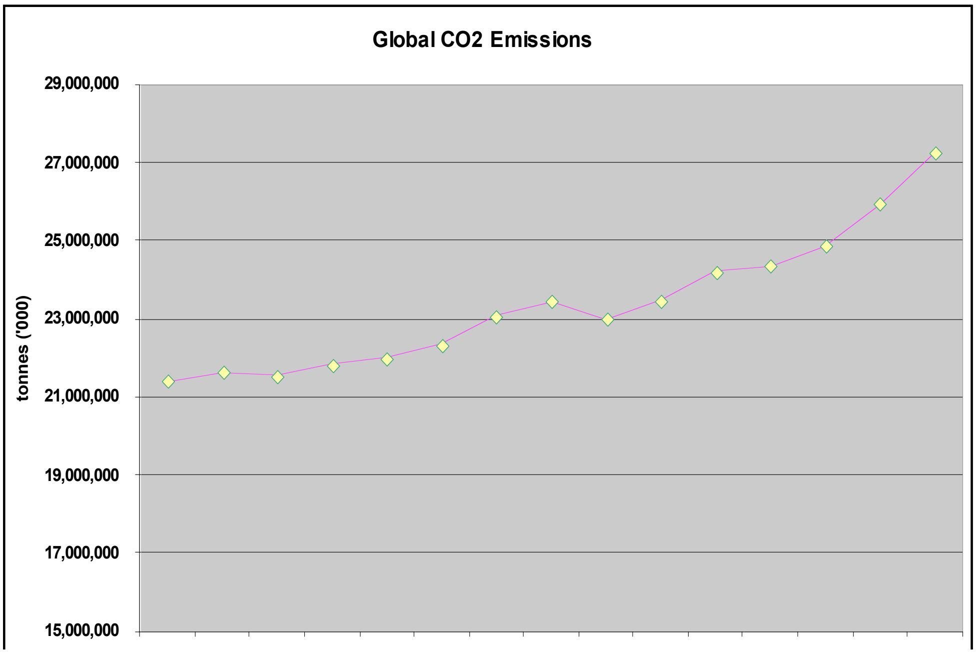


It can therefore be seen that CO_2 forms the very large majority of the UK's total GHG emissions at around 85% CO_2-eq (the equivalent figure was 75% in 1990). The other gases are far smaller in terms of absolute quantities, but are much more powerful in global warming potential terms. Nevertheless they remain a low proportion of total GHG emissions.

2.3 The Global Context

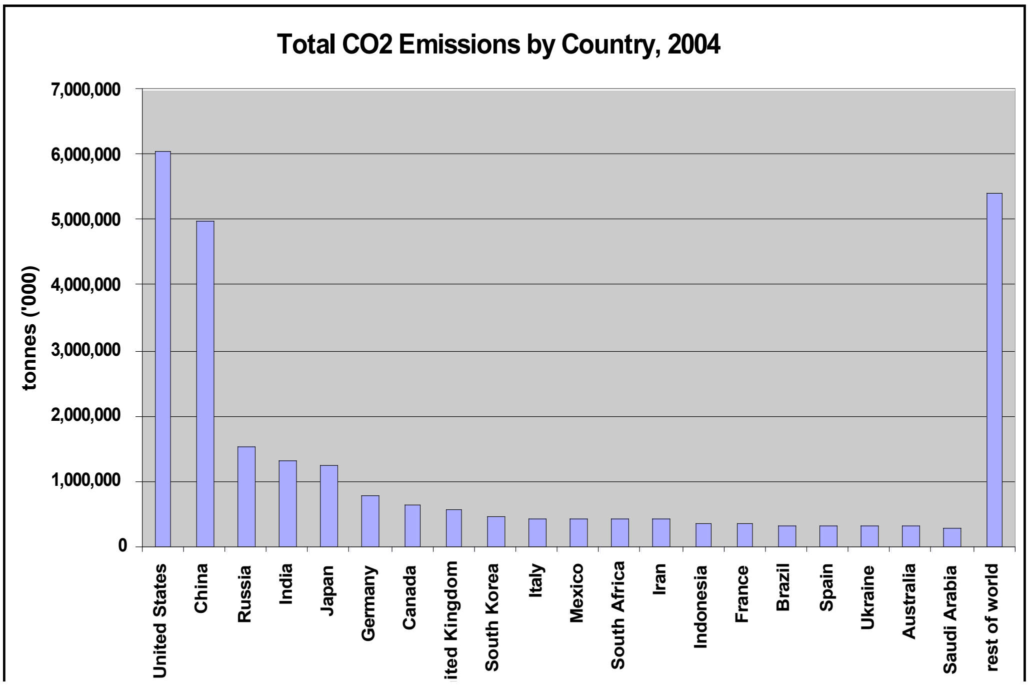
The total amount of CO_2 emitted from the burning of fossil fuels across the world in 2004 has been reported by the UN[3] as 27,245,758,000 tonnes[4] (or 27.2Gt). This represents a 27% increase on the 1990 figure. By contrast, in 1940 the figure was less than 10Gt. The trend is shown in the figure below.

The figure for total emissions of all anthropogenic GHGs was actually 49.0GtCO_2-eq[5], which includes CO_2 from deforestation and decay of biomass etc, methane, nitrous oxides and others. In total, CO_2 accounts for over three quarters of this global total (CO_2-eq), and transport accounts for 13% of total GHG emissions globally. However, CO_2 produced from the burning of fossil fuels, in fact only accounts for only 56.6% of total GHG emissions.



The remainder of this section considers fossil fuel-based CO_2 emissions only. The average annual growth rate of emissions was 0.9% between 1990-95, 1.6% between 1995-2000 and 3.0% between 2000-04, so the **rate of growth in global fossil fuel-based CO_2 emissions is actually accelerating significantly**.

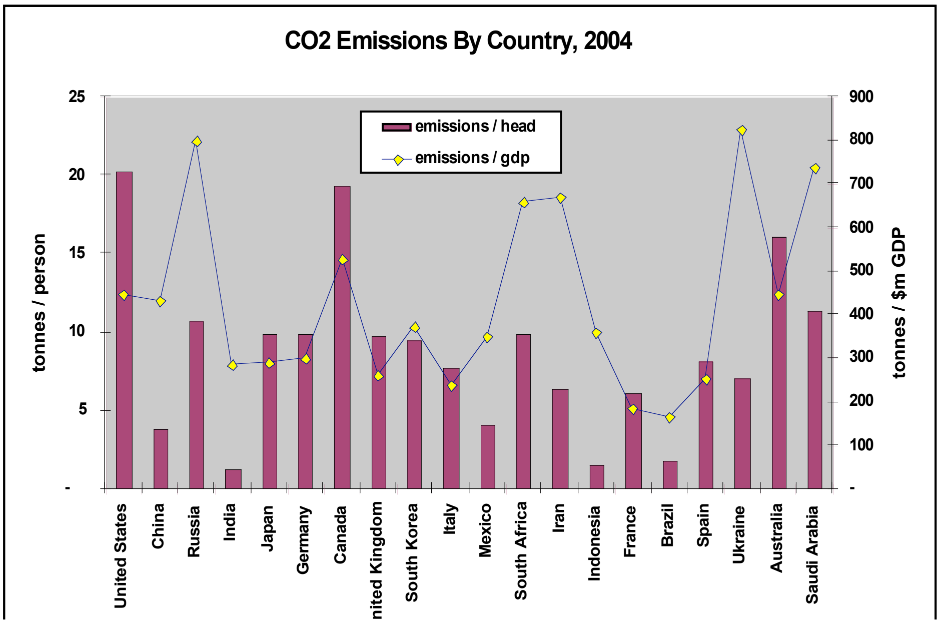
The UN reports on emissions from each of the 210 countries across the world. The top 20 countries, in terms of CO_2 emissions, account for around 80% of total CO_2 emissions, around 61% of global population and 77% of world GDP. Using the latest available figures (2004), the figure below shows the country level totals for the top 20 emitters.



Globally, it can be seen that the UK is the eighth largest emitter of CO_2 and is responsible for around 560m tonnes per annum - around 2% of the global total. UK emissions allocated to Scotland are around 8%, so Scotland's share of global CO_2 emissions is around 0.0016%, or rather less than three days worth of USA (2004) emissions.

The USA and China, as the world's two biggest economies dominate, between them accounting for 40% of all CO_2 emissions. Recent reports[6] have however indicated that as of 2006, China has in fact overtaken the USA as the world's biggest producer of CO_2, as its economy and emissions continue to grow rapidly.

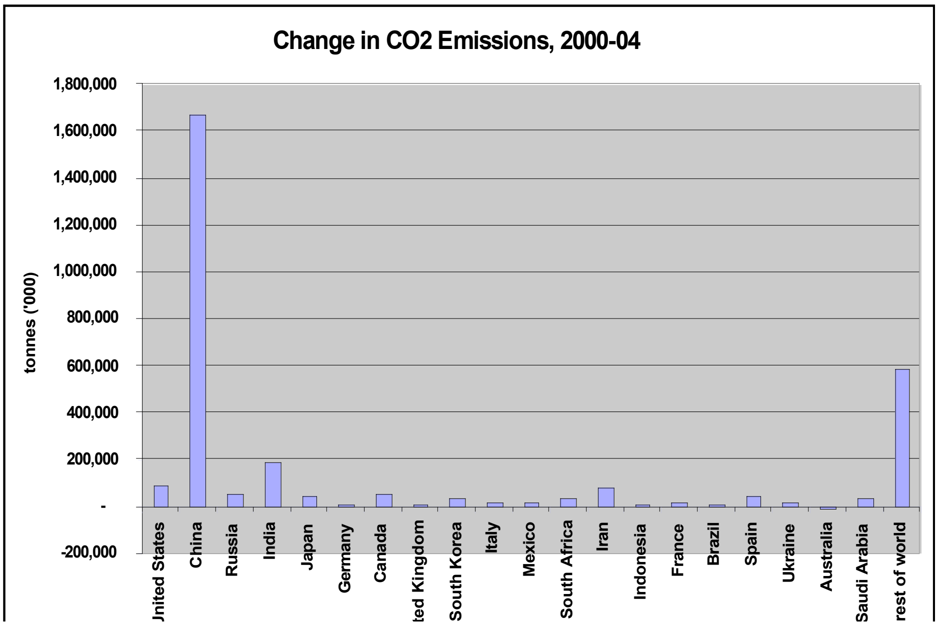
The figure below shows the level of emissions per head of population and also per unit of GDP.



Of the top 20 CO_2 producing countries, the USA and Canada are, by some distance the highest emitters of CO_2 on a per capita basis. Emissions per capita in China, India, Indonesia and Brazil are very low in comparison – and these are four of the five most populous nations on Earth with a combined population of around 2.8 billion people. On this basis, developing countries are perhaps entitled to take the view that developed countries should cut emissions first – especially when much of the emissions produced by developing countries stem from the production of goods for developed countries, rather than domestic consumption.

Looking at the GDP measure, the USA and China actually produce a similar amount of CO_2 per $m of GDP. This is likely to be a coincidental figure however – the US figure will be much more heavily influenced by personal wealth and consumption, whilst the Chinese figure will have a far larger industrial and production component.

The figure below shows the change in CO_2 emissions for the top 20 countries between 2000 and 2004.



The growth in CO_2 emissions from China in this period is dramatic and, in itself, accounts for over half of the global rise in CO_2 emissions. As mentioned above, China's emissions are now thought to have exceeded 6Gt which would make the above chart even more dramatic (ie the figure would be around +2,600,000). There are many reasons for this dramatic rise in China but they mainly stem from its strong economic growth and substantial use of coal in electricity generation. In 2005 for example, the BBC reported that China had plans for a further 544 coal-fired power stations[7], which are reportedly opening at the rate of 1-2 per week[8]. Similarly, there are reportedly plans for an additional 50 new airports to be opened in the coming five years.[9] However, China's economic growth is in the main fuelled by producing goods for consumption in developed countries. In this way, the west can be thought of as having 'off-shored' their emissions.

Against this backdrop of growing emission levels, the **number of cars** across the globe continues to grow rapidly. At present, there are around 600m cars on the road across the world, 30m of which are in the UK. Projections by Goldmann Sachs (quoted in King Review[10]) suggest that, by 2050, there could be over 600m and 500m cars in India and China respectively (equating to a still relatively low 382 and 363 cars per 1000). In the US, the projected growth is from around 140m in 2000 to around 240m in 2050. The magnitude of these figures speaks for itself, and has clear implications for future GHG emissions if conventional technologies were followed.

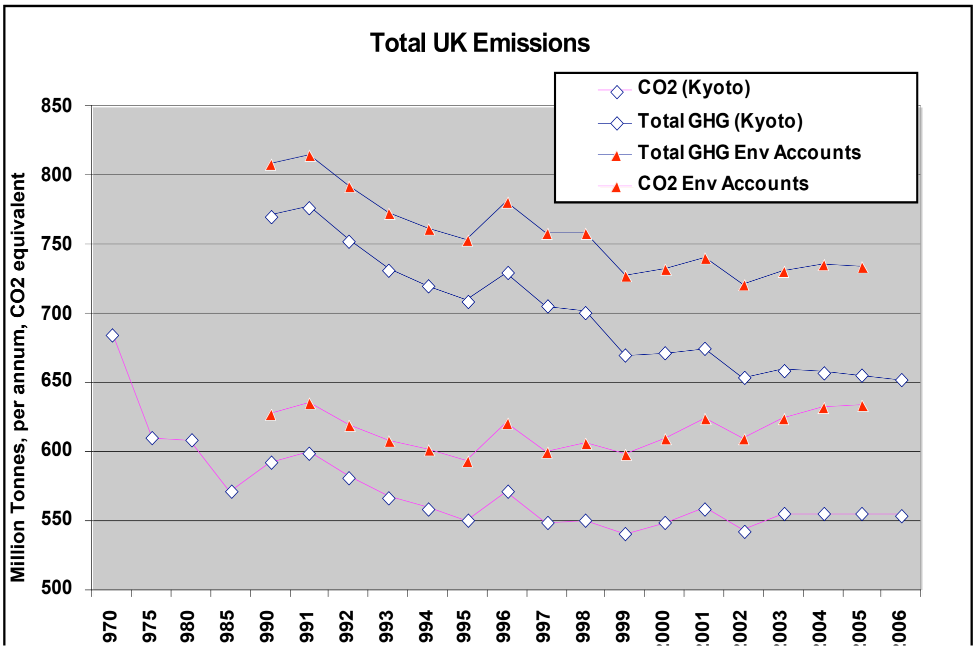
These car ownership projections reflect in part, global economic and population growth. The world's population in February 2008 is estimated to be around 6.7 billion. The UN has forecast that **global population** will grow to a peak of around 9.22 billion in 2075 before declining. In terms of economic growth, Stern estimates that the **global economy** will be 3-4 times present day levels by 2050.

In summary:

- Global GHG emissions are continuing to grow and the rate of growth is increasing;
- In most developed economies, the level of emissions has stabilised or is growing / declining slowly;
- Emissions per capita in developing countries remain far below those of developed countries and North America in particular;
- The recent growth of emissions in China dwarfs changes in other countries;
- There are major energy-related pressures in terms of population, economic and personal mobility growth.

2.4 Emissions in the UK

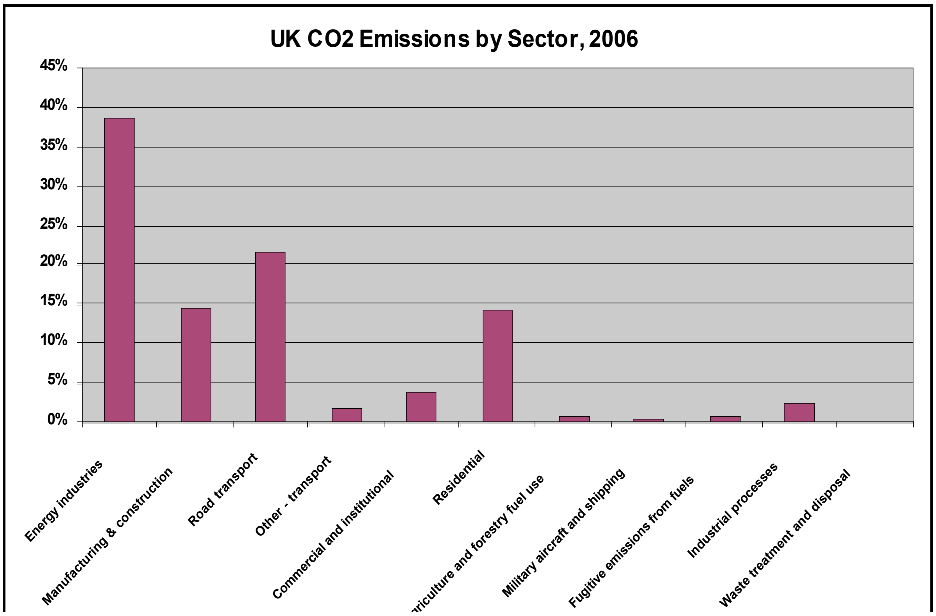
This figure below shows how UK emissions (CO_2 and total GHG[11]) have changed over time, using two measures, Kyoto and Environmental Accounts.



Using the Kyoto measure (white diamond symbol), it can be seen how both CO_2 and total GHG emissions have reduced, particularly since 1990. It is however notable that CO_2 emissions have remained broadly constant since the mid 1990s, whilst total GHG have continued to decline over this period. 'Environmental Accounts' (red triangle symbol) is a different accounting system, used by the ONS. Importantly, this system includes an allocation of the UK's share of international aviation and shipping emissions. Use of this method therefore adds significantly to the UK total. If the Environmental Accounts data is used, the UK's CO_2 emissions have, in fact, not reduced at all between 1990 and 2005 (up by 0.9% compared to a drop of 6.3% using the

Kyoto measure) and the drop in GHGs is less, at -9.3% compared to -15% using Kyoto.

Looking at Kyoto-defined CO_2 emissions by sector, energy generation, manufacturing / industrial / construction, residential and road transport are the main producers of CO_2 in the UK. Transport now accounts for around 25% of domestic CO_2 emissions up from only 10% in 1970.



The UK and Kyoto

The **Kyoto Protocol** was agreed in 1997 with the objective of reducing the emission of GHGs through international agreement. The overall target was to achieve (for 36 'developed' countries, and the EU) a 5.2% cut in GHG from 1990 levels by the period 2008-12. This looks likely to be met – largely due to economic restructuring in the former Soviet states. A further 137 (mainly developing) countries, including China, have signed the protocol, but are not actually obliged to reduce GHG emissions; only to commit to measuring and monitoring. The US (nationally) signed, but did not ratify the treaty.

For the UK, the target was to achieve a 12.5% reduction in total GHG emissions from 1990 levels (measured in terms of CO_2 equivalent) during the period 2008-12. It can be seen from the figure above that by 1997, the UK was already well on its way to meeting these targets, and indeed 1990 represented something of a peak in emissions, so the agreed UK requirement was perhaps not as onerous as it might have appeared. On 2006 figures, total GHG emissions (as defined for Kyoto) are around 15% less than 1990, so the UK is on track to meet its target. The reductions are considerably larger if the impacts of the EU's emissions trading schemes are taken into account.

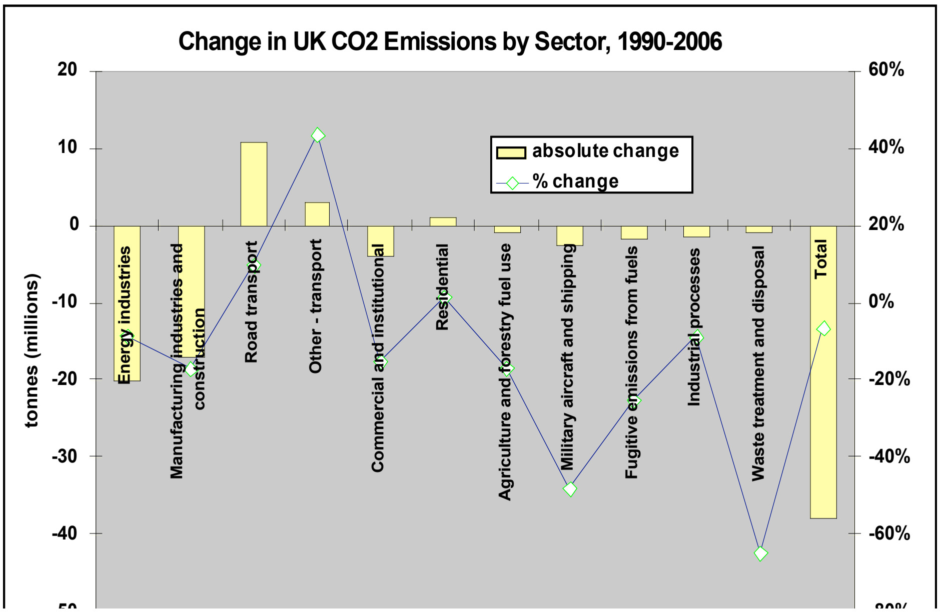
Emissions trading allows countries to remove CO_2 emissions off their 'balance sheet' by essentially 'allocating' them to other countries for a fee, where they have a remaining ‘allowance’ for emissions - ie each country in the scheme has an agreed national allowance and can ‘trade’ this. So in theory, only the most important carbon-based activities continue – carbon use which is the most easily replaceable will be replaced first.

The EU Emissions Trading Scheme is a Europe-wide scheme which aims to reduce emissions of CO_2. It puts a price on carbon that businesses use and creates a ‘market’ for carbon. However, not all sectors and GHGs are presently covered – the first phase included those responsible for only around 40% of CO_2 emissions. So for example, in 2005 UK business had to ‘buy’ 27m tonnes of GHG allowance from abroad or from future year allowances, where they had overshot their allotted ‘budget’ in the year. This ‘reduction’ in emissions is valid in Kyoto terms. Clearly, the success of emissions trading depends entirely on the agreed ‘caps’ put on the countries which are part of the scheme. The price of carbon will reflect the allocations – generous allocations would reduce the price. In practice, the price during this first phase 2005-2007 has been as low as 0.1 euro / tonne.

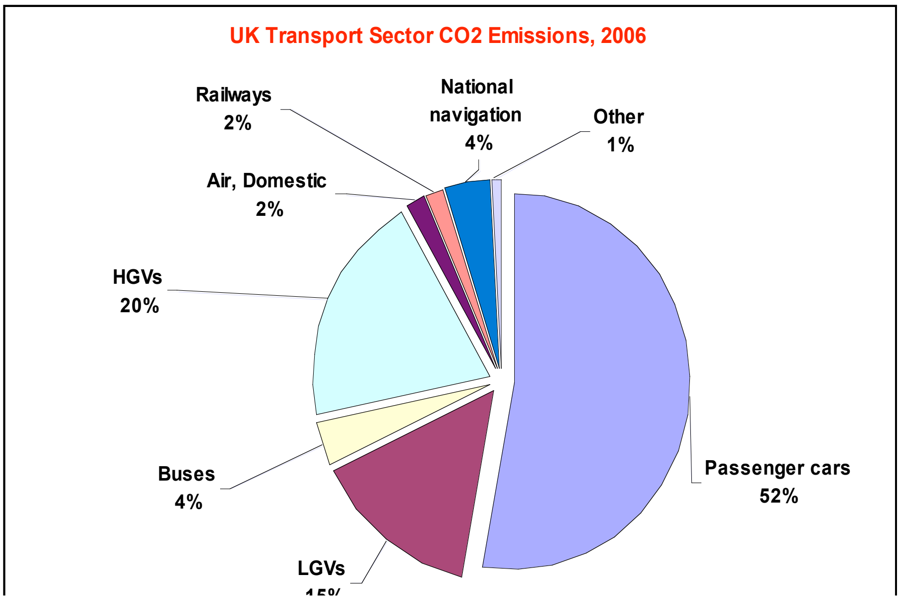
How has the UK’s Kyoto Target been met?

Greenhouse Gas	% change, 1990(95) - 2005
Carbon dioxide	-6.4
Methane	-52.3
Nitrous oxide	-37.7
Hydrofluorocarbons	-40.6
Perfluorocarbons	-25.5
Sulphur hexafluoride	-7.8
TOTAL	-15.8

Over the past 15 years, there have been substantial cuts in all of the most significant gases, with the exception of CO_2, and overall, GHG emissions have been reduced by over 15% during this period. The figure below shows the changes in CO_2 emissions by sector between 1990 and 2006.



The biggest reductions in CO_2 emissions have therefore been in the Energy and Manufacturing/Industrial/Construction sectors, due in the main to a switch from coal to gas in electricity generation in the 1990s, along with general reductions in manufacturing and industrial activity, respectively. The only substantial exceptions to the downward trend are **transport related**. CO_2 emissions from road transport have increased by around 11m tonnes (+10%), while emissions from 'other transport' have increased by 3m tonnes (+44%). The current share of UK domestic transport CO_2 emissions for all modes is shown in the figure below.



Road-based transport accounts for over 90% of UK domestic transport sector emissions.[12] HGV, LGV and bus traffic accounts for nearly 40% of emissions, with cars currently accounting for around half of transport's CO_2 emissions, possibly rather less than many would anticipate. The table below contains more details of how this picture has changed through time.

	2006 emissions (million tonnes)	Change in CO_2 emissions from 1990-2006 (tonnes)	Change in CO_2 emissions from 1990-2006 (%)	*Change in Volume of Travel, 1990-2006 (veh-km)*[13]
Passenger cars	68.7	-1.7	-2%	*+20%*
Light duty veh.	19.9	+9.3	+88%	*+61%*
Buses	4.9	+0.5	+12%	-
HGVs	25.8	+2.6	+11%	*+17%*
Motorcycles	0.5	-0.2	-25%	*-7%*
Domestic aviation	2.3	+1.1	+93%	-
Railways	2.2	+0.5	+29%	-
National navigation	5.5	+1.4	+33%	-
All domestic transport	**130.8**	**+14.4**	**+12%**	**-**

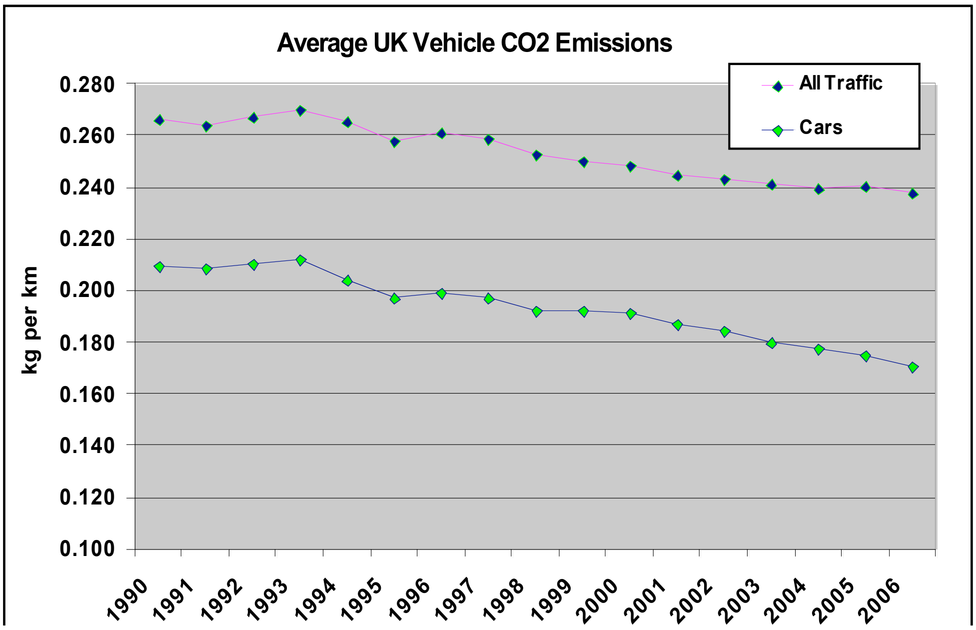
Perhaps a surprise to many would be that total CO_2 emissions from cars have actually reduced by 2%, especially when set against an increase in traffic of around 20%. Emissions from all other significant transport modes have gone up in this period. The single biggest absolute contributor to growth has been LGVs, outstripping the growth from, eg, domestic aviation by a factor of more than eight in absolute terms. All other substantive modes have seen increases, including domestic aviation (+93%), rail (+29%) and domestic shipping (+33%). In addition, car traffic's share of the total transport emissions is now less than in 1990.

In summary:

- The UK is likely to meet its Kyoto targets;
- Cuts in CO_2 emissions have been less than for other GHGs;
- Using an alternative accounting system (which includes a share of international shipping and aviation), UK CO_2 emissions are increasing, not falling;
- Emissions trading allows 'unreal' cuts in emissions to count;
- The transport sector is the only major UK sector where CO_2 emissions are rising;
- Total CO_2 emissions from passenger cars is falling however, all other vehicle types and modes are increasing.

2.5 Vehicle Standards

The emissions and traffic figures above for road transport reflect changes in vehicle efficiencies, as illustrated below.



Across all traffic types, CO_2 emissions have reduced from 266g/km to 238g/km, an 11% improvement between 1990 and 2006. The efficiency gains for the car fleet have been larger with g/km of CO_2 reducing by 19%, with the 2006 value being around 170g/kg for cars presently on the road. Efficiency gains for goods vehicles (not shown) have been much less, at around 6%.

In the UK, a 19% increase in car efficiency has led to a 2% drop in emissions. Over the 15 year period for total traffic, this 11% efficiency improvement has been offset by traffic growth of 23%, leading to an overall rise in CO_2 emissions of 10%. Vehicle fleet efficiency therefore has to increase by around 1.5% per year, just to keep pace with general traffic growth.

The EC sets **emissions regulations** relating to new and existing cars sold in the EU (Euro 1 – 4 and 5-6 forthcoming). However, these standards do not cover CO_2 emissions. Instead manufacturers have been working to a voluntary agreement (target of 120g/km by 2012), with the first stage agreed between the EC and the European Automobile Manufacturers Association in 1998. This first stage set a target of an average of 140g/km for each car manufacturer in terms of total cars sold by 2008. Only manufacturers of primarily smaller vehicles (Fiat, Citroen, Renault, and Peugeot) will meet this target. EU figures suggest that the average emissions from new cars have dropped from 186g/km in 1995 to around 160g/kg at present, some way short of the 140g/km target.

In response, the EC is now pursuing binding targets incorporating fines for manufacturers failing to meet these targets. The European Parliament recently voted for a target of an average of 125g/km for each manufacturer by 2015, a concession from the 120g/km by 2012 favoured by the Commission. With present day levels at around 160g/km, achieving the 125g/kg target would mean a 22% improvement in overall new car efficiency over the present day. In the intervening period, traffic levels across Europe will continue to rise, offsetting this reduction to some extent. It will also take some considerable time for older, higher emission vehicles to be replaced in the car fleet.

2.6 Other Targets

In 1997, the UK government set a separate target of achieving a 20% cut in CO_2 emissions by 2010, compared to 1990 levels. This target looks very unlikely to be met and is being overtaken by events surrounding the emerging **UK Climate Change Bill**, which was launched in March 2007 as a means to create a new, legally binding, post-Kyoto framework for emissions reductions. This proposes a target of a **60% cut in carbon emissions relative to 1990 levels by 2050**, including an **interim target of reductions of 26%-32% by 2020**. At present, an even more ambitious figure of **80%**, rather than 60% is being considered. There will also be five-year 'carbon budgets', set in advance, which will aim to limit total emissions over each period. This Bill is due to be debated and passed in the House of Commons during the first half of 2008. The House of Lords has recently voted for a key new clause which would ensure that at least 70% of this reduction has to take place in the UK, as opposed to being traded away.[14]

These new targets clearly represent a huge step change from Kyoto, which now appears to have been a rather modest target, in terms of both scale and scope. However, the implications of meeting these targets is perhaps only now being realised. As this realisation dawns, there are signs that a backlash against these targets is starting to emerge. In addition, the Scottish Government is presently consulting on its own Climate Change Bill[15].

Emissions targets to date have excluded **international aviation and shipping**, due to difficulties in agreeing methodologies to 'assign' emissions to individual countries. Yet these are two areas where emissions are growing strongly. The aviation industry in particular has become something of a *bête noire* for climate change campaigners in particular, due to the rapid rise in emissions from this sector and projections of continuing growth. Recent reports have suggested that emissions from the world's merchant fleet account for around 1.12bn tonnes of CO_2 (around 4.5% of the global total), a figure which is well in excess of the figure attributed to aviation, at around 650bn tonnes of CO_2. It is anticipated that this figure will rise by a further 30% by 2020.

A key **recent development** was the UN Climate Summit in Bali, December 2007. This was convened to reach an international agreement on cutting global emissions post Kyoto. The main thrust of the agreement reached was a 'road map' to a future deal, planned to be agreed in Copenhagen at the end of 2009. This includes a review of how richer countries can 'export' green technology to developing countries. No commitments to targets were agreed.

As we stand today though, it remains the case that there is no overarching international agreement governing emissions beyond the partial coverage of Kyoto. All hopes are pinned on Copenhagen 2009 to secure a truly global (and much more significant) successor to Kyoto.

2.7 How Should We Respond to Climate Change?

The way in which we respond globally is surely governed by how seriously we take the threat posed. Some analyses of the consequences of climate change are truly apocalyptic – perhaps too apocalyptic to be believed by many. If internationally, 'we' fully believed this, then surely much more drastic action would be being taken now. At the same time, there is still a voluble minority who dispute the existence of the threat. In 2007, the BBC cancelled a planned 'climate relief' project on the grounds of 'impartiality', providing a strong signal that the jury is essentially still out on whether we face a threat from climate change or not. Also, the Conservative Party 'Way Forward' group has recently published a paper casting doubt on the link between CO_2 emissions and climate change, instead attributing the observed change in temperature to cosmic rays[16], for example.

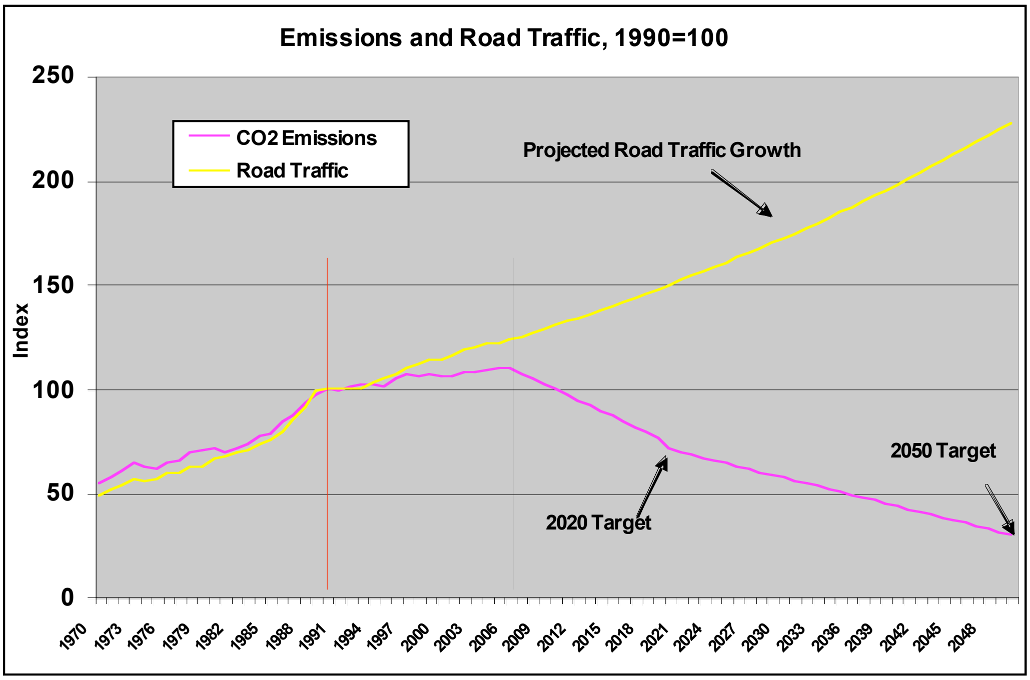
However, most commentators and the very large majority of scientific opinion are in agreement that climate change is real and is a threat. The debate surrounds the severity of the impacts and the measures required in response.

The IPCC concludes that GHG emissions must peak between 2000 and 2015, then drop by around 85% (from 2000 levels) by 2050 to maintain temperature increases at below 2C above pre-industrial levels. This pathway to emissions peaking and reducing would seem implausible from today's perspective – given that no international agreement is likely before late 2009 and globally, emissions are growing strongly, with this rate of growth increasing. Without comprehensive international agreement on emissions, (including potentially massive support to developing countries to grow using non-carbon energies), unilateral action by a single nation such as the UK is all but futile.

However, assuming international agreement is forthcoming, from the UK perspective, the Climate Change Bill will bring in very tough targets to reduce domestically produced CO_2. It proposes a target of a 60% (or possibly 80%) cut in CO_2 emissions relative to 1990 levels by 2050, including an interim target of reductions of 26%-32% by 2020. The Stern Review[17] also states the need for a 60%-80% cut in UK emissions by 2050.

For domestic transport, since 1990, CO_2 emissions have increased by 12%, despite significant progress in car efficiency in particular. In order to make its full contribution to the 2020 interim target (only 12 years away), CO_2 emissions from domestic transport would therefore need to reduce by 34%-39% from 2006 levels. This is set against continuing growth in the demand for transport – road traffic (vehicle-km) is currently growing by around 1.4% per annum, passenger throughput at UK airports is rising by around 5% per annum, and rail travel (pass-km) is increasing at around 3% per annum. Air passenger volumes are forecast to rise from 235m in 2006 (31m in 1970) to 465m by 2030[18] (central case).

As an illustration of the task, the figure below shows historic road transport CO_2 emissions and total road traffic (vehicle-km) between 1970 and 2006, indexed such that 1990=100 in both cases.



The yellow line shows historic and illustrative projected total road traffic - based on 2000-2006 growth rates. The pink line then shows the quantity of total previous road-based transport emissions and the path implied by the UK government's emissions targets. The divergence of the two lines illustrates the scale of the task. Indeed, the 2050 implied emissions target equates to rather less than the present day total emissions for all goods vehicles. **Present day and forecast travel volumes and means of travel, are therefore clearly not compatible with UK emissions targets**.

There are two ways in which the level of transport-related emissions can be reduced:

- Behavioural change – travel volumes and modal choices
- Technological change – improvements in vehicle efficiency and use of alternative fuels

Changing people's **travel behaviour** on such a dramatic scale would clearly be extremely difficult from a political perspective and would result in fundamental economic and social change. The policy and fiscal measures required would be extreme and politically unachievable. Having said that, minor measures such as enforcing speed limits, changing driving styles, and correct tyre inflation, would reduce emissions without major adverse impacts. In addition, other policy initiatives which influence travel decisions can make an impact at the margin but not on the scale required.

So the solutions currently envisaged by government are overwhelmingly **technology based**. The King Review[19] has recently undertaken an independent review of the role of technology in decarbonising road transport and concluded that: '….*in the long term (2050 in the developed world), almost complete de-carbonisation of road transport is a realistic ambition. If:*

- *substantial progress can be made in solving electric or other innovative vehicle and fuel technology challenges and, critically*
- *the power sector can be decarbonised and expanded to supply a large proportion of road transport demand,*

….per kilometre emissions reductions of around 90 per cent could be achievable for cars." [cuts of 50% by 2030 compared to the present day are also deemed obtainable].

Those are two substantial 'ifs?' but it is being suggested here that **within a generation or so, the 'environment' could be all but removed as a significant issue for the car**.

This does however present a peculiar position to the public. On the one hand, there are messages and policies which discourage car use, partly because of impacts on climate change. This has contributed strongly to the use of the car becoming something of a moral issue. But on the other hand, government is relying almost entirely on technology to resolve the emissions problem. This is perhaps not widely recognised. If it were, the case for the need for behavioural change is fundamentally weakened - why change now when the problem will go away in time anyway?

If 'the environment' were to be removed as a road transport issue, it would clearly have a substantial impact on transport policy and strategy. Congestion would become the principal 'external cost' of road transport. How would pricing structures and demand management respond?

If it is assumed that in the medium-term, technology will essentially eradicate damaging emissions from road-based transport, the key issue is the short-term response. It must be tempting for policymakers to rely on these future technological changes to make the problem essentially 'go away'. In this way, there is virtually no pain to the public and therefore little by way of political damage. This is essentially where we are now. **Indeed, behavioural change (through modal shift or reduced travel) is envisaged to account for only a very small proportion of the required reduction in CO_2 emissions.** Some modest financial measures through vehicle excise duty and some local schemes (emissions-based congestion and parking charging) are being implemented, but there are arguably no climate change-related policies which impact substantially on lifestyle - ie so far there has been very little climate change-related 'pain'. Current policy suggests that this is set to continue.

At the same time, government is to some extent re-focussing transport policy and investment on a more economy-based objective. As such, we are continuing to build new roads, in addition to sending out signals on road pricing and parking policy.

With the current understanding of climate change, under what circumstances is the building of roads, or the increasing of road capacity therefore acceptable? It is almost inevitable that building new roads encourages more travel by car. So increasing road capacity will in all probability increase vehicle kilometres travelled, and this also sends a clear signal to the travelling public regarding the use of the car.

In summary:

- Behaviour change can only have a modest impact on reducing transport emissions, in terms of the scale of reductions required;
- In the medium-term, to meet Climate Change Bill targets, road transport must be virtually decarbonised in its entirety – with the internal combustion engine being replaced with power itself generated from non fossil fuel sources;
- Removing 'the environment' as an issue for road transport would have a fundamental impact on transport policy;
- There is currently very little climate change related 'pain' for the travelling public – there is no political appetite to fundamentally change travel behaviour;
- We continue to invest in new road infrastructure;
- The public receives mixed messages regarding use of the car and climate change.

3 PEAK OIL

Although first raised many years ago, the issues surrounding 'peak oil' have, in recent years, gained increasing prominence, although it does not yet have the public profile of climate change as an issue.

In short, 'peak oil' refers to the inevitable point in time when global oil production hits a peak and starts to decline. In the past, global oil production has kept pace with global demand, but in the face of increasing demand, declining production levels and supply rates would have obvious implications in terms of supply levels and price. The consequences of 'peak oil' are therefore essentially price related.

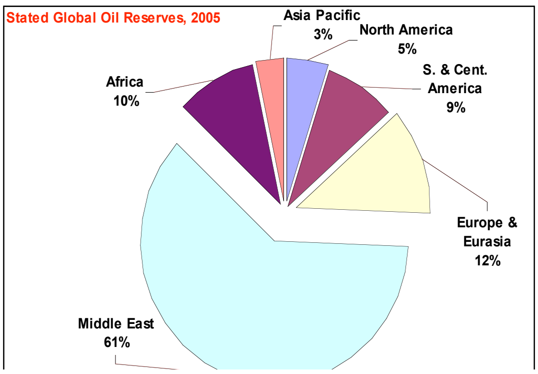
The debate surrounding 'peak oil' is rather simpler than that of climate change and is essentially one of supply and demand. The debate is centred on three main questions:

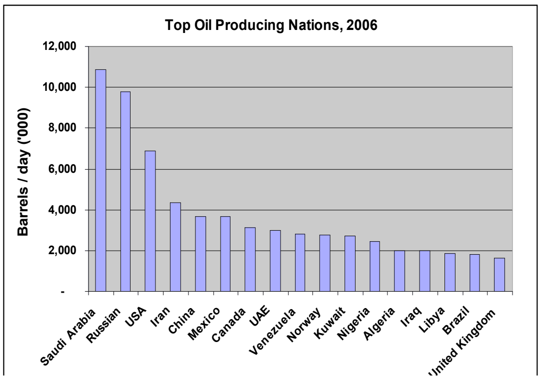
- How much obtainable oil is left in the ground?
- What is the capacity of the delivery systems to supply oil?
- What is the likely future demand for oil?

There are strong lobbies which, on the one hand, suggest that there are no issues with oil supply in the medium-term, and other groups who maintain we may have already hit peak oil, and are on the verge of a resulting economic and social disaster. Many oil industry figures are actually present in this latter group, which perhaps adds credibility to the argument. As with climate change, some analysts predict disaster up to and including the demise of society as we know it.

A key difference between this issue and climate change however, is that **peak oil is not yet seen as an issue for Government, either here or internationally**. The UK government's position is that fuel supplies are sufficient to sustain economic growth for the foreseeable future, taking its cue from the International Energy Agency (IEA), an autonomous OECD related body. Proponents of imminent peak oil take issue with this fundamental assertion, and the IAE figures - ie that the supply of oil can keep pace with the demand for oil in the medium-term.

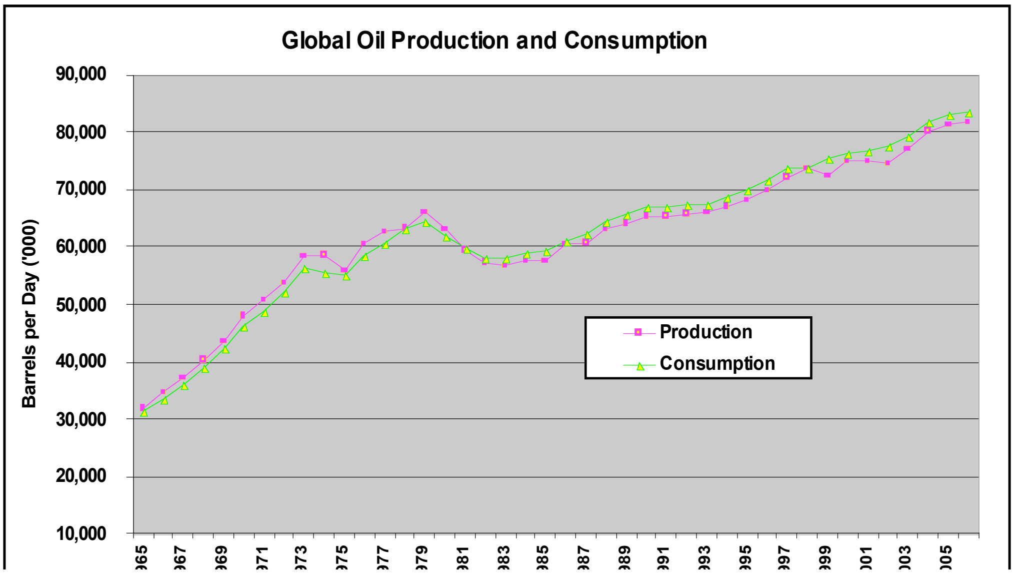
It goes without saying that oil is central to the global economy and indeed world geo-politics and has been for many years. The location of stated oil reserves, together with the top oil producing nations, are shown in the figures below[20].



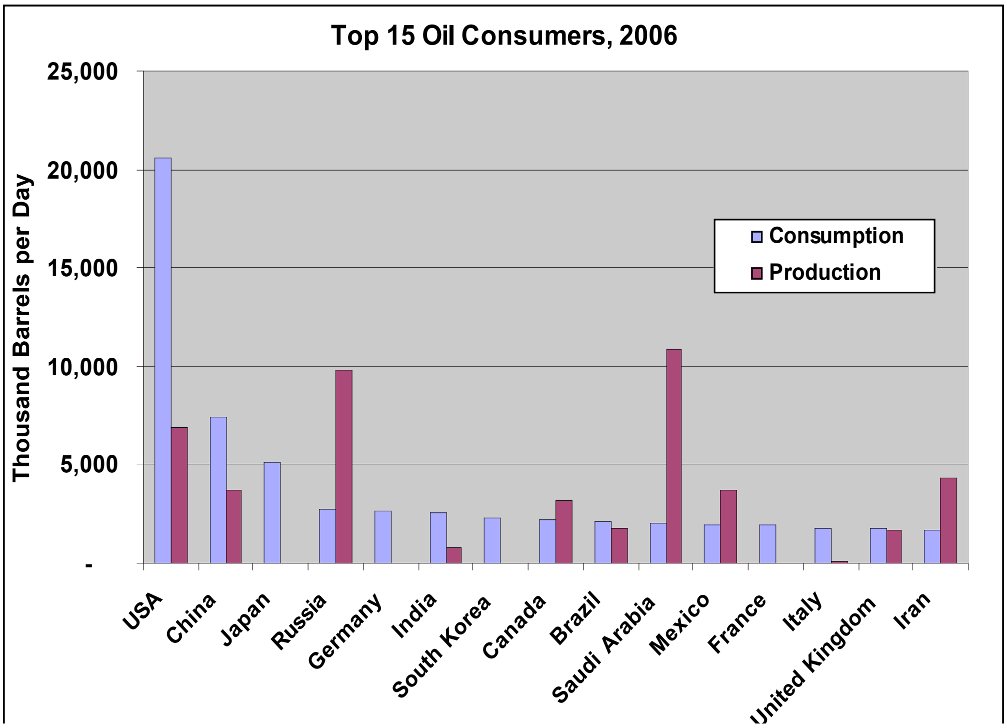


Total 'proved' oil reserves are currently reported at around 1208 thousand million barrels (1.2 trillion), the bulk of which is in the Middle East. Saudi Arabia and Russia are the dominant countries in terms of oil production, with the UK now well down the list.

At present, daily oil production is around 87 million barrels per day (mb/d). Since 2000, this figure has been rising at around 1.5% per annum (again mainly due to China). The historical trend for oil production and consumption is shown below. The pattern of growth has been fairly steady since the early 1980s.



In terms of consumption, the USA and China were the two largest consumers of oil in 2006. These two countries plus Japan in third place are net importers of oil.



The IEA's World Energy Outlook (2006), in its Reference Case scenario, reports that global oil demand is projected to grow from 87mb/d to 99mb/d in 2015 and then 116mb/d by 2030. Similarly, the US government's Energy Information Administration in its International Energy Outlook 2007 projects 97mb/d in 2015 and 118mb/d in 2030[21].

It is the ability of the oil industry to meet these projected demands that is the focus of debate in the peak oil community.

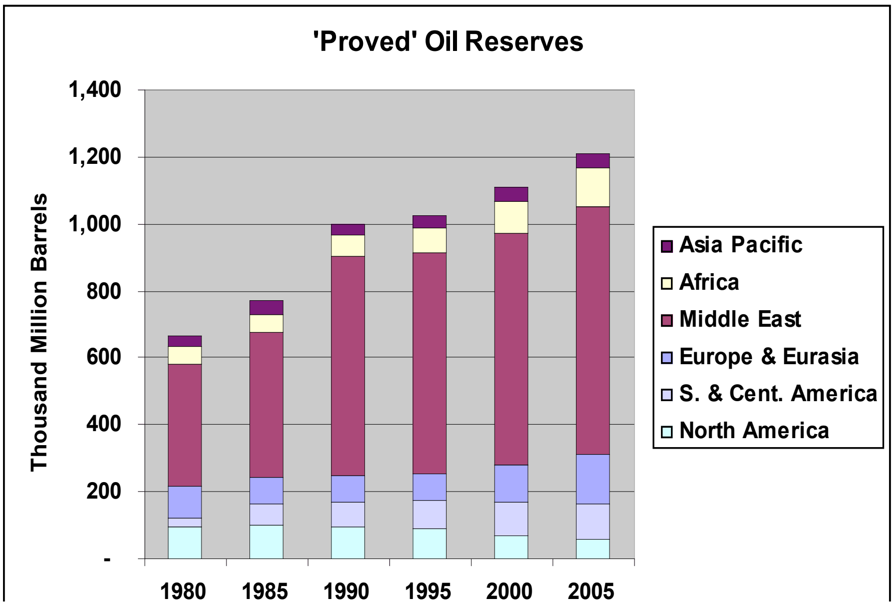
The peak year for the discovery of new oil was 1965 and since the early 1980s, the amount of oil consumed each year has exceeded that which is newly discovered - ie since then, we have been depleting our overall 'stock' of oil. At present, the amount of newly discovered oil per year is a small fraction of total consumption.

As noted above, current reserves are estimated at 1.2 trillion barrels. At current consumption rates, this is equivalent to around 40 years of oil. This figure of 1.2 trillion is the subject of considerable controversy however, with many (including industry figures) suggesting a much lower figure of around 780m (less than the total extracted globally to date).

In some countries, the level of oil production has already peaked and is now in decline. These include the USA (peaked in the early 1970) and the UK (peaked in 1999).

Peak oil 'advocates' also point to the following as evidence of imminent peak oil being reached:

- Corporate write downs of reserves – in 2004, Shell announced that there reserves had been overstated and cut the figure by 20%;
- Suspicion of stated reserves (OPEC / Middle East – where production quotas are based on stated reserves – ie it is states' interests to talk up levels of reserves) and levels of reserves increase through time despite the lack of new finds and increasing extraction;

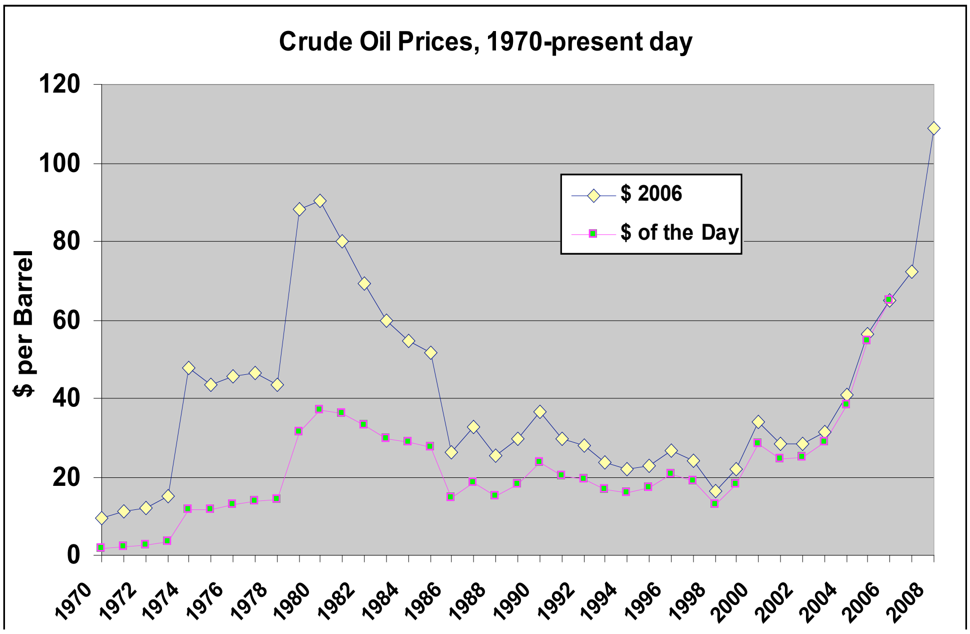


- The major oil discoveries have been made – the size of new discoveries since the 1970s have been small;
- Declining production rates in some of the major, aging fields, particularly in Saudi Arabia; and

- Little oil is kept in storage – 'just in time' principle applies in the oil business, so there is little 'slack' in the system.

For each of these points and many others, there will be an oil industry response, so taking a position on this issue is largely a matter of personal choice. However, looking at the evidence, it is difficult not to conclude that there is at least a risk of significant supply / demand and resulting price issues occurring in the foreseeable future. As a profession, transport planners should therefore be aware of the main issues and developments in this context.

However, against this backdrop and other global economic factors, the price of oil has recently risen sharply as illustrated below.



At present, oil is priced at a record high and this has impacted sharply on the prices paid at the pumps. At present (April 08), the price of Unleaded is around 108p per litre. This is around double the 1995 price. There is no immediate prospect of the price of oil easing and many commentators are suggesting that high oil prices are permanent. There are a number of reasons why prices are high, but many believe that it is at least in part due to tensions over future supply levels. As such, it is not unreasonable to speculate that prices could get very much higher as and when demand begins to outstrip the capacity to supply.

Further increases in the price of oil could bring political pressures to reduce **fuel duties** or VAT on fuel. In 1993, the fuel duty escalator was introduced, which increased fuel duties annually by 3% above the rate of inflation, later increased to 6%. This was eventually scrapped in 2000, and the level of duty has remained broadly unchanged in real terms since this time. Thus, Government signals on fuel price have eased in response to increases in crude oil prices.

Fuel Duty is however a significant source of tax revenue to the government. In 2006/07, fuel duties raised around £23.5bn of revenue[22], being fifth only to income tax, national insurance, VAT, and corporation tax in terms of monies raised. Any cut in fuel duties would clearly have to be balanced elsewhere. By way of context, a 1p rise in income tax generates around £4bn.

Today's fuel price levels are well beyond those recommended for use in forecasting transport demand in the DfT's Webtag[23]. Webtag forecast significant reductions in the resource cost of fuel between 2006 and 2010 followed by increases of <1% per annum. There must be severe doubts about the continuing use of this assumption moving forward.

Peak Oil is an emotive subject and attracts strong views on either side. The 'official' position is that oil supplies will be sufficient (and cheap) for the foreseeable future. This may be correct, but there is growing evidence to doubt this assertion. Given this, it would seem inappropriate to proceed entirely on a 'business as usual' basis. The potential impact of higher oil prices, in the absence of alternative technologies, would be highly significant in transport planning terms.

4. Summary and Conclusions

Ultimately, the pressures of (i) diminishing oil supply coupled with growing demand and (ii) climate change policies aimed at reducing the emission of GHGs (if these can be agreed), would appear to create an inexorable 'double whammy' for the use of oil and other fossil fuels in the medium-term. The transport sector will of course not be immune from these pressures.

The big question for the world economy is whether there is a 'soft' or a 'hard' landing as economies are transformed from fossil fuel to more sustainable or renewable energies. The timing of 'peak oil' is a key issue here, as this will determine to some extent the length of time available or urgency for the development of new technologies. The present 'credit crunch' illustrates how vulnerable the world economy is to 'events', and once confidence in oil supplies drops, there are likely to be major economic impacts.

As stated at the outset of this paper, current transport planning and appraisal methods are essentially based on a 'business as usual' scenario over a long appraisal period. In the light of climate change and pressures on oil supply, there must be a strong argument for routinely considering a more radical range of scenarios in determining transport strategies and investment programmes. In the short-term for example oil prices could continue to rise sharply and the timing of the transformation of the vehicle fleet is unknown. Some of these changes may also take us beyond previously 'observed' behavioural responses.

Accepting that the transport sector is required to be decarbonised in one way or another leads to the need to consider what this means for the formulation of transport policies, and price / availability issues in particular. At present, this thinking is at an early stage. For example, the costs associated with car ownership and running costs based on the new technologies are unknown.

At present, the prevailing government view appears to be that technological change will provide the solutions and the required changes within the transport sector will be achieved with little or no ‘pain’ to the public in terms the availability and cost of personal mobility. Only time will tell if this turns out to be correct.

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[1] http://en.wikipedia.org/wiki/IPCC_Fourth_Assessment_Report
[2] http://www.airquality.co.uk/archive/reports/cat07/0709180907_DA_GHGI_report_2005.pdf
[3] http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=749
[4] In contrast, the figure attributed to volcanoes is 130-230 million tonnes per annum.
[5] IPCC
[6] http://www.mnp.nl/en/service/pressreleases/2007/20070619Chinanowno1inCO2emissionsUSAinsecondposition.html
[7] http://news.bbc.co.uk/1/hi/programmes/newsnight/4330469.stm
[8] http://news.bbc.co.uk/1/hi/world/asia-pacific/6769743.stm
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[11] reliable figures are not available pre-1990
[12] http://www.defra.gov.uk/environment/statistics/globatmos/download/xls/gatb04.xls#N2O!A1
[13] Transport Statistics GB, 2007.
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[20] BP Statistical Review of World Energy June 2007
[21] http://www.eia.doe.gov/oiaf/ieo/oil.html
[22] Public Sector Finances Database, HM Treasury website
[23] Webtag Unit 3.5.6, Values of Time and Vehicle Operating Costs, February 2007