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What is a sustainable level of CO_2 emissions from transport activity in the UK in 2050?

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Abstract

The paper reports on the development of UK transport targets for CO_2 emissions for 2050. Five key studies containing future carbon emissions scenarios for the UK were used to establish targets for overall reductions in emissions to achieve stabilisation at 550 ppm and 450 ppm of atmospheric CO_2. Two approaches were used to consider the proportion of total emissions that would be attributable to transport in the future: 26% of total emissions as now and an increase to 41% of total emissions in line with forecasts. The overall targets and expected contributions from transport were used to derive target emissions for the transport sector to be achieved by 2050, which ranged from 8.2 MtC to 25.8 MtC. Even the weakest of these targets represents a considerable reduction from current emissions levels.

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Abbreviated article title
Sustainable levels of transport

1 Introduction

Climate change is an internationally recognised problem. Carbon dioxide is the most important greenhouse gas and is projected to account for around 70% of radiative forcing of climate by the end of the century (IPCC, 2001a). The United Nations Framework Convention on Climate Change (UN FCCC) was agreed in 1992 and at Kyoto in 1997 developed countries agreed to targets which will reduce their overall emissions of six greenhouse gases[1] to 5.2% below 1990 levels over the period 2008-2012. The UK Kyoto commitment is a 12.5% reduction. The UK also has a domestic target of a 20% reduction in carbon dioxide emissions below 1990 levels by 2010 (DETR, 2000a). The 2003 Energy White Paper (DTI, 2003a) accepts the need for deeper cuts of 60% by 2050.

Transport has potentially an important role to play in achieving reduction targets. In the transport sector CO_2 accounts for 96% of greenhouse gas (GHG) emissions. The transport sector is the third largest source of GHG emissions in the UK and as Table 1 shows the only sector where emissions are expected to be higher in 2020 than in 1990.

Table 1: UK Greenhouse Gas Emissions by End User (MtC)

Sector	Baseline (1990)	2000	2010	2020
Business	62.1	51.5	46.2	48.4
Industrial processes	20.5	11.8	11.1	11.1
Transport[1]	40.3	43.0	45.0	47.8
Residential	45.2	42.0	37.1	35.7
Public	9.2	7.0	5.9	5.4
Agriculture	16.4	14.7	12.9	12.6
Land use change	5.4	4.2	2.4	1.7
Waste management	7.3	3.9	2.2	1.8
Exports	2.8	3.2	2.7	2.0
Total	209.2	181.3	165.7	166.3

[1] Including emissions from domestic air travel
Source: DEFRA, 2004

The impacts of international aviation emissions are not considered here for two main reasons: (i) the studies reviewed which explore scenarios for future emissions do not consider international aircraft emissions as they are beyond the scope of current climate change agreements; and (ii) many aspects of air transport are subject to international treaties and agreements, and for this sector it is likely that the path to a solution will be through international negotiation rather than action at national, regional and local levels as may be the case for other transport modes. Current

[1] The six greenhouse gases are carbon dioxide, methane, nitrous oxide, hydroflurocarbons, perflurocarbons, and sulphur hexafluoride

emissions attributed to UK international flights are around 8 MtC, as opposed to 1 MtC for domestic flights (DTI, 2003a), while CO_2 emissions attributed to international aviation have increased by 87% between 1990 and 2001 (Baggott et al, 2003). Further rapid increases are forecast, to between 16 and 18 MtC by 2030 (DfT, 2003), posing a serious challenge for a low carbon transport strategy.

Work for the European Commission (Blok et al, 2001) suggests that the role of the transport sector in meeting the Kyoto targets for the European Union will be limited as reductions in other sectors are more cost effective. Thus if a least cost reduction strategy were pursued, emissions from the transport sector would rise in absolute terms, achieving only a 4% reduction from the 2010 baseline forecast through efficiency improvements. Transport would then be the second largest sectoral emitter in the EU after energy. In considering deeper cuts in emissions to 2050, transport would have to play a larger role.

The aim of this paper is to establish appropriate CO_2 emissions targets for the UK transport sector by 2050. This will be determined by looking first at the degree of consensus on appropriate stabilisation levels for atmospheric GHGs by 2050. The second step is to examine studies which have put forward scenarios for CO_2 emissions in the UK for 2050 for carbon constrained and non-carbon constrained futures. The level of transport emissions within these scenarios and the ways in which reductions in transport emissions are achieved are used to guide the construction of future targets for the transport sector. The final section considers how far the UK has got towards meeting the targets and what measures have the potential to help achieve these aims.

2 Stabilisation

2.1 Targets

The UN FCCC has stabilisation of atmospheric GHG levels as its ultimate objective, but does not define a stabilisation concentration, and neither does the Intergovernmental Panel on Climate Change (IPCC). The political, economic, ethical, social and scientific issues that need consideration make defining a stabilisation target difficult. However, examination of the literature shows key themes and preferences for certain target levels and these are outlined below. The emphasis is on the targets of 350, 450 and 550 ppm.

An upper limit of 550 ppm carbon dioxide has been advocated by both the European Commission (EC, 1996) and the Royal Commission on Environmental Pollution (RCEP, 2000). This recommendation refers solely to carbon dioxide though it is acknowledged that other greenhouse gases are also important contributors. Since industrialisation the increase in the concentration of other greenhouse gases has contributed the equivalent of 50 ppm carbon dioxide (RCEP, 2000).

The IPCC (2001a) states that stabilisation of carbon dioxide equivalence (including other GHGs) at 550 ppm would result in a temperature change greater than 2.0^0C.

The WMO/ICSU/UNEP Advisory Group on Greenhouse Gases (Rijsberman and Swart, 1990) state that a 2.0^0C increase in temperature is a high risk situation and that "temperature increases beyond 1.0^0C may elicit rapid, unpredictable, and non-linear responses that could lead to extensive ecosystem damage". Arnell et al (2002) compare the impacts of stabilisation at 750 ppm and 550 ppm with unmitigated increases in CO_2 and conclude that stabilisation at even the lower level, while reducing future water stress, is still likely to lead to increases in populations at risk from hunger and malaria.

The Global Commons Institute (GCI) (2002) expresses the view that, given the state of uncertainty as to the appropriate target level, it would be unwise to set the level too high as this would 'lockout' lower target levels. They suggest that if a target of 550 ppm were set, but later evidence pointed to a much lower target of 350 ppm, this would not be achievable after 2005. However, if the initial target was 450 ppm, then this could if necessary be switched to 350 ppm up to 2015. The GCI (2002) believes that 350 ppm is a desirable target and if this were implemented then there is a good chance that "large-scale damage to the world economy, human lives and natural ecosystems can be averted". It regards 450 ppm "as an upper limit for consideration, under which there is a chance that damage, though serious, will be containable".

Others advocating lower limits include Azar and Rodhe (1997) who suggest that stabilisation of carbon dioxide should be achieved in the 350 ppm to 450 ppm range. They acknowledge that policies are also needed to constrain emissions of other greenhouse gases. Alcamo and Kreileman (1996) suggest that "stabilising carbon dioxide alone in the atmosphere below 450 ppm substantially reduces climate impacts", and that controlling non-CO_2 emissions (i.e. other GHGs) in addition to CO_2 emissions is an effective policy to slow temperature increase.

Houghton (1997) initially examines carbon dioxide stabilisation alone and highlights the economic considerations, recognising that stabilisation below 400 ppm would require an immediate drastic reduction in emissions, and this would come at a high economic cost, which is considered to breach the UN FCCC (United Nations, 1992) requirement for "economic development to proceed in a sustainable manner". Stabilisation in the range from 400 ppm to 550 ppm is recommended.

To summarise, the most common stabilisation target is 550 ppm carbon dioxide. It is generally recognised that additional measures will be needed to reduce other non-CO_2 greenhouse gases. If non-CO_2 greenhouse gases are also included then the 'safe' target for carbon dioxide alone would have to be lower than 550 ppm. It was therefore decided to use both the 550 ppm and the 450 ppm stabilisation levels in developing the targets used here for the transport sector.

However it is not just the stabilisation target that is the subject of much debate. Other important connected issues include the expected role of different countries and the timescales the reductions should operate on.

2.2 The Contraction and Convergence approach

The Contraction and Convergence approach aims to reduce greenhouse gas emissions to an acceptable level. It is a two stage process: firstly convergence would occur, that is the emissions levels of the developing nations would rise, and emissions levels of developed countries would fall until an agreed point for convergence was reached. At this point all countries would have the same per capita emissions. Secondly all countries would reduce their emissions levels (contraction) to an appropriate sustainable level. International negotiations would determine the upper limit of the concentration of greenhouse gases, and the date when convergence would occur. A significant party in the promotion of this approach is the GCI (2002).

The RCEP used the contraction and convergence approach to estimate the level of reductions that would be required in the UK by 2050 and 2100 for different upper limits of carbon dioxide concentration. The reductions required for stabilisation at different levels are shown in Table 2.

Table 2: Contraction and Convergence: implications for UK carbon dioxide emissions

Maximum atmospheric concentration ppm	Permissible UK emissions in 2050 (% of 1997 level)	Permissible UK emissions in 2100 (% of 1997 level)
450	21	11
550	42	23
750	56	47
1000	58	61

Source: RCEP, 2000

This shows that in order to stabilise CO_2 at 550 ppm, emissions would have to be reduced by almost 60% from 1997 levels by 2050 and by almost 80% from 1997 levels by 2100. The RCEP therefore recommended that "the Government should now adopt a strategy which puts the UK on a path to reducing carbon dioxide emissions by some 60% from current levels by about 2050" (RCEP, 2000).

The Inter-departmental Analysts Group (IAG) (2002) has used the contraction and convergence approach to explore the role of other countries. This is shown in Figure 1. A key point is the 80% reduction that would be expected from the USA given the high current levels of emissions from that country.

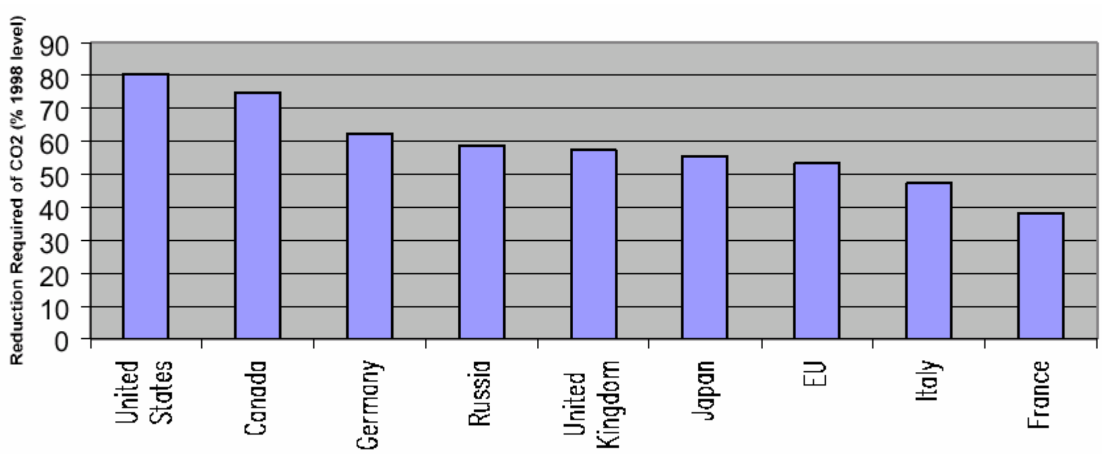

Figure 1: CO_2 reductions required by 2050 to achieve stabilisation at 550 ppm (Source: IAG, 2002)

The RCEP (2000) recognises that some developed nations may be wary of this approach because it involves very large reductions in their emissions, and suggests the introduction of greater flexibility to allow countries to trade their emissions quotas. However any form of trading needs to be 'transparent, monitored and regulated' and backed by enforceable penalties if nations emit more than their entitlement.

The likelihood of other countries adhering to the contraction and convergence approach will be an important consideration for the UK Government in deciding whether or not to follow such an approach. The Energy White Paper (DTI, 2003a) indicates that the UK government has now adopted the 60% target as an aim. However, the PIU (2002) states that greenhouse gases are global pollutants and that the UK should not incur abatement costs, and risk harming competitiveness, unless other countries are also willing to do so.

In this paper the RCEP targets of roughly 60% and 80% reductions for the targets of 450 and 550 ppm in 2050 shown in Table 2 have been used. There are several reasons for this. Firstly the stabilisation targets of 450 ppm and 550 ppm are those with greatest support in the literature. Secondly contraction and convergence has substantial political and scientific backing. Thirdly, since this work focuses on the UK, there is a need for UK based targets. Fourthly the RCEP is a long established, influential body, and these target figures are already being used in policy work for the UK. Hence the use of these figures will ensure consistency and enable comparison. In addition, even if the contraction and convergence approach is not followed, the emissions reductions required for the UK are likely to be substantial.

3 Scenarios

Five recent studies are reviewed here, each of which has utilised the RCEP recommendation of a 60% reduction target. Each provides some indication of the role that transport is expected to play. The studies acknowledge the difficulty both in predicting future change in the transport sector and in developing effective measures which will help sufficiently with current emissions trends. Naturally, given the need to forecast to 2050, the studies make a number of heroic assumptions about future conditions. The five studies are:

- The RCEP (2000) Twenty Second Report: Energy the Changing Climate.
- The Carbon Trust (2001): Draft Strategic Framework[2].
- The Policy and Innovation Unit (PIU) (2002): The Energy Review.
- The Interdepartmental Analysts Group (IAG) (2002): Long Term Reductions in Greenhouse Gas Emissions in the UK.
- AEA Technology (2002): Future Energy Solutions from AEA Technology in collaboration with the Imperial College Centre for Energy Policy and Technology (ICCEPT): Options for a Low Carbon Future[3].

All of the studies recognise the need for substantial change in order to achieve a 60% reduction in carbon dioxide emissions by 2050. The Carbon Trust (2001), the RCEP (2000), and the IAG (2002) all develop scenarios to show how a 2050 world may look. The PIU (2002) use the Foresight (1999a) scenarios as the base for their work. The IAG and the AEA Technology/ICCEPT collaboration also consider the Foresight work. The Foresight scenarios were developed in 1999 by the DTI in cooperation with SPRU (Foresight, 1999a). There are four scenarios: World Markets; Provincial Enterprise; Global Sustainability; and Local Stewardship. The scenarios are set within the context of two dimensions of change: social values and governance systems, with social values forming the X axis and governance systems forming the Y axis (see Figure 2). There is no business as usual scenario but the World Markets scenario could be considered to most closely resemble conventional development.

See Figure 2

Foresight (1999a) provides a synopsis of the key themes of the four scenarios:

- World Markets is “a world defined by emphasis on private consumption and a highly developed and integrated world trading system”.

- Global Sustainability is “a world in which social and ecological values are more pronounced and in which the greater effectiveness of global institutions is manifested through stronger collective action in dealing with environmental problems”.

- Provincial Enterprise is “a world of private consumption values coupled with a capacity for lower level policy-making systems to assert local, regional and national concerns and priorities”.

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[2] The Draft Strategic Framework is used rather than the Strategic Framework since information about the scenarios and baseline projections is provided in greater detail

[3] The AEA Technology/ ICCEPT work examines three emissions targets: a 45%, a 60% and a 70% reduction from 2000 levels.

- Local Stewardship is “a world where stronger local and regional governments allow social and ecological values to be demonstrated to a greater degree at local level”.

Table 3 summarises the varied roles transport is expected to play by the five different studies to achieve a 60% reduction. Table 3 includes only those scenarios that yield a reduction in CO_2 emissions of 60% or more. It is noticeable that there are differences in both the magnitude of the expected role and the combination of the different measures used to achieve the reduction.

Table 3: Transport Scenarios

Study and baseline	Baseline transport emissions MtC and share of total %	Changes to transport demand and supply	Total Emissions 2050 MtC	Transport Emissions 2050 MtC
RCEP	38.8 (26%)	Scenario 1: efficient vehicles, switch to fuel cells Scenario 2 and 3: 25% reduction in transport energy demand through use of fuel cells, increased public transport use, changing lifestyles, use of telecommunications. Scenario 4: 33% reduction in transport energy demand.	59	Scenarios 2 to 4 imply a slight increase in transport's share of emissions.
Carbon Trust Baseline 1	60 (41%)	Low carbon future, savings of 8.4 MtC from fuel cell efficiency and 14.96 MtC from sourcing H_2 from renewables	46.64	36.64 (78.6%)
Carbon Trust Baseline 2	43 (36%)	Low carbon future, savings of 6.82 MtC from fuel cell efficiency and 14.96 MtC from sourcing H_2 from renewables	37.26	21.22 (56.9%)
PIU no baseline		Global Sustainability and Local Stewardship both could reduce emissions by up to 30 MtC through increased efficiency, land use changes, increased use of public transport and non-motorised modes	55	25 (45.4%) GS 22 (40.0%) LS
IAG	59 (41%)	Technology leading to the use of low carbon fuels, congestion grows, no new road building, saturation of car ownership and reduced rail fares.	62	36 (58.1%)
AEA BAU	43 (37%)	A 60% reduction involves 87.8% H_2 fuel cells A 70% reduction involves 98.0% H_2 fuel cells	60 45	16 (26.7%) 13 (28.9%)
AEA World Markets	52 (39%)	A 60% reduction involves 90.7% H_2 fuel cells A 70% reduction involves 98.6% H_2 fuel cells	59 45	20 (33.9%) 12 (26.7%
AEA Global Sustainability	34 (34%)	A 60% reduction involves 74.2% H_2 fuel cells A 70% reduction involves 83.8% H_2 fuel cells	59 45	20 (33.9%) 12 (26.7%)

The RCEP (2000) develops four illustrative scenarios all of which are designed to reduce emissions by 60% (save scenario 1 which achieves 57%) through changes in energy supply and demand. In scenario 1 demand for energy stabilises at 1998 levels. A 57% reduction in CO_2 emissions is achieved by switching to less carbon intensive energy sources including 50% of energy from renewables and/or nuclear or fossil fuels with carbon sequestration. In scenarios 2 and 3 demand falls by 36% encouraged by energy efficiency measures and increases in energy prices. Scenarios 2 and 3 differ only in terms of the energy mix required to deliver them. Scenario 4 sees a fall in demand of 47% and no nuclear power or carbon sequestration. The report states that "It is difficult to see how energy demand reductions on this scale could be achieved". The RCEP scenarios examine sectors in terms of energy demand reductions.

The Carbon Trust (2001) use two baseline projections from which reductions are estimated. Baseline 1 is close to a business as usual scenario but still foresees increases in energy efficiency and 15% of electricity from renewable sources by 2050. Emissions would be close to current levels at 150 MtC. Baseline 2 sees a greater focus on efficiency and renewables and some constraints on the transport sector, resulting in emissions of 120 MtC. Four possible scenarios are considered involving low carbon markets, government, consumers and futures. Only the low carbon futures scenario (which combines the other three in order to remove all the main technical, economic, regulatory, institutional and behavioural constraints), achieves a reduction at or above 60%, namely 72% for Baseline 1 and 79% for Baseline 2.

The remaining three studies make use of the Foresight futures outlined above. The PIU (2002) study does not have a baseline as such. For the purposes of this paper the World Markets and Provincial Enterprise scenarios, in which carbon emissions increase, have been used as the baselines. The Global Sustainability and Local Stewardship scenarios both achieve reductions in excess of 60%, while the World Markets scenarios see a massive rise in emissions from transport. The IAG (2002) baseline includes the measures outlined in the UK Climate Change Programme. They do not foresee a 60% reduction in emissions under any of the Foresight scenarios. They therefore sought to find a prescriptive route to such a reduction, which involved: efficiency savings, 40% renewables, all power generation carbon free by 2050 and both technical changes and reduced demand in the transport sector. AEA Technology (2002) used a business as usual baseline together with World Markets and Global Sustainability, firstly without a carbon constraint to give a baseline, then imposing additional change to reach targets of 45%, 60% and 70% reductions. Figures from this study have been factored up by 15% to give end user emissions.

All five studies assume that some fuel switching will occur in transport. This is at its most extreme in the AEA Technology/ICCEPT study where the remit was to explore technological solutions. In this case up to 98.6% of transport power is from hydrogen fuel cells.

Efficiency measures suggested include increasing the fuel efficiency of current vehicles, the use of hybrids, and the reduction of road congestion to help reduce emissions produced by stop start movements, although IAG also see congestion as a constraint on traffic growth.

All the studies (except AEA Technology/ICCEPT, which had a specific brief) recognize the need for some behavioural change. The Carbon Trust Study incorporates some changes into Baseline 2 in the form of modal switching and no new roads. IAG suggestions included no new road build beyond 2010, and reductions in rail fares to encourage modal switch. However, the detail on how these measures would be achieved was not clear.

The PIU (2002) suggest that there will be increased demand for road transport which will remain dependent on oil for the next two decades, though this is likely to be offset by increased energy efficiency in road transport. This was considered to provide “a synergy with security objectives (no increased dependence on oil)” and “environmental objectives (no increase in greenhouse gas emissions; reduced vehicle noise)”. The PIU also indicated that energy efficiency measures could increase the price of new vehicles. There was little information in the other studies on possible conflicts and competition between or within sectors or how these might be resolved or avoided.

It is clear from these studies that emission reductions from the transport sector are expected to materialise from technological measures. This raises three issues for concern. Firstly, recent improvements in efficiency have been offset by a range of factors including: increased mileage driven by economic growth and lower motoring costs, increased size and weight of vehicles, and wider uptake of additional features such as air conditioning (Bristow, 1996, Fergusson, 2001, IPCC, 2001b). Secondly, technological improvements in efficiency will result in effective reduction in the per kilometre price of travel and hence lead to an increase in demand – the so-called ‘rebound’ effect (Greening et al, 2000). Hence, it is likely that technological improvements alone, without recourse to complementary demand management measures, could result in lower reductions in CO_2 emissions than expected. Thirdly there is the possibility that technology may not develop as quickly or as cost effectively as anticipated, suggesting that other options, which constrain the demand for vehicle use, need also to be examined.

4 Transport Scenarios and Targets

In this section specific scenarios for the transport sector are developed drawing on the studies reviewed in section 3. Two carbon dioxide emissions targets for the UK are examined and the role of the transport sector in achieving these targets is considered.

4.1 Targets and Baseline Scenarios

The carbon dioxide emission targets are determined using the RCEP interpretation of the contraction and convergence approach outlined in section 2. The focus here is on the transport reductions needed to achieve the 450 ppm and the 550 ppm stabilisation targets.

A 450 ppm stabilisation target requires a 79% reduction in carbon dioxide emissions from 1997 levels by 2050. Since carbon dioxide emissions were 148 MtC in 1997 in the UK (DEFRA, 2002), stabilisation at 450 ppm means UK carbon dioxide emissions would need to fall to 31.1 MtC per annum in 2050. A 550 ppm stabilisation target requires a 58% reduction in carbon dioxide emissions from 1997 levels by 2050. To achieve stabilisation at 550 ppm, UK emissions would have to fall to 62.2 MtC per annum in 2050.

4.2 Role of Transport

The key question is what role should transport play in achieving the overall carbon dioxide reduction targets identified as necessary to achieve stabilisation. Clearly there is considerable uncertainty about how much of a contribution to overall emissions will be made by different sectors. Two different options have been developed based on the forecasts discussed earlier. Option 1 assumes that transport's emissions remain at the same proportion of total emissions as in 1997. Option 2 allows transport's proportion of total carbon dioxide emissions levels to increase in line with forecasts.

Option 1: Transport's contribution fixed at 1997 levels
In 1997 the end use of transport produced 39 MtC of the total 148 MtC from carbon dioxide emissions, a 26.4 % contribution. Applying the 26.4% to the 31.1 and the 62.2 MtC overall emissions targets results in transport contributing 8.2 MtC and 16.4 MtC.

Option 2: Transports contribution derived from forecasts
The second approach looks at the implications of existing forecasts for transport emissions. To determine the potential future contribution from transport, four of the five studies previously analysed were used. The RCEP work was not included, since the role of transport in achieving stabilisation of demand at 1998 levels is not quantified. Table 3 shows as the transport baseline for each study what might happen in a non-carbon constrained world. There is a range but for those scenarios that are closest to business as usual the figure is around 40%. Although the PIU do not use a baseline, their forecasts for World Markets suggest that transport's share could be as high as 54%. In a carbon constrained world there is a wide range of predictions for transport's contribution. When compared to their non-carbon constrained forecast, the Carbon Trust and the IAG suggest that transport's share of emissions could be even higher; the PIU figures roughly correspond with those for a non-carbon constrained world; while the AEA Technology/ICCEPT work suggests a lower contribution.

To determine transport's future contribution it was decided to use the average contribution from transport to emissions in a carbon constrained world. This results in a higher contribution from the transport sector of 41.4%. This is in line with other UK research (DTI, 2003b) which indicates that carbon savings from developments in transport technology are among the higher cost options, compared to other sectors, and hence it is to be expected that transport's percentage carbon contribution may end up higher than it is now. The 41.4% figure is also close to the estimates for a non-carbon constrained world. Applying this to the 31.1 MtC and the 62.2 MtC results in emissions of 12.9 MtC and 25.8 MtC.

4.3 Transport Targets

Table 4 shows the derived emissions targets for the transport sector.

Table 4: Transport Target Emissions

	To achieve 450ppm stabilisation	To achieve 550ppm stabilisation
Total Emissions in 2050	31.1 MtC	62.2 MtC
Transport target emissions in 2050		
Option 1 (26.4% contribution)	8.2 MtC	16.4 MtC
Option 2 (41.4% contribution)	12.9 MtC	25.8 MtC
Reduction from Transport's 1997 emissions (39 MtC)		
Option 1 (26.4% contribution)	30.8 MtC	22.6 MtC
Option 2 (41.4% contribution)	26.1 MtC	13.1 MtC

Option 2 is based on forecasts and is therefore probably the better representation of the role of transport. However, the more stringent targets in Option 1 are also useful, given the risk that other sectors may not be able to deliver reductions in excess of the 60 and 80% targets to 2050. Emissions from international air travel alone (excluded from these estimates) are forecast to exceed all but the weakest target by 2030. Whatever is achieved domestically will need to be matched by action on international aviation.

5 Achieving the Targets in the UK

The targets developed in the preceding sections imply considerable change to the UK transport sector. This could be brought about through technological and infrastructural improvements, through behavioural and lifestyle change or more probably a combination of these. Even the weakest of the targets will require a significant reduction from current emission levels.

At present the UK Government is committed to reductions under the Kyoto Treaty and aims to go beyond that to achieve a 20% reduction by 2010. Evidence to date suggests that the Kyoto target will be met, but that the 20% target will not be, the expected reduction is 14% overall for the UK (DEFRA, 2004). Emissions from the transport sector are forecast to increase by 9% from 2000 to 2010, following a 10% increase in the previous decade (DEFRA, 2004). Clearly the targets outlined in this paper are far more demanding and would require major changes over the coming years both in the nature of transport and in the way that transport is perceived and utilised by individuals and organisations alike.

It is likely that changes in technology will go some way towards achieving the targets. Government has a range of fiscal and regulatory tools in place to encourage take up of more efficient vehicles and alternative fuels (HMT, 2004). Another key element is the voluntary agreement between the European Commission and European car manufacturers to improve the fuel efficiency of new cars by 25% from 1995 levels by 2008/9 (DfT, 2004a), though this represents a weakening of the original agreement that was to have met the target by 2005 (ACEA/EC, 1998). These measures alone will not be sufficient to offset increases in traffic growth and the move to heavier cars loaded with more energy using equipment (IPCC, 2001b and CfIT, 2003). In the longer term hydrogen fuel cells or hydrogen powered internal combustion engines are seen as a key element in a low carbon transport strategy by some (RAC, 2002). However there are a range of issues associated with reliance on such technological fixes:

- Risk that the technology is not capable of delivering the required reductions.
- Probability that even if it does deliver it may be too late and it is unlikely that hydrogen fuelled vehicles could form a significant element of the fleet before 2040 (High Level Group for Hydrogen and Fuel Cells, 2003; US National Academy of Sciences, 2004). In order to achieve the stabilisation targets, reductions will need to come sooner rather than later with significant reductions required by 2020 if stabilisation at 450ppm is to be possible by 2050 (IPCC, 2001c).
- Risk that the vehicle technology is delivered but that renewable sources of hydrogen are not. Use of current techniques for the manufacture and storage of hydrogen would mean that the carbon savings could be negative (Pridmore and Bristow, 2002).
- If hydrogen for transport is produced using electricity, then significant new generating capacity will be required (Dutton, 2002).
- If renewable sources of energy to produce hydrogen are available they would be more effective, in terms of reduced carbon emissions, if they were used for sectors other than transport (Eyre et al, 2002).

An alternative to a complete reliance on technological change is to start to implement schemes which are aimed at changing transport behaviour. At present the emphasis in Government policy is very much on technological change, see for example the Energy White Paper (DTI, 2003) which considers only technological solutions in the transport sector. Measures to secure behavioural shift at present are largely “soft” measures such as school and workplace travel plans, awareness campaigns, or walking buses which are unlikely to secure significant changes in behaviour in the absence of supporting measures to manage demand (Cairns et al, 2004). The 10 year plan for transport (DETR, 2000b), if fully implemented, would have stabilised CO_2 emissions from transport. It is now clear that some of the measures will be not implemented within the time frame, especially the road user charging and work place parking levy schemes envisaged and the provision of sufficient rail capacity to carry the planned 50% increase in passenger miles (May et al, 2002). The Sustainable Development Commission (2003) consider savings from the 10 year plan “insecure”. The recent White Paper on The Future of Transport (DfT, 2004a) addresses the issue of climate change with a range of proposed measures, most of which are related to technology and efficiency, the potential impacts of which are not quantified. Perhaps the most interesting ideas in the White Paper are to consider including surface transport in the EU Emissions Trading Scheme and the recognition of the need for debate on the role of pricing and the value of transport. There is some evidence on the effectiveness of pricing measures in this context in the UK, for example the fuel duty escalator, in place to 1999, was effective in reducing the rate of growth of transport CO_2 emissions and the linking of company car taxation to vehicle CO_2 emissions in 2002 which is expected to save up to 1 MtC by 2010 (DEFRA, 2004).

In order to achieve significant reductions in CO_2 emissions the scale of change is likely to be large and to require considerable lifestyle adaptation, though the advantage is that such changes could, at least theoretically, be implemented on a shorter timescale than technological change. There is a body of evidence on the effects of measures to improve passenger transport (Balcombe et al, 2004); on the relative effectiveness of price signals on fuel (Graham and Glaister, 2002) and growing evidence on the potential for appropriately supported soft measures (Cairns et al, 2004). There is also potential for synergy resulting from complementary packages of measures (see for example Potter, 2001) and synergy through measures that may also reduce other transport related externalities, particularly congestion (Proost, 2000). However, major barriers exist to implementing such policies and measures, in particular the need (still) to take the potential impacts of climate change seriously at both a political and individual level and for government to be willing to take a lead in promoting a more sustainable transport future. A good example of this is apparent in the recent guidance to Local Authorities on the development of Local Transport Plans (DfT, 2004b) which provides very little specific guidance on local measures to help reduce emissions of greenhouse gases.

6 Conclusions

The objective of this paper was to establish CO_2 emission targets for the UK transport sector in 2050. A literature review suggested two stabilisation targets for CO_2 of 550 ppm and 450 ppm. For the UK this implies total emissions in 2050 of 62.2 and 31.1 MtC respectively. Five key studies were reviewed containing future scenarios for CO_2 emissions for the UK. These studies were used firstly to establish feasible 2050 baseline projections for the UK and secondly to examine possible ways in which reductions could be achieved.

Two approaches were used to estimate the contribution of transport to total emissions in 2050:

- stabilisation at the current level of approximately 26%
- an increase to approximately 41% derived from the studies reviewed

These percentage contributions were then applied to the 62.2 and 31.1 MtC emission targets and the emission reductions needed from transport's 1997 levels calculated. The results gave a range of targets from 8.2 MtC to 25.8 MtC and a range of reductions from 13.4 MtC to 30.8 MtC. Even the weakest of these targets implies a significant reduction from current emission levels. When set against the forecast growth in emissions shown in Table 1, the weakest target would require a 50% reduction from trend by 2020.

The UK Government is on line to meet its Kyoto commitments on climate change but fall short of its self imposed additional target of a 20% reduction by 2010. Emissions from transport are forecast to increase to 2010. It is clear that if a 60% (or more stringent) target is adopted for the economy as a whole the transport sector will have to contribute. The scale of change required suggests that significant behavioural change will be needed to complement gains made through technological improvement and to avoid the rebound effect.

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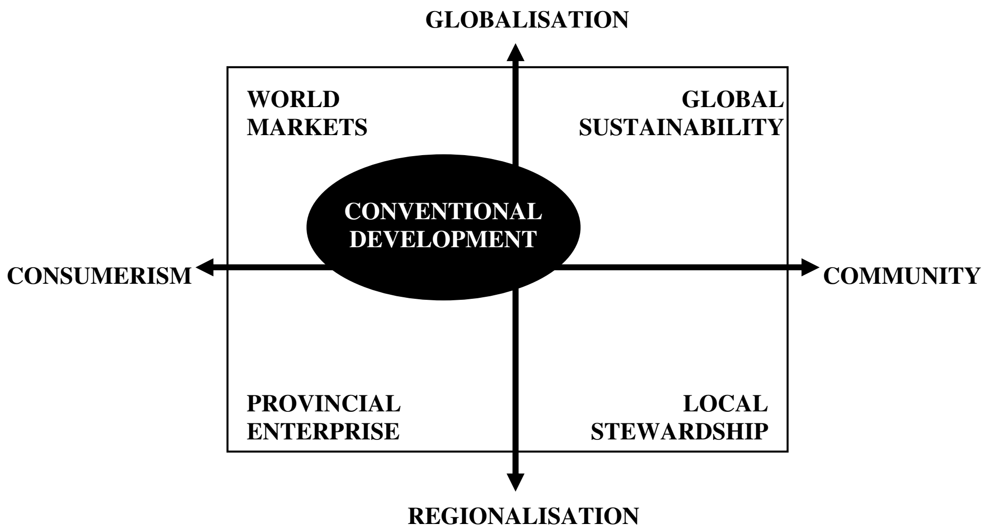

Figure 2: Four Contextual UK Futures scenarios (Source: Foresight, 1999a)