“Resource consumption and environmental degradation continues. [As yet] we are only aware of the process by which our species is committing environmental suicide.”

Castells (2002)
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1 Introduction

1.1 The Order of Things and Futures Studies

"If there is such a thing as growing human knowledge, then we cannot anticipate today what we shall know only tomorrow ... no scientific predictor - whether a human scientist or a calculating machine - can possibly predict, by scientific methods, its own future results."

Popper, K.R. (1961)

The importance of new knowledge for the development of society is hugely important, as greatly emphasised by authors such as Popper. The challenge for research is to provide evidence to help plan for the future development of society and to react positively to what we perceive as current trends.

Over the years various perspectives on societal change have evolved to tackle these issues. A number of ideas have gained much coverage in the literature. Kuhn’s celebrated concept of paradigm shift (1962), for example, attempts to depict ‘step-changes’ in the level of understanding. Seeking to explain scientific revolutions, Kuhn suggested that there was a ‘normal science’, which scientists and practitioners accepted for a time as a basis for everything they did. They accepted a particular ‘paradigm’ or in Kuhn’s own words: “some accepted examples of actual scientific practice - including law, theory, application and instrumentation - which together provide models from which spring particular coherent traditions of scientific research.”

Kuhn argues that, at particular points in time, scientists become aware of anomalies in their worldview; they find things that the prevailing paradigm does not explain well. Science then enters a new phase, in which the old paradigm is scrapped and a new one developed in its place. Applied to science (and indeed wider fields), Kuhn’s theory has become almost commonplace.

Kondratieff (1935) similarly developed the notion of waves of development. Arguing from a Marxist standpoint that the falling rate of profit operates with particular force every 50 years or so, a periodic major crisis is found in the capitalist system. This, Kondratieff says, is because the possibilities of a given generation of technologies have been exhausted. Only by the diversion of new capital into a new set of technologies, could this tendency be overcome. Schumpeter (1939) translates these principles into business cycles, giving dates to the rise of new industries.

Foucault (1970) more fundamentally asks “How is it that thought detaches itself from the squares it inhabited before - general grammar, natural history, wealth - and allows what less than twenty years before had been posited in the luminous space of understanding to topple down into error, into the realm of fantasy, into non-knowledge?” There is therefore a more philosophical point here: how do we change our methods of filtering the experience of reality, or what Foucault labels: ‘the order of things’?

Futures studies have developed on the back of such high-level thinking and are often used to illustrate what might happen to society in order to permit the individual, or society itself, to adapt to perceived future trends. The position
taken by Popper was that the level of future uncertainty was only partly determined by the present conditions and trends of society as we know them. Dreborg (1996) terms this problem as indeterminacy.

The most effective futures studies are used to define a broader conceptual framework for discussing the future and to contribute to policy formulation and the emergence of unforeseen new options. The Swedish lead the field in futures studies. Their tradition, for example, in backcasting allows different actors a better foundation for discussing goals and taking decisions, and either to act or seek further knowledge. France similarly follows a strong research tradition called La Prospective (translated as developing scenarios of future states); and Germany one of Leitbilder (inspiring visions or guiding images).

Few backcasting studies are used as a blueprint of the desirable future or a cut and dried action plan. Instead Steen et al (1994) and Van den Belt (1988) pursue the idea of a continual revision of targets or constructive technology assessment (CTA).

This research study seeks to build on this evolving work and develop thinking in the UK on futures studies, and particularly using visioning and backcasting techniques, focused on the transport policy sector.

1.2 Climate Change and Transport

The underlying question behind this study is how to tackle climate change in the UK. One of the most important issues facing the world community today, reducing emissions of greenhouse gases is an incredible challenge for countries throughout the world. On the positive side, the general rise in environmental consciousness is one of the major cultural and political transformations of recent years. Pre-Rio de Janeiro in 1992 and Kyoto in 1997 few people outside the research community had heard of the term ‘sustainability’.

Castells (2002) however makes an important point: “Resource consumption and environmental degradation continues. [As yet] we are only aware of the process by which our species is committing environmental suicide.”

There is thus a marked difference between awareness and action. The actual transformation of industrialised society towards a sustainable future is, not surprisingly, currently the subject of much debate. There appears to be little thought given to the processes required in attaining a sustainable society, the nature of and necessary steps towards change, and what consequences this would have on life in economic, social and environmental terms. The only consensus is (possibly) that sustainability requires major changes to industrialised societies in the long term.

Our thinking in terms of what a sustainable society would look like in the UK is similarly weak. The holy grail is thus there before us: however if sustainability is to be attained then integrated efforts will be required in many fields. And this includes the transport sector.

Traffic growth is a source of concern in the UK (and indeed throughout the world). Car ownership, for example, is increasing, and so is car use for most journey purposes. Urban sprawl, the use of the private car (as a relatively
cheap and convenient vehicle for multi-purpose trips) and rising incomes, are all resulting in a new spatial pattern of movements and increased travel (Banister et al, 2001). Critically, road transport is a major contributor to UK carbon dioxide emissions, making up around one quarter of total emissions.

Policy interventions measures, however, are not having the expected impacts. Increased road capacity and traffic management measures often generate more traffic. Grid-lock style conditions are being experienced in many cities and towns in the UK. Negative impacts are found in terms of accessibility, efficiency, image and, perhaps most importantly, quality of life. In addition to global climate change, road transport plays a significant part in local problems such as air pollution and the associated detrimental public health effects.

Transport problems are thus well-studied and in the more perceptive analyses increasingly being perceived as the result of multi-faceted behaviours, combining socio-economic and cultural variables. The transport policy response hence has to be concerned not only with travel, but increasingly with lifestyles, behavioural issues, the time management of people and (even) cyberspace. A sustainable future requires a wide range of measures, based on economic incentives and disincentives, traffic management, an effective choice of travel modes, ICT and integrated transport land use planning (Banister, 2000).

Hence the rationale and imperative for this study: the Bartlett School of Planning, University College London and the Halcrow Group were commissioned by the Department for Transport under the New Horizons Research Programme to examine the possibilities of reducing transport emissions in the UK by 60% by 2030.

The research, using a scenario building and backcasting approach, examines a range of policy measures (i.e. pricing, regulation and technological), and assesses how they can be effectively combined to achieve the required level of emissions reduction. The intention of the research is to assess whether such an ambitious target is feasible, identify the main problems (including the transition costs) and the main decision points over the 26-year time horizon. The study is titled ‘Visioning and Backcasting for UK Transport Policy’ (or VIBAT).

1.3 VIBAT Study Coverage

There are three main elements to the research project, as outlined below:

- The first stage is a literature review of relevant research, including governmental and academic contributions in the field. This stage also sets targets for 2030 and forecasts the ‘business as usual’ situation for

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1 New Horizons Research is commissioned by the DfT to support innovative research focused on the challenges and opportunities the UK might face over the next decade and beyond. New Horizons provides an opportunity for innovative researchers to conduct ground-breaking work identifying and investigating areas of change in the environment (e.g. technological advance, social trends, environmental or economic challenges). Thinking in the medium to long term, utilising ‘futures’ techniques and anticipating new issues and solutions is paramount. For more information see www.dft.gov.uk/stellent/groups/dft_science
all forms of transport in the UK over that period, so that the scale of change can be assessed in terms of achieving the emissions reductions.

- The second stage involves the description of the transport system in 2030 in order to meet the reduction target. This will take the form of alternative visions of the future that will push the technological and the pricing/regulatory options plus lifestyle change, separately and in combination.

- The third stage is the backcasting process, where alternative policy packages are assembled to lead from the image of the future, together with their sequencing and phasing in terms of when implementation should take place.

The final steps will include synthesis, drawing of conclusions and consideration of next steps. The benefits of using scenario building and backcasting techniques are that innovative packages of policy measures can be developed to address emissions reduction targets. This allows trend breaking analysis - by highlighting the policy and planning choices to be made and identifying the key stakeholders that should be included in the process - and by making an assessment of the main decision points that have to be made (the ‘step changes’). It also provides a longer-term strategic background against which more detailed analysis can take place.

A critical issue should be borne in mind throughout this study: (normally) a totally new idea or new knowledge will not be implemented immediately. There is a time span between the emergence of a new idea and it being widely applied in practice. Hence, existing knowledge and ideas may have a profound influence on future trends in the short term. Popper’s indeterminacy problem is often only experienced in the long term. The lack of progress in the transport sector towards achieving global environmental targets means that, if we are to meet medium and longer-term targets, we need to be agreeing policy pathways now. Futures-based research in the transport and environment field is thus paramount.

1.4 Structure of the Report
The remainder of this first stage study report is structured as follows:

- Section 2: VIBAT Study Methodology
- Section 3: Futures Studies
- Section 4: Climate Change and Global Warming
- Section 5: Demographic, Social and Transport Trends
- Section 6: Transport and Emissions
- Section 7: The Policy Response
- Section 8: Deriving the Baseline, Scenarios and Targets
- Section 9: How Do We Get There? Available Measures and Benchmarks
- Section 10: Synthesis, Conclusions and Next Steps
VIBAT Study Methodology

2.1 Introduction
A number of key issues underlie this VIBAT study. The key research question is:

What will the transport system look like if current levels of transport emissions were reduced by 60%?

The 60% target is directly sourced from the UK Government’s Energy White Paper (DTI, 2003) which suggests a path towards a 60% reduction in emissions of the main greenhouse gas – carbon dioxide (CO₂) - by 2050 in the UK.

The more detailed issues following from this are as follows:

- What are the policy measures available?
- And when will they have to be implemented to achieve such a change?

The long term objective of transport policy in the UK is to move towards sustainable transport, which within the transport context can be seen as maintaining economic growth but with less use of non-renewable resources in transport. This means that research must begin to look at the longer term and at trend-breaking alternatives.

2.2 Study Objectives
The two main objectives for this project are outlined below:

a) To test the visioning and backcasting methodologies as a means to assess challenging new environmental targets for UK transport policy (this is the methodological objective)

b) To produce a set of images of the future that represent different alternative visions for the year 2030, and to determine alternative policy packages that it would be necessary to introduce to achieve those images, together with the policy paths that highlight when change has to take place (the policy objective).
2.3 VIBAT Study Method: Key Work Stages

The VIBAT project runs over a 12-month period – from October 2004 to October 2005 - and is split into three main stages. The study process is shown in Figure 2.3.

2.3.1 Stage 1: Literature Review, Baseline and Targets

The study starts with a review of background research on previous futures and backcasting studies and considers the main external challenges likely to face transport policy makers over the next 20 years – these include social and demographic trends, technological innovation, globalisation and reduction of economic barriers, and environmental degradation, and their inter-relationships and relationships with travel behaviour in terms of energy consumption, journey lengths, mode share and congestion.

Stage 1 also establishes a baseline and targets within which the visions of the future can be constructed so that the nature and scale of change needed can be established from the trend-based future (the business as usual).

This stage will produce the main quantitative outputs from the project, namely a CO₂ emissions profile for UK transport from 1985-2030. This includes trend data for 1985 and 2000 and projective ‘business as usual’ data for 2015 and 2030. More detailed baseline data is also given for passenger kilometres, mode share, occupancy and energy consumption (and emissions) figures for each mode of transport. In addition a 60% target is also developed.

Stage 1 ends with an expert panel meeting with DfT and other experts to discuss the literature review, baseline and target for 2030. This current report provides a summary of the work to date [Stage 1] in the study.

2.3.2 Stage 2: Images of the Future

Images of the future are built up to comply with the policy targets. These futures are possible solutions to the perceived problems and are designed to initiate discussion; each alternative image takes a different emphasis. Two images will be identified, one based on a strong push on technological innovation, and the other with a strong behavioural perspective (mainly using pricing and land use policies). The external elements are taken as given in all images of the future, and the focus is on the strategic elements that are amenable to policy intervention.

This stage will end with a second focus group where experts in the technological aspects and the behavioural policy aspects will get together to discuss the draft images of the future.
Figure 2.3: The Study Process

NB. The scenario building process consists of three stages: the setting of targets for sustainable transport, the development of images of the future (2030) and the development of policy packages and paths. Strategic elements are those that are relevant to transport decision making, external elements are taken as given and are common to all scenarios.
2.3.3 Stage 3: Policy Packages

Here we assemble policy packages and paths and develop the backcasting methodology so that the mixture of policy measures that are available to get from “here to here” can be explored. The policy measures are assembled as packages, as it is unlikely that a single policy would achieve the scale of change required in the scenarios, and the paths relate to the timing of the introduction of the alternatives.

This stage involves an intensive discussion process, and the preliminary results will again be presented for discussion to the third focus group for comment and change.

Finally we will look to develop policy actions and conclusions. This will involve synthesis and evaluation where the alternative visions, together with their measures, packages and paths, are brought together as a coherent set of actions. This will form the basis of the final report and the presentation to the DfT at the end of the project.

2.4 Programme of Work

The management of the project is directed by Professor David Banister (from the Bartlett School of Planning, University College London) with the project management and research carried out by Robin Hickman (Halcrow Group and seconded to the Bartlett School of Planning, UCL). The work programme is shown in the Annex to this report.

2.5 Originality and Relevance of the Research

The importance and innovation in the VIBAT study can be considered in a number of ways, but mainly in terms of study topic and working method. For example, it is important for researchers and policy makers to think imaginatively over a long period of time, in order that they are able to gain a perspective on the overall direction of policy. Particularly important is the scale of any change that is required to move towards a more sustainable transport system. Visioning and backcasting are tools within a new set of empirical methods that can help to structure such an approach, which allow the range and scale of possible policy interventions to be assessed. Although backcasting approaches have been used to analyse Swedish energy policy, EU transport policy, sustainable transport at the city level, and the impact of ICT on transport, they have not been applied to UK transport policy.

Hence the VIBAT study is the first time that this approach has been used to investigate UK transport policy. The working method has been carefully designed so that the focus is on one key policy objective, namely to reduce levels of CO₂ emissions from the transport sector by 60% by 2030 using a base of 1990 levels.

The UK has taken a global lead in pushing for stringent targets for reductions in CO₂ and other emissions, yet the achievement of these targets in the transport sector has proved difficult to achieve. This project makes an important contribution to the debate by exploring some of the different ways in which challenging environmental targets can be achieved through technological and behavioural innovation.
Backcasting particularly provides an innovative way to develop thinking beyond the Transport 2010 publication (DfT, 2000), including the impacts of external factors on transport. It links in with the DTI Energy White Paper, the recent EU Directives (on Renewable Fuels and Emissions Trading), the UK Foresight Vehicle Programme, and develops each of these in a policy research context.

VIBAT addresses all three issues under the New Horizons Research Programme brief: the effects of current trends continuing into the future (and trend breaking alternatives); the consequences of step-changes (key decision points); and how non-transport developments may alter the transport landscape (impact of technological innovation, and land use and development options).

A further important element in the scenario building process is validation. Although there is some quantitative analysis of trends and the development of targets, much of the analysis is qualitative with expert groups being used to discuss key findings. Experience shows that these discussions add much richness to the analysis and have been instrumental in helping develop innovative images of the future and policy paths in other studies.
3 Futures Studies

3.1 Previous Methodological Approaches
Futures studies are often not concerned with predicting the future, but instead with creating a choice of futures by outlining alternative possibilities which can form the basis for planning and policy development. Banister and Stead (2004) categorise futures studies as considering one or more of the ‘three Ps’:

- Possible futures: what might happen?
- Probable futures: what is most likely to happen?
- Preferable futures: what we would prefer to happen?

A variety of related techniques have been employed over the years. For example, trend and mega-trend analyses (both quantitative and qualitative), Delphi studies, scenario building, wild card, visioning and futures workshops.

Steen and Åkerman (1994) have usefully carried out a survey of studies concerning transport and energy consumption in Sweden for the Swedish Committee on Climate Change. Their key conclusion is that few studies take sustainability seriously into account. Figure 3.1 characterises the range of possibilities. The horizontal axis represents different types of study approaches available; the vertical axis progress towards sustainability.

![Figure 3.1: Studies of Transport and Sustainability](image)

(From Steen and Åkerman, 1994)

The classification of study approached can be summarised as follows:

- Directional studies: these tend to concentrate on short or medium term horizons; typically investigating economic and other measures that promote behaviour more in accordance with the natural environment. Research often focuses on mitigation measures for environmental difficulties. Proposed measures work broadly in the direction of...
sustainability, but how close they bring society to the sustainable goal is not normally addressed. In the UK, a similar example from the transport sector would be many of the multi-modal studies carried out in recent years.

- Short term studies: take short term official (usually governmental) forecasts as a starting point and try to find a means of achieving them. These forecasts are often an initial (but critically unquantified) step to a broader goal such as sustainability. UK local transport plans provide an example here: they are focused on local objective and target achievement, yet their horizons are relatively short term and there is no attempt to understand the implications of investment on (or contributions towards) national environmental targets.

- Forecasting studies: often apply a longer term perspective using some form of forecasting methodology. Predicted developments often fall short of sustainability goals, either because study remit is restrictive or chosen methodology precludes major change. An example here might be some of the sub-regional, sustainable communities-related land use and transport growth studies.

- Alternative solutions and visions: a number of these studies use backcasting techniques, and start with the development of images of future scenarios. There have been few studies of this type in the UK.

3.2 Forecasting Studies and Scenario-Building

The traditional forecasting approach is still frequently used in many research studies. There are however strong concerns as to the usefulness of forecasting in the study of highly complex, long term sustainability problems (see, for example, Dreborg, 1996). Based on 'business as usual' existing trends, forecasting is unlikely to generate sufficiently radical solutions if these are required.

Achieving sustainability, for example, critically requires more than marginal changes at many levels of society. Approaches that focus on the problem to be solved, rather than on present conditions and current trends, are better suited to achieving real solutions that will move us towards sustainability.

Scenario development studies have been frequently used since the 1950s. One of the earliest and well-known scenario-based studies was originally developed for the U.S. federal government in the 1950s by the Rand Corporation to study how nuclear wars might start (Martino, 1983). The method was popularised as a business tool by organisations such as Shell Oil in the 1970s. Shell’s management team, armed with forecasts of how consumers and countries might react to oil shortages, were better equipped than many of their competitors to deal with the shock of the oil crisis in 1973 and its aftermath.

One of the first definitions of a ‘scenario’ dates back to Kahn and Wiener in the mid-1960s. Scenarios were defined as: “Hypothetical sequences of events for the purpose of focusing attention on causal processes and decision points” (Kahn and Wiener, 1967).

In the 1960s, many companies started using scenario-based studies, based on Kahn’s principles, because they faced increasing problems with ‘traditional’ prediction methods. The starting point for many of the scenarios
was to identify ‘predetermined’ and ‘undetermined’ elements. The predetermined elements are the same in each scenario; the undetermined elements are elaborated in several ways, depending on possible future developments, and thus result in different future images (Van der Heijden, 1996). A further, well-used definition of the term scenario emanates from the Netherlands: “A description of society’s current situation (or a part of it) of possible and desirable future societal situations, and the series of events between current and future situations.” (Becker et al, 1982).

There is a distinction to be made between scenarios and visions or images of the future. Visions or images of the future are often static ‘snapshots’ in time, whereas scenarios are dynamic, logical sequences of events.

May (1982) identifies a number of benefits of scenario-building to decision-making, including:

- Providing useful frameworks to decision-making: allowing a range of alternatives and different assumptions to be explored
- Identifying dangers and opportunities: considering a range of alternative futures increases the likelihood of identifying possible problems and opportunities in policy-making
- Suggesting a variety of possible approaches: the use of scenarios may generate a range of approaches to tackle issues or problems whereas the use of forecasts, based on single theories or simple extrapolations, often lead to the pursuit of singular solutions
- Helping to assess alternative policies and actions – scenarios may for example be used to identify the usefulness of different policies under alternative future conditions
- Increased creativity and choice in decision-making: identifying possible future developments and avoiding the acceptance of current trends as inevitable opens up new possibilities for policy development.

Banister and Stead (2004) make an important point: in transport analysis, travel is a product of changes in existing patterns of demand and the travel generated by new activities. Much of the growth in travel is caused by decisions taken outside the transport arena, yet it is often the transport system that has to accommodate these changes.

Two kinds of scenarios can also be distinguished: projective and prospective.

- A projective scenario’s starting point is the current situation; extrapolation of current trends results in future images (and known as forecasting). Forecasting scenario studies are very common in transport studies. Problems are assessed due to current and future transport activity, based on the continuation of current socio-economic trends.
- A prospective scenario starts with a possible or desirable future situation, usually described by a set of goals or targets described by a

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2 See also Stead and Banister (2004) for a discussion of the impact of information and communications technology on transport
set of goals or targets established by assumed events between the current and future societal situations. Prospective scenario methods are also known as backcasting.

3.3 The Advantages of Backcasting

The term backcasting was first introduced by Robinson in 1982\(^3\) to analyse future energy options in terms of how desirable futures could be attained. The major distinguishing characteristic is: “a concern, not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backwards from a particular desirable end-point to the present in order to determine the physical suitability of that future and what policy measures would be required to reach that point.” (Robinson, 1990).

Figure 3.2 shows the main features of the process. Instead of starting with the present situation and prevailing trends, the backcasting approach designs images of the future representing desirable solutions to societal problems. Possible paths back to the present are then developed. The term ‘scenario’ covers both the images of the future and the trajectory leading back to the present date.

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\(^3\) Robinson however credits the idea of backcasting to Amory Lovins.
major differences between forecasting and backcasting studies are shown in Table 3.1.

**Table 3.1: Comparing Forecasting and Backcasting**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Forecasting</th>
<th>Backcasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philosophy</td>
<td>Justification as the context</td>
<td>Discovery as the context</td>
</tr>
<tr>
<td></td>
<td>Causality determinism</td>
<td>Causality and intentions</td>
</tr>
<tr>
<td>Perspective</td>
<td>Dominant trends</td>
<td>Societal problem in need of a solution</td>
</tr>
<tr>
<td></td>
<td>Likely futures</td>
<td>Desirable futures</td>
</tr>
<tr>
<td></td>
<td>Possible marginal adjustments</td>
<td>Scope of human choice</td>
</tr>
<tr>
<td></td>
<td>Focus on adapting to trends</td>
<td>Strategic decisions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Retain freedom of action</td>
</tr>
<tr>
<td>Approach</td>
<td>Extrapolate trends into future</td>
<td>Define interesting futures</td>
</tr>
<tr>
<td></td>
<td>Sensitivity analysis</td>
<td>Analyse consequences and conditions for these futures to materialise</td>
</tr>
<tr>
<td>Method and technique</td>
<td>Various econometric models</td>
<td>Partial and conditional extrapolations</td>
</tr>
<tr>
<td></td>
<td>Mathematical algorithms</td>
<td>Normative models, system dynamic models, Delphi methods, expert judgement</td>
</tr>
</tbody>
</table>

(From Banister and Stead, 2004)

A number of studies have used backcasting as their methodological approach. The EU-POSSUM project (Banister et al, 2001) was the first to assess European transport policies as to their consistency and feasibility, using a qualitative scenario-based approach based on backcasting, see Table 3.2. Scenarios were constructed to meet the targets of regional development, efficiency and environmental protection.

**Table 3.2: Backcasting as used in POSSUM**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Commentary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Objective</td>
<td>Current key and emerging issues</td>
</tr>
<tr>
<td></td>
<td>Drivers of change</td>
</tr>
<tr>
<td>Projection</td>
<td>Key trends extrapolated to indicate possible future conditions in the absence of policy change and to provide a reference point for the assessment of scenarios</td>
</tr>
<tr>
<td>Policy targets</td>
<td>Challenging but desirable points in the future identified, based on key issues and projections</td>
</tr>
<tr>
<td>Images of the future</td>
<td>Assumptions set out about future conditions for policy making Assumptions specified about both strategic and contextual elements Providing the basis for policy analysis under a range of alternative futures</td>
</tr>
<tr>
<td>Policy options</td>
<td>Policy options for each of the images of the future must be consistent with the strategic and contextual elements and contribute to the achievement of one or more policy targets Policy paths and measures developed from the present to the future using backcasting process</td>
</tr>
<tr>
<td>Policy packages</td>
<td>Identifying combinations of policies that work well together, maximising synergies and minimising conflicts Measures outside</td>
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the transport sector also considered

<table>
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<tr>
<th>Policy paths</th>
<th>Identifying specific strategies about how to implement policy packages including consideration of the issues of timing, implementation, key actors and responsibilities</th>
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From Banister and Stead (2003), see [www.cordis.lu/transport/src/project.htm](http://www.cordis.lu/transport/src/project.htm)

The OECD project on Environmentally Sustainable Transport (EST) (OECD, 2000; 2001; 2002) is very well known and also used backcasting to consider what the transport system would look like in Europe if current transport emissions were reduced by 80-90% (see [www.oecd.org](http://www.oecd.org)).

### 3.4 Conclusions

Steen and Åkerman (1994) conclude that the backcasting approach is most appropriate when the subject to be studied is a major societal problem that needs to be addressed. The following characteristics favour backcasting approaches:

- When the problem to be studies is complex, affecting many sectors and levels of society
- When there is a need for major change, i.e. when marginal changes will not be sufficient

- When dominant trends are part of the problem, and when these ‘business as usual’ trends are often used as the basis for forecasting
- When the problem is one of externalities, which the market cannot treat satisfactorily
- When the timeframe is long enough to allow considerable scope for deliberate choice.

As we can see, all of these criteria are applicable to an analysis of reducing transport emissions in the UK and the contribution to global environmental targets.
4 Climate Change and Global Warming

4.1 Introduction
The phenomenon of climate change has been well documented in the literature. Research and debate on the particular contribution of human-induced factors has grown at a rapidly increasing rate. The Intergovernmental Panel on Climate Change (IPCC)\(^4\) provides evidence on scientific, technical and socio-economic information relevant to the understanding of climate change. Houghton (2004) provides a definitive review of some of this research, or the IPCC (2001) ‘Climate Change: the Scientific Basis’ provides the primary source. Within the UK, the Hadley Centre for Climate Prediction and Research\(^5\) has developed much of recent research on climate change monitoring and modelling. And the Tyndall Centre\(^6\) similarly develops transdisciplinary research on climate change. Our review in this study of climate change and global warming draws heavily from these sources.

4.2 How is the Climate Changing?
Major climate changes have of course been experienced in the distant past. Houghton (2004) describes how the last million years have seen a succession of major ice ages interspersed with warmer periods. The last of these ice ages came to an end about 20,000 years ago. We are now in what is called an ‘inter glacial’ period.

The key issue for researchers considering the significance and implications of climate changes is how these have manifest themselves over a shorter timescale, say over the last few decades. Although day-to-day variations in weather are occurring all the time, the 1980s and 1990s on average were unusually warm: the warmest years since accurate records began a 100 years ago (1998 was the warmest year based on near-surface temperatures). The nine warmest years on record have occurred since 1990.

Recent years have also been remarkable for the frequency and intensity of extremes of weather and climate. Figure 4.1, for example, shows the significant climate events and disasters during 1998.

Unusually strong storms in Europe (one infamous occasion in 1987, four others in 1990, and three in 1999) and more extreme hurricanes and typhoons elsewhere in the world have have become commonplace. El Niño events (comprising of warm surface ocean currents in the Pacific off the coast of South America) have become very intense, with high surface temperatures in 1982-83, 1990-95 and 1997-98. Not surprisingly, the research community is investigating the potential links between the character and intensity of El Niño events and global warming due to human-induced climate change.

\(^4\) For further information see www.ipcc.ch
\(^5\) see www.metoffice.com/research/hadleycentre
\(^6\) See www.tyndall.ac.uk
Figure 4.1: Significant Climate Anomalies and Disasters During 1998

(From the Climate Prediction Centre, National Oceanic and Atmosphere Administration, and in Houghton, 2004)
4.3 Global Warming: Why is it a Problem?

Human activities of all kinds, whether in industry, through deforestation, or transportation and home activity, are resulting in emissions of increasing quantities of gases, in particular carbon dioxide, into the atmosphere.

Every year these emissions add seven thousand million tonnes of carbon to that already present in atmospheric CO$_2$. Much of this is likely to remain in the atmosphere for a period of a hundred years or more. And, because CO$_2$ is a good absorber of heat radiation coming from the earth’s surface, increased carbon dioxide acts like a blanket over the surface, keeping it warmer than it otherwise would be. With the increased temperature comes an increased amount of water vapour in the atmosphere, providing more blanketing and even warmer conditions: this is known as the global warming effect.

Levels of CO$_2$ in the atmosphere have risen by more than a third in the UK since the industrial revolution. They are now rising faster than ever (again since records began). Over the 20th Century temperatures have risen by about 0.6%, largely due to increased greenhouse gas emissions from human activities. Houghton (2004) estimates that, in the absence of efforts to curb the rise in emissions of CO$_2$, the global average temperature will rise by around a third of a degree Celsius every ten years. This equates to around three degrees in a century.

This predicted rate of change of three degrees is probably faster than the global average temperature has changed over any time over the past ten thousand years. Although the level of change appears small and insignificant, this is not so. A few degrees change in average temperatures can represent a huge change in climate conditions. There is a difference in global average temperatures of only five or six degrees between the coldest part of an ice age and the warm periods in between ice ages.

Figure 4.2 shows changes in temperature over the past 140 years (global) and 1000 years (Northern Hemisphere). Figure 4.3 shows variations over the last 160,000 years of polar temperature derived from the Vostok ice core in Antarctica. It is estimated that the variation in global average temperature is about half that in the polar region. Also shown in Figure 4.3 is the current carbon concentration of around 370 ppm and the likely rise during the twenty-first century under various projections of growth. As a comparative figure, carbon concentration in 1750 was around 280 ppm. Over 50% of the total emissions since 1750 have occurred since the mid-1970s.

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7 The warming effect of greenhouse gases in the atmosphere was first recognised in 1827 by the French scientist Jean-Baptiste Fourier. He pointed out the similarity between what happens in the atmosphere and in the glass of a greenhouse, which led to the name ‘greenhouse effect’. Developing our understanding, John Tyndall, around 1860, measured the absorption of infra-red radiation by carbon dioxide and water vapour; and Svante Arrheius in 1896 calculated the effect of an increasing concentration of greenhouse gases, estimating that the doubling in concentration of carbon dioxide would increase global average temperature by 5°C to 6°C (an estimate not far from our present understanding).
**Figure 4.2: Short Term Variations in the Earth’s Surface Temperature (IPCC, 2001)**

**Figure 4.3: Longer Term Variations in the Earth’s Surface Temperature (Houghton, 2004)**
The vast majority of scientists are thus confident about the significance of global warming and climate change due to human activities. Uncertainty only remains as to the extent of the warming and about the patterns of change in different parts of the world.

A number of dissenting voices infrequently gain commentary in the national press. Danish academic Bjorn Lomborg, for example, promotes an argument that spending money on climate change is wasteful and that the world would be much better off spending it on other problems, such as halting Aids and providing water and sanitation (The Guardian, Tom Burke, October 23, 2004). Such views are however far from the mainstream debate on tackling climate change.

Figures 4.4-4.6 provide authoritative analysis from the IPCC (2001) on changes in annual temperature trends, CO₂ emissions by region (the industrialised countries accounting for much more than their equitable global share), projections of people flooded by coastal storm surges and the costs of extreme weather events. The IPCC provide many further illustrations of the potential effects of climate change.

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8 Lomborg recently invited eight Nobel prize-winning economists to decide how best to spend a (notional) additional $50bn dollars in order to advance global welfare, particularly in developing countries. The economists were offered a top 10 list of global challenges, such as disease, hunger, water, migration and climate change, and invited to use cost-benefit analysis to rank them in terms of value for money. They came to the same conclusion as Lomborg on the ranking of climate change: bottom. Some interestingly have reneged since as to the study conclusions. Tom Burke describes the analysis as “Neither scepticism nor science - just nonsense. The reality is that applying cost-benefit analysis to questions such as these is junk economics. Junk economics done by Nobel laureates is simply distinguished junk economics.”
**Figure 4.4:** Annual Temperature Trends 1976-2000 (IPCC, 2001)

**Figure 4.5:** Adaptation and Average Annual Number of People Flooded by Coastal Storm Surges, Projection for 2080s (IPCC, 2001)

Error! Objects cannot be created from editing field codes.

**Figure 4.6:** Costs of Extreme Weather Events 1950-1998 (IPCC, 2001)
4.4 Future Emissions of Carbon Dioxide

To obtain estimates about the future climate we need to estimate the future atmospheric concentrations of carbon dioxide. A number of scenarios have been developed by the IPCC; they are known as SRES scenarios (and are derived from the *Special Report on Emission Scenarios*, 2001). The scenarios are based on differing assumptions regarding human behaviour and activities, including population, economic growth, energy use and the sources of energy generation. Houghton (2004) gives a definitive summary.

The SRES scenarios are based on a set of four different story lines, and within each is a sub-set of further scenarios, leading to a total of 35 scenarios.

- **A1 Storyline**: describes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Further assumptions are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. Three sub-groups are distinguished by their technological emphasis:
  - Fossil fuel intensive (A1F1)
  - Non fossil fuel energy sources (A1T)
  - Balance across all sources (A1B)

- **A2 Storyline**: a heterogeneous world based on self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, resulting in a continuously increasing population. Economic development is primarily regionally orientated and per capita economic growth and technological change more fragmented and slower than other storylines.

- **B1 Storyline**: a convergent world, with a global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures towards a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, improved equity, but no additional climate-related initiatives.

- **B2 Storyline**: a world in which the emphasis is on local solutions to economic, social and environmental sustainability. Global population continuously increases, at a rate lower than in A2, with intermediate levels of economic development and less rapid and more diverse technological change than in B1 and A1. The storyline is orientated towards environmental protection and social equity, at local and regional levels.

None of the SRES scenarios include additional climate initiatives, e.g. no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.
4.5 The Impacts of Climate Change

The impacts of climate change are likely to vary a great deal from place to place. Ecosystems and areas are likely to respond very differently to changes in temperature depending on their sensitivity. Houghton (2004) provides a number of caveats to possible change:

- Sensitivity: the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli
- Adaptive capacity: ability of a system to adjust to climate change, to moderate potential damage, to take advantage of opportunities and/or to cope with the consequences
- Vulnerability: the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including variability and extremes

Effects are likely to manifest themselves in a number of ways; again Houghton (2004) is useful in summarising these:

- The environment is likely to be degraded, with sea level rises particularly affecting low-lying areas. The overuse of land and deforestation is likely to accelerate climate change impacts, with increasing droughts and flooding in some areas
- Adaptation measures will be required, such as changes in infrastructure, and new sea defences or water supplies
- Changes in the frequency and/or intensity of extreme events. For example, some parts of the world are likely to become warmer and drier, others having a greater likelihood of droughts and heatwaves and/or a greater incidence of floods
- Natural ecosystems are likely to be seriously affected, especially at high to mid latitudes. Forests will be affected by increased climate stress, causing substantial die-back and loss of production
- The average annual cost in monetary terms of the impacts that would arise under climate change have been estimated. A doubling of pre-
industrial atmospheric concentrations carbon dioxide concentrations, typically results in 1-2% of GDP for developed countries and around 5% or more for developing countries. Monetary aspects of course represent only a part of the overall impact story. Any assessment of impacts has to take into account the cost in human terms and the large social and political disruption that change might bring.

The Energy White Paper (DTI, 2003) also shows how the rise in temperatures has been accompanied by changes in the world around us. For example:

- Ice caps are retreating from many mountain peaks
- Global mean sea levels rose by an average of 1.2 mm a year during the 20th Century
- Summer and arctic sea ice has thinned by 40% in recent decades
- El Nino-type events have become more frequent and intense during the last 20-30 years
- Use of the Thames Barrier has increased from once in every 2 years to an average of 6 times a year over the past 5 years

A critical point is that global warming is a global problem. UK emissions of carbon dioxide account for around 2% of the global total. Although per capita wise this share is greater than the UK’s equitable share of emissions, the low absolute contributory figure means that concerted international efforts are required to tackle the problem throughout the world.

### 4.6 Current Carbon Emissions and Moves Towards Stabilisation

Despite the uncertainty as to the detailed impacts of climate change, the underlying changes are almost universally agreed upon. Houghton (2004) states that if atmospheric carbon dioxide concentration doubles, and nothing else changes apart from atmospheric temperature, then the average global surface temperature is likely to increase by around 1.2°C.

In 2000, total global emissions from fossil fuels amounted to 6,600 million tonnes of carbon (MtC). Emissions from North America (US, Canada and Mexico) made up a quarter of the total. Those from Western Europe accounted for around 15%.

In terms of annual emissions of carbon dioxide per capita, the world average in 2000 was just over one tonne carbon per capita (1tC), but varied dramatically country by country. For the UK emissions were at an average of 2.5tC (equating to 150 MtC). In the US they are 5.5tC, developed countries and transitional economy countries an average of around 2.8tC. The developing nations contribute much less: China’s emissions average 0.6tC per person, India 0.3tC. Afghanistan is currently the bottom of the emissions league at 0.01tC.

Hillman and Fawcett (2004) highlight the historical perspective: partly because the UK was the first to industrialise, and had an economy based on fossil fuels, our contribution to the total emissions since 1750 is much higher than our current contribution. Overall, the UK has been responsible for 15% of global emissions. By comparison, the US has been responsible for 29% of global emissions over the same period.
The United Nations Framework Convention on Climate Change (discussed in more detail in Section 7 of this paper) held at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 came into force in 1994. The Convention agreed that developed countries (Annex 1 countries) should take action to return greenhouse gas emissions, in particular those of carbon dioxide, to their 1990 levels by the year 2000. The long-term objective of the Convention, as expressed in Article 2, is that the concentrations of greenhouse gases in the atmosphere should be stabilised at a level which would prevent dangerous anthropogenic interference with the climate system.

The Kyoto Protocol and the various commitments required by different countries were further agreed in 1997. A series of mechanisms for implementation were agreed, and again further developed at subsequent meetings (such as at The Hague, Bonn and Marrakesh).

CO$_2$ is taken as the most important of the greenhouse gases that result from human activities. Under all of the SRES scenarios the concentration of CO$_2$ rises continuously throughout the twenty-first century and, apart from the scenario B1, none come anywhere near to stabilisation by 2100. IPCC scenarios that would lead to the stabilisation of atmospheric carbon dioxide concentration at different levels are shown in Figure 4.8. The baseline scenario that has most in common with a ‘business as usual’ continuation of current trends results in concentrations of carbon dioxide at around 950 ppm by 2100.

Houghton (2004) notes that stabilisation at any level, even at the higher levels, requires that anthropogenic carbon dioxide emissions eventually fall to a small fraction of current emissions. With constant emissions after the year 2000, the concentration of CO$_2$ in the atmosphere would still approach 500 ppm by 2100. To maintain a constant future CO$_2$ concentration, emissions must be no greater than the level of persistent natural sinks. The main known sink is the dissolution of calcium carbonate from the oceans into ocean sediments that, for high levels of carbon dioxide concentration, is probably less than 0.1 GtC per year.

Figure 4.8 represents just a few possible pathways towards stabilisation. The emissions profiles begin by following the current average rate of increase of emissions and then provide a smooth transition to the time of stabilisation.

There is a further difficulty here: feedback effects (Figure 6.8 does not include the effect of climate feedbacks on the carbon cycle). Two feedbacks are critically important – increased respiration from soil as temperature rises, and die-back from forests as the climate changes. Potential effects are large, Houghton (2004) estimates that emissions scenarios that are aiming at 450 ppm stabilisation (but not allowing for feedbacks) could in fact achieve around 550 ppm when the feedbacks are included. Aiming at 550 ppm would in fact only achieve around 750 ppm.
Figure 4.8: Emissions, Concentrations and Temperature Changes
Corresponding to Different Stabilisation Levels for CO₂ Concentrations (IPCC, 2001)
4.7 Conclusions

In summary, progression towards any form of future stabilisation is likely to be very difficult. Over the next 100 years or so, carbon emissions will need to be reduced by large amounts. There is little agreement as to actual levels, yet if they are to be reduced to levels that do not exceed the capacity of natural land and ocean sinks to absorb them.

Looking ahead to the year 2100, assuming that the world population rises to only around 7 billion, and under the scenarios leading to stabilisation at concentrations of 450 ppm and 550 ppm, the per capita annual carbon emissions averaged over the world would need to be around 0.3°C and 0.7°C respectively, less than the current global average of around 1°C, and much less than the current UK average of 2.5 tC. Critically, our success in addressing environmental problems depends not only on knowledge about them, but also on radical action.
5 Demographic, Social and Transport Trends

5.1 Demographic and Social Trends
It is important to understand the factors that contribute to our collective emissions of carbon and ultimately to the changes to our climate. Of particular interest to this study are those in the transport sector, however first we briefly review wider demographic, social and lifestyle changes.

The world’s population totals over 6.4 billion in March 2004, and is growing at an annual rate of over 1% - an extra 77 million people per year (i.e. over the size of the UK each year). The mid-range estimate for world population in 2050 is 9.3 billion, representing a rise of 50%. Most of the growth is forecast to occur in developing countries. Clearly such high levels of growth are likely to have an important impact on transport trends and CO₂ emissions. Within the UK, population levels total 49.6 million and are growing at a much slower rate, just 2.4% from 1991-2001 (ONS, Census 2001).

A number of key features of demographic change impact on transport trends and CO₂ emissions in the UK:\n
- There are 28.8 million males and 30.3 million females in the UK.
- The population is ageing: since 1971, the proportion of the population aged 65 and over has increased from 15.9% to 18% for females and from 10.5% to 13.7% for males (ONS, Census 2001). There is rapid projected increase from 2001-2021.
- The age distribution differs markedly across the country: 19% of the population living in the south west were aged 65 and over, compared to only 12% of the population in London.
- The proportion of one-person households in Great Britain increased from 18% to 29% between 1971 and 2003.
- The economic activity rate for working age males fell from 89% in 1984 to 84% in 2003, while the rate for working age females rose, from 67% to 73%.
- In 2003 (Spring) there were 28.1 million people in employment in the UK, the highest number since records began.
- Around 21% of employees working full time in the UK and 25% of those working part time had some type of flexible working arrangement in 2003.
- In 2001 unemployment in the UK was 1.44 million, its lowest level since 1990. Unemployment increased slightly to 1.53 million in Spring 2002, but then fell slightly by Spring 2003 to 1.48 million.
- Between 2001 and 2002, real household disposable income grew by 1.1%, slightly less than the growth in GDP per head in the UK.

\n
9 For more information see Social Trends 34 (ONS, 2004 Edition)
Households where the reference person was in a managerial or professional job spent almost £100 of their total weekly household expenditure on transport in 2002/02. Households where the reference person had never worked or was long term unemployed spent around £40.

During 2002, 1.6 million property transactions took place in England and Wales, of which just over 1.4 million were residential transactions.

5.2 Transport Trends
This section presents a brief summary of trends in travel in the UK. It is based on data drawn from a number of documents, but primarily Travel Trends (DfT, 2003) and Transport Statistics Great Britain (DfT, 2004)\(^\text{10}\). A number of summary trends can be found, as outlined below:

- There has been rapid growth in passenger distance travelled - particular by the private car - since the 1980s, although growth has slowed recently. Education, escort, shopping and business trips are seeing continued growth.
- Recent growth in rail usage, and an increase in bus usage in London (offset by a decline elsewhere in the UK).
- A fall in trips made by non-motorised modes of travel (walking and cycling).

Air travel has also grown rapidly, with 'low cost' airlines having a strong recent influence.

5.2.1 Explosive Growth in Road Traffic
Road traffic has grown at a fairly constant and rapid rate since the 1980s: by 77% since 1982 to 2002 (from 277 to 490 billion vehicle kilometres). Since 1990 growth has slowed slightly from that in the previous decade (a growth rate of 18% since 1990).

Many factors have affected traffic levels, including increasing car ownership and numbers of drivers, falls in car occupancy levels, fuel price changes and varying levels of expenditure on roads, both capital and current. Over a quarter of households now have two or more cars. Men are still more likely to have a driving licence but the number of women holding a licence has been increasing at a quicker rate.

\(^{10}\) These data sources are available at [www.dft.gov.uk](http://www.dft.gov.uk).
Figure 5.1: Growth in Road Traffic

The majority of the growth has been in car traffic, which has gone up by 83% since 1980, from 215 to 392 billion vehicle kilometres. Light van and goods vehicle traffic has increased substantially since 1980, from 46 to 83 billion vehicle kilometres in total. Most of this increase has been in light van traffic. Bus and coach traffic has seen a more modest increase, from 3.5 to 5.2 billion vehicle kilometres, whilst motor cycle and pedal cycle traffic have both fallen, although with some increase in recent years.

5.2.2 Traffic and Travel Intensity

Measures of traffic and travel intensity illustrate the extent to which economic growth and traffic growth have been de-coupled. Since 1980, traffic (vehicle kilometres) and overall travel (passenger kilometres) have grown broadly in line with GDP. However, since 1993, traffic and travel have increased more slowly than GDP. This reflects some de-coupling of traffic growth from economic growth.

5.2.3 Falling Car Occupancy Levels

In 2002, 61% of cars on the road had only one occupant. For commuting and business trips, the proportion was about 85%.

The average number of occupants per car has been falling slightly: from 1.64 in 1985/86 to 1.58 in 2002. This has contributed to vehicle kilometres increasing more than passenger kilometres over the same period, and reflects factors such as traveller choice, smaller average size of households, increasing car ownership and dispersed journey patterns.

Car occupancy varies according to journey purpose. The highest occupancy rates in 2002 were for holidays and day trips and for education (2.1 persons per car. The lowest rates were for commuting and business travel (1.2).

5.2.4 Congestion

The Government has a Public Service Agreement (PSA) target to reduce congestion on the inter-urban trunk road network and in large urban areas in England below 2000 levels by 2010. Congestion has been measured for the first time to give baseline results for 2000. It is defined as the average time

Source: DfT (Travel Trends, 2003)
lost per vehicle kilometre, when comparing actual speeds against free-flow speeds. The baseline figures against which the PSA target will be measured are an average of 3.2 seconds lost per vehicle kilometre on inter-urban trunk roads and 24.8 seconds per vehicle kilometre in large urban areas.

5.2.5 Increased Car Ownership and Driving License Ownership

The number of licensed vehicles increased by 59% between 1980 and 2002, from 19.2 to 30.6 million. The rise has been steady throughout this time, apart from a brief period of stability in the early 1990s.

71% of adults (an estimated 32.1 million people) now hold full car driving licences, compared with 57% (24.3 million) in 1985/86.

The biggest change has been in the proportion of women holding driving licences - up from 41% in 1985/86 to 61% in 2002. 81% of men now hold a driving licence, compared to 74% in 1985/86.

5.2.6 Travel Per Person Per Year

Car use has continued to increase as disposable incomes have risen and travel opportunities widened. Additional contributing factors have been the flat level of real costs of motoring and rising real costs of public transport fares. While the average time people spend travelling has remained relatively static, at around one hour per day, increased car use and increased speed of travel has allowed people to travel further in the same time.

Total passenger distance travelled increased by 52% between 1980 and 2002, from 491 to 746 billion passenger kilometres. Most of this growth occurred between 1980 and 1990 (growth of 41%). Since 1990, distance travelled has increased by only 8%.

Figure 5.2: Passenger Distance Travelled by Mode

![Graph showing passenger distance travelled by mode from 1980 to 1999.](image)
Figure 5.3: Passenger Distance Travelled by Non-Car Modes

Source: DfT (Travel Trends, 2003)
**Figure 5.4: Change in Relative Costs of Travel**

![Chart showing change in relative costs of travel](image)

Source: DfT (Travel Trends, 2003)
5.2.7  **Passenger Trips By Mode**

The majority of the growth in travel has been by car: up from 388 billion passenger kilometres in 1980 to 634 billion in 2001 (an increase of 63%). Increases in travel by rail and domestic air have also been experienced (of 37% and 182%). Distance travelled by bus and coach fell by 17% between 1980 and 1992, but it has since increased by 7%.

![Figure 5.5: Passenger Trips by Mode](source: DfT (Travel Trends, 2003)

Having peaked at 1,100 in 1989/91, the average number of trips made fell to 1,000 in 2002. The average number of trips made by car has increased by 26% since 1985/86, from 517 to 649.

Since 1985/86 there has been a continual decline in the number of trips made on foot, from 350 to 243, although the fall in trips between 1999/01 and 2002 is probably due in part to an under-recording by respondents of short walk trips in 2002. Trips by bicycle or motorcycle have also fallen, by 46% from 34 to 18. Trips made by rail or London Underground have remained fairly constant over the whole period. However, the number of trips made by local bus has fallen by 31 per cent since 1985/86, from 83 to 57.

5.2.8  **Distance Travelled By Mode**

Average annual distance travelled rose rapidly in the late 1980s: from 5,300 miles in 1985/86 to 6,500 miles in 1989/91 (a rise of 22%). It has since increased by 6%, to 6,900 miles in 2002.

The increase in distance travelled by car is of course larger than the average increase in distance for all modes. Distance travelled by car increased from 3,800 miles in 1985/86 to 5,400 miles in 2002: up by 41%.

Over the same period, average distance walked fell by 22%, from 244 to 189 miles a year, and distance travelled by bicycle or motorcycle went down by 30%: from 95 to 66 miles a year. Distance travelled by local bus also declined over the whole period, from 297 to 257 miles a year (down 14%).
5.2.9 **Time Spent Travelling By Mode**

Average time spent travelling increased by about 10% between 1985/86 and 1989/91, reaching 370 hours a year. Over the last decade the average has changed little, at about 360 hours per year, or an hour a day. This accords with the theory of constant travel time budgets\(^\text{11}\).

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\(^{11}\) Travel time budgets: the theory is that mode choice and household location decisions adjust to maintain a fairly constant amount of time devoted to travel. According to Grubler (1990) this is in the range of 1 to 1.5 hours per day. He notes that this time budget has remained “close to an anthropological constant” since ancient Rome. Hupkes (1982) calls this the “Law of Constant Travel Time”.

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The amount of time spent travelling by car has however risen. Travel by car now accounts for 62% of time spent travelling, up from 51% in 1985/86. Over the same period, the proportion of time spent walking has fallen from 25% to 19%. Of the 60 minutes spent travelling on average each day in 2002, 37 minutes were by car and 11 minutes were on foot.

5.2.10 Fuel Efficiency of New Cars
Steady progress has been made in recent years in the fuel efficiency of new cars in the UK. In 2003 new car fleet average CO2 emissions were 172.9 g/km, a fall from the 2002 level of 175 g/km.

There has been an increase in the sales of the most fuel-efficient vehicles. The Society of Motor Manufacturers and Traders (SMMT, 2003\textsuperscript{12}) shows 3% of new case are in the VED band AA (those emitting 101-120g/km of CO) compared to 2% in 2002. The share of the top two C and D VED bands (166-185g/km and over 185g/km fell by 3.2% from 2002-2003. The efficiency gains made though improved technology are however outweighed by the growth in traffic.

5.2.11 Petroleum Consumption
Petroleum consumption for unleaded and diesel vehicles has been increasing in the last decade, with a slight reduction since 2002 in unleaded usage. Leaded motor spirit usage has declined to almost zero in the last 10 years.

Figure 5.8: UK Petroleum Consumption by Transport

\textsuperscript{12} See \url{www.lib.smmt.co.uk/articles/sharedfolder/publications/co2%20report.pdf}
5.2.12 **Energy Consumption**

Energy consumption by transport has similarly risen, with a particular growth in the aviation sector. Road transport continues to account for the majority of energy consumption in the transport sector.

**Figure 5.9: UK Energy Consumption by Transport**

Source: DfT (Travel Trends, 2003)
6 Transport and Emissions

6.1 Transport, CO₂ Emissions and Other Pollutants

Transport is a major contributor to a range of emissions that are detrimental to air quality. These include global pollutants such as CO₂ (which contributes to global warming), regional pollutants such as NOₓ (which contribute to acidification or ‘acid rain’) and more local pollutants such as particulates (which contribute to respiratory problems). Transport’s contribution to environmental pollution varies spatially; urban areas, for example, are affected most, with a strong correlation to traffic volumes. Below we consider temporal trends by different type of emission: CO₂, NOₓ, CO, VOC and PM₁₀. Transport Statistics Great Britain (DfT, 2004), Travel Trends (2004) and Energy Paper 68 (DTI, 2003) are used as the primary sources for emissions data.

6.2 Carbon Dioxide

The transport sector, including aviation, produces around a quarter of the UK’s total carbon emissions. Road transport contributes 85% of this, with passenger cars accounting for around a half of all carbon emitted by the transport sector. Since 1990 the average carbon efficiency of new cars entering the fleet - the distance travelled for a given amount of carbon emitted - has improved by 10%. EU voluntary agreements on new car fuel efficiency are likely to reduce emissions for the average new car from a 1995 base of 190g/km to 140g/km by 2008 (a reduction of around 25%). The DfT and DTI (2004) suggest that family cars with carbon emissions of 100g/km (equivalent to 75m/gallon of diesel) or less may be achievable in the next 20 years. For more information see Section 9 of this report (Available Measures and Benchmarks).

Figure 6.1: Carbon Dioxide Emissions (by End User Category\(^{13}\))

Source: DfT (Travel Trends, 2004)

\(^{13}\) End user emissions for transport include a share of emissions from combustion of fossil fuels at power stations and other fuel processing industries, but exclude activities and emissions attributable to other industrial sectors. Source emissions relate directly to the vehicle.
Demand is also rising from the aviation sector internationally by around 4% a year. International aviation emissions do not count in the national inventories of greenhouse gas emissions. There is no international agreement yet on ways of allocating such emissions. The UK’s international emissions currently amount to 8MtC (9MtC including domestic: Energy White Paper, DTI, 2003). They are expected to rise to some 14-16 MtC by 2020. This increase is despite an improvement in the fuel efficiency of aircraft of around 1.7% per year. The Advisory Council on Aeronautics Research in Europe is however seeking to outline a 50% reduction in CO₂ emissions from new aircraft by 2020.

Other transport modes account for much smaller amounts of energy and carbon, but can still make useful contributions to reduction targets. Shipping, like aviation, is international in nature. The International Maritime Organisation (IMO) is working towards a global strategy for reducing greenhouse gas emissions from ships.

Rail transport carbon emissions account for <1% of total UK emissions. Typically they are about half of those for road-based modes per passenger or tonne per km. Reduced carbon emissions could be experienced by a shift towards rail transport and also by the provision of new, more efficient rolling stock.
6.3 Wider Pollutants

Transport also has an important impact on local air quality. Over the last decade air quality has improved significantly - in terms of Nitrogen Oxides (NO\textsubscript{x}), Carbon Monoxide (CO), Volatile Organic Carbon (VOC) and Particulates (PM\textsubscript{10}) - and DfT projections suggest that these trends will continue. This is largely due to a progressive tightening of emissions standards which have helped to encourage improvements in vehicle design and engineering.

Figure 6.3: Nitrogen Oxide Emissions

![Figure 6.3: Nitrogen Oxide Emissions](image)

Source: DfT (Travel Trends, 2004)

However the downward trend in NO\textsubscript{x} and PM\textsubscript{10} is likely to level off and could start rising again after 2015 unless further action is taken. The critical threshold is when technological innovation (in terms of reducing emissions) begins to be outweighed by the growth in traffic.

Figure 6.4: Carbon Monoxide Emissions

![Figure 6.4: Carbon Monoxide Emissions](image)

Source: DfT (Travel Trends, 2004)
Figure 6.5: Volatile Organic Carbon Emissions

Source: DfT (Travel Trends, 2004)

Figure 6.6: Particulates Emissions

Source: DfT (Travel Trends, 2004)
6.4 Conclusions
Transport hence has an important impact on global, regional and local quality. In recent years we have seen a significant reduction in most of the regional and local emissions (NO\textsubscript{x}, CO, VOC and PM\textsubscript{10}); CO\textsubscript{2} emissions remain a difficulty. In the next chapters we focus on CO\textsubscript{2} emissions and the various attempts to reduce impacts. In theory the significant use of renewably produced hydrogen or biofuels as transport fuels could reduce carbon emissions from the transport sector to near zero levels by 2050 (DfT, 2004)\textsuperscript{14}. Yet getting from 2005 to 2050 is likely to be a long and arduous transition.

7 The Policy Response

7.1 Introduction
Politicians and governmental decision-makers are increasingly beginning to draw on the empirical evidence base and to emphasise the importance of the issues concerning sustainability and CO<sub>2</sub> emissions. Three quotes are particularly enlightening and highlight the transformation in understanding:

David King, the UK Government’s Chief Scientific Adviser, suggests that: “Climate change is a far greater threat to the world than international terrorism ... and without immediate action flooding, drought, hunger and debilitating diseases such as malaria would hit millions of people around the world.”

Tony Blair, although not as definitive, has stated that: “Climate change is the world’s greatest environmental challenge ... our effect on the environment, and in particular on climate change, is large and growing. From the start of the industrial revolution more than 200 years ago, developed nations have achieved ever greater prosperity and higher living standards. But through this period our activities have come to affect our atmosphere, oceans, geology, chemistry and biodiversity. What is now plain is that the emission of greenhouse gases, associated with industrialisation and strong economic growth from a world population that has increased sixfold in 200 years, is causing global warming at a rate that began as significant, has become alarming and is simply unsustainable in the long-term. And by long-term I do not mean centuries ahead. I mean within the lifetime of my children certainly; and possibly within my own. And by unsustainable, I do not mean a phenomenon causing problems of adjustment. I mean a challenge so far-reaching in its impact and irreversible in its destructive power, that it alters radically human existence.”

This is all a long journey from the 1980s. Political perceptions have moved on dramatically in the UK in the last two or three decades. Margaret Thatcher in 1982 famously (and incredulously now if not then) stated that: “It’s exciting to have a real crisis on your hands, when you have spent half your political life dealing with humdrum issues like the environment.”

Below we summarise the recent key governmental policy statements, considering European-wide and UK-based publications, and also a number other important publications. Banister et al (2004) make the point that there is considerable uncertainty over the direction of policy. At one level efforts are being made to address perceived problems of transport capacity. In Germany this is known as Verkehrsinfarct (which translates as traffic blockage); in

15 From an article by David King in ‘Science’, January 2004
16 Tony Blair speaking on climate change in September 2004
17 Margaret Thatcher was of course talking about the Falklands War in a speech to the Scottish Conservative Party Conference (May 1982).
France bouchon (which rather aptly literally translates as ‘cork’). Further, there are problems with integration: many of the different transport systems are incompatible, technically and organisationally. And finally, there is a realisation that pursuing mobility objectives are not compatible with environmental and social (and even economic) objectives. The wide ranging nature of guidance, initiatives and quality of transport provision means that focused progress in a field such as transport and CO₂ emissions is difficult. Intervention itself is focused on decoupling, rail and pricing issues and mode share change.

7.2 Governmental Interventions

7.2.1 EU-Wide

European transport policy has developed slowly over the last half-century, since the Treaty of Rome in 1957. It is only since 1992 that the Common Transport Policy has been promoted by the European Union. Banister et al (2004) give a thorough description of developments, including the development of Trans-European Networks, the Maastricht Treaty (1991), the EU White Paper on a Common Transport Policy (1992), with an initial focus on competitiveness, cohesion and the environment, and a latter linkage to spatial planning through the European Spatial Planning Directive (ESDP, EU, 1999).


The European Commission seeks to develop a transport action plan aimed at bringing about substantial improvements in the quality and efficiency of transport in Europe. It proposes a strategy aimed at decoupling: designed to gradually break the link between transport growth and economic growth in order to reduce the pressure on the environment and prevent congestion but still maintaining the EU’s economic competitiveness.

The Commission targets mode shift as a primary focus, stating that "If nothing is done, Europe will rapidly be threatened with apoplexy at the centre and paralysis at the extremities.” In terms of the Trans European Networks, the Commission is proposing to concentrate on the missing links (in particular the Trans-European high-speed passenger rail network, which is taken to including airport connections).

The White Paper seeks a new approach to urban transport, which reconciles the modernisation of public services with a rationalisation of private car use, stating that this is required to comply with international agreements covering CO₂ emissions. Land use planning is mentioned as a requisite part of any integrated strategy for sustainable transport, helping to avoid ‘unnecessary’ increases in mobility. An objective of sustainable transport by 2010 is however a somewhat ambitious goal. See: www.europa.eu.int/comm/energy_transport

EU Directives on Renewable Fuels and Emissions Trading

The EU Emissions Trading Scheme (ETS) started on 1 January 2005, covering 10,000 installations across Europe. The scheme works on a ‘cap and trade’ basis. Each member state is required to set a cap on the total level of CO₂ emissions for all installations covered by the EU ETS within that country. Each installation is then allocated allowances equal to their proportion of the total cap. One allowance is equal to one tonne of CO₂.
Operators have the option to: keep emissions at their current level and purchase allowances from the European market to cover the shortfall, reduce emissions to the level of their cap, or reduce emissions below the level of the cap and sell excess allowances on the market.

At present transport is not included in the ETS scheme. The UK Government is in principle in favour of it being included in the future: the 2004 Transport White Paper stating the Government’s commitment to consider the scope for including surface transport in the EU ETS. The 2003 Air Transport White Paper also states that the UK Government is actively pursuing the inclusion of intra-EU aviation in the EU ETS, beginning in 2008.

7.2.2 UK-Based

UK Sustainable Development Strategy ‘Securing the Future’ (DEFRA, 2005)

The UK Government launched its new strategy for sustainable development in March 2005. The Strategy takes account of developments since 1999, and highlights the renewed international push for sustainable development from the World Summit on Sustainable Development in Johannesburg in 2002. Four priorities for action are set:

- Sustainable consumption and production
- Climate change and energy
- Natural resource protection and environmental enhancement
- Sustainable communities


The Energy White Paper (EWP) defines a long-term strategic vision for energy policy in the UK combining environmental, security of supply, competitiveness and social goals. It builds on the Performance and Innovation Unit’s Energy Review (Cabinet Office, 2003) and other reports which have looked at major areas of energy policy. The White Paper perceives there to be 3 key challenges to global warming: environmental, decline of energy supplies and the need to update energy infrastructure.

The EWP looks ahead to 2050 to set the overall context for energy reduction. The paper sets out the challenges the UK faces on the environment, the decline of indigenous energy supplies and the need to update energy infrastructure. It sets out the policies needed over the next twenty years and beyond to meet the challenges. Four goals for energy policy are set:

- To put ourselves on a path to cut the UK’s carbon dioxide emissions - the main contributor to global warming - by some 60% by about 2050, with real progress by 2020;
- To maintain the reliability of energy supplies;
- To promote competitive markets in the UK and beyond, helping to raise the rate of sustainable economic growth and to improve our productivity; and
- To ensure that every home is adequately and affordably heated.
The EWP is thus an important source for the VIBAT project in providing the 60% energy reduction target. The VIBAT project however considers a shorter timescale to 2030 (rather than 2050). The White Paper target is itself sourced from the Royal Commission on Environmental Pollution (RCEP) which recommended the 60% target.  

The EWP, on the basis of existing policies, expects UK carbon dioxide emissions of 135 MtC in 2020. To be consistent with ‘demonstrating leadership in the international process’ the EWP aims for cuts in carbon of 15-25 MtC below that by 2020. These targets will be achieved by reducing the amount of energy consumption, together with a substantial increase in renewable energy. Central to this will be the carbon emissions trading scheme.

The EWP vision is that “[in terms of the transport sector] hybrid vehicles will be commonplace in the car and light goods sectors, delivering significant efficiency savings. There will be substantial use of low carbon biofuels and hydrogen.”

The EWP committed the Government to undertaking an assessment of the long term energy implications of a large scale use of hydrogen and biofuels in road transport, with a time horizon of 2050 (this assessment was published alongside the Transport White Paper). It concluded that significant use of renewable hydrogen or biofuels could reduce total carbon emissions from road transport to very low levels and that improvements in fuel efficiency are essential but may not be sufficient to achieve very large carbon savings. Also it is not certain that a hydrogen economy will ever be realised; if it is, the UK could produce sufficient hydrogen for road transport from renewable resources, but at the expense of other energy sectors. The UK is capable of growing about a third of the biomass that would be needed if the road transport fleet were entirely fuelled by biofuels. The Government has now begun to develop a UK hydrogen energy strategic framework.

The EWP predicts a reduction of 2-4 MtC in total from road transport by 2020 (DTI, Energy White Paper Annex 4, 2003). This assumes the introduction of 5% biofuels into petrol and diesel (as blends), which could save around 1 MtC by 2020; and that the current voluntary agreement with European car manufacturers will be extended to require the new car fleet to achieve an average of 100-115g/km in 2020.

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18 The RCEP’s recommendation of putting the UK on a policy pathway to reducing carbon dioxide emissions by some 60% from current levels by about 2050 was based on a more detailed calculation of a 58% reduction from 1997 levels. This would lead to 2050 emissions of 64 million tonnes of carbon (MtC). The Kyoto protocol and the UK’s current domestic targets use 1990 as a baseline. A precise reduction of 60% in emissions from 1990 would result in emissions of 65.8 MtC in 2050. The Energy White Paper uses a definition of ‘around 65 million tonnes’ to describe the level of carbon emissions which a 60% cut would deliver by 2050.
Table 7.1: Achievement of 15-25 MtC Reductions by 2020

<table>
<thead>
<tr>
<th>Sector</th>
<th>Estimated MtC Reduction (Below the Baseline of 135 MtC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency in households</td>
<td>4-6</td>
</tr>
<tr>
<td>Energy efficiency in industry, commerce and the public sector</td>
<td>4-6</td>
</tr>
<tr>
<td>Transport: continuing voluntary agreements on vehicles, use of biofuels for road transport</td>
<td>2-4</td>
</tr>
<tr>
<td>Increased renewables</td>
<td>3-5</td>
</tr>
<tr>
<td>EU carbon trading scheme</td>
<td>2-4</td>
</tr>
</tbody>
</table>

(From EWP, DTI 2003)

The EWP is also (obviously) concerned about maintaining competitiveness. The IPCC (2001) suggests that action aimed at stabilising CO2 atmospheric concentrations at no more than 550 ppm would lead to a loss of around 1% in projected GDP. This is set against annual rises in GDP and also this figure takes no account of the costs avoided by tackling climate change. The IPCC note that the transition costs would be higher if carbon reduction targets were tackled in too short timescales.

The EWP reports that vehicle taxation has been altered to support EC targets. Vehicle Excise Duty (VED) pre-1999 was at a flat rate for all cars. It is now graduated, linked to a car’s CO2 emissions. VED ranges from £60-£160, with zero duty for electric vehicles. Company car taxation also shifted to a CO2-linked basis in 2003.

The EWP suggests that, taken together, the continuation of voluntary agreements on vehicle carbon dioxide performance, increased use of biofuels and other initiatives could improve carbon efficiency of transport by up to 10% by 2020. Carbon savings will increase further beyond 2020 as more fuel efficient cars spread progressively into the fleet. Deeper carbon reductions however require hydrogen (generated from non-fossil fuel sources) or biomass-based liquid fuels. The auto industry expects hydrogen powered fuel cells to move towards mass marketing around 2020.

The implementation of the EWP is being taken forward via the Sustainable Energy Policy Network (SEPN). AEA Technology and Imperial College London produced important background research to the Energy White Paper in their low carbon futures modelling work for the DTI (AEA, 2002).


The Transport White Paper (TWP) reports that: “Transport is currently responsible for about a quarter of total UK CO2 emissions. This figure excludes international aviation as there is currently no international agreement on ways of allocating such emissions. In the short term, emissions of carbon from road transport are expected to grow by about 10% from 2000 levels by 2010. This is because increased levels of traffic will offset improvements in fuel efficiency. Emissions from other sectors are due to fall in the same time period, so transport’s share of total emissions is likely to increase substantially. The trends change after 2010. Slower traffic growth and continued fuel efficiency improvements are expected to produce a
fall in road traffic CO\textsubscript{2} emissions of around 5% between 2010 and 2015, with further falls thereafter."

The TWP reaffirms the statements made in the Energy White Paper that the UK is committed to the Kyoto protocol, and to the target of reducing UK greenhouse gas emissions by 12.5% from 1990 levels by 2008-12. Also that the UK remains committed to a more challenging national goal of a 20% reduction in emissions of CO\textsubscript{2} by 2010, and of putting the UK on a path to reducing total carbon dioxide emissions by 60% by 2050, with real progress by 2020. The TWP however predicts a >25% increase in traffic from 2000-2010; a >30% increase from 2000-2015 and a 40% increase from 2000-2025.

The TWP states that  “transport is vital to the economy and the way we live. Decisions we take now will have an impact for decades to come. It is essential that we take a long term view.” And that “the challenge is to ensure that transport decisions are not viewed in isolation … clearly linked to other decisions, such as the location of new housing and of employment sites.”

**Transport 2010: Meeting the Local Transport Challenge (DfT, 2000)**

The 10-Year Plan for Transport sets out the Government’s strategy for modernising the transport network. It seeks to provide an integrated system, covering all modes of transport, and includes a long-term programme of new investment to deliver the priorities identified in the Integrated Transport White Paper (DfT, 1998), with £180 billion of public and private expenditure over the next 10 years.

### Table 7.2: Outcomes and Targets contained in the 10-Year Plan

<table>
<thead>
<tr>
<th>Challenges</th>
<th>Outcomes and Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better public transport</td>
<td>- A 10% increase in bus passenger journeys</td>
</tr>
<tr>
<td></td>
<td>- More reliable bus services, with a new national survey to monitor progress</td>
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<td></td>
<td>- Better quality, less polluting buses</td>
</tr>
<tr>
<td></td>
<td>- Light rail passenger journeys at least doubled</td>
</tr>
<tr>
<td>Better integration</td>
<td>- Better integration and co-ordination between transport modes through local transport plans and improved interchanges</td>
</tr>
<tr>
<td></td>
<td>- Integrated information, ticketing and booking, including smart card ticketing</td>
</tr>
</tbody>
</table>
| Better accessibility | • For disabled people, improvements in the accessibility of public transport and the pedestrian environment  
• For people in rural areas, a one-third increase in the proportion of rural households living within around ten minutes walk of an hourly or better bus service  
• Better access to jobs and services, including for deprived and rural areas  
• Growth of innovative and flexible transport services, including voluntary and community transport, with up to 500 new schemes over three years  
• Free bus passes entitling all pensioners and disabled people to at least half-fare discounts |

| Reducing the environmental impact of traffic | • Improvements in air quality, noise pollution and the local environment, and reductions in CO2 emissions |

| Easing urban congestion | • To reduce road congestion in large urban areas in England below current levels |

| Safer roads | • Improvements in local road safety, contributing to the achievement of national targets (to reduce the number of people killed or seriously injured in Great Britain in road accidents by 40%, and the number of children killed or seriously injured by 50%, compared with the average for 1994-98)  
• Halt the deterioration in local road condition by 2004 and eliminate the backlog by the end of the Plan period  
• Treble the number of cycling trips |

NB. all outcomes and targets to be achieved by 2010 unless otherwise indicated

**Transport 2010 (10-Year Plan Revised, DfT 2002)**

The data in the revised 10-Year Plan indicates that traffic is forecast to rise between 20% and 25% to 2010, while congestion will rise between 11% and 20%. This 20%-25% traffic growth forecast corresponds well with the high growth scenario developed by the DTI Technology Foresight Programme (DTI, 2001) and updated by AEA Technology and Imperial College London in their low carbon futures modelling work for the DTI (AEA, 2002), the latter of which was developed in the lead up to the 2003 Energy White Paper (DTI, 2003).

The combined savings from the policies in the 10-Year Plan is expected to be between 1.1-1.4 MtC per annum by 2010 (or 2.4 MtC if motoring costs are kept constant). Interestingly, the Sustainable Development Commission’s audit of the UK’s Climate Change Programme describes the original 10-Year Plan projection as ‘insecure’.

**National Transport Model (NTM)**

The NTM envisages that the level of road transport CO2 emissions will be stable (high forecast = +0.3%) or even fall slightly (-2.7%) by 2010 (DfT,
The new Transport White Paper contradicts the revised 10 Year Plan by predicting a 10% increase in CO\textsubscript{2} by 2010. It could be assumed that the Transport White Paper gives greater emphasis to fuel energy savings.

Both the NTM and the Transport White Paper predict that the impact of traffic growth will be offset to a greater or lesser extent by improvements in the average fuel efficiency of the road vehicle fleet. In the NTM, voluntary agreements with motor manufacturers will, it is assumed, provide a saving of 4 MtC by 2010 (DfT, 2003).

PPG13 Transport (DfT, 2000)
PPG13 seeks to integrate planning and transport at the national, regional, strategic and local level, with key objectives which seek to:

- Promote more sustainable transport choices for both people and for moving freight;
- Promote accessibility to jobs, shopping, leisure facilities and services by public transport, walking and cycling, and

There is no specific mention of relation to CO\textsubscript{2} emissions, global environmental targets, energy consumption, the sustainability agenda or sustainable communities. An update to the guidance - in the form of PPS13 - is in the pipeline.

7.3 Additional Initiatives

The Powering Future Vehicles (PFV) Strategy
Published in 2002 by the DfT and other governmental departments, the PFV strategy aims to address the impacts of road transport on the climate and local air quality. The strategy aims to shift the UK vehicle market to clean, low-carbon vehicles and fuels. The objectives of the strategy are to:

- Promote the development, introduction and uptake of clean, low carbon vehicles and fuels
- Ensure the full involvement of the UK automotive industry in the new technologies

The strategy sets a target for passenger cars that, by 2012, 10% of new cars sold in the UK will have CO\textsubscript{2} emissions of 100g/km or less at the tailpipe. Measures to help achieve this include duty incentives, Vehicle Excise Duty, Company Car Tax Systems and Transport Energy Grants.

An annual report of progress against key indicators is published each year (for example, see the latest progress report, DfT, 2004). For further information see [www.roads.dft.gov.uk/cv/plower/pdf/strategy.pdf](http://www.roads.dft.gov.uk/cv/plower/pdf/strategy.pdf).
second annual report concedes that the “current rate of improvement in average vehicle efficiency may not be sufficient in itself to ensure that the 2012 100g/km target is met.”

A further tailpipe emissions target is derived from voluntary agreements between the European Commission and the European, Japanese and Korean automotive vehicle industry: average CO₂ emissions from cars sold by EU members should be reduced to 140g/km by 2008/09. (Local Transport Today, 2 November 2004). On current progress it is unlikely that the UK will reach this target. Improvements in the fuel efficiency of new cars are being counteracted by a trend for consumers to buy larger, less fuel efficient cars (despite the graduated Vehicle Excise Duty20).

A second target within the PFV strategy is that by 2012, 600 or more buses coming into operation per year will be low carbon, defined a 30% below current average carbon emissions. No mention of progress towards this target is made in the strategy.

Low Carbon Vehicle Partnership (LowCVP)
The Low Carbon Vehicle Partnership is an action and advisory group, established in January 2003, which is leading the move towards clean low carbon vehicles and fuels in the UK. LowCVP is a partnership of organisations from the automotive and fuel industries, government, academia, environmental NGOs and other stakeholders. The LowCVP supports a series of working groups, for example:

- The passenger car sub-group supports EU voluntary CO₂ agreements and seeks to develop a new 10-year timeframe to achieve further CO₂ emissions from new passenger cars.
- The consumer information sub-group is looking at raising consumer awareness of clean low carbon vehicles and eventually to influence purchasing decisions. For example the group is developing a voluntary UK colour-coded CO₂ labelling scheme for new cars.
- The bus working group has developed the low carbon bus programme and is developing standards and procedures for testing low carbon buses. The group works with local authorities to help inform their policies, supply contracts and purchasing decisions.
- The research and development working group has developed plans for a Centre of Excellence for Low Carbon and Fuel Cell Technologies. The centre will coordinate the UK’s experience in this area and is due to open in Spring 2005.
- The fuels working group has been working to combine the results of numerous studies of whole-life, ‘Wells to Wheels’ CO₂ emissions from various fuel chains.

For more information see www.lowcvp.org.uk

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20 Motorists in the UK can save up to £110 in VED each year by choosing the most efficient and least polluting cars. This level of saving does not greatly influence the choice of type of car.
DTI Technology Strategy and Programme
Research fund sponsored by the DTI which supports the development of new technologies on environmentally friendly transport. See [www.dti.gov.uk/technologyprogramme](http://www.dti.gov.uk/technologyprogramme)

DTI Foresight Programme
Again DTI-sponsored, the Foresight Programme aims to provide “challenging visions of the future, to ensure effective strategies now.” The Intelligent Infrastructure Systems (IIS) theme seeks to explore how science and technology may be applied over the next 50 years to the design and implementation of IIS that are robust, sustainable and safe.

The focus of research is on transportation of goods and people and the alternatives to mass movement; and the future of transportation systems and the application of information technologies and infrastructure. See [www.foresight.gov.uk](http://www.foresight.gov.uk)

DTI New Vehicle Technology Fund (NVTF)
The DTI-sponsored New Vehicle Technology Fund (NVTF) is available to help with the costs of building new demonstration vehicles. A successful demonstration vehicles is seen as being:

- A full size family car
- Affordable and capable of being mass produced within a near to medium term timescale
- Have tail pipe CO$_2$ emissions of less than 90 g/km (compared with over 175g/km for a similar new petrol car today)
- Be fuel efficient and travel around 1,000 miles between refill, with today’s 12 gallon tank.
- Capable of doing 80 miles per gallon or more, compared to today’s average of 36 miles per gallon.

A number of new vehicles have been launched via NVTF in 2004, for example:

- A hybrid electric black taxi was launched in Trafalgar Square by London Taxis International and Azure Dynamics. The taxi is able to run in zero emission mode and has the potential to reduce emissions by up to 50% in inner city operation.
- A new electric shuttle bus was launched in Lincoln. The walk and ride bus service uses Zebra battery technology and transports visitors up Steep Hill between the market and cathedral sectors of the city. The bus recharges its batteries as it descends the hill on the return trip.
- The Connaught hybrid sports car was launched at the Goodwood Festival of Speed: the concept hybrid has been designed to show that the hybrid concept can be applied to high performance vehicles.

Ultra Low Carbon Car Challenge (ULCCC)
Launched in 2003 by the Secretary of State for Transport, the Ultra Low Carbon Car Challenge (ULCCC) offers grants to car manufacturers to build,
demonstrate and test full size full performance cars that could be mass produced at an affordable price, with well to wheel carbon emissions of less than 100 grams/km (equating to fuel consumption of at least 75 mpg). The first of the demonstration vehicles should be on the road in 2005.

**Low Carbon Bus Programme**

Also launched in 2003, the Low Car Bus Programme aims to support the introduction of demonstration fleets of low carbon buses, with carbon emissions 30% lower than equivalent conventional buses. Demonstration fleets are expected to begin operation in the first half of 2005 and two low carbon buses have been developed with the support of the NVTF in 2004. The Eneco hybrid bus has demonstrated tailpipe carbon reductions of over 50% in trials in Manchester.

**UK Foresight Vehicle Programme**

Administered by the Society for Motor Manufacturers and Traders (SMMT), the Foresight Vehicle Programme is a knowledge transfer network for the automotive industry. The initiative aims to promote technology and stimulate suppliers to develop market driven enabling technologies for future motor vehicles (cars, taxis, HGVs, buses and light commercial vans).

**DTI Sustainable Energy Programme**

Under the Sustainable Energy Programme, DTI are supporting two projects that are looking at the development of a commercially viable process for converting waste tallow from animals into biofuels.

**Towards a Strategy for Biofuels in the UK (DTI, 2004)**

Consultation paper seeking views on what more Government might do to encourage the development and use of biofuels, the levels of biofuels sales targets that might be set for 2005 and 2010, and views on the possible introduction of a Renewable Transport Fuel Obligation (RTFO). Similar to the obligation that applies to electricity suppliers, the road fuel obligation would require specified sections of the road transport fuel industry to demonstrate that a specified proportion of their aggregate fuel sales were renewable transport fuels.

Biofuels are now available at 150 sites in the UK, including a number of supermarkets (Tesco for example launched biodiesel on a pilot basis at 20 stores in 2004).

There also a number of developments on the processing side that offer the possibility of reducing costs and/or improving environmental benefits. For example, the major oil companies are looking at the possible use of biomass material (rapeseed and other vegetable oils in the short term; wood, grass and organic wastes in the long term) in conventional oil refineries. The product of this process would be conventional diesel or petrol, however the inputs would be a mixture of mineral and bio-products. This gives the benefits of conventionally-processed biofuels without the cost and complication of separate fuel blending and distribution arrangements.
Highways Authority Vision 2030 (HA, 2003)

Vision 2030 seeks to develop a vision for the mobility needs of people and goods, including the potential roles of the strategic highways in meeting future mobility needs.

Three alternative socio-economic scenarios are developed, each associated with a vision for the future transport network:

- Global economy: a market-driven approach
- Sustainable lifestyle: a community-based way of living
- Control and plan: based on greater regulation of movement

Includes visions of the future such as smart highways and smart cars (using intelligent transports systems to increase safety and reduce crashes and collisions); the connected customer (ITS used to provide real-time information on travel choices); freight foremost (freight travel prioritised on major highways); door-to-door seamless public transport; transferiums and multi-modal travel interchanges; transport nodes as transhipment centres and holding areas; active traffic management (“sweating the corridor”); fast intercity travel (using alternative technologies such as MagLev); management of demand (including slot allocation and road pricing); and integrated land use planning.


DfT-commissioned study from E4Tech and IEEP, which considers the potential for biofuels and hydrogen and low carbon transport by 2050. The following conclusions are reached:

- It would be possible, by 2050, to reduce total carbon emissions from road transport to very low levels, through significant use of renewable hydrogen or biofuels. This could help the UK to achieve its goal to reduce CO2 emissions by 60% by 2050.
- Improvements in vehicle efficiency will be essential, but may not be sufficient in themselves to achieve very large carbon savings;
- It is not certain that a hydrogen economy will ever be realised. If it is, the UK could produce enough renewable hydrogen for road transport, but at the expense of renewable energy resource for other sectors.
- If the road transport fleet were fuelled entirely with biofuels by 2050, the UK could grow about one third of the necessary biomass; the rest would have to be imported.
- Both renewable hydrogen and biofuels are likely to be more expensive than today’s fuels. But the increased efficiency of hydrogen fuel cell vehicles means that the per km costs of these vehicles could be roughly similar to today’s vehicles.
- The large-scale use of either fuel would have numerous local environment, social and economic impacts (positive and negative), all of which would benefit from greater study.
The Carbon Trust
The Carbon Trust is an independent company funded by the UK Government. The Trust aims to help the UK move to a low carbon economy by helping businesses and the public sector reduce carbon emissions and capture the commercial opportunities of low carbon technologies. See www.thecarbontrust.co.uk

Transport Visions (Southampton University)
Funded by the Engineering and Physical Sciences Research Council (EPSRC) the Transportation Research Group at Southampton University established a network of young professionals. Subsequent additional funding has been provided by the Rees Jeffreys Road Fund and the Department for Transport (DfT). A Network Website was built at the end of 1999 and is used as a mechanism for individuals to join as well as a medium for disseminating information. The aim of the Network is to explore, through email and face-to-face discussion, transport visions for the 21st Century. 8 main reports were produced on various future visions, the topics covering:

- Society and Lifestyles
- Transportation Requirements
- Land Use Planning
- Vehicles and Infrastructure
- Local Travel
- Long Distance Travel
- Freight and Logistics

Further Technology Initiatives
The HyTrans Ford Transit project has reduced fuel consumption by up to 25% on an urban delivery cycle. A demonstration vehicle is expected on the road in 2005.

General Motors completed a ‘fuel cell marathon’ in the summer of 2004, driving a GM ’HydroGen3’ fuel cell vehicle over 10,000 km through major cities across Europe to test its on-road durability and reliability under a variety of conditions.

Conclusions
The guidance – from EU directives to UK governmental guidance and quasi non governmental organisational position statements – is thus very wide ranging. Other groups not mentioned here, such as Friends of the Earth, Sustrans, World Wildlife Fund, also have funded research in the CO\textsubscript{2} emissions and transport field. A brief summary of on-going governmental initiatives is shown below.

Table 7.2: Summary of Governmental Initiatives

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powering Future Vehicles</td>
<td>Aims to shift UK vehicle market to clean, low carbon vehicles and fuel</td>
</tr>
<tr>
<td>Strategy</td>
<td></td>
</tr>
<tr>
<td>Low Carbon Vehicle Partnership (LowCVP)</td>
<td>Partnership of organisations from motor industry, government, environmental groups</td>
</tr>
<tr>
<td>Program</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DTI New Technology Fund</td>
<td>Available to help with the costs of building new demonstration vehicles</td>
</tr>
<tr>
<td>Ultra Low Car Carbon Challenge</td>
<td>Offers grants to manufacturers to build, demonstrate and test full size performance cars with low emissions</td>
</tr>
<tr>
<td>Low Carbon Bus Programme</td>
<td>Supports the introduction of demonstration fleets of low emissions buses</td>
</tr>
<tr>
<td>UK Foresight Vehicle Programme</td>
<td>A knowledge transfer network promoting new technology developments</td>
</tr>
</tbody>
</table>
8 Deriving the Baseline, Scenarios and Target Development

8.1 Introduction
The use of a backcasting methodology necessitates the development of a baseline projection and also a target(s) projection. The VIBAT study develops a business as usual projection based on published sources and also a target using a 60% reduction in transport emissions to 2030 (using a baseline of 1990). Intervening years used are 1985/2000/2015 and 2030.

8.2 Deriving the Transport Emissions Baseline
The baseline for CO$_2$ emissions is available from Transport Statistics Great Britain (DfT, 2004 and earlier series) and Energy Paper 68 (DTI, 2003). Table 8.1 shows retrospective and prospective data for the years 1985/2000/2015 and 2030. This is derived from the published sources using linear growth between available data. Clearly there is a large increase in expected CO$_2$ emissions: for example, end user emissions for road transport are projected to increase by 88%, all transport by 73% from 1985-2030, compared to all emissions with an increase of 6%.

As an additional consideration, UK international air emissions currently amount to 8 MtC (9MtC including domestic). They are expected to rise to some 14-16 MtC by 2020. This is despite an improvement in the fuel efficiency of aircraft of around 1.7% p.a. (DTI Energy White Paper, 2003).

Table 8.1: Carbon Dioxide Emissions Projection by End User and Source Category in the UK

<table>
<thead>
<tr>
<th>End user category</th>
<th>1985</th>
<th>2000</th>
<th>2015</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road transport</td>
<td>26</td>
<td>38</td>
<td>42</td>
<td>49</td>
</tr>
<tr>
<td>Railways</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Civil aircraft</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Shipping</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>All transport</td>
<td>30</td>
<td>41</td>
<td>45</td>
<td>52</td>
</tr>
<tr>
<td>All emissions</td>
<td>156</td>
<td>148</td>
<td>153</td>
<td>166</td>
</tr>
<tr>
<td>UK international air emissions</td>
<td>-</td>
<td>8</td>
<td>14</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source category</th>
<th>1985</th>
<th>2000</th>
<th>2015</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road transport</td>
<td>-</td>
<td>32</td>
<td>40</td>
<td>49</td>
</tr>
<tr>
<td>Railways</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Civil aircraft</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shipping</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>All transport</td>
<td>-</td>
<td>35</td>
<td>45</td>
<td>51</td>
</tr>
<tr>
<td>All emissions</td>
<td>-</td>
<td>148</td>
<td>153</td>
<td>165</td>
</tr>
</tbody>
</table>

Unit: million tonnes of carbon (MtC)

End user emissions for transport: include a share of the emissions from combustion of fossil fuels at power stations and other fuel processing industries, but exclude activities emissions

Source categories: relate directly to the vehicle or other piece of equipment producing the emission (source categories data not available pre-1991)

TSGB 2004 low fuel price scenario used (a high fuel price scenario is also available)
Further work will provide a more detailed baseline, disaggregating the overall trends by mode and car technology, and providing estimates of passenger and vehicle km and CO$_2$ emissions in g/km.

### 8.3 Towards Acceptable Targets

Surprisingly for a topic of such importance, targets for transport CO$_2$ emissions have not been widely developed, certainly not in a directly comparable form to the TSGB and EP68 baseline data. A number of comparator CO$_2$ targets are available – covering total UK emissions - for example:

- The UK Kyoto commitment is a 12.5% reduction in six greenhouse gases\(^\text{21}\) below 1990 levels over the period 2008-2012.
- The UK domestic target is for a 20% reduction in CO$_2$ emissions below 1990 levels by 2010 (DETR, 2000).
- A path towards a 60% reduction in CO$_2$ emissions by 2050 has also been adopted (DTI Energy White Paper, 2003), following the recommendation of the Royal Commission on Environmental Pollution (RCEP, 1994).
- The Carbon Trust (2001) develops two baseline projections for 2050. Both assume emissions are 157 MtC in 1997, Scenario 1 projects emissions of 150 MtC and Scenario 2 emissions of 120 MtC by 2050.
- Foresight scenarios were developed by the DTI (1999). There are four scenarios: world markets, provincial enterprise, global sustainability and local stewardship (which are closely aligned to the IPCC SRES scenarios A1, A2, B1 and B2). A separate Foresight report considers the transport implications of these scenarios.

Other research studies have also considered future targets specifically for the transport sector:

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\(^{21}\) The six greenhouse gases are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride
A study by Ricardo (2003)\(^{22}\) considered a feasible route to highly efficient hybrid-electric diesel vehicles and hydrogen fuel cell vehicles. Their initial study proposed that by 2020 it would be possible to produce diesel powered vehicles that would be around 50% more efficient than a standard 2003 vehicle. The 2003 updated report has revised upwards the estimated CO\(_2\) savings based on improved estimates of vehicle performance.

The Policy and Innovation Unit (PIU, 2002) suggest that energy efficiency improvements could contribute a 14 MtC reduction by 2020 and 30 MtC reduction by 2050 in the transport sector. Measures include the ACEA/EC voluntary agreement, the use of hybrid engines and use of fuel cells.

The Inter-departmental Analysts Group (IAG, 2002) suggests a baseline for the transport sector of 59 MtC by 2050, assuming a continuation of current trends including increased efficiency, but no increased fuel prices, technology improvements, effects of congestion or car ownership saturation.

AEA Technology (2002) suggest various baselines according to different scenarios to 2050: business as usual (116 MtC), world markets (132 MtC) and global sustainability (99 MtC). A 45% target reduction results in emissions of 81 MtC, a 45% target reduction in emissions of 60 MtC and a 45% target reduction in emissions of 45 MtC.

ITS (2003) usefully match emissions reduction in the transport sector to global stabilisation targets: 550 ppm of CO\(_2\) by 2050 equates to total emissions of 62.2 MtC and 450 ppm equates to 31.1 MtC.

Below we show a 60% CO\(_2\) emissions reduction target to 2030 - for the transport sector and for end users and source category - using a baseline of 1990.

**Table 8.2: Carbon Dioxide Emissions 60% Target by End User and Source Category in the UK**

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>2000</th>
<th>2015</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>End user category</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road transport</td>
<td>26</td>
<td>38</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Railways</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Civil aircraft</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shipping</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>All transport</td>
<td>30</td>
<td>41</td>
<td>28</td>
<td>15</td>
</tr>
<tr>
<td>All emissions</td>
<td>156</td>
<td>148</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Source category</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road transport</td>
<td>-</td>
<td>32</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>Railways</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Civil aircraft</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shipping</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>All transport</td>
<td>-</td>
<td>35</td>
<td>25</td>
<td>14</td>
</tr>
<tr>
<td>All emissions</td>
<td>-</td>
<td>148</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Unit: million tonnes of carbon (MtC)

\(^{22}\) See www.dft.gov.uk/stellent/groups/dft_roads/documents/page/dft_roads_026217.hcsp
Figure 8.2: Carbon Dioxide Emissions Target by End User in the UK

Again, further work is being carried out to provide a more detailed target breakdown, disaggregating the overall target by mode and car technology, and providing estimates of passenger and vehicle km and CO₂ emissions in g/km.

8.4 Conclusions
The scale of change required to meet global environmental targets is thus large. A number of studies have suggested emissions targets for the UK as a whole, a small number have focused on the contribution expected from the transport sector. None as yet have used a backcasting approach. The
9 How Do We Get There? Available Measures and Benchmarks

9.1 Introduction
Any emissions reduction target will necessarily require a range of measures to help achieve it. An ambitious target such as a 60% reduction in CO\(_2\) transport emissions by 2030 will require radical and trend-breaking measures. These are likely to comprise of two main categories, as outlined below:

- Technological change: including fuel-efficient technologies, etc.
- Behavioural change: including pricing, soft factors and land use planning

To help us judge the feasible scale of change a number of benchmarks can be identified from the literature:

- Importantly, many of the actions are available now that will help us reduce greenhouse gas emissions and will become important steps in a long transition to a low-emissions transport system. To achieve this long-term transition, it will be necessary to take certain actions very soon (IEA, 2004).
- The Energy White Paper (DTI, 2003), on the basis of existing policies, expects UK carbon dioxide emissions of 135 MtC in 2020. To be consistent with ‘demonstrating leadership in the international process’ the EWP aims for cuts in carbon of 15-25 MtC below that by 2020.

These targets will be achieved by reducing the amount of energy consumption, together with a substantial increase in renewable energy. Central to this will be the carbon emissions trading scheme. The EWP vision is that “[in terms of the transport sector] hybrid vehicles will be commonplace in the car and light goods sectors, delivering significant efficiency savings. There will be substantial use of low carbon biofuels and hydrogen.”

9.2 Technological Change
The technological possibilities for reducing CO\(_2\) emissions are wide-ranging and there is much hope that they will provide the key to resolving climate change difficulties. Below we consider the most likely important contributions, in terms of renewable energy, nuclear energy, energy efficiency, the hydrogen economy and carbon sequestration. Whether technological developments will be of the scale to become a new Kondratieff wave - as part of a new, CO\(_2\) emitting benign future - is currently not well understood. The critical point to bear in mind is whether the development of these technologies will allow us to continue with our current energy intensive and high CO\(_2\) emitting lifestyles, or whether behavioural change will be required as well.

9.2.1 Renewable Energy, Energy Efficiency and the Hydrogen Economy
Renewable energy sources make use of natural energy flows in the environment, and include wind, waves, running water, sunshine and biomass (plant matter). Since they are continuously replenished they have great attraction an energy source. Renewable energy also emits zero or very low
levels of CO\textsubscript{2}. However, in total renewable energy contributes just 1.4\% of primary energy use in the UK (2002), an increase of 0.2\% since 2000.

The UK government’s target is that renewable energy should supply 10\% of electricity by 2010; it is currently only around 3\%. Hydropower currently accounts for 42\% of electricity generated from renewable energy; landfill gas 23\% and wind 11\%. Biomass and wind turbines are likely to be two main areas of growth. Further into the future, other technologies such as solar heating, photovoltaics, wave and tidal power may be able to make substantial contributions. Hydropower or geothermals are unlikely to experience significant growth.

**Biomass and Biofuels**

Biomass refers to any plant material, and biofuels to liquid fuel derived from plant material or recycled vegetable oils. The crops used to make fuel take in CO\textsubscript{2} when they grow, hence biofuels can markedly help reduce the transport sector's contribution to climate change; there is no net CO\textsubscript{2} emission over the lifecycle of the plants. Crops may be specially grown as an energy crop, or (in the vast majority of cases) be derived from a waste stream from another industry, e.g. forestry and sawmill waste.

Most biomass is currently used to produce heat; little is used for electricity generation. By far the largest contribution comes from wood burning for industry and domestic uses. Around 3\% of UK wood production is used for fuel. Hopes are again high that biomass can make a major contribution to electricity generation. At present the technology for growing and harvesting is in the prototype stage.

Biofuels have the added advantage that, after being processed from biomass, they produce only one third to half the emissions of petrol. There are two main types: biodiesel, which can be used as a direct substitute for fossil fuel diesel and alcohol, which can be blended with petrol in various formulations. Biodiesel is an oil which is extracted from various crops, usually rapeseed or sun flowers, and then treated. Alcohol (methanoll or ethanol) is produced from the fermentation of sugars and starches from various crops, e.g. sugar beet. The potential for biomass production is limited by the availability of arable land and the competing need for food production. Even if 25\% of the UK’s agricultural land was used to produce biofuel, it would displace at the most only 30\% of the current demand for transport fuels. Thus the potential for biofuels is somewhat limited, and is unlikely to reach even 1 or 2\% of current demand in the foreseeable future.

The Energy White Paper (DTI, 2003) states that a 5\% penetration of biofuels might be possible by 2020. This level could deliver carbon savings up to 1 MtC per year. E4tech and DfT (2004) suggest that biofuel use could reduce transport CO\textsubscript{2} emissions to very low levels; halving 2000 emissions by 2035 and 2045 (under rapid and slow uptake scenarios). Biofuels demand could in theory be satisfied to 2020 by UK-sourced biofuels, under both high and low demand scenarios, with both slow and rapid uptake of biofuels. Beyond 2020 this would not be the case under the high demand scenario with rapid uptake, and imports would be required. For all scenarios, under slow and rapid take up, imports would be required from around 2035 at the latest.
The Hydrogen Economy

The vision of using energy from electricity and electrolysis to generate hydrogen from water is a compelling but as yet unrealised ambition. Uses could of course include transportation and energy storage, and reducing environmental emissions. Hydrogen can be generated from a number of sources including water, biomass, natural gas or (after gasification) coal.

The hydrogen economy is not a new idea. In 1874, Jules Verne, recognising the finite supply of coal and the possibilities of hydrogen derived from water electrolysis stated that “water will be the coal of the future”.

A full build out of a hydrogen economy in the USA would be require 150 million tons per year, and this just for transportation needs. Current USA production is around 9 million tons per year. The possibilities of producing, storing, and distributing this level of hydrogen (just for USA consumption, never mind the rest of the world) are questionable.

An estimate as to the amount of hydrogen required for the vehicle fleet in the USA has been produced by Turner (2004), see Table 9.1. Conversion of the USA light-duty fleet (230 million vehicles) to fuel cell vehicles would require 100 billion gallons of water per year to supply the needed hydrogen. An equivalent calculation for the total UK vehicle fleet is also given below.

<table>
<thead>
<tr>
<th>Assumption</th>
<th>USA</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel economy</td>
<td>60 miles per kg of H₂</td>
<td>60 miles per kg of H₂</td>
</tr>
<tr>
<td>Vehicle miles travelled</td>
<td>2.6 x 10¹² miles per year²⁷</td>
<td>297 x 10⁶ miles per year</td>
</tr>
<tr>
<td>Proportion of hydrogen in</td>
<td>1 Gallon of water contains</td>
<td>1 Gallon of water contains</td>
</tr>
<tr>
<td>water</td>
<td>0.42 kg of H₂</td>
<td>0.42 kg of H₂</td>
</tr>
<tr>
<td>Total water required for</td>
<td>(2.6 x 10¹²) x (1/60) x (1/0.42) = 1 x 10¹¹ gallons of H₂O per year</td>
<td>(297 x 10⁶) x (1/60) x (1/0.42) = 11.8 billion gallons of H₂O per year</td>
</tr>
</tbody>
</table>

Note. UK vkm in 2001 = 478 bvkm = 297 bvmiles

9.2.2 Applying New Technologies to the Transport Sector

Many technologies and strategies are available today that can significantly reduce transport CO₂ emissions over the short to medium term. These include ‘incremental technologies’ to make vehicles more technically efficient than they are today and lessen their fuel consumption/km travelled; technologies to make transport systems and infrastructure more efficient,

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²³ Turner (2004) defines the hydrogen economy as “the production, storage, distribution and use of hydrogen as an energy carrier.
²⁶ Based on an estimate in Turner (2004)
reducing the need for vehicle travel, including more efficient routing, better in-use fuel efficiency and mode switching; and new lower carbon fuels and fuels lower in greenhouse gas emissions on a ‘well-to-wheels’ basis\(^{28}\) (IEA, 2004).

**Alternative Vehicle Technologies**

There are a number of alternative vehicle technologies that offer ways of reducing CO\(_2\) emissions. These include electric vehicles, hybrid electric vehicles, and vehicles powered by LPG, natural gas or fuel cells. Hillman (2004) gives a good description.

Electric vehicles have been under development for over a hundred years, yet have suffered from one key difficulty: that of not being able to travel very far on a single charge. And this has persisted despite improvements in battery technology. Another problem is in delivering enough power for acceleration. Given existing performance expectations by drivers, these are serious barriers to further uptake of electric vehicles. For specialist vehicles there is likely to be a larger market potential, e.g. milk floats (there are around 18,000 of these) and other delivery vans. The best prospect for electric vehicles is for urban deliveries over short journeys and at low speeds. There is little prospect of electric vehicles replacing conventional ones. The CO\(_2\) emissions associated with electric cars are directly related to the type of electricity production: renewable electricity is needed for zero carbon operation.

More promising are hybrid vehicles. These typically have a fossil-fuel internal combustion engine and an electric motor powered by batteries. There are different types of hybridisation, ranging from the capture of energy lost during braking and returning this to the battery (this is called regenerative braking), to full hybrids allow periods of electric-only operation and have an extended battery range. The electric fuel system is used for low speeds and for stop-start driving, and the fossil-fuel engine for travel at high speeds and outside urban areas. Energy efficiency savings differ, but models can reach 28 km/litre (80 miles/gallon), representing a saving of around 50% of energy and CO\(_2\) emissions on current conventional cars. Some progress has been made in improving vehicle efficiency for cars. Hybrid-electric vehicles are being developed by many major manufacturers, using power from both fossil fuel and electricity, and capturing energy usually lost through breaking. There are currently (2004) two hybrid-electric cars on sale in the UK: the Toyota Prius and the Honda Civic IMA.

Car manufacturers are investing considerably in research and development for fuel cell vehicles. There is much hope held for combining the fuel cell with the use of hydrogen as an environmentally safe transport solution. In the long term renewably produced hydrogen could allow road vehicles to operate with zero emissions. Fuel cells, like batteries, produce electricity by converting energy through a chemical reaction directly into usable electric power. However, unlike a battery, a fuel cell has an external fuel source, typically hydrogen gas. Hydrogen from a fuel tank and oxygen from the air combine to

\(^{28}\) For a fair comparison of the emissions associated with different energy carriers, the total well-to-wheels fuel chain should be considered. The use of fuel in vehicles is only the last stage in this chain. The total fuel chain consists of feedstock production (the well), feedstock transport, fuel production, fuel distribution, and fuel use in vehicles (the wheels).
produce electricity and warm water. The advantages of fuel cells depend on how the fuel they use is supplied. There are three options:

- Pure hydrogen produced by renewable energy
- Pure hydrogen produced by using fossil-fuel energy
- Fossil fuel, which is used to create hydrogen on board the vehicle

Only by using the first option are zero emissions achieved. Achieving large amounts of hydrogen from renewable energy lies at least 30 years in the future. The two other options however remain important. Using fossil fuels to power a fuel cell would still achieve emissions reductions, of a similar order to that of hybrid electric vehicles (up to 50%). The technology for fuel cell vehicles is however still in development, and is not expected to be commercially available for at least 10 years.

Alternative hydrocarbon vehicles are also available. Natural gas and LPG can be used as an alternative to petrol and diesel. LPG is mainly used in cars and light vans. Natural gas tends to be used in lorries and buses. There are around 25,000 LPG vehicles in the UK. Refuelling is carried out at the 1,000 or so refuelling sites in the UK, most are located at petrol stations. Natural gas vehicles are operated by many local authorities and companies. The natural gas has to be compressed or liquified for use in engines and requires a heavy storage tank. Hence the majority of natural gas vehicles are heavy duty trucks and buses. Natural gas is unlikely to be used in cars. Emissions from LPG vehicles are around 15% lower than the petrol equivalent and emissions from vehicles using compressed natural gas are 20% lower (IPPR, 2003).

Figure 9.1 shows the main alternative vehicle technologies in terms of energy sources, carriers, infrastructure and power trains.
Figure 9.1: Alternative Vehicle Technologies

Source: Sustainable Mobility Project
Vehicle Efficiency
Since 1990 the average carbon efficiency of new cars entering the fleet - the distance travelled for a given amount of carbon emitted - has improved by 10%. In 2003 new car fleet average CO₂ emissions were 173 g/km, a fall from the 2002 level of 175 g/km. EU voluntary agreements on new car fuel efficiency are likely to reduce emissions for the average new car from a 1995 base of 190g/km to 140g/km by 2008 (a reduction of around 25%). The DfT and DTI (2004) suggest that family cars with carbon emissions of 100g/km (equivalent to 75m/gallons of diesel) or less may be achievable in the next 20 years. The DfT suggests that a fuel efficiency improvement of 20% is possible by 2010 (DfT, 2003).

Improvements in the fuel efficiency of new cars are however being offset by a trend for consumers to buy larger, heavier, less fuel-efficient cars (despite the graduated Vehicle Excise Duty29), and wider uptake of additional features such as air conditioning (Bristow, 1996). In addition, as car ownership has risen, occupancy has fallen. Hence on current progress it is unlikely that the UK will reach the 100g/km target. There are difficulties associated with take-up: hybrid cars are still relatively expensive, few incentives are provided to buy high-efficiency vehicles. More effective labelling systems may prove effective.

The EU voluntary agreement also only relates to new cars entering the car fleet. The vehicle turnover time lag means that cars built in the 1990s are still likely to make up much of the car fleet in the early 2000s. In the coming years, much of the improvement in new car CO₂ emissions is expected to come from a switch to diesel. Diesel cars are more efficient than petrol, hence emit less carbon. In 2002, diesel represented 24% of new car registrations in the UK (SMMT, 2002). A critical point to bear in mind is that the improvements seen in vehicle efficiency have been massively outweighed by the increasing use of transport.

Table 9.2: Current New Car Fuel Efficiency (Well-to-Wheels)30

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>CO₂ emissions (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honda Insight (petrol/electric hybrid 1.0 IMA coupe)</td>
<td>92</td>
</tr>
<tr>
<td>Renault Clio (1.5 80bhp Diesel)</td>
<td>127</td>
</tr>
<tr>
<td>Smart City Coupe (Pure Petrol)</td>
<td>130</td>
</tr>
<tr>
<td>Toyota Prius (1.5 petrol/electric hybrid)</td>
<td>131</td>
</tr>
</tbody>
</table>

(From Bristow et al, 2004)

29 Motorists in the UK can save up to £110 in VED each year by choosing the most efficient and least polluting cars. This level of saving does not greatly influence the choice of type of car.

30 Fuel efficiency is expressed in terms of 'test cycle' results. Real on-road emissions differ significantly from these as driving conditions differ. The relationship between test cycle and real world emissions is likely to change as vehicle technologies develop. For example, increases in congestion may mean that this relationship diverges further.
Fuel efficiency improvements are estimated to be slightly less for freight vehicles. The DfT (2003) forecasts an improvement of 15% for LGVs and articulated HGVs and 12.5% for rigid HGVs by 2010 (DfT, 2003). The trend for LGV CO₂ emissions over time is not available. It is worth noting that much of the growth in HGV traffic is occurring in the largest articulated lorries.

Table 9.3: Current New Light Goods Vehicle Fuel Efficiency (Well-to-Wheels)

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>CO₂ emissions (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Vans</td>
<td></td>
</tr>
<tr>
<td>Citroen Berlingo Multispace (1.9 Diesel)</td>
<td>181</td>
</tr>
<tr>
<td>Peugeot New Partner Combi (2.0 Diesel)</td>
<td>152</td>
</tr>
<tr>
<td>Volkswagen CV Caddy Kombi (1.9 Diesel)</td>
<td>154</td>
</tr>
<tr>
<td>Fiat Doblò Range (1.9 Diesel)</td>
<td>176</td>
</tr>
<tr>
<td>Large Vans</td>
<td></td>
</tr>
<tr>
<td>Ford New Transit Torneo (2.0 Turbo Diesel)</td>
<td>209</td>
</tr>
<tr>
<td>Volkswagen CV Caravelle (2.5 Diesel)</td>
<td>213</td>
</tr>
<tr>
<td>Volkswagen CV Multi-Van (2.5 Diesel)</td>
<td>240</td>
</tr>
<tr>
<td>Volkswagen CV Kombi (2.8 Diesel)</td>
<td>289</td>
</tr>
</tbody>
</table>

(From Foley and Fergusson, 2003, and based on estimates by DfT using information supplied by vehicle manufacturers in 2003)

Passenger Transport
An EU-funded project (with contributions from the New Vehicle Technology Fund) is a demonstration project for hydrogen fuel cell bus fleets in major cities across Europe. London is one of the cities taking part, with three hydrogen fuel cell bus buses starting a two-year trial in 2004. The first hydrogen refuelling station in the UK has been built at Hornchurch in Essex.

Ultra low sulphur diesel buses have also been trialled in London by Shell, with reduced emissions of key air pollutants and a small reduction in emissions of tailpipe CO₂. Gas to liquids fuel technology is further being tested by Shell in conjunction with Toyota cleaner engine and catalyst technology in a fleet of Avensis cars. The DfT is also carrying out emission tests of water diesel emulsion fuels (WDE) with the London Borough of Camden.

In terms of air transport, British Airways has led the industry in setting a target of 30% reduction in fuel consumption per passenger km over a 20-year period. But this improvement is largely outweighed by the expected growth in flights.

9.2.3 The Potential for Change
Dramatic reductions in emissions (in some cases over 90% reduction potentials - see Tables 9.3 and 9.4) can in theory be achieved by using available and emerging energy vehicle saving technologies coupled with propulsion systems that rely on cleanly produced biofuels, electricity produced centrally without accompanying emissions, and electricity from fuel cells powered by cleanly produced hydrogen (IEA, 2004). A critical issue for this study is to judge the most likely contribution from the technological sector.
Figure 9.2: Technological Change Possibilities

Table 9.3: Vehicle-Related Technologies Potential Well-to-Wheels CO₂ Emissions Reductions (per km of driving)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Condition</th>
<th>Well-to-wheels CO₂ emissions reduction potential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&gt;10%</td>
</tr>
<tr>
<td>Higher gasoline engine</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher diesel engine</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid engine</td>
<td>Largest efficiency gains in urban traffic</td>
<td>✓</td>
</tr>
<tr>
<td>Lightweight vehicle</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Electric vehicle</td>
<td>Using electricity produced from renewable or</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>nuclear energy or from fossil energy with CO₂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>capture and storage</td>
<td></td>
</tr>
<tr>
<td>Fuel cell vehicle</td>
<td>Using hydrogen produced from renewable or</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>nuclear energy or from fossil energy with CO₂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>capture and storage</td>
<td></td>
</tr>
<tr>
<td>Intelligent transport system</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Notes (IEA, 2004): Criterion can be met ✓ Criterion may be met ? Criterion cannot be met ✗
### Table 9.4: Alternative Fuels Potential Well-to-Wheels CO₂ Emissions Reductions (per km of driving)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Condition</th>
<th>Well-to-wheels CO₂ emissions reduction potential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&gt;10%</td>
</tr>
<tr>
<td>Liquefied petroleum gas (LPG)</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>Natural gas</td>
<td></td>
<td>?</td>
</tr>
<tr>
<td>Dimethyl ether (DME)</td>
<td>Produced from natural gas</td>
<td>?</td>
</tr>
<tr>
<td>Ethanol, methanol (current technologies)</td>
<td>Produced from starchy crops (e.g. wheat, sugar beets); significant fossil energy in fuel chain</td>
<td>✓</td>
</tr>
<tr>
<td>Biodiesel (current technologies)</td>
<td>Produced from oil seed crops; significant fossil energy in fuel chain</td>
<td>✓</td>
</tr>
<tr>
<td>Advanced biofuels - ethanol, diesel, DME</td>
<td>Produced from lign-cellulosic biomass, primarily renewable energy in fuel chain</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Produced from fossil energy (e.g. fossil powered electricity or directly from natural gas)</td>
<td>✓</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>Produced from renewable or nuclear energy or from fossil energy with CO₂ capture and storage</td>
<td>✓</td>
</tr>
<tr>
<td>Electricity</td>
<td>Produced from renewable or nuclear energy or from fossil energy with CO₂ capture and storage</td>
<td>✓</td>
</tr>
</tbody>
</table>

Notes (IEA, 2004): Criterion can be met ✓  Criterion may be met ?  Criterion cannot be met ×

The IEA (2004) gives guidance on the likely take up of these technologies:

- A 5% displacement of transport motor fuels across ECD countries could be achieved by 2010 with stronger national programmes, particularly those targeting liquid biofuels
- A 10% reduction in the fuel used for freight movement over the next ten years. Reductions in the order of 25-30% appear achievable in the freight sector over the next 15 to 20 years.

Current UK transport policy aims to reduce greenhouse gas emissions from transport by 5.6 MtC below trend by 2010. This would leave emissions from the sector slightly above 2000 levels. The Energy White Paper (DTI, Annex 4, 2003) predicts a reduction of 2-4 MtC in total from road transport by 2020. This assumes the introduction of 5% biofuels into petrol and diesel (as blends), which could save around 1 MtC by 2020; and that the current voluntary agreement with European car manufacturers will be extended to require the new car fleet to achieve an average of 100-115g/km in 2020. The EWP suggests that, taken together, the continuation of voluntary agreements on vehicle carbon dioxide performance, increased use of biofuels and other initiatives could improve carbon efficiency of transport by up to 10% by 2020. Carbon savings will increase further beyond 2020 as more fuel efficient cars spread progressively into the fleet. Deeper carbon reductions however require hydrogen (generated from non-fossil fuel sources) or biomass-based
liquid fuels. The auto industry expects hydrogen powered fuel cells to move towards mass marketing around 2030.

In terms of achieving a sustainable, near-zero-emissions transport system there are only three current possibilities: (1) converting to a hydrogen fuel cell system, (2) moving to a purely electric vehicle system, or (3) relying on liquid fuels that are derived from biomass. Transition to such a transportation system is likely to take 40 years or more (IEA, 2004). The UK government has recently begun to develop a hydrogen energy strategic framework.

9.3 Behavioural Change

Efforts to reduce the growth in vehicle travel are often related to goals other than saving reducing CO₂ emissions or saving energy. The literature on behavioural change - estimating the potential contribution of integrated pricing, soft factors and land use planning in reducing travel - is much less developed than that on technological change. This is a major research gap; there is a need for a real push on the research effort here. The major tools include:

- Pricing for road use: The Commission for Integrated Transport (CfIT, 2002) calculates that a national road user charging scheme, implemented in 2010 and revenue neutral to 2015 (offset by reductions in vehicle excise duty and fuel duty) would yield a maximum 5% reduction in vehicle kilometres.

- Soft factors: measures such as workplace and school travel plans, personalised travel plans, car clubs and teleworking could lead to a reduction in peak period urban traffic of around 20%, a reduction of peak period non-urban traffic of around 14%, and a nationwide reduction in all traffic of around 11% (Cairns et al, 2004).

- Land use planning: the literature dealing specifically with the interaction of land use planning with travel behaviour has developed from the late 1980s onwards and has come to include a rapidly expanding literature. The academic debate as to the potential for structuring urban form and influencing travel behaviour has been mainly carried out in the UK, the USA and Australia. Key authors include Newman and Kenworthy (1989 and 1999), Cervero (1989), Headicar and Curtis (1995) and Banister et al (1997). The underlying theme of much of the research has been to evaluate the potential contribution of land use planning in reducing car-based travel. A number of topic areas have received considerable coverage in the literature, such as the influence of population size, density, public-transit orientated development, smart growth, urban sprawl, the provision and mix of local facilities, local neighbourhood design, the location of development, balance of jobs and housing and also wider socio-economic variables. Few authors have managed to estimate the contribution that land use planning might play in reducing travel, partly due to the difficulty in isolating the effect of land use factors from other variables. Ecotec (1993) are most often quoted in the UK: suggesting that land use planning measures could achieve a 10-15% reduction in CO₂ emissions over 20 years in a large urban sub-region. Some authors in the USA have suggested much larger contributions. WS Atkins (1999) have suggested reductions in traffic of up to 2% could be achieved by 2010.
Stead (1999) has recently brought a number of these areas together using regression analysis. For example, he suggests that socio-economic variables explain between 19-24% of the variation in distance travelled and land use variables up to 3% at the individual level of analysis. At an area-wide level this influence increases: socio-economic variables explain between 23-55% of the variation in distance travelled and land use variables up to 27%. Hickman (2005) suggests that land use can explain up to 5% of the variation in energy consumption in the commute to work, compared to socio-economic (including attitudinal) variables of up to 14%. Critically a wide range of land use and socio-economic measures can be mutually reinforcing in contributing to travel reductions. Figure 9.3 shows the main options available in terms of reducing vehicle kilometres (and CO\textsubscript{2} emissions): remove trips, switch mode or reduce distance. This project needs to understand the likely potential for behavioural change by 2030.

Figure 9.3: Behavioural Change Options

(Source: Banister and Marshall, 2000)
Hillman (2004) outlines the potential for carbon rationing. A system of tradable CO₂ emission permits would have several effects. Say, for example, that individuals are given a free yearly CO₂ budget (and are free to buy or sell permits at a market price); they may try to optimise their travel patterns within their budget. Possible effects are:

- A reduction in the number of passenger kilometres, depending on the total CO₂ budget for passenger transport and the price of buying extra CO₂ permits
- Less energy use per vehicle kilometre, with improved energy efficiency of cars and better driving behaviour, so that more vehicle kilometres can be driven with the same CO₂ permit
- Modal split changes, with the use of non-motorised transport increasing

Some authors see carbon rationing as critical to meeting future CO₂ targets.

**Figure 9.4: Behavioural Change Possibilities**

![Diagram showing CO₂ emissions and possible behavioral changes over time.](image_url)
9.4 Conclusions
The interesting issue for this study is to identify the particular contribution of (integrated) technological and behavioural change, and the balance of effort that is required to help achieve the selected targets. The next stages of the study will move on to consider these issues.

Figure 9.5: An Integrated Approach

What is becoming clear is that it is very unlikely that the technological option will be sufficient by itself to achieve ambitious CO₂ targets. An added dimension is that surveys tend to highlight that public support for technological change is stronger than that for changes in lifestyle and (travel) behaviour.
10 Synthesis, Conclusions and Next Steps

10.1 Concluding Thoughts: The Imperative for Change

Goodwin et al (1991) identified a new realism in transport planning, using the publication of the National Road Traffic Forecasts (DoT, 1989) as a watershed moment. The forecasts of economic growth and existing trends meant that traffic levels would increase by between 83% and 142% from 1988 to 2025. This scale of potential traffic growth meant that road building could not hope to keep up with demand. Whatever road construction policy was adopted, congestion would increase and hence the new requirement for policy was one of demand management.

The transport world has however moved on apace. A new determinant is now the global environmental imperative. The new realism in 2005 is that CO₂ emission targets necessitate radical change in the transport sector. We need to start implementing traffic demand management strategies across the UK, and critically to appraise transport investment plans against global environmental targets. There is little understanding as to how local transport plans and other investment strategies are likely to contribute to emissions targets. This appears to be a huge evidence gap.


“One day we walked down to Trafalgar Square. The tide was in, and the water reached nearly to the top of the wall on the northern side, below the National Gallery. We leant on the balustrade, looking at the water washing around Landseer’s lions, wondering what Nelson would think of the view his statue was getting now …

She took my arm, and we started to walk westward. Halfway to the corner of the Square we paused at the sound of a motor. It seemed, improbably, to come from the south side. We waited while it drew closer. Presently, out from the Admiralty Arch swept a speedboat. It turned in a sharp arc and sped away down Whitehall, leaving the ripples of its wake slopping through the windows of august Governmental offices.”

Global catastrophicism maybe; but useful, at least, in articulating the scale of the problem. The difficulties of Popper still remain - we cannot anticipate today what we shall know only tomorrow - yet the imperative for reducing transport emissions is here. A critical issue should be borne in mind: (normally) a totally new idea or new knowledge will not be implemented immediately. There is a time span between the emergence of a new idea and it being widely applied in practice. The classic example here is fuel efficiency.

31 From Wyndham, J. (1953) The Kraken Wakes
improvements in vehicles. Hence, existing knowledge and ideas may have a profound influence on future trends in the short term. Popper's indeterminacy problem is often only experienced in the long term.

Scenario building and backcasting provide a way forward empirically, and form the next stages of the VIBAT research through the development of images of the future and policy packages. The lack of progress in the transport sector towards achieving global environmental targets means that - if we are to meet medium and longer-term targets - we need to be agreeing policy pathways now. If global sustainability targets are to be achieved then the transport sector needs to make a contribution in terms of emissions reduction; this necessarily means action on both technological and behavioural fronts. And action needs to start now [in 2005] if a Wyndham-esque future is not to be realised.

10.2 Next Study Steps

The VIBAT research continues into Stages 2 and 3 by developing images of the future and policy packages.

This background paper has been produced by Robin Hickman and David Banister as part of the VIBAT project under a contract with the Department for Transport. Any views expressed are not necessarily those of the Department for Transport.

For more information on the project see

http://www.bartlett.ucl.ac.uk/research/planning/vibat
Annexes

Annex 1: The Study Team
Annex 2: VIBAT Work Programme
Annex 3: Workshop 1 Key Issues
Annex 4: Detailed Baseline and Targets
Annex 5: References

Flysheet photo credit: Satellite Picture of the Earth in 1983 (from 60 Years of Photojournalism, Black Star Pictures, 1997)
Annex 1: The Study Team

The Bartlett School of Planning, University College London

Over the past 10 years, the Bartlett has focused much of its research on the interface between transport and sustainable development. This has involved the development of methods to analyse the links between transport, density and urban form, exploring the spatial and social implications, looking at policy interventions, and evaluating alternatives. Included here has been the using of scenario building methods and the development of modified backcasting as a means to vision about the future (2020-2050) and to develop policy paths from the present to alternative futures. Recent studies include:

- Policy scenarios for sustainable mobility (POSSUM) – this project developed the backcasting scenario building methodology
- Designs to avoid the need to travel in Europe (DANTE) – looks at the methods to analyse and monitor policy packages together with implementation problems
- The Impact of ICT on Transport (ICTRANS) and Transport – a recent application of the methodology (2003)
- Transport, land use and sustainability (TRANSPLUS) – examines the institutional aspects of sustainable transport

Additional city-based scenario building studies have been carried out for:

- Foresight for Transport research on the social and motivational impacts of new transport and ICT technology
- The German Government as part of their URBAN21 project
- RICS (Visions of the Future project)

David Banister is Professor of Transport Planning at University College London. He gained a BA Geography from Nottingham University and a PhD Transport (1976) from Leeds University. From 1994-1997 he was Visiting VSB Professor at the Tinbergen Institute, Amsterdam, and in 2000-2001 was a Visiting Fellow at the Warren Centre for Advanced Technology, Sydney.

He was elected as a Member of the Chartered Institute of Transport (1977), as a Fellow of the Royal Society of Arts (1988), and as a Member of the Institute of Logistics and Transport (2000). He has also been a member of research council committees (ESRC, EPSRC) for the last 20 years, and various government research committees, and an advisor to national and international agencies on their research programmes in transport, the environment and sustainability.


In addition, he is the author or co-author of more than 70 papers in international refereed journals, and he has published a further 70 papers in journals or as chapters in books. Other outputs include research monographs (more than 30), reports for researcher sponsors (over 100) and he has presented over 100 papers at international and national conferences, and made written and oral contributions to several government and other reviews, and has contributed to over 50 consultancy projects. He is editor of two international journals Transport Reviews and Built Environment and a book series on Transport and Development.

Halcrow Group Ltd

Halcrow is one of the world’s leading firms of multi-disciplinary consultants with staff who are expert in a range of relevant disciplines including transport and urban planning, policy research, masterplanning and urban design, economic development, infrastructure and engineering, and environmental assessment. With over 4,500 staff in some 40 countries across five continents, and with 29 offices in the UK, Halcrow provides a comprehensive range of specialist services to clients.

Halcrow has extensive experience of providing transport and planning policy guidance to government departments, local authorities and environmental agencies. They have undertaken policy, research and management studies — often in tandem with leading academic institutions such as University College London - on behalf of the DfT, ODPM, Cabinet Office, DEFRA, DTI, English Partnerships, RDAs, Regional Assemblies, English Nature, English Heritage, Countryside Agency, Highways Agency, Environment Agency and numerous local authorities.

Robin Hickman is an associate transport and urban planner at Halcrow with wide experience in transport and urban planning, policy research, master planning, urban design, economic development and regeneration. He has project-managed and assisted with a variety of commissions for central, regional and local governments and the private sector, throughout the UK and abroad. Current work includes the Thames Gateway Integrated Land Use and Transport Study (for TfL), a Local Development Framework for Ashford and masterplanning principles and sustainability criteria for Harlow.

Robin is currently seconded to the Bartlett School of Planning, UCL to work on Visioning and Backcasting for UK Transport Policy (VIBAT). See www.bartlett.ucl.ac.uk/research/planning/themes

Previous research studies include Going to Town: Improving Access to Town Centres (published in 2002 as a companion guide to PPG6, available on www.nrpf.org), and Transport and City Competitiveness, available on www.dft.gov.uk. Master planning and urban development frameworks include the London Plan Sub-Regional Development Frameworks; a Spatial Strategy for the Leeds Sub-Region; Cambridge Eastern Expansion; Cambridge Northern Fringe; Walker Riverside Masterplan; Camborne, Pool and Redruth Urban Development Framework; Park Royal Industrial Estate
Regeneration; Brixham Harbour Masterplan; Coatesville Main Street
Revitalisation (USA); and the Merseytram Urban Design Guide.

Robin is currently completing his PhD in Planning Studies at the Bartlett
School of Planning with a thesis titled "Reducing Travel by Design: A Micro
Analysis of New Household Location and the Travel to Work in Surrey". For
more details see www.bartlett.ucl.ac.uk/planning/people/phd
Annex 2: VIBAT Work Programme

The VIBAT study is planned in three main work stages as shown below. Each stage includes a study seminar and draft working paper.

Figure A2.1: Work Programme

<table>
<thead>
<tr>
<th>Study Phase</th>
<th>TASKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study Phase</td>
<td>TASKS</td>
</tr>
<tr>
<td>Literature review and target development</td>
<td>Study workshop 1</td>
</tr>
<tr>
<td>Previous methodological approaches</td>
<td>Study workshop 2</td>
</tr>
<tr>
<td>Environmental imperative</td>
<td>Study workshop 3</td>
</tr>
<tr>
<td>Demographic and transport trends</td>
<td>Final Stage 3 Final Report</td>
</tr>
<tr>
<td>Technological intervention/lifestyle change</td>
<td>Final Stage 3 Final Report</td>
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<td>Report to Client DfT</td>
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<td>Images of the Future</td>
<td>Robin Hickman</td>
</tr>
<tr>
<td>Possibilities for technology/lifestyle change</td>
<td>David Banister</td>
</tr>
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<td>Image 1: technology</td>
<td>Task in detail</td>
</tr>
<tr>
<td>Image 2: lifestyles</td>
<td>Draft paper</td>
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<tr>
<td>Image 3: composite</td>
<td>Final stage report</td>
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<td>Policy Measures and Policy Paths</td>
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<td>Conclusions</td>
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Annex 3: Study Workshop 1

A series of workshops are planned throughout the VIBAT study to gain expert opinion at key stages of the study.

Workshop 1

Topic: CO₂ transport emissions baseline and target derivation

Participants:
- David Banister (The Bartlett School of Planning, UCL)
- Robin Hickman (Halcrow Group)
- Ian Hawthorne (Department for Transport)
- Stephen Hennigen (Department for Transport)
- Liz Cox (Department for Transport)
- Michael Bach (Office for the Deputy Prime Minister)
- Steve Atkins (Strategic Rail Authority)
- Alan Wenban-Smith (Urban and Regional Policy Consultant)
- Jillian Anable (Robert Gordon University)
- Abigail Bristow (Institute for Transport Studies, University of Leeds)
- Miles Tight (Institute for Transport Studies, University of Leeds)
- Alison Pridmore (Sustainable Development Commission)
- Simon Lister (Independent Researcher0
- Stephen Plowden (The Slower Speeds Initiative)
- Ian Skinner (Institute for European Environmental Policy)
- Stephen Joseph (Transport 2000)
- Peter Lipman (Sustrans)

A summary note of the discussion is available as a separate working paper.
Annex 4: Detailed Baseline and Targets

Available as a separate working paper.
Annex 5: Definitions and Glossary

Units of Measure

- GtC: gigatonnes of carbon (a thousand million tonnes)
- kgC: kilogrammes of carbon
- kgCO$_2$: kilogrammes of carbon dioxide
- MtC: million tonnes of carbon
- mtoe: million tonnes of oil equivalent
- ppm: parts per million
- tC: tonnes of carbon
- tCO$_2$: tonnes of carbon dioxide
- toe: tonnes of oil equivalent

Note: Carbon dioxide emissions are usually measured in tonnes of carbon (tC). Occasionally tonnes of carbon dioxide (tCO$_2$) are used.

One tonne = 1,000 kg
One tonne of carbon = 3.67 tCO$_2$

Abbreviations

- CfIT: Commission for Integrated Transport
- DEFRA: Department for Environment, Food and Rural Affairs
- DfT: Department for Transport
- DTI: Department for Trade and Industry
- EU: European Union
- IEA: International Energy Agency
- IPCC: International Panel on Climate Change
- ODPM: Office for the Deputy Prime Minister
- OECD: Organisation for Economic Co-operation and Development
- RCEP: Royal Commission on Environmental Pollution
- UCL: University College London
- CO$_2$: Carbon Dioxide
- NO$_x$: Nitrogen Oxides
- CO: Carbon Monoxide
- VOC: Volatile Organic Carbon
- PM$_{10}$: Particulates
Annex 6: Selected References

AEA Technology (Future Energy Solutions) and Imperial College Centre for Energy Policy and Technology (2002) Options for a Low Carbon Future.


