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Looking over the horizon: Transport and reduced CO_2 emissions in the UK by 2030

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Abstract

Transport is a major user of carbon-based fuels, and achievement of the targets set at the Kyoto Protocol and elsewhere means that the EU and national governments must reduce CO_2 emissions in all sectors, including transport. This paper reports on a recently completed study for the UK government on the options available to meet a 60% CO_2 reduction target by 2030 in the UK transport sector. The study follows a backcasting study approach, developing a business as usual baseline for transport emissions, and two alternative scenarios to 2030. Different policy measures are assessed and assembled into mutually supporting policy packages (PP). Although 2030 seems a long way ahead, action must be taken now if the targets for CO_2 reduction are to be met. The achievement of a carbon-efficient transport future, combined with holding travel levels at present levels, is likely to be very difficult. A major transformation in the way transport and urban planning is carried out is required. As transport and urban planners, we need to think very differently in tackling the new environmental and liveability imperative.

Keywords: Transport; Global warming; Carbon emissions; Futures; Backcasting

1. Introduction

The issues relating to climate change have risen dramatically to the top of the political agenda, and the importance of transport in contributing to reducing levels of CO_2 is clearly evident. Yet the difficulty remains that traffic levels continue to rise and all the projections suggest that more emissions rather than less are likely to arise by 2030 and beyond. We hence need to start to think very differently in tackling the global emissions problem.

The Visioning and Backcasting for UK Transport Policy[2] (VIBAT) project has examined the possibility of reducing UK transport CO_2 emissions by 60% by 2030. It has examined a range of policy measures (i.e., technological, behavioural and regulatory), and assessed how they can be effectively combined to achieve this level of CO_2 emissions reduction. The intention has been to assess whether such an ambitious target is feasible, to identify the main problems, and to comment on the main decision points.

There are three main stages in this innovative research project (Fig. 1). The first is to set targets for 2030 and to forecast the business as usual situation for all forms of transport in the UK over that period, so that the scale of change can be assessed. The second is to describe the transport system in 2030 that will meet the reduction target. This has taken the form of two alternative visions of the future that will push both the technological and the behavioural options, separately and in combination. The third stage is the backcasting process, where alternative

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(*footnote continued*)
Transport. Full documentation and background reports are available: ⟨http://www.ucl.ac.uk/ucft696/vibat2.html⟩.

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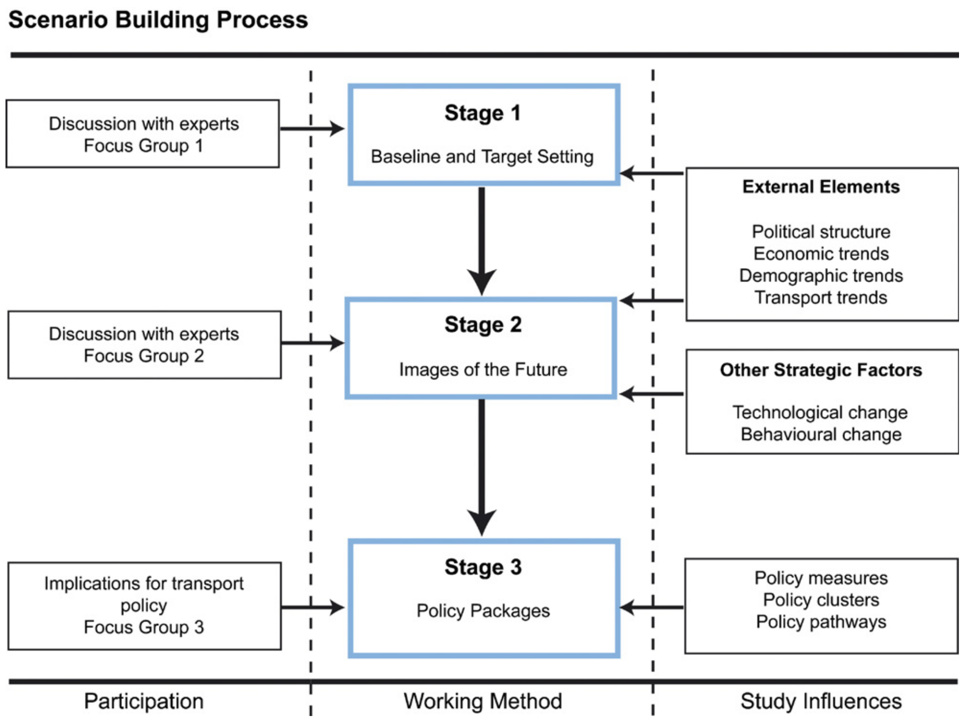

Fig. 1. The VIBAT study approach.

policy packages (PP) are assembled to lead to the images of the future, together with their sequencing in terms of when implementation should take place.

The benefits of scenario building are that packages of policy measures can be developed to address ambitious CO_2 emissions reduction targets. This allows trend-breaking analysis, by highlighting the policy and planning choices to be made, by 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 background against which more detailed analysis can take place. This paper presents the methodological approach followed in the study as well as some of the findings in terms of measures, PP and policy pathways that might help us move towards a more sustainable transport future.

The VIBAT study considers a similar topic to previous studies, such as the OECD project on Environmentally Sustainable Transport, EST (OECD, 2000), Pridmore et al. (2003) and Bristow et al. (2004), in considering the ways of achieving large-scale cuts in carbon emissions. It, however, modifies the usual backcasting study approach to quantify the likely impacts of policy measures and PP.

2. Future studies and the backcasting approach

It is important to look at the longer term future, particularly when dealing with policies relating to sustainable transport, as many interventions require long lead times to be effective, impacts often take time and may have unexpected results, and also different policies combined to work in synergetic ways are likely to be the most effective. To help us understand these longer term futures, a number of empirical research techniques are available.

Futures studies have been increasingly used in the last few decades to illustrate what might happen to society in adapting to challenging future trends and targets, and they are now making a substantial impact on policy making. The traditional forecasting approach is still dominant in many research studies looking over the shorter term, but there are strong concerns as to the usefulness of forecasting in the study of highly complex, long-term problems where trend-breaking futures are required. Sustainable transport is such a topic. Based on extrapolating existing trends, forecasting is unlikely to generate creative and radical solutions to current policy challenges. Scenario building approaches offer one alternative approach to looking over the longer term, and they can be considered as being complementary to the current range of transport models.

This study has taken and adapted one particular scenario building approach to UK transport policy over a 30-year time horizon. The backcasting study approach has been used widely in Scandinavian research over the last 20 years and also in a number of pan-European projects, such the OECD EST study (OECD, 2000) and the EU-POSSUM project (Banister et al., 2000). The latter was the first to assess European transport policies as to their consistency and feasibility, using a qualitative scenario-based approach based on backcasting.

The term backcasting was first introduced by Robinson (1982) 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

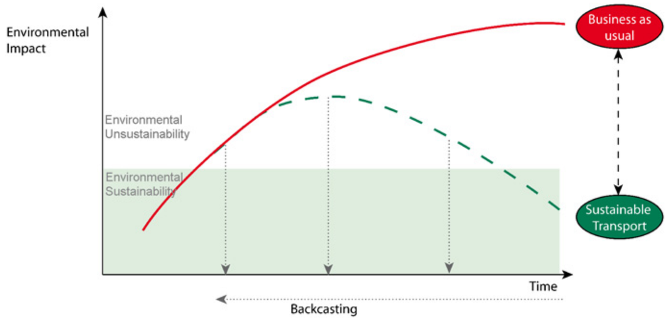

Fig. 2. The backcasting framework.

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). There is a considerable literature on the methodology and technical issues relating to backcasting (Geurs and van Wee, 2004; Dreborg, 1996; Banister et al., 2007; and Akerman and Höjer, 2006).

Fig. 2 shows the main features of the backcasting 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—'casting back' from the future—in 25, 20, 15, 10 and 5 years time. The term 'scenario' covers both the images of the future and the trajectory leading back to the present. This definition is more comprehensive than those normally used; where a scenario is seen more as an end in itself.

3. The business as usual baseline

The first stage of the backcasting process is in understanding the baseline and the likely targets to the future forecast year (2030 in this study). In deriving a baseline and projections for CO_2 emissions, we have used historical data from NETCEN, the National Traffic Forecasts (DETR, 1997), and the published projections made available in Transport Statistics Great Britain (Department for Transport, 2005) and Energy Paper 68 (DTI, 2003). This secondary data has been supplemented by outputs from the Department for Transport National Traffic Model. The situation is therefore complicated in the UK by there being no central business as usual baseline for transport CO_2 emissions to 2030 and beyond.

Clearly there is likely to be a large increase in expected CO_2 emissions over time. Using the latest projections from Transport Statistics Great Britain, all transport emissions[3] are expected to rise from 38.6 MtC in 1990 to 52 MtC in 2030, a projected increase of 35% (Department for Transport, 2004). This compares to all emissions of greenhouse gases in the UK, where an increase of 3% is expected over the same period (Anable and Boardman, 2005). The official projections from the DfT, based on the assumptions in the 2004 Transport White Paper (and which in turn broadly reflect the current UK transport policy) show a reduced level of emission-holding levels in 2030 to something similar to present day emissions Table 1.

Table 1
Carbon dioxide emissions projection by end user in the UK

End user category	1985	1990	2000	2015	2030
Road transport	28	35	38	42	49
Railways	1	2	2	1	1
Civil aircraft (domestic)	0	0	1	1	1
Shipping (domestic)	2	2	1	1	1
All transport	31	39	41	47	52
All emissions	156	161	149	153	166

Units: 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. Projections are based on Transport Statistics Great Britain (Department for Transport, 2005) low fuel price scenario (a high fuel price scenario is also available, but the differences are not substantial).

The VIBAT target aims to reduce all transport end user CO_2 emissions by 60% from a 1990 base, this results in an emissions target level of 15.4 MtC in 2030. This level is ambitious, but around the level required to achieve a future CO_2 atmospheric concentration of 450–500 parts per million, depending on the levels of reductions that are made in other carbon emitting sectors. Further research is required to assess the actual targets required in the transport sector and how they are likely to work alongside industrial, commercial and household reductions.

Table 2 provides an indication of the scale of the problem at the individual level by considering typical journeys by different modes and carbon emissions. It compares these to average per capita emissions for the UK, US and India, and also a globally equitable figure, which is in the range of 1000–4500 kg per annum per capita. Clearly UK average vehicle km per year and international flying become very difficult if globally equitable targets are to be achieved (unless huge advances are made in terms of carbon-efficient technologies).

A number of CO_2 targets are available as a comparison to the VIBAT research. For example:

- The UK Kyoto commitment is a 12.5% reduction in six greenhouse gases below 1990 levels over the period 2008–2012;
- The UK domestic target is for a 20% reduction of CO_2 emissions below 1990 levels by 2010 (DETR, 2000);
- A path towards a 60% reduction of CO_2 emissions by 2050 has been adopted by the UK Government (DTI, 2003), following the recommendation of the (Royal Commission on Environmental Pollution (RCEP), 1994, 1997).

[3]All domestic surface transport emissions, hence not including international air and shipping. Note Bows and Anderson (2007) will consider the issue of carbon emissions from the air sector.

Table 2
A few relevant carbon calculations—the scale of the problem

Typical (one-way) journeys and approximate carbon emissions per person[a]:
London–Glasgow by bus = 648 km = 58 kg
London–Glasgow by rail = 648 km = 71 kg
London–Glasgow by car[b] = 648 km = 120 kg
London–Glasgow by air[c] = 648 km = 386 kg
London–Sydney by air = 16,500 km = 11,500 kg
London–New York by air = 5500 km = 1900 kg
Average car km per annum = 11,000 km per annum = 1980 kg
Walking and cycling are virtually carbon free.
For all emissions per person per annum (transport and domestic use, etc):
The US average = 19,800 kg
The UK average = 9400 kg
The Indian average = 1200 kg
A globally "sustainable" figure is 1000–4500 kg per person (for all emissions, not just transport!!)
Hence the scale of the problem

NB. Calculated using method in The Guardian (24 February 2007) How to calculate your carbon footprint. The definitive guide. This was based on Lynas (2007) Carbon counter: calculate your carbon footprint. Collins.
Vehicle distance by AA online route planner: ⟨http://www.theaa.com⟩ and air distance: ⟨http://www.chooseclimate.org/flying⟩ (including the aviations radiative emissions multiplier).
[a]Assuming average all day occupancies and average vehicle specifications.
[b]Assuming use of an average specification, Ford Focus, 1.8, which emits 180 g/km.
[c]Air travel includes a radiative forcing impact; a multiplier of 2.7 is required to cover aviation's warming impact on the climate. Jet emissions occur high in the atmosphere, where carbon dioxide is augmented by warming from water vapour in contrails.

The striking feature of all these targets, particularly the more ambitious ones, is the huge gap between the business as usual projection and each of the emissions reduction targets. Achieving this scale of change is not likely to be easy, even when 1990 base levels are taken.

UK international air emissions, which currently amount to 8 MtC (9 MtC including domestic emissions) are not included in the VIBAT study, even though they are expected to rise to some 14–16 MtC by 2020 (and, if extrapolated, potentially to 20 MtC by 2030). This is despite an improvement in the fuel efficiency of aircraft of around 1.7% p.a. (DTI, 2003). International shipping is also not accounted for in the domestic projections. These levels of emissions on their own are likely to be greater than all other emissions from domestic UK travel targeted in this research, and it gives an indication of the scale of the problem facing transport as it attempts to move away from carbon dependence. This is a critical area for further research in terms of assessing how the international air sector can make a contribution to reducing CO_2 emissions. There is current discussion as to including international air emissions within the EU Emissions Trading Scheme; yet the basic (and unpalatable) requirement must be to reduce future air travel demand.

4. Images of the future

Two alternative images of the future were constructed to reflect some of the different alternatives in terms of achieving the 60% CO_2 reduction target. One focused more on market forces with higher GDP growth and lower oil prices ($60 a barrel in 2003 prices), suggesting more travel and greater input from technological innovation—this was labelled the "New Market Economy". The second focused more on a social welfare and environmental perspective, with lower GDP growth and higher oil prices ($80 and $100 a barrel in 2003 prices), suggesting less travel and a greater reliance on behavioural change—and labelled "Smart Social Policy".

The intention was to establish two visions that were both feasible but were sufficiently different to each other to warrant description as alternative policy approaches. They were not intended to be prescriptive, but to illustrate different potential futures. Of course there are an infinite number of potential futures; the VIBAT visions are put forward to highlight the potential for relying on a technological and/or behavioural response to the global warming problem. They can be read alongside, and compared to, other futures work such as the recent DTI Foresight futures (DTI Foresight, 2006). In each case, the two VIBAT images of the future for the transport sector in the UK are set within the context of broader demographic and socioeconomic changes (such as globalisation and population increase), and each provides an alternative, qualitatively different future (Table 3). Note assumptions in terms of population growth are that the population increases by 9% to 2030, broadly reflecting current demographics. In reality, growth is likely to be more complicated, with a differential growth across age and socioeconomic cohorts, and this is likely to have an impact in traffic generation terms. Both images are developed to represent publicly and politically acceptable futures, and are broadly based on linear progressions into the future rather than sudden shocks and sharp transformations. Climatic changes may, of course, lead to a future that is based around dramatic and uncertain change.

Table 3
Images of the future—external elements

	New market economy	Smart social policy
Key drivers	Economic growth	Quality of life
Values	Individualism, economic efficiency	Community and social welfare, environmental quality
Globalisation	Continuous production in low cost locations	Slightly more localised production, with specialisation, clusters and agglomeration
Economic growth	+2.5% pa = +110% (2000–2030)	+2.2% pa = +92% (2000–2030)
Population change	+9%	+9%
Role of ICT	High levels of take up and maximum use by individuals	Substantial take up, but concerns over those unable to use the technology (affordability and knowledge)
World oil prices	$60 a barrel	$80 a barrel and $100 a barrel sensitivity
Governance	Central and top down	Multi level and partly bottom up

Within the *New Market Economy,* the main aim of transport policy is to achieve the required CO_2 emissions target with a minimum of change in terms of behaviour. Car traffic hence still grows (by 35% on 2000 levels) and dominates in terms of modal share, with trip lengths increasing and occupancy levels increasing. The main changes are in pushing hard on hybrid technologies so that the overall average emissions profile of the total car fleet reduces to 90 g/km in 2030 (down from 171 g/km for the new car fleet and 185 g/km for the total car fleet in 2005). This is achieved through the rapid phasing in of the hybrid technology over the next 25 years so that by 2030 all new vehicles are hybrid or ultra lean burn. There is also considerable investment in alternative fuels to reduce the carbon content of existing internal combustion engines and the non-electric parts of hybrids. There is less effort made in terms of behavioural change, this image of the future relies on technology to deliver the lower carbon future.

The New Market Economy image is very ambitious in terms of new technology penetration. There is, however, a need for realism here: there is little evidence that, over the period to 2030, new technologies will actually achieve anything like the considerable improvements envisaged. Of the evidence so far, the current new car fleet is not achieving the (not exacting) voluntary targets set for them in terms of carbon emissions (Transport and Environment, 2006).

Within the *Smart Social Policy* behavioural change plays a central role, with less reliance on technological change. The expectation in this image is that there will be a slight reduction in the amount of car travel per person in 2030 (−10% from 2000 levels), but the overall levels of travel will be higher as population will have increased by 9%. The main reduction is not in the number of trips made but in the length of trips. The distribution has changed, with some growth in long-distance trips. These are more than compensated for by the increase in shorter, more local trips. The desire for less travel (and distance for freight distribution) links in with the greater social awareness of the population, and the importance of community and welfare objectives. The lock-in to car dependency (experienced under Image 1) is broken with social priorities pushing for greater use of public transport and other clean modes of transport. Reducing carbon emissions is hence placed at the centre of policy making-investment in national, regional urban planning and transport strategies, and local transport plans is targeted at achieving a lower carbon future. There is less dependence on technological solutions, but cars still become cleaner over the period (125 g/km for new cars and a total fleet level of 140 g/km in 2030) through new taxation and pricing incentives to use more efficient and cleaner technologies. Tax reductions are also available for not owning a car or for participating in car sharing schemes. It is expected that real fuel prices increase by 40% over the period.

There is a very strong shift to public transport, walking and cycling and to the greater use of local facilities. The use of walking and cycling both increase to European best practice levels–the number of walking trips per person doubles and cycling trips increase fivefold. Land use planning favours compactness (or polynuclear urban form) and public transport-orientated development patterns with mixed use and high-quality local environments. Urban form is hence structured to reduce travel (as well as improve urban quality). Traffic demand management is accepted by the public as being necessary to achieve environmental targets, and it is perceived as helping to reduce the impact of the car and in improving the quality of life in cities. Road pricing (based on environmental emissions), information and communications technology (ICT) developments, soft factors, ecological driving including lower-speed limits and enforcement, long-distance travel substitution and freight transport subsidiarity all make major contributions to this image of the future.

5. Policy packages (PP)

This stage proved to be the most complex and time-consuming part of the project, but in terms of the backcasting approach the most interesting. A comprehensive review of the full range of policy measures was carried out. This identified some 122 individual policy measures that could contribute to carbon efficiency in transport. Estimates were also made as to the timescales necessary for their implementation. These policy measures were then assembled into packages that were mutually supporting.

The difficulty here was in the packaging, and the potential number of packages. Most of the packages had variants that were more suited to one image of the future than the other.

The packaging process was very fruitful as measures could be combined, and efforts made to ensure their impact would be made more effective. To achieve substantial reductions in emissions requires combinations of mutually supporting policies—often involving a variety of stakeholders. Individual policies will not contribute significantly to reductions in CO_2 emissions. Combinations (together with the supporting "smarter measures" such as awareness raising) can help control for rebound effects, where initial reductions in emissions are subsequently reversed as people travel further, thus negating some of the benefits. Many of the packages are extremely interrelated and even the technological options (such as low emission vehicles) require supporting behavioural change such as using incentives to influence consumer preferences towards low-carbon vehicles.

These packages were then clustered together to see whether the targets set in each of the images could be reached. In this study, an additivity assumption was used, namely that the savings from each package were supportive of others. This assumption gives an optimistic view of target achievement, and further research should explore non-additive effects, synergies and rebound effects in implementation (Lautso and Wegener, 2007). The final stage was to establish the sequencing of implementation so that the targets set for 2030 in each image would be achieved. These are the policy paths.

In addition, potential carbon savings were calculated using a spreadsheet model covering estimates of the likely reductions in travel and the likely change in CO_2 emissions. These figures proved to be enormously useful in working out how the targets set could be achieved, in illustrating likely levels of change, and they also give an indication of the importance of each package, the clusters and their variants.

PP are developed by combining sets of individual measures that are likely to work well together, concentrating on those that might create positive synergies. Eleven PPs are developed. Some of the PPs are technologically based, some rely on pricing to drive them, while others depend more on regulation and control or behavioural change. They cover all modes of transport, including freight and passenger movement, and they also relate to land use and spatial change. Some of the packages are more directed at the policy level, while others involve primarily industry and individual actions. Summary findings, including initial estimates of carbon reduction potential, are outlined below. All have ranges of values that reflect different levels of intensity of application as all of the PPs have variants.[4]

PP1 Low Emission Vehicles: the take-up of low-emission vehicles, based largely on hybrid technology and lean burn engines, is very important. Full introduction of the 90 g/km car in the total fleet by 2030 requires massive investment by car manufacturers. Table 4 gives an indication of the large differential in emissions by vehicle type and specification. The current latest generation of fuel-efficient vehicles have emissions levels of around 100 g/km (the Toyota Prius, 1.5 l, emits 104 g/km). A typical distance travelled in a Prius, of say 11,000 km per annum, would emit 1144 kg of carbon dioxide. Diesel cars also perform well in terms of carbon emissions (the VW Golf Diesel TDI, 2 l, emits 154 g/km), although less well for other emissions such as particulates. At the other end of the scale, the Ferrari Superamerica emits a huge 499 g/km. A typical distance travelled in this vehicle, again of 11,000 km per annum, would emit 5489 kg of carbon dioxide.

Relying on this option may be high risk, and further work is required to establish the costs and feasibility of converting the whole of the UK car fleet to hybrids and lean burn by 2030. There is a major role here for the motor industry. The full potential of hybrids for the freight and public transport sectors also needs further investigation.

Carbon reduction potential = 18.3 MtC–9.1 MtC.

PP2 Alternative Fuels: additional benefits can be obtained if alternative fuels are used in conjunction with petrol and diesel hybrids and conventional internal combustion engines. There are many possible alternative fuels on the market, including compressed natural gas, liquid petroleum gas, methanol, ethanol, biodiesel, hydrogen and electricity. Many alternative fuels can be used with existing engines (e.g. bioethanol E5), but others need to have engine modifications (e.g., bioethanol E85). The International Energy Agency (2004) suggest that by 2030, some 20–40% of all fuels in transport could come from alternative sources. Much further work is, however, required to investigate the potential of alternative fuels, and this should include the necessary infrastructure required to make them work effectively.

Carbon reduction potential = 9.1 MtC–1.8 MtC.

PP3 Pricing Regimes: road pricing can also make a substantial difference, whether this is operated nationally or just within cities and on the motorways. In combination with other policies, road pricing on an environmental basis (i.e., the charging relates to the carbon emissions profile of the vehicle and the number of passengers), can give clear signals to consumers to switch to more efficient cars or to other modes of transport.

Carbon reduction potential = 2.3 MtC–1.1 MtC.

PP4 Liveable Cities: this package focuses on using urban form to support sustainable transport, with higher-density development clustered around an upgraded public transport system, and urban areas that have been planned to vastly improve their urban design quality and attractiveness for living and working. There is complementary heavy investment in walking and cycling facilities as well as public transport. Applications of this package on a substantial

[4] For a fuller description of the VIBAT policy packages, see http://www.ucl.ac.uk/ucft696/documents/VIBAT_Stage_3_Jan_06_FINAL.pdf.

Table 4
Vehicle emission benchmarks

Vehicle manufacturer and model	Emissions (g/km)	Annual travel (km)	Annual CO_2 emissions (kg)
Toyota Prius, 1.5 l	104	11,000	1144
Toyota Prius, 1.5 l	*104*	*5000*	*520*
Honda Civic, 1.3 l	109	11,000	1199
VW Golf, Diesel TDI, 2.0 l	154	11,000	1694
VW Golf, Diesel TDI, 2.0 l	*154*	*6500*	*1001*
Ford Focus, 1.6 l	161	11,000	1771
Ford Ka, 1.6 i	189	11,000	2079
Lexus "Sustainable" Hybrid SUV, RX 400 h	191	11,000	2101
Lexus "Sustainable" Hybrid SUV, RX 400 h	*191*	*5225*	*998*
BMW 3-series, 2.0 l	196	11,000	2156
Ford Mondeo, 2.0 l saloon	218	11,000	2398
Land Rover Discovery, 4.4 l	354	11,000	3894
Bentley Arnage R	495	11,000	5445
Ferrari Superamerica	499	11,000	5489
Ferrari Superamerica	*499*	*2000*	*998*

Based on 〈http://www.vcacarfueldata.org.uk〉 Notes/benchmarksAverage car km per annum = 11,000 km per annum.
For all emissions per person per annum (transport and domestic use, etc).
The US average = 19,800 kg.
The UK average = 9400 kg.
The Indian average = 1200 kg.
A globally "sustainable" figure is 1000–4500 kg per person (for all emissions, not just transport!!).

scale has a major impact, but largely over the medium term, as decisions on the location of new housing and other development take place gradually over time. For areas of new or redevelopment, impacts are realised in the shorter term. These decisions have a substantial effect on both distances travelled and modes used as urban structure provides part of the rationale for travel.

Carbon reduction potential = 2.4 MtC–0.5 MtC.

PP5 ICT: this option explores the potential for carbon reduction from ICT developments. The measures are targeted at personal and freight travel, and include advanced route and parking guidance, car sharing, public transport information systems, freight logistics, local traffic regulation and teleactivities. The potential levels of carbon reduction seem limited, and there may be rebound effects as ICT may encourage more, not less, travel.

Carbon reduction potential = 1.8 MtC–0.8 MtC.

PP6 Smarter Choices: including workplace and school travel plans, future changes in car ownership (including leasing and car clubs), car sharing, travel awareness and travel blending programmes. These are important supporting measures to other packages, but they also have an important impact on carbon emissions in their own right.

Carbon reduction potential = 2.4 MtC–0.9 MtC.

PP7 Ecological Driving: this has substantial immediate benefits, particularly if combined with lower national and local speed limits and improved enforcement. Slower speeds potentially provide extensive savings, with prospects for some 15–20% reductions in carbon emissions if a maximum speed limit of 80 km/h is introduced on motorways and trunk roads, with lower speeds on other roads and in urban areas. Although the fuel use and speed value curves for new cars are flatter than those for older cars, there are considerable fuel savings from lower speeds. These speed limits need to be combined with awareness programmes and better driving techniques to reduce fuel use.

Carbon reduction potential = 4.6 MtC–2.5 MtC.

PP8 Long-Distance Travel Substitution: there is some limited potential for long distance travel substitution of rail for air, and coach for rail, but the savings here are not substantial, particularly if load factors are high for the substituted mode and if high-speed rail, for example, is of very-high speed specification–this tends to be less energy and carbon efficient.

Carbon reduction potential = 0.7 MtC–0.5 MtC.

PP9 Freight Transport: freight transport is covered in several of the packages, but subsidiarity (local production and knowledge transfer) and dematerialisation (miniaturisation, advanced logistics and distribution networks, load matching and material consumption) can all lead to carbon savings, some substantial.

Carbon reduction potential = 2.5 MtC–0.7 MtC.

Two more PPs are also very relevant: carbon rationing (PP10) and increased oil prices (PP11). Under a carbon rationing package, individuals are given an annual carbon budget, on an equitable basis, and a market is created so that heavy CO_2 users can buy additional rations from less intensive users. The overall usage on a national and regional scale is reduced over time to meet carbon reduction targets. Both carbon rationing and increased oil prices are seen as supporting or enabling packages, ensuring the effective take up of the policy measures and packages. Much more research is required on the likely implementation pathways on both of these supporting packages. There are potential difficulties in implementation with both.

Although the VIBAT research takes us a long way forward in terms of estimating the likely contribution of the transport sector to carbon emissions reductions, it is based on limited analysis, using a range of secondary sources on travel, fuel and emissions savings. Much further research is required here in terms of calibration of likely scales of change.

6. Package clustering and policy pathways

The final task was to cluster the packages together so that the target levels of reduction can be achieved within each of the two images of the future. The intention here is not to be prescriptive or comprehensive in showing every possible combination of packages that can be used to achieve the image targets, but to illustrate the ways in which package clustering can be undertaken. Figs. 3 and 4 illustrate the most likely PP clusters under Image 1 (New Market Economy) and Image 2 (Smart Social Policy).

The critical policy conclusions here are that the 60% target reduction under Image 1 is not possible over the timescale envisaged, even when pushing hard on all options. This is because the additional population (9%) and the increase in travel (+35%) that is expected in this image effectively increases the target to 36.9 MtC. Technological innovation on its own cannot bridge that gap, even if there is a very strong push on efficient vehicles and alternative fuels. We should again note that international air emissions are not included in these calculations—adhering to anything near equitable carbon budgets when including international air emissions becomes *very* difficult.

The 60% target reduction (27.2 MtC) however can be achieved under Image 2 (with the same population increase, but a small reduction of 10% in car travel), through a variety of PPs that are well-known now, but even here major change is required that combines strong behavioural change with strong technological innovation. Again, for clarity, this calculation does not include international air emissions.

7. The new imperative: a carbon-efficient transport system

The initial aim of the VIBAT research was to establish whether a 60% CO_2 reduction target in the UK transport sector could be achieved by 2030. The analysis concentrates on the domestic UK travel modes, which means that the actual target for 2030 is 15.4 MtC, or a 60% reduction on the 1990 level of 38.6 MtC. This target needs to be set against the expected increases in travel, with levels of carbon emissions increasing to 52 MtC by 2030. The two alternative future images developed generate less travel than the business as usual: with Image 1 (New Market Economy) increasing travel by 35%; and Image 2 (Smart Social policy) having slightly less travel than now (−10%). In addition, there will be a population increase of 9% in both images, and this adds to the levels of travel and carbon emissions.

The overall conclusion reached is that the 60% CO_2 reduction target (in 2030) can be achieved by a combination of strong behavioural change and strong technological innovation. But it is in travel behaviour that the real change must take place, and this should be implemented now. Changes in the built environment will largely become effective in the medium term (over 10–15 years), while the

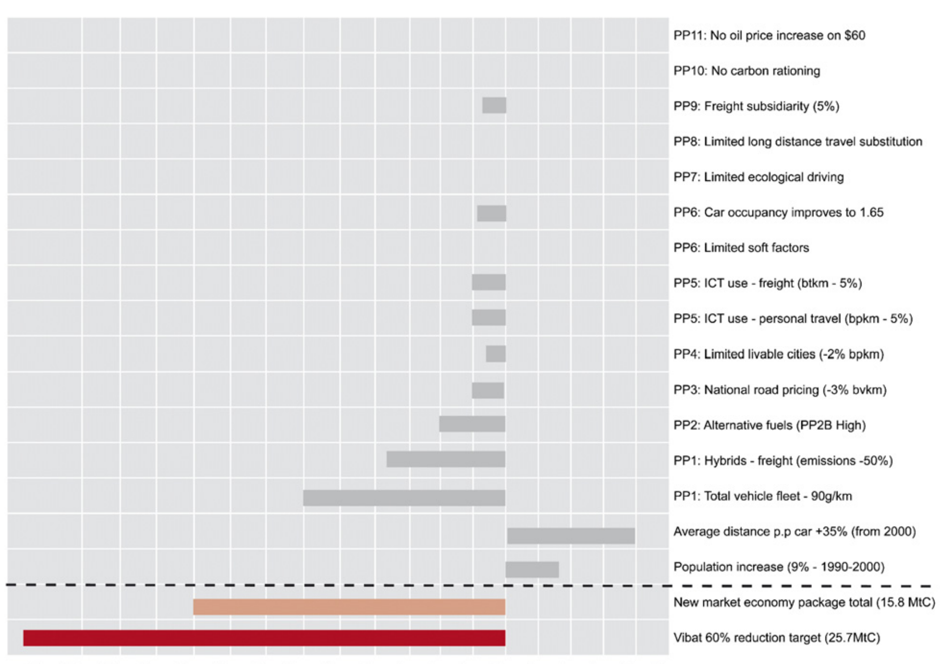

Fig. 3. New market economy package cluster (carbon reduction, MtC).

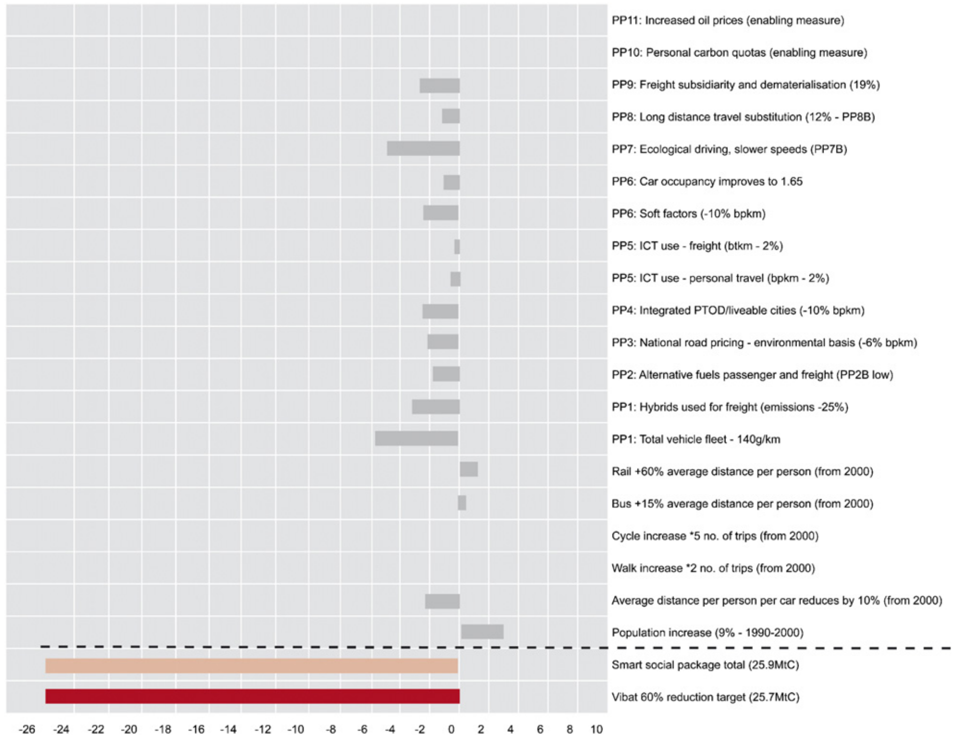

Fig. 4. Smart social policy package cluster (carbon reduction, MtC).

major contribution of technological innovation will only be effective in the period after 2020. It is not possible to achieve the 60% CO_2 reduction target (by 2030) with the expected growth in travel under Image 1—which is close to the business as usual—as the increase in CO_2 emissions from this growth outweighs many of the possible savings from behavioural change and technological innovation.

A series of important recommendations are also made to reflect the needs for further research. Although this should not slow the immediate implementation of packages of policy measures that we perceive as important now, there is a need for an intensive research debate in the transport and global warming field. The topic is critical to our future way of life yet seems to be hugely under researched. For example:

- There should be a reliable baseline data source that brings together DfT, Defra and DTI forecasts in a consistent way, to at least 2030, if not 2050 and beyond. This database can be regularly updated and used to monitor progress towards transport and environmental targets.
- An inventory of measures and packages, together with their carbon reduction potential, would help establish where most effort needs to be placed. This inventory should also have details on costs, benefits, responsibilities for implementation and the risks entailed.
- Good practice guides on the introduction of transport demand management schemes, including savings (or increases) in travel and the associated carbon savings (or costs). The VIBAT research has assumed that each package adds to the overall savings potential, but this needs further analysis to see whether this is a valid assumption.
- Issues relating to synergies, to critical "trigger" points where "real change happens", to unintended and rebound effects, and to monitoring the effects of change all need further investigation.
- In addition it would be useful to have more detailed estimates of the potential savings identified within this research from secondary sources. This would include the costs of any actions that might be taken, and of the costs of not taking actions.
- Similarly the risks of alternative pathways could be assessed in terms of the potential benefits and costs of action or no action.
- More detailed case studies are required—testing the ability to achieve carbon reduction targets in, for example, London and the other major metropolitan areas. Also at a regional level and for selected sub-regional centres. The actual policy packaging is likely to vary hugely as to context.
- It is important to open up the debate about the issues raised in this research with all stakeholders as this begins to create an understanding about the scale and importance of the CO_2 reduction issues, and it would begin to remove some of the barriers to effective implementation. Included here would be questions relating to the concept of sectoral-based targets, and how CO_2 reduction targets can become central in transport decision making. In addition there is a clear

necessity to raise public awareness and to get the public's active involvement in seeking solutions, and how to encourage behavioural change that can be maintained and continued over time.

A number of critical issues have emerged from the VIBAT study and they have provided a major input to the recent Environmental Audit Committee report on Reducing Carbon Emissions from Transport (House of Commons Environmental Audit Committee, 2006):

1. There is growing acceptance concerning the gravity of the global warming problem, the diminishing window of opportunity to act, and that the transport sector must play a key role in reducing CO_2 emissions (however this, critically, is not reflected in moves towards carbon efficient travel).
2. There is very scarce evidence as to how the transport sector can positively contribute to reduced CO_2 emissions, and what level of carbon reduction is most appropriate. There is some emerging discussion on the need for a specific sectoral transport carbon reduction target.
3. It appears that a dramatic reduction in transport emissions is possible — at least a 60% reduction by 2030. Much further work is however required in terms of quantification of likely impacts of different measures and policy packages.
4. Despite this lack of evidence, a number of issues appear to be gaining further credence. Technological developments, such as improved vehicle technologies and alternative fuels, are likely to provide a major contribution to carbon reduction efforts. They do not provide the solution as any carbon reduction impacts of technological improvements are likely to be offset, if not completely outweighed, by forecast increases in population and traffic growth.
5. The only possible solution lies in an integrated package of technological and behavioural policy measures, ensuring that we travel in more carbon efficient ways and we travel little further than at present.
6. There remains a huge implementation gap, as investment patterns still appear to be focused on road-based, carbon-intensive solutions. For example, there is still little evidence as to the likely transport carbon intensity impacts of Regional Transport Strategies, Local Transport Plans, or of development in the Growth Areas or Housing Pathfinder Areas. Sustainability and liveability objectives (including reduced CO_2 emissions) need to be placed at the heart of the transport and urban planning debate and made central to transport investment plans.

A much improved evidence base is thus required. We urgently need to further our understanding of the best consensual way forward for transport and urban planning. However, this should not result in no or little initial action in terms of implementation. Radical and concerted efforts are required now. The current debate is now concentrating on the need for the transport sector to urgently accelerate its efforts to meet the challenging issues surrounding carbon reductions. At present it points to "a failure of purpose from the Department of Transport" (House of Commons Environmental Audit Committee, 2006, para 21). A major transformation in the way transport planning is carried out is thus required. As practitioners we need to think very differently about the way we tackle the new environmental and liveability agenda. The new imperative is for carbon efficiency in transport and urban planning.

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