Visioning and Backcasting for UK Transport Policy (VIBAT)

The Bartlett School of Planning and Halcrow Group Ltd

Stage 3 Report

Policy Packaging and Pathways

Department for Transport

DfT Horizons Research Programme

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1 Introduction

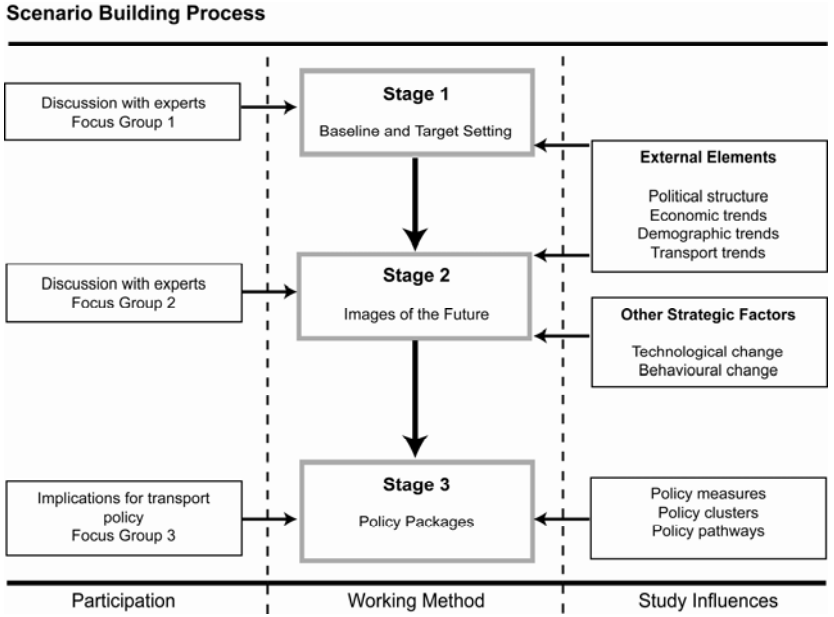
1.1 Policy Packaging and Clustering: the Rationale

The most complex (and interesting) part of the backcasting approach is the assembly of individual policy measures into packages and suitably consistent groupings so that they can then be implemented in a manner that may generate complementary benefits.

This requires an iterative process that matches the range of packages against the objectives set out in the images of the future (stage 2 of the VIBAT study). It also requires an understanding of the way in which mutually supporting elements (the policy measures) can be assembled together into packages, with some indication of how effective those measures that make up each package are likely to be in terms of contributing to the 60% CO_2 reduction target. The packages themselves are then clustered together as a set to achieve the target set, and placed in a time-based sequencing process for implementation – this is called a policy path.

As can be seen from Figure 1.1, this report forms the final stage 3 of the VIBAT project. It is the most important part of the project in that it provides a view as to the likely implementation path for the agreed images of the future and VIBAT target. With such an ambitious CO_2 emissions reduction target, achievement of these target levels is likely to be the largest problem faced.

Figure 1.1: *Study Process*



The purpose of this final stage in the backcasting approach has several objectives, as outlined below:

1. The primary purpose is to demonstrate whether it is possible over the time horizon covered to achieve the 60% CO_2 reduction target.

2. The intention is not to be prescriptive, but to show which combination of packages might be most effective. A judgement is not being made on any particular combination of measures or packages, but to show a variety of

ways (if possible) to achieve the primary objective. One issue here is that if particular policy packages feature in several of the paths, then they can be considered common to all futures. This means that they should be implemented irrespective of which future path is actually followed.

3. As part of the process, it is important to look at the features of each potential package and path in terms of the sequencing of the measures in each package. Some can be introduced very early on, but others may require legislation or clear signals to industry that change will be implemented at specified times in the future. The costs and risks embodied in each package also need to be addressed so that any major decisions taken are fully informed.

4. Implementation should be seen as a continuum with a clear debate and rationale over what the objectives of transport policy are and how or to what extent they are likely to be achieved – here it is a simple and clear objective, namely to reduce CO_2 emissions in the transport sector by 60% over the study period (from 38.6 MtC in 1990 to 15.4 MtC in 2030). Initial change can be gradual and uncontroversial, but the direction should be consistent with more “radical” measures and opportunities coming into effect later over the time period. We should note that CO_2 emission levels in the transport sector reached 41.2 MtC in 2000 and 41.6 MtC in 2003 - so the current trend is moving away from our required target.

5. At each stage of implementation there should be debate and explanation so that the continued support for policies is guaranteed from all stakeholders (individuals, businesses, institutions and industry). This is even more evident in the case of effective radical change - here it will be essential to have the active and continued support of all stakeholders. Pricing regimes and carbon trading are classic examples of these more radical measures. A transport and urban planning 'great futures debate' may be required, initiated very early on in the process, and continued throughout.

6. Measures that require long lead times and are essential to the achievement of the target should be introduced early in the process, as should those that might help trigger change and are relatively easy to introduce. Thinking must be long term, but effective short term measures should not be ignored.

7. The implementation process should maintain flexibility so that the future is not constrained by the actions taken today (this phenomenon is known as 'lock-in'). It is also important to maintain effectiveness of actions so that additional measures can be taken and counter any possible rebound effects. We discuss these issues towards the end of this paper.

Finally, when thinking about alternative futures, it is important to maintain a sense of reality and to work within the limits of known technologies and behavioural patterns. Innovation will take place in the future - and naturally we cannot know now what we will know tomorrow - but the argument used here is that over the time horizon being viewed (2000-2030), it is unlikely that any single (or multiple) innovation will be invented, developed and have a real impact on CO_2 emissions because of the lead times involved. Even if such an innovation was made, the risk-averse strategy must be to continue to make the best use of available policy options. Hence our thinking is based on

the basis of current knowledge and technology - luckily we can build on a large and rich body of work in terms of technological and behavioural change opportunities.

Where scenario building can particularly help is in putting together innovative packages of policy measures that together are likely to have an impact on CO_2 emissions. The whole concept of packaging is to put mutually supporting elements together. This means that implementation should also be seen in a holistic way, and if outcomes do not match up to expectations then modifications should be made.

An example of how the process works is shown in Figure 1.2: the individual policy measures are grouped into consistent policy packages, and clusters of policy packages are then developed to help achieve the alternative images of the future. Within the clusters of packages there are a series of potential policy pathways towards the images of the future. The packaging process allows us to identify a number of key measures that contribute a disproportionately large amount to the CO_2 reduction target. These should be the focus of serious implementation investment. However, in practice, all contributions will be welcome - a number of small steps are also likely to make a difference in aggregate.

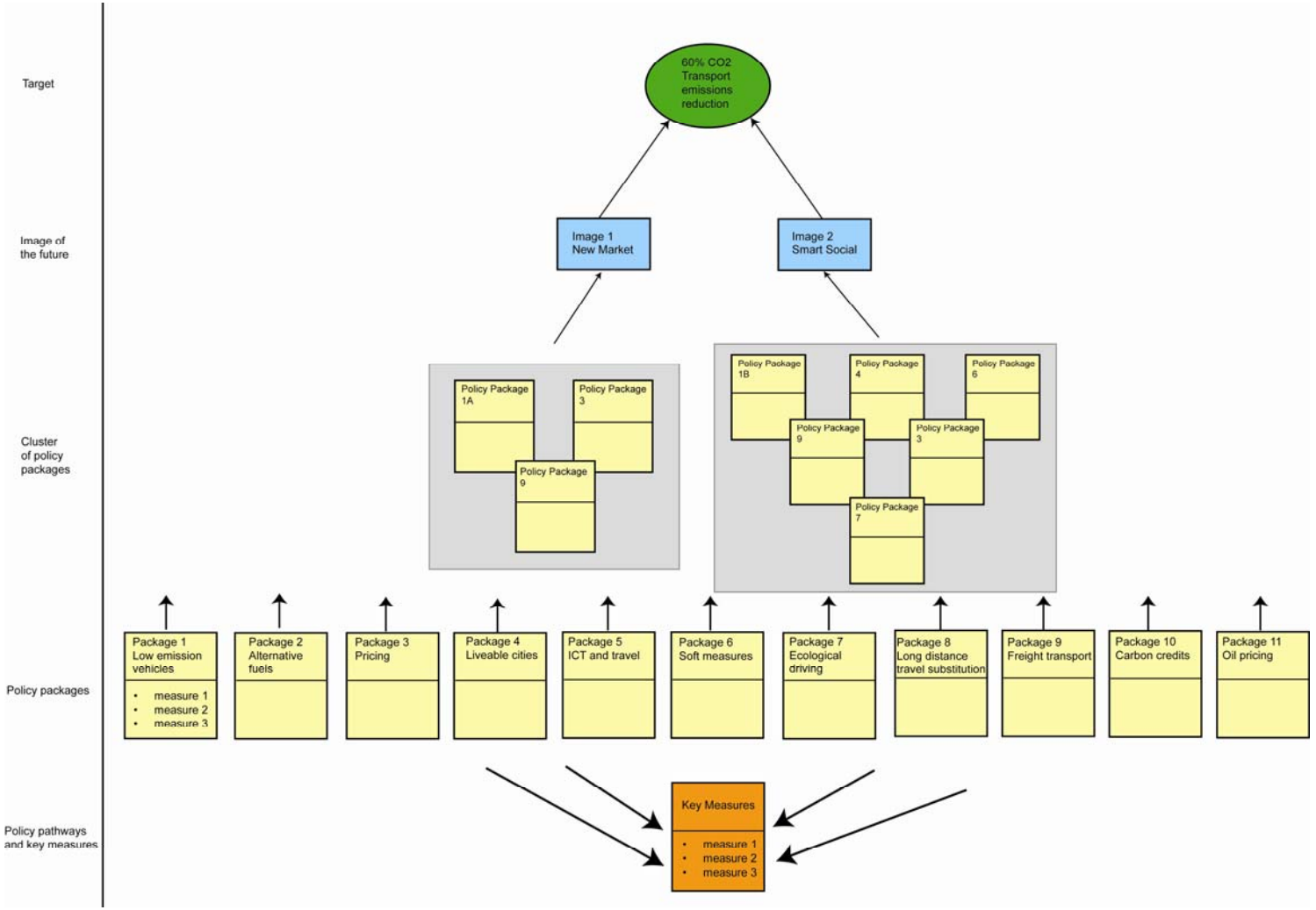
1.2 Structure of the Report

The remainder of this stage 3 report has a series of sections as outlined below:

- Section 2: Policy Measures
- Section 3: Policy Packages
  - Low Emission Vehicles (Package 1)
  - Alternative Fuels (Package 2)
  - Pricing Regimes (Package 3)
  - Liveable Cities (Package 4)
  - ICT and Travel (Package 5)
  - Soft Measures (Package 6)
  - Ecological Driving (Package 7)
  - Long Distance Travel Substitution (Package 8)
  - Freight Transport (Package 9)
  - Carbon Credits (Package 10)
  - Oil Pricing (Package 11)
- Section 4: Package Clustering and Pathways
- Section 5: Synthesis, Conclusions and Next Steps

The Annex to this report outlines the VIBAT work programme, a list of the expert panel contributors for the Stage 3 workshop (held on 11 October 2005) and selected references.

Figure 1.2: *Packages, Measures and Pathways*



2 Policy Measures

2.1 Introduction

In this section we first consider the range of measures likely to be available to help achieve our images of the future and lead us towards our 60% CO_2 emissions reduction target.

Following this we develop a number of policy packages which help to structure our thinking and pull together similar measures. Each of the policy packages is made up of a range of individual measures.

2.2 An Inventory of Potential Policy Measures

As the prerequisite to building policy packages we must consider the range of measures available to help achieve our CO_2 emissions reduction target. Table 2.1 shows the huge potential on offer. We also consider the likely timescale of implementation of the measures – whether these are likely to be initiated in the short, medium or long term. This is useful later in the packaging process as it gives us a guide as to likely phasing timescales. Note that timescale is given in terms of when measures should be implemented; actual effects will follow at a later date. In many cases, multiple timing is shown - this reflects situations where policy interventions need ongoing implementation and refinement. Also, there is some overlap between the categories in the table - many measures have different objectives according to policy emphasis.

Most of the individual policy measures are well known, and many have been implemented on an ad-hoc basis in recent years in the UK. A key message that follows during the policy packaging stage is that the roll out of many of the measures needs to be prioritised, with a 'step change' in resource used. 'Tinkering' around the edge of the business as usual policy thrust will not deliver our ambitious CO_2 reduction target.

A key area for future research is to develop an exhaustive list of policy measures available to practitioners, one that can be developed over time, with an indication of current best practice, likely travel reduction and CO_2 emission reduction effects (the VTPI website - see www.vtpi.org - is a good model of this in North America). Such a resource would be of great use for practitioners in the UK.

The vast majority of the measures mentioned below are implicitly included in the policy packages that follow, although all are not directly mentioned.

Table 2.1: *An Inventory of Measures Available to Influence CO_2 Emissions*

Measure	Potential Timescale of Implementation		
	Short Term	Medium Term	Long Term
Technical Improvements			
Standards for emissions, noise and safety	✓	✓	
Fuel quality standards and alternative fuels	✓	✓	
Efficiency improvement of materials and energy (e.g. factor 4)		✓	
Dematerialisation of products and miniaturisation		✓	
Vehicle test cycles		✓	
Enforcement and monitoring	✓	✓	✓
Infrastructure Investment			
Improvement of public transport - bus, guided bus and LRT, ultra light rail, palletisation	✓	✓	
Increased rail capacity and high speed trains (HST)	✓	✓	✓
Public transport subsidy (investment)	✓	✓	
Deregulation/regulation	✓		
Fare integration and schedule co-ordination	✓	✓	
Intermodality		✓	
Traveller information	✓	✓	
Bus service improvement	✓		
Park and ride	✓		
Rail freight facilities	✓		
Walking and cycle facilities	✓		
Cycle/public transport integration	✓		
Cycle parking	✓		
Shuttle services	✓		
Small wheeled public transport/paratransit		✓	
Demand responsive services	✓	✓	
Taxi services	✓		
Telecommunications and Technology			
Teleworking/telecommuting/teleconferencing	✓	✓	
Teleshopping/telebanking/telecottages	✓	✓	
Telematics, informatics available locally		✓	
Infrastructure technology	✓	✓	
Multipurpose personal communications		✓	
Broadband, Wi-fi, smartdust and other technological developments	✓	✓	
Urban Planning			
Integrated planning	✓		
Regional development policies, strategic planning	✓	✓	
Compact cities	✓	✓	
Decentralised concentration and polycentricity	✓	✓	
Mixed use	✓	✓	
Zoning regulations	✓	✓	
Public transport orientated development (PTOD)	✓	✓	
Smart growth	✓	✓	
New urbanism	✓	✓	
Clustered land use/location efficient development	✓	✓	
Access to transport services	✓		
Pedestrian and cycle friendly developments	✓		

Car free districts		✓	
Car free or low car housing	✓	✓	
Low emission zones	✓		
Pedestrianisation	✓		
Fiscal incentives for relocation in designated areas	✓	✓	
Relocation of activities		✓	
Green belts, development restrictions	✓	✓	
Regeneration of decaying areas (city centre, inner city, waterfront, suburban)	✓	✓	✓
Housing renewal, improvements to neighbourhood quality and facilities	✓	✓	✓
Car and cycle parking standards for new development	✓		
Pricing and taxation			
Road pricing – congestion or environmental basis		✓	
Road tolls for freight		✓	
High occupancy vehicle (HOV) pricing		✓	
Fuel tax/escalators	✓		
Vehicle purchase tax	✓		
Car ownership tax	✓		
Parking tariffs/pricing	✓		
Parking restrictions/controls	✓		
Pay as you drive vehicle insurance	✓		
Excise tax for aircraft fuel		✓	
Airport charges	✓		
Air travel restrictions/rations			✓
Traffic management			

Entry restrictions/access control/environmental zones	✓		
Goods traffic restraint	✓		
Road capacity restraint	✓		
Advanced traffic management systems	✓		
Home zones	✓		
Street reclaiming	✓	✓	
Traffic calming	✓		
Traffic bundling	✓		
Driver information systems	✓		
Village/area bypasses	✓		
Road space reallocation	✓		
Pedestrian priority and road space	✓		
Cycle priority and road space	✓		
Direct routes for walking, cycling and PT relative to the car	✓	✓	
Priorities for bus, tram and high occupancy vehicles (HOV)	✓	✓	
Segregated rights of way for public transport	✓	✓	
Lower speed limits and enforcement	✓		
Casualty reduction targets (zero objective)	✓		
Information and public awareness, incentives for change			
Campaigns for the promotion of environmentally friendly modes	✓	✓	
Campaigns for reducing private transport externalities	✓	✓	
Increased awareness of public transport services	✓	✓	
Travel information	✓		
Transport chaining awareness	✓	✓	
Personalised travel planning, travel blending	✓		

Commute trip reduction programmes	✓		
School travel planning	✓		
Special event management	✓	✓	✓
Car free planning	✓	✓	
Campus management	✓		
Car clubs	✓	✓	
Commuter planning	✓	✓	
Eco labelling of vehicles	✓		
Commuter financial incentives	✓	✓	
Parking cashouts	✓		
TDM marketing	✓	✓	✓
Behavioural patterns			
Changed activity patterns – commuting, retail and/or leisure trips		✓	✓
Alternative work schedules		✓	✓
Changing lifestyles – e.g. not travelling at weekends			✓
Home location		✓	✓
Job location		✓	✓
Career downsizing			✓
Promotion of local destinations and local activity patterns			✓
Locally sourced retailing		✓	✓
Car sharing	✓	✓	
Flexitime	✓		
Guaranteed ride home	✓		
Teleworking and teleshopping	✓	✓	
Freight Management			
Logistics management	✓	✓	
Increased load factors	✓	✓	
Home delivery of goods/services	✓	✓	
Freight distribution – centralised/decentralised centres		✓	✓
Locally sourced distribution chains		✓	✓
Economic/Wider Policies			
Ecological tax reform		✓	
Tradable mobility credits		✓	✓
Carbon rations/domestic tradable quotas (DTQs)		✓	✓
Carbon tax	✓		
Taxes and feebates based on fuel consumption and weight	✓		
Vehicle scrappage bonuses and tax increases	✓		
Decentralisation of health and social services	✓	✓	✓
Decentralisation of education facilities	✓	✓	✓

(Based on Banister et al, 2000; Banister and Marshall, 2000; and www.vtpi.org TDM encyclopaedia)

3 Policy Packaging

3.1 Combining Measures

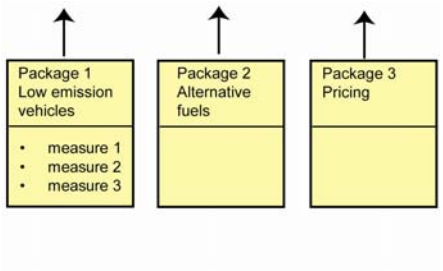
Policy packages are developed by combining sets of individual measures that are likely to work well together and those that might create synergies (see Figure 3.1). 11 policy packages have been developed and are summarised below.

Some of the policy packages are technologically based, some rely on pricing to drive them, whilst 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, whilst others involve primarily industry and individual actions.

In each case the presentation of the packages is similar in that there is a short tabular summary of the rationale behind the package, together with a comment on role (which image of the future the package is targeted towards), whether the focus is primarily market based or socially based, and its key strategic elements. In some cases, there are two variants of the basic package with different elements to each, and in all cases the key measures, stakeholders and levels of decision making are identified. At the end of each section, an estimate is made of the likely importance of the package in terms of achieving our CO2 reduction target.

An important point to note is that CO_2 emission reduction estimates are based on the best currently available emissions and travel datasets. They thus only give an estimate of the *scale* of likely change. Further research and analysis is required to develop a robust assessment of the likely effects of measures and combinations of measures.

Figure 3.1: *Developing Policy Packages*



3.2 Policy Package 1: Low Emission Vehicles

Construction logic: this policy package aims to substantially improve the efficiency of vehicles by reducing fuel consumption and by innovative design based on current technologies. This in turn will have a major impact on CO_2 emissions.	
Designed for Images 1 and 2 Main policy orientation ▪ Market ▪ Regulation	Key strategic elements ▪ Passenger and freight ▪ Technology ▪ Organisation

In terms of passenger vehicles, the current best generations of hybrid petrol vehicles have an emissions level of around 100 g/km of CO_2 (the Honda Insight emits 80 g/km and the Toyota Prius emits 104 g/km). Diesels are not far behind (the Citroën C2 emits 107 g/km) and the intention with technological improvements is to push hard to reduce this level even further. One possibility would be to require all new cars over the next 25 years to adopt hybrid technology so that, by 2030, this will have pervaded the entire vehicle fleet. This means that the average CO_2 emissions for cars would be 90 g/km, and this on its own will contribute a large amount of the required savings under Image 1. The current fleet average emissions of CO_2 is 183.8 g/km, whilst the new fleet average is 171.4 g/km (2004 data). These hybrid vehicles would be diesel or petrol with electric engines.

CO_2 emissions vary hugely between passenger vehicles. Compared to the more efficient, smaller and lighter vehicles in the market there are a number of larger and heavier models that emit higher levels of CO2: for example a Bentley (Arnage R) emits 495 g/km, a Porsche (Cayenne S) 380 g/km, a BMW (3-series E46) 229 g/km; and even the more utilitarian Skoda (Octavia 1.6) 184 g/km, Vauxhall (Astra 1.6) 182 g/km and Ford (Focus 1.6) 161 g/km. The 'sustainable' sports utility vehicle the Lexus (RX400h) still emits 192 g/km.

Hence to move all fleet average emissions towards the standards of the Toyota Prius or better will mean that every day car usage in the future ideally is not made in the currently highly sought after vehicles. Even the supposed technological 'silver bullet' requires change to individual behaviour and individual choice – the Toyota Prius in 2004 has sold under 2,000 vehicles (and is priced at over £17,000); only 2 Honda Insights were registered in the UK in 2004 . The car stock is 20 million. There is therefore a long way to go in terms of cultural change and customer choice in vehicles.

In addition to hybrids, manufacturers will be encouraged to develop a new generation of ultra efficient ICE diesel engines, such as those used in some small cars at present. The target here will be to achieve 3 litres per 100km (95 mpg), and increased efficiency of about 25% on the current most efficient diesel engine, and about twice as efficient as the standard diesel engine. The hybrid and lean burn diesel would also be extended to include delivery vans and commercial vehicles (including the bus). New materials would be used to make sure that vehicles are lighter (by about 25%) without compromising safety (see speed limits discussion in policy package 7). This weight reduction goes against recent trends where there has been an increase of 12.2% in car weights (1995-2003, ACEA).

Recent diesel penetration has been impressive in the UK, hence there is a positive trend to build on. Diesel vehicles account for 32.5% of the fleet in 2004, up from 27% in 2003 and 16% in 1997. They are forecast to increase to 38% by 2008. This is still lower than some European countries where rates run between 60% and 70%, reflecting lower duty rates on diesel vehicles compared to petrol. Diesel CO_2 emission levels are 6% lower than the average petrol car emissions in 2004. The recent increase in diesel's share of the vehicle market has largely been the factor behind improved CO_2 emission rates in the UK.

Electric vehicles would have a niche role within our future package, particularly in cities and some rural areas, where speed is not important. These vehicles would be small, cheap, easy to handle, very clean and require little parking space – their maximum speed would be 50 km/h. They would be allowed in environmental zones, along with bikes and low impact freight vehicles, and younger and older people would be able to use them, thereby enhancing their mobility. The energy source for the electricity (batteries) would have to come from renewable sources to reduce the carbon content of the electricity.

We also envisage a similar uptake of hybridisation in the freight sector and passenger transport sector.

Main Measures

- Strong incentives to the motor industry to dramatically increase the output of diesel and petrol hybrid cars and LGVS/HGVs/buses.
- Research and development on hybrid technology and lighter materials, together with improved battery design.
- The system of vehicle taxation would have to be radically changed over time to reflect the emissions profile, with factor of 10 differences between the high and low charges for clean and dirty vehicles (Revised Bands AAA to D).
- Design of vehicles to improve with light materials and aerodynamic design, especially for freight vehicles.
- Programmes to raise awareness of CO_2 profiles and to label vehicles according to various eco dimensions.
- Tax incentives to encourage purchase of clean vehicles and tax disincentives to purchase vehicles with high CO_2 emissions.
- Fuel prices to reflect carbon content and to rise in real terms by 20%, but as most vehicles will be more efficient the actual fuel costs of travel will reduce.
- Diesel engines likely to continue to increase their share of the market from 17% of cars (1997) to 33% of cars (2000), to about 70% of cars by 2030. The CO_2 benefits from diesel will need to be balanced with new efficient catalytic converters (and oxidisers) to filter out other pollutants.
- Monitoring stations to be set up to locate any pollution hotspots and to ensure that target levels are not exceeded. These monitoring systems should be able to identify individual polluting vehicles so that they can be taken off the road for maintenance.

- On vehicle diagnostics systems will give information to drivers that their vehicles are operating at optimal efficiency and within the accepted emissions range.

Impacts on Stakeholders

The technologically-led alternative allows travel growth trends to continue, with the increased costs of taxation and fuel being offset by far greater efficiency. It will only be those people (and firms) operating polluting vehicles that will pay more. Those levels of payment will be substantially higher and eventually polluting vehicles will not be allowed into towns. Clean city vehicles will have full access to all urban areas, and even hybrids may not be allowed full access to all locations which are designated clean. Greater access will be permitted to vehicles for the young (14+) and elderly as the low speed (50 km/h) city electric vehicle will be common.

Central government is required to take the lead in giving directions to industry, city planners and the public by providing a programme of change from carbon based fuels to efficient clean technology. In particular, industry needs to act now to provide the vehicles for the future and to invest in the research and development to push this technology hard. Initially, large numbers of existing vehicles must be imported to make an impact with the public, together with incentives to buy clean vehicles. Car manufacturing and maintenance support should become more widespread in the EU as the hybrid and other new technology is licensed globally.

Action is also needed to monitor emissions from all vehicles by location and by the individual vehicle. High levels of maintenance are needed to ensure that the technology is operating at maximum efficiency, and there should be on board diagnostics to support economical driving habits. Advertising and education programmes must focus on good and safe driving habits and on efficiency rather than speed. The education of professional drivers (commercial, bus and taxi) is also important, and it may be possible to provide incentives for fuel efficient and safe driving.

The variants within the package are as follows:

Variant 1A

- High take-up of hybrids in the passenger vehicle fleet - all fleet emissions in 2030 = 90g/km.
- High take-up of hybrids in HGV and LGV fleet – freight emissions reduce by 50%.

Variant 1B

- Lower take-up of hybrids in the vehicle fleet - all fleet emissions in 2030 = 140g/km.
- Lower take-up of hybrids in HGV and LGV fleet – freight emissions reduce by 25%.

Note we would expect the motor industry to produce as high savings as possible from hybridisation of the fleet. 140g/km is not hugely ambitious and is given only to illustrate 'poor' delivery with this policy package.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% VIBAT Target
1A High Passenger	90g/km	189g/km	-11.8 MtC	-46%
1A High Freight	50% emissions reduction	12.9 MtC	-6.45 MtC	-25%
1B Low Passenger	140g/km	189g/km	-5.9 MtC	-23%
1B Low Freight	25% emissions reduction	12.9 MtC	-3.2 MtC	-13%

Potential carbon savings and % VIBAT target contributions are based on 2000 travel and carbon emission relationships and derived using a carbon emissions spreadsheet.

To illustrate, the carbon reduction contribution of policy package 1B (low passenger) is calculated as follows:

- Average total vehicle fleet emissions in 2000 = 189 g/km
- Motor car carbon emissions in 2000 = 23.9 MtC
- Assumed total vehicle fleet emissions in 2000 = 140 g/km
- Therefore reduction of 49 g/km
- Potential carbon saving = (0.12)*49 = 5.9 MtC (with rounding)

Note policy package 9 also provides savings in the freight sector through subsidiarity and dematerialisation measures.

3.3 Policy Package 2: Alternative Fuels

Construction logic: this is complementary to policy package 1 (low emission vehicles) and is designed to reduce the carbon content of the fuels being used. It includes the use of biofuels and renewables, but also provides an incentive structure to reflect the carbon content of fuel.	
Designed for Images 1 and 2 Main policy orientation ▪ Public service ▪ Regulation	Key strategic elements ▪ Passenger and freight ▪ Organisation

There are many possible alternative fuels on the market, many of which have a lower carbon content than petrol and diesel. Khare and Sharma (2003) provide a good overview. The main options are summarised below:

- Compressed natural gas: a gaseous mixture of hydrocarbons with 80-90% methane. Colourless, odourless, non-toxic and highly flammable and compressed to improve storage capability. Most of the CNG vehicles are retrofits, converted from gasoline and diesel vehicles. CNG contains less carbon than any other fossil fuel. Main drawback is the lack of refuelling facilities.
- Liquid petroleum gas: a mixture of gases, liquefied by compression or refrigeration. Major drawback is limited supply – ruling out any mass conversion to LPG fuel.
- Methanol: an alcohol, most of the world's production of methanol is produced by a process that uses natural gas as a feedstock. It is possible to produce methanol from feedstocks such as coal or biomass, or urban waste and refuse.
- Ethanol: again alcohol based, but considerably cleaner, less toxic and less corrosive than methanol. Ethanol also has a high volumetric energy content. Can be produced by the fermentation of sugar cane or corn. More expensive to produce than methanol and requires large harvests of crops and large amounts of energy for production. One third of the 12 million cars in Brazil are ethanol powered.
- Biodiesel: produced by reacting vegetable or animal fats with methanol or ethanol to produce a lower viscosity fuel that is similar in physical characteristics to diesel.
- Hydrogen: potential to be the cleanest fuel option. However, suffers from two major problems – production and storage – the fuel is highly flammable and requires large storage capsules. Hydrogen is not a fossil fuel and is not found in significant quantities in nature. It therefore needs to be manufactured – the most common methods are electrolysis of water, reforming natural gas, or partial oxidation and steam reforming other fossil fuels. The most economical form is from reforming natural gas. Significant investments are needed in infrastructure for delivery, storage and dispensing of hydrogen if it is to be used as a vehicle fuel. The combustion of hydrogen produces mainly water vapour and no direct CO_2 emissions. Indirect CO_2 emissions however depend on the nature of the energy source used to produce hydrogen.
- Electricity: as mentioned in the previous package, there is potential for electricity-fuelled vehicles as a niche part of the market. CO_2 emissions

depend on the nature of the energy source used to produce the electricity.

Many alternative fuels can be used on their own, but others can be blended with existing fuels and used in vehicles without any major modifications to the engines. Apart from the production of these fuels, it is important to consider the supporting infrastructure that is necessary to make them work effectively.

Ethanol and biodiesel reduce CO_2 emissions per litre by 20-50% compared with petrol and diesel on a well-to-wheels basis (IEA, 2003). If the ethanol can be produced from biomass (the enzymatic hydrolosis of cellulosic feedstock) then there is an almost zero net CO_2 content. But commercial production is still some way off. Advanced liquid biofuels can be blended with diesel (0-100%) and cellulose ethanol can be blended with petrol (to 10%), and to higher levels with some minor changes to engines and fuel systems.

Here, alternative fuels will form an important element in supporting more efficient vehicles, and their role is substantial in the commercial vehicles and public transport (and taxi) fleets. Biodiesel (produced from oil crops, sunflower, rapeseed and waste) can replace diesel in cars (5%), city buses (30%) and trucks (30%), with higher levels for modified engines. Biofuels should provide 5.75% of EU energy by 2010, with renewables providing a further 10% by 2010. This optimism is reflected in the IEA report (2004) where it is suggested that by 2030, some 20-40% of all fuels in transport could come from these sources.

Main Measures

- Research and development on biofuels and renewable energy sources and their suitability for transport – to include issues relating to storage and distribution.
- Promote the use of biofuels in city transport, for taxis and buses, and for the freight sector (including local distribution).
- Use the taxation system to maintain the attractiveness of biofuels and renewables, making it economically beneficial to switch to fuels with a low carbon content.
- Encourage the production of biofuels and renewables within the UK to achieve EU targets for 2010 and later.

Impact on Stakeholders

There is little change here for the end user, except to encourage them to mix fuels for their vehicles whenever possible, as this would save them money. For commercial vehicles (taxis, buses, vans and lorries), there are substantial environmental and cost benefits from switching fuels. Although biofuels offer the greatest potential to save carbon, transition technologies such as the use of gas (LPG and CNG) also provide benefits, and for these vehicles the supporting refuelling infrastructure does not need to be ubiquitous.

National government needs to act in two main ways. One is to provide the right incentives for users to switch fuels by taxing “cleaner” fuels by their carbon content. Some progress has already been made here, but the differentials need to be maintained and increased so that manufacturers can

provide a new generation of mixed fuel vehicles. The other is to provide the means to give farmers the opportunity to switch land to the production of biofuels and biomass, so that energy crop production in the UK comes up to the EU averages by 2010 (for 5.75% of energy). Similar incentives and direction to local authorities need to be given with respect to the production of electricity (for battery vehicles) from renewables through wind farms and other sources.

The variants within this policy package are as follows:

- Variant 2A: 50% alternative fuel penetration in the hybrid vehicle fleet – passenger and freight vehicles
- Variant 2B: 20% alternative fuel penetration in the hybrid vehicle fleet – passenger and freight vehicles

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% VIBAT Target
2A High take up of alternative fuels	50% of passenger and freight	-50% of fuel use in new hybrid fleet (see policy package 1)	-9.1 MtC (based on 1A high hybrid) or -4.6 MtC (based on 1B low hybrid)	-36% or -18%
2B Low take up of alternative fuels	20% of passenger and freight	-20% of fuel used in new hybrid fleet (see policy package 1)	-3.7 MtC (based on 1A high hybrid) or -1.8 MtC (based on 1B low hybrid)	-14% or -7%

Note. Policy package 9 also provides savings in the freight sector through subsidiarity and dematerialisation measures.

3.4 Policy Package 3: Pricing Regimes

Construction logic: pricing is one of the key elements in all strategies to reduce consumption, to enhance rationality in decision making and to achieve behavioural change. Here it is argued that all forms of road space (in use and for parking) should be priced. Two variants are used - congestion charging and emissions charging.	
Designed for Images 1 and 2 Main policy orientation ▪ Market	Key strategic elements ▪ Passenger and freight ▪ Organisation

There has been considerable debate over the use of road pricing to reduce levels of congestion, lasting for at least 40 years and initially suggested in the Smeed Report (1964). Within the VIBAT study it is proposed that road pricing should relate to the emissions profile of the vehicle if CO_2 emissions reduction is taken as the overall objective for policy. In addition, it is proposed that even when the vehicle is parked there should be a charge payable as it is occupying space. The level of parking charge would relate to where it is parked, with a minimal charge if parked at home off the road, but a higher charge if it is parked away from the home. These charges would relate to all activities (e.g. work and shopping), and include both public and private parking spaces. Effectively, this becomes a charge on the ownership and use of the car.

To show two levels of likely change, two types of charging are suggested - one that is related to congestion and limited to the main cities and motorways and is revenue neutral (directed at image 1); the second is more comprehensive in relating to the distance travelled and the emissions profile of the vehicle and is revenue raising (directed at image 2). In the latter charge, if the vehicle is not used very much and produces no pollution, then the charge will be close to zero. Conversely, if the vehicle is used extensively and has a high pollution profile, then the charge will be substantial. The pollution charge can be related to the CO_2 g/km figure or a composite value to include other pollutants.

Under the revenue neutral variant compensatory measures will be used to reduce tax on fuel and other motoring costs, with the majority of the charges being placed on the use of the vehicle (and when it is parked). Under the revenue raising variant the road pricing would be via a national scheme covering all roads and its intention would be to make a major contribution to the CO_2 reduction target.

The combination of road pricing and the availability of cleaner vehicles provide a major means to achieve the overall CO_2 emissions target. All motorised vehicles would be subject to road pricing, but there may be mechanisms to reduce the charge if certain levels of occupancy are achieved (or load factors). It is expected that congestion will also be reduced as the costs of motoring have been increased for the average vehicle, and there are clear incentives to reduce unnecessary travel.

Main Measures

Variant 3A – City and Motorway Road Pricing

- Parking charges to relate to location and activity with zero charges for off-road parking at home and increasing rates for all other activities.
- Promotion of a congestion charge in cities and selected motorways.
- Incentives to increase occupancy and load factors to offset the costs of road pricing to user.
- Reductions in other forms of charges for using the car to ensure that the scheme is revenue neutral.

Variant 3B – National Road Pricing Scheme

- Parking charges to relate to location and activity with zero charges for off-road parking at home and increasing rates for all other activities.
- Promotion of a CO_2 emissions charge related to type of vehicle and distance travelled.
- Incentives to increase occupancy and load factors to offset the costs of road pricing to user.
- The national scheme would be revenue raising so that greater behavioural change is encouraged.

Impact on Stakeholders

It is argued here that congestion charging is a difficult concept to grasp for the public and that emissions charging provides an easier way to charge according to road use. There is no need to use values of time to estimate the discounted values assigned to pollution, as the charge is based on the output of CO_2 g/km and the distance travelled with discounts for high occupancy rates (or load factors). This means that the message is clear to drivers, namely that to pay less you must pollute less either by driving less in distance, or by using a cleaner vehicle, or by making best use of available space. The same argument applies to commercial vehicles, taxis and buses, as they would all pay the charge according to their emissions profile.

Transition arrangements would be necessary to ensure that clean vehicles are available for hire and purchase. The lead time required for industry would need to be resolved, as would the necessity to have a tagging system in the vehicle and the means to identify occupancy levels and load factors. Operationally there may be difficulties, and so the scheme may have to be introduced in a simplified form in the initial stages.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% Vibat Target
3A City and Motorway Road Pricing	Bvkm reduction - 3%	470 bvkm	-1.1 MtC	-4%
3B National Road Pricing Scheme	Bvkm reduction - 6%	470 bvkm	-2.3 MtC	-9%

3.5 Policy Package 4: Liveable Cities

Construction logic: this package aims at making cities more attractive by using strategic and local urban design to reduce the dependence on car travel. Measures are targeted at commuting, leisure and shopping trips. Strategic measures include public transport orientated development; and decentralised concentration in urban form. Local land use planning favours mixed use areas; better conditions for walking, cycling and public transport; decreased space for cars and parking; and short, direct routes to everyday services and amenities. Intensified access to IT plays an important supporting role.	
Designed for Images 1 and 2 Main policy orientation ▪ Regulation ▪ Public services	Key strategic elements ▪ Passenger ▪ Technology

This package has two key parts: strategic and local interventions as discussed below.

Strategic integrated urban planning and transport

- Regional and sub-regional planning and urban design.
- Public transport orientated development.
- Smart growth urban form, decentralised concentration, polycentricity.
- Decentralisation of services - health and education.

Local urban design

- Local urban design and masterplanning, with a focus on reducing the need to travel and sustainable travel.
- Regeneration of decaying areas and housing renewal.
- Improved alternatives to car use, radical improvement to walking, cycling and public transport.
- Limited road and parking space for motor vehicles.
- Limits on the environmental impact of motor vehicles (emissions, noise, accidents).
- Local community facilities, leisure and retail opportunities.

The use of public space in cities is thus critical to this policy package - the aim is to radically improve the quality of life for city living - for all age groups and stages of lifecycle and suburban as well as inner area life. It is mainly enabled by masterplanning of urban areas and quarters. Reducing the volume and impact of car traffic has a high priority in this context – a much higher emphasis than is currently given in masterplanning studies.

The improvement of alternatives strongly depends on the space available. With regard to the process of implementation, the use of IT to replace trips plays a crucial role. Unnecessary travel is - wherever possible - replaced by IT use. Reduced space for cars is hard to accomplish without an alternative way of getting access to the activity required. If public transport is the alternative, it cannot be fast and reliable if car use is not restrained. A type of

"stalemate" position may occur. In this context, emerging IT presents a major opportunity to accomplish an initial decrease of car travel (drawbacks like urban sprawl can be counteracted) which could make it possible to increase space for walking, cycling and public transport. Some roadspace is replaced by dedicated lanes for public transport, cycling and walking. Networks for these modes are made purposively more direct (and quicker) than those for the car. New developments have state-of-the-art provision for walking, cycling and public transport built in from the start. The average speed of public transport is much increased through, for example, dedicated lanes, priority at intersections and payment with smart cards. The advantages multiply: reduced travel times, higher economic and environmental efficiency as well as increased capacity of the public transport system.

Environmental zones will be established which only allow clean low speed cars. The progressive extension of these areas will create growing markets for such vehicles and new technologies (electric, hybrid, biofuels – see policy packages 1 and 2). Low speed zones and homezones in residential areas make it more attractive and safe to cycle or walk. More generally it increases the quality of life in these areas, especially for children. Lower speeds and less conventional cars significantly reduce noise. Appropriate strategic land-use planning such as decentralised concentration and high densities around public transport nodes enhances the efficiency of public transport and the possibilities to telecommute from tele-offices in local centres[1]. Less space for cars will also help to facilitate higher density development which in turn may help suppress car ownership. Mixing residential, working and shopping/service areas will reduce the need for commuting and shopping travel.

Shopping with individual cars can be strongly reduced by provision of neighbourhood shops and commercial delivery services. E-commerce could play an important role too. Planning regulations can provide improved infrastructure for delivery services, such as standardised depot boxes for every household. Reduced car traffic density allows the enhancement of recreation opportunities within cities and their immediate surroundings. The pressure for leaving the city for leisure purposes is thus reduced. The time horizon for realisation of the measures proposed in this package will differ considerably: the effects of modified land-use regulations will take very long times compared to all other measures, which in turn depend considerably on land-use.

Main Measures

- Strategic urban planning and design.
- Urban design focused on reducing the need to travel.
- Radically improved conditions for walking, cycling and public transport.
- Progressive reduction of space available for cars.
- Low speed zones (20-40 km/h) in residential areas.
- Environmental zones reserved for clean, slow speed vehicles.

[1] For discussion of the potential for land use planning and urban design to influence travel behaviour see Hickman (2006) Reducing Travel by Design. Unpublished PhD thesis. UCL.

- Promotion of car-pooling, car sharing and car rental.
- Improved opportunities for telecommuting, tele-services, tele-shopping/ doorstep delivery.
- Promotion of home delivery services and co-ordinated distribution with very clean vehicles.
- Land-use planning supporting decentralised concentration, functional mix, neighbourhood services and public transport.
- Upgrading of local urban facilities, amenities and recreational areas.

Two levels of intervention are shown - a minimal level under image 1, which represents the current level of 'token' investment in integrated urban planning, urban design and transport planning in the UK. A higher level of investment is envisaged under image 2, where a full use of current knowledge is used, with strategic and local planning initiatives, ranging from public transport orientated development to local urban design and ICT investment.

Impact on Stakeholders

Urban citizens will benefit hugely from a safer, quieter and cleaner environment. This will be particularly appreciated by families with children, and elderly people. Non car drivers will get both improved IT-accessibility and physical mobility. The improved accessibility of everyday services arising from changes in city planning and land-use regulations will reduce travel costs and time. Many people may save considerable amounts of time through telecommuting and home delivery services. Frequent car drivers on urban-rural connections will be confronted with reduced direct accessibility. However, telecommuting and teleservices may substitute some of their travels. Considerable changes in lifestyle are necessary. Urban sprawl will tend to diminish.

IT-related industries will flourish. Equipment for teleworking, teleshopping and teleservices will be in great demand. Distribution to shops and home delivery services require an extensive use of IT to optimise load factors and route selection. This could also significantly increase economic efficiency. Public transport companies will improve their economic situation because of the increased demand and higher efficiency. The vehicle industry will sell less conventional cars. However new markets will develop for clean, slow vehicles (passengers and freight), for integrated public transport systems, semi-public transport systems (fleet management, reservation and rental systems, call systems), and traffic management (access management, guidance systems). Environmentally-centred products become the new markets and the UK leads the development of these. Densely populated and well-connected areas will thrive whereas less well-connected areas will be faced by declining demand unless IT connections are enhanced.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% Vibat Contribution
4A Limited Application	Bpkm reduction - 2%	639 bpkm	-0.5 MtC	-2%
4B Extensive Application	Bpkm reduction - 10%	639 bpkm	-2.4 MtC	-9%

3.6 Policy Package 5: ICT and Travel

Policy package 5 is divided into two sub-packages: the use of ICT *in* transport and the use of ICT *on* transport. It therefore distinguishes between measures to increase operating efficiency and vehicle occupancies and those which reduce travel by providing an (ICT) alternative to physical travel.

Sub Package 5A: Use of ICT in Transport

Construction logic: this package aims at making all forms of transport more convenient through the use of ICT. Its main aim is to increase the flexibility and accessibility of transport by raising vehicle occupancies and load factors.	
Designed for Images 1 and 2 Main policy orientation ▪ Regulation ▪ Public services	Key strategic elements ▪ Passenger and freight ▪ Organisation

A number of measures are available for use. Technological innovation allows the development of a personal communicator with smart card facilities to allow payment and stored value. Each person will have a dedicated multi-purpose personal communicator (MPC) that can be used for all forms of communication and information services. The MPC will have real time information on travel services and facilities, including multi-modal travel so that journeys can be planned in advance and modified as circumstances arise. This requires co-operation of all public transport providers so that journeys from door to door can be booked with a single transaction. Car rental firms should also be integrated into the system. The intention would be to encourage multi-modal journeys which are flexible and convenient. Standardisation and full compatibility between functions and locations should be completed by 2010. The MPC has an advisory function in that it can suggest alternatives, in terms of where and when to go, special deals, or linking services with other people. The MPC can also be used for individual banking facilities, shopping, booking leisure and other activities. Supporting infrastructure will be required, and consideration given to the noise nuisance and potential health risks.

Longer distances improve the competitiveness of rail, but considerable efforts will be necessary in order to fully exploit this opportunity. Technical and organisational harmonisation of railways has to be enhanced to meet individual requirements and sustainability targets. Integrated transport and interchange possibilities grow considerably, together with automatic flexible freight handling, logistics planning and goods tracing.

Substituting individual shopping travel by professional home-delivery is another important strategy in this package (see also Policy Package 5B). Co-ordination of distribution, including home delivery, will be encouraged in order to increase load factors. Information technologies and especially e-commerce will strongly contribute to this. Integrated information systems may lead to shorter supply chains, especially when presentation and buying decisions are separated from the physical presence of a product (e-commerce).

Integrated logistic services overarching several steps of production and distribution and based on complex information systems will be mainly

provided by large international companies or networks. An important task of politics will be to support the development of standardised interfaces ensuring the inter-operability of different company systems in order to avoid new monopolies, to ensure the access of SMEs to such systems and to improve the acceptance of these efficiency-improving technologies.

Main Measures

Passenger travel

- Advanced route and parking guidance systems to allow drivers to take the shortest routes and to find the nearest available parking space.
- Communication systems to permit drivers to match their journeys with others to increase levels of car sharing. Initially this will be work based, but it can be expanded to cover other activities (e.g. shopping and leisure).
- Establishment of a public transport information system combining local, regional, national and European systems.
- More flexibility in local public transport (responsive buses, etc.) with the help of information systems.
- Separated lanes and absolute priority for public transport in traffic regulation.
- Luggage deposit and other facilities at major public transport stops to be tagged.
- Improved integration of public transport, semi-public transport (taxis, etc.), car rental, car sharing and car pooling with the help of integrated information, booking and payment systems.

Freight travel

- Support for the development of technologies and standards for automatic flexible freight handling and tracing.
- Promotion of integrated logistical systems - an IT system is established for facilitating the exchange of logistics related information. It should serve as an infrastructure for the operation of integrated logistics systems by companies or networks. This will be particularly important for the survival of small transport companies and the logistic efficiency of small producing companies.
- Introduction of mileage-related taxes for freight vehicles - tax levels that effectively raise road transport costs. Taxes may depend on time of the day or geographical area. Realised directly through Policy Package 3, but technically this can be realised with ICT developments such as GPS.
- Public investment in additional infrastructure (tracks and intermodal nodes).
- Local traffic regulation, giving priority to professional home-delivery and coordinated urban distribution with clean vehicles.

Impacts on Stakeholders

IT industries will have a strong interest in setting up information systems and selling correspondent company and individual equipment. Mobility information and booking systems may provide a strong impetus to selling personal communication devices (multi-purpose mobile phones with internet features) to everybody. The impact on the sale of cars will be limited. The vehicle industry may discover new opportunities in developing new forms of car use and in operating fleet management systems. If the systems are too complicated, elderly and technically less experienced people may have difficulties in using them.

Small transport companies will have difficulties in surviving as the larger firms move quickly to safeguard their logistics networks and only provide services to other firms at a premium price. SMEs will have high logistics costs or will risk getting increasingly dependent on these large logistics companies. There may be a case for more regulation to ensure small companies can benefit from the new technology, and there may need to be strong incentives to encourage cooperation.

Sub Package 5B: Teleactivities

Construction logic: the use of ICT allows many activities to be carried out remotely, thereby (potentially) reducing the need to travel – teleactivities covers work, shopping, leisure and socially related activities. The intention is to increase flexibility, reduce travel distance and frequency of travel.	
Designed for Images 1 and 2 Main policy orientation ▪ Market ▪ Regulation	Key strategic elements ▪ Technology ▪ Organisation

Broadband communication has allowed many activities to be carried out remotely, and it is likely that most households will have high speed internet access within the next 10 years. About 60% of those over 14 in the UK make use of the internet (in 2003). Even among non users, some get others to use the internet for them (9%) and a further 18% are "indifferent but know about its potential". It is only the remaining 14% that are real non users of the internet[2]. There is substantial potential for fundamentally changing the way in which many activities are carried out, but there are also potential barriers for

[2] For further details see (www.oii.ox.ac.uk). For a general discussion of the interactions between ICT development, urban form and travel see Hickman and Banister for DTI Foresight Panel (2005) State of Science Review: How to Design a More Sustainable and Fairer Built Environment - Transport and Communications.

certain groups. It is the higher income groups that currently have most access, with age and education being important determinants of use. Those people in poorer households with lower levels of skill and knowledge are less likely to have access to the technology and the ability to use it. Over the next 25 years (to 2030), the use of the internet will expand substantially and access will be at a low (or even zero) cost to all users.

It is likely to affect work patterns and shopping activities most fundamentally, through providing remote access and increased flexibility. It is unclear whether there will be less travel associated with remote working or shopping, as it allows people to live further away from their work and as there are also delivery journeys associated with internet shopping. Other types of activities relating to social and leisure events will also become more important as these two activities are providing much of the growth in travel. Again the likely effects are unclear as the impact could be positive, negative or neutral in terms of travel.

There is also the potential for multi-tasking whilst travelling, and this reflects the co-evolution of technology and society. The importance of real time information and the potential to adapt travel and activities whilst actually doing it reflects the enormous potential for flexibility facilitated by the mobile technology. The functional requirements of being able to carry out daily activities and for business to run efficiently needs to be balanced against the social needs of the individual and employer. The different requirements are reflected in the complexity of response and the speed of take up of innovation, as expectations are often higher than actual use, and as users make use of the technology in innovative ways.

The effects of teleactivities in terms of CO_2 reductions is dependent on whether there is less travel or more, and the likelihood is that there is no simple substitution effect, rather that travel behaviour becomes ever more complex, and aggregate travel is not reduced. Our CO_2 emission reduction impacts are therefore marginal.

Main Measures

- Encouragement of the use of the internet and mobile technology to help reduce travel frequency and distance.
- Awareness raising campaigns to inform users about the substantial potential benefits.
- Involvement of industry in looking at ways to use the technology creatively to reduce the overall level of transport activity to all types of facilities.

Impact on Stakeholders

Much of the potential here - as to the impacts of ICT on travel - has yet to be supported by high quality empirical data. There is a need for further research here. The market suggests that rational choices should be made that enhance individual welfare, but the implications for travel are less clear. On its own, there may be minimal effect, but when combined with other measures that reflect full environmental costs and emissions levels, the impact may be greater. This is particularly so in the freight sector. In terms of achieving the CO_2 reduction target, this policy package is mainly seen as a second order set of measures that can helpfully reinforce other more directly-

effective policy packages - hence the MtC reduction contributions are small. For each of the policy package variants we estimate passenger and freight travel emissions reductions.

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% Vibat Target
5A Use of ICT in Transport	Passenger: bpkm reduction - 5%	639 bpkm	-1.2 MtC	-5%
	Freight: btkm reduction - 5%	158 btkm	-0.6 MtC	-3%
5B Teleactivities	Passenger: bpkm reduction - 2%	639 bpkm	-0.5MtC	-2%
	Freight: btkm reduction - 2%	158 btkm	-0.3MtC	-1%

3.7 Policy Package 6: Soft Measures

Soft measures have gained increasing coverage in the literature in recent years. The generic title includes measures such as workplace and school travel plans, personalised travel plans, car clubs and teleworking. The most recent research (Cairns et al, 2004) estimates that implementation of the measures 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%. Earlier research (Halcrow for DfT, 2000) was slightly more conservative in the estimation of impacts. Below we consider the likely effects of soft factors such as travel planning, car ownership reduction and travel awareness initiatives.

Sub Package 6A: Travel Plans

Construction logic: the thinking here is that all activities generate and attract traffic, and to enable effective action requires those generators and attractors of traffic to become fully involved in achieving the CO_2 reduction targets. This means that they should help reduce CO_2 emissions through their own actions and understand (and accept) the importance of the global environmental problem.	
Designed for Images 1 and 2 Main policy orientation ▪ Public service ▪ Regulation	Key strategic elements ▪ Passenger and freight ▪ Organisation

Increasingly, the parties concerned with the problems of transport have been brought into the debate in a more proactive way. Businesses, schools, educational establishments, hospitals and major employers have all been seen as contributors to traffic congestion and they should also be seen as part of the solution. This involves discussion and debate over their particular requirements and an understanding of how they can contribute to a reduction in single occupancy car trips – measures have included car sharing, trip matching, cycle priority and support, providing bus services, reducing car parking spaces etc. This covers the freight deliveries in and out of the site, and looks at ways to reduce empty running and to consolidate loads (see policy package 9). In many ways a transport plan directed at the individual company is seen as part of their corporate social responsibility, and reflects the quality of management and "health" of the organisation. With respect to CO_2 emissions this means that the debate goes beyond traffic, but still the main arguments are similar in that targets for reduction are set and the means to achieve them are set for the firm and monitored.

Travel plans can be extended to individuals and groups in residential and other areas, where the possibilities for travel and CO_2 reduction are discussed, using travel blending and other marketing methods. These have proved successful in Australia and the EU (especially the Netherlands), where creative packages of local measures have been highly effective over a period of time.

Some indication of the scale of change possible is given below, using two possible futures (Sloman, 2003).

Measure	Reductions in National Car Travel	
	Enlightened business as usual	Ambitious change scenario
Workplace travel plans	-1.0% and up to - 3.4% in the peak	-2.1% and up to – 7.1% in the peak
Teleworking	-1.6% and up to –5.4% in the peak	-2.8% and up to – 9.7% in the peak
School travel plans	-0.4% and up to - 1.4% in the peak	-1.3% and up to – 4.5% in the peak
Individual marketing	-0.8% and potentially as much as -5% in urban areas	-1.6% and potentially as much as -5% in urban areas
Car clubs	-0.02% by 2010, and up to 1.6% in the longer term	-0.04% by 2010, and up to 1.6% in the longer term
Better cycling facilities	-0.3% and up to -5% in the longer term	-1.2% and up to -5% in the longer term
Incentives to walk more	-0.7%, but most of this is included in other measures – therefore net effect –0.1%	-1.6%, but most of this is included in other measures – therefore net effect -0.2%

Source: Sloman for Transport 2000 (2003) *Less Traffic Where People Live*. Note: Enlightened business as usual – car travel demand can be reduced by -12% in the peak or up to -15% overall in a large urban area such as the West Midlands. The

national impact on car demand is a -5% reduction. The ambitious change scenario means that car travel demand can be reduced by -26% in the peak or up to -33% overall in a large urban area. The national impact on car demand is a -10% reduction.

Main Measures

- Travel plans established for all major traffic generating and attracting activities in local authority areas, with clear targets and means to achieve them - travel plans are focused on achieving travel reduction and CO_2 reduction targets.
- Individuals are also included through local discussion forums to explore the potential for travel blending and personalised travel planning to reduce CO_2 emissions.

Impacts on Stakeholders

As with many of the packages discussed, this one involves extensive participation from all individuals and businesses. Its intention is to be holistic as all travellers contribute to CO_2 emissions levels and all should be seen to also contribute to its reduction. The intention is to gain support for effective action through debate and discussion, through people buying into the need to reduce CO_2 levels, and through individuals changing their habits. Its effectiveness depends on the levels of individual support.

Most of the actions here can be taken locally and it would probably depend on the local authority to open up the discussion and debate. They should act as facilitators, but there may also be a role for professional companies and consultancies that are trained and expert in helping with devising the most appropriate options for a particular situation. Initially there are no 'blueprints' or even best practice, but over time certain patterns and 'solutions' will emerge, and there is already considerable amounts of experience that can be used. As experience increases, those who have experienced successful implementation, e.g. in travel planning, can contribute to helping others.

Sub Package 6B: Car Ownership

Construction logic: levels of car ownership are reaching saturation levels in the UK, but niche markets mean that multi-car ownership is still increasing. Here the possibilities are discussed in terms of new forms of car ownership, rental and sharing with the encouragement of car clubs	
Designed for Images 1 and 2 Main policy orientation ▪ Market ▪ Regulation	Key strategic elements ▪ Passenger ▪ Organisation

In a mature economy the levels of car ownership still increase but at a lower rate, with manufacturers targeting multi-car owning households for niche vehicles. On average, most cars are used for about 60 minutes a day and are parked for the remainder of the time. Although this does not produce CO_2, the option value is still seen to be important and the availability of the car is often seen as the principal reason for using it. With the advent of smart technology, it is possible to think about new forms of ownership and whether a car is really needed at all in urban areas. If facilities are local and the quality of public transport (and cycling facilities) are good, then why own a car? Even late at night there are taxi services and at weekends a car could

be hired to take a longer trip, perhaps into the country. The costs of owning an urban car that is little used are high and through the measures being proposed here (for example in policy packages 5 and 8), the role of the car in the city is substantially reduced.

There is now considerable experience (e.g. in Switzerland and elsewhere) of car clubs and innovative rental schemes that fill this potential niche for those who do not want to own a car in the city but want occasional access. Priority can be given to these car clubs in terms of parking and the attractiveness is enhanced with reductions in fares on public transport. The eventual objective is to make cities highly attractive with quality travel alternatives and local facilities in people-friendly neighbourhoods so that cars do not feature.

In the UK car clubs are promoted by organisation such as Carplus (see www.carclubs.org.uk) and CityCarClub (see www.smartmoves.co.uk). Current provision in London is particularly extensive with coverage for much of the urban area.

Main Measures

Variant A

- Continued growth in car ownership with efficient niche cars dominating multi-car ownership households.

Variant B

- Reduced levels of car ownership, particularly in towns and cities.
- Replacement of ownership with car clubs, rental and sharing schemes.
- Priority access and parking for those participating in car clubs, rental and sharing schemes.
- Certain areas of the city to become car free.
- Investment in high quality cycling facilities and networks to reduce the need to own and use a car in the city.
- Improved public transport and taxi services.

Impacts on Stakeholders

The debate over the role and future of the car in the city is fundamental to the achievement of CO_2 reduction targets. It is accepted that technology has a key role to play and that the car is essential in certain situations, but not in all. Addressing issues relating to ownership is central to identifying where the car can be replaced. This policy package requires local communities and representatives to open the debate about the role of the car in the city and to find the balance between individual freedom and local community benefits. The CO_2 reduction targets provide the opportunity for this debate and for new forms of ownership and use of the car to be considered. A wide range of complementary measures need to be taken to facilitate such a transformation.

Sub Package 6C: Improved Travel Awareness

Construction logic: all the measures presented here in the policy packages provide the opportunities for change and movement towards the achievement of the CO_2 reduction targets. But there is an equal requirement for complementary awareness improving measures that can help persuade and encourage change to take place, and to gradually increase the levels of acceptance so that they become permanent.	
Designed for Images 1 and 2 Main policy orientation ▪ Public service	Key strategic elements ▪ Passenger and freight ▪ Organisation

Radical policy change cannot be implemented without explanation and debate, and even then there needs to be acceptance. Scenario building approaches attempt to overcome some of the potential problems of effective policy implementation through putting individual measures together in packages, and through open debate about the purpose of the change and how they relate to policy objectives. Such discussion goes beyond the normal publicity and awareness raising exercises aimed at getting people and firms engaged in the process through discussion and debate. The information flow is two way, and it is reflected by listening and understanding, including the modification of the original proposals. This is an iterative process that involves all participants so that they can gain knowledge and take ownership of the policy.

This discussion might seem rather idealistic, but the CO_2 reduction target is one concrete way to give it realism with the message that we must all be involved in its resolution, whether it is through our patterns of consumption (the cars we buy) or through our actual behavioural patterns. It goes way beyond the eco labelling and good practice guides to informing us how to become eco drivers.

Main Measures

- Much more ambitious funding and resources are required for travel awareness initiatives such as Travelwise (see www.travelwise.org.uk) and travelblending. Campaigns such as "National Bike Week", "In Town Without Your Car", "National Bike Week", "Bike2Work", "European Mobility Week" and "Walk to School Week" need much more publicity and to become more frequent if they are to seriously start to challenge private motor car advertising.
- Education programmes at schools designed to raise awareness about issues relating to global warming – this should be a key element in the national curriculum.
- University courses on sustainable urban development and transport – to educate urban planners, transport planners, decision makers and business people about the choices and options available.
- CPD programmes for NGOs and community groups as well as refresher courses for those involved in city planning and transport.
- Evening classes and serious TV (and internet) programmes to raise awareness and help people gain skills to reorganise their activities with lower levels of CO_2 use.

- Research and development to reduce energy input to production and the use of energy in the lifetime of that product, and to ensure recycling at the product life end.

Impacts on Stakeholders

This list of measures is primarily targeted at the education, learning and skills development processes – a life long learning activity. It equally applies to the actions taken. To take effective action and achieve a 60% CO_2 reduction target requires an understanding of the problem and a commitment to action over a period of time, and the best way to achieve such a permanent change is to embed it within the continuing education system.

As part of policy package 6 we also consider improvements to private car occupancy. Current levels are approximately 1.59 per vehicle (DfT, 2000 data). The main measures to enable change here are implementation of travel awareness programmes, travel plans etc., to elicit a change in travel behaviour towards higher occupancy levels; and also high occupancy vehicle (HOV) lanes. These might be HOV highway and arterial lanes; reversible (or "counter flow" lanes), which provide additional traffic capacity in the peak direction for vehicles with higher occupancy levels; lanes open only to buses; or even queue-jumping lanes (other vehicles must wait in line to enter a highway or junction, but HOVs enter directly); or preferred parking spaces or parking. HOV lanes might also be tolled. There are therefore a number of policy options. There are concerns here with double counting in terms of the likely carbon contribution potential – this however needs to be the subject of further research.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% Vibat Target
6A Travel Plans 6B Car Ownership 6C Travel Awareness	Car bpkm - 10%	639 bpkm	Combined saving for 6A, 6B and 6C = -2.4 MtC	-9%
6D Improved car Occupancy (to 1.65)		1.59	-0.9 MtC	-4%

3.8 Policy Package 7: Ecological Driving

Construction logic: the efficiency of vehicles varies with their speed, and the optimum speed is around 60-80 km/h. At optimum speeds vehicles are some 20% more efficient than when they are travelling at faster speeds (over 110 km/h). The objective of this policy package is to ensure that traffic is travelling at optimal speeds given the local conditions.	
Designed for Images 1 and 2 Main policy orientation ▪ Regulation	Key strategic elements ▪ Passenger and freight ▪ Technology ▪ Organisation

Much of conventional thinking in transport is designed to speed traffic up as congestion and delay are seen as "wasted" time, resulting in loss of time that could be productively used on other activities. Much of the current appraisal process for major transport projects is based on time savings potential.

More recently, it has been demonstrated (for example, see Plowden and Hillman, 1996) that lower speed limits, and less lane switching, can allow traffic to flow more smoothly, thereby increasing capacity. There has also been a clear move towards lowering speed limits in residential areas (home zones) and in other locations (e.g. around schools), where priority has been reallocated to people. Lower speed limits can have major safety benefits.

WWF (2000) advise that drivers of both cars and goods vehicles could typically save between 5-10% on their fuel bills by adopting more fuel-efficient driving behaviour, and in some cases, a 20% improvement in fuel economy could be achieved. An innovative driving programme in the Netherlands promotes a revised driving style that fits better with emissions reduction. Driving after the programme improved average fuel consumption by 13% on a 40km test drive, with no changes in final driving time. Among the driving techniques identified as reducing emissions and improved fuel economy are:

- Driving at moderate speeds (e.g. in the 30 to 80 kph range).
- Avoiding excessive acceleration and harsh braking.
- Observing motorway speed limits.
- Starting the engine without using the accelerator.
- Changing up through the gears at relatively low engine revolutions.
- Driving in the highest comfortable gear at any given speed.
- Controlled use of the accelerator.
- Remaining in high gear when decelerating.

The following simple measures can also be beneficial:

- Having roof-racks on cars only when needed.
- Keeping tyres inflated to correct pressures.
- Avoiding unnecessary use of in-car equipment, especially air conditioning.
- Avoiding unnecessary warm-up or engine idling time.

Within this policy package, lower speed limits can therefore perform a dual role - reinforcing the safety theme and also reducing CO_2 emissions. This also supports the case for reasonable travel times between locations, so that long distance travel can be made more efficiently by public transport rather than the private car. Hence the emphasis moves away from travel time savings towards energy, CO_2 and safety benefits, as well as wider sustainability and quality of life goals. This will involve major change to transport appraisal and investment patterns.

The Slower Speeds Initiative (http://www.slower-speeds.org.uk) actively promotes an increased understanding of the importance of speed control as a key instrument of transport policy. They mention additional potential innovative measures such as electronic vehicle identification or "black box" technology which will make it impossible to escape speed cameras, eCall systems which automatically call the emergency services in the event of a crash, alcolocks on the dashboard, biometric smart cards, cameras to identify tailgating and illegal crossing of double white lines; and campaign for evidence-based (reduced) speed limits.

This VIBAT policy package is therefore based on changed priorities that involve moving from concerns with speed to greater concerns over the environment – this gives clear messages to the motor industry about where their research should now be directed. Enforcement will be carried out through vehicle monitoring systems that operate remotely so that individual vehicles can be followed over measured distances. Within the urban areas, speed levels will be even lower as the car is sharing space with other road users (e.g. pedestrians and cyclists) and the speeds (and local design) will need to reflect the priorities. There are strong linkages to policy package 5, with ICT developments used to facilitate reduced speeds – technology can be used in the form of maximum speed limiting, ensuring drivers don't drive too close to the car in front and to prevent unnecessary drifting across lanes in congested conditions.

Main Measures

Variant 6A – National System

- There is a maximum speed limit on all roads of 80km/h with lower speed limits where appropriate.
- Monitoring systems to be set up to ensure speed limits are respected with fines for those that exceed them.
- Ecological driving skills as part of the driving licence test.

Variant 6B – National and Local System

- There is a maximum speed limit on all roads of 80km/h.
- Local schemes encouraged with speed limits of 20 km/h in residential areas and other sensitive locations (e.g. schools and shopping streets).
- Monitoring systems to be set up to ensure speed limits are respected with fines for those that exceed them, increased use of ICT to facilitate reduced speeds.
- Local authorities encouraged to design low speeds into layouts of town centres, residential and shopping areas.

- Ecological driving skills as part of the driving licence test.

Impact on Stakeholders

Individuals and firms will have to allow more time for their journeys as average speeds will fall, but so will travel time unreliability, hence net effects may be minimal. The attractions of public transport will increase as the speed difference will be smaller, and over longer distances public transport will be substantially faster then car (see policy package 8). It will also provide greater opportunities for multi-tasking during the journey (see policy package 5).

For industry, there are clear signals that the focus on speed and performance of vehicles needs to be replaced by energy efficiency, reduced environmental impact and comfort. Qualitative differences between vehicles become more important. New agencies will be required to monitor traffic flow and speed enforcement on the motorways and in the towns. Local authorities will have new opportunities to design quality into local neighbourhoods so that the space allocated to the car can be balanced against the needs of other users of that urban space. Slower urban speeds means that niche electric vehicles (policy package 1) may prove attractive, particularly for young and older drivers.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% Vibat Target
7A National System	- 26% in fuel, 25% efficient	38.1 MtC	-2.5 MtC	-10%
7B National and Local System	- 30% in fuel, 40% efficient	38.1 MtC	-4.6 MtC	-18%

3.9 Policy Package 8: Long Distance Travel Substitution

Construction logic: this package is directed at reducing the impacts of long distance passenger travel by substituting highly energy intensive modes with less energy intensive modes and other forms of communication. It also involves the reduction of travel distances.	
Designed for Images 1 and 2 Main policy orientation ▪ Market ▪ Public service	Key strategic elements ▪ Passenger and freight ▪ Technology

The increase in long distance travel - particularly by air travel and air freight transport - causes particular concern for CO_2 emissions. For example:

- The modal share of air transport is still very low but growth rates are much above those of all other modes.
- Air transport is operating with a type of 'extraterritorial' status being exempted from taxes that in national contexts are charged to all other modes.

Long range leisure travel and airborne freight transport are growing at a high speed on the basis of the present cost situation. As increasingly important economic structures are relying on cheap air transport, attempts to internalise at least a part of the considerable externalities will become increasingly difficult in the years to come. Individuals are also becoming used to the availability of inexpensive, short-haul flights. Rapid action is therefore necessary in both our images of the future. The primary concern within the VIBAT study is over internal air travel within the UK, but this cannot be separated from the wider growth in international air traffic.

Given the existing capacity problems, restrictive policies concerning airports may offer another opportunity. However - although environmental pressure near airports is high and expansion plans always cause strong local resistance - the employment opportunities are so 'tempting' that local governments tend to strongly favour airport development. Restrictive policies at the local and regional level would require a high degree of co-ordination.

Rail has the potential to offer a serious alternative to air travel over distances of around 300-500km. The considerable improvements brought by high speed trains on a limited number of national and international routes, together with faster services on existing infrastructure (e.g. with tilting technology and new signalling), technical harmonisation, organisational cooperation and strongly improved conditions for competition means that there is considerable potential for long-distance rail-air substitution and even cooperation. In addition, innovations to improve passenger comfort, flexibility, freight tracking and handling will all add to that potential. The present 'conservative' rail culture needs to be developed in order to be able to answer these challenges.

The growth of long range leisure travel may be very difficult to contain. The strategies such as those described in Liveable Cities (policy package 4) may have some effect, but the use of Carbon Rationing (policy package 10) and lifestyle oriented policies, together with substantially raised costs and limiting capacities, seem to be the only realistic possibilities for major CO_2 emissions

reductions. There is some opportunity for linkage with ICT developments (policy package 5) – the growth of long range business travel may be reduced by increased use of telecommunications and teleconferencing.

Main Measures

Variant 8A - Air Travel and Some Substitution

- Tax on air fuel, moderate, but increasing over time.
- Linking airports with the rail network to allow substitution of air by rail.
- Restrictive policy regarding airport expansion.
- Demonstration of teleconferencing facilities.
- Promotion of local destinations for leisure and tourist travel.

Variant 8B – High Speed Train and Coach

- Investment in UK high speed rail network and in upgrading existing lines.
- Exclusive coach lanes on the motorway network.
- Full integration of booking and ticketing of all public transport modes to allow better interconnectivity.
- Further restrictive policies concerning airport expansion.
- Promotion of local destinations for leisure travel.

Impact on Stakeholders

Stakeholders in air transport may oppose this policy package, but air transport will still grow quite fast (Variant 8A). There will be a strong pressure on and encouragement to railways to reform their structures and to offer faster and more customer-friendly services. If successful, they could gain a larger market share. Frequent air travellers are offered improved alternatives for access without flying. If these are not utilised they will have to pay more. Restrictions will motivate air companies to invest in new technology for engines to reduce noise and energy use.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% Vibat Target
8A Air Travel and Some Substitution	Passenger share 0.66, 8% saving on baseline	40.8 MtC	-0.5 MtC	-2%
8B High Speed Train and Coach	Passenger share 0.66, 12% saving on baseline	40.8 MtC	-0.7 MtC	-3%

3.10 Policy Package 9: Freight Transport

Policy package 9 is divided into two sub-packages: freight transport subsidiarity which refers to reduced distances involved in the flow of goods; and freight dematerialisation which is concerned with load consolidation and reduced transport content of products.

Sub Package 9A: Freight Transport Subsidiarity

Construction logic: policies for decoupling freight transport from economic growth cannot limit themselves to the narrow field of traditional transport policy. Structural approaches are required. One basic strategy is to reduce the travel distance of goods.	
Designed for Images 1 and 2 Main policy orientation ▪ Market ▪ Regulation ▪ Public service	Key strategic elements ▪ Freight ▪ Organisation

There is considerable potential for the 'regionalisation' or 'decentralisation ' of material flows. As very differentiated approaches are needed (for example, different scales for different products), subsidiarity may be a better term to use. The proposed policies address the spatial patterns of production and consumption, and the results are expected only in the medium and long term.

Consumers - private, public and commercial - are to be addressed through awareness and information campaigns promoting the use of products which come from nearby. For example, food retailers can label goods, in a similar manner to motor cars or white goods, with CO_2 content and kilometres travelled in production (known as food kilometres).

Adequate information is essential to enable customers to make responsible choices in buying goods. Appropriate systems and declaration requirements have to be developed by public authorities and others. Further, European agricultural policy needs to stop its continued opposition to regionally oriented commercialisation. Opportunities for purchasing regional products are important and concern the structure of distribution flows. An extraordinary consolidation and concentration has taken place amongst the major retail companies in the last 30 years, and this has strongly contributed to large scale increases in material flows. This process has been facilitated by land-use planning and urban policies, by technological development, by changing lifestyles, by a neglect of local cultures and an ideology of homogenisation in economic polices. Interestingly, distribution is even more concentrated than production. Changing the underlying conditions may permit the advantages of more flexible, small-scale structures to be discovered. The transport implications of such changes might prove to be important.

In terms of production, economic development policies at all levels could encourage regional networking and co-operation between companies, and the formation of industrial districts or clusters of specialisation. Sourcing strategies strongly determine the transport input to manufactured goods. As transport has always been seen as a servicing function (and not the primary

function), information concerning the transport impact of business and policy decisions is often absent. Information systems which trace the transport input of goods over the whole life-cycle could considerably help to make better choices. Likewise, a transport impact analysis of major political decisions could help to avoid perceived errors and to improve our poor understanding of the relationship between transport and development, e.g. the centralisation of health and education facilities and the effect this process has on travel and CO_2 emissions. At the moment the transport impacts of these wider policy changes are being ignored. The growth in travel is often largely influenced by external factors – such as changes to health or education policy – yet there is little research, and hence understanding, that covers these cross-disciplinary areas.

Transport will remain as a servicing and disregarded function as long as it stays inexpensive relative to the other inputs to manufactured goods. Continued subsidy of transport has led - and continues to lead - to inefficient structures. Differentiated pricing of transport according to different regional contexts (by differentiated road pricing for example) may considerably improve the possibilities of attributing real costs.

Public spending plays a very important and mostly underestimated role on many markets. Public procurement may be used very effectively for strengthening subsidiarity in the flow of goods. This must not end up in anti-innovative, local or regional protectionism, but it must allow differentiated approaches and a balanced subsidiary approach to be introduced. Price mechanisms can be widely used (policy package 3), and/or a strong emphasis could be placed on the compulsory introduction of information systems on transport carbon content and regional origin declaration. Hence the qualification and quantification of public procurement plays an important role here.

Main Measures

- Promotion of 'regional' consumer markets - Governments at all levels can promote regional consumer markets by improving public awareness and information, by introducing the notion of flexible subsidiarity in internal market regulations, and by promoting adequate distribution structures through land use planning.
- Promotion of company networking and industrial districts - Networking and local sourcing can be encouraged by development policies at all levels. Incentives, facilitation and the provision of specialised infrastructure (technology and training centres for example) can be promoted.
- Information system on the "CO_2 content" of all goods - Parallel to the introduction of EMAS[3], a European system for tracing and declaring the embedded transport costs in terms of the CO_2 in all products (in tkm by different modes) would be established within 10 years.

[3] The Eco-Management and Audit Scheme (EMAS) is the EU voluntary instrument which acknowledges organisations that improve their environmental performance on a continuous basis. See http://europa.eu.int/comm/environment/emas/index_en.htm

- Labels with declaration of regional origin - Easier to introduce would be a labelling of end consumer products concerning their regional origin. Such labelling could be made compulsory within five years.
- Environmental impact assessment for major political decisions – This could be introduced at all political levels and include statements of the lifetime use of CO_2 in the project.
- Differentiated road pricing and increases in road transport costs (policy package 3) would allow the costs of road freight transport in particularly sensitive areas or corridors to be substantially raised.
- Public procurement could be revised so that the exchange of knowledge and information is favoured while flows of goods would be contained in the spirit of subsidiarity.

Impacts on Stakeholders

Compared to present trends, populations along long-distance transport corridors would be relieved with reduced freight transport movement. Urban and rural populations would have better access to services and would have to rely less on their own cars, and this would benefit the young and the elderly. Even a small price increase would not offset these advantages. However, this trade-off does not seem to be self-evident for all. Large-scale distributors would lose opportunities and will be amongst the strongest opponents of such policies. Structural change will be accelerated in such a direction that traditional material-intensive and mass-production oriented industries will have more difficulties to adapt than flexible high-tech oriented ones. The vehicle industry will possibly lose out and oppose such a policy, while the ICT industry will discover large new markets in information systems and road-pricing systems. New systems for more flexible local logistics may create new opportunities, and SMEs may benefit from such policies more than large companies. Generally, entrepreneurship and local employment may be strengthened. Areas with high intensity, export-oriented agricultural production may oppose such policies. Railways will find it more difficult to compete since long-distance transport of mass products form their traditional market, but this may be offset by the road pricing options and a general requirement for mode shift away from the private car in the transport sector. The swift introduction of compulsory information and declaration systems may encounter lasting and detailed resistance from industry.

Policy Package 9B: Freight Dematerialisation

Construction logic: A basic strategy for reducing the necessity of freight transport is to reduce the material throughput of the economy. Also this requires approaches which go far beyond traditional transport policy and explores the potential for load consolidation and less transport content in products.	
Designed for Images 1 and 2 Main policy orientation ▪ Market ▪ Regulation ▪ Public service	Key strategic elements ▪ Freight ▪ Organisation ▪ Technology

Dematerialisation is a current trend which can be observed in many sectors. Three sub-strategies can be used to enhance it: substitution of products by services, increased durability of products and miniaturisation. Generally, dematerialisation of the economy does not only contribute to the solution of transport CO_2 problems, but also to reducing a wide range of other environmental problems. Therefore, joint efforts between different policy fields are advisable. This policy package addresses all three strategies with different kinds of policies. The general awareness and information concerning the problems caused by material consumption and the opportunities to reduce it can be overcome by appropriate policies at all levels. For example, appropriate information systems can help to improve transparency. A process of Transport Content Declaration (TCD – stating the transport involved in producing and taking a good to market) or Material Flow Accounting would be very helpful in this context. Note the effective material consumption for complex products - such as computers - is difficult to estimate for the final customers.

The substitution of products by services can be encouraged by changes in the frame conditions for the economy. Economic and fiscal policies are still strongly oriented towards hardware-producing and not to a service-oriented economy. Shifting the tax burden from labour to material or energy consumption (or impact on sustainability or quality of life goals), shifting development policy priorities away from infrastructure and hardware investments to the improvement of the human and social capital could make a huge difference. A series of more specific changes (for example, labour regulations, insurance for borrowed or rented equipment, setting of professional service standards) could support a general shift in perception concerning the service dimension of consumption. The internalisation of external environmental costs (including CO_2 consumption) will generally curb the material intensity of the economy. Therefore, the full life-cycle responsibility of manufacturers for their products is helpful, as introduced into waste policies in some countries. These policies will also tend to increase the durability and stimulate the more intensive use of products. All kinds of sharing and rental of equipment tend to lead to more intense use, and this may in turn lead to technical development towards more durability.

Miniaturisation can only marginally be influenced by public policies, but many technical and safety standards prescribe an oversized use of materials which, on a closer investigation and considering new technologies, may be considerably reduced, for example in the building sector. Changing the

admissible conditions of use, could reduce material consumption - for example, lower speed limits would allow for the construction of lighter vehicles (policy package 7). Lifestyles may not only be influenced by awareness campaigns and information, but also by providing opportunities for other 'genres de vie'. The permanent availability of cars for moving heavy goods and of frequent waste collection inevitably reduces the awareness for ones own material consumption. Encouraging car-less lifestyles by improving public transport, facilitating car sharing and rental or providing home delivery services would not only reduce private car circulation and car production - which makes up for up to 10% of total freight transport - but would also change the attitude towards the everyday consumption of materials (policy package 5).

Strengthening the trends towards dematerialisation would also change the structure of freight transport requirements. Transported goods will diminish in size and increase in specific value. This will reinforce the trend towards more careful and flexible handling and shorter transport times. This in turn may create problems for the railways and intensify the trend towards air transport. Therefore, balancing policies for these two modes will be important in order to avoid additional environmental problems.

Main Measures

- Give incentives for rental and sharing of goods and services: tax and other polices aimed at encouraging hardware investments should be linked to incentives for organisational forms that allow most intensive use of equipment. Legal frameworks for service contracting could be improved.
- Shift tax burden from labour to materials, energy and emissions of CO_2. Moves in this direction can already be observed in various other European countries. European co-ordination in this respect, especially concerning taxes on energy and co-ordinated waste policies could be very helpful.
- Shift development policy priorities (including structural funds) towards human resources: Improving the capability of mutual learning, of co-operation and of thinking in terms of optimal service delivery would become the main focus of development policies at all levels. To enhance cross-cultural learning in this respect and to pioneer in setting new priorities could be an important contribution of European Structural Funds.
- Introduce product responsibility of manufacturers for the whole life cycle: Manufacturers of all kinds of end products should be made responsible for all recycling, dismantling or disposal costs of their products also after use. This would lead to more responsible technology development and to more service-oriented marketing strategies.
- Revise standards which affect material consumption (cars and building).

Impacts on Stakeholders

Dematerialisation of the economy is an approach that allows for coalitions with a variety of actors in environmental policy. There are also strong political forces which call for effective policies for reducing unemployment and alliances seem possible to achieve a shift of tax burdens.

However, the consequences of this policy package will be quite different for different sectors of industry. The result amounts to accelerating the pace of important trends of present structural change. Traditional, hardware-oriented industries will be exposed to increased pressure to reorient themselves. ICT and service-oriented industries will gain new opportunities. Losers of an accelerated change towards a more service-oriented economy will oppose dematerialisation policies. The pressure for developing new service-oriented and communication-oriented skills for large parts of the working population will increase. Economies which are advanced in this direction will tend to be more competitive and more stable. However, accelerated change may create political conflicts with those representing and depending on traditional industries. Small and large companies may be equally affected in both directions. A strong shift in tax policy, as envisaged in variant A, may cause broader political opposition than the regulation-oriented approach which concerns more specific stakeholders.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Potential Carbon Saving	% VIBAT Target
9A Freight Transport Subsidiarity	5% reduction in Btkm	12.9 MtC	-0.7 MtC	-2.5%
9B Freight Dematerialisaiton	19% reduction in Btkm	12.9 MtC	-2.5 MtC	-9.7%

Assumptions based on McKinnon (2005) - he suggests that for each freight sub-sector there is potential for carbon savings. As an estimation he uses two calculations: if those companies performing below the mean at present were to raise their efficiency to the mean, this would lead to a 5% saving. If those companies performing below the mean of the top third of companies were to perform to that level, this would lead to a saving of 19%.

Note that in addition to these potential savings in the freight sector through subsidiarity and dematerialisation measures, there are also major savings for hybrids in freight transport with 1A freight savings of 6.45 MtC and 1B freight savings of 3.2 MtC.

3.11 Policy Package 10: Carbon Rationing

Construction logic: raising transport costs creates social and geographical distribution problems. Differentiated approaches are required, which avoid these problems. This policy package provides a flexible solution combining simple market mechanisms with new information technology and is focused on an equitable distribution of emissions.	
Designed for Image 2 Main policy orientation ▪ Market	Key strategic elements ▪ Passenger transport ▪ Organisation ▪ Technology

Much has been written on the principle of carbon rationing in recent years. Hillman and Fawcett (2004), for example, outline the potential for carbon rationing based on an equitable distribution of carbon rations - individuals are given a yearly CO_2 budget and this is gradually reduced over time to meet carbon reduction targets. Carbon and rationing is set - in the above publication - within the challenging framework of contraction and convergence (developed by Meyer and GCI, 2000). Others have written on the subject of carbon rationing, including Anderson and Starkey (2004), using the term domestic tradeable quotas. There are also alternatives to a rationing system, including taxation reform based on carbon emissions.

Within the VIBAT project we see carbon rationing as a policy package that supports and enables policy packages 1-9. An important point to bear in mind in implementation terms is social equity. The present structure of land use, housing and workplace locations, leisure and other amenities mean that mobility patterns are to a certain extent 'fixed' in the short term. Hence, for social equity reasons, a minimum level of car accessibility might need to be ensured (at least in early years). The distinction between ensuring greater accessibility to workplace and other opportunities and encouraging further mobility should however be clear.

The argument therefore is that effective incentives for not further increasing (and, in time, decreasing) overall mileage cannot rely directly on increased monetary costs as this would create unacceptable social inequities. Introducing carbon credits can solve the social distribution problem, as every person gets a limited number of credits for paying road fees and other mobility services at reasonable prices, corresponding to slightly less than present average mileage. Establishing a market for these credits will lead to higher costs for those who travel further and to extra incomes for those driving less. Those living low carbon lifestyles are hence rewarded financially.

A similar system was intensively discussed in Switzerland in the 1980s. Many variations concerning the rules for this market and its regulation are conceivable. For example, more credits could be given to those with 'environmentally clean' vehicles, but any variations from the basic scheme would need to be carefully discussed as increased complexity means a greater possibility of failure in implementation.

Encouraging the use of public transport may be coupled with the same system of carbon credits as they could also be used for paying public transport services. This would effectively decrease car mileage if public transport is attractive. Technically, smart-cards would present an excellent form for realising a carbon credit system. The cards could easily be sold (or recharged) by public authorities according to the respective personal quota, be used for payment of fees on the car taxometer, payment for public transport and easily be traded between private persons or over electronic systems. A strong differentiation in taxes (road fees) for vehicles depending on the geographical area and their emissions becomes easy to implement with such a system.

Main Measures

- Introduction of carbon credits for all individuals related to the overall levels of carbon permitted in transport to reach the CO_2 reduction target – this would be equal shares for all.
- Education programme and an extensive public debate to help convince the public of the need for carbon credits and of the fairness of the scheme.
- Introduction of a market to allow trading between those that have spare allocations and those that need more.
- Clear and transparent rules about which forms of transport count for how much carbon, and how this relates to their emissions levels and to the numbers of people (or amount of goods) carried.

Impact on Stakeholders

Persons with less than average car mileage would benefit most from such a system. Especially families with small children and elderly people, who are suffering most from pervasive car traffic and whose personal mileage is much below the average. These types of people would get an extra income by selling unused carbon credits. On the other hand, frequent drivers would have to spend much more or to change travel behaviour. Urban and rural inhabitants could both take considerable advantage from such a system since differentiated solutions are possible.

Hillman and Fawcett (2004) have developed some useful estimates of carbon emissions for specific types of journeys, see opposite. This type of information will be critical for people to help them see the level of travel behaviour change that would be required under this type of system. Much more research is required to develop a more easily useable carbon calculator for all journeys. Some efforts have been made - for example see www.safeclimate.net/calculator and www.resurgence.org/carboncalculator - but all need developing into something more easily useable.

Very important new markets would be developed in information technology and related equipment for managing the carbon credit system. Incremental development of such systems will take many years – at least 10 years. Car producers may be confronted with decreasing car sales but would be considerably challenged to provide cleaner and more durable cars with sophisticated electronic tracking equipment. Strong incentives to substitute car ownership by car rental could motivate car manufacturers to provide extended and various car services instead of only selling cars for individual

use. Banks and financial service providers could develop important new activities in developing and managing the new accountancy systems required.

Obviously this policy package represents a radical departure from current practice – yet this type of intervention may prove to be what is required to achieve our ambitious 60% reduction target. The difficulties in implementing such a system should not be underestimated, including the proliferation of black market trading.

Carbon Emissions from Typical Journeys

Destination	Round Trip (km)	Carbon Dioxide Emissions ($KgCO_2$)
Long distance journey by rail		
London - Birmingham	386	42
London - Glasgow	1,334	147
Commuter journey by rail		
Guildford - London	90	14
London Underground		
Ealing Broadway - Victoria	16	1.1
Air travel		
Heathrow - Paris	690	560
Heathrow – New York	11,070	3,930
Heathrow - Melbourne	34,020	11,090

(From Hillman and Fawcett, 2004). Note the comparator for carbon emissions journeys – the UK individual average is 5.4 tCO_2. A return trip by air to New York accounts for 3.93 tCO_2 - 73% of this annual average. For reference, Hillman and Fawcett suggest that 2 tC per person per annum equates to a 550 ppm future by 2050; and 1.1 tC per person per annum to a 450 ppm future.

Summary of Potential Impact

Package Variant	Assumption	Base 2002	Potential Carbon Saving	% VIBAT Target
10A 550ppm	Personal energy use 0.927 MtC and total energy use 1.855 MtC	1.47 MtC personal and 2.92 MtC total	-25.7 MtC	-100%
10B 450ppm	Personal energy use 0.409 MtC and total energy use 0.818 MtC		-34.1 MtC	-133%

Note: this policy package is really a stand alone option that helps facilitate change under the other policy packages. The figures are taken from Hillman and Fawcett (2004). They divide energy use in the UK into all energy use and personal energy use (which is part of total energy use). The CO_2 figures used there have been converted from $KgCO_2$ to MTC (using a conversion factor of 44/12 = 3.67).

3.12 Policy Package 11: Oil Pricing

Construction logic: Similar to carbon rationing, oil pricing can be perceived as external to the images of the future being constructed here. Oil prices provide an important factor in influencing attitudes towards technology and behaviour –increased prices particularly will help the transformation to a lower carbon future. The era of inexpensive oil prices has led to car dependent lifestyles. Within the VIBAT study we consider a range of possible values - $60, $80 and $100 - and the likely implications of price changes.	
Designed for Images 1 and 2 Main policy orientation ▪ Market	Key strategic elements ▪ External

Over the past thirty years there has been some stability in oil prices – at relatively low levels - but recently this has changed with a current level of over $60 a barrel. Substantially higher oil prices mean a transfer of money from the oil intensive consuming countries (and other countries) to the oil producing nations. It also means supernormal profits for the oil companies and the potential to explore previously uneconomic sources of oil. In the longer term it encourages industry to diversify and to look to other sources of energy for transport, including biofuels and renewables (policy package 2). The difference between the current increase in prices and previous increases contributes to historically high levels of global demand. Much of modern (industrialised) life has also become highly dependent on oil.

High prices lead to new exploration, diversification of energy sources and more investment in efficiency. The global market for oil means that prices must rise in the short term, although in the UK the consumer is shielded by the high tax component in the price of petrol and diesel. Nevertheless, a $60 barrel means that the pump price per litre of fuel is about 100p. If the current levels of tax are maintained (76% in 2003), then an increase in the cost of a barrel of oil to $80 would result in a litre of fuel costing 135p, and an increase to $100 results in the 170p litre. Increases of this scale again provide clear signals to industry and consumers to look at ways of increasing efficiency.

11A	Oil prices $60 a barrel	Pump price per litre = 100p
11B	Oil prices $80 a barrel	Pump price per litre = 135p
11C	Oil prices $100 a barrel	Pump price per litre = 170p

There is much concern in the literature about the likely extent of oil supplies. See for example John Vidal in the Guardian "*The end of oil is closer than you think*." (Thursday April 21, 2005). He comments on research which shows that oil production could peak next year (2006). Hirsch (2005) is more 'optimistic', giving various estimates from the literature – ranging from 2006/07 to "after 2010" (World Energy Council) and 2025 (Shell). All of these however are in the relatively near future. Oil peaking will result in dramatically higher oil prices and affect the transport sector hugely. This is a critical issue - much more research is required in the UK so that we can better understand the challenges and uncertainties involved with higher oil prices and supply reductions, together with likely impacts on the transport sector. We need to actively manage our movement away from oil dependency in the transport sector in a transparent manner, and in a way that does not produce huge price shocks.

The main reason for including oil prices as part of the internal measures being examined in the VIBAT study is as a type of sensitivity analysis. A number of literature reviews have considered the elasticity of fuel demand, including Graham and Glaister (2002) and Hanly, Dargay and Goodwin (2002). DfT use a long term price elasticity of demand of around 0.3.

In the short term demand is likely to be reduced, but in the longer term income rises mean that the effectiveness of high fuel prices are dampened and purchasing patterns of vehicles change. But there are again strong signals to industry and government about the need for active support measures that will encourage more fuel efficient vehicles so that the impacts of higher fuel costs can be reduced. It is also giving messages to promote diversification of fuel sources and the importance of using a variety of energy inputs to transport rather than its almost complete reliance on oil.

Within VIBAT, oil price changes are perceived as external to the scenario building exercise, mainly as the UK Government does not have control over world prices. Government can assist in keeping prices lower by releasing more supplies from the strategic reserve to dampen down the potential shortfall, and it can look at ways of reducing the tax levels on fuel (at least in the short term). But this strategy would have to be seen as part of the macro economic policy of government, as fuel tax revenues provide an important element in the overall revenue streams to government. Higher prices are also a useful tool in reducing traffic growth. Current high oil prices provide strong signals to industry and individuals that the costs of travel are likely to increase and this means that change is necessary in terms of travel patterns, but also investment decisions.

Summary of Potential Impact

Package Variant	Assumption	Base 2000	Change	Factor	Potential Carbon Saving
11A	$60 a Barrel	$40	+50%	100p/l	-1.3 MtC
11B	$80 a Barrel	$40	+100%	135p/l	-6.4 MtC
11C	$100 a Barrel	$40	+150%	170p/l	-10.7 MtC

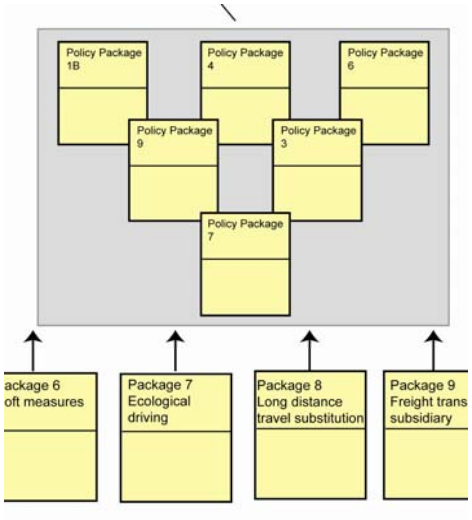
Note: This policy package is viewed as a second order measure that can reinforce other more directly-effective policy packages.

4 Package Clustering and Pathways

4.1 Introduction

The major task now is to cluster the packages together so that the target levels of reduction can be achieved within each of the two images of the future (see Figure 4.1). The intention here is not to be prescriptive or comprehensive to show every possible combination of packages that can be used to achieve the image targets, but to illustrate the ways in which it can be undertaken. Usually there is a core package that is the foundation on which the clustering takes place. This core package is then combined with others that support it or are mutually compatible with it and the underlying rationale behind the alternative images.

Figure 4.1: *Package Clustering*



4.2 Clustering of Packages

The material presented in the previous section of this report is summarised in Table 4.1, for each of the packages and the variants, including separation by passenger and freight where necessary. The summary table can be used to pull together a range of different packages, or clusters, to see how far we achieve the targets set for each image of the future. As noted previously, packages 10 and 11 are rather different to the others and can be viewed as external packages/factors that can help facilitate radical changes in emissions.

Table 4.1: *Summary of the Policy Packages*

Package	Variants	Comments	Potential Carbon Saving
PP1: Low emission vehicles	1A High (90g/km) and 50% freight emissions reduction	Passenger: -11.8 MtC Freight: -6.5 MtC	-18.3 MtC
	1B Low (140g/km) and 25% freight emissions reduction	Passenger: -5.9 MtC Freight: -3.2 MtC	-9.1 MtC
PP2: Alternative fuels	2A (50%)	With 1A (passenger + freight)	-9.1 MtC
		With 1B (passenger + freight)	-4.6 MtC
	2B (20%)	With 1A (passenger + freight)	-3.7 MtC
		With 1B (passenger + freight	-1.8 MtC
PP3: Pricing regimes	3A City and motorway		-1.1 MtC
	3B National		-2.3 MtC
PP4: Liveable cities	4A Limited application		-0.5 MtC
	4B Extensive application		-2.4 MtC
PP5: ICT and travel	5A ICT in transport – passenger and freight		-1.8 MtC
	5B Teleactivities – passenger and freight		-0.8 MtC
PP6: Soft measures	6A Travel plans		-2.4 MtC (6A, B, C combined)
	6B Car ownership		
	6C Travel awareness		
	6D Improved car occupancy		-0.9 MtC
PP7: Ecological driving	7A National system		-2.5 MtC
	7B National and local system		-4.6 MtC
PP8: Long distance travel substitution	8A Air travel and some substitution		-0.5 MtC
	8B High speed train and coach		-0.7 MtC
PP9: Freight	9A Freight transport subsidiarity		-0.7 MtC
	9B Freight dematerialisation		-2.5 MtC
PP10: Carbon Rationing	10A 550ppm	This is an enabling mechanism	-25.7 MtC
	10B 450ppm		-34.1 MtC
PP11: Oil Pricing	11A $60 a barrel (100p a litre)	This is an enabling mechanism	-1.3 MtC
	11B $80 a barrel (130p a litre)		-6.4 MtC
	11C $100 a barrel (170p a litre)		-10.7 MtC

Alternative clusters of packages can be made to achieve the targets for each image of the future, assuming that the majority of the carbon savings are additive. Further research is required on this issue - additive (and synergetic effects) are likely to play a role in our target achievement. A further issue to bear in mind is expected population growth over the study timescales. We have allowed 9% population growth from 1990-2030 - which (using 2000 travel relationships) equates to an additional 2.75 MtC.

As can be seen from the illustrative examples given below, it is difficult to achieve savings of the magnitude necessary to reach the target levels in image 1 (new market). We provide illustrations of different policy package clusters – developing a core package cluster and two variant clusters - each of which would take us along a different pathway towards our emissions reduction target. The main reason for none of the technologically-led packages achieving the target is the expected increase in car travel (+35%) over the 30-year period. This, together with the expected population increase, outweighs the potential in technological carbon savings. This growth in traffic means that 8.4 MtC more will be produced (to 2030) as compared with the current situation (2000). The target reduction under image 1, including increases in travel and population growth, therefore increases, in effect, to 36.8 MtC.

Image 2 (smart social) is easier to achieve as this assumes a decrease in car travel (-10%) over the 30-year period. This reduction in car traffic provides a reduction in carbon emissions of -2.4 MtC. Compensatory increases in usage are expected in walking (*2 number of trips on 2000 levels); cycling (*5 number of trips on 2000 levels); bus (15% increase in distance on 2000) and rail (60% increase in distance on 2000). The carbon contribution of this increase in usage of the “green modes” is however very low - just 1.1 MtC.

The actual target reduction required under image 2, including car travel reduction, walking, cycling and public transport increases and population increases, therefore increases marginally, in effect, to 27.2 MtC. Hence, in practice, the 'low carbon' modes can increase in usage as much as required - to unprecedented levels - as they have a disproportionately low impact on carbon emissions. Investment in walking, cycling and public transport to ensure state-of-the-art facilities - and in developing local communities that support usage of these green modes - should thus be hugely increased throughout the UK. Increased useage of walking, cycling and public transport can offset the expected reduction in car travel, maintaining aggregate mobility levels.

A key conclusion from the VIBAT research therefore is that technological change won't take us all the way towards our 60% emissions reduction target. Figures 4.2 and 4.3 illustrate this - our core technological package takes us just 60% of the way towards our target. Reliance on technological means is also additionally risky - the package is dependent on only a small number of measures. For example, if hybridisation of the fleet does not occur to take fleet averages below 100g/km - perhaps based on a continuation of current consumer choice trends for larger and heavier cars - then our progress towards the 60% target will be very limited. Image 2 however spreads the risks of delivery much wider - a larger number of contributory measures are at

work. Unexpected failure to deliver on some of these measures will not mean that a sustainable future becomes unachievable. The message should be strong and very positive here - a large number of smaller changes in terms of behaviour could add up to major aggregate change.

Figures 4.4 and 4.5 illustrate this picture - our core behavioural package takes us 100% of the way towards our target. We should note, however, that image 2 (smart social policy), although predominantly dependent on behavioural change, does involve significant technological change - hybrids in the passenger and freight fleet plus alternative fuels still deliver 10 MtC expected savings.

In practice therefore we should seek to deliver carbon savings from all sectors - technological and behavioural - as quickly as possible. All carbon reductions should be regarded as positive contributions to our target. A balanced approach is required.

Table 4.2: *Package Clusters (New Market Economy)*

Image 1: New Market Economy		
Target reduction of -25.7 MtC (2000-2030)		
Basic assumptions ▪ Oil price $60 ▪ Travel +35% bpkm, mobility higher than 2000 but less than BAU ▪ Average distance by car +35% ▪ Trip lengths by car +10% and trip frequency stable		
Core Policy Cluster 1.1		
Policy Package	Target Contribution	
Population increase (9% - 1990-2030)	+2.8 MtC	+10.7%
Average distance per person car increases by 35% from 2000	+8.4 MtC	+32.5%
PP1A: Total vehicle fleet - 90 g/km	-11.8 MtC	-46.0%
PP1A: Hybrids used for freight (emissions - 50%)	-6. 5 MtC	-25.1%
PP2B: Alternative fuels passenger and freight (PP2B 20%))	-3.7 MtC	-14.2%
PP3A: National road pricing (congestion basis -3% bvkm)	-1.1 MtC	-4.4%
PP4A: Limited PTOD/liveable cities (-2% bpkm)	-0.5 MtC	-1.9%
PP5A: ICT use for personal travel (bpkm -5%)	-1.2 MtC	-4.6%
PP5A: ICT use for freight (btkm -5%)	-0.6 MtC	-2.5%
PP6: Limited soft factors	0 MtC	-0.0%
PP6: Car occupancy improves to 1.65	-0.9 MtC	-3.5%
PP7: Limited ecological driving	0 MtC	0%
PP8: Limited long distance travel substitution	0 MtC	0%
PP9A: Freight subsidiarity and dematerialisation (5%)	-0.7 MtC	-2.5%
PP10: No carbon rationing	0 MtC	0%

PP11: No oil price increase on $60	0 MtC	0%
Total approx change	-15.8 MtC	61.6%
VIBAT Target	-25.7 MtC	100%
MtC short	9.9 MtC	38.4%

NB. Because of the expected increase in travel and population, the target under image 1 effectively increases to 36.8 MtC.

Variant Policy Cluster 1. 2		Variant Policy Cluster 1.3	
Policy Package	Target contribution	Policy Package	Target contribution
Population increase	+2.8 MtC	Population increase	+2.8 MtC
Travel increase	+8.4 MtC	Travel increase	+8.4 MtC
PP1A (passenger)	-11.8 MtC	PP1B (passenger)	-5.9 MtC
PP1A (freight)	-6.5 MtC	PP1B (freight	-3.2 MtC
PP2A (high)	-9.1 MtC	PP2A (low)	-4.6 MtC
PP3A	-1.1 MtC	PP3B	-2.3 MtC
PP4A	-0.5 MtC	PP7A	-2.5 MtC
PP5A and 5B	-2.6 MtC	PP9B	-2.5 MtC
PP9A and 9B	-3.2 MtC		
Total	-23.6 MtC	Total	-9.8 MtC
Target	-25.7 MtC	Target	-25.7 MtC

Note. Variant policy cluster 1.2 illustrates what might be achieved if there is very high achievement with alternative fuels together with hybridisation of the fleet.

Figure 4.2: *New Market Economy - Package Contributions (Policy Cluster 1.1)*

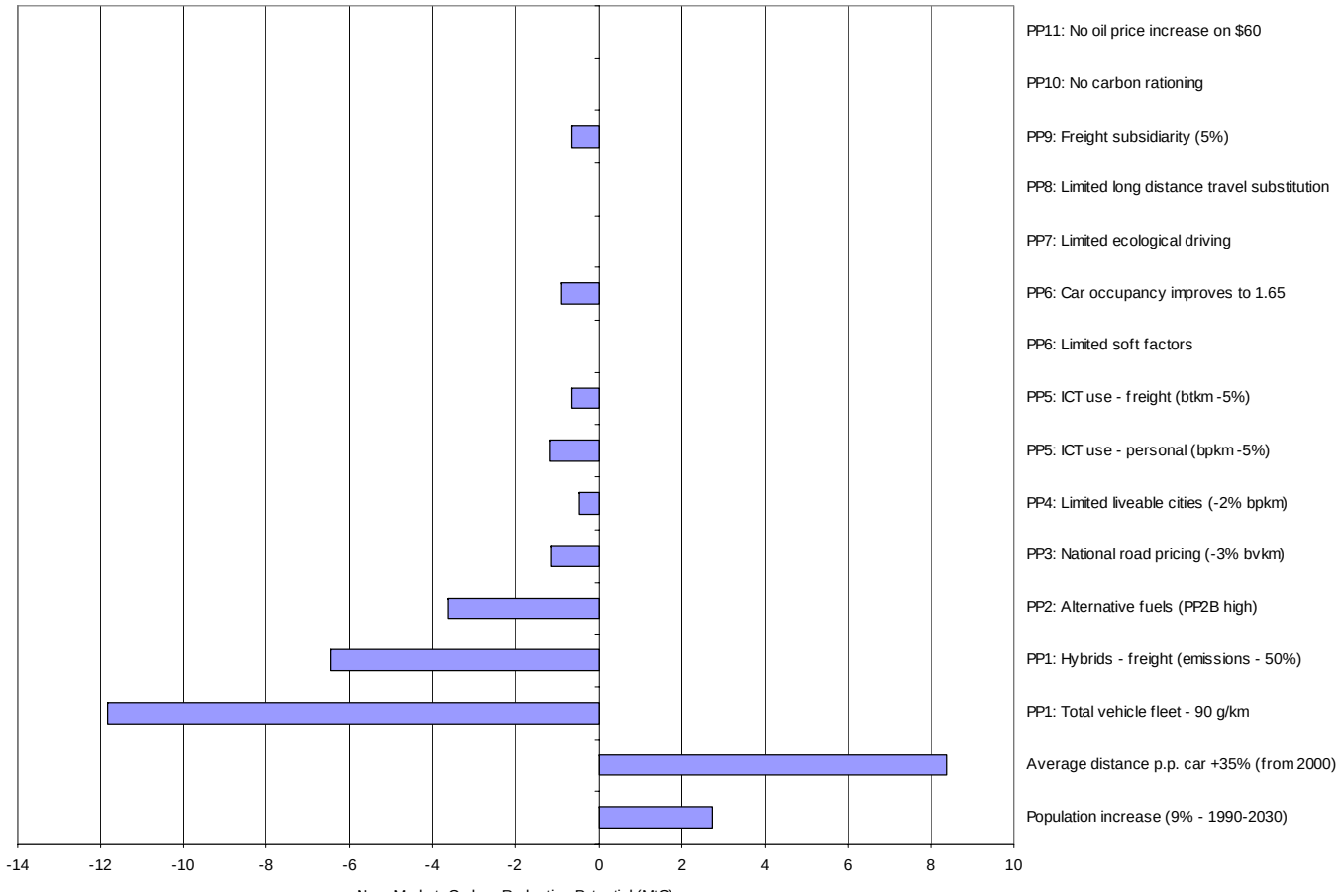


Figure 4.3: *New Market Economy – Potential Target Achievement*

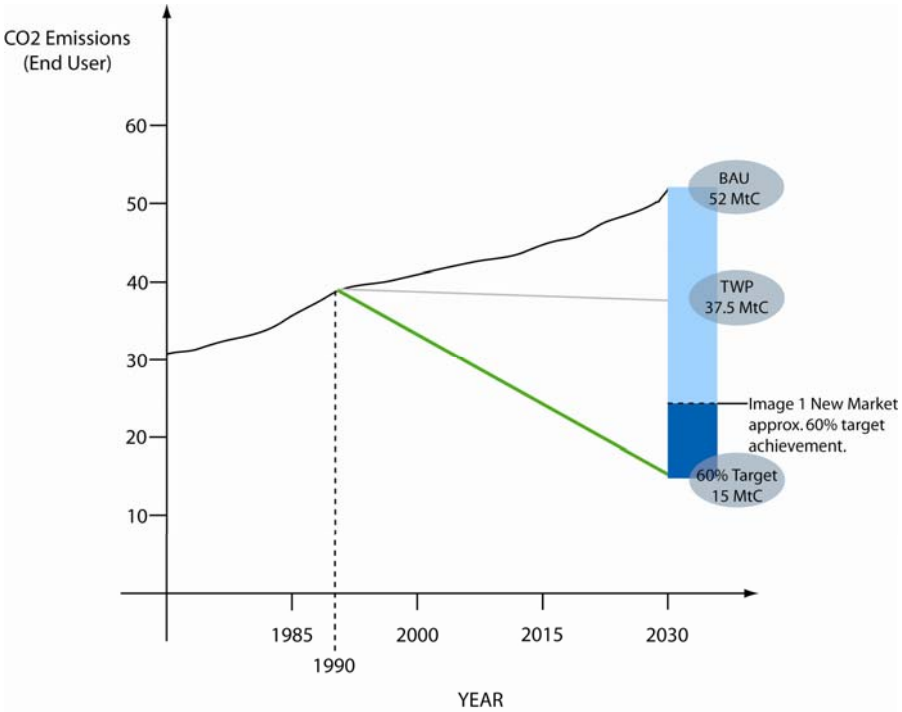


Table 4.3: *Package Clusters (Smart Social Policy)*

Image 2: Smart Social Policy		
Target reduction of -25.7 MtC (2000-2030)		
Basic assumptions ▪ Oil price $80 or $100 ▪ Car mobility reduces, average distance by car reduces by 10% from 2000, car trip lengths reduce by 10%, trip frequency stable ▪ Aggregate multi-modal mobility similar to 2000 ▪ Walk *2 number of trips; cycle *5 number of trips, bus +15% in distance, rail +60% in distance		
Core Policy Cluster 2.1		
Policy Package	Target Contribution	
Population increase (9% - 1990-2030)	+2.8 MtC	+10.7%
Average distance per person per car reduces by 10% from 2000	-2.4 MtC	-9.3%
Walk *2 number of trips from 2000	0 MtC	0%
Cycle *5 number of trips from 2000	0 MtC	0%
Bus +15% in distance from 2000	+0.2 MtC	+0.8%
Rail +60% in distance from 2000	+0.9 MtC	+3.5%
PP1B: Total vehicle fleet - 140 g/km	-5.9 MtC	-22.8%
PP1B: Hybrids used for freight (emissions - 25%)	-3.2 MtC	-12.5%
PP2B: Alternative fuels passenger and freight (PP2B low)	-1.8 MtC	-7.1%
PP3B: National road pricing (environmental, road transport -6%)	-2.3 MtC	-8.9%
PP4B: Integrated PTOD/liveable cities (-10% bpkm)	-2.4 MtC	-9.3%
PP5B: ICT use for personal travel (bpkm -2%)	-0.5 MtC	-1.9%
PP5B: ICT use for freight (btkm -2%)	-0.3 MtC	-1.0%
PP6: Soft factors	-2.4 MtC	-9.3%
PP6: Car occupancy improves to 1.65	-0.9 MtC	-3.5%
PP7B: Ecological driving, slower speeds	-4.6 MtC	-17.8%
PP8B: Long distance travel substitution (12% - PP8B PP7B)	-0.7 MtC	-2.6%
PP9B: Freight subsidiarity and dematerialisation (19%)	-2.5 MtC	-9.7%
PP10: Personal carbon quotas (potential enabling measure)	*25.9 MtC*	*100%*
PP11: Increased oil prices (potential enabling measure)	*25.9 MtC*	*100%*
Total approx change	-25.9 MtC	-100.7%
VIBAT Target	-25.7 MtC	100%
MtC short	-0.2 MtC	-0.7%

NB. The projected reduction in car travel offsets the increase in carbon consumption resulting from increases in bus and train usage and population growth. The effective target under image 2 is hence 27.2 MtC.

Variant Policy Cluster 2.2		Variant Policy Cluster 2.3	
Policy Package	Target contribution	Policy Package	Target contribution
Population increase	+2.8 MtC	Population increase	+2.8 MtC
Car travel decrease	-2.4 MtC	Travel decrease	-2.4 MtC
Bus increase	+0.2 MtC	Bus increase	+0.2 MtC
Rail increase	+0.9 MtC	Rail increase	+0.9 MtC
PP3B	-2.3 MtC	PP1B	-9.1 MtC
PP4B	-2.4 MtC	PP2B (high)	-3.7 MtC
PP5A	-1.8 MtC	PP7B	-4.6 MtC
PP5B	-0.8 MtC	*PP10: Personal carbon*	*- 15.9 MtC*
PP6 (Soft Factors)	-2.4 MtC	*quotas (potential enabling*	
PP6 (Car occupancy)	-0.9 MtC	*measure)*	
PP7B	-4.6 MtC	*PP11: Increased oil prices*	*- 15.9 MtC*
PP8B	-0.7 MtC	*(potential enabling*	
PP9A and 9B	-3.2 MtC	*measure)*	
PP10: Personal carbon quotas (potential enabling measure)	*-17.6 MtC*		
PP11: Increased oil prices (potential enabling measure)	*-17.6 MtC*		
Total	-17.6 MtC	Total	- 15.9 MtC
Target	-25.7 MtC	Target	-25.7 MtC

Note. Variant policy cluster 2.2 illustrates what might be achieved without using low emission vehicles or alternative fuels.

PP10 Carbon quotas and PP11 Oil price increases are included as enabling measures which might potentially be required to facilitate this level of change.

Figure 4.3: *Smart Social Policy Package Contributions (Policy Cluster 2.1)*

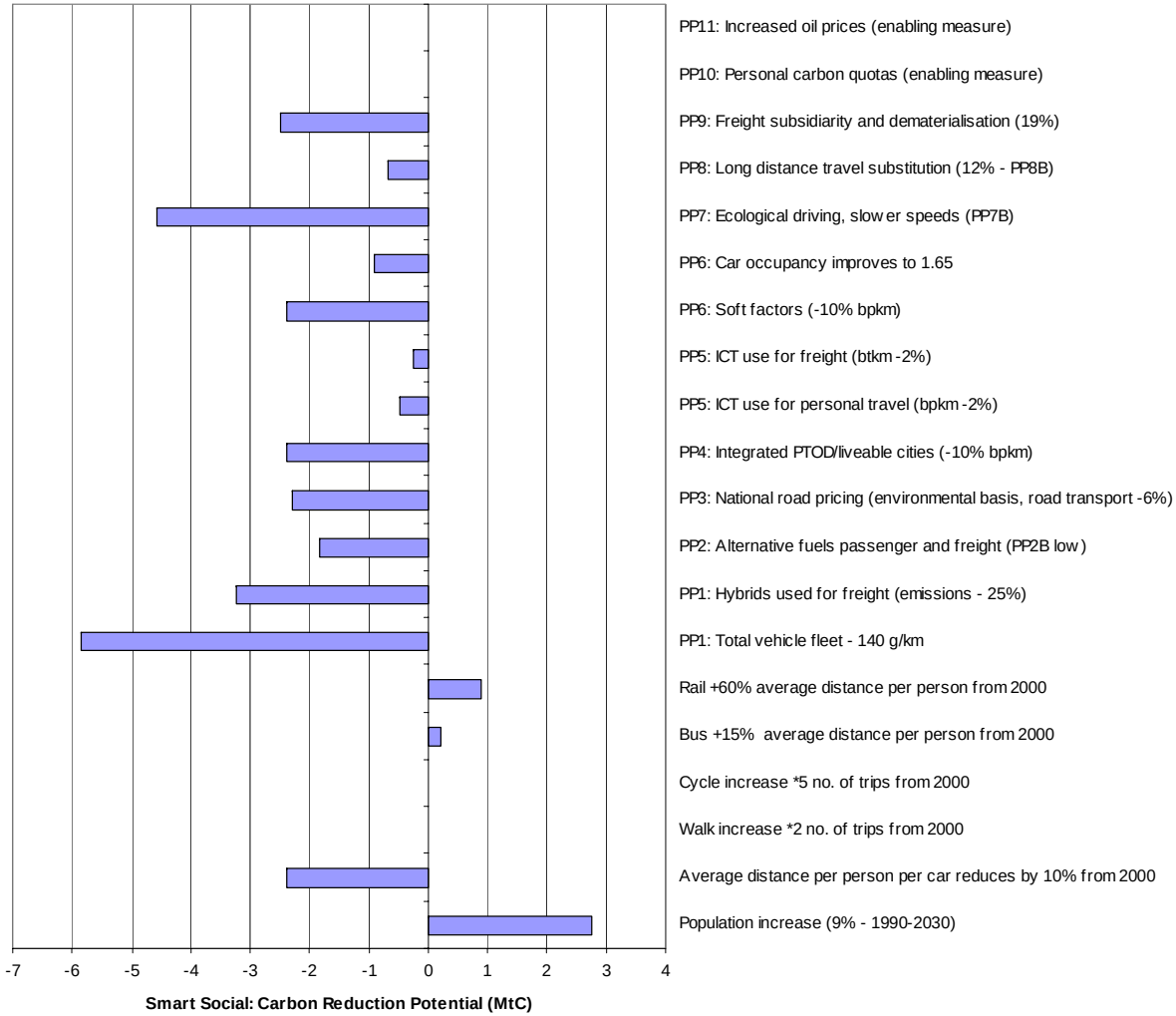
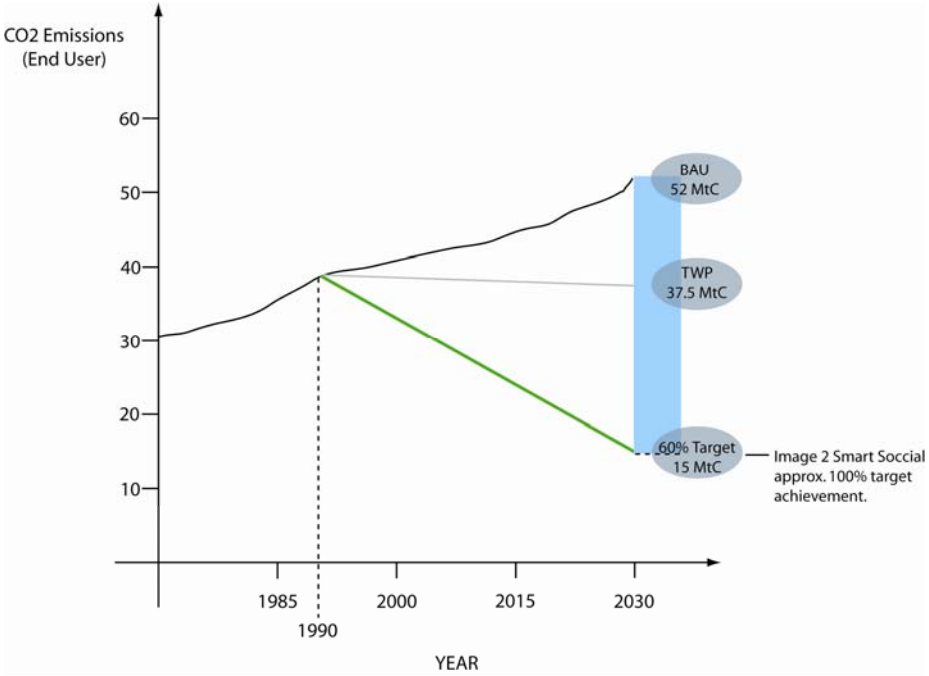


Figure 4.4: *Smart Social Policy – Potential Target Achievement*



4.3 Policy Pathways

The policy packages have been grouped into clusters so that the targets set in the two images of the future can be achieved. We have already commented that it is extremely difficult to reach the image 1 targets with any of the available combinations of policy packages (Table 4.2) because of the increase in travel and the expected growth in carbon emissions resulting from this. But for image 2, there are several ways in which the targets set can be reached (Table 4.3). This would suggest that the risks (and costs) involved with image 2 are less than those with image 1.

The policy paths try to establish the timelines along which certain decisions need to be made. Many innovative policies require long lead times, as primary legislation may be necessary and as industry needs clear signals (or incentives) from government to change production lines and innovate.

Individuals do not change behaviour over night and need to be informed about the policy measures (and packages) being introduced to obtain their support. The intention of developing timelines is not to be rigid, but to allow flexibility and to begin to move in the direction of the 60% CO_2 reduction target. Actions cannot be left until near to 2030, as this again will increase the risks (and costs) of not achieving the targets set.

Most of the policy packages allow for considerable flexibility in their application and continuous assessments should be carried out to adjust the strategy according to circumstances that may arise. Unintended and unexpected consequences of some/all of the measures are very likely. A further development of the approach described here would be the use of a database management tool that allows different policy packages to be tested by decision makers with different levels of severity to establish whether the targets set can be achieved over the timescale envisaged. A spreadsheet of this sort has been developed within this project, but could be further refined and tested using a 'bottom up' aggregation of best practice change achievement.

As noted in the clustering of the policy packages (Section 4.2), there are various ways in which the targets can be achieved for both images. Table 4.4 gives some indication as to the sequencing of the changes. Because of the scale of the 60% CO_2 reduction target, it is crucial that action is taken early. In all eleven policy packages a 2006 start date is proposed, apart from the alternative fuels package (Policy Package 2). This is because the UK is trying to achieve its 10% renewables target for energy production by 2010, and this is not likely to include transport. Biofuels for transport will either have to be imported before 2010 or developed later, and there are concerns over the costs (and risks) of production. Debate over the introduction of a Renewable Transport Fuel Obligation (RTFO) should be continued – eventually requiring that transport fuel suppliers ensure that a percentage of their sales in the UK are from renewable sources.

Table 4.4 gives details on the timing and a commentary on each of the policy packages, but it should also be remembered that to achieve the targets for each image it is necessary to combine several of the policy packages into

clusters. It can be argued that as more elements are included in the cluster, the greater the risk that the targets will not be achieved, as the total consists of the sum of the parts. However a greater number of elements in the cluster also balances the risk of non delivery or under delivery. There is an assumption within the packaging process undertaken within VIBAT that the effects are additive or can be made additive – this needs further exploration, as does the effect of potential synergetic effects.

It is estimated that in most cases measurable effects will be apparent by 2010 (if implementation commences in 2006), and this is important as success in achieving the targets depends on demonstrable results. The risks involved in many of the policy packages are not great and most are based on known technologies that do not cost much to implement. The highest costs (and risks) are associated with the two technological innovations (policy packages 1 and 2), and the costs of a reliable GPS system to monitor traffic flows as part of the national road pricing scheme (policy package 3). The other measures embedded in the policy packages are based on technologies that are already in use. This makes early implementation possible, with low risks.

The *technological risk* relates to whether the car (and freight) industry can produce sufficient hybrid vehicles to replace the entire UK stock by 2030. A change of this magnitude is dependent on the producers changing their production process to make hybrids, either through their own design or licensed. It also depends on the price of cars (and lorries) being reduced through economies of scale and mass production, and it needs a concerted marketing strategy to sell the vehicles. Industry may require clear signals from government and there may need to be a system of incentives (e.g. subsidised prices) and disincentives (e.g. higher fuel costs) to users.

Political risk is also an important concern. With all the policy packages there seems to be little risk apart from those that result in substantial cost increases to the user. The risk here can (and should) be reduced by encouraging people (and businesses) to switch to more efficient cars and public transport (including walk and cycle). To support all policy packages and paths, government needs to engage the public in promoting the move towards a low carbon economy. We suggest some form of 'great futures' debate. Some travel will cost substantially more (e.g. for domestic air and inefficient vehicles), but this must be balanced against better quality public transport, local accessible facilities, and the opportunities for travel substitution. These types of choices need to be made explicitly clear to the public, together with the range of options, risks and costs.

Table 4.4: *The Policy Paths*

Policy Package	Start	Effect	Overall	Comments
1. Low emissions vehicles	2006 Increase production of hybrid vehicles.	2010 Mass production of hybrids from several producers.	2020 Incentives to purchase hybrids – costs reduced, but fuel costs increase (PPP11).	Toyota to produce 1m Prius cars (and other hybrids) by 2010 (13% of output) – other producers need to do the same. UK market 2.5m cars (2004).
2. Alternative fuels	2010 10% renewables target in UK – Biofuels blended with diesel.	2020 Target needs to be raised to 20% - market for public transport and taxis.	2030 Target raised to 50% with economies of scale in production of biofuels.	Risk here in high costs of production and the land required to meet targets – also whether transport fuels should be included.
3. Pricing regimes	2006 Charging in many cities with re-investment in public transport.	2010 National system of pricing and parking controls – revenue raising .	2020 Reductions in charges for high occupancy and clean vehicles.	Technology now available to monitor access to city centres, with GPS on the main motorway and road networks – some costs to set up and enforce.
4. Liveable cities	2006 Reduce space available for cars – promote public transport, walk and cycle.	2010 Urban design to reduce the need to travel – strategic and local design (focus on Sustainable Communities and Growth Areas).	2020 New generation of cities and locations designed for walking and cycling and public transport. Much improved tangential public transport offer (in addition to radial).	Most measures are available and would be adapted to local conditions, but design would be for people and to reduce journey lengths.
5. ICT and travel	2006 Information guidance and integration.	2010 Teleactivities to replace trips. Logistic systems.		Affects both freight and passengers – key supporting measure to replace trips and increase load factors.
6. Soft measures	2006 All those available now to be introduced en-masse.	2010 Reductions in car ownership under Image 2 – niche vehicles and car clubs.		Many small savings, but important to change attitudes and behaviour – shorter trips and use of public transport, walk and cycle.
7. Ecological driving	2006 Reduce speeds in towns and local areas, ecological driving training.	2010 Reduce speeds on main roads and motorways.	2015 Enforcement through GPS – on total journey times – better local design.	Huge potential savings with lower speed limits and better driving techniques – also safety benefits.

8. Long distance travel and substitution	2006 Investment in high speed rail – coach lanes on motorways.	2010 Higher prices and limitations on air travel – full costs to be paid.		Speeds would be reduced and public transport becomes more competitive on time with the car. Use of efficient modes and full loads.
9. Freight	2006 Reduce empty loads.	2010 Create markets for load matching – less distance travelled.	2015 More efficient lorries with hybrids and alternative fuels - miniaturisation of products.	Potential to increase load factors and reduce distances travelled and volume of freight – also local sourcing.
10. Carbon Credits	2006 Stand alone means/enabling measure to achieve target – to reduce levels by 15% a year from 2005 allocations.			Figures from Hillman and Fawcett (2004).
11. Oil Pricing	2006 Reduce fuel consumption and encourage shift to alternative fuels and efficient vehicles – important enabling mechanism.			Oil prices determined by factors outside the control of the scenario building. Various estimates as to year of reaching peak oil. Difficult to see VIBAT carbon reduction targets being met with cheap fuel.

In conclusion, we can see that image 1 is more risky as it depends on achieving the targets through the technological policy packages, and it is in these policy areas that the future is most uncertain (Table 4.4). In addition there is an increase of 35% in the levels of mobility over this period that makes this image very difficult to achieve. Even with the strong implementation of the technological options, there is also a need for strong supplementary supporting policy packages from the other options (Tables 4.2 and 4.3). This is really a *complexity risk* as achievement of the targets is dependent on all actions working fully in support of each other. Even then, only one combination of policies was possible (Policy Cluster 1.2) – all other policy clusters were well short of the 60% target. Carbon Credits could be used to achieve the saving, but it is very unlikely that the levels of travel envisaged in the New Market Economy (Image 1) could be maintained.

Image 2 provides greater potential in terms of alternative paths, and this is mainly because the anticipated levels of travel have not increased on 2000 levels. In fact mobility is slightly less (-10%) than it was in 2000. This gives much greater flexibility and reduces the complexity risk, as different combinations of policy packages can be used to significantly move towards the targets set (policy clusters 2.1, 2.2 and 2.3). Image 2 is less dependent on a small number of measures and delivery of the potential technological change. Common elements should be introduced as early as possible and the necessary supporting elements can also be introduced with adjustments being made later as necessary.

Throughout this process, there has been a consistent set of objectives that have been underpinning the scenario building process, and these are summarised in Table 4.5. Each of the policy packages are trying to make travel more efficient through the use of less carbon in fuel. This can be achieved through the use of alternative fuels or more efficient engines (ICE and hybrid). In addition, the aim has been to address the number of trips made (trip frequency), trip distance, the mode of transport used, and the occupancy levels (or load factors). In each case energy (and carbon) savings can be made and the summary table gives an indication of the scale of the saving that might be expected. To achieve CO_2 reductions of 60% by 2030 requires all of these indicators to be used, although savings in one column may be countered by increases elsewhere.

Table 4.5: *Policy Packages and Likely Impacts on Travel*

Policy Package	Variant	Efficiency	Trip Frequency	Trip Distance	Mode Shift	Occupancy or Load Factors
Low emissions vehicles	1A	+++	-	-	-	?
	1B	++	+	+	?	?
Alternative fuels	2A	++	-	-	-	-
	2B	++	-	-	-	-
Pricing regimes	3A	+	++	++	+	+
	3B	++	+++	+++	++	++
Liveable cities	4A	+	- -	+	+	+
	4B	+	- -	++	++	+
ICT and travel	5A	+	+	?	?	++

	5B	++	++	+	?	+
Soft measures	6A	+	+	+	+	+
	6B	+	+	+	++	++
	6C	+	+	+	+	+
Ecological driving	7A	++	+	+	+	+
	7B	+++	+	++	+	++
Long distance travel and substitution	8A	+	-	-	?	+
	8B	++	+	+	++	++
Freight	9A	+	+	++	?	+
	9B	++	+	+	?	++
Carbon Credits	10A	+++	+	+	+	+
	10B	+++	++	++	++	+
Oil Pricing	11A	+	+	+	+	+
	11B	++	+	++	+	++
	11C	+++	+	+++	++	++

Notes: Variants relate to those described in Section 4.1 and Table 4.2. Savings are denote by + and costs by -, with more + or – meaning greater or less. ? means the effect is uncertain.

4.4 Likely Key Trade-Offs: Average Distance Travelled and Vehicle Fleet Emissions

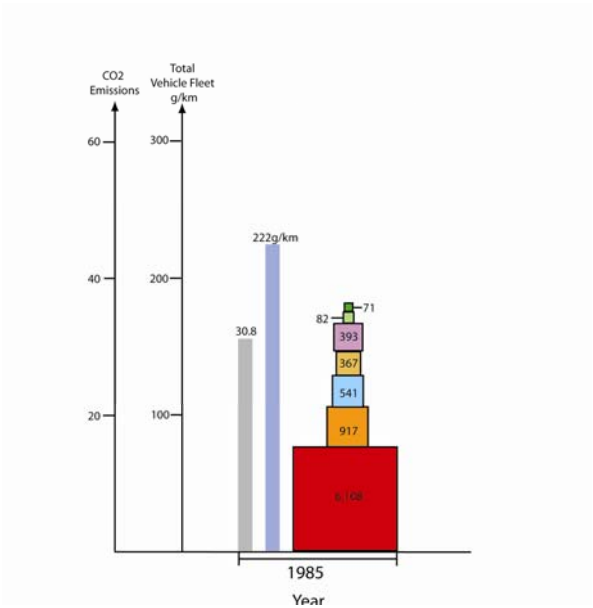
A number of important trade offs are therefore likely to be required during the implementation stages of our images of the future. In this section we look at a central trade off - average distance travelled per person per year (km) versus average vehicle fleet emissions (g/km) – for 1985/1990/2000/2030 and for our two images of the future – the new market economy and smart social policy. Considering fleet emissions and distance travelled neatly represents the technology and behaviour dichotomy, though obviously there are more dimensions to the argument.

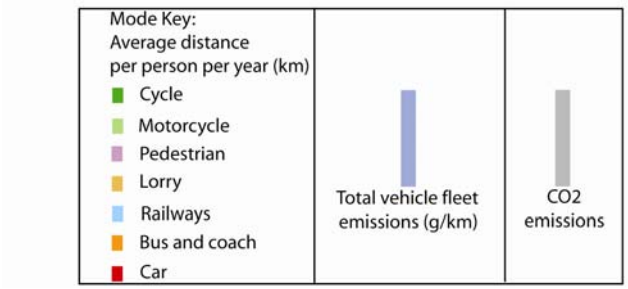
Clearly if fleet emissions reduce then the amount of car-based travel can increase for a given fixed level of emissions. Note that increases in car travel require effective implementation of technological developments. Increases in walking, cycling and public transport however are much less carbon intensive.

The following 'skyscraper' diagrams illustrate all transport CO_2 emissions and average vehicle fleet emissions with vertical bars, and mode shares in terms of average distance per person per year (km) by area of the 'skyscraper' blocks. Historical data is given for 1985/1990 and 2000; with projections for 2030 (National Traffic Model projection, which broadly equates to the continued 2004 Transport White Paper policy approach), 2030 New Market Economy, and 2030 Smart Social Policy.

1985

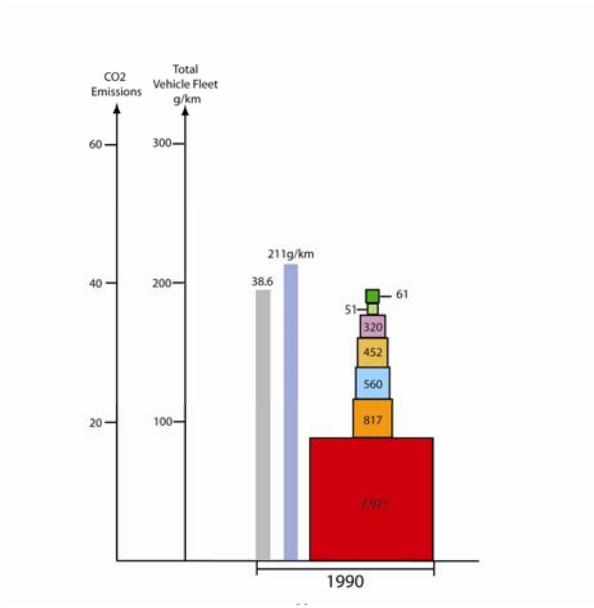
Historical data: NETCEN emissions and National Travel Survey data

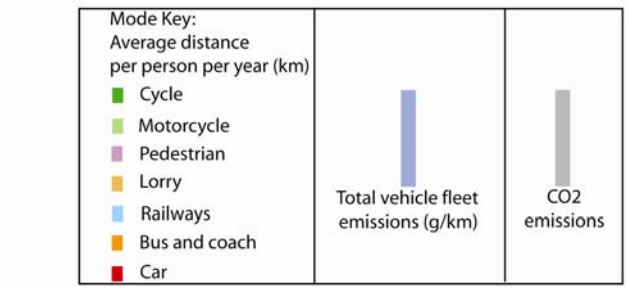




1990

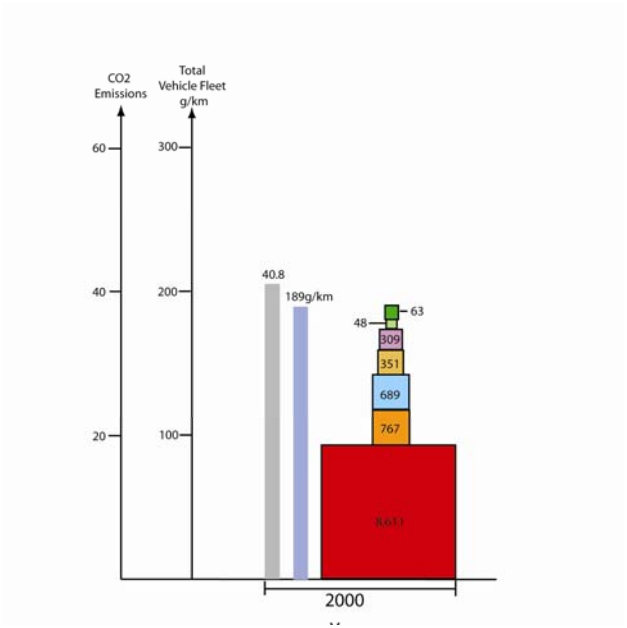
Historical data: NETCEN emissions and National Travel Survey data

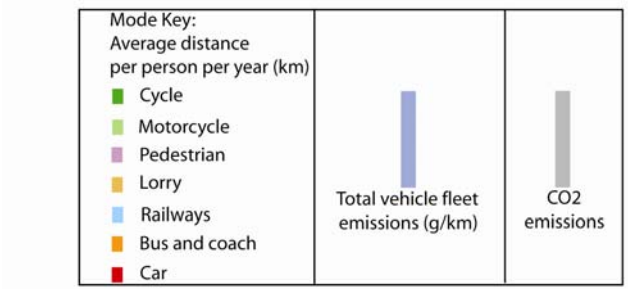




2000

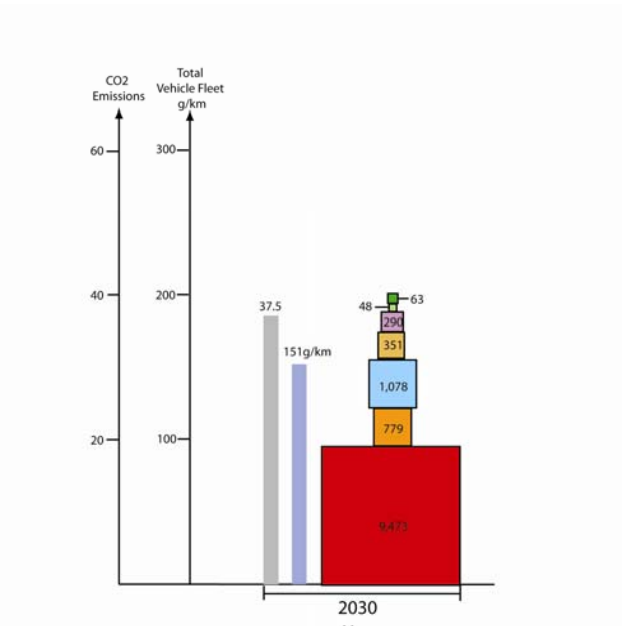
Historical data: NETCEN emissions and National Travel Survey data

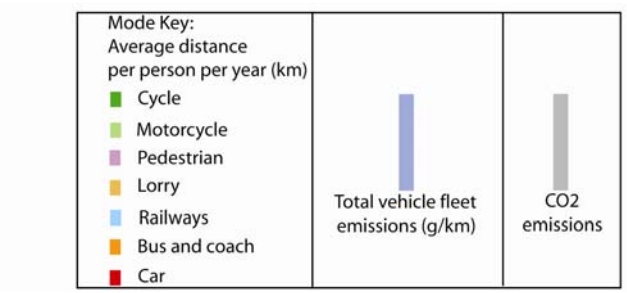




2030

DfT projection (2005) using National Traffic Model



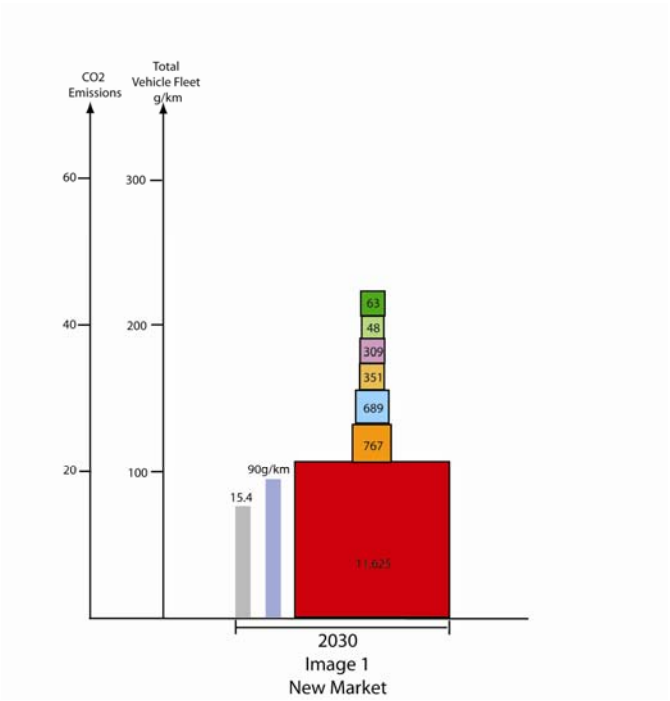


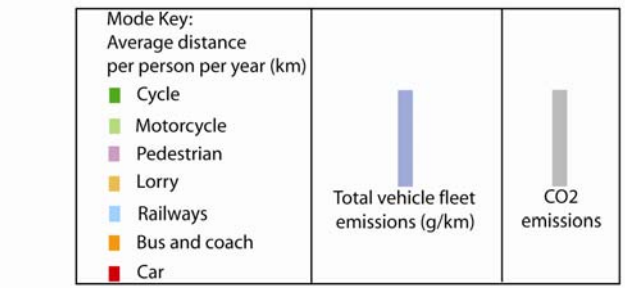
2030

Image 1 New Market Economy Projection

Assumptions:

- Mobility higher than in 2000
- Technological change relied on to deliver emissions reduction target: all or virtually all vehicles hybrid
- Average distance per person increases by 35% from 2000
- Total vehicle fleet = 90 g/km



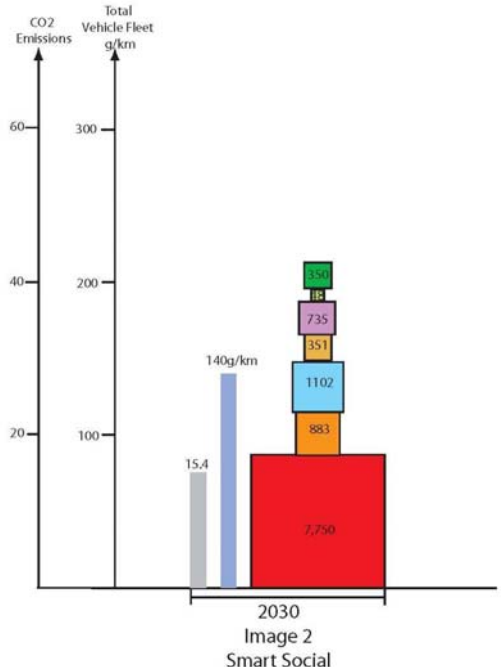


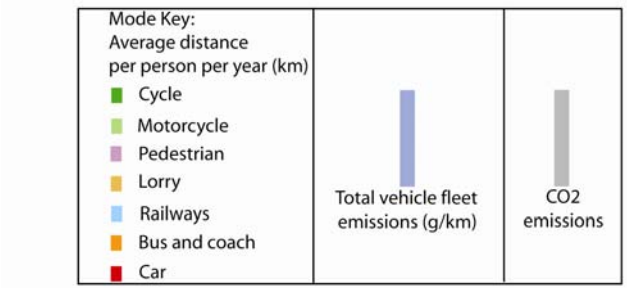
2030

Image 2 Smart Social Economy

Assumptions:

- Behavioural change and technological change relied on to deliver emissions target
- Car mobility lower than in 2000: average car distance per person reduces by 10% from 2000
- Increased use of walking, cycling and public transport
- Technological uptake less impressive: total vehicle fleet = 140 g/km





4.5 Policy Package Clustering: Conclusions

Our policy package clustering exercise has therefore drawn out a number of important issues.

1. A 60% CO_2 emissions reduction target can be achieved in the transport sector, however this requires radical and concerted action, commencing in 2006.

2. Hybridisation of the vehicle fleet and alternative fuels are potentially the most important single packages in terms of CO_2 emissions reduction potential. However even a radical introduction of these packages is not likely to lead to the full achievement of our 60% emissions reduction target.

3. A much wider packaging of measures is required – including action in terms of low emission vehicles, alternative fuels, pricing regimes, liveable cities, ICT and travel, soft measures, ecological driving, long distance travel substitution, freight transport, and carbon credits and higher oil prices.

4. Behavioural measures are critical and should not be underestimated. Much greater usage of walking, cycling and public transport, and less use of the private motor car, can lead to great benefits in terms of carbon emissions. Walking and cycling are virtually carbon free options.

5. A 60% CO_2 emissions reduction can be achieved in a variety of ways – focused on behavioural measures - without a strong push on low emissions vehicles in the passenger and freight sectors or a switch to alternative fuels. However, again, this is not recommended. A package of technological and behavioural measures is likely to be the most successful way forward. It is here that risks are lowered and additionality and synergetic effects are likely to be greatest.

6. The particular difficulty faced in image 1 is the expected growth in travel. In effect this means that the 25.7 MtC reduction target is increased to 36.8 MtC, and this proves a very difficult target to achieve.

7. In Image 1, if there was no growth in traffic, then again the 60% target could be reached with solely technological solutions, such as low emissions vehicles (PP1) and 50% alternative fuels (PP2) in both the passenger and freight sectors. This would give a total reduction of 27.5 MtC.

8. Image 2 is relatively “easy” to reach as there is no expected growth in overall travel, a substantial shift to walking, cycling and public transport, and less use of the car. This image however still requires the use of significant technological input together with pricing and regulation in a variety of forms to achieve the target set.

5 Synthesis and Conclusions

5.1 A Radical and Integrated Package

The issues relating to climate change have risen dramatically to the top of the political agenda in recent months, and the importance of transport in contributing to reducing levels of CO_2 is clearly evident: yet the paradox remains that traffic levels continue to rise and all the projections suggest that significantly reducing emissions in the transport sector is likely to be very difficult.

The contribution of the transport sector to global environmental targets remains unclear at best. The VIBAT study attempts to fill this gap and the findings provide a new way forward for transport planning and investment in the UK. A critical point is that as urban and transport planners we need to begin to think very differently in tackling the global emissions problem.

Albert Einstein said that "*We can't solve problems by using the same kind of thinking we used when we created them*". These thoughts very clearly apply to the difficulty with current rising transport emissions and divergent global environmental targets: firstly the level of change required in the transport sector is huge (and will be perceived by many as unattainable); and secondly to provide a vision of where we would like to be in the future we need to develop different problem-solving techniques to those traditionally used.

On the empirical side, traditional forecasting studies are unlikely to help us in achieving a future that breaks current trends. The backcasting approach as used in the VIBAT study is however one that is ideally suited to examining futures that are trend-breaking in nature. Much more research needs to be carried out of this type in the transport field.

In practical terms, what is eminently clear is that a business as usual approach, or limited variations around this, will not deliver the low carbon future we aspire to. Collectively, as urban and transport planners, decision-makers and the public, we need to raise our game; we cannot be content with current trends continuing as they are at present. Very significant changes in technology and behaviour are likely to be required in the next 30 years.

We should bear in mind that a 60% CO_2 emissions reduction target is hugely ambitious; there is certainly no guarantee that such a level of change is achievable. However it does signify the likely scale of change required to achieve a more sustainable future and the VIBAT study analysis suggests that this scale of change is achievable.

To give an idea as to the scale of the target in relation to global warming stabilisation levels - we perceive our 60% CO_2 emissions reduction target in the transport sector as providing a likely contribution [only] to a 500-550 ppm CO_2 concentration future by 2030, dependent obviously on what other sectors achieve. An 80% CO_2 emissions reduction target is more likely to lead us towards a 450 ppm future - and this is the level of atmospheric concentrations that most commentators feel comfortable with. Further research is required

here though - we need a more robust understanding of the contribution the transport sector has to make relative to various levels of atmospheric carbon concentrations.

5.2 The Vibat Contribution

The task undertaken in the study has been of a substantial scale, as it has developed a systematic review of the literature, established a sound database and forecast the likely business as usual projection for 2030. It has also presented the methods available for change, assembled them into mutually consistent packages, clustered the core packages, and concluded with the development of policy paths for implementation. The study has added to the usual backcasting process by estimating the likely carbon reduction contribution of different policy packages towards the required target. This proved to be a very useful addition in explaining the likely levels of change.

The analysis demonstrates that the two images developed to achieve the overall 60% CO_2 reduction target for 2030 are both achievable, but image 1 is much harder than image 2. The backcasting methodology provides a systematic, consistent and robust framework within which to examine challenging alternative futures. Three different types of risk have been identified and addressed – technological, political and complexity.

It is concluded that major and innovative policy changes are required, as the business as usual approach will not achieve the target reduction set. There is no alternative to radical transport policy change if the CO_2 emissions target is to be reached in transport. However, the conclusions are positive: a 60% emissions reduction in the transport sector can be met with radical change.

The measures being proposed here broadly relate to traditional policy measures in transport, but are concerned with UK-wide, effective implementation. We need to enter into new partnerships with industry (car manufacturers and fuel producers), technological innovators (the ICT industry, GPS providers and database management systems), city and regional authorities (the design of cities, priorities within cities and urban form considerations), and the general public (car drivers, pedestrians, cyclists and public transport users, long distance travellers and freight hauliers).

The elements in all of the policy packages are based on known technologies and carry little risk, but implementation needs to be immediate, starting from 2006. The window of opportunity is closing as atmospheric concentrations of CO_2 continue to rise year on year. Any delay will substantially reduce the likelihood of the 2030 60% target reduction date being met.

Certain benchmarks have been suggested for new vehicles in 2030, namely that CO_2 emissions per kilometre are well below 100 g/km. This is not a particularly tough target technologically, but it does require substantial change over current levels in terms of consumer choice and buying behaviour. Similarly, it should not be difficult to increase load factors (or vehicle occupancy) and to reduce average trip distance, but these necessary changes require a reversal of current trends. This is the key obstacle to

overcome – a reversal of current trends in terms of consumer choice and travel behaviour.

Throughout this scenario building process there have been many challenges, each of which have been overcome. The end result is:

1. A set of images of the future that "map out" alternative ways forward in terms of what might happen given slightly different assumptions on growth (and oil prices), technology, trade, social priorities and values;

2. A full range of policy measures have been identified and put together into one of eleven policy packages, with a commentary on variants and their potential contribution to the CO_2 reduction targets;

3. These policy packages have in turn been clustered together to give overall levels of savings, based on an additionality assumption, and a commentary has been given on the timing and sequencing for implementation as policy paths.

Throughout the whole process, a considerable amount of debate has been generated by the research team, the workshops and the numerous presentations made. All this formed an integral part of refining ideas and in adding new possibilities or directions to the images and the policy packages. All contributions made during the workshop sessions have been very gratefully received. These have proved to be a creative part of the backcasting approach, and have resulted in a continuous process of understanding and progression throughout the study.

Backcasting as a technique therefore has much potential in terms of raising the level of interest and debate in the understanding of the complexity that is the future.

5.3 Further Research Requirements

The debate has thus been pushed forward; however much more is required. A major research effort is required to consider the likely contribution of the transport sector to global environmental targets, and indeed wider quality of life goals. CO_2 emission reductions, although the focus of this study, are only part of what we should be trying to achieve in terms of our future society in 2030.

Such a major research effort needs to be led by a body such as a Royal Commission, and include funding contributions from bodies such as the DfT, CfIT, research councils and others. This needs to focus on our societal requirements for the next 30 years, and set the direction of transport policy to achieve this vision. Particular themes within this research effort might include:

- A robust baseline, including DfT/DTI/Defra consistency in terms of emissions projections. Anable and CfIT (2005) provide initial thoughts.
- The testing of the VIBAT methodology on a city (London), a region (south east) and/or a northern metropolitan area. The importance of this

topic is paramount. The level of resource given to understanding it should be commensurate.

- Emphasis on the likely role of suburban areas may prove important in terms of the contribution that can be made from a typically car dependent area. Less of a contribution in such an area might mean that emissions reduction targets in urban areas need to be more stringent.
- A required early phase is the development of a robust inventory of measures, based on good practice achievement, and each measure's likely contribution to a lower carbon future (including some modelling of effects).
- An estimation of the costs of urban sprawl in terms of CO_2 emissions, and the likely contribution of land use planning to travel reduction. There is a particular dearth of evidence on this topic.
- The likely effects of change in terms of wider sustainability objectives – including monetary consequences of change, business attitudes, environmental effects, quality of life effects, and social dimensions – who loses, wins, is excluded?
- Consideration of effective packaging, additionality, synergies, snowball effects, unintended consequences and rebound effects (less traffic on roads is likely to lead to induced traffic from latent demand; fuel efficiency measures are likely to lead to more travel through cheaper travel).
- Linkage to other carbon emitting sectors – again synergies are likely.
- Achieving public consensus – this is likely to be the greatest barrier to change.

The scope for further research is thus great – we have mentioned just a few areas above - and this future research should be carried out as quickly as possible. A critical point however is that this should not be at the expense of taking radical and positive action in the transport sector now so that we can achieve the 60% CO_2 reduction by 2030. Concerted action is required now.

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.

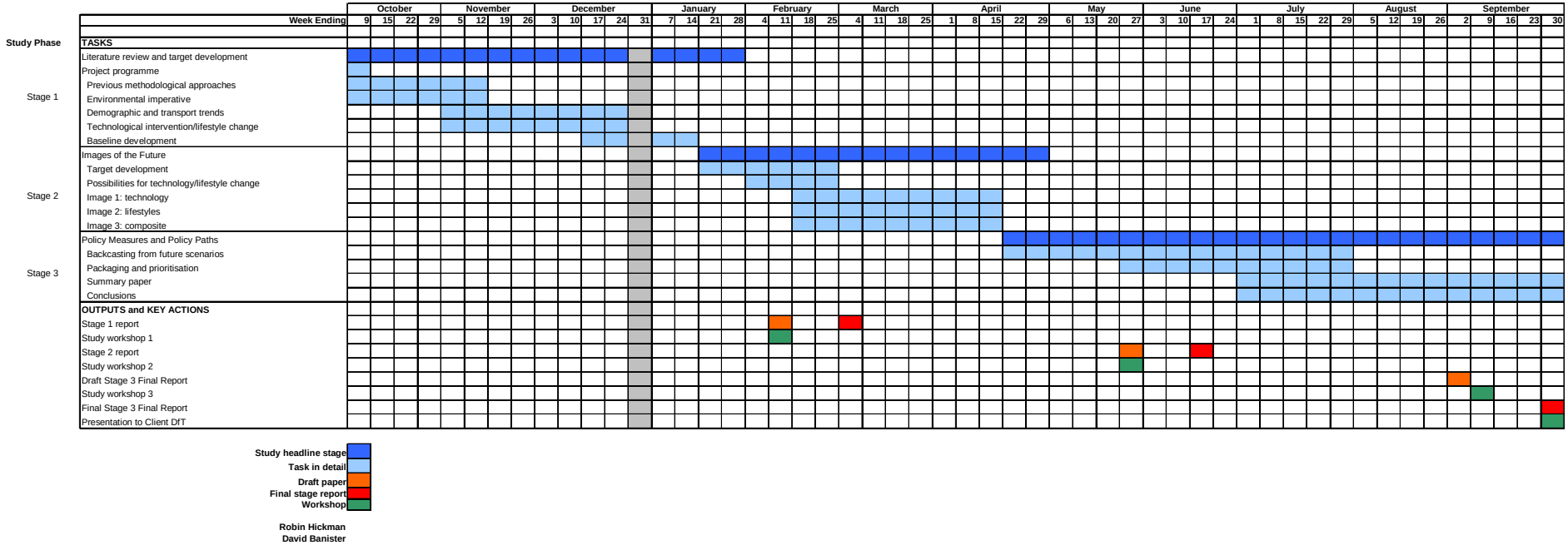
For more information on the project see
http://www.bartlett.ucl.ac.uk/research/planning/vibat

Annex 1: VIBAT Work Programme

The VIBAT study was carried out in three main work stages as shown below.

Each stage included a study seminar and draft working paper.

Figure 1: *Work Programme*



Annex 2: Study Workshop 1

The final workshop for the VIBAT study was held on 11th October 2005.

Workshop 3

Topic: policy packages and pathways

Participants:

- David Banister (The Bartlett School of Planning, UCL)
- Robin Hickman (Halcrow Group)
- Ian Hawthorne (Department for Transport)
- Nick Barter (Department for Transport)
- Salina Ladha (Department for Transport)
- Jillian Anable (Robert Gordon University)
- Abigail Bristow (Loughborough University)
- Miles Tight (Institute for Transport Studies, University of Leeds)
- Alison Pridmore (Sustainable Development Commission)
- Ian Skinner (Institute for European Environmental Policy)
- Paige Mitchell (Slower Speeds Initiative)
- Jason Torrance (Transport 2000)

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