TRANSPORT AND GLOBAL WARMING: WHAT IS THE POTENTIAL FOR CARBON REDUCTION IN SCOTLAND?

Robin Hickman, Paul McCartney
Halcrow Group

David Banister,
Transport Studies Unit, Oxford University

Abstract

Transport is a major user of carbon-based fuels, and achievement of the targets set at the Kyoto Protocol and elsewhere mean that the EU and national governments must reduce CO2 emissions in all sectors, including transport. This will be a difficult task and will require action on many fronts.

This paper reports on two recently completed studies considering these issues – for the UK Department for Transport and the Scottish Executive. The core analysis considers the options available to meet a 60% CO2 reduction target by 2030 in the transport sector at the UK level and, using an innovative backcasting study approach, develops a business as usual (BAU) baseline for transport emissions, and alternative scenarios to 2030. Different policy measures are assessed and assembled into mutually supporting combinations. These are grouped into policy packages to establish whether the challenging 60% CO2 reduction target can be reached and when the key actions need to be taken.

The distinct role that can be played in Scotland is also reviewed, considering the likely policy options available, using “new” policy measures or “more intensive” applications of existing policy measures.

Although 2030 seems a long way ahead, action must be taken now in Scotland if the targets for CO2 reduction are to be met. The opportunity is there to develop a niche as a market leader in carbon efficient transport. Combining this with behavioural change, aimed at holding car-based travel at or near to present levels, will help Scotland move towards even the more stringent carbon reduction targets. A major transformation in the way transport and urban planning is carried out is however required. As transport, urban planners and the public we need to think very differently in tackling the new environmental imperative.

TRANSPORT AND GLOBAL WARMING: WHAT IS THE POTENTIAL FOR CARBON REDUCTION IN SCOTLAND?

Robin Hickman, Paul McCartney
Halcrow Group

David Banister,
Transport Studies Unit, Oxford University

1. Introduction

Transport is potentially a major enabler of economic growth in Scotland and can make a significant contribution to improving social inclusion and reducing environmental degradation. The transport sector hence has a huge role to play in achieving sustainable lifestyles in Scotland.

This paper concentrates on the role of transport in supporting environmental sustainability, with a focus on "strategic" environmental issues, and particularly in reducing carbon emissions. The problems here are huge and seemingly intractable. Although our awareness of the global warming problem has risen remarkably in recent years, there is little evidence of any real change in travel behaviour. Traffic levels in Scotland continue to rise (the current Transport Model for Scotland, TMfS, forecasts total road traffic to grow by around 22% to 23% between 2002 and 2011) and all the projections suggest that more carbon emissions rather than less are likely to 2030 and beyond. We hence need to start to think very differently in tackling the global emissions problem. The importance of the transport sector in contributing to reducing levels of CO2 is clearly evident, yet remains largely unquantified, and certainly is likely to undershoot its potential.

The discussion within this paper draws on two studies recently carried out covering these issues:

- The VIBAT[1] project (Visioning and Backcasting for UK Transport Policy), for the Department for Transport, which examined the possibility of reducing transport CO2 emissions by 60 per cent by 2030 in the UK;
- An Appraisal of Policy Options for the National Transport Strategy[2], for the Scottish Executive, which considered the most likely and fruitful policy levers available to help achieve Scottish sustainability objectives.

Much of the commentary is provided at two levels – first an examination of the evidence available at the UK level; followed by an assessment of what

[1] The VIBAT project is Visioning and Backcasting for UK Transport Policy, and was part of the Department for Transport Horizons Research Programme 2004/06. It was carried out by David Banister at the Bartlett School of Planning, UCL and Robin Hickman from the Halcrow Group. Any views expressed within the study are not necessarily those of the UK Department for Transport. Full documentation and background reports are available: http://www.ucl.ac.uk/~ucft696/vibat2.html.

[2] The Appraisal of Policy Options for the National Transport Strategy, carried out for the Scottish Executive, as part of the background research to the National Transport Strategy uses a literature review to examine the likely impacts of a variety of policy options on sustainability objectives. Full documentation is available on: http://www.scotland.gov.uk/Topics/Transport/NTS/halcrow-report

information is available for Scotland (mainly drawn from Scotland's National Transport Strategy; SE, 2006).

It is also worth noting the Scottish devolution context in relation to transport: broadly the Scottish Executive has devolved responsibility for the Scottish road network, bus policy, cycle and walking policy, enforcement of vehicle emission standards, much of rail funding and policy, financial assistance for freight facilities, and consultative arrangements for public transport. Reserved matters include fiscal measures, such as road tax and fuel duty escalator.

Table 1: A Few Relevant Carbon Calculations - the Scale of the Problem

Typical (one-way) journeys and approximate carbon emissions per person[3]:

London-Glasgow by bus = 648 km = 58 kg
London-Glasgow by rail = 648 km = 71 kg
London-Glasgow by car[4] = 648 km = 120 kg
London-Glasgow by air[5] = 648 km = 386 kg

Edinburgh-Glasgow by bus = 73 km = 7 kg
Edinburgh-Glasgow by rail = 73 km = 8 kg
Edinburgh-Glasgow by car = 73 km = 13 kg
Edinburgh-Glasgow by air = 73 km = 140 kg

Inverness-Glasgow by bus = 273 km = 25 kg
Inverness-Glasgow by rail = 273 km = 30 kg
Inverness-Glasgow by car = 273 km = 49 kg
Inverness-Glasgow by air = 273 km = 246 kg

Glasgow-Sidney by air = 16,500 km = 11,500 kg
Glasgow-New York by air = 5,500 km = 1,900 kg

Average car km per annum = 11,000 km per annum = 1,980 kg

Walking and cycling are virtually carbon free.

For all emissions per person per annum (transport and domestic use, etc):
The US average = 19,800 kg
The UK average = 9,400 kg
The Indian average = 1,200 kg

A globally "sustainable" figure is 1,000 kg per person!!

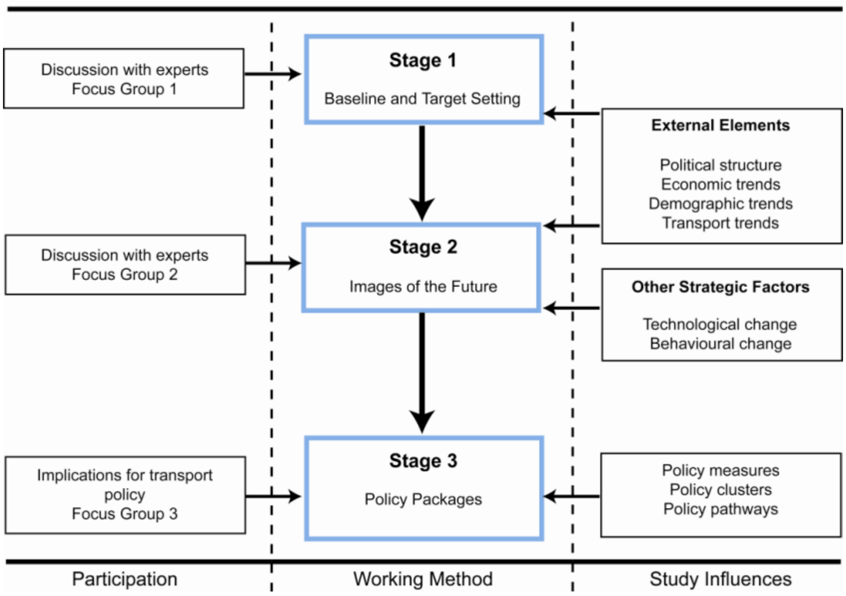
Hence the scale of the problem.

[3] Assuming average all day occupancies and average vehicle specifications
[4] Assuming use of an average specification, Ford Focus, 1.8, which emits 180 g/km
[5] Air travel includes a radiative forcing impact; a multiplier of 2.7 is required to cover aviations' warming impact on the climate. Jet emissions occur high in the atmosphere, where carbon dioxide is augmented by warming from water vapour in contrails.

2. The Backcasting Approach

Methodologically the paper follows a backcasting study approach. This has three main phases. The first is to set targets for a future year (in this case 2030) and to forecast a business as usual (BAU) situation for all forms of transport over that period, so that the scale of required change can be assessed. The second is to describe a transport system in 2030 that will meet the reduction target. In our UK work this took the form of two alternative visions of the future, that push both the technological and the behavioural policy options, separately and in combination, but at different intensities. The third stage is the core of the backcasting process, where alternative policy packages are assembled to lead to the images of the future, together with their sequencing in terms of when implementation should take place. Figure 1 highlights the main features of the study approach.

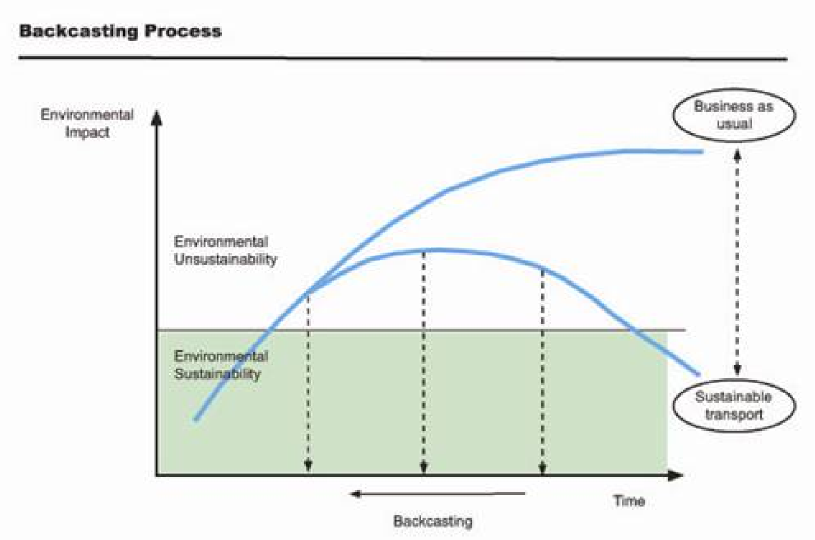
Figure 1: The Study Approach



The benefits of scenario building are that packages of policy measures can be developed to address ambitious CO2 emissions reduction targets. This allows trend-breaking analysis, by highlighting the policy and planning choices to be made, by identifying the key stakeholders that should be included in the process, and by making an assessment of the main decision points that have to be made. It also provides a longer-term background against which more detailed analysis can take place.

Figure 2 shows the main features of the backcasting process. Instead of starting with the present situation and prevailing trends, the backcasting approach designs images of the future representing 'desirable solutions' to societal problems. Possible paths back to the present are then developed - 'casting back' from the future - in 25, 20, 15, 10 and 5 years time. The term ‘scenario’ covers both the images of the future and the trajectory leading back to the present. This definition is more comprehensive than those normally used; where a scenario is seen more as an end in itself.

Figure 2: The Backcasting Framework



(Based on OECD, 2000)

3. The Business as Usual Baseline

The first stage of the backcasting process is in understanding the baseline and the likely targets to the future forecast year (2030).

The UK Situation

In deriving a baseline and projections for CO2 emissions the VIBAT study uses historical data from NETCEN, the National Traffic Forecasts (DETR, 1997), and the published projections made available in Transport Statistics Great Britain (Department for Transport, 2005) and Energy Paper 68 (DTI, 2003). This secondary data has been supplemented by outputs from the Department for Transport National Traffic Model. The situation is therefore complicated in the UK by there being no central business as usual baseline for transport CO2 emissions to 2030 and beyond.

Clearly there is likely to be a large increase in expected CO2 emissions over time. Using the latest projections from Transport Statistics Great Britain, all transport emissions are expected to rise from 38.6 MtC in 1990 to 52 MtC in 2030, a projected increase of 35%. This compares to all emissions of greenhouse gases in the UK, where an increase of 3% is expected over the same period. The official projections from the DfT, based on the assumptions in the 2004 Transport White Paper (and which in turn broadly reflect the current UK transport policy) show a reduced level of emissions - holding levels in 2030 to something similar to present day emissions.

Table 2: Carbon Dioxide Emissions Baseline Projection by End User in the UK

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

Units: million tonnes of carbon (MtC)
End user emissions for transport include a share of the emissions from combustion of fossil fuels at power stations and other fuel processing industries. Projections are based on Transport Statistics Great Britain (Department for Transport, 2005) low fuel price scenario (a high fuel price scenario is also available, but the differences are not substantial).

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

The Scottish Situation

In terms of baseline, the transport sector accounts for around a fifth of Scotland's greenhouse gas (GHG) emissions. Road transport emissions have increased from 2,507 KtC in 1990 to 2,792 KtC in 2004 - an increase of 11%. This contrasts with a decline in emissions from other sectors. The increase in emissions is due to increases in road travel and also consumer choices in vehicles – in terms of heavier, higher specification vehicles (which tend to emit higher carbon emissions). Some trends are working in the opposite direction, such as dieselification of the car fleet, which reduces carbon emissions per vehicle.

Table 3: Greenhouse Gas Emissions Baseline in Scotland

End User Category	1990	2000	2004
Road transport	2,507	2,678	2,792
Railways	68	80	78
Civil aircraft (domestic)	51	69	79
Other	403	281	281
All transport	3,029	3,108	3,230

Units: KtCarbon
National Atmospheric Emissions Inventory (Reported in Scotland's NTS, 2006)

Without further action, future emissions from the transport sector look set to continue to rise and any nominal transport sectoral target reductions will certainly be difficult to achieve. The growth in the level of car use in Scotland is forecast to continue. The latest version of the Transport Model for Scotland forecasts total road traffic to grow by around 22% to 23% between 2002 and 2011.

The Scottish Executive does not currently have an overall target on transport carbon emissions. It does have an aspiration to stabilise road traffic (in vehicle kilometres) at 2001 levels by 2021, but this is not a "full-scale target'. It is however committed to developing sector specific targets to tackle climate change and this will include the transport sector.

The "Scottish Share[6]" for carbon reduction has been calculated to be approximately 1.7 million tonnes of carbon (MtC) in annual savings by 2010. The Scottish target is to exceed this amount by 1 MtC in annual savings by 2010 (Scottish Executive, 'Changing Our Ways', 2006) – this is a cross-sectoral target.

Commentary

A number of CO2 targets are available as a comparison for the VIBAT and Scottish Executive research. For example:

- The UK Kyoto commitment is a 12.5% reduction in six greenhouse gases below 1990 levels over the period 2008-2012;
- The UK domestic target is for a 20% reduction of CO2 emissions below 1990 levels by 2010 (DETR, 2000);
- A path towards a 60% reduction of CO2 emissions by 2050 has been adopted by the UK Government (DTI, 2003), following the recommendation of the Royal Commission on Environmental Pollution (RCEP, 1994 and 1997).

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

An additional (and potentially huge) problem is UK international air emissions. These currently amount to 8 MtC and are not typically included in national carbon emission inventories. They are, however, expected to rise to some 14-16 MtC by 2020 (and, if extrapolated, potentially to 20 MtC by 2030). This is despite an improvement in the fuel efficiency of aircraft of around 1.7% p.a. (DTI, 2003). For the Scotland, the envisaged picture is similar. There has been a significant recent increase in air transport in Scotland, with a seven fold rise in passenger numbers between 1970 and 2004. This reflects a steady fall in fares and a wider choice of flights at Scottish airports. Air traffic in Scotland is forecast to increase from 20 million passengers per annum (mppa) to 50 mppa in 2030.

[6] The "Scottish share" quantifies the amount of carbon savings that need to be achieved within Scotland through devolved policies in order to make an equitable contribution to UK-level savings via all devolved policies. This is based on per capita calculations (Scotland's population is 8.3% of the UK; hence the Scottish share is 8.3% of 20.7 MtC = 1.7 MtC.

These levels of emissions on their own are likely to be greater than all other emissions from domestic UK surface transport by 2030, and it gives an indication of the scale of the problem facing the transport sector as it attempts to move away from carbon dependence. This is a critical area for further research in terms of assessing how the international air sector can make a contribution to reducing CO2 emissions. There is current discussion as to including international air emissions within the EU Emissions Trading Scheme; yet the basic (and unpalatable) requirement must be to reduce future air travel demand.

4. Images of the Future

The UK Situation

Within the VIBAT study, two alternative images of the future were constructed to reflect some of the different alternatives in terms of achieving the 60% CO2 reduction target. One focused more on market forces with higher GDP growth and lower oil prices ($60 a barrel in 2003 prices), suggesting more travel and greater input from technological innovation – this was labelled the "New Market Economy". The second focused more on a social welfare and environmental perspective, with lower GDP growth and higher oil prices ($80 and $100 a barrel in 2003 prices), suggesting less travel and a greater reliance on behavioural change – and labelled "Smart Social Policy".

The intention was to establish two visions that were both feasible but were sufficiently different to each other to warrant description as alternative policy approaches. They were not intended to be prescriptive, but to illustrate different potential futures. In each case, the two images of the future for the transport sector in the UK were set within the context of broader demographic and socio-economic changes (such as globalisation), and each provides an alternative, qualitatively different future (see Table 4).

Table 4: Images of the Future – External Elements

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

Within the *New Market Economy* the main aim of transport policy is to achieve the required CO2 emissions target with a minimum of change in terms of behaviour. Car traffic hence still grows (by 35% on 2000 levels) and dominates in terms of modal share, with trip lengths increasing and occupancy levels increasing. The main changes are in pushing hard on hybrid technologies so that the overall average emissions profile of the total car fleet reduces to 90 g/km in 2030 (down from 171 g/km for the new car fleet and 185 g/km for the total car fleet in 2005). This is achieved through the rapid phasing in of the hybrid technology over the next 25 years so that by 2030 all new vehicles are hybrid or ultra lean burn. There is also considerable investment in alternative fuels to reduce the carbon content of existing internal combustion engines and the non-electric parts of hybrids. There is less effort made in terms of behavioural change - this image of the future relies on technology to deliver the lower carbon future.

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

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

The Scottish Situation

The VIBAT study was premised on envisioning “new horizons” in the transport sector; hence the analysis was able to consider radically different images of the future. The context of Scottish practice is somewhat different in that there is a [broadly] agreed future development and transport investment vision. Hence developing alternative future is most likely to be along the lines of that agreed within the National Transport Strategy (SE, 2006). What this doesn’t have, however, is a forward look to 2030 and beyond. The smart social vision, as developed within the VIBAT study, might be a good proxy for the most likely future to 2030, but obviously further futures work might be worthwhile to consider potential policy trajectories for Scotland in the long term. The DTI Foresight Programme (Intelligent Infrastructure Futures, Scenarios to 2055; DTI, 2006) has also produced useful future scenarios for the transport sector, within which Scottish based scenarios might be developed.

5. Policy Packages

The UK Situation

The VIBAT study provided a comprehensive review of the full range of policy measures available to help reduce transport carbon emissions. This included some 122 individual measures. Information was gathered as to their potential effectiveness in reducing emissions, and the timescale necessary for their implementation. These policy measures were then assembled into packages that were mutually supporting. The difficulty here was in the packaging, and the potential number of packages. Most of the packages had variants which were more suited to one image of the future than the other.

The packaging process was very fruitful as measures could be combined, with efforts made to ensure their impacts would be made more effective. To achieve substantial reductions in emissions requires combinations of mutually supporting policies, often involving a variety of stakeholders. Individual policies will not contribute significantly to reductions in CO2 emissions. Combinations (together with the supporting “smarter measures” such as awareness raising) can help control for rebound effects, where initial reductions in emissions are subsequently reversed as people travel further, thus negating some of the benefits. Many of the packages are extremely interrelated and even the technological options (such as low emission vehicles) require supporting behavioural change such as using incentives to influence consumer preferences towards low carbon vehicles.

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

In addition, potential carbon savings were calculated using a spreadsheet model covering estimates of the likely reductions in travel and the likely change in CO2 emissions. These figures proved to be enormously useful in working out how the targets set could be achieved, in illustrating likely levels of change, and they also give an indication of the relative importance of each package, the clusters and their variants.

Policy packages were developed by combining sets of individual measures that are likely to work well together, concentrating on those that might create positive synergies. Eleven policy packages were developed. 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. Summary findings, including initial estimates of carbon reduction potential, are outlined in Table 5. All have ranges of values that reflect different levels of intensity of application as all of the policy packages have variants[7].

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

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

Table 5: VIBAT Summary 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) With 1B (passenger + freight)	-9.1 MtC -4.6 MtC
	2B (20%)	With 1A (passenger + freight) With 1B (passenger + freight)	-3.7 MtC -1.8 MtC
PP3: Pricing regimes	3A City and motorway 3B National		-1.1 MtC -2.3 MtC
PP4: Liveable cities	4A Limited application 4B Extensive application		-0.5 MtC -2.4 MtC
PP5: ICT and travel	5A ICT in transport - passenger and freight 5B Teleactivities - passenger and freight		-1.8 MtC -0.8 MtC
PP6: Soft measures	6A Travel plans 6B Car ownership 6C Travel awareness 6D Improved car occupancy		-2.4 MtC -0.9 MtC
PP7: Ecological driving	7A National system 7B National and local system		-2.5 MtC -4.6 MtC
PP8: Long distance travel Substitution	8A Air travel and some substitution 8B High speed train and coach		-0.5 MtC -0.7 MtC
PP9: Freight	9A Freight transport subsidiarity 9B Freight dematerialisation		-0.7 MtC -2.5 MtC
PP10: Carbon rationing	10A 550ppm 10B 450ppm	This is an enabling mechanism	25.7 MtC 34.1 MtC

The Scottish Situation

Within Scotland there are, in theory, a similar range of policy packages available to affect carbon reductions from the transport sector, with a slight complication in terms of devolved and reserved matters. The National Transport Strategy (SE, 2006) suggests that there are five areas of progress for the transport sector, as outlined in Table 6.

The total contribution from the transport sector is not impressive – an estimated 548 KtC annually by 2010. Devolved matters contribute, in the form of “wider transport measures”, just 70 KtC. There is therefore much work to be done to strengthen this policy area. To reiterate, the transport sector accounts for around a fifth of Scotland’s GHG emissions; and is the only sector where emissions continue to rise. A 60% reduction on 1990 levels would mean that the transport sector in Scotland reduces its annual carbon emissions by 1,817 KtC (1.8 MtC).

Table 6: Existing Transport Policies – Carbon Reduction Potential in Scotland

Policy	Annual Carbon Savings (KtC) by 2010	Reserved or Devolved
From UK Climate Change Programme, 2000		
Voluntary Agreement Package (company cars, vehicle excise duty)	190	Reserved
Fuel duty escalator (1993-1999; discontinued)	150	Reserved
Wider transport measures (including sustainable distribution)	70	Devolved
In UK Climate Change Programme/Scotland's Climate Change Programme 2006		
Renewable Transport Fuel Obligation (RTFO)	130	Reserved
Future EUs level voluntary agreement with car manufacturers to reduce C02 emissions	8	Reserved
TOTAL	**548**	

The National Transport Strategy (SE, 2006, p.43) suggests that "We want to go further than we currently do". The key policy options outlined as contributing include:

- Delivering the biofuels target by 2010 and beyond;
- Promoting and encouraging new vehicle technologies;
- Promote better synergies between transport and land use planning;
- Actively promote "smarter choices" such as travel plans and travel information;
- Promote cycling and walking;
- Promote sustainable distribution strategies;
- Eco-driving and car buying information;
- "Appraise" stricter adherence to speed limits;
- Support moves towards aviation and surface transport emissions trading in the EU emissions trading scheme.

A wider selection of options is reviewed below, with much of the discussion drawn from the VIBAT study. We also show the potential carbon reduction contribution by each policy package (at the UK level). Clearly this only gives us a very initial idea as to the likely range of potential impacts. Further modelling work should test these simplistic calculations; in Scotland this could be done using the Transport Model for Scotland (TMfS).

PP1 Low Emission Vehicles: the take up of low emission vehicles, based largely on hybrid technology and lean burn engines, has the potential to be one of the most important policy measures. Full introduction of the 90 g/km car in the total Scottish fleet by 2030 would require massive investment by car manufacturers. The current latest generation of fuel efficient vehicles have emissions levels of around 100 g/km (the Toyota Prius emits 104 g/km). Relying on this option may be high risk as there is no evidence that take up is likely to occur at a large enough scale. Further work would be required to establish the costs and feasibility of converting the whole of the Scottish car fleet to hybrids

and lean burn by 2030. There is a major role here for the motor industry. The full potential of hybrids for the freight and public transport sectors also needs further investigation. Current trends do not suggest that a 100g/km car fleet is likely to be met by 2030.
UK carbon reduction potential = 18.3 MtC-9.1 MtC

Table 7: A Few Vehicle Emission Calculations

Vehicle Manufacturer and Model	Emissions (g/km)	Annual Travel (Km)	Annual CO2 Emissions (kg)
Toyota Prius, 1.5l	104	11,000	1,144
Toyota Prius, 1.5l	*104*	*5,000*	*520*
Honda Civic, 1.3l	109	11,000	1,199
VW Golf, Diesel TDI, 2.0l	154	11,000	1,694
VW Golf, Diesel TDI, 2.0l	*154*	*6,500*	*1,001*
Ford Focus, 1.6l	161	11,000	1,771
Ford Ka, 1.6i	189	11,000	2,079
Lexus “Sustainable” Hybrid SUV, RX 400h	191	11,000	2,101
Lexus “Sustainable” Hybrid SUV, RX 400h	*191*	*5,225*	*998*
BMW 3-series, 2.0l	196	11,000	2,156
Ford Mondeo, 2.0l saloon	218	11,000	2,398
Land Rover Discovery, 4.4l	354	11,000	3,894
Bentley Arnage R	495	11,000	5,445
Ferrari Superamerica	499	11,000	5,489
Ferrari Superamerica	*499*	*2,000*	*998*

Notes/benchmarks:
Average car km per annum = 11,000 km per annum

For *all* emissions per person per annum (transport and domestic use, etc):
The US average = 19,800 kg
The UK average = 9,400 kg
The Indian average = 1,200 kg
A globally "sustainable" figure is 1,000 kg per person!!

PP2 Alternative Fuels: additional benefits can be obtained if alternative fuels are used in conjunction with petrol and diesel hybrids and conventional internal combustion engines. There are many possible alternative fuels on the market, including compressed natural gas, liquid petroleum gas, methanol, ethanol, biodiesel, hydrogen and electricity. Many alternative fuels can be used with existing engines (e.g. bioethanol E5), but others need to have engine modifications (e.g. bioethanol E85).

The International Energy Agency (2004) suggests that by 2030, some 20-40% of all fuels in transport could come from alternative sources. Much further work is however required to investigate the potential of alternative fuels in Scotland, and this should include the necessary infrastructure required to make them work effectively. Biofuels may become a particular niche that Scotland specialises in.
UK carbon reduction potential = 9.1 MtC-1.8 MtC

PP3 Pricing Regimes: road pricing can also make a substantial difference, whether this is operated nationally on a UK-wide basis, within Scotland or just within cities and on the motorways. In combination with other policies, road pricing on an environmental basis (i.e. the charging relates to the carbon emissions profile of the vehicle and the number of passengers), can give clear signals to consumers to switch to more efficient cars or to other modes of transport. Pricing is likely to be a very important policy measure, an indication that change is occurring, and a "facilitator" to reducing car mode share.
UK carbon reduction potential = 2.3 MtC-1.1 MtC

PP4 Liveable Cities: this package focuses on structuring urban form to support sustainable transport, with higher density development clustered around an upgraded public transport system, and urban areas that have been planned to vastly improve their urban design quality and attractiveness for living and working, and for travel by walking and cycling.

There is complementary heavy investment in walking and cycling facilities as well as public transport. Applications of this package on a substantial scale has a major impact, but largely over the medium term, as decisions on the location of new housing and other development take place gradually over time. For areas of new or redevelopment impacts are realised in the shorter term. These decisions have a substantial effect on both distances travelled and modes used as urban structure at the strategic and local level provides part of the rationale for travel.
UK carbon reduction potential = 2.4 MtC-0.5 MtC

PP5 Information and Communications Technology (ICT): this option explores the potential for carbon reduction from ICT developments. The measures are targeted at personal and freight travel, and include advanced route and parking guidance, car sharing, public transport information systems, freight logistics, local traffic regulation and teleactivities. The potential levels of carbon reduction seem limited, and there may be rebound effects as ICT may encourage more, not less, travel. ICT developments however are likely to gain wide take up in the more remote areas of Scotland.
UK carbon reduction potential = 1.2 MtC-0.3 MtC

PP6 Smarter Choices: including workplace and school travel plans, future changes in car ownership (including leasing and car clubs), car sharing, travel awareness and travel blending programmes. These are important supporting measures to other packages, but they also have an important impact on carbon emissions in their own right. A high intensity scenario in terms of smarter choices investment and implementation is required.
UK carbon reduction potential = 2.4 MtC-0.9 MtC

PP7 Ecological Driving: this has substantial immediate benefits, particularly if combined with lower national and local speed limits and improved enforcement.

Slower speeds potentially provide extensive savings, with prospects for some 15-20% reductions in carbon emissions if a maximum speed limit of 80 km/hr is introduced on motorways and trunk roads, with lower speeds on other roads and in urban areas. Although the fuel use and speed value curves for new cars are flatter than those for older cars, there are considerable fuel savings from lower speeds. These speed limits need to be combined with awareness programmes and better driving techniques to reduce fuel use.
UK carbon reduction potential = 4.6 MtC-2.5 MtC

PP8 Long Distance Travel Substitution: there is some limited potential for long distance travel substitution of rail for air, and coach for rail, but the savings here are not substantial, particularly if load factors are high for the substituted mode and if High Speed Rail, for example, is of very high speed specification – this tends to be less energy and carbon efficient.
UK carbon reduction potential = 0.7 MtC-0.5 MtC

PP9 Freight Transport: freight transport is covered in several of the packages, but subsidiarity (local production and knowledge transfer) and dematerialisation (miniaturisation, advanced logistics and distribution networks, load matching and material consumption) can all lead to carbon savings, some substantial depending on extent of take up.
UK carbon reduction potential = 2.5 MtC-0.7 MtC

Two more policy packages are also potentially very relevant - carbon rationing (PP10) and increased oil prices (PP11). Under a carbon rationing package, individuals are given an annual carbon budget, on an equitable basis, and a market is created so that heavy CO2 users can buy additional rations from less intensive users. The overall usage on a national and regional scale is reduced over time to meet carbon reduction targets. Both carbon rationing and increased oil prices are seen as supporting or enabling packages, ensuring the effective take up of the policy measures and packages. Much more research is required on the likely implementation pathways on both of these supporting packages. There are potential major difficulties in implementation with carbon rationing, and oil prices are an “external” factor, over which Scotland has little control.

5. Package Clustering and Policy Pathways

The UK situation

The UK evidence is that technological change by itself is not likely to achieve the higher carbon emission reduction targets. The final task of the VIBAT study was to cluster the packages together so that the target levels of reduction can be achieved within each of the two images of the future. Figures 3 and 4 illustrate the most likely policy package clusters under Image 1 (New Market Economy) and Image 2 (Smart Social Policy).

Figure 3: New Market Economy Package Cluster (Carbon Reduction, MtC)

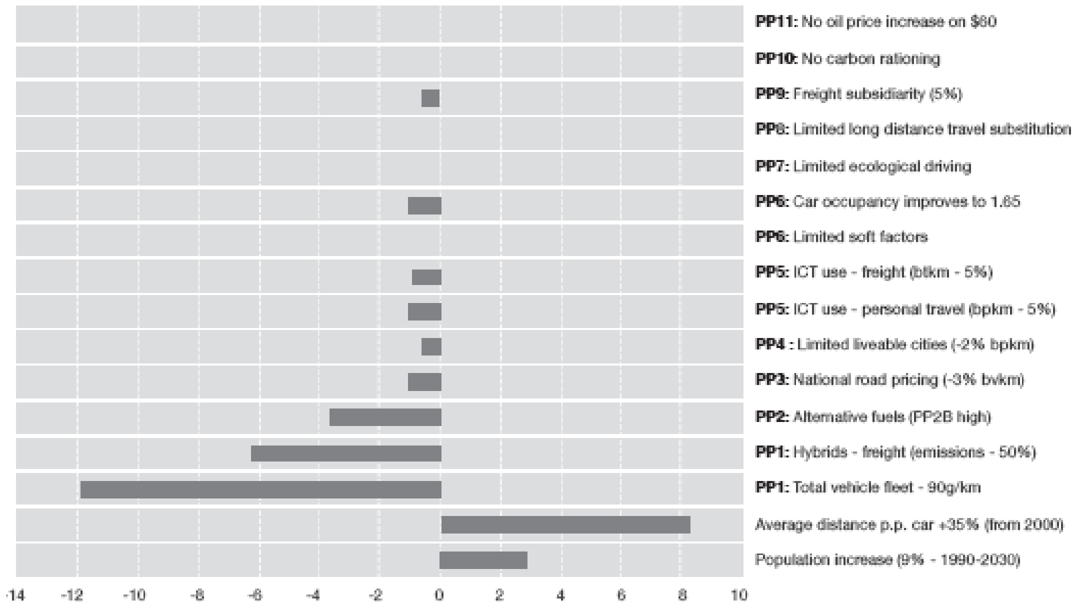
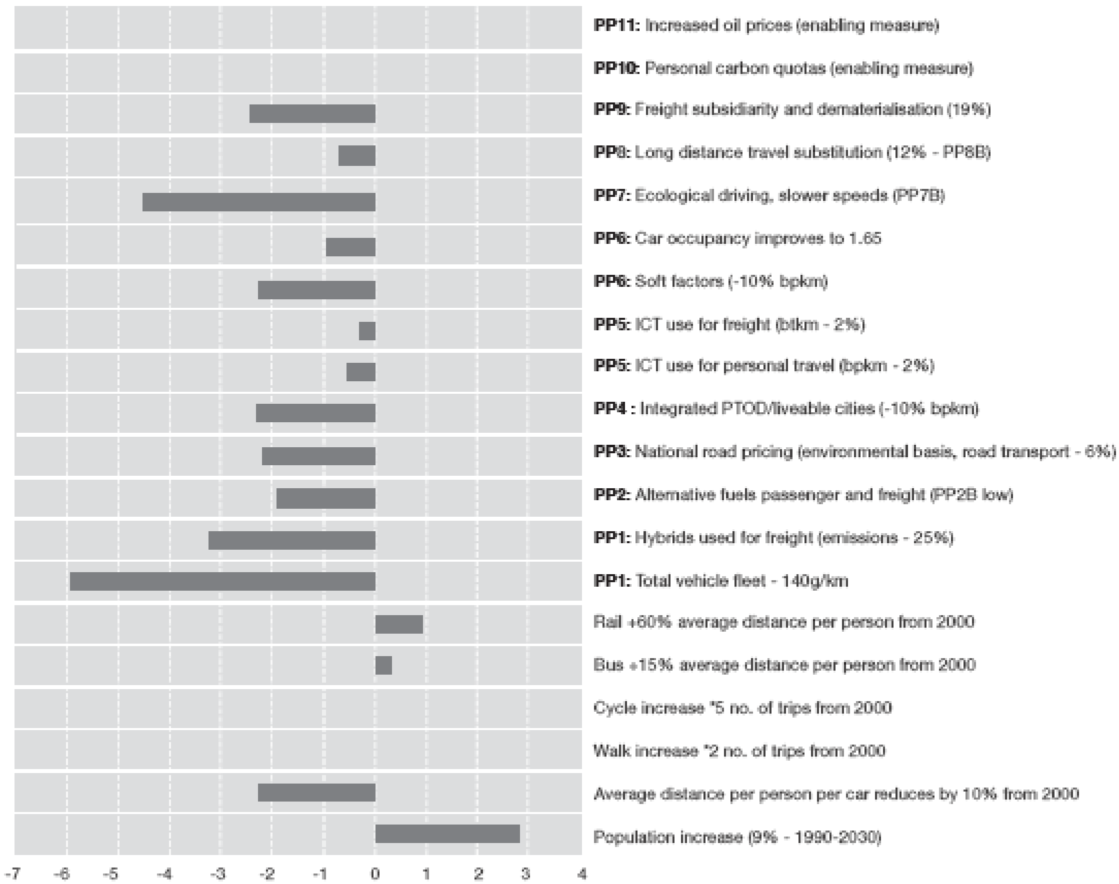


Figure 4: Smart Social Policy Package Cluster (Carbon Reduction, MtC)



The critical policy conclusions here are that the 60% target reduction under Image 1 is not possible over the timescale envisaged, even when pushing hard on all options. This is because the additional population (9%) and the increase in travel (+35%) that is expected in this image effectively increases the target to 36.9 MtC. Technological innovation on its own cannot bridge that gap, even if there is a very strong push on efficient vehicles and alternative fuels.

The 60% target reduction (27.2 MtC) however can be achieved under Image 2 (with the same population increase, but a small reduction of 10% in car travel), through a variety of policy packages that are well known now. Even here major change is required that combines behavioural change with technological innovation.

The Scottish Situation

Clearly there is much analysis required on this topic to provide a future strategy for transport carbon reduction in Scotland. A simple population pro-rata calculation, based on the VIBAT analysis, would suggest that:

- A technological solution, similar to the VIBAT new market economy package, might lead to annual carbon reduction savings in the region of 1.3 MtC;
- A behavioural solution, similar to the VIBAT smart social policy package, might lead to savings in the region of 2.1 MtC.

Clearly these are only very initial indicators of the likely scale of change. Much more detailed analysis is required to quantify the potential impacts of policy measures, and packages of policy measures.

The make-up of suitable policy packages for Scotland are likely to vary as to the specific context in Scotland. The devolution context also adds a further layer of difficulty – some policy measures will be led from Edinburgh, others from London.

The likelihood, however, is that similar "strategic" conclusions will be made to those in the VIBAT study – that a 60% reduction target is possible in the transport sector; but that technological and behavioural options are required to achieve this.

6. The New Imperative for Scotland: A Transport System that Supports Sustainability

Firstly, a huge caveat to the findings reported in this paper. They give only an indication of the scale of potential change. They are based on very initial analysis and should be tested by robust modelling work which assesses the likely impact of individual policy measures and packages of policy measures.

The initial aim of the VIBAT research was to establish whether a 60% CO2 reduction target in the UK transport sector could be achieved by 2030. The analysis concentrated on the domestic UK travel modes, which means that the actual UK target for 2030 is 15.4 MtC, or a 60% reduction on the 1990 level of 38.6 MtC. This target needs to be set against the expected (BAU) increases in travel, with levels of carbon emissions increasing to 52 MtC by 2030. The two alternative future images developed generate less travel than the business as usual: with Image 1 (New Market Economy) increasing travel by 35%; and Image 2 (Smart Social Policy) having slightly less travel than now (-10%). In addition, there is a population increase of 9% in both images, and this adds to the levels of travel and carbon emissions.

The overall conclusion reached is that the 60% CO_2 reduction target (in 2030) can be achieved by a combination of strong behavioural change and strong technological innovation. This is likely to apply in Scotland as well; however a much wider range of measures will be required than considered in the National Transport Strategy. It is in travel behaviour that the real change must take place - and this is the seemingly intractable problem – there is little sign that people are willing to restrict their growth in travel. Huge investment is therefore to be required likely in inducing changed travel behaviour –in terms of creating an urban structure that facilitates carbon efficient travel, in creating a public transport, walking and cycling network that serves previous car-based trips, and in influencing attitudes to travel (typically through smarter choices measures).

A number of critical issues have emerged from the VIBAT study and they have provided a major input to the recent Environmental Audit Committee report on Reducing Carbon Emissions from Transport (House of Commons Environmental Audit Committee, 2006). Many equally apply to the emerging transport and global warming agenda in Scotland:

1. There is wide acceptance concerning the gravity of the global warming problem, the diminishing window of opportunity to act, and that the transport sector must play a key role in reducing CO_2 emissions;
2. This is not reflected in our collective travel behaviour; we continue to emit unsustainably high levels of carbon emissions;
3. There is very scarce evidence as to how the transport sector can positively contribute to reduced CO_2 emissions, and what level of carbon reduction is most appropriate. There is some emerging discussion on the need for a specific sectoral transport carbon reduction target;
4. It appears that a dramatic reduction in transport emissions is possible - at least a 60% reduction by 2030. Much further work is however required in terms of quantification of likely impacts of different measures and policy packages;
5. Despite this lack of evidence, a number of issues appear to be gaining further credence. Technological developments, such as improved vehicle technologies and alternative fuels, are likely to provide a major contribution to carbon reduction efforts. They do not provide the solution as any carbon reduction impacts of technological improvements are likely to be offset, if not completely outweighed, by forecast increases in population and traffic growth;

6. The only possible solution lies in an integrated package of technological and behavioural policy measures, ensuring that we travel in more carbon efficient ways and we travel little further than at present;
7. This provides the [seemingly intractable] difficulty: we need to change our individual travel behaviour;
8. There remains a huge implementation gap, as investment patterns still appear to be focused on road-based, carbon-intensive solutions. For example, there is still little evidence as to the likely transport carbon intensity impacts of Regional Transport Strategies, Local Transport Plans, or of development in the development Growth Areas. Sustainability and liveability objectives (including reduced CO2 emissions) need to be placed at the heart of the transport and urban planning debate and made central to transport investment plans;

A much improved evidence base is thus required. We urgently need to further our understanding of the best consensual way forward for transport and urban planning. However, this should not result in little initial action. Radical and concerted action is required now.

The current debate is concentrating on the need for transport to urgently accelerate its efforts to meet the challenging issues surrounding carbon reductions. Although 2030 or 2050 seems a long way ahead, wide-ranging action must be taken now in Scotland if targets for CO2 reduction are to be met. The opportunity is there to develop a niche as a market leader in carbon efficient transport. Combining this with behavioural change, aimed at holding car-based travel at or near to present levels, will help Scotland move towards even the more stringent carbon reduction targets. A carbon efficient transport future is possible to attain; yet it requires a major transformation in the way transport and urban planning is carried out.

References

Anable, J. (2006) Transport and Climate Change: Tackling Emissions. Conference Paper – Scottish NTS Consultation. Dunblane.

Banister, D. and Hickman, R. (2006) Submission and Oral Evidence to the House of Commons Environmental Audit Committee Inquiry into Transport and Carbon Emissions. Bartlett School of Planning, UCL and Halcrow Group.

Banister, D. and Hickman, R. (2006) Visioning and Backcasting for UK Transport, VIBAT. Bartlett School of Planning, UCL and Halcrow Group for DfT Horizons. See full documentation and background reports on: http://www.ucl.ac.uk/~ucft696/vibat2.html

Banister, D., Hickman, R. and Stead, D. (2007) Looking over the Horizon: Visioning and Backcasting, in Perrels, A, Himanen, V and Lee-Gosselin, M (eds) Building Blocks for sustainable Transport – Dealing with Land Use, Environment, Health, Safety, Security, Congestion and Equity, Amsterdam: Springer (forthcoming).

Department for Transport (2005) Transport Statistics Great Britain. London: Stationery Office.

DETR (1997) National Road Traffic Forecasts (Great Britain). London: HMSO.

DETR (2000) Climate Change – The UK Programme. London: Stationery Office.

DTI (2003) Energy White Paper. EP68, London: Stationery Office.

Halcrow Group for Scottish Executive (2006) Appraisal of Policy Options for the National Transport Strategy. Edinburgh: Halcrow Group.

House of Commons Environmental Audit Committee (2006) Reducing Carbon Emissions from Transport. Ninth Report of the Session 2005-06. HC981-1. London: Stationery Office, August.

Institute for Transport Studies, University of Leeds (2004) How Can We Reduce Carbon Emissions from Transport? Tyndall Centre.

Royal Commission on Environmental Pollution (1997) Transport and the Environment - Developments since 1994, 20th Report. Cm 3752. London: The Stationery Office.

Scottish Executive (2006) Scotland's National Transport Strategy. Edinburgh: SE.