Assessing the effectiveness of policy options to reduce CO_2 emissions from surface passenger transport: A summary of findings from the 2009 UKERC Technology and Policy Assessment report

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Introduction

Transport is responsible for approximately a quarter of the UK's domestic CO_2 emissions and over 90% of these emissions are from road transport, with over 50% from passenger cars. Buses and railways account for approximately 5%, the bulk of the remainder being road freight (DfT 2008). By 2025, annual car vehicle kilometres travelled are forecast to grow by 28% from a 2003 baseline (Eddington 2006). Transport is therefore already a very significant contributor to UK CO_2 emissions, and whilst efficiency improvements are expected to reduce emissions per vehicle km travelled, demand is likely to grow considerably in coming years.

The UK Government has put in place legally binding targets to reduce greenhouse gas emissions by 80% by 2050, from a 1990 baseline. Initial progress towards this target will be monitored by interim five-year carbon budgets to 2022. The Low Carbon Transition Plan (DECC 2009) sets out how the UK Government believe the interim targets could be achieved, with all sectors of the economy contributing to emissions reductions. However in contrast to power generation for example, technology options for decarbonising the road transport sector are currently limited; electric vehicles are emerging in niche markets and other options such as hydrogen vehicles are in the research arena, whilst biofuels present policymakers with a range of challenges. Recent policy analysis in the transport sector has focused on the potential to improve the efficiency of motor vehicles and the timescales for development and challenges facing alternative power systems and fuels (Gallagher 2008; King 2007). Yet it is possible for policies to address not merely vehicle technologies and fuels, but also whether, where and how to travel, including how we drive and choose our vehicles.

The rationale for the report

A recent report (Gross et al. 2009) from the Technology and Policy Assessment (TPA) function of the UK Energy Research Centre (UKERC)[1] examined the merits of a range of different policies that offer the prospect of CO_2 emissions reduction from surface passenger transport. The TPA's advisors had

[1] The UK Energy Research Centre (UKERC) is a cross-university collaboration funded by the UK Research Councils that acts as a focal point for UK research on sustainable energy. www.ukerc.ac.uk

indicated that the potential for policies to deliver carbon emissions reduction through encouraging changes to 'behaviour' (changing people's 'travel choices' and reducing car travel) may not be as well understood as policies that target vehicle technologies. The report therefore had the following objectives:

- Review the evidence for CO_2 emission reduction potential and cost-effectiveness across policies that target car technology/choice and those that target wider travel choices;
- Identify the key issues and problems associated with each policy type;
- Identify whether and where policies are complementary or synergistic;
- Identify evidence gaps and highlight future research needs;
- Draw conclusions relevant to current UK energy policy, and address the key question:

What policies are effective at reducing carbon emissions from surface passenger transport?

The project team did not undertake new modelling or empirical research. The report is intended to provide a thorough review of the current state of knowledge on the subject, guided by experts and in consultation with a range of stakeholders. The project team undertook a systematic search for every report and paper related to the assessment question. The search revealed over 500 reports and papers on the subject, each of which was categorised and assessed for relevance. The evidence on each policy was reviewed against the following criteria:

- Potential emissions saving; in absolute and percent terms where the evidence permits.
- Key issues and problems; including reasons for effectiveness, evidence gaps, obstacles to policy implementation, interactions with other policies and potential rebound effects.
- Costs; where possible we provide evidence of costs in £/tonne carbon terms. Where this is not available in the literature we provide a discussion of what evidence does exist.

The full report represents one output from this process of review, evaluation and synthesis. The other main output is a set of detailed 'evidence tables' which are published on the project web pages[2] alongside the report. These tables contain a summarised description of each policy type and details of each piece of evidence relating to the effectiveness of the policy. To illustrate the wide range of potential areas for influence, the 'policy taxonomy' used by the TPA project team is summarised in Table 1.

[2] http://www.ukerc.ac.uk/support/tiki-index.php?page=Completed+TPA+Projects

Table 1 Policy types used to group evidence

Policy Group	Policy Type
Alternative Fuels	Fuel CO2 Policies
	Refuelling Infrastructure
Awareness Campaigns and Travel Planning	Awareness and Marketing
	Commuting Travel
	Flexible Trip Generation
	Individualised Marketing
	Travel Planning (Residential or Community)
	Travel Planning (Schools)
	Travel Planning (Workplace)
Fuel Prices and Taxes	Fuel Taxes
How to Travel: Mode Switching	Bus and Fuel Choice
	Bus and Rail Pricing
	Bus Infrastructure
	Bus Pricing
	Cycling
	Light Rail Infrastructure
	Rail Infrastructure
	Rail Pricing
	Walking
Information on Car Choice	Information on Car Choice
Reducing Demand for Travel	Teleworking/Teleconferencing
Road Space Provision and Reallocation	Road Planning and Investment
Road User Charging	Congestion Charging
	Parking
	Road Pricing
Using Vehicles More Efficiently	Car Clubs
	Eco Driving
	Road Traffic Management
	Vehicle Occupancy
Vehicle Efficiency Standards	Low Emission Zones
	Vehicle Air Quality Emissions Standards
	Vehicle Fuel Economy Standards
Vehicle Taxes and Subsidies	Company Car Tax
	Vehicle Capital Grants
	Vehicle Circulation Taxes
	Vehicle Procurement
	Vehicle Purchase Tax

Understanding transport choices

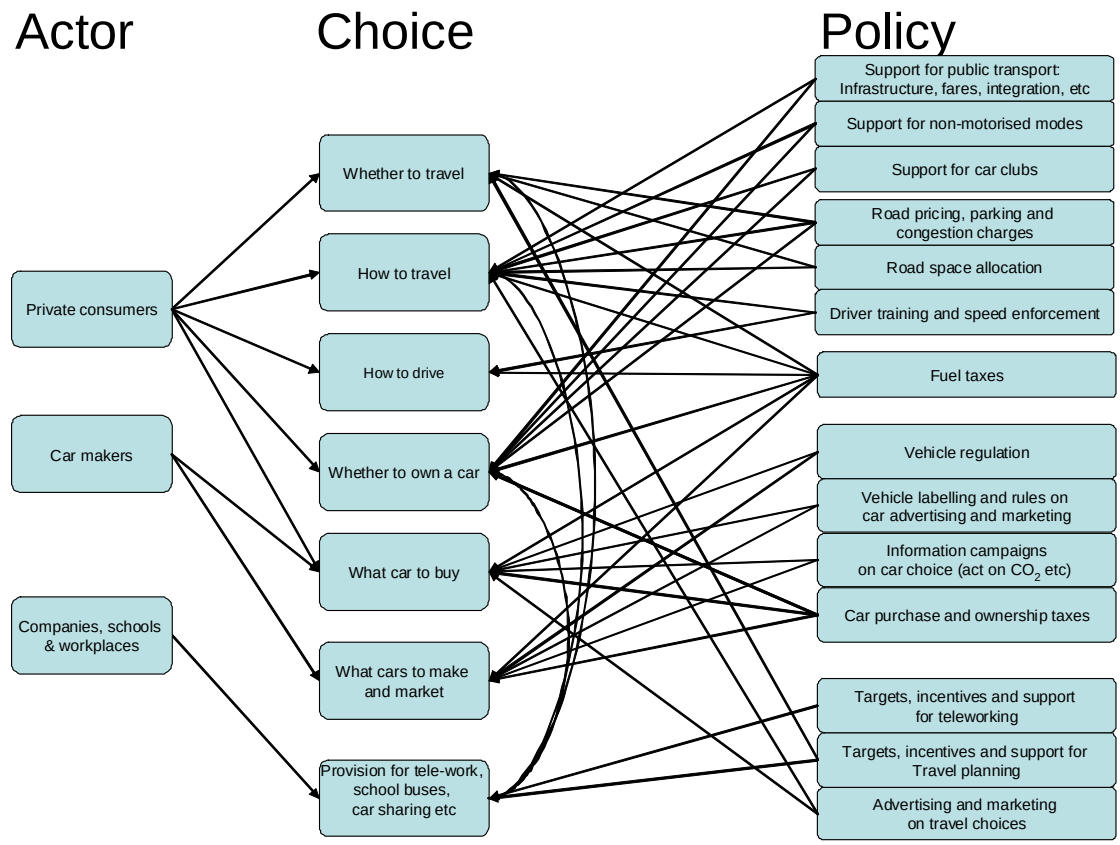
The analysis presented in the UKERC report is concerned primarily with the relationship between policy and the behaviour of a range of actors in the transport sector. Travel choice is complicated. A range of socio-economic as well as psychological factors affect the choice of whether or not to make a journey in the first place. The choice of destinations and thus travel distances are affected by a related set of factors to do with cost, accessibility and issues outside the transport sector relating to labour and

housing markets and land use configuration. Journey time and convenience, as well as costs, service quality, perceptions, social norms and availability, will determine the mode of travel. Decisions about whether, when and how far to drive are affected by a range of prices related to car use, such as road tolls, parking fees and fuel costs as well as ease of road access to the destination and congestion. All of these factors vary over a range of timescales and are differentiated by type of consumer.

Vehicle choice is similarly affected by a complex set of vehicle attributes and consumer preferences. The former are a product of decisions made by car manufacturers about car development and design, about the characteristics of individual vehicles and about their model range. In turn, the factors affecting the investment decisions made by manufacturers are diverse and include voluntary or mandatory standards imposed on them. Consumer preferences are a product of lifestyle and income, fashion and social norms, demography, geography and of the costs of fuel, vehicles and vehicle ownership. Different consumers have different preferences. Consumer preferences and vehicle manufacturer choices are inter-related, since manufacturers will seek to both respond to consumer demands and to influence them through marketing and advertising. This is one example where choices made by one group of actors may constrain or expand the lower carbon choices available to other groups – e.g. consumers can only buy lower carbon cars if manufacturers make them, and consumers may need incentives to buy them, and then use them in the most efficient way.

Assessing policy outcomes is complicated by the interaction and dependencies between actors, choices and policies illustrated in Figure 1. Further difficulties are created by the multitude of different responses, which can take place over different times and geographical scales. For example, attempts to reduce emissions may be subject to so called ‘rebound’ effects where potential fuel consumption or carbon emissions savings are ‘taken back’. This may happen in a number of ways: greater fuel economy due to improved vehicle technology, perhaps as a result of regulatory standards, may lead to an increase in overall mileage travelled because the cost of travel for a given unit of distance has fallen. The potential energy saving is taken back in the form of increased mobility. Similarly, if road tolls reduce total traffic and ease congestion then traffic speeds may increase, to the detriment of overall fuel economy. The potential energy saving has been taken back in decreased journey times. Likewise, engine efficiency gains may be used to power heavier or faster cars rather than reduce fuel consumption. See (Sorrell 2007; Sorrell et al. 2009) for detailed examinations of the rebound effect.

Figure 1 Actors, choices and policies in the transport arena



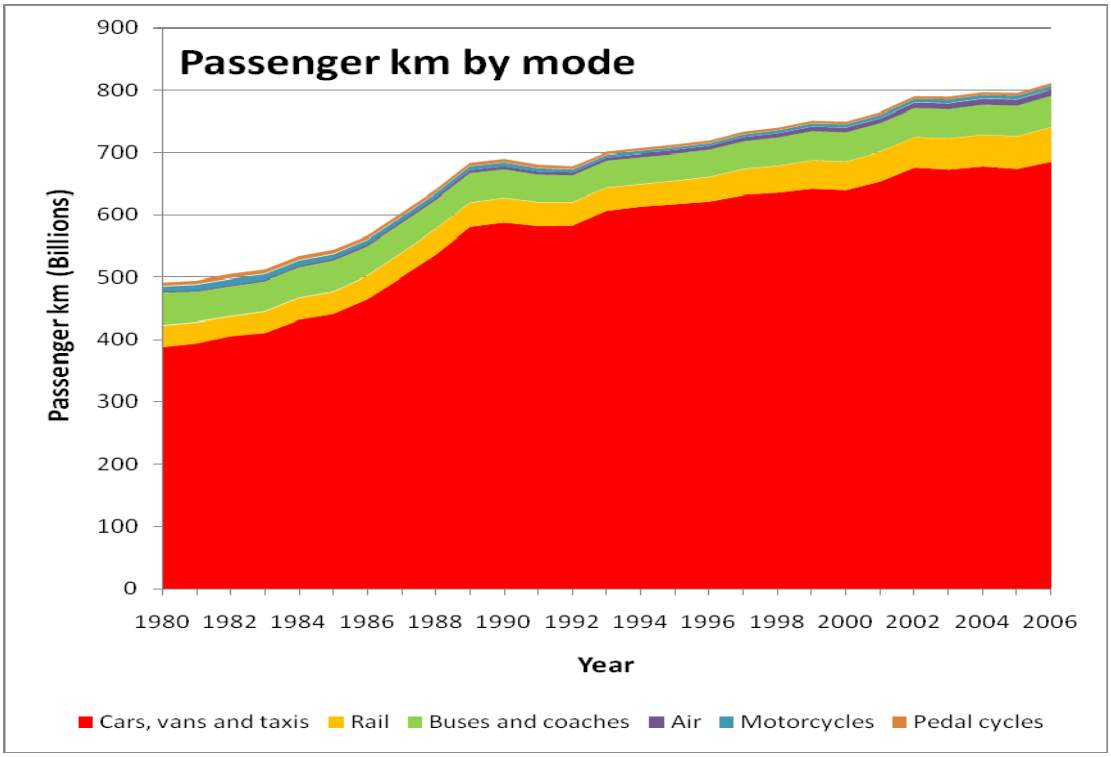
In order to deal with this complexity, the analysis for the UKERC report was grouped into four main headings, recognising that for the reasons described above, there is a degree of overlap and interaction between: (1) the absolute level of demand for travel (i.e. *whether and how far to travel*), (2) mode switching between travel options (i.e. *how to travel*, (3) using vehicles more efficiently (i.e. *how to drive*), and (4) moving to a lower carbon vehicle fleet (i.e. *car choice*). The main findings from (Gross et al 2009) are summarised below.

Altering consumer behaviour could play a significant role in reducing carbon emissions

In addition to purchasing fewer and more efficient cars in the first place, consumers can be persuaded to make fewer trips, change destinations, switch mode and use cars more efficiently. The quality and cost of public transport options are key to influencing long run travel trends. This is not simply about short run 'mode-switching', partly because even a relatively small percentage shift from car to public transport trips represents a large percentage increase in public transport passenger volumes (see Figure 2 below), but that having practical public transport options affects the medium and longer term choices people make over where to live and work. The evidence suggests that there is a significant

potential from non-motorised modes (walking and cycling), but this is an area where a better understanding of costs in terms of £/tonne of CO_2 saved is needed. Whilst the potential for tele-working is large, the CO_2 emissions impacts are unclear, with some evidence suggesting that the 'rebound' effects are significant as tele-working allows individuals to adopt lifestyles that may negate some of the CO_2 savings (for example, individuals may use tele-working to cut down on the number of days each week they commute to their workplace, but then choose to live further away). The role that eco-driving (adapting driving style to maximise fuel economy) can play is important, particularly as it can deliver CO_2 savings immediately, but continuous effort is required to ensure that effects are fully sustained over time. Fuel prices (affected through fuel duty), and road pricing are both important influencers of demand for car travel, and are discussed separately below.

Figure 2 Passenger kilometres travelled by mode in the UK (source: (DfT 2007)



Vehicle regulations can work

Regulation works if properly designed and implemented. Fiscal measures to influence consumer choices are also important. It is clear from the evidence that regulatory measures to limit new vehicle CO_2 emissions can be successful, but to do so they need to be mandatory, ambitious and without loopholes. They also need to be supported by measures such as taxes and rebates at the time of sale to overcome 'myopia' – consumers 'failure' to fully account for the fuel savings that a more efficient vehicle will deliver over its lifetime. Vehicle labelling at the point of sale and supportive marketing can help with this, although the direct effects of such measures on their own are difficult to quantify.

Whilst the potential for rebound effects is real as consumers may use some of the efficiency savings to increase their annual mileage, absolute savings are possible provided that other policies, such as fuel duty increases, are also employed.

Road pricing can have an impact but is no 'silver bullet'

The evidence from modelling studies suggests that national road pricing schemes may reduce congestion, but will not reduce CO_2 emissions if ,as is sometimes proposed, revenues are hypothecated to reductions in fuel duty. There *is* clear evidence, that 'cordon schemes' (such as the London Congestion Charge) have, as part of a package of other measures such as improved public transport and road space reallocation (e.g. bus lanes), reduced overall transport CO_2 emissions.

Fuel prices, and fuel taxes, are an important determinant of vehicle choice and use but should not be relied upon in isolation

Notwithstanding the political sensitivity surrounding fuel taxes, the short run demand response to fuel price rises is relatively small, particularly where there are few alternatives to car use. However, the evidence suggests that demand does respond to price increases over longer timescales, as individuals factor higher prices into their lifestyles (e.g. choices about what type of car to buy, and where to live and work). There is a clear interaction here with other policies such as vehicle CO_2 regulations, provision of public transport and land use planning – since these can help individuals choose long term, lower CO_2 options – for the reasons described above.

Rebound effects can be planned for and mitigated

The 'classic' rebound example is where more efficient cars reduce the cost of travel and increase car use. But rebound effects are not confined to improvements in vehicle efficiency as the reconfiguration of costs and benefits of almost all transport policies can mean that unintended consequences occur. These include: the potential for policies to 'backfire' through loopholes e.g. the CAFE (Corporate Average Fuel Economy) standards in the US encouraged the SUV market; induced travel – increasing capacity on any mode can simply encourage more of its use rather than a substitute for less efficient modes; policies may 'leak' – shift purchase or other choices from the target sector to another e.g. company car tax in the UK led to a reduction in company car sales whilst sales of privately owned cars increased; policies which seek to address non-carbon goals may create perverse incentives from a carbon saving perspective e.g. congestion charging combined with fuel duty reduction has the potential to decrease the cost of motoring on uncongested roads and increase their use.

In all cases well designed instruments and/or a combination of policies can mitigate rebounds and unintended consequences. An important implication is that carbon needs to be factored into policies

which have other goals to both maximise combined benefits and guard against rebounds or unintended consequences.

Timescales

The evidence suggests that the short run options with clear potential to reduce carbon emissions in the UK include eco-driving and speed enforcement, expanding the use of non-motorised modes and improving vehicle occupancy. Improving the off-peak utilisation of existing public transport in cities and overall utilisation of buses and trains outside the major metropolitan areas may also be possible. Policies to promote these options include travel planning, fuel and road price increases, dedicated infrastructure or prioritisation for non-motorised modes, and training and education campaigns. Whilst policies to promote lower carbon car choices can have immediate effect on new car sales it takes time for the vehicle fleet to turnover, so short run impacts on transport emissions are modest. Despite the political problems that surround fuel taxes in particular, relative prices of different transport modes can play an important role in determining longer run travel and vehicle choices.

Medium term potential exists in reallocating road space to extend bus and light rail provision. Road pricing and fuel taxes rises, competitive fares and service improvements, combined with information provision through travel plans are likely to be effective policy packages. It may also be possible to accelerate a shift to a much more efficient vehicle fleet. Circulation taxes (Vehicle Excise Duty in the UK) and fuel taxes combined with scrappage subsidies may be able to deliver this goal if combined with information and education.

In the long run both travel and car choices can deliver significant emissions reduction. The evidence suggests that it is possible to provide an integrated approach to delivering new infrastructure for public transport and non-motorised modes, linked to land use planning such that demand for travel is reduced and significant mode and destination shifting is delivered. This is most likely to be achieved if support for mode shift is accompanied by road use and parking charges, fuel tax increases, road space reallocation and travel planning and other information provision campaigns. Relative prices of different modes play an important role in shaping long-term travel choices. It is also possible over time to facilitate a substantial shift to lower carbon cars. The TPA team's review suggests that the most effective policies for this are emissions regulation, purchase taxes and fuel tax, aided by rules on marketing and labelling. Rebound effects need to be addressed, and can be, through the complimentary and flanking policies described above – a point which serves to reinforce the message that the complexities and interactions between transport choices mean that policy packages are essential if the CO_2 effectiveness of measures is to be maximised.

Conclusion

The UKERC report identifies both a wealth of policy options and huge policy potential *and* some fundamental inadequacies in our ability to quantify, compare, or in some cases even meaningfully discuss relative roles in reducing CO_2 emissions from surface passenger transport. Some options are better understood, more widely tested and have easier to quantify impacts than others. Some policies that serve multiple policy goals are well proven with regard to non-carbon transport policy issues (congestion, accidents, etc) yet have not been analysed adequately in terms of carbon impact and cost-effectiveness. Policymakers are faced with a complex set of issues related to the long and short run potential of a range of policy options, reflecting the complex choices open to individuals in the transport arena.

In general it is particularly difficult, indeed inappropriate, to attempt to pick 'winners' between policy types. In part this is a result of evidence that varies in focus, quality and quantity, but more important it is because it makes little sense to consider policies in isolation. It is clear that policies work best as *packages*; for example, provision of better or cheaper public transport, improved cycling facilities and opportunities to reduce travel can be augmented by travel planning/information, road pricing, fuel taxes and road space reallocation. Similarly, car choices can be affected by a range of fiscal measures and market information as well as through regulation. Whilst there is some evidence that policies are indeed implemented in an integrated fashion there is also evidence that this has failed to occur in many instances. For example, rebound effects are not catered for as smarter choices are still implemented without locking in mechanisms, and vehicle efficiency improvements are not matched by equivalent fiscal levers to at least stabilise the cost of motoring. Moreover, whilst outside the direct scope of this report, it is also possible that land use and other 'non-transport' policies are continuing to create demand for travel and/or to favour car dependent long-term choices.

Overall, the report demonstrates the wide diversity of evidence related to *both* lower carbon *travel choices* and lower carbon *vehicle choices*. The evidence suggests that policies can change behaviour, that behaviour can make a real impact on CO_2 emissions, and in several key instances there is evidence that such policies are able to deliver emission reduction at relatively low cost, and *relatively quickly*, provided a well-designed package of policies is put in place. This aspect is particularly important given that decarbonising the UK vehicle fleet, whether through step changes in efficiencies or a move to electrification is only possible over much longer timescales.

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