Eco-driving including in-car information systems

Introduction

This record of evidence forms part of the work undertaken by UKERC's Technology and Policy Assessment team relating to its project on policy strategy for carbon emissions reduction in the passenger transport sector. The material was produced alongside the project's main report and since it supports that report, it was judged appropriate to make this material available to a wider audience. The main report itself '*What Policies are Effective at Reducing Carbon Emissions from Surface Passenger Transport*?', and the supporting evidence can be found at:

http://www.ukerc.ac.uk/ResearchProgrammes/TechnologyandPolicyAssessment/TPAProjects.aspx

Explanation of Content

Evidence on this policy measure has been collected by the TPA team on the basis that it has, or may have, the potential to result in carbon dioxide emissions reductions in the passenger transport sector. This evidence document begins with a summarised description of the policy measure. The evidence itself follows the summary and is presented in table form.

Each piece of evidence has been assigned a separate row and tabulated using four columns:

- Year of publication, arranged chronologically, beginning with the most recent year
- Name of author, including where applicable additional cited authors (and year); and a Reference ID number.
- Type of evidence:
  - Evidence containing quantitative information is denoted by the letter 'Q'
  - Qualitative evidence is denoted by the letter 'C' for 'comment'
- The evidence itself

The evidence was originally gathered and assessed using several sub-headings. The purpose of this was primarily internal i.e. to facilitate the handling of evidence and the production of the main report. These sub-headings have been retained here as follows:

- Policy Measures and Carbon Savings
- Other potential CO_2 Impacts i.e. outside of the immediate policy influence
- Other Benefits e.g. air quality improvement or traffic congestion reduction
- Policy Costs and/or Revenues i.e. to local or national government
- Business and Consumer Costs
- Unintended Consequences e.g. rebound effect
- Reasons/Arguments for Carbon Savings Achievement or Failure
- Policy Suitability for the UK

A list of references follows the evidence tables. Note that the Reference ID numbers are allocated by Reference Manager, the referencing software used by the TPA team.

Any charts, figures and tables referenced in the evidence are not reproduced here but can be found in the original publication or evidence material.

Where no relevant evidence was found for a particular sub-heading, this has been noted.

Policy Description

The evidence recorded here covers measures to reduce fuel use in cars during driving, including information campaigns, vehicle maintenance, in-car information systems, and courses on driving style (smoother driving, improving efficiency at part load etc).

Evidence Tables

Carbon Savings and Policy Measures

Year	Author	Type	Evidence
2008	ETSC (ref 11617)	Q	France enforced strict speed limits on main motorways in 2004. Its environment ministry in its 'Plan Climate' (2004) concluded that the potential impact of full compliance with speed limits has been worked out at 2.1 Mt CO2 for private cars (plus a further 0.4 million tonnes for heavy goods vehicles and 0.5 million tonnes for light utility vehicles) amounting to a total of 3 million tonnes of CO2 per annum. This is equivalent to a 2% CO2 emissions reduction in transport sector emissions.
2008	ETSC (ref 11617)	Q	The German Ministry for the Environment calculated that a 120 and 100 km/h speed limit on German motorways would reduce CO_2 emissions from cars on motorways by 10% and 20% respectively.
2007 2007	DEFRA (ref 11342); King (ref 11312) citing Act on CO2, DfT	Q	Eco driving can immediately reduce emissions from cars, and fuel consumption, by 8 per cent.
2007	King (ref 11312) citing EST, 2005	Q	Other studies have indicated that, over time, drivers could achieve efficiency savings of as much as 10-15 per cent (citing Treatise – Ecodriving - Energy Saving Trust, 2005)
2005	IEA (ref 11618)	Q	In the USA a 55 mph national speed limit was in place for 21 years from 1974 following energy shortages caused by the OPEC oil shocks. The IEA estimate that the US could save 2.4% of total oil consumption if the 55 mph limit was re-imposed. The equivalent figure for Europe was 2.1%.
			Information Campaign
2007	Anable & Bristow (ref 12297) citing Ecodrive, 2005	Q	A widespread mass media campaign targeted at private car drivers commenced in the Netherlands in 2004, and aimed to stimulate eco-friendly driver behaviour. This programme has been estimated to have saved around 0.6 MtC per year (population 6m).
			Training
2007	Anable & Bristow (ref 12297) citing UKERC,	Q	By incorporating eco-driving into the UK driving test from the beginning of 2008, the savings from new drivers alone would be in the region of 168 thousand tonnes of CO2 per year by 2010.

Year	Author	Type	Evidence
	2006		
2007	Anable & Bristow (ref 12297)	Q	Incorporating energy efficient driving techniques into driving lessons in the Netherlands (the 'Eco-drive' scheme in 2001) resulted in new drivers driving 4% more efficiently after their test compared to new drivers who took the standard training, even though their speeds were identical. More recent figures suggest this figure has now risen to 10%. Training and support was provided to instructors by the government to help instructors incorporate the changes into lessons.
2007	Anable & Bristow (ref 12297)	Q	The Driving Standards Agency found that eco-driving training yields immediate results, with an 8.5% improvement in fuel efficiency for drivers on a set course after two hours of training. In the recently launched Act on CO2 campaign, DfT says that if all drivers in the UK followed the Smarter Driving tips, CO2 emissions from cars could be cut by 8% and motorists would save over £2bn in fuel bills.
2007	Anable & Bristow (ref 12297) citing Kroon, 2006	Q	Eco-driving has the potential to save 25% of energy if strictly adhered to, 5-10% actual savings by fleet operators.
2006	Smokers (ref 11268)	Q	In the EU-15, if eco-driving is included in the lessons for new drivers, then a total reduction of 1.8 Mtonne/y could be achieved in 2012, increasing to 5.5 Mtonne/y in 2020.
2006	TNO (ref 11616)	Q	In the Netherlands, analysis of a hypothetical reduction of speed on Dutch highways from 100 kph (62mph) to 80kph (50mph) based on uncongested driving behaviour, concluded that CO2 from petrol and diesel cars emitted on highways could be reduced by 21% and 26% respectively.
2007; 2006; 2003	CEC (refs 11259 & 11381); Smokers (ref 11268); Kageson (ref 11175) citing Jochim Donner, MOTIVA, personal communic-ation, and Trivector, 1999	Q	Directly after having received instructions or lessons, depending on their driving style, drivers may achieve fuel efficiency savings of the order of 5-10% (Smokers, 2006 and Kageson, 2003). In the long term, in Finland and Sweden this has been sustained (Kageson, 2003, citing (Jochim Donner, MOTIVA, personal communication, and Trivector, 1999). Other studies indicate that the effect reduces over time. (Smokers, 2006 went on to assume that the long term effect of applying eco-driving is a fuel consumption reduction of 3%). CEC, 2007 notes that there is less data available on the long-term effect, but that it is expected to be significantly smaller.
2003	Anderson (ref 11240)	Q	The introduction of safe and efficient driver training programmes would have a direct impact on car use, rather than car choice. According to Anderson's modelling results, such programmes have the potential to reduce UK transport

Year	Author	Type	Evidence
			CO2 emissions by 231 kt CO2 eq by 2010 (406 kt by 2050), however such initiatives would only have a short-term impact when introduced to the current driving population (e.g. fleet drivers), as drivers tend to revert back to their old habits over time. However, the introduction of a programme similar to the Swiss led Eco-Drive scheme into the current driving test would have the potential for long-term impacts on driving style.
			Gear Shift Indicator (GSI)
2007	CEC (refs 11259 & 11381)	Q	The total effect of mounting GSI systems on new vehicles is estimated at 38 Mt Cumulated CO2eq over the period 2010-2020, with a (negative) cost per ton of WtW CO2 equivalent of -113 €.
2006	Smokers (ref 11268)		In the EU-15, the total effect on GHG emissions of mounting GSI systems on new vehicles is estimated at 1.5 Mtonne/y in 2012 and 4.4 Mtonne/y in 2020.
			Training and GSI
2007	CEC (refs 11259 & 11381) citing Smokers, 2006	Q	The long term effect of applying eco-driving is a fuel consumption reduction of 3%, reaching 4.5% when combined with a Gear Shift Indicator (GSI), which helps the driver to maintain fuel-efficient driving behaviour. The effect of GSI in the absence of a specific eco-driving training is a fuel consumption reduction of circa 1.5%.
2006	Smokers (ref 11268)	Q	In the EU-15, for a combination of measures promoting the application of eco-driving by existing drivers the overall (GHG) reduction potential is estimated at 4.0 Mtonne/y in 2012 growing to 9.1 Mtonne/y in 2020. If GSI is used to assist these drivers in maintaining a fuel-efficient driving style these values increase to 6.0 Mtonne/y in 2012 and 13.7 Mtonne/y in 2020.
			Cruise Control and Econometers
2001	IEA (ref 11354) and citing NOVEM 1995	Q	IEA (2001) cites a study (NOVEM 1995), which found fuel savings per kilometre of 13% for econometers and 12% for cruise control for private drivers (a later study – NOVEM, 1998 – indicates an average of 10% for a package of on-board technologies and lower speed limits). Cruise control devices have a more direct effect on fuel consumption than do training programs, as they do not depend on driver attitudes about saving fuel or achieving long-term changes in driving habits.
2001	IEA (ref 11354)	Q	IEA (2001) estimated, conservatively, that a package of on-board technologies (including cruise control and/or econometers and warning lights for under-inflated tires) could result in 5%-10% fuel savings per vehicle. If it is assumed that 25% of new cars are already equipped with a package and that, with the new policy, all new cars would carry them, by 2010 [written in 2001] average fuel use and CO2 emissions for new light-duty vehicles could decline by 4%-8%, but just by 2%-5% for the entire stock, since new cars comprise a small part of the stock.
			Tyre inflation

Year	Author	Type	Evidence
2007	Anable & Bristow (ref 12297) citing ACEA, 2006	Q	The ACEA, without providing the methodology used to derive these figures, estimates a potential 12.5Mt CO2/yr saving by 2012 due to eco-driving at a cost of 185 €/t CO2. Optimal tire pressures have the potential to save 1 Mt CO2 /yr by 2012 at a cost of -25€/t CO2 (i.e. a net benefit).
2007	Anable & Bristow (ref 12297)	Q	A combination of both tyre pressure monitoring systems and low rolling resistance tyres is estimated to improve fuel efficiency in real driving conditions by 4-6%, whereas on their own, TPMS can reduce fuel consumption by 2.5% (assuming the driver responds to the signals given by the system). The benefits are assumed to last the lifetime of the vehicle and are strengthened by the reduction of tyre wear and safety improvements.
2006	Noland (ref 11450) citing IEA, 2003 and CEC, 2003	Q	Noland (2006) states that maintaining the proper tire pressure can have a significant effect on total fuel consumption. Citing IEA (2003) Noland (2006) reports estimates of a 2.5–3.0% increase in fuel consumption for every pound per square inch (psi) below the optimal tire pressure. Citing California Energy Commission (CEC) (2003), Noland (2006) reports a somewhat lower estimate of a 1% increase per 1.0 psi below the optimal level. It has been estimated that a significant fraction of cars have their tyres under-inflated, suggesting some room for increased efficiency (citing IEA, 2003). This suggests a possible policy option of providing information to drivers on maintaining optimal tire pressures.
2006	Noland (ref 11450) citing survey data from IEA, 2003	Q	It has been estimated that the average light duty vehicle tire is under-inflated by 3 psi. For all vehicles, it was assumed that the policy could not be 100% effective due to mis-inflation, leakage, and similar factors; thus tires were estimated to remain an average of 1 psi underinflated. This would result in a 1.9% overall reduction in road transport fuel consumption
			Engine pre-heaters
1998	Lindqvist (ref 11235)	Q	The calculated potential for the use of engine preheaters in Stockholm could reduce CO2 emissions by almost 5 kiloton per year (0.4 %).
			Vehicle navigation systems
2003	Wiegmans (ref 2273)	C	Regarding Vehicle Navigation systems, because of all subsequent effects the CO2-emission will increase rather than decrease.
			Eco-driving - bus
2007	Anable & Bristow (ref 12297) citing Allen 2007 and citing Erkilä & Nylund, 2007	Q	Evidence on eco-driving in the bus industry indicates savings in fuel consumption of between 2 and 10%. Other benefits reported include less wear and tear on brakes and hence less maintenance, reductions in driver stress, improved on board comfort.
			Eco-driving - rail

Year	Author	Type	Evidence
2007	AEA (ref 11298)	Q	Using coasting, rather than flat out running and braking could result in a 10% CO2 saving could be attained from a journey time increase of 3%, or a saving between 32 and 38% from a 9% journey time increase.
2007	AEA (ref 11298)	Q	"Energy efficient driving techniques offer potential energy saving of 5-15% ….improved traffic management and optimisation of rail flows can have similar benefits".
2008	Deutsche Bahn (ref 11688)	Q	"energy-saving driving patterns that permit train drivers to cut energy consumption by as much as 10 per cent"

Other CO2 Impacts

Year	Author	Type	Evidence
			No specific evidence found.

Other Benefits

Year	Author	Type	Evidence
2006	Smokers (ref 11268)	C	Possible positive impacts of eco-driving on traffic safety.
2003	Harmsen (ref 11449)	C	"The measure has low costs. There are many positive effects related to noise, fewer traffic incidents and accidents, less stress for the driver, emissions and costs (less wear and tear) beside fuel savings. Eco-driving is a no-regret option."

Policy Costs and/or Revenues

Year	Author	Type	Evidence
2007	Anable & Bristow (ref 12297) citing Eco-drive, 2005; and citing Harmsen et al., 2007	Q	In the Netherlands, eco-driving has formed part of the driving test since 2001 plus about 1.5% of existing drivers had been reached by training programmes by 2004. Together with an information campaign, the cost is estimated to be around £13 per tonne of carbon saved (citing Eco-drive, 2005) A recent estimate by Harmsen et al, (2007) put the cost at around £22 per avoided tC based on eco-driving programme costs of about £1.4 million annually (including subsidised training programmes and communication campaigns).
2007	Anable & Bristow (ref 12297)	Q	A combination of both tyre pressure monitoring systems and low rolling resistance tyres is estimated to have a cost of carbon saving estimated at -£123/tonne CO2e. (i.e. a benefit).
2007	CEC (refs 11259 & 11381)	Q	The cost of mounting GSI systems on new vehicles per ton of WtW CO_2eq abated is estimated at -113 € (i.e. a net benefit). GHG abatement costs for tyre pressure monitoring systems are approximately -64€/ton (negative cost = benefit),

Year	Author	Type	Evidence
			according to modelling using TREMOVE. This implies a reduction potential of 42 Mt throughout the EU.
2006	Smokers (ref 11268)	Q	Eco-driving is a very cost effective means of reducing CO2 emissions of passenger cars for oil prices ranging from 25 €/bbl upwards. The cost of carbon saving is negative for all combinations of fuel cost, eco-driving course cost, GSI cost, and duration of effect modelled. Smokers (2006) cites a previous ACEA study for CARS21 which assumes much shorter term effects (2 years), and therefore a higher cost of carbon saving (comparable to that of vehicle technical improvements).
2006	Smokers (ref 11268) citing Goudappel, 2005	Q	Smokers (2006) estimates that an information campaign (radio, tv, posters etc) in the Netherlands, (which resulted in ~1.5% of drivers fully applying the eco driving tips) cost 3.2 M€ in 2004, equivalent to approximately €25/driver (citing Goudappel, 2005).

Business and Consumer Costs

Year	Author	Type	Evidence
2007	Anable & Bristow (ref 12297)	Q	European motorists are wasting €15 billion a year through not having enough air in their tyres (results of an EU-wide vehicle safety check by Bridgestone).
2007	CEC (refs 11259 & 11381)	C	Teaching eco-driving as part of driving license tuition (for new drivers) is likely to be significantly cheaper than a large scale campaign to raise awareness amongst all drivers, notably those that would not voluntarily participate in training courses.
2006	Smokers (ref 11268)	Q	The additional cost of providing eco-driving as part of existing driving license training is estimated to be less than €1 per driver. Costs of eco-driving lessons are estimated at €50-100 (in general a half day – 4 hour – group session should suffice).
2006	Smokers (ref 11268)	Q	The additional manufacturer costs of GSI are €15 (€22 additional retail price).
2003	Harmsen (ref 11449)	Q	An overall fuel reduction of about 5% is achieved for those receiving eco-driving training in various EU countries. This could provide a payback in under a year for business vehicle operators – at an estimated cost of €7/ton CO2 by one estimate.
2003	Kageson (ref 11175)	Q	Under Swedish conditions the limit for profitability currently lies at approximately 13,000 km for drivers of diesel cars and 19,000 km for gasoline cars (the positive effect of reduced wear not included). A higher fuel price, however, would extend the profitability of training to drivers with fewer hours behind the wheel. Training drivers of buses and trucks always pays off as they drive very long annual distances in high-consuming vehicles.
2001	IEA (ref 11354	Q	A general estimate for the cost of intelligent cruise-control systems is USD 300-USD 350. If this estimate is correct for

Year	Author	Type	Evidence
	citing Institute of Transport-ation Engineers, 1996		a system that saved drivers 5% of fuel use per kilometer, then for many drivers this technology would more than pay for itself in fuel savings over the life of their car, even using a substantial discount rate for future fuel savings.

Unintended Consequences

Year	Author	Type	Evidence
			No specific evidence found.

Reasons/Arguments for Carbon Reduction Achievement and/or Failure

Year	Author	Type	Evidence
			Duration
2007; 2006	CEC (refs 11259 & 11381); Smokers (ref 11268)	C	While the initial effect of ecodriving is reasonably well documented, there is less data available on the long term effect, which is expected to be significantly smaller.
2006	Smokers (ref 11268) and citing ACEA study for CARS21	C	Estimates of the duration of eco-driving training range from 2 years (citing ACEA study for CARS21), to 40 years (new drivers, following a dedicated eco-driving course) (Smokers, 2006).
2003	Harmsen (ref 11449)	C	To retain the effects of eco-driving training, a procedure for an individual follow-up may be necessary.
			Improving uptake of eco-driving
2001	IEA (ref 11354	C	Two difficulties to implementing driver-training programmes are: 1. involving significant numbers of drivers 2. ensuring that the lessons learned are not soon forgotten.
2001	IEA (ref 11354	C	New approaches to increasing the numbers of drivers trained over the years, through various kinds of marketing campaigns and initiatives, appear promising: • Including energy-efficient driving techniques as part of the written and practical driving license tests. • Promoting the purchase of econometers for existing vehicles through pricing and marketing techniques. • Working with original equipment manufacturers to increase the use of on-board technologies in new vehicles. • Providing incentives for or requiring that new vehicles are equipped with cruise control and/or econometers. • Car manufacturers and employers providing free or reduced-price eco driving lessons to car purchasers.
			Barriers to implementation
2007;	CEC (refs	C	Compared to other policy measures, the monitorability and

Year	Author	Type	Evidence
2006	11259 & 11381); Smokers (ref 11268)		accountability of a downstream measure such as eco-driving do not provide the same level of reliability in the range of CO2 reductions to be delivered.
2006	Smokers (ref 11268)	C	There may be difficulty in drivers understanding eco-driving advice. As a result, promoting lessons is more likely to be effective than giving eco-driving tips.
2003	Harmsen (ref 11449)	C	It can be difficult to change the behaviour of a driver who thinks that he already has a good driving style.
			Other
2007	DfT (ref 11614)	Q	The speed limit on these roads is 70mph for cars. However, 54% of these vehicles travel in excess of this limit at any one time, 18% of these above 80mph.
2007	NAEI (ref 11615)	Q	Depending on the vehicle driven, running the car at constant speed at 80 mph (130 kph) instead of 70 mph (110 kph) increases fuel consumption by 15 to 20 percent.
2006	Harbord et al. (ref 11619)	Q	When motorways become congested, reducing the speed limit to 60mph or 50mph reduces rather than increases journey times. There has been some evidence of this from the UK 'controlled motorway' trials where speeds are reduced below the normal speed limit at congested times.
2003	Harmsen (ref 11449)	C	Campaigns and interventions need to be repeated on a regular basis to make sure that the effect does not fade out.
2003	Harmsen (ref 11449)	C	The stronger the accompanying economic incentive (e.g. fines for violation of speed limits or fuel taxes) the stronger and more sustainable the effect of eco-driving training is likely to be. In-car feedback instruments can improve the effect. A first priority would be to implement eco-driving into the regular driver training and exams.

Policy suitability for UK

Year	Author	Type	Evidence
2006	Smokers (ref 11268)	C	There are larger gains to be made in Southern European countries which have more dynamic/aggressive driving styles than in Northern European countries.
2003	Harmsen (ref 11449)	C	Harmsen (2003) points to the 'barrier of consciousness' because most drivers do not see that they can learn something new in a field they think they already know well enough. This can be overcome (according to the Dutch govt response) by using intermediary - consumer and business-organisations and through frequent communication with the public.

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