GETTING THE GENIE BACK IN THE BOTTLE:

Limiting speed to reduce carbon emissions and accelerate the shift to low carbon vehicles

Paper prepared for the
LowC^VP Road Transport Challenge

by:

Jillian Anable, UKERC and The Centre for Transport Policy, The Robert Gordon University

Paige Mitchell, The Slower Speeds Initiative

Russell Layberry, UKERC and The Environmental Change Institute, The University of Oxford

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INTRODUCTION

In the discussion relating to the myriad of carbon abatement solutions from the transport sector, surprisingly little attention is paid to speed enforcement and reduction. Speed limits are rarely regarded as an innovative instrument to achieve carbon reductions or to alter the context for the supply and demand of low carbon vehicles. Where the carbon reducing potential is acknowledged, limiting speed is generally dismissed as not politically viable.

This paper will demonstrate that a lower, or even merely better enforced, top speed limit should not be ignored as it is one of the most certain, equitable, cost effective and potentially popular routes to a lower carbon economy.

The best available official data on the vehicle fleet, fuel consumption, emissions factors, traffic flows and speeds on motorways and dual carriageways have been used to develop a model to assess potential carbon savings between now and 2010 from (i) enforcing the current top 70mph speed limit and (ii) reducing this limit to 60mph. In addition, the wider effects of a lower top speed limit on traffic demand, vehicle design, traffic flow and road safety are explored. Together these provide an overview of the direct and indirect effects of speed on carbon emissions in the road transport sector. **Figure 1** outlines the relationships explored in this paper:

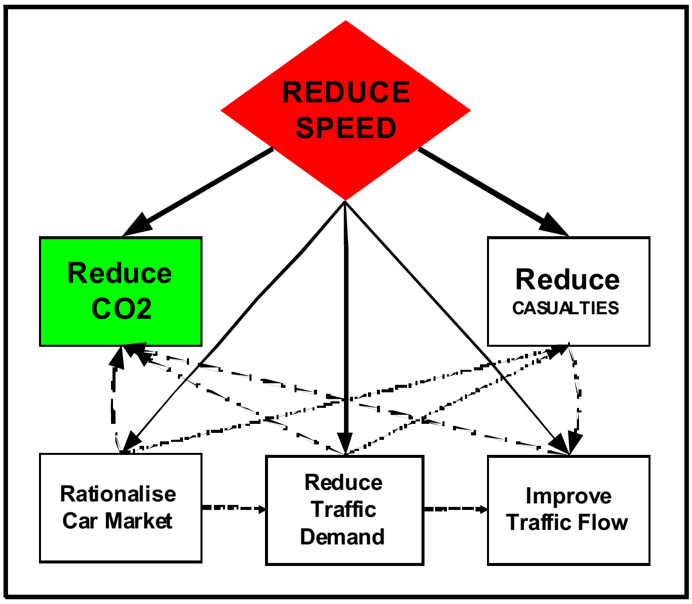

Figure 1: The relationship between speed enforcement and CO_2 reduction

SUMMARY FINDINGS

- A properly enforced 70mph speed limit would cut carbon emissions from road transport by nearly **1 million tonnes of carbon (MtC) per annum**, or nearly 5 MtC over 5 years.
- **A new 60mph limit would nearly double this reduction**, reducing emissions by an average **1.88 MtC a year,** or approximately **9.4 MtC over 5 years**.
- These savings, which are based on low projections of traffic growth**, represent between 15% and 29% of the total savings expected from the transport sector by 2010, as stated in the 2006 Climate Change Programme Review (CCPR).**
- These savings compare favourably to other policies in the CCPR such as the 1.6 MtC expected from the Road Traffic Fuels Obligation (RTFO), yet to be introduced in the UK.
- These figures assume that speed enforcement and reduction will not affect travel demand. However, **if restraint were included in the calculation, the reduction in emissions would be even greater.**
- A better enforced 70mph limit on motorways would **prevent over 300 deaths and serious injuries per annum** on motorways alone. A 60mph limit would **prevent over 600 deaths and serious injuries.**
- Lower top speeds and the safety benefits would **incentivise the market for lighter and less powerful cars**, thus increasing the carbon savings further.
- Initial indications of cost are that this would be **one of the cheapest carbon abatement polices,** across all sectors, especially when ancillary benefits such as casualty and congestion reductions are considered.
- Of all measures to manage the demand for travel by car, **speed limits are simultaneously the mildest, most straightforward, the least intrusive and most egalitarian in their impacts**.

THE VITAL STATISTICS: SPEED, MOTORWAY TRAFFIC AND CO_2 EMISSIONS

Fuel consumption and carbon dioxide emissions are a function of speed, mileage, vehicle weight, engine and fuel type, driving style, traffic flow conditions and, to an increasing extent, optional features such as air conditioning. **Figure 2** shows the relevant carbon dioxide emission curves for two engine size groups of Euro II cars[i]. Petrol Euro II cars with engines between 1.4 litres and 2 litres emit 10% less CO_2 at 60mph than they do at 70mph. Diesel Euro II cars with engines under 2 litres emit about 16% less. At 80mph, Euro II petrol cars with engines between 1.4 litres and 2 litres emit 14% more CO_2 per kilometre and cars with engines over 2 litres will emit 19% more CO_2 than at 70mph.

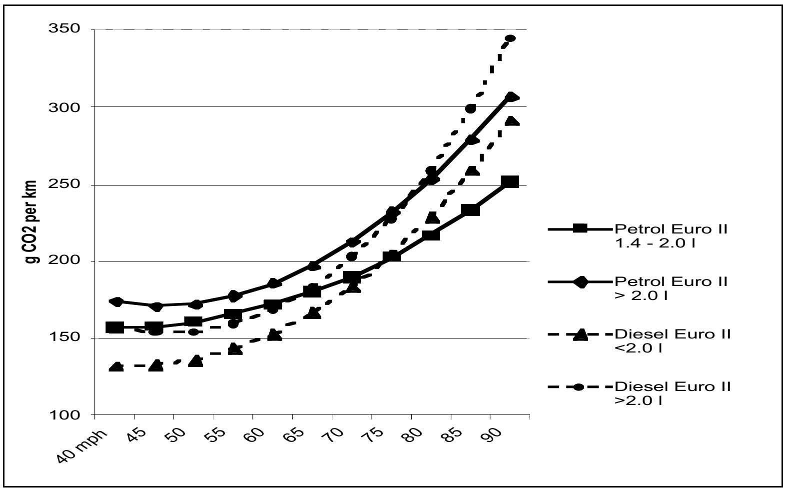

Figure 2: Changes in CO_2 emissions with speed
(Source: NETCEN National Atmospheric Emissions Inventory)

Motorways account for less than 1% of Britain's total road length, yet account for 19% of total annual road mileage[ii], of which 75% is accounted for by 'cars and taxis'. Driven speeds on motorways and dual carriageways are well above the optimum for fuel efficiency. Traffic is distributed across various speed bands, ranging from 50mph and below to 90mph and above[iii]. These figures take current levels of congestion on the motorway network into account. During the morning and evening weekday peak, 51% and 48% of cars respectively exceed the motorway speed limit[iv]. The average motorway speed during congested periods is 55mph[v].

In 2003, road transport accounted for just under 33 MtC - 21% of the UK's total CO_2 emissions of 156.1 MtC[vi]. Using the most recent figures[vii] on the distribution of distance travelled by each vehicle type in each speed band, 13.2 MtC was emitted by all categories of four-wheeled vehicles driving on roads with 70mph limits on motorways and in 2005. This is about 40% of the annual emissions by source from the road transport sector. This figure forms the basis of the calculations on potential carbon savings to follow.

HOW MUCH CO_2 COULD BE SAVED BY ENFORCING OR REDUCING THE CURRENT TOP SPEED LIMITS ON MOTORWAYS AND DUAL CARRIAGEWAYS?

A model was developed to calculate the emissions savings from speed reduction and enforcement under a number of scenarios[viii]. These included different speed limit scenarios (Business as usual (BAU), 70mph enforced and 60mph enforced) and different assumptions relating to the extent to which speed reductions will curb traffic growth.

Table 1 shows the annual and cumulative carbon savings from (i) enforcement of the current 70mph speed limit and (ii) enforcement of a 60 mph limit on motorways and dual carriageways, assuming that no change in mileage takes place as a result of the policy.

Table 1: Carbon savings from speed enforcement on motorways and dual carriageways to 2010

	Per Annum carbon savings (MtC)					Total cumulative savings in 2010
	2006	2007	2008	2009	2010	
70mph enforced	0.94	0.96	0.98	1.00	1.00	**4.87**
60mph enforced	1.81	1.84	1.88	1.91	1.94	**9.38**

Taking 2006 as a baseline, our calculations show that carbon emissions would be reduced by between an average of 0.97 and 1.88 MtC in each year to 2010. These estimates are conservative because of our moderate estimates of traffic growth and the assumption that there would be no restraining effect on traffic growth. We take the potential impact on distances travelled into account below.

Given that the BAU projections for emissions from 4 wheeled vehicles on roads with 70 mph limits are projected in this model to be just under 14.6 MtC in 2010, this equates to a reduction of between 6.6% and 12.9% in 2010. As total road traffic (all roads and all vehicle types) is projected to be 34.5Mtc in 2010, this policy could be responsible for a reduction of between 2.8% and 5.4% of carbon emissions from this sector.

The scale of this reduction, given that it essentially limited to motorways and dual carriageways, is of a similar order to that projected by the Royal Commission on Environmental Pollution in 1994 in its influential report: *Transport and the Environment*.[ix].:

> *'Effective enforcement of the 70mph limit on dual carriageway roads and the 60mph limit on single carriageway roads would reduce casualties and would also lower carbon dioxide emissions from road vehicles by about 3%.'*

The Commission found that a reduction of the speed limit on inter-urban roads to 55mph would achieve a further reduction of 3%. Our figure is also consistent with a recent assessment of the potential of a 55mph motorway speed limit to reduce oil demand in the case of a sudden disruption in supply. It is estimated that this measure would achieve a 3.3% reduction in transport fuel use in European countries[x].

ADDITIONAL CARBON SAVINGS FROM SPEED ENFORCEMENT AND REDUCTION

Recent carbon savings from improvements in vehicle efficiency have been eroded by offsetting changes in vehicle weight, performance and distance travelled. Countervailing demand management measures are needed if the benefits of greater fuel efficiency are to be realised. The argument for a lower speed limit is also primarily based on increasing fuel efficiency by ensuring that average speeds are closer to the optimum. However, a lower motorway speed limit has the advantage of being simultaneously a demand management measure by having an effect on traffic flow, journey time and the utility of high performance vehicles. Hence, speed enforcement could amplify the benefits of many of the changes that are being proposed to curb emissions from road transport in the following ways:

Reduction in traffic growth

Traffic growth is at least partly driven by the ability to travel further, faster. Indeed, an important parameter determining the attractiveness of roads and other traffic infrastructure is the speed they permit. In 1994, the Standing Advisory Committee on Trunk Road Assessment concluded that 'travel speed affects the amount of traffic'[xi] and this 'speed elasticity' can determine the traffic induced by the improvement of infrastructure[xii]. SACTRA concluded that in the short term, half the time savings created by road improvements would be used for additional travel. In the longer term, nearly all the times savings would be used up in additional travel.

National statistics also demonstrate this relationship. Between 1992/94 and 2005 average distance travelled per person per year increased by 5%, average trip length increased by 12% but the time spent travelling has remained about an hour a day[xiii]. Given the relative invariance of the average travel time budget, reducing average speeds, especially on motorways where the longer journeys are made and where traffic is growing the fastest, has the potential both to reduce present levels of traffic and slow the rate of traffic growth. Drivers would be encouraged to make fewer journeys, choose closer destinations or switch to other modes. If accompanied by other changes such as road pricing and improved rail services, the effect of slower speeds on reducing traffic would be even greater.

Thereby, speed enforcement and reduction is the only fuel efficiency measure with a built-in restraint mechanism. Whereas fuel efficient engines have reduced the cost of travel, speed limiting effectively increases the cost of a journey through time penalties and the discouragement of longer journeys.

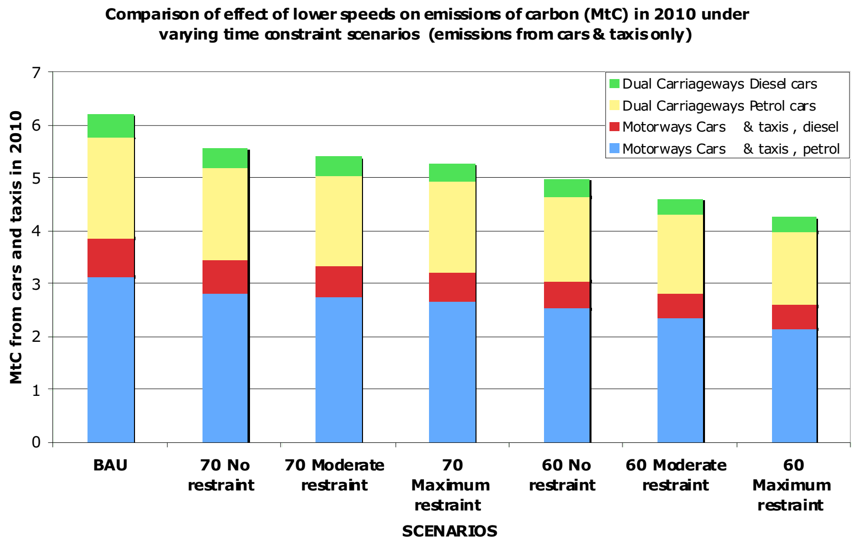

Figure 3: Comparison effect of lower speeds on carbon under different restraint scenarios

Figure 3 shows that traffic reduction would have an even greater effect on the carbon savings calculated above. To illustrate the potential effect of a fixed time budget, we have carried out calculations for 'moderate' and 'maximum' restraint on distances driven. For moderate restraint, we assume that only half of the distance driven at speeds above the new effective speed limit would 'disappear' due to time constraints. Under this scenario, some drivers would carry on making their journeys as before because they could not change their origin or destination or because they could increase their travel time budget (or both). Under the maximum restraint scenario, we assume all the mileage over the new speed limit will be affected. Both scenarios assume that the 'lost' mileage applies to all motorway and dual carriageway journeys, whereas it is likely that the longest journeys will actually be the ones to disappear. Our calculations show if lower speeds on motorways and dual carriageways moderated traffic growth even slightly, as is likely, the benefits in reducing emissions (and casualties (see below)) would be even greater. Under the 70mph enforcement scenario, moderate restraint results in an additional 3% less carbon emissions from cars and taxis on these roads, and 7% under the 60mph scenario.

Maximising existing capacity by improving traffic flow

Highway capacity is also a function of speed. The highest speed at which maximum capacity is safely and reliably achieved is 60mph. The traffic smoothing effects of a 60mph limit would help to reduce harsh driving styles and overtaking which can cause flow breakdown, crashes and disruption, further reducing CO_2 emissions and optimising existing capacity. Making better use of existing capacity would render motorway widening schemes unnecessary. Creating additional capacity by widening would ultimately generate traffic, increase CO_2 emissions, and make their reduction even more intractable. A speed limit of 60mph or less would increase capacity while simultaneously discouraging traffic growth due to the restraining effect of lower speeds.

Rationalising car design

Setting a limit to the top speeds acceptable on the public highway could trigger far-reaching changes to vehicle design, reducing impacts across the network and effectively acting as a 'system boundary' to the ever increasing cycle of counter-efficient vehicle design and longer distance travel.

In the short to medium term, lower limits and appropriate levels of enforcement would encourage the voluntary uptake of speed limiters. Fiscal incentives to drivers to adopt speed limiters would hasten this process. However, emissions can also be reduced 'at low or negative cost' by reducing vehicle weight, top speed and acceleration[xiv]. Downsizing car body, engine and powertrain would make vehicles lighter, removing obstacles to making engines yet smaller, less powerful, and more fuel efficient. Currently, 64% of the car fleet has engine capacities well above the 10 best performing petrol and diesel vehicles where CO_2 emissions are concerned[xv]. The average top speed of these 'best performing' models is 102mph.

Hence, in the longer term, vehicles could be designed, possibly through the use of regulation, to 'cap' top speed capability. This would ensure that top speed is more closely related to the highest permitted speed limit and would help re-orientate vehicle design and re-appropriate the improvements in fuel efficiency which have so far been devoted to travelling further, faster, in heavier cars. Even without fiscal incentives, slower motorway speeds and proper enforcement would reduce the attractiveness of the most powerful and polluting vehicles in relation to lighter and more fuel-efficient cars already on the market. In addition, the safety margins of lighter and less powerful cars would be improved at lower speeds. Consequently, Kroon[xvi] observes:

> *The semi-sustainable European medium-range (Golf class) petrol-fuelled car in the year 2000 geared to low fuel consumption could have the following characteristics: weight <800kg, engine capacity <700 cc, top speed <140 km/hour [87mph], 0-100km/hour >20 seconds; 3l/100km fuel consumption. A fuel consumption computer will optimise driving habits and save an extra 5% fuel.*

Research in the Netherlands has shown that 'a combined approach of downsizing power and speed, enforcing speed limits and in-car guidance of drivers' behaviour' could reduce CO_2 emissions by 50%[xvii]. This synergistic combination of design, regulation and driver education should be at the forefront of policies to reduce transport emissions. While ultimately EU-wide action would be needed to ensure a level playing field, the failure of the Voluntary Agreement to deliver the average fuel efficiency, in combination with climate change and energy security concerns, and moves to harmonise European speed limits, may bring a directive forward. Indeed, in May 2005, EU Energy Commissioner Andris Piebalgs put the case for a top speed limit of 100kph (62mph) for Europe's roads in order to conserve energy and reduce crashes[xviii]. Meanwhile, the carbon reducing potential of lower top speed limits would help the UK meet its medium and long-term commitments on climate change, commitments which are increasingly looking too weak and too late to contribute to slowing climate change.

OTHER BENEFITS OF ENFORCING AND REDUCING SPEED LIMITS

Speed enforcement and reduction have certain advantages over other transport measures to reduce carbon emissions:

Early Win/ Certainty

Unlike other technologies needing a lead time, the enforcement of the 70mph limit and the introduction of a 60mph limit could begin immediately with immediate benefits. Above all, it is certain. No technological development or innovation is required and it is straightforward and relatively cheap.

Safety

Enforcement and speed limit reduction would bring safety benefits. Camera enforcement of speed limits typically reduces average speeds by about 7%[xix]. If strict enforcement only reduced the average speed of cars on motorways from 71mph to 66mph, it would still save around 60 lives and prevent 270 serious injuries a year. A 60mph limit would almost halve current rates of death and serious injuries on motorways (see Table 2). Using official estimates of the cost of road crashes, these excess casualties cost society £120 million[xx].

Table 2: Casualty reduction potential of enforcing and reducing the 70 mph limit on motorways*

	2003	If average speed 66 mph (70 mph enforced)	If average speed 60 mph (60 mph enforced)
Deaths	217	156	102
Deaths and serious injuries	1451	1120	802

** separate data for casualties on dual carriageways not available*

Source: Road Casualties Great Britain 2004, Table 12 Accidents, vehicles and casualties: casualties by severity: by built-up and non built-up roads: 2003

Rational vehicle design would also make compliance with low urban speed limits much easier and thus reduce urban casualties and the costs of traffic calming. Likewise, it would greatly reduce the danger and intimidation that discourage the most important CO_2 minimising forms of transport - fossil-fuel-free walking and cycling.

Equity

Unlike many other transport demand restraint mechanisms, lowering speed limits would be one of the fairest ways of reducing emissions as it applies to all of the people, regardless of income or geography, all of the time and will reduce the differential between the fast and the slow, the rich and the poor.

Cost-effectiveness

Current policy to reduce carbon emissions from transport relies on novel and largely untried or as yet unavailable fuels, technologies and infrastructures, and accepts that progress will be both slow and costly. Hybrid vehicles, biofuels and hydrogen fuel cells are among the most expensive transport options evaluated by the Energy White Paper[xxi]. Estimates of the implementation costs for hybrid vehicles are between £100 and £400 and for biofuels, between £200 and £700 per tonne of carbon saved in 2020/25. Hydrogen fuel cells are even more expensive, with a high estimate of £5500 per tonne of carbon saved in 2020/25.

There is other evidence that a lower speed limit would be cost effective. A recent report to Defra on reducing road transport emissions (NOx, PM10 and CO_2) ranked 'revised speed policy for motorways close to urban areas' as the second out of three options which should be prioritised for the 2005-2010 time period on the basis of a cost benefit analysis. The top option was the 'increased uptake of low emission passenger cars'[xxii]. In addition, a lower motorway speed limit (90kph or 55mph) has been shown to be among the most effective and least expensive ways to 'save oil in a hurry'. The implementation cost of a 55mph motorway speed limit in Europe, including signage and enforcement, has been calculated to be around $11 per barrel of oil saved, or around £40 per tonne of carbon saved [xxiii]. The additional benefits of casualty reduction and costs of time penalties were not taken into account. This compares extremely well with the technological improvements upon which the Energy White Paper relies, especially given that reductions in CO_2 emissions would be immediate, rather than coming late in the target timeframes[xxiv].

Finally, it is likely that a lower motorway speed limit could produce a net benefit to society, even without taking climate change into account. A methodology for determining optimal speed limits was set out by Plowden and Hillman[xxv]. This used the accepted approach of monetizing values for casualties, time, fuel and vehicle operating costs but also took into account the effects of reduced flow and changes in tax revenues. The authors estimated that:

> *[assuming] motorists would take account only of time and fuel costs when deciding how to react to lower speeds ... the apparent optimal speed limit on motorways should be no higher than 60 mph and that 55 [was] a strong contender.* (p102)

Taking non-monetized impacts, such as noise, severance and pollution, including climate change, into account would further strengthen the case for a lower limit.

Public acceptance

The general absence of lower speed limits from discussions of measures to curb CO_2 emissions may be due to the assumption that lower limits would be politically unacceptable. However, objections from motorists might be far less than feared. They would experience direct benefits in fuel savings and operating costs. Moreover, speed limit enforcement/ reduction would require less behavioural change than other technological/ regulatory/fiscal measures. In other words, of all measures to manage the demand for travel by car, speed limits are simultaneously the mildest, the most straightforward, the least intrusive and the most egalitarian in their impacts.

There is little evidence that policy options currently preferred to speed limit reductions would necessarily be more popular, more equitable or easier to implement than speed enforcement or even reduction. Any measures requiring behaviour change require publicity campaigns explaining the need for the change. With suitable publicity and explanation, the public and business may consider lower speed limits the most acceptable as well as most convenient of all the options. Alternative fuels, road user charging, car pooling, modal shift to public transport, more walking and cycling, high occupancy vehicle lanes, tele-commuting would all either cost more or entail changes to travel behaviour which could be even less popular, more intrusive and harder to sustain or enforce. For inter-urban travel, shifts from the private motor car, for instance to public transport or car-sharing, would also normally entail time penalties. Moreover, lower speed limits would bring direct economic benefits to individuals and companies in the form of better fuel economy and lower operating costs and casualties.

Consequently, if the trade-offs are explained, drivers may prefer a lower speed limit to many other demand management interventions. Indeed, there is very recent UK evidence on driver response to lower motorway speed limits that show for the majority, the time penalties of speed enforcement proved to be non-existent, minimal or outweighed by the gains of improved fuel economy, safety, reliability and reduced stress. On a 30km stretch of the M25, speed is controlled to smooth traffic flow, reduce congestion and prevent crashes and associated disruption. In order to do this, speed limits of 60mph or 50mph are imposed. An even lower 40mph limit is introduced when required for safety. These speed limits are strictly enforced[xxvi]. The measured benefits of the controlled motorway are smoother and more reliable journeys in certain periods, reduction in stress for drivers, reduction in the number and severity of crashes, reductions in traffic noise, vehicle emissions and fuel consumption and improved driver behaviour. The majority (68%) of drivers liked the system and wanted to see it extended to other sections of motorways. Significantly, the survey found that 'the most irritating aspect of a journey relates to congestion and resultant delays'. The users themselves generally consider their journeys vital and do not wish to consider re-routing or using other forms of transport*,* they wish to see improvements in the current network to deal with the demand placed upon it.

HOW DOES THIS COMPARE TO OTHER POLICIES TO SAVE CARBON FROM TRANSPORT?

In 2000, the Department for Transport forecast that its policies would reduce emissions from transport by 5.6MtC below trend by 2010[xxvii]. This figure reflected the EU Voluntary Agreement between car manufacturers which was predicted to reduce average carbon dioxide emissions from new cars to 25% below 1995 levels[xxviii] translating into a 4MtC reduction. The remaining 1.6MtC was to be achieved by measures set out in the Government's 10 Year Plan for Transport[xxix]. These figures have subsequently been reduced as the DfT have had to revise their figures for potential savings downwards in the light of slower than expected progress in the average fuel economy improvements of new cars brought into the market in the UK[xxx]. In 2004, the DTI published new projections and allocated a 4.42 MtC reduction to the transport sector by 2010. This comprises 1.1MtC from 10 Year Plan policies and the remainder from the VA[xxxi]. In 2006, the UK Climate Change Programme Review[xxxii] forecast that measures included as part of the 2000 Climate Change Programme would reduce emissions by 5.1 MtC below trend by 2010 and new measures introduced from 2006 (The Road Traffic Fuels Obligation (RTFO) and a further Voluntary Agreement after 2008) would add a further 1.7 MtC to this total.

Hence, the policy of speed enforcement described here, saving between 1.00 and 1.94 MtC (based on low projections of traffic growth and not including traffic restraint or knock on effects on the car market) represent between 15% and 29% of the total savings expected from the transport sector by 2010, as stated in the 2006 Climate Change Programme Review (CCPR). These savings compare favourably to other policies in the CCPR such as the 1.6 MtC expected from the Road Traffic Fuels Obligation (RTFO), yet to be introduced in the UK.

CONCLUSIONS

The need to meet CO_2 reduction targets and protect society from the economic effects of energy shocks is increasingly urgent. A policy of current speed limit enforcement and, better still, lowering the speed limits, would bring significant, certain, immediate, equitable and highly cost-effective reductions in carbon emissions. What is more, this policy instrument has the potential to slow traffic growth and influence the vehicle market with further carbon reduction benefits, in addition optimising current road network capacity and leading to significant safety benefits. Overall, it would help to create the conditions for the transition to a more sustainable transport system.

We have not attempted in this paper to quantify all the benefits that a lower motorway speed limit would bring. There is more work to be done in this area and the need for a balanced public debate on the issues. We have used an enforced 70mph limit and a lower and enforced 60mph limit here for illustration. These are not necessarily the speeds that might prove to be optimal when the full range of benefits of lower speeds are taken fully into account. A good case can be made for 55mph or even 50mph. A comprehensive appraisal should explore the options and include the full range of impacts, their distribution, and the values assigned to them. It should be transparent enough to provide a systematic and relatively objective basis for explaining the choices to politicians and public alike.

In doing so, the public mood on this issue must be thoroughly and scientifically gauged. The 'unpopular' measure of a lower top national speed limit was introduced in the world's most car-dependent nation, the USA, in 1973 and, although being revised in some States now, stood for nearly a quarter of a century. It still applies on many highways in the US, some of them toll roads. These have some of the densest traffic and fewest casualties on the US road network. The public response to lower limits could be assessed by undertaking a representative social survey covering both attitudes to speed limits and their enforcement and knowledge of the relationships between speed, the adverse effects of traffic, including climate change and the policy choices available to mitigate these effects. This would show the extent to which any resistance to lower speeds is accompanied and perhaps explained by ignorance of their potential benefits. Such a survey could also compare the relative acceptability of the measures currently being proposed in preference to speed control.

ACKNOWLEDGEMENTS

Grateful thanks to Stephen Plowden for all his help and support with this paper.

NOTES

[i] The way emissions vary with average speed for most vehicle types making up the national fleet has been calculated for the National Atmospheric Emissions Inventory (NAEI): NETCEN (2003) Vehicle Emissions Factor Database v02.8.xls
[iiii] Department for Transport (2005) Road Traffic Statistics 2004
[iii] Department for Transport (2005) Vehicle Speeds in Great Britain: 2004, Table 1
[iv] Ibid, Table 2
[v] Department for Transport (2004) A Measure of Road Traffic Congestion in England: Method and 2000 Baseline figures
[vi] http://www.defra.gov.uk/news/2005/050321a.htm
[vii] On 22nd December 2005, the DfT released a Freedom of Information (FOI) request for an analysis of the impact on carbon of changes to vehicle speeds. The figures provided in their spreadsheet formed the basis for many of the figures used in the model developed for this paper. See: http://www.dft.gov.uk/stellent/groups/dft_foi/documents/divisionhomepage/610911.hcsp
[viii] The following assumptions were used in the modelling:

- An average emissions coefficient reflecting fleet technology mix for each year and the relevant speed distribution based on 2004 data for motorways and dual carriageways. (Netcen (2003) Vehicle Emissions Factor Database; DfT (2005) Vehicle Speeds Great Britain 2004; and the FOI spreadsheet cited in note 7.
- For speed reduction scenarios, all of the distance previously driven above either 70mph or 60mph is redistributed to the highest remaining band.
- Figures for traffic growth are based on the National Traffic Model *midpoint* projections for interurban roads between 2000 and 2010 (29-35%). Given the actual growth rates witnessed since these projections were made, this appears to be a conservative estimate of growth, and therefore the emissions savings in the model may be an underestimate.
- Figures apply to all vehicles travelling in 70mph speed limits except motorcycles.
- Levels of non compliance with the speed limits are not accounted for in this model.

[ix] Royal Commission on Environmental Pollution (1995) Eighteenth Report: Transport and the Environment, Oxford: Oxford University Press (paras 12.23-12.26)
[x] International Energy Agency (2005) Saving Oil in a Hurry, Paris: International Energy Agency
[xi] SACTRA (The Standing Advisory Committee on Trunk Road Assessment) (1994) Trunk Roads and the Generation of Traffic, London: HMSO
[xii] Pfleiderer, R. and Dieterich, M. (2003) Speed elasticity and mileage demand World Transport Policy and Practice Vol.9 (4), pp.21-27
[xiii] Department for Transport (2005) National Travel Survey: 2004
[xiv] Kågeson, P. (2005) Reducing CO_2 Emissions from New Cars, Brussels: T&E European Federation for Transport and Environment (p4).
[xv] Vehicle Certification Agency (2006) (www.vcacarfueldata.org.uk/information/tables.asp)
[xvi] Kroon, M. (1998) Downsizing Power and Speed: The Safe Road to Fuel Economy, Road Safety and Sustainability, paper for the Safety of Transportation Congress, Delft (p7)
[xvii] Ibid
[xviii] Sunday Times, May 2005
[xix] Gains, A., Heydecker, B., Shrewsbury, J., and Robertson, S. (2004) The national safety camera programme: Three-year evaluation report, London: PA Consulting Group
[xx] Department for Transport (2004) Highways Economics Note No. 1: 2003 Valuation of the Benefits of Prevention of Road Accidents and Casualties (www.dft_rdsafety_033570.pdf)
[xxi] Department of Trade and Industry (2003) Our energy future - creating a low carbon economy, Annex 1
[xxii] Kollamthodi, S. (2005) Technical and Non-technical Options to Reduce Emissions of Air Pollutants from Road Transport: Final Report to Defra, Didcot, Oxfordshire: AEA Technology Environment
[xxiii] International Energy Agency (2005) *Saving Oil in a Hurry*, Paris: International Energy Agency
[xxiv] It must be noted, however, that more work is needed on the cost effectiveness of various transport carbon abatement measures. The figures quoted here are indicative, as the same calculation methods are not used.
[xxv] Plowden, S. and Hillman, M. (1996) *Speed Control and Transport Policy,* London: Policy Studies Institute
[xxvi] Highways Agency (2004) *M25 Controlled Motorways: Summary Report* (http://www.highways.gov.uk/news/press_releases/general/2004_12_06b.htm 050915)
[xxvii] Bristow, A., Pridmore, A., Tight, M., May, T., (2004a) *Low Carbon Futures: How acceptable are they?* Paper presented at World Conference on Transport Research, Istanbul, July
[xxviii] Association des Constructeurs Europeens d'Automobiles/ European Community (1998) *CO_2 emissions from cars: The EU implementing the Kyoto Protocol*
[xxix] Department for Environment, Transport and the Regions (2000b) *Transport 2010: the 10 Year Plan* (http://www.dft.gov.uk/trans2010/)
[xxx] The estimate has been revised downwards from 140 g/km by 2010 to 1762g/km. (pers. comm with DfT as part of research for Anable, J. and Boardman, B. (2005) Transport and CO_2 UKERC Working Paper 002. (www.ukerc.ac.uk.)
[xxxi] DTI (2004) *Updated Emissions Projections- Final Projections to inform the National Allocation Plan Annex 1.* However, these projections do not assume that a new Voluntary Agreement will be negotiated for after 2008, so the savings may be higher than this.
[xxxii] DEFRA 2006 Climate Change The UK Programme 2006 available at http://www.defra.gov.uk/environment/climatechange/uk/ukccp/index.htm