Summary: Intervention & Options

Department / Agency:	Title:	
Department for Transport	**Impact Assessment of the Carbon Reduction Strategy for Transport, *Low Carbon Transport: A Greener Future***	
Stage: Strategy	**Version:** 1	**Date:** 13 July 2009

Related Publications: *Low Carbon Transport: A Greener Future* (DfT, 2009); *UK Low Carbon Transition Plan: Britain's path to tackling climate change* (DECC, 2009).

Available to view or download at:

http://www.dft.gov.uk/carbonreduction/

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What is the problem under consideration? Why is government intervention necessary?

Climate change is caused by the emission of greenhouse gases into the atmosphere. An externality exists as those who emit do not have to directly bear the full cost of their actions. The global causes and consequences of climate change, coupled with the long term and persistent nature of the impacts, highlights the need for government intervention. Tackling climate change is therefore a key priority for the UK Government. To this end, the UK has a target to reduce greenhouse gas emissions by 34% by 2020 on 1990 levels. The transport sector contributes about 21% of UK greenhouse gas emissions. Government intervention is necessary in order to maintain a trajectory of emission reductions consistent with achieving our climate change targets.

What are the policy objectives and the intended effects?

The policy objective is to substantially decarbonise our transport system by 2050, by reducing greenhouse gas emissions cost-effectively from across the sector, whilst supporting national economic competitiveness and growth; contributing to better safety, security and health; promoting greater equality of opportunity for all citizens to achieve a fairer society; improving our quality of life, and promoting a healthy natural environment.
Intended effects are to achieve a cost-effective contribution from the transport sector to the required reductions in greenhouse gas emissions consistent with achieving the UK's climate change targets.

What policy options have been considered? Please justify any preferred option.

a) "Do nothing" – this is the baseline against which the other options are assessed;
b) Take forward the transport measures proposed in the Carbon Reduction Strategy for Transport (2009), *Low Carbon Transport: A Greener Future*; and
c) Take forward the additional transport measures proposed by the Committee on Climate Change.

Option 2 is our preferred option. We believe that this provides the most appropriate combination of measures to contribute towards the achievement of our climate change targets in terms of cost-effectiveness, practicality and certainty of delivery. However, we are also continuing to investigate and pursue ways to realise any cost-effective technical abatement potential identified under option 3.

When will the policy be reviewed to establish the actual costs and benefits and the achievement of the desired effects?

The Climate Change Act (2008) sets out a statutory annual reporting process that will evaluate the UK's progress towards achieving its targets and five-year carbon budgets.

Ministerial Sign-off For final proposal/implementation stage Assessments:

I have read the Impact Assessment and am satisfied that (a) it represents a fair and reasonable view of the expected costs, benefits and impact of the policy, and (b) that the benefits justify the costs.

Signed by the responsible Minister:

Date: 13 July 2009

Summary: Analysis & Evidence

Policy Option: 2	Description: Carbon Reduction Strategy for Transport (costs and benefits are presented relative to option 1)

COSTS

ANNUAL COSTS		Description and scale of **key monetised costs** by 'main affected groups'
One-off (Transition)	**Yrs**	Different policies will impact on different groups. Key costs include: technology costs: £24.8 billion; air quality: £0.025 billion; congestion: £6.3 billion; and indirect noise, accidents and infrastructure costs: £2.4 billion.
£ 0.3 billion		
Average Annual Cost (excluding one-off)		
£ 1.9 billion		**Total Cost** (PV) **£29.6bn to £39.5bn**

Other **key non-monetised costs** by 'main affected groups'

BENEFITS

ANNUAL BENEFITS		Description and scale of **key monetised benefits** by 'main affected groups'
One-off	**Yrs**	Key benefits include: reduction in carbon dioxide emissions: £7.4 billion; fuel resource cost savings: £20.2 billion.
£ -		
Average Annual Benefit (excluding one-off)		
£ 2.0 billion		**Total Benefit** (PV) **£33.4bn to £55.7bn**

Other **key non-monetised benefits** by 'main affected groups'

Positive impact on innovation, security of supply and related macroeconomic impacts. Reduction in cost of meeting Renewable Energy Directive.

Key Assumptions/Sensitivities/Risks

Price Base Year: 2009	Time Period: Life-time of measures	**Net Benefit Range** (NPV) **-£5.2bn to £19.2bn**	**NET BENEFIT** (NPV Best estimate) **£1 billion**

What is the geographic coverage of the policy/option?			UK	
On what date will the policy be implemented?			Variable by policy	
Which organisation(s) will enforce the policy?			Variable by policy	
What is the total annual cost of enforcement for these organisations?			Variable by policy	
Does enforcement comply with Hampton principles?			Yes	
Will implementation go beyond minimum EU requirements?			No	
What is the value of the proposed offsetting measure per year?			n/a	
What is the value of changes in greenhouse gas emissions?			£0.3 billion	
Will the proposal have a significant impact on competition?			Variable by policy	
Annual cost (£-£) per organisation (excluding one-off)	Micro	Small	Medium	Large
Are any of these organisations exempt?			N/A	N/A

Impact on Admin Burdens Baseline (2005 Prices)			(Increase - Decrease)
Increase of £	Decrease £	**Net Impact**	**£** Variable by policy

Key:	Annual costs and benefits: Constant Prices	(Net) Present Value

Evidence Base

Contents

1. Introduction

1.1. This is an impact assessment for the Carbon Reduction Strategy for Transport (DfT, 2009), ***"****Low Carbon Transport: A Greener Future*", which is part of the UK Government's wider *UK Low Carbon Transition Plan* (DECC, 2009), "*Britain's path to tackling climate change*". It provides a high level discussion of the expected costs, benefits and other impacts of the Carbon Reduction Strategy between 2008 and 2022.

1.2. The proposed Strategy consolidates our planned measures in the transport sector, extends some measures and proposes certain additional measures. Some policies will therefore be more advanced in their design and implementation than others, and will already have an Impact Assessment associated with them (such as the EU regulation to reduce the carbon dioxide (CO_2) emissions of new cars). Any new policies put forward will be subject to a separate Impact Assessment at the appropriate time, which will look in detail at the costs, benefits and impacts of the specific policy. These specific Impact Assessments will therefore provide more detailed information on individual policy measures.

Background

1.3. There is now an overwhelming body of scientific evidence highlighting the serious and urgent nature of climate change, largely due to emissions of greenhouse gases as a result of human activities, such as the combustion of fossil fuels and changing patterns of land use. The international community has a coordinated response to the challenge – the 1992 UN Framework Convention on Climate Change (UNFCCC) has as its ultimate objective the "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

1.4. The Kyoto Protocol, which aims to reduce greenhouse gas emissions from "Annex I" Parties (a number of industrialised countries including the UK, other European Union (EU) member states, the Russian Federation, Canada, Australia, and Japan), was agreed in December 1997. Under the Protocol, Annex I Parties agreed to reduce their collective greenhouse gas emissions to 5.2% below base-year levels between 2008 and 2012.

1.5. The EU has agreed a goal of keeping global average temperature rise below 2°C, a point beyond which the risk of serious impacts may increase. Heads of Government agreed at the March 2007 EU Spring Council an ambitious, binding target to reduce Europe's greenhouse gas emissions by at least 20% by 2020 (compared to 1990 levels) and to increase this commitment to a 30% reduction as part of an international agreement. The adoption of the 30% reduction target is contingent on other developed countries committing themselves to comparable emissions reductions and economically more advanced developing countries contributing adequately according to their responsibilities and respective capabilities.

1.6. In December 2008, the European Council and the European Parliament agreed a package of measures (the EU "Climate and Energy Package") to deliver the emissions reductions agreed at the 2007 EU Spring Council. The package is comprised of three main elements: a strengthening of the EU Emissions Trading System (EU ETS); national emissions reduction targets for those sectors not covered by the ETS (the 'non-traded sector'); and national targets for the proportion of energy supplied by renewable sources in order to ensure that 20% of the EU's energy is supplied by renewable sources by 2020.

1.7. The Climate Change Act (2008) enshrines our domestic commitments in statute. It includes a legally binding target to reduce the UK's greenhouse gas emissions to at least

80% below 1990 levels by 2050. To drive progress towards this target, the Act introduces five year "carbon budgets", which define the emissions pathway to the 2050 target by limiting the total greenhouse gas emissions allowed in each five year period, beginning in 2008. The Government announced the level of the first three carbon budgets – for 2008-12, 2013-17, and 2018-22 – at Budget 2009, having taken into account the advice from the independent Committee on Climate Change (CCC). The CCC was established under the Act to advise the Government on setting carbon budgets and to report to Parliament on the progress made in reducing greenhouse gas emissions.

1.8. The CCC published its first report on 1 December 2008[1]. The report proposed two sets of carbon budgets for the UK, one to apply before a global deal is reached ('Interim' budgets), and a more challenging set to apply once a global deal on climate change has been agreed ('Intended' budgets). The Government agreed with this approach, and has set the carbon budgets based on the CCC's Interim budgets, consistent with the UK's share of the EU's target to reduce greenhouse gas emissions to 20% below 1990 levels by 2020.

1.9. The carbon budget for the non-traded sector is therefore consistent with the UK's share of the EU Climate and Energy Package. This means a target to reduce greenhouse gas emissions from the UK non-traded sector by 16% from 2005 levels by 2020. The non-traded sector in the UK is mainly made up of emissions from transport, domestic heating and agriculture. The transport sector contributes about half of UK non-traded sector greenhouse gas emissions.

1.10. The vast majority of transport emissions are not covered by the EU ETS, the exceptions being electricity used for rail transport, and aviation emissions once aviation joins the EU ETS from 2012. The majority of reductions in greenhouse gas emissions from transport policy interventions will therefore occur in the non-traded sector.

1.11. The UK does not have sectoral emission reduction targets within the non-traded sector – this is because emission reductions should be made wherever it is most cost-effective to do so across the non-traded sector. This will ensure that the target is met (and therefore a specified level of emission reduction achieved) at least cost to the UK economy.

The case for Government intervention

1.12. The Stern Review of the economics of climate change[2] highlighted that climate change is the result of several complex market failures.

1.13. The climatic changes that result from increasing concentrations of greenhouse gases in the atmosphere will impose costs (and some benefits) on society. However, the full cost of these emissions is not borne by the emitter, meaning that firms and individuals do not account for the cost of emissions when making their production and consumption choices. Without Government intervention there is therefore little economic incentive for firms or individuals to alter their behaviour, and greenhouse gas emissions are unlikely to be reduced to levels consistent with avoiding the serious consequences of climate change.

1.14. Further, the climate is a global 'public good' – those who fail to pay for it cannot be excluded from enjoying its benefits and one person's enjoyment of the climate does not diminish the capacity of others to enjoy it too. These characteristics of non-rivalry and non-

[1] Committee on Climate Change (December 2008), "Building a low-carbon economy - the UK's contribution to tackling climate change", available at http://www.theccc.org.uk/reports/.
[2] Stern Review on the Economics of Climate Change (October 2006), available at http://www.hm-treasury.gov.uk/sternreview_index.htm.

excludability mean that, without government intervention, the market is unlikely to provide adequate protection to the climate. Individuals are not incentivised to reduce their emissions when the benefits will be felt not just by themselves but also by all others. Conversely, individuals do have the incentive to 'free-ride' on the mitigation efforts of others, as they cannot be excluded from the benefits. In this case, markets for goods and services that have an impact on the climate (such as energy, land use, transport and so on) do not reflect the consequences of different consumption and investment choices for the climate.

1.15. Even when individuals and businesses wish to reduce their emissions, there may be information failures which prevent them from doing so, such as knowing the relative efficiency (and therefore level of emissions) of cars within a class or between different classes when making a choice to purchase a new car, or how to reduce emissions from the movement of freight.

1.16. Another market failure, associated with taking action on climate change, relates to the positive spill-over effects from innovation, meaning that firms are not able to capture the full benefit from the research, development and demonstration that they undertake. This is largely because other firms will be able to replicate the technology over time. Government intervention can help bring forward emerging low carbon technologies, and help reduce the cost of deploying these technologies, leading to greater benefits for the economy from the innovation.

1.17. The Stern Review estimates that the cost of inaction on climate change significantly outweighs the expected cost of co-ordinated global action. Without effort to tackle climate change, the Review predicts that the loss of GDP from climate change could cost the global economy significantly more than the global cost of action to stabilise atmospheric concentrations of greenhouse gases at 450-550ppm carbon dioxide equivalent (CO_2e).

1.18. Domestic transport greenhouse gas emissions have increased by about 12% since 1990. The largest contributor to domestic transport emissions is from road transport, which makes up about 92% of the total. Passenger cars emit the greatest proportion of road transport emissions, at just over 58% of total domestic transport greenhouse gas emissions.

1.19. The Department for Transport's latest central forecast[3] suggests that road transport emissions will fall a little and then stabilise slightly below current levels. In addition to the economic slowdown, the main causes for the reduction towards 2010 are the introduction of biofuels in line with the Renewable Transport Fuel Obligation (RTFO), and the continued improvements in vehicle fuel economy. Without these policy interventions, we would expect emissions to be significantly higher.

Policy objectives and intended effects

1.20. The objective of the Carbon Reduction Stategy for Transport is to substantially decarbonise our transport system by 2050. To achieve this, we need to ensure that the transport sector makes a contribution towards the achievement of the UK's carbon budgets that is informed by an assessment of, for example, the cost-effectiveness, practicality and certainty of delivery of measures. By having a carbon budget for the whole of the UK non-traded sector, emissions savings can be made wherever it is most cost-effective to do so. The measures contained within the Carbon Reduction Strategy for Transport and analysed in this Impact Assessment should therefore be considered

[3] Available at http://www.dft.gov.uk/pgr/economics/ntm/roadtransportforcasts08/.

alongside the measures in the *UK Low Carbon Transition Plan*[4] which are also contributing towards the non-traded sector carbon budgets.

1.21. The intended effect of the Strategy is to avoid dangerous levels of climate change in an economically efficient way.

Sectors and groups affected

1.22. The overall Strategy will benefit all sectors and groups to the extent that they form part of the global population at risk from impacts of climate change (such as increased climate variability and more frequent extreme weather events).

1.23. The different measures included within the Carbon Reduction Strategy will also have specific impacts to differing degrees on different sectors and groups. For example, the EU new car CO_2 regulation will have an impact on car manufacturers as well as purchasers of new cars; the target for renewable transport fuels in the Renewable Energy Strategy will have an impact on the agricultural sector as well as suppliers and purchasers of transport fuel.

1.24. The specific Impact Assessments for each measure will set out the particular sectors and groups affected in each instance. The distributional impact of the Strategy (as a whole) on different groups is given in section 5 below.

2. Policy Options

2.1. The options considered in this Impact Assessment are:

1. "Do nothing". This is the baseline option against which the impact of the other options are compared.

2. Take forward the transport measures proposed in the Carbon Reduction Strategy for Transport.

3. Take forward the additional transport measures proposed by the Committee on Climate Change in their first report to Government, "Building a low-carbon economy – the UK's contribution to tackling climate change" (December 2008)[5].

Option 1: "Do nothing".

2.2. To be consistent with the baseline used by the CCC and in other Government modelling, we have taken this option to mean no further measures in the transport sector beyond those in the 2006 Climate Change Programme[6] (CCP), updated to reflect the policies as finally agreed and to reflect the latest modelling assumptions. These measures are:

- the **Voluntary Agreements package** – this package of measures refers to policies in place over the period 1998-2009 which were aimed at improving new car fuel efficiency. These include an EU voluntary agreement with car manufacturers to reach an average level of emissions from new cars sold across the EU by 2008/09; graduated Vehicle Excise Duty, linked to the CO_2 emissions of the vehicle; and Company Car Tax, also linked to the approved CO_2 emissions figure for the car and its list price;

[4] Available at http://www.decc.gov.uk/en/content/cms/publications/lc_trans_plan/lc_trans_plan.aspx.
[5] Available at http://www.theccc.org.uk/reports/.
[6] Available at http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/ukccp06-all.pdf.

- the **Renewable Transport Fuel Obligation** (RTFO) – this requires transport fuel suppliers to ensure that 4% by energy (5% by volume) of total fuel sales for road and rail transport are from renewable sources (such as sustainable biofuels) by 2013/14;
- the existing '**Smarter Choices'** programme – Smarter Choices are techniques for influencing travel behaviour towards more sustainable options, such as walking, cycling, travelling by public transport, car clubs and car sharing; and
- the **Sustainable Distribution** programme – improvements in the efficiency of Heavy Goods Vehicles (HGVs) as a result of a scheme that provides drivers and fleet operators with best practice advice on fuel-saving measures (Freight Best Practice) and promotes safer and more fuel-efficient driving (SAFED), as well as the new Driver Certificate of Professional Competence that is being introduced from September 2009;
- **fuel duty rates** announced up to and including Budget 2009;
- **rail efficiency measures** as set out under the "business as planned" scenario in the Carbon Pathways Analysis (2008)[7] – primarily passenger and freight operating companies introducing a range of energy saving initiatives, and new trains coming in to service.

2.3. More information on these measures is provided in annex A.

2.4. Option 1 is included as a baseline against which the impact of the other options are compared.

Option 2: Take forward the transport measures proposed in the Carbon Reduction Strategy for Transport.

2.5. Option 2 is our preferred option.

2.6. The Carbon Reduction Strategy for Transport is based on four key themes:
  a) supporting a shift to new technologies;
  b) decarbonising transport fuels;
  c) promoting lower carbon transport choices; and
  d) using market-based measures to encourage a shift to lower carbon transport.

2.7. The measures in the Strategy that we have been able to model are:
  a) the EU regulation to reduce the CO_2 emissions from passenger cars (the "EU new car CO_2 regulation") and supporting measures (such as fiscal measures; incentives for the up-take of electric vehicles, and information provision);
  b) the complementary measures to the EU new car CO_2 regulation (gear shift indicators; tyre pressure monitoring systems; low viscosity lubricants; low rolling resistance tyres; and more efficient air conditioning);
  c) a potential EU new van CO_2 regulation;
  d) the Renewable Energy Directive target for the UK of 10% of transport fuel (by energy) to come from renewable sources by 2020 (primarily expected to be biofuels);
  e) low rolling resistance tyres for Heavy Goods Vehicles;
  f) Safe and Fuel Efficient Driving (SAFED) training for bus drivers;
  g) low carbon emission buses; and
  h) illustrative analysis for the electrification of 750 single track kilometres of rail line.

[7] DfT (2008) *"Carbon Pathways Analysis: Informing Development of a Carbon Reduction Strategy for the Transport Sector"*, available at http://www.dft.gov.uk/pgr/sustainable/analysis.pdf.

2.8. More detail on each of the measures modelled is provided in Annex A.

2.9. The Strategy also contains a number of measures for which we have not been able to quantify the potential emissions savings, such as the Act on CO_2 campaign and the Sustainable travel demonstration towns.

Option 3: Take forward the additional transport measures proposed by the Committee on Climate Change.

2.10. In their December 2008 report, the Committee on Climate Change (CCC) provided advice on the emissions abatement opportunities in the UK across different sectors of the economy[8]. These sectoral assessments were then aggregated to produce three economy-wide scenarios that they entitled: "current ambition", "extended ambition" and "stretch ambition".

2.11. The "current ambition" scenario is made up of measures already in place, and/or those below the CCC's forecast of the price of allowances in the EU ETS. The technologies included in the "extended ambition" scenario were assessed by the CCC to ensure that the UK meets the domestic reductions required in both the interim and the intended budgets. The CCC's "stretch ambition" scenario includes measures which the CCC believed could compensate for a shortfall in delivery of measures in the "extended ambition" scenario, or which could be pursued as an alternative to the purchase of offset credits.

2.12. The proposed Carbon Reduction Strategy includes measures which should incentivise many of the technologies that the CCC identified as providing emissions abatement potential in both the current ambition and extended ambition scenarios. Additionally, our proposed Strategy includes options to reduce emissions from buses (such as low carbon emission buses and bus driver training).

2.13. The additional options proposed by the CCC that are not included in the Strategy at this time to the extent that the CCC believed was technically feasible, are:

a) extension of the 'Smarter Choices' programme;
b) far-reaching eco-driving lessons for existing car licence holders;
c) speed reduction and enforcement at 60mph; and
d) "radical" technology options for HGVs (such as improved aerodynamics and plug-in and electric small HGVs).

2.14. Further detail on the measures in option 3 is provided in Annex A.

3. Modelling approach

Non-CO_2 greenhouse gases

3.1. Emissions of CO_2 make up about 99% of domestic transport greenhouse gas emissions, the remaining 1% being methane and nitrous oxide. Transport measures will therefore mainly reduce UK CO_2 emissions, although reductions in fuel consumption might be expected to deliver proportionate reductions in emissions of methane and nitrous oxide. Given that the impact on non-CO_2 greenhouse gas emissions would be very small, we

[8] Further information about the CCC's assumptions, analysis and results is available in their December 2008 report, "Building a low-carbon economy – the UK's contribution to tackling climate change", available at http://www.theccc.org.uk/reports/.

have not quantified the change in these emissions[9]. However, we will continue to monitor the non-CO_2 greenhouse gas emissions performance of vehicles as new emissions control technologies emerge.

Marginal Abatement Cost curve modelling

3.2. The approach used to produce a bottom-up assessment of the impact of transport measures is based on Marginal Abatement Cost (MAC) curve modelling. This approach considers a wide range of abatement options and for each of these, assesses the emissions reduction potential and the cost per tonne of CO_2 saved. The analysis we have undertaken implicitly recognises the interlinkages between policies and considers the cumulative impact of individual measures, in order to avoid any double counting of savings. For example, as our biofuels target is expressed as a percentage of transport fuel, the actual CO_2 savings from the use of biofuel will depend on the total quantity of transport fuel used, which in turn will depend on the efficiency of vehicles using the fuel.

3.3. The measures within the Strategy under option 2 that are additional to those in the baseline (option 1) and have been assessed using the MAC curve modelling approach are:

a) EU new car CO_2 regulation target of 130gCO_2/km by 2012-15; including supporting measures (such as fiscal measures; incentives for the up-take of electric vehicles, and information provision);
b) additional savings from the EU new car CO_2 regulation target of 95gCO_2/km by 2020, including supporting measures;
c) 10% biofuels (by energy) by 2020 to comply with the Renewable Energy Directive (additional to the RTFO in the baseline);
d) complementary measures to the EU new car CO_2 regulation;
e) a possible EU new van CO_2 regulation;
f) low rolling resistance tyres for Heavy Goods Vehicles;
g) safe and fuel efficient driving training for bus drivers;
h) low carbon emission buses; and
i) illustrative electrification of 750 single track kilometres of rail line.

3.4. For option 3, the measures that have been modelled using the MAC curve approach also include:

a) an extension to the Smarter Choices programme;
b) eco-driving training for existing licence holders; and
c) speed reduction and enforcement at 60mph.

3.5. The results of the analysis of each measure is provided in annex A.

3.6. Our modelling approach has mainly been to consider the abatement potential of measures based on what we expect different policies to deliver. This differs slightly from the approach taken by the CCC, who identified the technical potential that would be available if there were no constraints on emission reductions, and then adjusted this potential to reflect the real world constraints associated with inertia, lack of information, hidden costs and so on. This adjustment was based on an assessment of the social research evidence base and the existing and potential policy framework.

3.7. In practice, it would be expected that all other things being equal, an assessment of the abatement potential from policy is likely to be lower than the technical abatement potential. For example, the technical potential for emissions savings from replacing existing cars with

[9] We have, however, monetised the non-CO_2 greenhouse gas impact in the agricultural sector for biofuel production.

ultra-low carbon cars is highly significant, given that technically, 100% of the car fleet could be replaced. However, whilst informative as to where the potential exists to make emissions reductions, this analysis does not inform policy makers as to what can be achieved in reality, with a given set of policy levers.

3.8. In some cases, the design of policy in the UK to achieve our carbon targets may already be shaped by international agreements. For example, the EU new car CO_2 regulation agreed in December 2008 does not set targets for cars that are bought in any one member state, as the target is for sales across the EU as a whole. Measures could be implemented to encourage the take-up of the lowest emitting cars in the UK, but as the target is set as an average across the EU, this would not affect the level of global emissions, but would displace emissions reductions elsewhere in the EU, resulting in an impact on UK abatement costs rather than global climate change.

3.9. A MAC curve approach based on the modelling of policy options ensures that a realistic assessment of potential emissions savings is made, given the international policy landscape, and this was therefore considered the most suitable approach to inform the Carbon Reduction Strategy for Transport.

"What if?" modelling

3.10. Certain measures that we intend to take forward as part of the Strategy are at earlier stages of development. For these measures, the data we have on which to base our analysis is generally less certain or incomplete. We have therefore undertaken the analysis of these measures on a "what if?" basis, applying the best assumptions that we have available. For example, the up-take of low carbon emission buses will in part be driven by incentives provided through a reform of the Bus Services Operators Grant (BSOG), and the actual rate of take-up by bus operators in practice is uncertain. We have therefore calculated the abatement potential and the cost-effectiveness of this measure on the basis that the policy would incentivise rates of up-take such that 20% of the bus fleet are low carbon emission buses by 2020, increasing to 34% of the fleet by 2022. This does not necessarily represent future policy or actual delivery; rather, assumed up-take rates for low carbon emission buses.

3.11. The measures that rely on this type of modelling are:

a) safe and fuel efficient driving (SAFED) training for bus drivers;
b) low carbon emission buses;
c) rail electrification;
d) extension of the Smarter Choices programme;
e) eco-driving training for existing licence holders; and
f) the assessment of additional potential from electric vehicles.

3.12. This type of analysis contains far greater uncertainty than analysing a measure which has supporting legislation, for example. Details of the assumptions used to generate the results given here are provided in annex A.

Qualitative assessment

3.13. Finally, there are a number of measures within the Strategy for which it has not yet been possible to estimate the potential emissions savings. For these measures, a qualitative assessment has been made. These include, for example:

- domestic aviation measures (such as improvements in air operations, both in terms of more fuel efficient practices and air traffic management);

- domestic shipping measures (such as technical and operational measures to reduce CO_2 emissions from ships);
- the Act on CO_2 campaign; and
- increasing the number of Sustainable Travel Towns and introducing Sustainable Travel Cities.

3.14. We would look to provide a fuller assessment of these measures as they are worked up further. More detail about this measures can be found in the Carbon Reduction Strategy for Transport.

Cost-effectiveness

3.15. For each of the measures modelled, we have assessed the emissions reduction potential and the cost-effectiveness; that is, the net cost of the measures per tonne of emissions saved. This is calculated as:

$$\text{Cost-effectiveness} = \frac{\text{(Present Value of the costs)} - \text{(Present Value of the benefits (excluding the value of the } CO_2 \text{ emissions savings))}}{\text{Tonnes of } CO_2 \text{ saved in the non-traded sector}}$$

where the present value is the value of a stream of costs or benefits discounted to 2009 values, using a discount rate of 3.5%, in line with HM Treasury guidance[10]. We also consider the Net Present Value (NPV) of each measure – this is the value of total benefits minus total costs discounted over the lifetime of the measure. A positive NPV therefore suggests that the total discounted benefits of a policy measure outweigh the total discounted costs.

Direct and indirect impacts

3.16. In presenting the results for individual policy measures we have identified both 'direct' and 'indirect' impacts. Direct impacts include all effects arising as a direct result of the policy; for example, tighter efficiency standards for new cars results in fuel savings and therefore lower CO_2 emissions. Indirect impacts are those arising from an expected change in behaviour as a knock-on effect of the measure. For example, an improvement in fuel efficiency means that less fuel is required to drive a given distance, and hence fuel costs are reduced. We would therefore expect drivers to respond to this reduction in the cost of driving in a number of ways, such as increasing the mileage driven (expected to be the largest impact), and/or taking extra comfort when driving, such as increasing the use of air-conditioning, seat heaters and so on. This is known as the 'rebound effect'. The implications of this rebound effect are that the fuel and CO_2 saved as a result of improvements in fuel efficiency are lower than we might otherwise expect.

3.17. There are other indirect impacts associated with changes in mileage driven, such as the impact on congestion, air quality (primarily nitrogen oxides (NOx) and particulate matter (PM) emissions), noise, accidents, and infrastructure maintenance. We have estimated the impact of measures on congestion using the DfT's National Transport Model (NTM).

3.18. For the assessment of air pollutant emissions, we have used an estimate of air pollutant damage costs per kilometre consistent with the guidance of the Interdepartmental Group on Costs and Benefits (IGCB)[11]. Noise, accidents and infrastructure maintenance costs

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[10] For further information about discounting, see annex 6 of the HM Treasury guidance in the Green Book, available at http://www.hm-treasury.gov.uk/data_greenbook_index.htm.
[11] See the IGCB website, at http://www.defra.gov.uk/environment/airquality/panels/igcb/index.htm.

are monetised using agreed estimates of marginal external costs per kilometre driven[12]. Each of these monetised impacts is then included within the assessments of costs and benefits. The monetary value assigned to accidents is based on an estimate of the change in the number of accidents of different degrees of severity using established parameters for the number of accidents per million vehicle-kilometres on different types of road[13]. As the number of vehicle kilometres on the network change as a result of the introduction of an intervention, so the number of accidents will also alter. We are therefore not able to present the results in terms of the change in number of casualties, for example.

3.19. There is assumed to be no real growth in infrastructure costs overtime (due to the absence of other evidence). Accidents, local air pollution and noise costs are all assumed to grow in line with GDP per capita reflecting increases in people's willingness to pay to avoid these impacts. Additional indirect impacts that we are not able to value include ‘spillover’ benefits; for example, innovation in car and component manufacturers spilling over into other sectors.

Ancillary impacts

3.20. The ancillary impacts of a policy are those that are not related to the central objective(s). For example, many policies in the transport sector with the objective of reducing greenhouse gas emissions will also have an impact on air quality. The EU new car CO_2 regulation, for instance, could lead to an increase in air pollution. This is an ancillary impact of the regulation. The increase could come about in two ways – first, as a direct result of the technology adopted by manufacturers to meet the target in the regulation. This would be a direct ancillary impact. Second, air pollutants could increase as a consequence of the rebound effect described above, which leads to an increase in the mileage driven. This would be an indirect ancillary impact.

Key assumptions

3.21. Each policy measure included within the Strategy will have its own particular set of assumptions, and more detail will be provided in the specific Impact Assessments for each measure. However, some assumptions are common across measures, and these are set out below.

Baseline

3.22. Option 1 is used as the baseline in terms of the existing measures against which the other options are assessed. So, for example, in the absence of the EU new car CO_2 regulation, it is assumed that UK average new car fuel economy would have remained constant at 2009 levels[14] (around 160gCO_2/km). Any further reductions in emissions as a result of the mandatory EU new car CO_2 regulation are therefore **additional** to the impact of the voluntary agreements package. It is also assumed that the RTFO (the requirement that 5% of road and rail transport fuel by volume (4% by energy) is from renewable sources) is in place by 2013/14, and remains at this level thereafter.

[12] For further details and the values used, see the DfT transport analysis guidance at http://www.dft.gov.uk/webtag/webdocuments/3_Expert/9_Major_Scheme_Appraisal_in_LTPs/3.9.5.htm#081.
[13] We have not therefore produced an estimate of the impact on the number of mortalities, for example. See Webtag guidance, available at http://www.dft.gov.uk/webtag/webdocuments/3_Expert/4_Safety_Objective/3.4.1.htm#01.
[14] This assumption is based on analysis of historical trends by the automotive consultants, Ricardo. They concluded that any 'natural' improvements in fuel efficiency have been almost exactly offset by increases in vehicle weight.

3.23. The baseline has been generated using near-term (to 2011) economic growth assumptions consistent with the HM Treasury announcements in Budget 2009. Longer term growth assumptions are broadly consistent with the Treasury's latest assessment of economic prospects, as set out in Budget 2009.

Figure 3.1: GDP growth projections for selected years.

Percentage increase per annum	2010	2015	2020	2025
GDP growth assumption	1.25	2.4	2.3	2.4

3.24. We have used the latest government projections of population growth and oil prices. The oil price projection used for the central case scenario was taken from scenario 2 – “timely investment and moderate demand”[15].

Figure 3.2: Central case oil price projections for selected years.

Oil price (Brent), $/barrel, 2008 prices	2010	2015	2020	2025
Scenario 2: Timely investment, moderate demand	70	75	80	85

Source: Department of Energy and Climate Change (2009)

Ordering of measures

3.25. The baseline for appraising the impact of a particular policy measure depends on the assumptions we make about the nature and stringency of policies that precede it. For example, in each MAC curve, the first policy measure appraised is the EU new car CO_2 regulation target of 130gCO_2/km by 2012-15. This is appraised against a baseline of no efficiency improvements in new cars; that is, in the absence of a target, we would expect any ‘natural’ improvements in efficiency to be outweighed by increases in vehicle weight. The second measure to be appraised is a long term EU new car CO_2 regulation target of 95gCO_2/km in 2020. This is appraised against a baseline of the 130gCO_2/km target in 2015 in order to ensure that emissions savings from the long term target do not double-count the savings from earlier efficiency improvements. Increasing the proportion of biofuels in transport fuel is then added to the package and appraised against a baseline which includes the EU new car CO_2 efficiency target of 130gCO_2/km in 2015 followed by the 95gCO_2/km target in 2020. We continue with this approach until all measures have been appraised.

3.26. Using this methodology, the ordering of policy measures can affect the estimate of emissions savings from each measure. For example, the higher the total quantity of fuel used, the higher the expected absolute level of savings from biofuels, since biofuels make up a fixed proportion of total fuel (e.g. 5% by volume). Thus if we assume that transport fuel contains a percentage of biofuels before improvements in new car fuel efficiency are made, then the savings assigned to the use of biofuels will be higher. However, in this example we would expect CO_2 savings from improvements in car fuel efficiency to be lower, since each litre of fuel saved would contain less CO_2 (since a proportion of this fuel is biofuel). Despite this effect on the potential savings from individual policies, it should be noted that the overall estimate of total emissions reductions is not affected by the ordering.

[15] Department of Energy and Climate Change’s fossil fuel price projections, published May 2009, available at http://www.berr.gov.uk/files/file51365.pdf.

3.27. The measures for all options were modelled in the following order:

a) EU new car CO_2 regulation target of 130gCO_2/km by 2012-15; including supporting measures (such as fiscal measures; incentives for the up-take of electric vehicles, and information provision);
b) additional savings from the EU new car CO_2 regulation target of 95gCO_2/km by 2020, including supporting measures;
c) 10% biofuels (by energy) by 2020;
d) complementary measures to the EU new car CO_2 regulation;
e) a possible EU new van CO_2 regulation;
f) low rolling resistance tyres for HGVs;
g) safe and fuel efficient driving training for bus drivers;
h) low carbon emission buses;
i) an extension to the Smarter Choices programme;
j) eco-driving training for existing licence holders;
k) speed reduction and enforcement at 60mph; and
l) electrification of an illustrative 750 single track kilometres of rail line.

Appraisal period

3.28. The costs and benefits of each of the measures are assessed over their lifetime in order to produce an estimate of the cost-effectiveness of each measure. The measures may have a lifetime beyond the policies; for example, new cars will continue to perform with higher levels of efficiency even after the policy target to improve new car efficiency has been met in 2020. Estimated costs and benefits are converted into present values using a discount rate of 3.5%, in line with HM Treasury guidance[16]. The estimated emissions savings are presented as the total CO_2 savings over each carbon budget period.

4. Costs and benefits

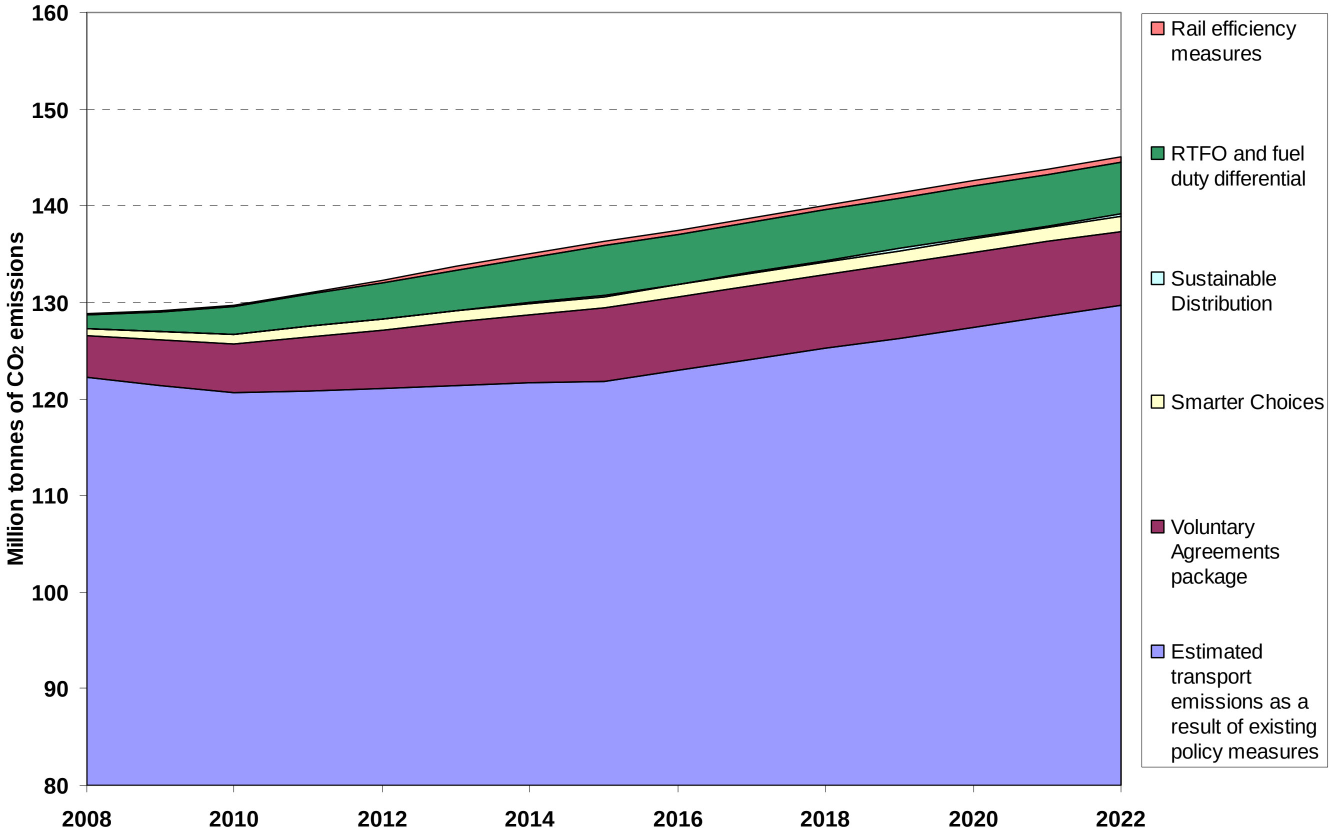
Option 1: "Do nothing"

4.1. There are **no additional costs or benefits** associated with this option, as there is no additional action taken beyond business as usual. This option provides the baseline against which the other options are assessed.

4.2. However, the baseline already includes a significant level of greenhouse gas emissions savings from the transport sector. Figure 4.1 below sets out the level of savings expected out to 2020 from each of the measures included in the baseline.

[16] See the HM Treasury Green Book, available at http://www.hm-treasury.gov.uk/data_greenbook_index.htm.

Figure 4.1: Forecast transport emissions and the impact of measures in the baseline



Source: DfT analysis (2009)

4.3. Figure 4.1 shows that we expect to achieve emissions savings of about 15 $MtCO_2$ (about 11%) in 2020[17] from the measures in our baseline. The majority of this (about 8 $MtCO_2$) is expected to come from the Voluntary Agreements package, with the Renewable Transport Fuels Obligation delivering another 5 $MtCO_2$ in 2020. The savings from the measures in the baseline over each of the first three carbon budgets is given in Figure 4.2 below.

Figure 4.2: Estimated emissions savings from the measures in the baseline

Policy measure	**Total emissions savings over each carbon budget ($MtCO_2$)**		
	2008-2012	**2013-2017**	**2018-2022**
Voluntary Agreements package	25.6	36.4	38.4
Renewable Transport Fuels Obligation	13.4	24.2	26.3
Smarter Choices programme	4.8	6.1	7.1
Sustainable Distribution programme	0.1	0.5	1.1
(Diesel) rail efficiency measures	0.5	1.4	1.8

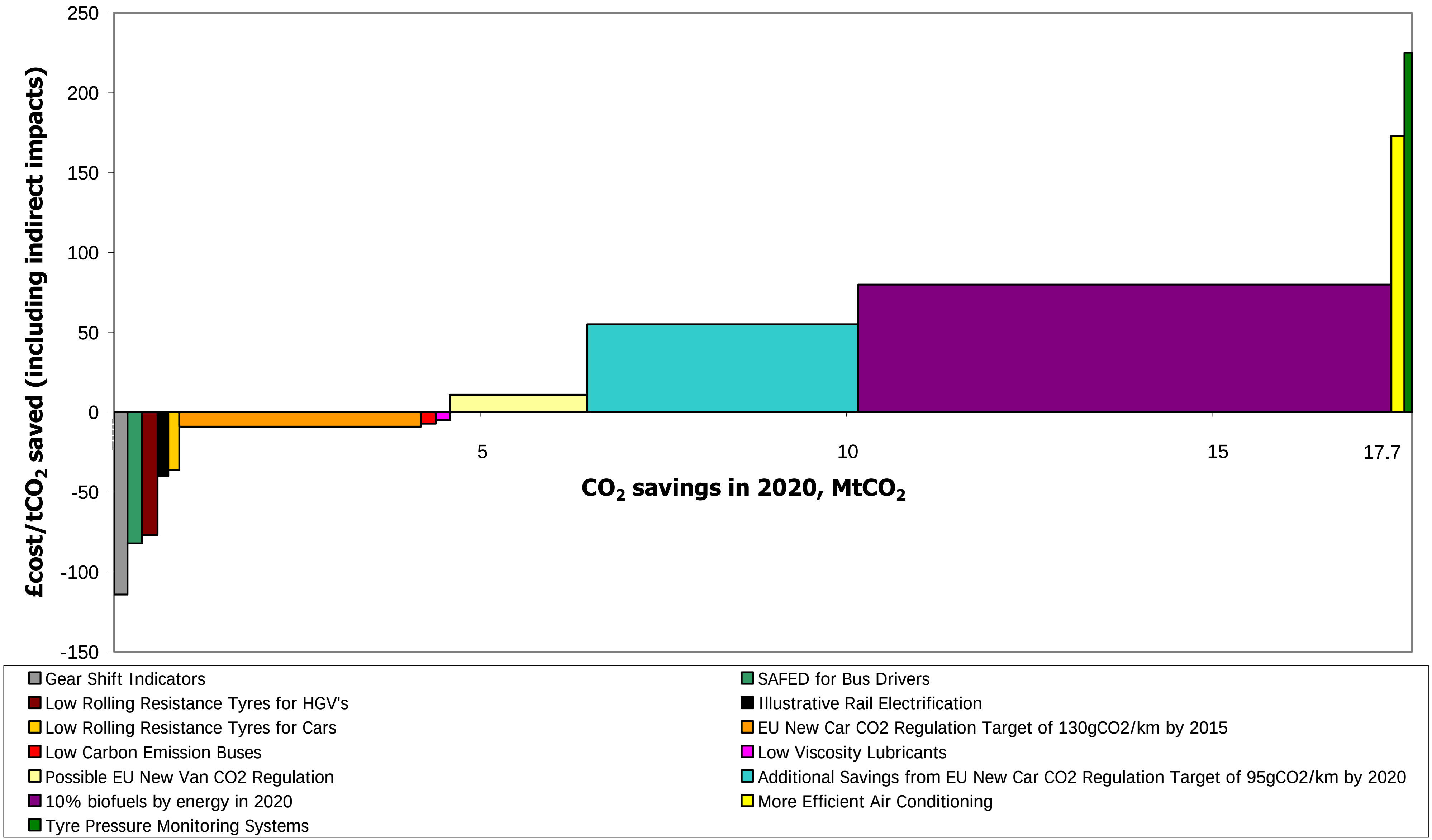
Source: DfT analysis (2009)

[17] This is lower than the estimated level of savings in DfT (June 2008) "*Carbon Pathways Analysis*" as the savings are from a different set of policy measures and assessed against an updated baseline.

Option 2: Take forward the transport measures proposed in the Carbon Reduction Strategy for Transport

4.4. Figure 4.3 below shows the results of our MAC curve modelling under our central case for option 2. The horizontal axis shows the additional level of CO_2 savings expected from each additional measure in the Strategy **in 2020**, whilst the vertical axis shows the estimated net cost of the measure per tonne of CO_2 saved (£cost/tCO_2). Measures that are below the horizontal axis have a negative cost (that is, a net benefit) per tonne of CO_2 saved. For example, low viscosity lubricants are expected to have a negative cost (benefit) per tonne because they reduce engine friction, thus reducing the cost of fuel consumption.

Figure 4.3: Central case transport sector MAC curve



Source: DfT analysis (2009)

4.5. The estimated level of emissions savings from each of the measures over each of the three budget periods is shown in Figure 4.4 below. These are the CO_2 savings including the indirect impacts on emissions from the rebound effect. The NPV and the cost-effectiveness (shown for two cases: first, when direct non-ancillary impacts only are assessed; and second, when both indirect and ancillary impacts are included) of each of the measures in the order they were modelled is also given in Figure 4.4.

Figure 4.4: Summary of the central case cost-benefit analysis results

Measure	**Total emissions savings in each carbon budget period ($MtCO_2$)**			**Net present value[2] (£million, 2009 prices)**		**Cost-effectiveness[3] (£/tCO_2 saved)**	
	2008-2012	**2013-2017**	**2018-2022**	**Direct only**	**Incl. indirect**	**Direct only**	**Incl. indirect**
EU new car CO_2 regulation: 130gCO_2/km target for 2012-15[1]	0.6	6.6	16.6	£3,304m	£2,393m	-£9	-£9
EU new car CO_2 regulation: 95gCO_2/km target for 2020	0.0	1.0	18.5	£817m	-£1,146m	£28	£55
10% transport fuel from renewable sources by 2020[1]	0.0	10.5	33.3	-£3,293m	-£1,666m	£123	£80
Complementary measures for cars:	0.3	2.6	3.7	£779m	£18m	-£32	£39
Gear shift indicators	*0.0*	*0.4*	*0.8*	*£504m*	*£329m*	*-£164*	*-£114*
Tyre pressure monitoring systems	*0.0*	*0.3*	*0.5*	*-£128m*	*-£231m*	*£129*	*£225*
Low viscosity lubricants	*0.1*	*0.7*	*0.9*	*£252m*	*£91m*	*-£71*	*-£5*
Low rolling resistance tyres	*0.1*	*0.6*	*0.7*	*£259m*	*£124m*	*-£98*	*-£36*
More efficient air conditioning	*0.1*	*0.6*	*0.9*	*-£108m*	*-£295m*	*£83*	*£173*
Possible EU new van regulation	1.0	5.2	9.3	£487m	£487m	£11	£11
SAFED for bus drivers	0.4	1.0	1.0	£417m	£417m	-£82	-£82
Low carbon emission buses	0.0	0.2	0.9	£215m	£215m	-£7	-£7
Low rolling resistance tyres for HGVs	0.0	0.1	1.1	£282m	£282m	-£77	-£77
Electrification of 750 single track km of rail line[4]	0.0	0.0	0.8	-	-	-£40	-£40
Total of measures modelled for the Carbon Reduction Strategy	**2.3**	**27.2**	**85.2**	**-**	**£1,000m**	**-**	**£32.81[5]**

Numbers may not add due to rounding. *Source: DfT analysis (2009)*

Note 1: These results are very similar but slightly different to the savings presented in the *UK Low Carbon Transition Plan*, as they are derived from the DfT's National Transport Model, rather than the DECC Energy Model. See http://www.dft.gov.uk/pgr/economics/ntm/roadtransportforcasts08/rtf08.pdf for more detail about the differences between the two models.
Note 2: A **positive NPV** suggests that there is a **net benefit** from the measure.
Note 3: The lower the cost-effectiveness value the more cost-effective the measure – a negative cost-effectiveness suggests that the measure has a net benefit per tonne of emissions saved.
Note 4: As the analysis for rail electrification is illustrative only, we have assumed that the savings only occur in the third budget period, due to the length of time it takes to put the appropriate infrastructure in place. An assessment of the NPV will be worked up as the policy is developed further.
Note 5: Excludes illustrative cost-effectiveness of rail electrification.

4.6. It should be noted that Figure 4.4 shows the total estimated emissions savings from the measures modelled – there may be additional but as yet unquantified savings from the other measures in the Strategy.

4.7. For the EU new car CO_2 target of 130gCO_2/km by 2015, the results show that when indirect impacts are included, the NPV falls from £3,304 million to £2,393 million. Indirect impacts are a result of the rebound effect, which results in an increase in the mileage driven. When they are included, the NPV falls because the additional costs to society associated with the increase in mileage driven – such as congestion, noise and air pollution – outweigh the additional benefits.

4.8. The cost-effectiveness result is calculated by taking the NPV, minus the value of the CO_2 savings, and dividing this number by the total CO_2 savings, to give a net cost per tonne of CO_2 saved. When indirect impacts are included, the NPV minus the value of the CO_2 savings is lower, as the additional costs are higher than the additional benefits. However, as the CO_2 savings are also lower when indirect impacts are included, this means that the NPV minus the value of the CO_2 savings is divided by a smaller number. Coincidentally, the cost-effectiveness result with and without indirect impacts is the same, at a net benefit of £9 per tonne of CO_2 saved.

4.9. To take another example, the results for the complementary measures package (including indirect impacts) show a positive NPV of £18 million, but also a net cost per tonne of CO_2 saved of £39. The NPV is positive, because the benefits (including the value of the CO_2 emissions reduction) outweigh the costs of the package. However, the NPV minus the value of the CO_2 savings is negative; that is, the costs outweigh the benefits when the CO_2 reduction benefits are not included. Hence the package has a net cost per tonne of CO_2 saved (a positive cost-effectiveness value).

4.10. In total, the measures modelled in the Strategy are expected to result in emissions savings from the transport sector additional to our baseline of just over 2 MtCO_2 over the first carbon budget, increasing to just over 27 MtCO_2 over the second carbon budget and about 85 MtCO_2 over the third. Under the central case, including indirect impacts, the Strategy is estimated to have a positive NPV of about £1 billion, with a cost per tonne of CO_2 saved of about £33.

4.11. The present value of the costs and benefits of the Strategy under our central case, as well as under different assumptions about fossil fuel prices, are given in Figure 4.5 below. Also shown are the costs and benefits of the Strategy when the cost of driving per kilometre remains at the level it would have been in the absence of the EU new car CO_2 regulation[18] (which would otherwise be expected to reduce the cost of driving per kilometre). The bold numbers indicate the values used to create the range presented on the analysis and evidence summary sheet above.

Figure 4.5: The costs and benefits of option 2 under different scenarios

	Option 2 central case	Fossil fuel price forecast scenario		Scenario: Cost of motoring per kilometre stays constant
		Scenario 1: Lowest oil prices	Scenario 4: Highest oil prices	
Present value of the benefits	£39,762m	£34,351m	**£55,745m**	**£33,401m**
Present value of the costs	£38,761m	**£39,541m**	£36,582m	**£29,557m**
Net present value	£1,000m	**-£5,188m**	**£19,163m**	£3,845m

Source: DfT analysis (2009)

4.12. Adding the estimates of emission reductions from the transport sector to those identified in the rest of the non-traded sector suggests that the UK would be on track to meet the carbon budgets. Indeed, implementing the measures in the *Carbon Reduction Strategy for Transport* and the *UK Low Carbon Transition Plan* is expected to result in an over-achievement of the first three carbon budgets by about 44 $MtCO_2e$, 64 $MtCO_2e$ and 39 $MtCO_2e$ respectively under central assumptions.

4.13. However, the uncertainty in projecting future emissions is such that there is a significant chance that domestic emissions could be higher than central projections. We therefore need to ensure that our existing measures deliver as expected; that we have a degree of contingency to deal with unexpected events; and that we continue to look for further opportunities to reduce emissions wherever this can be achieved at least cost.

Rail electrification

4.14. The results of the analysis given in Figure 4.4 above are illustrative of the potential emissions savings and cost-effectiveness of electrifying 750 single track kilometres of rail line. It does not represent electrification of a specific line. CO_2 savings from electrifying a specific route will depend heavily on its traffic density and rolling stock characteristics. The most cost-effective routes for electrification will be busier lines where the cost savings from running electric trains can offset the additional infrastructure costs.

4.15. For the purposes of this analysis we have estimated the CO_2 savings from electrifying a typical main line carrying a relatively high level of passenger traffic. We estimate that electrifying such a line would deliver a reduction in diesel emissions of approximately 20,000 tonnes of CO_2 per 100 single track kilometres electrified. This illustrative analysis suggests that rail electrification could be a relatively cost-effective way of reducing transport emissions (which reduces costs per tonne of emissions saved).

[18] More information about the results of the analysis under different fossil fuel price assumptions and excluding indirect impacts is given in section 6 on sensitivity analysis below.

4.16. About 40% of the rail network is currently electrified, accounting for about 60% of passenger travel. In practice, most of the busiest routes, for example key intercity and commuting routes into London, have already been electrified.

4.17. Electric trains offer better environmental performance (including air quality benefits), can increase capacity and reliability, and offer a more comfortable passenger experience. Electric trains are also significantly cheaper to buy, maintain and operate than diesel trains, which can help to reduce the overall cost of running the railway.

4.18. Electric trains typically emit between 20% and 35% less CO_2 emissions than equivalent diesel trains on the basis of the current electricity generation mix. This already substantial advantage will increase over time as our generation mix becomes less carbon intensive. In addition, the use of regenerative braking enables many electric trains to re-use the energy that would otherwise have been lost when braking. This system, already in widespread use on parts of the network, can reduce overall energy consumption and CO_2 emissions by a further 25%.

4.19. Given the environmental and operational benefits of electrification and the opportunity it provides for reducing the cost of running the railway, there is a compelling case for electrifying more of the rail network subject to affordability. We have undertaken work to look at this case more closely and will shortly confirm our plans for a major new rail electrification programme.

Electric cars and Plug-in hybrid electric vehicles

4.20. The Strategy includes various measures designed to realise this abatement potential in the UK. For example, we have committed to providing help worth in the region of £2,000 to £5,000 per vehicle towards reducing the price of ultra-low carbon cars, from 2011, in order to create a more favourable market both to consumers and industry. To support the uptake of electric and plug-in hybrid cars, up to £20 million will also be made available for EV charging infrastructure in a number of lead cities and regions. The ultimate aim is to create a network of EV charging infrastructure across the UK that will lead to the linking of cities and regions.

4.21. Replacing conventional vehicles with electric vehicles (EV) and plug-in hybrid electric vehicles (PHEV) could deliver significant emissions savings in the transport sector as emissions are measured at the tailpipe (0gCO_2/km for EV and 56gCO_2/km for PHEV). However, a key uncertainty is whether any savings from EV and PHEV would be additional to the EU new car CO_2 regulation. On the one hand, it is very likely that manufacturers would offset the lower emissions from EV and PHEV in their fleet to meet their target. In this case the savings would not be additional. On the other hand, changes to the regulation to focus on only conventional technologies could lead to additional savings from EV and PHEV.

4.22. We have therefore undertaken additional analysis to consider the potential savings available under different scenarios for the uptake of EV and PHEV, based on the mid-range scenario from a recent report commissioned from ARUP/Cenex[19] by the Department for Business, Enterprise and Regulatory Reform and the DfT. This scenario is based on

[19] Available at http://www.berr.gov.uk/files/file48653.pdf.

having around 600,000 EV and 200,000 PHEV on the road by 2020 with certain incentive measures in place (the cost of these is not included in the analysis). The analysis estimates CO_2 savings from EV and PHEV by replacing increasingly efficient new conventional vehicles (as a result of the EU new car CO_2 regulation) such that the conventional vehicles which EV and PHEV are replacing will improve over time.

4.23. The results of the analysis suggests that there could be up to 1.2MtCO_2 of additional abatement potential in 2020 (about 6 MtCO_2 over the third budget period) in the UK from EVs and PHEVs. These potential savings are very uncertain, would require enabling policy measures, such as consumer incentives, and are subject to how manufacturers comply with the EU new car CO_2 regulation in different EU countries.

4.24. Greater electrification of the car fleet would affect the potential savings from other measures. For example, it would affect the potential for savings from eco-driving and would reduce the need for the use of biofuels, and therefore also the potential emissions savings. However, this impact is not expected to be significant.

4.25. Given the expected levels of take-up of EVs and PHEVs and the issues of additionality set out above, their impact on emissions savings is not expected to be significant by 2020. However, in the period up to 2050, these vehicles, and other ultra-low emission technologies, could make major contributions towards decarbonising the road transport system.

Option 3: Take forward the transport measures proposed by the Committee on Climate Change

4.26. The abatement potential of the additional technologies and behaviours identified by the CCC is given in Figure 4.5 below. As noted in section 3, this is based on (adjusted) technical feasibility. The DfT assessment is based on the potential abatement from policy, and is therefore not necessarily directly comparable with the CCC options. However, Figure 4.6 shows the DfT central assessment of the potential emissions savings from policy measures that would result in the take-up of the options proposed by the CCC.

Figure 4.6: Additional abatement opportunities identified by the CCC.

Measure	CCC's assessment of emissions savings in 2020 ($MtCO_2$)		DfT's central assessment		
	Extended ambition scenario	Stretch ambition scenario	Emissions savings in 2020 ($MtCO_2$)	Cost per tonne of CO_2 saved (£/tCO_2)	Net present value (£m)
Extension of the Smarter Choices programme	2.9	2.9	0.9	-£74	£1,475m
Eco-driving lessons for existing car licence holders	0.3	1.0	0.2	-£45	£152m
Speed reduction and enforcement at 60mph	-	5.2	1.4	£307	-£5,008m
HGV radical technology options[1]	0.9	1.0	-	-	-
Total additional abatement potential	**4.1**	**10.1**	**2.5**	**-**	**-**

Source: Committee on Climate Change (2008); DfT analysis (2009)

Note 1: This package of technologies includes low rolling resistance tyres for HGVs, which is part of our Strategy and therefore included in option 2.

4.27. The results presented in Figure 4.6 above suggest that certain measures in option 3 (Smarter Choices and eco-driving lessons) are relatively cost-effective and have positive NPVs. However, speed reduction and enforcement has a large negative NPV, suggesting that the costs of this measure outweigh the benefits.

4.28. Figure 4.7 below shows the present value of the costs and benefits under the central case for option 3 in its entirety, and therefore includes all of the measures in option 2 as well as the additional measures identified under option 3. The results are also provided under different assumptions about fossil fuel prices and when the cost of motoring per kilometre is held constant.

4.29. The results of the analysis show that the central case of option 3 has a negative net present value overall (suggesting that the costs outweigh the benefits) of -£2.4 billion. This compares to a positive net present value under option 2 of £1 billion.

Figure 4.7: The costs and benefits of option 3 under different scenarios

	Option 3 central case	Fossil fuel price forecast scenario		Scenario: Cost of motoring per kilometre stays constant
		Scenario 1: Lowest oil prices	Scenario 4: Highest oil prices	
Present value of the benefits	£60,435m	£54,064m	£77,189m	£53,087m
Present value of the costs	£62,815m	£64,105m	£60,049m	£53,397m
Net present value	-£2,381m	-£10,040m	£17,142m	-£309m

Source: DfT analysis (2009)

Extension of the Smarter Choices Programme

4.30. The 'Smarter Choices' programme includes measures that are designed to support and encourage cycling, walking, and public transport use, and have the potential to help ease congestion, increase physical activity and reduce emissions of greenhouse gases and air pollutants in major urban areas. Assessments of the potential greenhouse gas impacts from the Smarter Choices programme are reliant on current estimates of car trip and traffic reduction from Smarter Choices measures. The data available is being improved, but currently significant uncertainties remain – making any estimates at this time more prone to error.

4.31. The main reason for the difference between the DfT and the CCC estimate of the potential savings is the assumptions used. The CCC estimate originates from previous DfT analysis reported in the "Synthesis of Climate Change Policy Appraisals" report, 2007[20]. This assumes that the Smarter Choices programme is aggressively rolled-out nationwide in both urban and rural areas. It assumes a reduction in vehicle kilometres by 2020 of 4.0% in urban areas and 3.1% in rural areas. We have since updated our analysis based on what we consider to be more realistic but cautious assumptions; that the impact of the Smarter Choices programme only has an impact in urban areas (because of fewer alternatives to the use of the car in rural areas), and a reduction in vehicle kilometres in urban areas of 3.7% by 2020 (as we now have to assume that the roll-out programme would be started later).

4.32. A lack of robust data on the effectiveness of Smarter Choices measures and the degree to which small scale local initiatives are replicable across different parts of the country means that any estimates of the potential savings are very uncertain. Similarly, further work is needed to improve estimates of the potential costs and benefits of the measures in order to construct more reliable estimates of cost-effectiveness.

4.33. However, given the potential for a wide range of benefits, Smarter Choices measures are likely to represent good value for money, but experience so far suggests that effective packages require significant upfront investment of revenue funding.

[20] Defra (January 2007), "Synthesis of Climate Change Policy Appraisals", available at: http://www.defra.gov.uk/environment/climatechange/uk/ukccp/pdf/synthesisccpolicy-appraisals.pdf.

4.34. Smarter Choices packages of measures are by their nature diverse and locally-focused. Therefore delivery is best achieved by local authorities, which limits the extent to which this approach can realistically be seen as a national measure or driven from national Government.

4.35. Through our Sustainable Travel Town demonstration projects (now completed) and the recently announced “Sustainable Travel City” project, we aim to test and develop the apparent potential of Smarter Choices measures, in partnership with local authorities. By doing this, we want to give all local authorities the evidence, confidence and shared expertise to develop their own sustainable travel programmes and harness the potential benefits in their areas.

4.36. Our Sustainable Travel Town programme has already produced encouraging results in 3 medium-sized urban areas – the “Sustainable Travel City” will test this at a larger-scale. A more detailed evaluation of the Sustainable Travel Town programme is currently underway and will be available in late 2009.

Far-reaching eco-driving lessons for existing car licence holders

4.37. Eco-driving is a term for those techniques that enable drivers to use their vehicles more efficiently, thus reducing fuel consumption, fuel costs and emissions from their driving. For new drivers, eco-driving has been successfully integrated into the driving test. This ensures that drivers know from the outset that it is possible to drive in a way that will reduce emissions and is economical and safe.

4.38. For existing licence holders, the DfT modelling is based on estimates from TNO (2006)[21]. They estimate that depending on driving style, drivers may save between 5% and 25% fuel directly after receiving instructions or lessons. However, they find that the average reduction in practice is more in the order of 5-10% and tends to reduce over time. They estimate that the long term effect of eco-driving is a fuel consumption reduction of around 3%.

4.39. The DfT modelling therefore uses an assumption that 1% of existing drivers (around 350,000 drivers) are trained each year, each with a reduction in fuel consumption of 3%. The CCC make the same assumptions under the extended ambition scenario, and therefore generate a very similar level of savings. In the stretch ambition scenario, they maintain the assumption that eco-driving increases fuel efficiency by 3%, but that more car drivers adopt eco-driving behaviour, reaching 40% of existing licence holders (more than 13.5 million drivers) in 2020.

4.40. This analysis suggests that there could be considerable potential for emissions savings from promoting eco-driving techniques, and that this would be a relatively cost-effective way of reducing emissions. However, the estimate of potential savings are very dependent on the assumptions used and are particularly uncertain, given that we do not yet have robust data on the potential for take-up, on the average level of savings per driver when rolled out more widely, and on the longevity of the behaviour (and therefore the savings over time).

[21] TNO (October 2006), *“Review and analysis of the reduction potential and costs of technological and other measures to reduce CO2-emissions from passenger cars”*, available at http://ec.europa.eu/enterprise/automotive/projects/report_co2_reduction.pdf.

4.41. Our approach is therefore to work with the Energy Saving Trust (EST) to promote eco-driving techniques to existing drivers. The EST has undertaken a pilot programme of smarter driving lessons and will widen the programme during 2009-2010. These lessons will be organised through employers, with the cost partly subsidised by DfT.

Speed reduction and enforcement at 60mph

4.42. The CCC assessment of the potential savings from reducing the speed on motorways and A roads to 60mph with effective enforcement is much higher than the DfT assessment of this measure (a difference of 3.8MtCO_2 in 2020). The differences between the estimates can again be attributed to differences in the assumptions made in each case.

4.43. For example, the CCC estimate is based on a distribution of traffic speed that is based on traffic flow measurements in free flow conditions. The CCC note that this could produce an over-estimate of the potential savings. In reality, certain sections of the road network are likely to experience some slowing of traffic flows as a result of congestion. The DfT modelling makes an adjustment to take account of this tendency and would therefore be expected to produce a lower savings potential than the CCC estimate.

4.44. Further, the DfT estimate follows on cumulatively from the modelling of other policy measures to be taken forward as part of the Strategy. This means that the emissions savings relating to reduced fuel consumption from lower speeds are decreased, by 10% in our central scenario, to take account of the uptake of biofuels in transport. EU new car and new van CO_2 standards also reduce the extent of CO_2 savings from speeds policy, by between some 10% and 20% depending on vehicle type in the central scenario.

4.45. Our analysis therefore suggests that the potential savings are much lower than assessed by the CCC at 1.4 MtCO_2 in 2020, and also that the policy appears not to be cost-effective, with a net cost of £307 per tonne of CO_2 saved. This result is primarily driven by the low emissions savings and the very high costs, both in terms of enforcement (assumed deployment of average speed cameras across the relevant stretches of the network) and the time lost by motorists who will take longer to drive to their destination.

4.46. The analysis is in line with a recent DfT consultation on road safety – "A Safer Way: Consultation on Making Britain's Roads the Safest in the World"[22]. However, one of the options being consulted on is to recommend local authorities to "prioritise a review of 'A' and 'B' class national speed limit single carriageways…and encourage the adoption of lower limits wherever the risks are relatively high and there is evidence that a lower limit would reduce casualties". Where highway authorities consider certain individual roads to benefit from a reduction in speed limit to maximise safety benefits at minimal cost, such a policy is likely to have an overall social benefit.

Radical technology options for HGVs

4.47. The CCC analysed a package of what they termed "radical" technical measures aimed at reducing emissions from HGVs. These measures include Low Rolling Resistance Tyres

[22] Available at http://www.dft.gov.uk/consultations/open/roadsafetyconsultation/roadsafetyconsultation.pdf.

(LRRT), 'teardrop' trailers for articulated HGVs (a teardrop shaped trailer has improved aerodynamic specifications) and the introduction of hybrid rigid HGVs.

4.48. LRRT for HGVs are included within our Strategy, and are therefore within option 2. The European Regulation concerning type-approval requirements for the general safety of motor vehicles will introduce a package of measures to improve the safety and environmental performance of vehicles in the EU.

4.49. We have not modelled the impact of policy measures to realise the rest of the technical abatement potential identified for HGVs by the CCC. Decarbonising freight and logistics is a key part of our longer term strategy, but the nature of the sector presents particular challenges. Whilst we recognise that there is technical abatement potential from HGVs, in practice we need to consider the best type of framework to drive the necessary technological innovation on the part of industry – whether that be regulatory measures, or funding to support investment and best practice programmes.

4.50. Reducing emissions from HGVs also presents a different set of issues from other road transport modes. The emissions from an HGV will depend on how the vehicle is pieced together for operational use, and will vary significantly depending on the engine, transmission and other automotive components used, on the cab and trailer design, and on the load being carried. Because so many different factors need to be taken into account, it is very difficult to test and measure CO_2 emissions from an HGV and emissions testing is currently done only on the engine.

4.51. Alongside the Strategy, we are publishing the findings of a study of the CO_2 emissions savings that can be achieved from a number of HGV technologies, such as aerodynamic trailers, different types of engine systems and accessories, and alternative powertrain technologies, such as electric and hybrid vehicles and alternative fuels[23]. Importantly, this study has helped us to identify the technologies that have the greatest emissions saving potential for HGV operations.

4.52. The evidence from this study will help to inform consideration of the required incentives or frameworks that will help us achieve a level of uptake to deliver the technically feasible abatement identified by the CCC, and most notably will allow us to contribute actively to wider discussions within the EU around developing CO_2 standards for complete HGVs.

Behavioural Freight measures

4.53. As well as the technological options discussed above, the CCC also identified significant abatement potential from eco-driving training in the freight sector. These emissions savings are included in our baseline (option 1) to reflect the impact the 'Safe and Fuel Efficient Driving' (SAFED) programme for vans and HGV drivers and the continuing expansion of Freight Best Practice for HGV drivers. The baseline also includes the likely expansion of eco-driving that may result from the introduction of the EU Driver Certificate of Professional Competence in September 2009.

4.54. The SAFED programme teaches road skills to help industry increase safety as well as reduce fuel costs and emissions. To date we have provided most of the cost of training for

[23] Available at: www.dft.gov.uk/pgr/freight/research

800 instructors, 12,000 HGV drivers and 7,500 van drivers. SAFED has been shown to save up to 16% of fuel on the day of training and around 5% overall.

4.55. Further, we are increasing the effectiveness of our Freight Best Practice programme, which provides advice to industry on how to reduce fuel consumption and so CO_2 emissions, by extending the programme to include advice to the rail and water freight industry, as well as the road freight industry. We will also launch a new Van Best Practice programme in the Autumn, which will extend the benefits achieved through our Freight Best Practice programme to the rapidly growing van sector.

4.56. However, further abatement potential may be available from these schemes. In particular, preliminary analysis suggests that if 90% of HGV drivers used eco-driving techniques, we could save up to $3MtCO_2$ over the third carbon budget period from 2018-2022. We therefore need to explore how to achieve a 90% up-take and then consult on the potential options for doing so, including whether making eco-driving a mandatory part of the EU Driver Certificate of Professional Competence will help us do this. But as with all behaviour change measures, these savings will only be realised if the benefits of training do not erode over time. We have therefore awarded a contract to assess this, including the impact of eco-driving alongside other initiatives within an organisation which aims to support their drivers.

4.57. We are also providing targeted capital and revenue support to enable companies to transfer from road to rail or water where the economic benefits indicate that this support is justified. In 2007 we spent £17.5 million to promote intermodal and bulk rail freight journeys through freight modal shift grant schemes. This programme is estimated to have removed 880,000 lorry journeys from British roads, and saved over 120,000 tonnes of CO_2 emissions. Again, the continuation of this policy is included in the do nothing scenario.

4.58. We are in the process of revising our rail revenue support scheme to include inland waterways bulk transport from 1 April 2010, and will be issuing new guidance to ensure the scheme is easier for the industry to understand and use. Shifting freight movements from road to rail or water also brings benefits across our other transport goals – reducing both congestion and emissions.

Quantified indirect and ancillary impacts

4.59. The measures in the Strategy are likely to have various ancillary impacts. These have been quantified (discounted to present values) where possible and included in the assessment of costs and benefits provided above, as well as being summarised in Figure 4.7 below. A positive number in the table against a policy measure represents a net benefit relating to each impact; a negative number, a net cost.

Figure 4.7: Summary of the ancillary impacts of the measures in the Carbon Reduction Strategy.

Key:

++	Significantly positive impact
+	Positive impact
-	Negative impact
- -	Significantly negative impact

Option 2: Measures	**Air quality**	**Congestion**	**Noise, accidents and infrastructure**	**Security of energy supply**	**Innovation**
EU new car CO_2 regulation (130gCO_2/km by 2015)	-£38m	-£2,684m	-£1,176m	++	++
EU new car CO_2 regulation (95gCO_2/km by 2020)	-£38m	-£3,734m	-£1,373m	++	++
10% transport fuel from renewable sources by 2020	£57m	£539m	£412m	++	+
Complementary measures:	-£6m	-£389m	-£309m	+	+
Gear shift indicators	*-£1m*	*-£89m*	*-£72m*		
Tyre pressure monitoring systems	*-£1m*	*-£52m*	*-£42m*		
Low viscosity lubricants	*-£1m*	*-£83m*	*-£65m*		
Low rolling resistance tyres	*-£1m*	*-£69m*	*-£54m*		
More efficient air conditioning	*-£1m*	*-£96m*	*-£76m*		
Possible EU new van CO_2 regulation	No impact assumed[1]	No impact assumed[1]	No impact assumed[1]	++	++
SAFED for bus drivers	No impact assumed	No impact assumed	No impact assumed	+	No impact assumed
Low carbon emission buses	No impact assumed	No impact assumed	No impact assumed	+	++
HGV low rolling resistance tyres	+	No impact assumed	No impact assumed	+	+
Illustrative rail electrification	+	No impact assumed	Some reduction in noise	+	No impact assumed
Overall impact of the Carbon Reduction Strategy for Transport	**-£25m**	**-£6,268m**	**-£2,446m**	**++**	**++**

Source: DfT analysis (2009)

Note 1: The analysis assumes that there is no rebound effect even though the cost of van driving has fallen, as it is assumed that van owners only use their vehicles for commercial purposes. While the reduced cost of running the van may make one or two jobs viable at the margin (and thereby increase mileage driven) this effect is likely to be so slight it has been excluded from the analysis. This means there are no indirect ancillary impacts, such as congestion, associated with this measure.

Option 3: Measures	Air quality	Congestion	Noise, accidents and infrastructure	Security of energy supply	Innovation
Extension of Smarter Choices	£77m	£3,679m	£1,480m	+	No impact assumed
Eco-driving for existing car licence holders	No impact assumed[1]	No impact assumed[1]	No impact assumed[1]	+	No impact assumed
Speed reduction and enforcement at 60mph	£89m	No impact assumed	£4,889m	+	No impact assumed
HGV radical technology options	+	No impact assumed	No impact assumed	+	++

Source: DfT analysis (2009)

Note 1: The analysis assumes that there is no rebound effect from eco-driving; that is, drivers do not respond to the reduction in fuel costs by driving more.

Air Quality

4.60. The Strategy contains several measures that are expected to have impacts on air quality. For example, the EU new car CO_2 regulation could have an adverse impact on air quality both directly from the technology that manufacturers introduce into vehicles in order to meet their targets, and indirectly from the expected increase in mileage driven as a result of the reduction in the cost of driving.

4.61. However, an increase in the use of biofuel is expected to partially offset this reduction in the cost of travel, due to the higher relative cost of biofuels. Further, the increased use of biodiesel as a percentage of total diesel used is also expected to have air quality benefits.

4.62. Overall, the measures modelled as part of the Strategy are expected to have modest impact on air quality, resulting in a net cost of £25m over the lifetime of the measures. However, there are further measures within the Strategy that we have not been able to model and which are expected to lead to an improvement in air quality. For example, any increase in walking and cycling which replaces car journeys (as a result of investment in the Cycling Demonstration Towns and Cities Programme and Sustainable Travel Cities, for example) would lead to an improvement in air quality. We have sought to minimise the risks to air quality through careful design of policy instruments – and will monitor the impacts closely.

Congestion

4.63. Where policy measures reduce the costs of driving per kilometre, this is expected to result in an increase in the amount of kilometres driven, thereby adding to congestion. Congestion results in a cost to the economy as a result of increasing journey times as well as reducing the reliability of journey time. Slow moving traffic and stop/start conditions also has a negative impact on emissions.

4.64. The measures within the Strategy that are expected to reduce the cost of driving per kilometre are the EU new car CO_2 regulation and the expected EU regulation for new vans. The modelling undertaken for the EU new car CO_2 regulation suggests that increases in congestion would be relatively small, but would increase over time as more fuel efficient cars make up a greater proportion of the total fleet relative to the baseline.

4.65. Other measures within the Strategy will tend to reduce congestion. For example, an increase in the amount of transport fuel from biofuels would be expected to lead to an increase in the cost of driving, compared to the baseline, as the cost of biofuels is generally higher than the cost of fossil fuels. This increase in cost is expected to decrease the amount of kilometre's travelled, offsetting some of the reduction in the cost of driving as a result of the EU new car CO_2 regulation.

4.66. Other measures that will tend to decrease congestion include those aimed at increasing the amount of walking and cycling, as well as investment in public transport and schemes to encourage car sharing, which reduce the number of journeys undertaken by car. Improvements in technology which reduce the need to undertake business and commuting journeys (such as teleconferencing or teleworking) and reduce the number of car trips will also have a beneficial impact on congestion. Similarly, freight modal shift grants that shift freight from the roads to other modes of transport will tend to reduce congestion on the roads.

Noise, accidents and infrastructure

4.67. There may be some increase in noise levels, accidents and infrastructure costs from road transport as a consequence of the expected increase in the mileage driven as a result of reducing the cost of driving per kilometre. As electric and other ultra-low emission vehicles are much quieter than their conventionally fuelled counterparts, there may be some offsetting reduction in noise levels as a result of any uptake of ultra-low carbon vehicles to meet the EU new car CO_2 regulation targets.

4.68. The expected increase in mileage will be offset to some extent by the increasing use of biofuels, which is expected to increase the cost of driving per kilometre compared to the baseline. Any switch from road transport to cycling and walking would also have a beneficial impact.

4.69. Overall, the measures modelled as part of the Strategy are expected to have a net cost in terms of noise, accidents and infrastructure costs of £2,446m over the lifetime of the measures. As these costs are directly related to the change in vehicle mileage, this cost is primarily a result of the rebound effect – that is, the expected reaction of motorists to the reduction in the cost of driving by driving more.

Unquantified indirect and ancillary impacts

4.70. There may be other impacts of the Strategy that we have not been able to quantify and are therefore not included in the assessment of costs and benefits outlined above. For these impacts, we have provided a qualitative assessment below.

Wider environmental impacts

4.71. We would not expect the Strategy to have a significant impact on the **landscape**, or on **biodiversity**. We do not expect the Strategy to have a significant impact on **water quality** or the **risk of flooding** or coastal erosion, other than to the extent that the latter are caused by dangerous levels of climate change that this Strategy is aiming to help avoid.

Security of Energy Supply

4.72. The Strategy is expected to have a positive impact on security of energy supplies in two ways: first, through a reduction in the demand for energy; and second, through a diversification of the fuel used for transportation.

4.73. In relation to energy demand, encouraging companies to innovate around fuel efficiency and CO_2 emissions through measures such as incentivising low carbon buses and the EU new car (and proposed van) CO_2 regulation are expected to lead to an increase in the fuel efficiency of new vehicles, thus reducing the quantity of transport fuel demanded by the UK and therefore make our economy more resilient to any future scenarios with high fossil fuel prices. It will also reduce the cost of meeting our renewable energy targets, since these are specified as a proportion of total energy used.

4.74. In relation to diversification of energy supplies, the Strategy is expected to lead to an increase in the use of renewable transport fuels, such as biofuels. Biofuels can contribute to energy security by diversifying and increasing the number of supply sources and routes for transport energy. Increasing the proportion of biofuels in retail fuels also decreases the amount of petroleum product or crude oil imports needed to satisfy domestic demand. While there are also risks associated with the import of biofuels, overall we assess that biofuels could to a certain extent positively impact the UK’s security of supply.

4.75. Any increase in the uptake of electric vehicles as a result of the EU new car and proposed new van CO_2 regulations will also reduce the UK’s demand for fossil fuels in favour of electricity from the grid. An increasing amount of this electricity is generated from renewable sources, such as wind or tidal power.

Innovation

4.76. The Strategy is also expected to have a positive impact on innovation. For example, the EU new car CO_2 regulation will provide a stimulus for research into low carbon technologies. This may be particularly beneficial for the UK (where many manufacturers conduct their Research & Development work), and enhance the UK's competitive position. There may also be spillover effects from low carbon innovation in passenger cars into other sectors, such as vans and HGVs, and into cars that are sold outside the EU. It has not been possible to quantify these benefits in the above analysis.

5. Distributional Analysis

5.1. The distributional impacts of the Strategy have been estimated in terms of the NPV for different groups (firms, consumers and bus operators), including the indirect impacts. Emissions savings are assigned to consumers. The results are given in Figure 5.1 below.

Figure 5.1: Distributional impacts of the Strategy, NPV (£m, 2009 prices)

Option 2: Measures	Consumers	Firms	Bus operators
EU new car CO_2 regulation (130gCO_2/km by 2015)	£21,226m	-£3,916m	-
EU new car CO_2 regulation (95gCO_2/km by 2020)	£24,254m	-£3,370m	-
10% transport fuel from renewable sources by 2020	-£4,456m	-£6,326m	-
EU new car complementary measures (total)	£1,335m	-£503m	-
Possible EU new van CO_2 regulation[1]	£641m	£2,977m	-
SAFED for bus drivers	-	-	£406m
Low carbon emission buses	-	-	£247m
HGV low rolling resistance tyres	£96m	£696m	-
Electrification of illustrative 750 single track kilometres of rail line	Not available	Not available	-
Total for the Carbon Reduction Strategy	**£43,096m**	**-£10,442m**	**£653m**

Source: DfT analysis (2009)

Note 1: We have used a simplifying assumption that all vans are used for commercial use (rather than private). Therefore firms benefit from the reduction in fuel costs, whilst consumers benefit from the reduction in emissions.

5.2. Overall, the analysis suggests that there is a net benefit to consumers and to bus operators from the measures in the Strategy, but a net cost to firms. In practice, the gain experienced by bus operators may be passed on to consumers in the form of lower fares and / or higher services levels but the uncertainty associated with this means this has not been quantified.

5.3. The main benefit to consumers is from reduced fuel costs (as a result of the EU new car CO_2 regulation) and the value of the reduction in CO_2 emissions as a result of the Strategy. Bus operators also receive a net benefit from a reduction in fuel costs. The net cost to firms is primarily because of an increase in resource costs relating to the price of fuel (as a result of the renewable transport fuel target) and technology (as a result of the EU new car CO_2 regulation) which offsets the fuel saving per kilometre driven.

5.4. The distributional impacts of the additional measures in option 3 is given in Figure 5.2.

Figure 5.2: Distributional impacts of option 3, NPV (£m, 2009 prices)

Option 3: Measures	Consumers	Firms
Extension of Smarter Choices	£5,988m	£3,152m
Eco-driving for existing car licence holders	£648m	£161m
Speed reduction and enforcement at 60mph	£2,037m	-£1,494m
HGV radical technology options	Not available	Not available
Total for option 3	**£8,673m**	**£1,819m**

Source: DfT analysis (2009)

5.5. Under option 3, measures such as those in the Smarter Choices programme and eco-driving techniques that save on fuel costs would be expected to have a positive impact overall. Consumers are also assigned the benefit of the value of CO_2 emissions saved.

5.6. Both firms and consumers suffer from increases in journey time from a reduction in speed limits from 70mph to 60mph. For firms this time cost is only partially offset by the benefits of improved safety and reduced fuel costs. For consumers there is an overall benefit from improved safety, fuel costs, CO_2 savings and improvements in air quality. The NPVs above do not include the private journey time costs of a reduction in speeding, as this is an illegal activity.

6. Sensitivity Analysis

6.1. Given the inherent uncertainty in the range of assumptions that underpin this analysis, sensitivity analysis on the key variables was undertaken in order to test the range of costs and benefits to variations in key assumptions. Some of these may be interrelated; for example, it may be most appropriate to test a low set of GDP projections with a low set of fossil fuel price projections. For individual policy measures, these sensitivities can be combined, for example to form a "worse case" scenario or a "best case" scenario.

6.2. When looking across a package of measures, this exercise becomes more difficult, as different sensitivities may be appropriate for the different policy measures. For this Strategy, we have therefore considered sensitivities to varying assumptions that are common across the package as a whole.

6.3. In addition to our 'central' case, we have considered the sensitivity of the results to:
   a) different assumptions about **fossil fuel price projections** – oil prices will have an impact on the demand for fuel and therefore both the baseline and the potential savings from transport measures;
   b) the impact of having **measures in place to counter the rebound effect** by keeping the price of driving per kilometre constant – the impact of the rebound effect on both the costs and the benefits of measures can be significant*;* and
   c) different values for the**Shadow Price of Carbon** (SPC) – for measures that reduce greenhouse gas emissions, the assumed value of the SPC is likely to be the main determinant of the value of the benefits of the policy.

6.4. Further sensitivity analysis for specific measures is detailed in annex A.

Fossil fuel prices

6.5. For our central case, we have used the "Timely investment, moderate demand" oil price scenario, produced by DECC. As a sensitivity, we have also considered the impact on our estimates of abatement potential of DECC's alternative oil price projections given in Figure 6.1 below.

Figure 6.1: Oil price forecasts, selected years ($/barrel, 2008 prices)

Year	Oil price scenario			
	Scenario 1: Low global energy demand	**Scenario 2:** Timely investment, moderate demand	**Scenario 3:** High demand, producers' market power	**Scenario 4:** High demand, significant supply constraints
2010	50	70	84	103
2015	58	75	102	142
2020	60	80	120	150

Source: Department of Energy and Climate Change (2009)

6.6. The results of the analysis using these alternative oil price forecasts are set out in Figure 6.2 below. Oil prices can have a significant impact on the results as they influence the benefits of policy measures in terms of the fuel savings and therefore the amount of CO_2 saved. In a world of high oil prices, the baseline level of CO_2 emissions is lower because oil is relatively expensive and therefore demand is lower. For example, drivers may cut back on the amount of mileage driven because of the increase in the cost of driving.

6.7. The measures in the Strategy tend to reduce emissions by reducing the amount of fuel required to go a certain distance. However, under higher oil price scenarios, fuel efficiency improvements will deliver less CO_2 savings as there is a lower level of fuel use (and therefore CO_2 emissions) to act upon. On the other hand, fuel efficiency is valued more highly because each litre of fuel saved is worth more. The combined impact of these effects is generally to slightly reduce the level of emissions savings whilst at the same time improving the cost-effectiveness of measures, the higher the oil price scenario used.

6.8. The overall impact on transport emissions will depend on the combined effect of the change in the baseline and the change in the potential level of savings from the measures in the package. The overall impact is given in Figure 6.3 below. Generally, it can be seen that, under higher oil prices:

- the total saving from policy measures is reduced; but
- the baseline level of transport emissions is also lower; resulting in
- a lower forecast of transport emissions in 2020 given the impact of the measures in the Strategy.

Figure 6.2: Impact of alternative oil price forecasts on the savings from individual policy measures, including indirect impacts.

Policy measure	Scenario 1: Low global energy demand (lowest oil prices)		Scenario 2: Timely investment, moderate demand (central scenario)		Scenario 3: High demand, producers' market power		Scenario 4: High demand, significant supply constraints (highest oil prices)	
	$MtCO_2$ savings in 2020	£/tCO_2 saved	$MtCO_2$ savings in 2020	£/tCO_2 saved	$MtCO_2$ savings in 2020	£/tCO_2 saved)	$MtCO_2$ savings in 2020	£/tCO_2 saved
EU new car CO_2 regulation (130gCO_2/km by 2015)	3.6	£33	3.3	-£9	3.0	-£86	2.7	-£183
EU new car CO_2 regulation (95gCO_2/km by 2020)	4.0	£89	3.7	£55	3.4	-£1	3.2	-£60
10% transport fuel from renewable sources by 2020	7.5	£94	7.3	£80	7.1	£61	6.9	£48
Gear Shift Indicators	0.2	-£62	0.2	-£114	0.2	-£217	0.1	-£342
Tyre Pressure Monitoring Systems	0.1	£256	0.1	£225	0.1	£153	0.1	£81
Low Rolling Resistance Tyres	0.2	£14	0.2	-£36	0.1	-£137	0.1	-£269
Low viscosity lubricants	0.2	£43	0.2	-£5	0.2	-£105	0.2	-£231
More efficient Air Conditioning	0.2	£209	0.2	£173	0.2	£95	0.1	£9
Possible EU new van CO_2 regulation	2.0	£33	1.9	£11	1.9	-£35	1.8	-£80
Low carbon emission buses	0.2	£15	0.2	-£7	0.2	-£38	0.2	-£66
SAFED for bus drivers	0.2	-£56	0.2	-£82	0.2	-£120	0.2	-£161
HGV low rolling resistance tyres	0.2	-£44	0.2	-£77	0.2	-£126	0.2	-£167
Electrification of illustrative 750 single track km of rail line	0.2	-£40	0.2	-£40	0.2	-£40	0.2	-£40

Source: DfT analysis (2009)

Figure 6.3: Impact of alternative oil price assumptions on transport emissions.

Oil price scenario	Baseline domestic transport emissions in 2020, without policy ($MtCO_2e$)	Savings from the Carbon Reduction Strategy in 2020 ($MtCO_2e$)	Forecast domestic transport emissions in 2020, with policy ($MtCO_2e$)
Low global energy demand **(lowest oil prices)**	130.4	18.6	111.8
Timely investment, moderate demand **(central scenario)**	127.4	17.7	109.7
High demand, producers' market power	124.8	16.9	107.9
High demand, significant supply constraints **(highest oil prices)**	121.2	16.1	105.2

Source: DfT analysis (2009)
Note: Numbers may not add due to rounding

Accounting for the rebound effect

6.9. We expect the Strategy to lead to more fuel efficient vehicles, mainly as a result of the EU regulations on new car and van CO_2 standards, and therefore a reduction in the cost of driving. As discussed in section 3 above, we would expect this reduction to lead to an increase in total mileage driven. This additional travel will result in a number of indirect impacts, such as additional congestion, air pollutants, noise, accidents and infrastructure maintenance. The indirect costs of the regulation would therefore not occur if the cost per kilometre remained at the level it would have been in the absence of the regulation, through higher costs elsewhere (such as oil prices).

6.10. Figure 6.4 below shows the impact on our estimates of CO_2 savings and the net cost per tonne of CO_2 saved for a scenario without the indirect impacts of the EU new car CO_2 regulation.

6.11. Figure 6.4 suggests that, as might be expected, emission savings are higher if the rebound effect associated with the EU new car CO_2 regulation is offset, thereby avoiding the additional mileage driven (and associated ancillary impacts) as a result of reducing the cost of driving.

Figure 6.4: Emissions savings and cost-effectiveness with the rebound effect associated with the EU new car CO_2 regulation offset by other factors.

Policy measure	Central case including indirect impacts		Central case offsetting the indirect impacts of the EU new car CO_2 regulation	
	$MtCO_2$ savings in 2020	£/tCO_2 saved	$MtCO_2$ savings in 2020	£/tCO_2 saved
EU new car CO_2 regulation (130gCO_2/km by 2015)	3.3	-£9	4.6	-£9
EU new car CO_2 regulation (95gCO_2/km by 2020)	3.7	£55	4.6	£28
10% transport fuel from renewable sources by 2020	7.3	£80	7.2	£79
Gear shift indicators	0.2	-£114	0.2	-£123
Tyre pressure monitoring systems	0.1	£225	0.1	£251
Low rolling resistance tyres	0.2	-£36	0.1	-£35
Low viscosity lubricants	0.2	-£5	0.2	-£1
More efficient air conditioning	0.2	£173	0.2	£193
Possible new van CO_2 regulation	1.9	£11	1.9	£11
Low carbon emission buses	0.2	-£7	0.2	-£7
SAFED for bus drivers	0.2	-£82	0.2	-£82
HGV Low Rolling Resistance Tyres	0.2	-£77	0.2	-£73
Illustrative electrification of 750 single track km of rail line	0.2	-£40	0.2	-£40
Total impact of the Strategy	**17.7**	**£32.81**[1]	**19.7**	**£24.97**[1]

Source: DfT analysis (2009)
Numbers may not add due to rounding.
Note 1: Excludes illustrative cost-effectiveness of rail electrification.

The Shadow Price of Carbon

6.12. The approach used within Government to value greenhouse gas emissions in policy appraisal (the "Shadow Price of Carbon", or SPC) has been based on estimates of the lifetime damage costs associated with greenhouse gas emissions drawn from the Stern Review (known as the Social Cost of Carbon, or SCC).

6.13. Alongside the *UK Low Carbon Transition Plan*, the Government is publishing a paper setting out a revised approach, following a review over the course of 2008 and early 2009. The review concluded that the approach to valuing greenhouse gases should be changed to one based on estimates of the (marginal) abatement costs of measures required to meet specific emissions reduction targets.

6.14. This review has produced a new set of values for the SPC which differs between the traded and the non-traded sectors. The majority of emissions reductions from the Carbon

Reduction Strategy for Transport occur in the non-traded sector, and therefore the non-traded SPC has been used. The exceptions would be any reduction in emissions from increasing the efficiency of electric rail, and any reduction in aviation emissions after the aviation sector joins the EU Emissions Trading System from 2012. As these reductions would occur in the traded sector, the traded sector SPC would be used to value the savings.

6.15. The central value in 2020 for the non-traded sector is £60, within a range of £30 to £90. We have undertaken sensitivity analysis to consider the impact that this range of values has on the results of our analysis. Generally, for measures in the transport sector, the SPC does not impact on the level of emissions savings or the cost-effectiveness of each measure (which both use the absolute level of emissions savings in millions of tonnes of CO_2), but it would change the NPV, which values the emissions savings at the SPC.

Figure 6.5: The impact of the Shadow Price of Carbon on the NPV of measures, including indirect impacts, £m (2009 prices)

Measure	**Net Present Value including indirect impacts (£m)**		
	Central SPC	**Low SPC**	**High SPC**
EU new car CO_2 regulation: 130gCO_2/km target for 2012-15	£2,393m	£1,424m	£3,393m
EU new car CO_2 regulation: 95gCO_2/km target for 2020	-£1,146m	-£2,389m	£98m
10% transport fuel from renewable sources by 2020	-£1,666m	-£2,547m	-£803m
Complementary measures for cars:	£18m	-£170m	£208m
Gear shift indicators	*£329m*	*£286m*	*£372m*
Tyre pressure monitoring systems	*-£231m*	*-£256m*	*-£205m*
Low viscosity lubricants	*£91m*	*£51m*	*£132m*
Low rolling resistance tyres	*£124m*	*£91m*	*£158m*
More efficient air conditioning	*-£295m*	*-£342m*	*-£249m*
Possible EU new van regulation	£487m	£156m	£819m
SAFED for bus drivers	£417m	£349m	£484m
Low carbon emission buses	£215m	£126m	£304m
Low rolling resistance tyres for HGVs	£282m	£234m	£331m
Electrification of illustrative 750 single track km of rail line	Not available.	Not available.	Not available.
Total of measures modelled for the Carbon Reduction Strategy	**£1,000m**	**-£2,817m**	**£4,834m**

Source: DfT analysis (2009)

6.16. As would be expected as a result of measures which reduce emissions, if the value of emissions is reduced (the use of the low SPC), the NPV will reduce, and if the value of emissions is increased (the use of the high SPC), the NPV will improve. The main point of interest is when this changes a positive NPV of a policy (where the benefits outweigh the costs) to a negative NPV, or vice versa.

6.17. Figure 6.5 above suggests that the NPV of the package of complementary measures as a whole goes from positive to negative if the CO_2 savings are valued at the low range of the SPC. However, individually, the range of values for the SPC does not change the NPV in this way. All other measures with a positive NPV under the central SPC values retain a positive NPV at the lower SPC values.

6.18. Using the higher estimate of the SPC would result in a positive NPV for the longer term EU new car CO_2 target of 95gCO_2/km, such that the (quantified) benefits of the regulation would outweigh the (quantified) costs under a higher value of the emissions savings.

7. Small Firms Impact Test

7.1. We expect the voluntary SAFED training for HGV drivers and both the Freight and Van Best Practice Schemes to have positive impacts on small firms taking up the advice in terms of a reduction in fuel costs.

7.2. In addition, the key measures within the Strategy that are expected to have the biggest potential impact on small firms are the EU new car (and potential van) CO_2 regulation and the 10% renewable energy target to comply with the Renewable Energy Directive.

7.3. In relation to the EU new car CO_2 regulation, small scale and specialist car manufacturers could be faced with disproportionately high costs if they were required to comply with the targets set by the regulation. This is of particular concern for the UK as we have a number of small scale specialist car manufacturers who would be adversely affected without special provisions to accommodate small scale 'de minimis' manufacturers.

7.4. Under the regulation, small volume manufacturers with EU sales of less than 10,000 cars per year are eligible to apply for a derogation from the utility-based targets that apply to other car manufacturers. However, these manufacturers must commit to reducing the CO_2 emissions from their products and will be required to propose their own target, agreed with the Commission. More detail is given in the UK Impact Assessment for the regulation[24].

7.5. The regulatory proposal for the EU new van CO_2 regulation has not yet been released, but we would expect it to include a similar small volume provision to avoid imposing disproportionate costs on small firms.

7.6. In relation to the transport target in the Renewable Energy Directive, there are three types of small firms that are expected to be impacted:
- small firms that retail petrol through one or more forecourts;
- small renewable fuel producers; and
- farmers producing crops for fuel (feedstock).

7.7. The retailers are impacted by the need for a one-off clean of their tanks and other measures. This cost is included in the assessment for the MAC curve modelling (and therefore in the total costs for the Strategy outlined above) and is described in more detail in the Impact Assessment supporting the *UK Renewable Energy Strategy* (RES)[25].

7.8. The renewable fuel producers and the producers of feedstock crops should see an expanded market for their products. Biofuel sales could increase from the current level of approximately 5 billion to 7.5 billion litres a year by 2020. Most of this fuel will be sold to be

[24] Available at http://www.dft.gov.uk/consultations/closed/co2emissions/fia.pdf.
[25] Available at http://decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/res/res.aspx.

blended into petrol and diesel by the major oil companies, who will be able to choose how they source their fuels, which may include importing. Nevertheless, this represents a significant opportunity for both farmers and biofuel producers.

8. Competition Assessment

8.1. Measures to reduce emissions from freight, such as SAFED training, the Freight and Van Best Practice schemes, and freight modal shift grants, are voluntary and available to all businesses. They are therefore not expected to result in any adverse impacts on competition (although the results of SAFED and the Freight and Van Best Practice schemes should be an improvement in the competitiveness of firms taking up this advice).

8.2. The measures targeted at individuals (such as to encourage walking and cycling) or at public transport are also not expected to have a significant impact on competition.

8.3. The key measures in the Strategy that are targeted at industry are again the EU new car CO_2 regulation and the RES. More detail about their potential impact on competition can be found in the respective Impact Assessments.

8.4. In summary, the EU new car CO_2 regulation is unlikely to *directly* limit the number or range of suppliers. However, there is a risk that the regulation will *indirectly* limit the number or range of suppliers, although given certain mitigating factors, the risk of this is considered to be small. New entrants to the car market will face the same costs as existing manufacturers. In terms of limiting the ability of suppliers to compete, there is a risk that in improving the efficiency of the vehicles, manufacturers may have to alter the characteristics of the vehicle (such as by reducing power or using lightweight materials) which may affect their ability to compete in some markets. However, the regulation also provides opportunities for manufacturers to compete in other markets, such as high-tech powertrain manufacturing; making breakthroughs on long term technology challenges, such as in battery technology; and demonstrating and improving the most advanced technologies and licensing them to manufacturers. Finally, the regulation seems unlikely to reduce suppliers' incentives to compete vigorously with each other.

8.5. The EU new van CO_2 regulatory proposal has not yet been published or the regulation agreed. However, its impacts on competition are likely to be similar to those of the EU new car CO_2 regulation. Once the Commission have published their proposal we will complete a full Impact Assessment for the regulation.

8.6. The promotion of biofuels through the RES would result in fossil fuels for road transport being substituted by renewable fuels. It is therefore expected to have a significant impact on the current markets in terms of further developing and mainstreaming the biofuel market in the UK, which is expected to lead to both increased imported biofuels and domestic capacity. However, it is not anticipated that the effects would negatively affect the competitiveness of the fossil fuel or emerging biofuel markets.

9. Administrative Burdens

9.1. The Strategy is not expected to result in significant additional administrative burdens. This will be kept under review as new policies within the Strategy are developed.

9.2. A policy that is currently expected to have an impact is the EU new car CO_2 regulation. However, since manufacturers are already required to type approve their vehicles and provide data on CO_2 emissions and other vehicle characteristics to Member State agencies, the regulation is unlikely to lead to significant additional administrative burdens on manufacturers.

9.3. However, since the regulation requires manufacturers to meet mandatory (as opposed to voluntary) targets, the regulation also sets out the details of the supporting enforcement regime for non-compliance with the 2012 - 2015 target. This is likely to impose a small additional administrative burden on those manufacturers having to pay an Excess Emissions Premium for missing their target. The mechanism for reaching the 2020 target, and in particular, the penalty regime for non-compliance, will have to be defined in a review to be completed no later than 1 January 2013. This is also likely to impose a small additional administrative burden on those manufacturers having to pay the penalty.

9.4. The EU new van CO_2 regulation is also likely to have a similar administrative impact as the EU new car regulation. However, we cannot properly assess the impact until a regulatory proposal is published and the details of the potential reporting arrangements and enforcement regime are put forward.

10. Enforcement and Monitoring

10.1. The Climate Change Act (2008) requires that if UK greenhouse gas emissions exceed the targets set, the Government must set out its proposals and policies for making up for the excess.

10.2. The CCC has a primary function in reporting on progress towards meeting the budgets and targets, maintaining a consistent approach regardless of the Government of the day. Requiring the Government to respond to the CCC's annual report ensures that Parliament and the public are able to monitor policy in this area and that the Government can be held to account annually in Parliament.

11. Implementation and delivery plan

11.1. To ensure that there is clear responsibility for managing total UK emissions and that every department plays its part in delivering the budgets, the Government is establishing a system of departmental carbon budgets. For each department, these will include both a share of the major economic sectors, reflecting that department's relative influence in each of them, and the total emissions from their own estate. Taken together, departmental carbon budgets will cover the whole of the UK's carbon budget for any budget period. The UK is the first country to trial this approach and there will be a full review of the system of departmental carbon budgets ahead of the second budget period.

11.2. To show how we will achieve our budgets, the DfT will be one of the departments producing a detailed implementation plan, to be published in Spring 2010, including detailed key performance indicators and milestones to help assess progress against the UK's climate change targets.

12. Post-implementation review

12.1. The post-implementation review will follow the process set out in the Climate Change Act (2008) for the UK as a whole. It will focus on the UK's performance towards meeting its legislated carbon budgets and targets, and will be ongoing, as detailed in the reporting requirements of the Act. Specifically, this means that the following reviews will be required:

- an annual report by the CCC, laid before Parliament, assessing the UK's performance and progress towards achieving its legislated targets and budgets. The first report is due by 30th September 2009;

- a Government response to the CCC's annual report, laid before Parliament by 15th January 2010;

- a repetition of this process by 30th June and 15th October in subsequent years; and

- in the CCC's annual report for 2014 (when all of the relevant data for the first budget period becomes available) a statement of its views on the manner in which the Government has carried out its functions in relation to meeting its legislated budget for the period 2008-12; this statement will then be repeated after each budget period, when all data for that budget becomes available – in 2019, 2024, 2029 and so on.

Specific Impact Tests: Checklist

Type of testing undertaken	Results in Evidence Base?	Results annexed?
Competition Assessment	Yes	No
Small Firms Impact Test	Yes	No
Legal Aid	No	No
Sustainable Development	No	Yes
Carbon Assessment	Yes	No
Other Environment	Yes	No
Health Impact Assessment	No	Yes
Race Equality	No	Yes
Disability Equality	No	Yes
Gender Equality	No	Yes
Human Rights	No	No
Rural Proofing	No	Yes

Summary of impact tests

A **Competition Assessment** and **Small Firms Impact Test** are set out in the evidence base, above. A full **legal aid impact test** has not been undertaken as we do not expect the Strategy to have an impact on legal aid requirements. The **Sustainable Development assessment** is set out in annex B, and concludes that the Strategy supports and complies with the Government's sustainable development principles. The **carbon assessment**, as well as the assessment of **other environmental impacts** (such as air quality) are assessed under the relevant options in the evidence base and presented above. A **health impact assessment** is available at annex C as the Strategy is expected to have an impact on health through changes in air quality and increased physical activity (cycling and walking).

A **race equality assessment** is attached at annex D. A **disability equality assessment** is presented in annex E, and a **gender impact assessment** is at annex F. We have not undertaken a **human rights impact assessment** as we do not expect the Strategy to have an impact on human rights. A **rural proofing assessment** is provided at annex G. We do not expect the Strategy to have a disproportionate impact on rural communities.

Annexes

Annex A – Synthesis of policy appraisals

A1. This annex provides more detail about the approach that we have used to model the measures in the baseline, the measures in the Carbon Reduction Strategy for Transport, and the additional abatement opportunities identified by the Committee on Climate Change. All projected emissions savings are expected to count towards the non-traded sector carbon budget, unless otherwise stated.

Option 1 measures: Policies included in the baseline

The Voluntary Agreements Package

A2. This refers to policy measures in place over the period 1998-2009 that are aimed at improving new car fuel efficiency. It is difficult to isolate the impact of these individual policies on vehicle fuel efficiency since they are all contributing to the same outcome. The estimated savings are therefore given for the package as a whole.

A3. The policies within the package include:

a. **EU voluntary agreements** on new car fuel efficiency – a voluntary agreement with car manufacturer associations in Europe, Japan and Korea to reduce new car CO_2 emissions to 140gCO_2/km by 2008/09. This represented a cut of around 25% on 1995 levels. The target was a sales-weighted average to be met at a European level by each of the three associations. This therefore gives manufacturers a degree of flexibility over levels of achievement in different countries. The UK started from a higher than average position compared with other EU countries, and has historically tracked above the EU average by about 7gCO_2/km; average new car emissions in the UK were 158gCO_2/km in 2008. Despite significant progress, the EU target is expected to be missed.

b. **Graduated Vehicle Excise Duty (VED)** – VED is the UK annual circulation tax on vehicles; and was reformed in 2001 to link the annual payment to the CO_2 emissions of the vehicle. The Pre Budget Report 2008 announced further structural reform to strengthen environmental incentives to purchase and develop more fuel efficient cars.

c. **Company Car Tax** – this tax was reformed in 2002 to base the charge primarily on the CO_2 emissions for the car and its list price in order to incentivise the use of cars with lower emissions. From 2008/09 a new lower rate band was introduced for company cars with very low emissions (120gCO_2/km or less). The Company Car Tax Fuel Benefit Charge – paid by those who receive employer provided fuel for unlimited personal use – was also reformed in 2003 to follow the company car tax emissions basis. Since 1997 the number of employees in receipt of free fuel for unlimited private use has fallen by around 600,000, partly as a result of the 2003 reforms. Budget 2009 announced lower CO_2 emissions thresholds for company car tax in 2011, to encourage uptake of low carbon company cars.

A4. Although the voluntary agreement package is only in place until 2009, CO_2 savings continue to accrue beyond this date, as new cars purchased up to 2009 are expected to remain in the fleet for some time (and new cars produced after this date will be more efficient than they would have been in the absence of the agreement). These cars will emit less CO_2 (compared to a baseline of no improvements in fuel efficiency in the absence of the package) over their entire lifetime in the fleet.

Renewable Transport Fuels Obligation (RTFO)

A5. The RTFO requires the fuel industry to supply a proportion of road fuel from renewable sources (primarily biofuels). The level of the RTFO assumed in the baseline is 2.5% (by volume) of total fuel supplied for the first year of the obligation (2008/09), rising by 0.5% per annum to reach 5% in 2013/14, in line with the recommendation of the Gallagher review of the indirect effects of biofuels production.

"Smarter Choices" Programme

A6. "Smarter Choices" are techniques for influencing travel behaviour towards more sustainable options, such as walking, cycling, travelling by public transport, car clubs and car sharing. They include improved information, marketing of options, organising services to address the needs of target groups, providing new services focused on target groups (such as workplaces or developments) and providing new options that reduce the need to travel at all, such as teleworking and teleconferencing.

A7. These measures are planned and delivered at a local level by local authorities.

A8. The baseline assumes a 1.6% reduction in trips and a 1% reduction in traffic in 2025.

Sustainable Distribution Programme and HGV efficiency improvements

A9. The National Transport Model (NTM) assumes that there is a 1% per annum improvement in the HGV fleet to 2010. *New* HGVs are not assumed to improve their fuel efficiency between 2010 and 2015 (due to the impact of the latest air quality Euro standard), but then improve at a rate of 0.5% per annum between 2016 and 2030. Given an average HGV life of eight years, this translates into the fleet improving at an average rate of 0.63% p.a. between 2010 and 2015 and 0.41% p.a. for 2016 to 2030.

A10. Policy is assumed to improve the efficiency of HGV fuel use by 0.1% per annum. This reflects the combined impact of the Freight Best Practice (FBP) and Safe and Fuel Efficient Driving (SAFED) programmes, as well as the new Driver Certificate of Professional Competence that is being introduced in September 2009 (EU Directive 2003/59). This will require HGV drivers to undertake 35 hours of training every 5 years. The Directive does not stipulate SAFED training. However, part of the syllabus covers 'the ability to optimise fuel consumption' and it seems likely that many hauliers will require their drivers to undertake this training, delivering significant benefits. However, there are many options for training so it is unclear what proportion of drivers will undergo SAFED training.

A11. The assumptions about new HGV and HGV fleet fuel efficiency improvements used in the baseline are summarised in Figure A1 below.

Figure A1: HGV annual fuel efficiency improvements

	Percentage improvement per annum	
	2010-2015	**2016-2030**
New HGVs	0%	0.5%
Whole fleet	0.63%	0.41%
Whole fleet without policy	0.53%	0.31%

Source: DfT analysis

Fuel duty

A12. Main fuel duty rates rose by 1.84 pence per litre on 1 April 2009. To support fiscal consolidation, Budget 2009 announced that fuel duty will increase by 2 pence per litre on 1 September 2009 and by 1 pence per litre in real terms on 1 April each year from 2010 to 2013. This increase is projected to save about 2 $MtCO_2e$ per annum by 2013/14, and is included in the baseline against which the following measures are assessed.

A13. The baseline also takes account of previous fuel duty changes; for example the fuel duty escalator was introduced in 1993 and set an annual increase in the tax on petrol and diesel above the rate of inflation. The first annual rate was set at 3% above inflation and raised to 5% later in 1993. It was increased to 6% in July 1997. Since 1999, the level of fuel duties has been set on a budget by budget basis.

Rail Efficiency Measures

4.77. Rail efficiency measures are expected to come from new trains coming in to service and from passenger and freight operating companies introducing a range of energy saving initiatives. It is also assumed that diesel rail (passenger and freight) will use biofuel blends, in line with achieving 10% of transport fuel by energy from renewable sources by 2020.

4.78. The estimate of emissions savings from rail measures was generated by DfT and the Rail Carbon Trajectory Working Group, as set out in DfT (2008), *"Carbon Pathways Analysis"* and reported by the CCC in their December 2008 report. This analysis has since been updated, and suggests that savings of about 0.5 $MtCO_2$ are estimated in 2020 from a number of initiatives that are being or expected to be implemented by passenger and freight train operators. These measures include eco-driving, auxiliary power units and a driver advice system. The 0.5 $MtCO_2$ is made up of about 0.4$MtCO_2$ from diesel trains, and just under 0.2$MtCO_2$ from electric trains. Only the savings from diesel rail are provided counted towards the achievement of the non-traded sector carbon budget, as savings from electric rail will occur in the traded sector.

Option 2 measures: the Carbon Reduction Strategy for Transport

A14. The measures in option 2 were assessed in the following order:

- the EU new car CO_2 regulation target of 130gCO_2/km by 2012-15; including supporting measures (such as fiscal measures; incentives for the up-take of electric vehicles, and information provision);
- additional savings from the EU new car CO_2 regulation target of 95gCO_2/km by 2020, including supporting measures;
- 10% biofuels (by energy) by 2020;
- complementary measures to the EU new car CO_2 regulation;
- a possible EU new van CO_2 regulation;
- low rolling resistance tyres for HGVs;
- safe and fuel efficient driving training for bus drivers;
- low carbon emission buses;
- electrification of illustrative 750 single track kilometres of rail line.

A15. Figure A2 provides a summary of the results of the analysis for the measures modelled.

Figure A2: Summary of the assessment of measures in the Carbon Reduction Strategy.

Measure	Savings in 2020, MtCO2e	Total emissions savings in each carbon budget period ($MtCO_2e$)			Lifetime savings, MtCO2e	Net present value[1] (£million, 2009 prices)		Cost-effectiveness[2] (£cost/tCO_2e saved)	
		2008-12	**2013-17**	**2018-22**		**Direct only**	**Incl. indirect**	**Direct only**	**Incl. indirect**
EU new car CO_2 regulation: 130gCO_2/km target for 2012-15	3.3	0.6	6.6	16.6	49.1	£3,304m	£2,393m	-£9	-£9
EU new car CO_2 regulation: 95gCO_2/km target for 2020	3.7	0.0	1.0	18.5	65.4	£817m	-£1,146m	£28	£55
10% transport fuel from renewable sources by 2020	7.3	0.0	10.5	33.3	43.9	-£3,293m	-£1,666m	£123	£80
Complementary measures (cars):	0.8	0.3	2.6	3.7	9.1	£779m	£18m	-£32	£39
Gear shift indicators	*0.2*	*0.0*	*0.4*	*0.8*	*2.1*	*£504m*	*£329m*	*-£164*	*-£114*
Tyre pressure monitoring systems	*0.1*	*0.0*	*0.3*	*0.5*	*1.3*	*-£128m*	*-£231m*	*£129*	*£225*
Low viscosity lubricants	*0.2*	*0.1*	*0.7*	*0.9*	*1.9*	*£252m*	*£91m*	*-£71*	*-£5*
Low rolling resistance tyres	*0.2*	*0.1*	*0.6*	*0.7*	*1.6*	*£259m*	*£124m*	*-£98*	*-£36*
More efficient air conditioning	*0.2*	*0.1*	*0.6*	*0.9*	*2.3*	*-£108m*	*-£295m*	*£83*	*£173*
Possible EU new van regulation	1.9	1.0	5.2	9.3	15.5	£487m	£487m	£11	£11
Low rolling resistance tyres for HGVs	0.2	0.0	0.1	1.1	2.4	£282m	£282m	-£77	-£77
SAFED for bus drivers	0.2	0.4	1.0	1.0	3.5	£417m	£417m	-£82	-£82
Low carbon emission buses	0.2	0.0	0.2	0.9	4.9	£215m	£215m	-£7	-£7
Electrification of illustrative 750 single track km of rail line	0.2	0.0	0.0	0.8	-	-	-	-£40	-£40
Total of measures modelled for the Carbon Reduction Strategy	**17.7**	**2.3**	**27.2**	**85.2**	**193.8**	**-**	**£1,000m**	**-**	**£32.81**[3]

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs). *Source: DfT analysis*
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
[3] Excludes illustrative rail electrification.

A16. Sensitivity analysis has been undertaken on each of the measures to consider the impact of different oil price forecast assumptions. The assumptions used are given in section 3 above and reproduced here for ease of reference.

Figure A3: Oil price forecasts, selected years ($/barrel, 2008 prices)

Year	Oil price scenario			
	Scenario 1: Low global energy demand	Scenario 2: Timely investment, moderate demand	Scenario 3: High demand, producers' market power	Scenario 4: High demand, significant supply constraints
2010	50	70	84	103
2015	58	75	102	142
2020	60	80	120	150

Source: Department of Energy and Climate Change

How to interpret the results tables

A17. For each of the measures modelled, a table setting out the key results from the analysis is provided. The example table below explains how each of these results should be interpreted.

	Direct impacts only Central SPC	Including indirect impacts		
		Central SPC	High SPC	Low SPC
	This column provides the results of the analysis when indirect impacts are excluded	*These columns provide the results of the analysis when the indirect effects of the measures (such as air quality, congestion etc) are included. The three columns present the results when CO_2 emissions are valued at the central, the high and the low Shadow Price of Carbon respectively.*		
Impact on annual CO_2 in 2020 ($MtCO_2$)	Estimated CO_2 emissions savings as a result of the policy in 2020.			
Impact on other greenhouse gases in 2020 ($MtCO_2e$)	Estimated savings in non-CO_2 greenhouse gas emissions as a result of the policy in 2020.			
Savings in 1st budget period 2008-2012 ($MtCO_2$)	Total estimated CO_2 savings over the 5 years of the first carbon budget period.			
Savings in 2nd budget period 2013-2017 ($MtCO_2$)	Total estimated CO_2 savings over the 5 years of the second carbon budget period.			
Savings in 3rd budget period 2018-2022 ($MtCO_2$)	Total estimated CO_2 savings over the 5 years of the third carbon budget period.			
Cumulative savings over appraisal period ($MtCO_2$)	Total estimated CO_2 savings over the appraisal period. This could be longer than the life of the policy e.g. new cars that meet the EU new car CO_2 target in 2020 will continue to			

	contribute emissions savings after this date.
Present value of costs (£m)	This is the total value of the monetised costs in each year discounted to 2009 values, using a discount rate of 3.5%.
Present value of benefits (£m)	This is the total value of the monetised benefits in each year discounted to 2009 values, using a discount rate of 3.5%.
Net Present Value (£m)	The Net Present Value (NPV) is the Present Value of the benefits minus the Present Value of the costs. A positive NPV therefore signifies that the (monetised) benefits outweigh the (monetised) costs; a negative NPV signifies the opposite.
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)	The cost-effectiveness is the Present Value of the costs minus the Present Value of the benefits (excluding the value of emissions savings), divided by the total amount of emissions saved. The higher the number, the more expensive is the measure per tonne of emissions saved. A negative number indicates that there is a net benefit from the measure per tonne of emissions saved.
Average value of CO_2 saved (£/tCO_2)	This is the total value of CO_2 savings over the life of the measure, valued at the Shadow Price of Carbon for the relevant year, divided by the total amount of CO_2 savings. This can then be compared against the cost-effectiveness value given above – if the average value of the CO_2 emissions saved is higher than the cost-effectiveness value, this suggests that the benefits outweigh the costs, and therefore the measure is cost-effective.
Social benefit-cost ratio	This is the ratio of the benefits to the costs to society for the measure. Therefore a number above 1 suggests that the benefits outweigh the costs; a number below 1 suggests the opposite.
Fuel saved in 2020 (m litres)	This is the estimated fuel saving in millions of litres in 2020 as a result of the measure.
Impact on Renewable Energy Target	Qualitative assessment of how the policy measure will impact on the UK's target to source 15% of our energy and 10% of our transport energy from renewable sources by 2020.
Other non-quantified impacts	The effect of the policy on other ancillary impacts that have not been monetised and are therefore not included in the costs and benefits results given in the rest of the table.

A. EU New Car CO_2 Regulation

Description of policy

A18. In December 2008, the EU agreed to set binding targets on the CO_2 emissions from new cars by setting targets for each manufacturer. The regulation includes a target to reduce new car emissions to 130gCO_2/km across the EU by 2012, and a longer-term new car CO_2 target of 95gCO_2/km by 2020. In 2012, 65% of each manufacturer's newly registered cars must on average comply with the target set by the legislation. This will rise to 75% in 2013, 80% in 2014, and 100% from 2015 onwards. In light of this, our modelling assumes that manufacturers aim to meet their targets by 2015 and then increase the annual rate of improvement from 2015 onwards in order to meet their 2020 targets.

A19. The mechanism for reaching the longer term target, and in particular, the penalty regime for non-compliance, will have to be defined in a review to be completed no later than 1 January 2013.

A20. Other measures that support the achievement of the targets include fiscal measures, such as graduated Vehicle Excise Duty and Company Car Tax, and the provision of information, including the Act on CO_2 campaign (which provides details of the lowest emitting cars by class) and car labelling.

Key points

- The targets are to be met on average across all vehicles sold in the EU. Member States are not themselves subject to targets. We would therefore expect the average CO_2 emissions of cars sold in individual Member States to vary, some ending up above, and some below, the target. Our assumption in our central case is for new cars sold in the UK to reach 98gCO_2/km by 2020.
- There are a number of factors that make the CO_2 savings and cost-effectiveness uncertain, including: any variation in compliance costs between manufacturers; how much costs fall over time; whether there is any shift in car purchases between car market segments; and the extent of any rebound effect which gives rise to indirect costs. The analysis presents some sensitivity on these factors.
- The results from this analysis differs from those published in the UK Impact Assessment for the regulation published in April 2009[26]. This is because the analysis uses outputs from the National Transport Model (NTM) which has subsequently been revised to include latest GDP and fuel price forecasts.
- The central results suggest that the 130gCO_2/km target should deliver carbon savings of around **3.3 MtCO_2 in 2020** at a **net benefit of £9/tCO_2** saved. A long-term target of 95gCO_2/km should deliver additional savings of **3.7MtCO_2 in 2020** at a **net cost of £55tCO_2**.

Key assumptions and uncertainties

A21. The model estimates the costs and benefits of the measure for the period 2009 to 2022, and over the lifetime of the policy (i.e. over the lifetime of the cars that

[26] See http://www.dft.gov.uk/consultations/closed/co2emissions/fia.pdf.

enter into the market between 2009 and 2020). The analysis relies on a host of assumptions described below. Some of these are more uncertain and influential than others, particularly: future technology costs; indirect costs; oil prices; segment shift; and long-term target. Sensitivity analysis is provided of some of these factors.

Baseline

A22. The mid-term target (130gCO_2/km) is evaluated against a baseline where CO_2 emissions from new cars are assumed to remain static at 2009 levels, derived by applying the historical rate of improvement over the last decade or so the latest CO_2 figures from 2007. The assumption of a 0% improvement figure assumes that there is a balance of factors affecting CO_2 emissions, trading off improved engine efficiency against the trend toward larger vehicles and the CO_2 penalty of car safety and air quality regulation. When looking at the long-term target, the analysis takes the mid-term target as the baseline to establish the additional CO_2 savings that the long-term target delivers.

Numbers of new cars purchased each year and composition of fleet

A23. The analysis makes the simplifying assumption that sales of new cars remains the same across the assessment period and that there is no shift in sales between the 6 fuel-type segments looked at (small, medium, and large petrol and diesel cars). Segment shift – where sales switch from one segment to another, e.g. from medium to small – can affect CO_2 emissions, causing the headline target to be missed. The regulation sets CO_2 targets proportional to average vehicle weight such that if cars become heavier, manufacturers will be given higher CO_2 targets. So even if all manufacturers are fully compliant with their (higher) targets, the weighted average of these targets is now higher than the desired 130gCO_2/km. This obviously will affect CO_2 savings and cost-effectiveness. This analysis doesn't take account of segment shift because there is no evidence that the regulation will cause a shift between segments. This issue was looked at in the Initial Impact Assessment which was published in July 2008[27] and some of the findings are presented in the discussion on sensitivity analysis below.

Additional costs of technology to improve fuel economy and composition of the fleet

A24. Estimates of the cost of fuel saving technology were made using cost curves developed by TNO and consultants CE Delft. The cost curves identify bundles of CO_2 reducing technology and plot these against cost per gramme reduction. They are therefore highly stylised and are applied in the analysis to each manufacturer. The analysis therefore assumes that the same CO_2 reduction options are available to all manufacturers at the same cost, but in practice this is unlikely to be the case. The cost estimates should therefore be treated with some caution.

A25. It is assumed that all costs are passed on to consumers. The TNO cost curves were developed to cost CO_2 reduction technology for 2012. Applying these

[27] Available at http://www.dft.gov.uk/consultations/closed/co2emissions/impactassesment.pdf.

curves beyond this point would therefore risk leaving out other CO_2 reduction technologies as well as not taking account of the potential for costs to fall over time. CE Delft was commissioned therefore to adapt the cost curves, specifically to evaluate any long-term targets in 2020. This resulted in a series of cost curves which steadily fall and stretch from 2012 to 2020, offering the same CO_2 reductions at a cheaper price and incorporating more CO_2 reductions into the curve. The analysis uses these falling cost curves for both the mid-term and long-term targets. Some sensitivity on this is discussed further below.

A26. Costs of monitoring new car CO_2 emissions have not been included in the analysis since the data is already required for the classification of vehicles into graduated vehicle excise duty bands.

Long-term target

A27. Although the agreed long-term target is 95gCO_2/km by 2020, this is subject to review in 2013. Clearly, varying the long-term target will significantly impact on CO_2 savings in 2020, but also will impact on the cost-effectiveness.

Consumer surplus

A28. The principal benefit of the policy is to reduce the cost of motoring because by improving fuel efficiency to reduce CO_2 emissions, less fuel needs to be purchased to travel a given distance. This confers a financial benefit to drivers who now pay less for all the journeys they would have taken. Furthermore, as the cost of driving has lowered, theory suggests they will drive further and will enjoy a benefit for all the additional mileage they travel. This is known as the rebound effect (discussed below). The analysis monetises the benefits to drivers by calculating the change in price per kilometre and multiplying this by the driver's original kilometres driven, and adding the change in price multiplied by the additional kilometres, divided by half. Essentially this method tries to capture consumer surplus: the benefit consumers (drivers) derive from driving above the cost they pay.

Rebound effect and indirect costs

A29. The rebound effect is the demand response to the increase in fuel efficiency. We assume there are three parts to this effect:

- an increase in mileage due to a fall in the price of driving per kilometre (estimated as having an elasticity of -0.2 but declining over time in line with NTM assumptions);
- extra comfort taken when driving – e.g. increasing the use of air-conditioning, seat heaters etc and more aggressive driving (estimated as having an elasticity of -0.05); and
- the choice of a bigger car when making a purchase decision (this is taken into account in the new car fuel economy averages).

A30. Increased mileage due to the rebound effect leads to additional, indirect costs such as congestion, air pollution, noise and impacts on infrastructure. These impacts are monetised and the analysis is presented with and without these impacts. There is some uncertainty over where these indirect impacts would occur in practice as it is likely that additional policy measures could be put in place to mitigate their impact. As such, results are also presented where the cost of motoring (p/km) remains constant across the period. In this case there is no rebound effect to the policy.

Results of cost-benefit analysis

<u>Mid-term target: 130gCO_2/km</u>

A31. The main results of our analysis are given in Figure A4 below. It is estimated that the mid-term target could result in an annual CO_2 saving of **3.3MtCO_2 in 2020** at a **net benefit of £9/tCO_2** saved (including indirect impacts).

A32. The costs of the policy mainly come from the cost of new technologies and the costs of congestion while the benefits arise from fuel-cost savings and CO_2 savings.

Figure A4: Summary of central case results for the EU new car CO_2 regulation 130gCO_2/km target

		Direct impacts only	Including indirect impacts		
		Central SPC	Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		4.6	3.3	3.3	3.3
Impact on other greenhouse gases in 2020 ($MtCO_2e$)		Negligible	Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.9	0.6	0.6	0.6
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		9.4	6.6	6.6	6.6
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		22.9	16.6	16.6	16.6
Cumulative savings over appraisal period ($MtCO_2$)		67.5	49.1	49.1	49.1
Present value of costs (£m)		£8,279	£12,178	£12,178	£12,178
Of which	*Technology*	£8,279	£8,279	£8,279	*£8,279*
	Indirect congestion		£2,684	£2,684	£2,684
	Indirect air pollution		£38	£38	£38
	Indirect noise, accidents, infrastructure		£1,176	£1,176	£1,176
Present value of benefits (£m)		£11,584	£14,571	£15,541	£13,602
Of which	*CO_2 savings*	*£2,669*	*£1,939*	*£2,909*	*£970*
	Fuel resource cost savings	*£8,915*	*£8,915*	*£8,915*	*£8,915*
	Welfare benefit from driving more		£3,717	£3,717	£3,717
Net Present Value (£m)[1]		£3,304	£2,393	£3,393	£1,424
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		-£9	-£9	-£9	-£9
Average value of CO_2 saved (£/tCO_2)		£39	£39	£59	£20
Social benefit-cost ratio		1.4	1.2	1.3	1.1
Fuel saved in 2020 (m litres)		1,169	861	861	861
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.			
Other non-quantified impacts		Positive impacts on innovation and security of supply.			

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).

[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.

Source: DfT analysis

Sensitivity analysis

a) *Impact of segment shift*

A33. We have not looked at this issue in detail because there is no evidence that the regulation will lead to a segment shift, and the regulation includes a measure to adjust the basis on which manufacturers targets are set if there is a shift between segments.

A34. However, this issue was investigated in the UK Impact Assessment on the EU new car CO_2 regulation, published in July 2008. It is important because segment shift has the potential to reduce CO_2 savings. The Impact Assessment looked at two segment shift scenarios: to heavier; and to smaller cars. The shift to heavier vehicles reduced CO_2 savings in 2020 by 14%, whereas the shift to smaller vehicles increased CO_2 savings by 13%. As under both scenarios manufacturers are fully compliant with their targets, this shows that there is an inherent uncertainty with the way the regulation will be implemented, meaning that actual CO_2 savings in a given year are likely to deviate from expectations.

b) *Impact of oil prices*

A35. Oil prices have a profound effect on the results as they influence both the benefits of the policy in terms of fuel savings, and the amount of CO_2 saved. In a world of high oil prices, CO_2 emissions are lower because less oil is burnt as it is expensive. Therefore fuel efficiency improvements deliver less CO_2 savings as there are fewer CO_2 emissions to begin with. On the other hand, fuel efficiency is valued more because it is expensive to use oil. The combined impact of these effects is to vastly improve the cost-effectiveness figure if a higher oil price scenario is used. With the higher oil price assumptions (scenario 3), savings fall to 3MtCO_2 in 2020 but at a net benefit of £86/tCO_2 saved. With the even higher oil price assumptions (scenario 4), savings fall further to 2.7MtCO_2 in 2020, but the net benefit becomes £183/tCO_2 saved. Conversely, with the low oil price assumptions (scenario 1), savings are highest at 3.6MtCO_2 in 2020 but at a net cost of £33/tCO_2 saved.

c) *Impact of indirect costs*

A36. As Figure A4 shows, including the indirect impacts from the rebound effect changes the welfare impact of the target – congestion, air quality and noise impacts increase costs. However, consumers receive a benefit from driving further, but by doing so they emit more CO_2, lowering overall CO_2 savings. The balance of these impacts is to lower the NPV to £2,847 million. On the other hand, cost-effectiveness improves because the NPV without CO_2 savings is quite similar with and without the rebound effect and yet when indirect impacts are included, this value is divided by a smaller number of CO_2 savings. This means the net benefit of the policy is spread over fewer tonnes of CO_2 saved, improving cost-effectiveness.

A37. By contrast, looking at the direct costs only where the rebound-effect has been mitigated, Figure A4 above shows that CO_2 savings are greater at 4.6MtCO_2 but the measure is slightly less cost-effective at a net benefit of £9/tCO_2 saved, with an NPV of £3,304 million.

Long-term target: 95gCO_2/km

A38. The main results of our analysis are given in Figure A5 below. It is estimated that a long-term target of 95gCO_2/km could result in additional annual CO_2 savings of **3.7MtCO_2 in 2020** at a **net cost of £55/tCO_2** saved (including indirect impacts). Note that all figures are relative to the mid-term target baseline.

A39. The costs of the policy mainly come from the cost of new technologies and the costs of congestion, while the benefits arise from fuel-cost savings and CO_2 emission reductions.

Figure A5: Summary of central case results for the EU new car CO_2 regulation 95gCO_2/km target

		Direct impacts only	Including indirect impacts		
		Central SPC	Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		4.6	3.7	3.7	3.7
Impact on other greenhouse gases in 2020 ($MtCO_2e$)		Negligible	Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.0	0.0	0.0	0.0
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		1.3	1.0	1.0	1.0
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		22.9	18.5	18.5	18.5
Cumulative savings over appraisal period ($MtCO_2$)		79.7	65.4	65.4	65.4
Present value of costs (£m)		£11,808	£16,953	£16,953	£16,953
Of which	*Technology*	*£11,808*	*£11,808*	*£11,808*	*£11,808*
	Indirect congestion		*£3,734*	*£3,734*	*£3,734*
	Indirect air pollution		*£38*	*£38*	*£38*
	Indirect noise, accidents, infrastructure		*£1,373*	*£1,373*	*£1,373*
Present value of benefits (£m)		£12,625	£15,807	£17,051	£14,564
Of which	*CO_2 savings*	*£3,031*	*£2,487*	*£3,730*	*£1,243*
	Fuel resource cost savings	*£9,594*	*£9,594*	*£9,594*	*£9,594*
	Welfare benefit from driving more		*£3,727*	*£3,727*	*£3,727*
Net Present Value (£m)[1]		£817	-£1,146	£98	-£2,389
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		£28	£55	£55	£55
Average value of CO_2 saved (£/tCO_2)		£38	£38	£57	£19
Social benefit-cost ratio		1.1	0.9	1.0	0.9
Fuel saved in 2020 (m litres)		1,407	1,163	1,163	1,163
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.			
Other non-quantified impacts		Positive impacts on innovation and security of supply.			

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) Impact of oil prices

A40. As before, higher oil prices impact on CO_2 savings and cost-effectiveness. When the 95gCO_2/km 2020 target is assessed using DECC's oil price scenario 3 ("high demand, producers' market power"), CO_2 savings are reduced slightly to 3.4MtCO_2 in 2020 but the cost falls to a net benefit from the measure of £1/tCO_2 saved. Scenario 4 ("high demand, significant supply constraints") improves cost-effectiveness to a net benefit of £60/tCO_2 saved but CO_2 savings fall to 3.2MtCO_2 in 2020. By contrast, scenario 1 ("low global energy demand") improves CO_2 savings to 4MtCO_2 in 2020 but at the greater net cost of £89 per tonne of CO_2 saved.

b) Impact of indirect costs

A41. Figure A5 shows the impact of including indirect costs associated with the rebound effect. While benefits increase, these are outweighed by costs from increased congestion, air quality pollution and other external costs such as noise pollution and infrastructure wear and tear. This contrasts with the mid-term target, where including indirect effects improves the NPV and cost-effectiveness.

A42. The difference is because while the benefits increase linearly with additional mileage, the costs, especially the congestion costs, increase non-linearly (at an increasing rate). This means that as fuel efficiency improves, the cost per additional kilometre will rise. As the long-term target evaluates improvements in fuel efficiency relative to the mid-term target (i.e. when kilometres driven have already been increased by the policy), this means that the unit costs of congestion are higher. As a result, the impact on congestion costs relative to the mid-term target is larger than the relative impact on the benefits from additional mileage driven (the costs from additional kilometres are greater than the benefits). This means that when indirect impacts are included, cost-effectiveness worsens. Of course, measures could be put in place to offset this. As Figure A5 shows, when the rebound effect is mitigated, CO_2 savings increase to 4.6MtCO_2 and cost-effectiveness improves to a net cost of £28/tCO_2 saved.

Distributional impacts

A43. The costs of the new targets on firms and consumers have been estimated. The results of the distributional analysis include indirect effects. They cannot be summed to find the cost to society, as this would entail double counting. Note that the long-term distributional impacts are additional to the mid-term target. Both the mid-term and long-tem targets result in a net benefit for consumers, but a net cost to firms. Consumers and firms incur the technology costs of achieving the new targets, but save on fuel costs. Consumers are assigned the benefit of the reduction in CO_2 emissions. Consumers therefore benefit significantly from the mid-term target but less so by moving from the mid-term to the long-term target. This helps to explain why the long-term target appears less cost-effective than the mid-term target.

Figure A6: Summary of distributional analysis for the 130gCO_2/km mid-term target

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	-£3,916
	Consumers	£21,226

Source: DfT analysis

Figure A7: Summary of distributional analysis for the 95gCO_2/km long-term target

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	-£3,370
	Consumers	£24,254

Source: DfT analysis

Other considerations

A44. The analysis necessarily makes a number of simplifying assumptions, most notably on sales and the structure of the market. However, such considerations are important for determining the impact of the regulation, on CO_2 emissions but also on the industry. The target is potentially threatened if consumers prefer to buy larger vehicles, and if sales fall then manufacturers are left with less profit-margin with which to invest in low CO_2 technologies. The analysis assumes that costs are passed on to consumers such that the price of cars will rise. However, it is unclear what the demand response of consumers will be to such price rises, by how much overall sales will fall, how it will impact on the choice of car consumers make, and how it will impact on the second-hand market and scrappage rate. Though these considerations will have an impact on the CO_2 savings of the policy, they are likely to be slight.

B. Biofuels

Description of policy

A45. The modelling for the Carbon Reduction Strategy looked at the impact of an increase in consumption of biofuels as a proportion of road and rail transport fuel from around 4% by energy to 10% by 2020.

Key points to note

- CO_2 savings come from the displacement of fossil fuel with biofuel. Biofuels are assumed to have zero tailpipe emissions.
- The emissions from the production of biofuel in the agricultural and industrial sectors have been valued and included in the cost-effectiveness analysis.
- The potential benefits and costs of biofuels are subject to much uncertainty. The main uncertainty is around the price of biofuels and their overall net emissions savings. Both significantly impact the cost-effectiveness of the policy.
- The results suggest that the 10% biofuel by energy should deliver CO_2 savings of around **7.3** MtCO_2 in 2020 at a net cost of between **£80/tCO_2** saved.

Key assumptions and uncertainties

Policy Background

A46. Two EU Directives will have critical implications for the future levels of biofuels:

- The Renewable Energy Directive (RED) contains two targets to be met by Member States by 2020. There is a specific 10% renewable energy target for the transport sector (excluding aviation and shipping). Biofuels are expected to make up the majority of the effort.

- The Fuel Quality Directive (FQD) requires that in 2020 transport fuel suppliers must deliver a 6% reduction in the life cycle greenhouse gas (GHG) emissions. The obligation is expected to be met through (i) improved industrial practices in the extraction and refining of fossil fuels, and (ii) the use of GHG saving biofuels. Biofuels are again expected to make up the majority of the effort.

Baseline

A47. Early in 2009 the RTFO order was amended to slowdown the biofuel obligation so that it would increase from 2.5% by volume in 2008-09 to 5% from 2013-14 and thereafter. Figure A8 below illustrates the baseline and scenario analysed. The baseline is presented in volume and energy basis for ease of comparison.

Biofuel Scenario

A48. The model estimates the costs and benefits of the additional use of biofuel for the period 2009 to 2022. Due to the combination and interaction of the Renewable Energy and Fuel Quality Directives and the market's response to government biofuel regulation - the consumption of biofuel by 2020 cannot be exactly predicted. However, a range was considered of between 8% and 12% by energy of road and rail transport fuel from biofuel by 2020, with a central scenario of 10%.

A49. As discussed in the ‘Energy Penalty of Biofuels’ section below, biofuels have a lower energy content compared to fossil fuels. Thus meeting a 10% by energy target in 2020 will require more than 10% of road and rail fuel to come from biofuels on a volume basis. Figure A8 below compares biofuel consumption in the baseline and central scenario analysed on a volume and energy basis.

Figure A8: Baseline RTFO and Central Scenario

Year	Baseline RTFO (by volume)	Central Scenario (by volume)	Baseline RTFO (by energy)	Central Scenario (10% by energy)
2013	4.9%	4.9%	4.3%	4.3%
2014	5.0%	6.0%	4.4%	5.1%
2015	5.0%	7.1%	4.4%	6.0%
2016	5.0%	8.2%	4.3%	6.8%
2017	5.0%	9.3%	4.3%	7.6%
2018	5.0%	10.3%	4.3%	8.4%
2019	5.0%	11.3%	4.3%	9.2%
2020-22	5.0%	12.3%	4.3%	10.0%

Source: DfT analysis

Fuel Resource Costs

A50. Analysing the potential fuel resource cost savings of a policy involves comparing the total resource fuel cost to consumers and businesses for the central scenario and the counterfactual. Overall, biofuels on average cost more than fossil fuels and biofuels have a lower energy content than fossil fuels, so a rise in their use increases the number of litres of fuel needed to travel a certain distance and thus fuel costs.

Resource cost of conventional (fossil) fuels

A51. DECC’s oil price assumptions to 2030 have been converted into petrol and diesel prices using the DECC-DfT Fuel Price Forecasting model. The assumed resource cost of petrol and diesel in 2020 are shown in Figure A9 below.

Resource Cost of Biofuels

A52. The biofuel prices that are assumed in the analysis are derived from outputs produced by the OECD-FAO Aglink-Cosimo model, a partial equilibrium agricultural commodities model that has a biofuels module attached to it. The model covers 95% of world ethanol production and 82% of world biodiesel production in 2007. Net cost production functions take into account feedstock prices, production costs, revenues from by-products and capital costs. These net cost functions interact with demand functions that are defined by mandates and the price of fossil fuel substitutes. This market clearing price mechanism operates in terms of a global market, taking into account prevailing restrictions on international trade. The assumed cost of biofuels in 2020 are shown in Figure A9 below.

Figure A9: Resource cost of Petrol, Diesel, Bioethanol and Biodiesel in 2020 (£2009/litre)

Oil Price Scenario	Biofuel Price Scenario	Diesel	Biodiesel	Petrol	Bioethanol
Scenario 2	**Central**	£0.41	£0.65	£0.38	£0.42

Source: DfT analysis

Energy Penalty of Biofuel

A53. A lower energy content has been factored in for all biofuel blends. Bioethanol has around 2/3 of the energy of petrol, and biodiesel has about 9/10 of the energy of diesel.

Welfare Impacts

A54. An increase in the cost of driving from the higher use of biofuel will cause motorists to decrease the amount of mileage travelled. This has been estimated using a price elasticity of petrol and diesel of -0.2 in 2010, falling to -0.15 by 2025. A price induced decrease in mileage travelled is a dis-benefit to motorists. This welfare loss has been estimated by multiplying the amount of less fuel used due to the price increase by the increase in fuel cost.

Congestion impacts

A55. Reduced mileage travelled will also reduce congestion on the roads, which is a benefit to society. The total congestion cost was assessed within the National Transport Model.

Greenhouse gas savings from biofuels

A56. Two approaches to assessing the impact of the scenario on GHG emissions, a gross and a net GHG emission impact were used for this analysis:

- The gross GHG impact - is a Tank-to-Wheel emission impact for the transport sector. According to IPCC accounting guidelines, tailpipe emissions from biofuels are zero as any GHG released from the burning of the fuel is offset by the sequestration of GHG when the crops for biofuel are grown. Thus, the gross GHG impact of the scenario analysed is the emission savings from the displaced combustion of fossil fuels.
- The net GHG impact - is a Well-to-Wheel (lifecycle) assessment. This takes into account all of the emissions released in the production and

distribution of the fuel; thus it takes into account the emissions from the production and combustion of fossil fuels compared to the emissions from the production of biofuel.

A57. For the purposes of the MAC curve analysis, the gross GHG impact was used to estimate the amount of GHG saved from the use of biofuels in the transport sector.

A58. The net estimate was not used to assess the GHG savings of the scenario, as the purpose of the analysis was to estimate the GHG impact only in the transport sector. However, they have been valued and included in the cost-benefit and cost-effectiveness analysis:

- Emissions from the biofuel production in the UK agricultural sectors were valued using the UK non-traded sector SPC.
- Changes in emissions from the reduction in production of fossil fuels and increase in production in biofuels in the UK industrial sector were valued at the traded sector SPC.
- Emissions from the production of UK consumed biofuel from outside of the EU were valued using the marginal damage price of carbon.
- Emissions from the production of UK consumed biofuel from inside of the EU were not valued as there is an effective cap on emissions through the EU's GHG targets and thus no net increase in emissions are expected.

A59. There can be a significant variance in the net emission savings associated with renewable fuels depending upon the feedstocks used. Given the potential for greater than minimum GHG savings, but also the uncertainty around the potential future impact of indirect land use change on GHG emission calculations - for simplicity, this analysis has assumed that the average GHG saving will be the minimum EU threshold of 35% and then 50% from 2017.

Calculating the cost effectiveness of biofuel deployment

A60. The cost-effectiveness of biofuel deployment as a GHG saving measure is calculated by subtracting the value of UK emissions savings that occur in the transport sector from the NPV inclusive of ancillary benefits, and then dividing this sum by the cumulative GHG saving that is attributable to the UK transport sector.

Cost-effectiveness of biofuel deployment in the transport sector =

$$\frac{\text{NPV including ancillary benefits – (UK transport emissions savings x SPC}^{28}\text{))}}{\text{2009-2022 }CO_2\text{ emission savings in UK transport sector}}$$

Results of the Cost-Benefit Analysis

A61. The main results of our analysis for our central case are given in Figure A10 below. 10% biofuels by energy could result in an annual saving of **7.3 $MtCO_2$ in 2020** at a lifetime net cost of **£80/tCO_2 saved**.

[28] The price of carbon used is the non-traded sector Shadow Price of Carbon

Figure A10: Summary of central case results for achievement of 10% renewable transport fuel by 2020

		Direct impacts only Central SPC	Including indirect impacts		
			Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		6.7	7.3	7.3	7.3
Impact on other greenhouse gases in 2020 ($MtCO_2$)		Negligible	Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.0	0.0	0.0	0.0
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		9.5	10.5	10.5	10.5
Savings in 3rd budget period 2018-2022 ($MtCO_2$)[1]		30.8	33.3	33.3	33.3
Cumulative savings over appraisal period ($MtCO_2$)		40.3	43.9	43.9	43.9
Present value of costs (£m)		£4,563	£4,109	£4,109	£4,109
Of which	*Fuel Resource Costs*	*£4,298*	*£3,824*	*£3,824*	*£3,824*
	Industrial Infrastructure	*£265*	*£265*	*£265*	*£265*
	Welfare loss from driving less		*£19*	*£19*	*£19*
Present value of benefits (£m)		£1,270	£2,443	£3,306	£1,562
Of which	*CO_2 savings*	*£1,270*	*£1,435*	*£2,298*	*£554*
	Indirect congestion		*£539*	*£539*	*£539*
	Indirect accidents, infrastructure and noise		*£412*	*£412*	*£412*
	Indirect air quality		*£57*	*£57*	*£57*
Net Present Value (£m)[1]		-£3,293	-£1,666	-£803	-£2,547
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		£123	£80	£81	£79
Average value of CO_2 saved (£/tCO_2)		£42	£42	£63	£21
Social benefit-cost ratio		0.28	0.59	0.80	0.38
Fuel saved in 2020 (m litres)		2,687	2,904	2,904	2,904
Impact on Renewable Energy Target		Large positive impact from the use of biofuels			
Other non-quantified impacts		Positive impacts on innovation and security of supply.			

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Distributional impacts

A62. The costs and benefits estimated in the analysis have been disaggregated across firms and consumers to form a distributional analysis of the effects of the policy. There is a net cost to the firms and consumers, primarily from increased fuel resource costs. CO_2 savings are allocated to consumers in the distributional analysis.

Figure A11: Summary of distributional analysis for 10% renewable transport fuel by 2020

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	-£6,326m
	Consumers	-£4,456m

Source: DfT analysis

Sensitivity Analysis

Oil Price Scenarios

A63. As set out in the evidence base above, DECC have developed four oil price scenarios. The main results presented in the table above use the *timely investment, moderate demand* scenario. Different oil price scenarios generate a difference in the estimate of CO_2 savings in 2020 and the cost-effectiveness estimate due to a change in the change in the CO_2 saved and the relative cost between biofuels and fossil fuels. The higher the oil price the lower the CO_2 savings from biofuels as overall demand for road fuel is lower and thus less fossil fuel is displaced. However, the cost-effectiveness also falls as oil price increases, and to a greater degree, as the cost of fossil fuel increases and thus the additional cost of biofuels reduce. Figure A12 below illustrates the impacts of using the different Oil prices.

Figure A12: Impact of different oil price assumptions

	MtCO_2 saved in 2020	**Cost-effectiveness (£cost/tCO_2)**
Scenario 1 - *low global energy*	7.5	£94
Scenario 2 - *timely investment, moderate demand*	7.3	£80
Scenario 3 - *high demand, producers' market power*	7.1	£61
Scenario 4 - *high demand, significant supply constraints*	6.9	£48

Source: DfT analysis

Electric Vehicles

A64. A greater uptake of electric cars will reduce the use of biofuel, its CO_2 savings and therefore the costs of the scenario. Due to the relatively low uptake of electric vehicles however the impact is estimated to be negligible.

Figure A13: Summary of results for achieving 10% renewable transport fuel given an assumed level of take-up of electric vehicles.

		Direct impacts only	Including indirect impacts		
		Central SPC	Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		6.7	7.2	7.2	7.2
Impact on other greenhouse gases in 2020 ($MtCO_2$)		Negligible	Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.0	0.0	0.0	0.0
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		9.5	10.5	10.5	10.5
Savings in 3rd budget period 2018-2022 ($MtCO_2$)[1]		30.4	33.0	33.0	33.0
Cumulative savings over appraisal period ($MtCO_2$)		39.9	43.5	43.5	43.5
Present value of costs (£m)		£4,524	£4,070	£4,070	£4,070
Of which	*Fuel resource costs*	*£4,259*	*£3,785*	*£3,785*	*£3,785*
	Industrial infrastructure	*£265*	*£265*	*£265*	*£265*
	Welfare loss from driving less		*£19*	*£19*	*£19*
Present value of benefits (£m)		£1,257	£2,429	£3,285	£1,556
Of which	*CO_2 savings*	*£1,257*	*£1,423*	*£2,278*	*£549*
	Indirect congestion		*£538*	*£538*	*£538*
	Indirect accidents, infrastructure and noise		*£412*	*£412*	*£412*
	Indirect air quality		*£57*	*£57*	*£57*
Net Present Value (£m)[1]		-£3,267	-£1,641	-£785	-£2,514
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		£124	£80	£81	£79
Average value of CO_2 saved (£/tCO_2)		£42	£42	£63	£21
Social benefit-cost ratio		0.28	0.60	0.81	0.38
Fuel saved in 2020 (m litres)		2,656	2,873	2,873	2,873
Impact on Renewable Energy Target		Large positive impact from the use of biofuels			
Other non-quantified impacts		Positive impacts on innovation and security of supply.			

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

C. EU Complementary Measures

Description of policy

A65. Complementary measures are a collection of technologies that could improve 'real world' fuel efficiency of cars but which wouldn't be fully captured in new cars' official CO_2 figures and could also improve fuel efficiency within the existing fleet. They are expected to contribute to the additional 10gCO_2/km reduction required on top of the 130gCO_2/km EU new car CO_2 regulation target. There are separate regulations under discussion or expected from the European Commission for:

- More Efficient **Mobile Air-Conditioning** systems (EMACs) – making vehicle air conditioning units more efficient has the potential to reduce their CO_2 emissions;
- **Gear shift indicators** (GSI) – changing gear at the optimal time can reduce revs and therefore fuel consumption. Gear Shift Indicators are instruments on the dashboard that give information to the driver on the optimal point to change gear;
- **Low Rolling Resistance Tyres** (LRRT) for cars – reduced rolling resistance tyres help to reduce the amount of energy needed to maintain speed therefore improving fuel efficiency and reducing CO_2 emissions. The full potential has not been modelled within this package as that would risk double-counting savings from the new car CO_2 regulation;
- **Tyre Pressure Monitoring Systems** (TPMS) – evidence suggests that the majority of vehicles are driven with under-inflated tyres. This reduces fuel economy as well as increases tyre wear and reduces safety. Tyre Pressure Monitoring Systems inform the driver when a tyre requires inflating; and
- **Low Viscosity Lubricants** (LVL) – these lubricants reduce engine friction which accounts for a large part of a vehicle's energy consumption, thereby helping to reduce CO_2 emissions.

A66. These technologies are referred to as 'complementary measures' as they are expected to contribute to the additional 10gCO_2/km reduction required on top of the 130gCO_2/km EU new car CO_2 target.[29] Separate draft regulations covering the introduction of each of these technologies are currently under discussion or expected from the European Commission.

Key points to note

- Delivery of the CO_2 savings would rely on reaching agreement at EU level on the specific Directives required to ensure uptake of particular technologies. Existing legislation does not provide any incentive to the car manufacturers to implement the indicated technological solutions and so the impact the measures may have is characterised by a high level of uncertainty. For some technologies (e.g. GSI, TPMS), delivery of CO_2 savings would also rely on drivers responding to the advice provided.

[29] Other contributions to the additional 10gCO_2/km reduction are expected to come from CO_2 targets for new light commercial vehicles (vans) and increased use of biofuels.

- The combined package of complementary measures is estimated to save about **0.8MtCO_2 in 2020** at a **net cost of £39/tCO_2**. However, these results are extremely sensitive to the assumptions made on costs and the potential for efficiency improvements. Sensitivity analysis is presented below.

Figure A14: Summary of results, central estimates

Technology	Including indirect impacts	
	MtCO_2 saved in 2020	**Cost, £/tCO_2 saved***
More Efficient Mobile Air-Conditioning (EMACs)	0.18	£173
Gear Shift Indicators (GSI)	0.18	-£114
Low Rolling Resistance Tyres (LRRT)	0.15	-£36
Tyre Pressure Monitoring systems (TPMS)	0.10	£225
Low Viscosity Lubricants (LVL)	0.20	-£5
Combined package of measures	**0.8**	**39**

* A negative estimate indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Key assumptions and uncertainties

Common assumptions

A67. There are several key assumptions and aspects of the methodology that are common to the modelling of individual complementary measures. These are discussed below.

Defining 'complementary measures'

A68. The reason that these 'complementary measures' are being treated differently from other vehicle technological improvements such as increasing powertrain efficiency or using lightweight materials is primarily due to the vehicle testing procedure. The EU new car CO_2 target of 130gCO_2/km refers to the tailpipe emissions as measured by the EC Whole Vehicle Type Approval (WVTA) process. This process requires all new cars which are type approved for sale in Europe to undergo standardised tests to determine their fuel consumption.

A69. Because of the need to maintain strict comparability of results achieved by the standard tests, it is recognised that they are not fully representative of real life driving conditions. In particular, whilst the CO_2 impact of some in-vehicle technologies are captured in the testing procedure, the impact of other technologies is only partially captured (e.g. LRRT) or not captured at all (e.g. EMACs, GSI, TPMS). In part this is down to the practical difficulties in revising the test every time a new technology becomes available. In addition, the CO_2 impact of some of these technologies is heavily dependent on driver behaviour and therefore CO_2 savings are more difficult to verify.

A70. As such, the 130gCO_2/km target is intended to refer to all technologies whose impacts are captured in the WVTA process. Other technologies that can contribute to CO_2 reductions but which cannot be measured in the type approval process (i.e. 'complementary measures') are dealt with in this appraisal.

A71. However, the list of technologies considered here is not exhaustive. Several other technologies exist which could improve 'real world' fuel efficiency of cars but which wouldn't be fully captured in new cars' official CO_2 figures. These technologies have been labelled 'eco-innovations' and include technologies such as energy efficient headlights, the use of solar panels, storage and re-use of heat etc. The final draft of the EU new car CO_2 regulation allows manufacturers to count the CO_2 savings from these technologies towards their tailpipe emissions targets (up to 7gCO_2/km), provided CO_2 reductions are accountable, verifiable and not already identified as being part of the 'complementary measures' package. As such, 'eco-innovations' are unlikely to deliver any additional savings to those expected from new car CO_2 targets. The focus of this analysis is therefore on the 'complementary measures' previously identified.

A72. The majority of the complementary measures we have modelled (e.g. EMACs, GSI, TPMS) are only likely to be applied to new cars[30], whilst others (e.g. LRRT, LVL) could more easily be applied to all vehicles on the road. This is reflected in assumptions about uptake of these technologies.

Calculation of CO_2 savings

A73. For each measure, we present an estimate of fuel consumption savings in terms of a percentage reduction in 'real world' fuel consumption, based on current available evidence. As discussed above, we would not expect these measures to affect a vehicle's official CO_2 figures as produced by the Type Approval process.

A74. For any given vehicle, 'real world' emissions tend to be on average around 15% higher than the official gCO_2/km figure. However, if we were to apply a 15% uplift to fuel consumption figures of all cars and model the amount of fuel consumed, this would be significantly higher than actual fuel used (as measured by fuel duty receipts). The most likely reason for this is that more efficient vehicles tend to drive more, on average, than less efficient vehicles. This is supported by evidence from the National Travel Survey.

A75. We build this assumption into our modelling by weighting gCO_2/km figures by kilometres driven in a given year i.e. assuming new cars are driven more than older cars. By using this method, estimates of total fuel consumption are more in line with actual fuel used (as measured by fuel duty receipts). In this way, we can infer that the average gCO_2/km figure we use in the model broadly reflects the average car kilometre driven in the 'real world'. To estimate the impact of complementary measures, we therefore apply the percentage reduction directly to the gCO_2/km figure rather than applying an uplift first.

[30] In theory some of these technologies could be retrofitted to existing vehicles but this is likely to be at prohibitively high cost and so not considered here.

Baseline & modelling approach

A76. As with the modelling of other measures in the MAC curve, the complementary measures are appraised cumulatively. As such, the results reflect the additional CO_2 savings each measure could deliver, given the other policies that are already assumed to be in place. The baseline assumes there is an EU-wide CO_2 target for new cars of 95gCO_2/km by 2020. Biofuels are assumed to make up 10% (by energy) of transport fuel used.

A77. The CO_2 savings from complementary measures were estimated using the National Transport Model (NTM). For simplicity the measures were modelled as a package using the NTM and then the contribution of individual measures disaggregated using a spreadsheet model.

A78. The model underlying the analysis uses assumptions about car efficiency, biofuel use and annual kilometres driven by vehicles of different ages to forecast annual fuel consumption and CO_2 emissions from petrol and diesel cars. Forecasts of car fuel consumption, CO_2 emissions and vehicle kilometres travelled are calibrated to National Transport Model (NTM) forecasts (given the above assumptions of efficiency and biofuel use).

Appraisal period

A79. The model estimates the costs and benefits of individual technologies that are introduced into vehicles over the period 2010 to 2020. The benefits of these technologies are assumed to continue over the lifetime of those vehicles (up to 2032 for new cars sold in 2020).

Rebound Effect

A80. Increased mileage due to the rebound effect can lead to additional, indirect costs such as congestion, air pollution, noise and infrastructure maintenance. We consider these effects as indirect in that they arise from a behavioural response to the policy, rather than as a direct result of the policy itself.

A81. The fuel price elasticity that we use in our modelling to estimate the rebound effect is implied from the NTM. The fuel price elasticity (to account for increased mileage due to a fall in the price of driving per kilometre) starts at around -0.2 in 2010 and declines over time to -0.17 in 2020 and -0.15 in 2025.

A82. Two sets of results are presented: one showing direct impacts only (excluding the rebound effect) and the other including indirect impacts (including the rebound effect). The results are presented separately to highlight the scale of the potential indirect impacts and their impact on the results. There is uncertainty over where these indirect impacts would occur in practice as we would expect additional policy measures to be put in place to mitigate their impact.

Assumptions specific to individual measures

A83. The key factors influencing the cost of individual complementary measures and their impact on CO_2 emissions are set out below. These assumptions do not prejudge decisions on the scope or scale of potential policy measures in this area, but are used merely for illustrative purposes.

<u>More efficient air conditioning (EMACs)</u>

A84. The use of air conditioning within a vehicle brings about direct greenhouse gas emissions from the leakage of coolant and indirect CO_2 emissions from the energy required to power the unit (and carry its weight in the vehicle). These emissions are not currently captured in the Type Approval process, although direct EMAC emissions (from coolant leakage) are the subject of recent legislation restricting the use of coolants with a high global warming potential. However, there is the potential to reduce indirect EMAC emissions through improving the efficiency of EMACs. It is this aspect on which the Commission's consultation[31] launched in 2008 (and our modelling) is focused.

A85. TNO (2006)[32] suggest that the increase in emissions as a result of EMAC use is between 2-6%, although the UK is likely to be at the lower end of this range because of our climate. They estimate that a more efficient EMAC could reduce indirect emissions by around 30% at a cost of around €60 (~£44) per vehicle. This implies an improvement in real-world efficiency of 0.6-1.2%. In our modelling we have used a central estimate of 0.9%. Following TNO (2006) we assume in our 'do something' scenario that more efficient air conditioning systems gradually enter the market from 2010, reaching near 100% of new car sales by 2015.

<u>Gear Shift Indicators (GSIs)</u>

A86. Changing gear at the optimal time can reduce revs and therefore fuel consumption. GSIs are instruments on the dashboard that give information to the driver on the optimal point to change gear. Adhering to this advice is optional and therefore the CO_2 savings that result will be wholly dependent on the extent to which the advice is followed.

A87. The recent EU Commission consultation on GSI[27] states that these instruments could reduce CO_2 emissions by up to 6%, but that driver acceptance may mean that only a quarter of this (1.5%) is achieved on average. In terms of cost, TNO (2006)[28] estimate a cost of €15 (~£11) per new car. The King Review quotes research that suggests GSIs are cheaper to fit to new cars: £5 is suggested as a suitable target volume price. DfT modelling assumes GSI are added to new cars from 2012, rising to 81% of new cars by 2015, delivering a 1.5% efficiency improvement at a cost of £11 per car.

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[31] DG Enterprise have recently launched a public consultation on a future regulation on efficiency of mobile air conditioners (EMACs) and gear shift indicators (GSIs). This is available at: http://ec.europa.eu/enterprise/automotive/environment/mac/consultation/index.htm.

[32] TNO (October 2006), *"Review and analysis of the reduction potential and costs of technological and other measures to reduce CO2-emissions from passenger cars"*, available at http://ec.europa.eu/enterprise/automotive/projects/report_co2_reduction.pdf.

Tyre Pressure Monitoring Systems (TPMS)

A88. Evidence suggests that a significant proportion of vehicles are driven with under-inflated tyres (TNO (2006)[28]). This reduces fuel economy as well as increases tyre wear and reduces safety. Tyre pressure monitoring systems inform the driver when a tyre requires inflating. TNO estimated that the introduction of tyre pressure monitoring systems could reduce fuel consumption by 2.5% if the driver acts on the information provided by the system.

A89. DfT modelling assumes 2% average improvement in fuel consumption, assuming the driver inflates his or her tyres when prompted. This is slightly lower than the TNO assumption of 2.5%, but more consistent with data supplied by the tyre industry of 0.12% to 2.4%. We assume around 33% of drivers actually follow the advice and inflate their tyres when prompted. We also assume a gradual introduction of TPMS in new vehicles between now and 2020 at a cost of around £37 (€50) per vehicle (from TNO (2006)).

Low Rolling Resistance Tyres (LRRT)

A90. Reduced rolling resistance helps reduce the amount of energy needed to propel a vehicle, which reduces fuel consumption. IEA (2007)[33] cited in the King Review estimates that LRRT could lead to around a 2-4% energy saving and cost around £50 to £100 per vehicle.

A91. TNO (2006)[28] present a range of potential efficiency savings from LRRT of 1-5%. The scenario they model assumes 3% average improvement in fuel consumption. An assumption of 2% was modelled in the General Safety Regulation impact assessment[34]. Given the potential for LRRT to contribute to the EU new car CO_2 target it would be double counting to also include the full potential for savings under 'complementary measures'.

A92. However, LRRT could deliver additional savings for existing cars in the fleet. In their base case TNO assume LRRT will increase linearly to 71% of the entire car fleet by 2020. DfT modelling considers the potential for additional take-up i.e. in the remaining 29% at a cost of around £36 (€48) per vehicle (from TNO).

Low viscosity lubricants (LVL)

A93. LVL reduce engine friction which accounts for a large part of a vehicle's energy consumption. TNO (2006)[28] estimate that LVL could reduce test cycle emissions by 1.5%, and real world emissions by 2.5%. Given that the impact on the test cycle is already likely to be captured by the EU new car CO_2 regulation, DfT modelling assumes an additional impact on 'real world' emissions of 1%. TNO estimate a cost of around €15-€25 for a complete engine oil replacement. DfT modelling has taken the upper end of this estimate (£20 per vehicle) to reflect the fact that costs may be higher for existing cars. In their base case TNO assume LVL will increase linearly to 25% of the entire car fleet by 2020.

[33] IEA (2007) "*Vehicle efficiency and transport fuels*".
[34] Available at http://www.dft.gov.uk/consultations/closed/motorvehiclessafety/ia.pdf

DfT modelling considers the potential for additional take-up i.e. in the remaining 75%.

Results of the cost-benefit analysis

A94. The direct costs of complementary measures arise from the cost of the technology. The benefits arise from fuel-cost savings and CO_2 savings. There may also be indirect impacts (predominantly costs) as a result of the rebound effect. Figure A15 presents the results considering direct impacts only. The results including indirect impacts are presented in Figure A16. This shows that the package of complementary measures is expected to save about **0.8MtCO_2 in 2020** at a **net cost of £39/tCO_2** saved.

Figure A15: Summary of central case results for the complementary measures, direct impacts only

		Complementary measures package	More efficient air conditioning	Gear Shift indicators	Tyre Pressure Monitoring Systems	Low Rolling Resistance Tyres	Low Viscosity Lubricants
Impact on annual CO_2 in 2020 ($MtCO_2$)		0.9	0.21	0.20	0.12	0.18	0.23
Impact on other greenhouse gases in 2020		negligible	negligible	negligible	negligible	negligible	negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.4	0.1	0.0	0.0	0.1	0.1
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		3.0	0.7	0.5	0.3	0.7	0.8
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		4.3	1.0	1.0	0.6	0.8	1.0
Cumulative savings over appraisal period ($MtCO_2$)		10.6	2.6	2.5	1.4	1.8	2.2
Present value of costs (£m)		£2,037	£795	£124	£494	£257	£367
Of which	*Cost of Technology*	£2,037	£795	£124	£494	£257	£367
PV of benefits (£m)		£2,816	£687	£627	£367	£516	£619
Of which	*CO_2 savings*	£438	£107	£99	£58	£79	£95
	Fuel resource cost saving	£2,378	£579	£527	£308	£438	£526
Net Present Value (£m)[1]		£779	-£108	£504	-£128	£259	£252
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		-£32	£83	-£164	£129	-£98	-£71
Average value of CO_2 saved (£/tCO_2 saved)		£41	£41	£40	£40	£43	£42
Social benefit-cost ratio		1.4	0.9	5.1	0.7	2.0	1.7
Fuel saved in 2020 (million litres)		197	51	50	29	44	56
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.					
Other non-quantified impacts		Positive impact on safety with TPMS. Positive impact on security of supply. Reduction in vehicle wear and tear from fewer stops and fewer gear changes.					

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Figure A16: Summary of central case results for the complementary measures, including indirect impacts

		Complementary measures package	More efficient air conditioning	Gear Shift indicators	Tyre Pressure Monitoring Systems	Low Rolling Resistance Tyres	Low Viscosity Lubricants
Impact on annual CO_2 in 2020 ($MtCO_2$)		0.8	0.18	0.18	0.10	0.15	0.20
Impact on other greenhouse gases in 2020		Negligible	Negligible	Negligible	Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.3	0.1	0.0	0.0	0.1	0.1
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		2.6	0.6	0.4	0.3	0.6	0.7
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		3.7	0.9	0.8	0.5	0.7	0.9
Cumulative savings over appraisal period ($MtCO_2$)		9.1	2.3	2.1	1.3	1.6	1.9
Present value of costs (£m)		2,740	968	285	589	382	516
Of which	*Cost of technology*	2,037	795	124	494	257	367
	Indirect congestion	389	96	89	52	69	83
	Indirect air pollution	6	1	1	1	1	1
	Indirect accidents, noise, infrastructure costs	309	76	72	42	54	65
PV of benefits (£m)		2,759	673	614	358	506	608
Of which	*CO_2 savings*	438	107	99	58	79	95
	Fuel resource cost saving	2,378	579	527	308	438	526
	Offsetting increase in CO_2 emissions	-61	-15	-13	-8	-11	-14
	Welfare benefit from driving more	3	1	1	0	0	1
Net Present Value (£m)[1]		18	-295	329	-231	124	91

Cost-effectiveness: Net Cost per tonne of CO_2 saved (£/tCO_2)[2]	39	173	-114	225	-36	-5
Average value of CO_2 saved (£/tCO_2 saved)	41	41	40	40	43	42
Social benefit-cost ratio	1.01	0.7	2.2	0.6	1.3	1.2
Fuel saved in 2020 (million litres)	197	44	43	25	37	48
Impact on Renewable Energy Target	Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.					
Other non-quantified impacts	Positive impact on safety with TPMS. Positive impact on security of supply. Reduction in vehicle wear and tear from fewer stops and fewer gear changes.					

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) *Impact of different oil price scenarios*

A95. The main results presented in the table above use the *timely investment, moderate demand* oil price forecast scenario (scenario 2). Different oil price scenarios do not generate significant differences in the estimate of CO_2 savings in 2020 for the complementary measures package. However, they do have a marked impact on the cost-effectiveness estimates (as the value of the fuel savings is changed). Using the *low global energy* scenario (scenario 1), the cost-effectiveness result for the full package increases to a higher net cost of £84/tCO_2. The higher oil price scenarios 3 and 4, *high demand, producers' market power* and *high demand, significant supply constraints* scenarios generate results showing a net benefit of £52/tCO_2 and £161/tCO_2 respectively.

b) *Impact of changing technology cost and efficiency improvement assumptions*

A96. In their 2006 report, TNO include estimates of the cost of different technologies. We have generally taken the mid-point of these estimates for our central case, but also look at higher and lower costs as sensitivity.

A97. If costs are 20% lower than in our central case and the different policy measures deliver higher efficiency improvements than in the central case, the cost-effectiveness estimate improves from a net cost of £39/tCO_2 saved to a net benefit of £132/tCO_2 (including indirect impacts). If costs are 20% higher than in our central case and different policy measures deliver lower efficiency improvements than in the central case, the estimate of cost per tonne of CO_2 saved increases to a net cost of £215/tCO_2 (including indirect impacts).

Distributional impacts

A98. The scenario we have modelled results in a net benefit for consumers but a net cost to firms. Consumers and firms are both assumed to save on fuel costs. Because motoring by private individuals makes up the majority of kilometres driven, consumers are expected to reap the majority of this welfare gain. For firms, this benefit appears to be outweighed by the additional technology cost.

A99. We split the benefits of fuel savings, costs of technology and the indirect costs between firms and consumers using the proportion of vehicle kilometres driven by company cars (assumed to be firms) and non-company cars (assumed to be consumers). The value of the CO_2 saved is allocated to consumers.

Figure A17: Summary of distributional analysis for the complementary measures

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	-£503m
	Consumers	£1,335m

Source: DfT analysis

D. EU New Van CO_2 Regulation

Description of policy

A100. The EU Commission has issued a draft communication which sets out its intention to bring forward legislation to reduce the average level of CO_2 emissions from new vans across the EU. This legislation is similar in nature to that for new cars described above.

Key points to note

- The EU Commission is considering publishing a proposal to regulate emissions from new vans. An earlier draft suggested targets for average CO_2 from new vans sold in the EU of 175gCO_2/km in 2012 and 160gCO_2/km in 2015, although in the current climate these targets seem unlikely.
- In the absence of any formal proposal, this analysis examines three scenarios: a pessimistic improvement of 1% per annum; an optimistic expectation of what the Commission may propose (175gCO_2/km in 2015 and 160gCO_2/km in 2020); and a central scenario, mid-way between the two.
- Although a commercial dataset of van sales and CO_2 emissions was purchased for the analysis, there is a still a lack of robust baseline data for CO_2 emissions from vans. This means that the potential CO_2 savings from any regulation are very uncertain. DfT is in the process of improving the quality of its data and the methodology used in the analysis. The numbers presented here should therefore be viewed as a work in progress representing the best available estimates given current data limitations.
- While cost curves have been drawn from a report for the Commission by consultants TNO (2009) identified cost curves for reducing CO_2 emissions from vans, these are generalised cost curves and so not wholly applicable to all manufacturers covered by the regulation. Therefore, the cost estimates should be treated with caution.
- Given these caveats, the analysis suggests that the central scenario could deliver CO_2 savings in the UK of **1.9MtCO_2 in 2020** at a **net cost of £11/tCO_2** saved but a much more detailed van CO_2 dataset needs to be developed to improve confidence in these numbers.

Key assumptions and uncertainties

A101. The model estimates the costs and benefits of the measure for the period 2009 to 2022. The analysis relies on a number of assumptions, some of which are more influential and give rise to greater uncertainty, such as: the regulated target; actual CO_2 emissions (data source used); cost curves; application of target at industry or manufacturer level. The impacts of these on costs and CO_2 savings are explored further in the sensitivity section below.

Baseline and van data

A102. The baseline used in the analysis is derived from two sources. The Polk 2008 dataset is used to determine average CO_2 emissions from new vans at the EU and UK level. Baseline emissions for the stock of vans in the UK were taken from modelling done for the Committee on Climate Change (CCC). This should be treated with some caution as CO_2 emissions from vans have only recently started to be recorded. The CCC figure of 269gCO_2/km in 2006 therefore represents a best estimate rather than anything definitive.

A103. New van sales in the UK were taken from Polk 2008 and assumed to stay constant across the period. Van stock data came from Transport Statistics Great Britain[35] and is expected to grow over the period by the same growth factor as forecast by the NTM for van kilometres.

A104. To determine the impact of the policy, the analysis requires an assumption about how baseline fleet efficiency would change over the period. As with new cars, it is assumed that **new** van efficiency stays at 2008 levels for the whole period. Given an absence of robust data of fleet fuel efficiency for vans it is very difficult to determine reliable estimates for how baseline fleet efficiency will change. It was therefore decided to make a simplifying assumption and assume that the van **fleet** will improve at the same rate as the car fleet (given fleet turnover and therefore an increasing proportion of new vans in the fleet over time), at about 9.3% from 2008 to 2025.

A105. However, there is some evidence to suggest this might understate the baseline improvement because there appears to be a greater turnover in the van fleet and which is growing faster than the car fleet so the impact of new vans is greater. Therefore the following estimates should be treated with caution. The DfT is currently engaged in improving its data on van CO_2 emissions and with new data this assumption will be reviewed in any future analysis.

Methodological difficulties of measuring CO_2 emissions from vans

A106. The issue of measuring CO_2 emissions is further complicated by the use that vans are put to. Unlike passenger cars, the weight of vans will vary enormously from that used on a test-cycle depending on the load of the van. This could mean that in real-world terms exactly the same make and model of van will have very different gCO_2/km emissions depending on what it is being used for. Extra care needs to be taken therefore when simply applying test-cycle figures to determine real-world emissions: they are likely to be an underestimate. Work for DfT is currently ongoing which seeks to determine some form of scale-up factor which can be applied to better estimate real-world emissions. While this would still be approximate, it would give a better fit than existing test-cycle data.

A107. A further complication is that around 25% of vans are produced and tested as chassis-cabs such that there is a relatively large proportion of the market where measured emissions will be a serious underestimate of real-world emissions.

Additional costs of technology to reduce CO_2 emissions

A108. Estimates of the cost of fuel saving technology are taken from the TNO report (2006)[28]. The report develops 6 cost curves (one for each fuel type-class) based on bundles of compatible fuel-improving technology. These are an updated version of work carried out by TNO when investigating the scope for improvements in car fuel efficiency as many of the technologies can be employed in both cars and vans. The cost curves were based in 2002 and so have been 're-based' for 2009 (the start of the appraisal period) by taking into account actual and forecast improvements in van CO_2 emissions between 2002 and 2009.

A109. As these are generalised cost curves, there is significant scope for believing that the true costs could be considerably higher or even lower, particularly as they are applied to some very specialist manufacturers who in reality may not have the same CO_2 reducing technologies available to them. Also, the cost curves are "static" across the period, which means that they most likely will over-estimate the true costs as it would be expected that via learning effects the costs should fall over time.

[35] Available at http://www.dft.gov.uk/pgr/statistics/datatablespublications/tsgb/.

Regulation and Targets

A110. The EU Commission published a draft communication in February 2007 followed by a paper in August 2008. This set out the Commission's intention to bring forward legislation to reduce average CO_2 emissions from new vans sold in the EU to 175gCO_2/km in 2012 and 160gCO_2/km in 2015. However, no formal proposal has yet been published. Given the time it is likely to take to reach EU-wide agreement and the lead-times of the industry, it is very hard to believe that a 2012 target is feasible. The 2015 target, while more feasible, would be open to negotiation so could end up being much higher (or lower).

A111. Three scenarios were therefore modelled: 1% p.a. improvement; 175gCO_2/km in 2015 and 160gCO_2/km in 2020; and a scenario mid-way between the two as a central case. The latest report published in December 2008 by the Commission of work done by TNO indicates that a weight-based utility approach may be taken by the regulation in line with the new car CO_2 regulation. The analysis therefore uses this approach to assign targets to all manufacturers for which there is CO_2 and weight data from the Polk dataset.

Fuel savings and oil prices

A112. CO_2 reductions are achieved by improving the fuel efficiency of the vehicle. This confers a financial benefit to the driver as they now require less fuel to drive a given distance. The value of this resource saving to society is included in the analysis. This relies on a forecast of oil prices that are highly uncertain.

Rebound Effect

A113. The analysis assumes that there is no rebound effect even though the cost of motoring has fallen, as it is assumed that van owners only use their vehicles for commercial purposes. Whilst reducing the cost of running a van may make one or two jobs viable at the margin (and thereby increase km driven) this effect is likely to be so slight that it has been excluded from the analysis. This means there are no indirect costs, such as congestion, associated with this measure. However, the latest statistics from Transport Statistics Great Britain show that a sizeable number of vans are privately owned. It is perfectly reasonable to expect a portion of these are not used for commercial purposes. Also, a number of the vehicles covered by any EU van regulation may well be used predominantly for personal use. In which case, some form of rebound effect could be applied. Therefore, as this is excluded from the analysis for a lack of data, it should be noted that both the benefits and costs could be under-estimated although it is hard to say what overall impact this would have on the NPV.

Results of the cost-benefit analysis

A114. The main results of our analysis are given in Figure A18 below. Notwithstanding the uncertainties highlighted above, it is estimated that the central scenario could result in an annual saving of **1.9MtCO_2 in 2020** at a lifetime **net cost of £11/tCO_2** saved. The costs of the policy mainly come from the cost of new technologies while the benefits arise from fuel-cost savings and CO_2 savings.

Figure A18: Summary of the central case results for a possible EU new van CO_2 regulation

		Direct impacts only Central SPC	Including indirect impacts		
			Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		1.9	1.9	1.9	1.9
Impact on other greenhouse gases in 2020 ($MtCO_2e$)		Negligible	Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		1.0	1.0	1.0	1.0
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		5.2	5.2	5.2	5.2
Savings in 3rd budget period 2018-2022 ($MtCO_2$)[1]		9.3	9.3	9.3	9.3
Cumulative savings over appraisal period ($MtCO_2$)		15.5	15.5	15.5	15.5
Present value of costs (£m)		£2,173	£2,173	£2,173	£2,173
Of which	*Technology*	*£2,173*	*£2,173*	*£2,173*	*£2,173*
Present value of benefits (£m)		£2,660	£2,660	£2,992	£2,329
Of which	*CO_2 savings*	*£663*	*£663*	*£995*	*£332*
	Fuel resource cost savings	*£1,997*	*£1,997*	*£1,997*	*£1,997*
Net Present Value (£m)[2]		£487	£487	£819	£156
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[3]		£11	£11	£11	£11
Average value of CO_2 saved (£/tCO_2)		£43	£43	£65	£22
Social benefit-cost ratio		1.2	1.2	1.4	1.1
Fuel saved in 2020 (m litres)		815	815	815	815
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.			
Other non-quantified impacts		Positive impacts on innovation and security of supply.			

[1] Savings calculated only up to 2020.
[2] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[3] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) *Impact of varying oil prices*

A115. Higher oil prices mean that fuel savings are worth more to drivers. Using DECC's oil price scenario 3 ("high demand, producers' market power"), the value of fuel savings increases by 35%. This improves the cost-effectiveness to a net benefit of £35/tCO_2 saved, but CO_2 savings fall marginally to 1.86MtCO_2 in 2020. With the even higher oil price scenario 4 ("High demand, significant supply constraints"), savings in 2020 slip further to 1.81MtCO_2 but cost-effectiveness improves to a net benefit of £80/tCO_2 saved. Conversely, with the lower oil price under scenario 1, CO_2 savings in 2020 rise to 2.0MtCO_2 but cost-effectiveness worsens to a net cost of £33/tCO_2 saved.

Distributional impacts

A116. The costs of the new targets on firms and consumers (as a proxy for wider society) have been estimated. They cannot be summed to find the cost to society, as this would entail double counting. The policy results in a net benefit for firms as their savings on fuel outweigh the increase in technology costs that are passed on to them. Consumers (wider society) gains from the value of reduced CO_2 emissions.

Figure A19: Summary of distributional analysis for a possible EU new van CO_2 regulation

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	£2,977
	Consumers	£641

Source: DfT analysis

Other considerations

A117. The data issues identified above mean that analysis of potential CO_2 savings from van efficiency improvements contains significant uncertainties. Requirements for manufacturers to record CO_2 emissions have only recently been introduced and so even if emissions from new vans are known, it will be some time before a reliable figure for emissions of the van fleet will be known. Without a robust dataset of fleet emissions it is very difficult to determine the potential CO_2 savings and cost-effectiveness of any intervention to reduce CO_2 emissions from vans.

A118. Any regulation of vans would need to be done at the EU level both as member-state legislation is likely to be considered against the internal market, and because as manufacturers operate at the EU level setting the target at this level gives them most flexibility to comply, thereby reducing the overall cost. However, at this stage although the Commission is minded to publish a proposal this year, this could be delayed and it is also unclear: how Member States will react to this; what the targets aimed for would be; how the regulation would be designed to share the CO_2 reduction burden and deal with specialist and small manufacturers; and the penalty regimes to enforce the regulation. All of which means that the van CO_2 regulation is far from certain, and it is unclear how ambitious or expensive it will end up being.

E. Low Rolling Resistance Tyres for Heavy Goods Vehicles

Description of Policy

A119. The European Regulation concerning type-approval requirements for the general safety of motor vehicles (COM(2008) 316 final), "the Regulation", will introduce a package of measures to improve the safety and environmental performance of vehicles in the EU. The measures include new performance criteria for tyres, including rolling resistance and noise limits.

A120. The rolling resistance of the tyres can make a significant difference to the overall resistance to motion, fuel consumption and CO_2 emissions of the vehicle. This analysis quantifies the impacts of compliance with the limit values for rolling resistance for Heavy Goods Vehicle (HGV) tyres prescribed in the Regulation, in comparison to the current state of technology in the tyre market. This analysis does not quantify the potential benefits of purchasing special low rolling resistance tyres, rather the impact of the introduction of a maximum limit value for tyres on sale in the UK. A separate directive on tyre labelling (COM(2008)779) will introduce efficiency labelling to denote and encourage the uptake of special low rolling resistance tyres, but the impacts of this policy have not been quantified here.

Key Points

- The measure has been quantified based on a set of assumptions about the current state of the market for HGV tyres in the UK, the proportion of these that will be affected by the directive, and the impact on fuel efficiency of a unit reduction in rolling resistance[36].
- The impact on fleet average fuel efficiency was run through the DfT's Great Britain Freight Model (GBFM) to assess the impacts on vehicle kilometres and the relative use of rigid vehicles ("rigids") and articulated vehicles ("artics").
- The central scenario is estimated to save **0.2MtCO_2 in 2020** at a **net benefit of £77/tCO_2** saved. However, these results are very sensitive to the assumptions made on additional costs of low rolling resistance tyres and the relationship between reductions in rolling resistance and improvements in fuel consumption.

Key Assumptions & Uncertainties

Scale of impacts

A121. The size of the HGV fleet is assumed to remain at 2007 levels throughout the appraisal period. The analysis was used to calculate fleet weighted average fuel efficiency improvements against the forecast baseline fuel efficiency, and these impacts were input to the GBFM to calculate the impact on fleet vehicle kilometres and CO_2 emissions.

A122. Unlike car tyres, HGV tyres are often re-treaded and re-used. Re-treaded tyres are made by forging new rubber onto the carcass of an expended tyre. The performance of these tyres varies, meaning they cannot be regulated in the same way as new tyres, and are therefore exempt from the Regulation. They are popular among hauliers due to their significant cost advantage. It is estimated that in the UK, 37% of HGV tyre sales are re-treads (RMA, 2006[37]). The analysis assumes that 37% of vehicles therefore run wholly on re-treaded tyres and 63% run wholly on new tyres. In practice, anecdotal evidence from

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[36] The unit of rolling resistance is Kg/ton

[37] RMA (2006) *"Overcoming Market Barriers for Key Stakeholders in Retread Tyre Markets"* AEA Technology plc, available at http://www.retreaders.org.uk/aeatreport.htm.

fleet managers contacted suggests that HGV and Public Service Vehicle (PSV) fleets often run a combination of re-treaded and new tyres.

Costs

A123. The central estimate of increased production costs per tyre of meeting the minimum standards for rolling resistance set in the Regulation is based on an estimate by TNO (2006). TNO estimated increased costs for car tyres at around £8 per tyre. In the central case, it is assumed that the per-tyre increase in production costs is the same for HGV tyres. Per vehicle costs for HGVs will be higher as they use more tyres.

A124. The overall change in vehicle kilometres for HGVs as a result of this measure is relatively small and so any congestion impacts are likely to be limited. The main change that occurs as a result of changes in fuel costs is a shift between rigids and artics, and the CO_2 impacts of this have been taken into account in the modelling.

Benefits

A125. For an HGV, fuel consumption is assumed to improve by the following percentages, for each 1kg/tonne reduction in the rolling resistance of all tyres fitted to the vehicle (estimated from heavy truck tests in SAE, 2008[38]).

Figure A20: Percentage reductions in fuel consumption per 1 Kg/tonne reduction in rolling resistance of all tyres fitted to a vehicle.

Low	Central	High
-2.19%	-3.71%	-5.24%

Source: SAE (2008)

A126. A report by EPEC (2008)[39] was carried out for the European Commission as part of the impact assessment of the Regulation. The report assessed the current state of the market with respect to the rolling resistance performance of tyres, and found the range to be wide. The distribution of tyres within that range was estimated to be approximately normal. In calculating the effect of the Regulation, the current average rolling resistance of tyres on the market has been estimated based on the best and worst tyres on the market according to EPEC. The with-policy average rolling resistance is based on the new limit value as a maximum. It is assumed that the normal distribution of tyre rolling resistance performance is retained, although in practice one might expect that the distribution would become skewed, potentially with some bunching around the limit value.

A127. The Regulation will come into force in a number of stages, applying an initial limit value and a later, stricter limit value to new types of tyres, then to tyres destined for new vehicles, and subsequently to all replacement tyres. The analysis takes this into account and estimates the fleet weighted average fuel consumption impact over time.

Key areas of uncertainty and non-quantified impacts:

A128. The key areas of uncertainty are:

[38] SAE (2008) *"Reducing Tire Rolling Resistance to Save Fuel and Lower Emissions"*, Barrand, J. & Bokar, J., SAE International Technical Paper Series 2008-01-0154.

[39] EPEC (2008) *"Impact Assessment Study on Possible Energy Labelling of Tyres"*, Annex to the Impact Assessment to the European Commission Directorate-General Transport and Energy, carried out under contract: DG TREN No TREN/D3/375-2006.

- The technology or production cost of meeting the limits and how these may change over time.
- The market distribution of tyres by rolling resistance after the limits have been introduced, and how this will change over time.
- The relationship between rolling resistance reductions and fuel consumption improvements in real-world driving.
- Any rebound effect for HGV fuel efficiency improvements.
- The decision by hauliers to switch between rigid and articulated vehicles.

A129. Non-quantified impacts include:

- Possibility that the regulation will lead to increased use of re-treaded tyres (theoretically limited by the supply of expended tyres).
- Air quality impacts have not been quantified due to the complex nature of the way the regulation phases-in and how it will affect new vehicles. For replacement tyres, there will be a positive fuel consumption and air quality impact, but new vehicles whose compliance with Euro VI will be mandatory when the Regulation begins to apply will not benefit to the same extent.

Results of the Cost-Benefit Analysis

A130. The main results of the analysis are given below. The results presented are for the central scenario.

Figure A21: Summary of central case results for HGV LRRTs

		Direct impacts only		
		Low SPC	Central SPC	High SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		0.2	0.2	0.2
Impact on other greenhouse gases in 2020		Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.0	0.0	0.0
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		0.1	0.1	0.1
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		1.1	1.1	1.1
Cumulative savings over appraisal period ($MtCO_2$)		2.4	2.4	2.4
Present value of costs (£m)		£99	£99	£99
Of which	*Cost of technology*	*£99*	*£99*	*£99*
Present value of benefits (£m)		£333	£381	£429
Of which	*CO_2 savings*	*£46*	*£96*	*£144*
	Fuel Resource Cost Savings	*£285*	*£285*	*£285*
Net Present Value (£m)[1]		£234	£282	£331
Cost-effectiveness: Net Cost per tonne of CO_2 saved (£/tCO_2)[2]		-£77	-£77	-£77
Average value per tonne of CO_2 saved (£/tCO_2)		£20	£40	£59
Social Benefit-Cost ratio		3.4	3.9	4.4
Road fuel saved in 2020 (m litres)		92	92	92
Impact on Renewable Energy Target	Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.			
Other non-quantified impacts	Positive impacts on innovation and security of supply.			

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) *Impact of different oil price scenarios*

A131. As set out in the main impact assessment, DECC have developed four oil price scenarios. The main results presented in the table above use the timely investment, moderate demand scenario. Different oil price scenarios do not generate a marked difference in the estimate of CO_2 savings in 2020 for HGV LRRT. However, they do impact on the cost-effectiveness of the measure (as the value of the fuel savings is changed). Using the low global energy scenario, the measure results in a net benefit of £44/tCO_2. The higher oil price scenarios: “high demand, producers’ market power”, and “high demand, significant supply constraints” result in a net benefit per tonne of CO_2 saved of £126/tCO_2 and £167/tCO_2 respectively.

b) *Varying technology costs*

A132. Costs in the central case are based on the effect on the average price of new tyres resulting from manufacturers re-designing the worst-performing tyres to comply with the limits set out in the Regulation. This is not to be confused with the voluntary purchase of tyres of exceptionally low rolling resistance, as this would provide greater fuel efficiency benefits than have been modelled in this analysis. The cost to be represented here is simply the cost of an average tyre on the market after the limit values have been implemented. Recent market research by Ricardo for the Department for Transport suggests that even special low rolling resistance tyres available today carry no purchase premium, but one manufacturer cites potential decreased service life on the drive axle of the vehicle.

Distributional impacts

A133. The policy results in a net benefit for consumers and firms. Firms are assumed to save on fuel costs. The value of the CO_2 saved is allocated to consumers.

Figure A22: Summary of distributional analysis for HGV LRRTs

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	£696m
	Consumers	£96m

Source: DfT analysis

F. Safe And Fuel Efficient Driving training for Bus Drivers

Description of policy

A134. In 2008, the DfT undertook a consultation on the Bus Services Operators Grant (BSOG). This grant is a payment to bus operators to offset a high proportion of the fuel duty costs they incur (equal to around 80% of the fuel duty cost). The DfT has been considering how to better align this funding with its objectives, particularly with respect to the environment, and has implemented a series of changes aimed at improving the environmental performance of buses. The 2008 pre-budget report announced that the BSOG reforms would include incentives to improve fuel efficiency, with the DfT supporting a demonstration project to encourage more fuel efficient driving by bus operators.

Key points to note

- The Safe and Fuel Efficient Driving (SAFED) demonstration programme is aimed at encouraging fuel efficient driving in the bus and coach sector.
- The trials of SAFED consistently show significant improvements in fuel efficiency – between 5% and 15% – and reductions in accidents.
- While the freight transport sector has generally adopted eco-driver training, only a couple of bus operators have invested in this so far.

Key assumptions and uncertainties

A135. We have assumed an appraisal period that runs from 2009 to 2030 and have discounted all future costs and benefits into 2009 prices and values.

Fuel costs

A136. The assumed resource cost of fuel over the appraisal period is taken from DECC's oil price projection scenario 2. We have also assumed that fuel duty rises in line with inflation and the rate of BSOG increases by 3% per year (both these are reasonable given current discussions on BSOG reforms and past trends in fuel duty).

Wage and training costs

A137. These are assumed to equal £85 per driver per day and rise by 3% per year. The SAFED training programme is initially assumed to reach 1% of drivers (around 1,260) and costs £1m. Average training costs per driver after this point are based on research at a figure between £500 and £600 (and assumed in our model to be £515).

Fuel efficiency

A138. We have assumed that each driver improves their fuel consumption by 10%.

Depreciation of benefits

A139. We have assumed each driver "loses" 5% of the fuel efficiency benefits they obtained through SAFED each year i.e. in year 1 the 1% of drivers trained might reduce fuel consumption by 1 million litres but in year 2 they would only reduce fuel consumed by 0.95 million litres. After 5 years it is assumed that each driver is re-trained. This is in line with assumptions on SAFED for freight drivers.

Uptake of SAFED

A140. We have assumed that the SAFED programme reaches 30% of drivers by 2010 and 80% by 2014. We envisage this relatively fast uptake given the strong possibility that the possible BSOG reforms will be tied to fuel efficiency improvements and given the relatively large capacity to train drivers. Whilst the CPC directive may encourage more bus operators to send drivers onto SAFED courses, it is certainly not mandatory do so: the 80% figure reflects the willingness that the largest five bus operators in the UK (approximately 70-80% of the market share) have shown towards safe and fuel efficient driving techniques and their incentive to profit maximise by cutting fuel costs.

A141. We have not made any allowances for rebound effects. In theory it might be feasible that bus operators would expand bus services given the fuel cost savings. However, it could be argued that the marginal costs of operating additional bus services is likely to be significantly more than the marginal benefits of operating additional services in the presence of lower fuel costs. There are therefore only assumed to be direct impacts associated with the policy.

Results of the cost-benefit analysis

A142. The appraisal has been done on the basis of a ‘do nothing’ scenario that involves no driver having under gone the SAFED programme while the ‘do something’ includes a steady roll out of drivers being trained. It is assumed that by 2020 80% of bus drivers are SAFED trained. The main results of our analysis are given in Figure A23 below. It is estimated that the future SAFED programme would result in an annual CO_2 saving of **0.2MtCO_2 in 2020** at a lifetime **net benefit of £82/tCO_2** saved.

A143. The costs of the policy mainly come from the training cost of SAFED and the wages paid while drivers are training. The benefits of the policy mainly come from the lower fuel costs.

Figure A23: Summary of central case results for SAFED training for bus drivers.

		Direct impacts only
Impact on annual CO_2 in 2020 ($MtCO_2$)		0.2
Impact on other greenhouse gases in 2020 ($MtCO_2e$)		Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.4
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		1.0
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		1.0
Cumulative savings over appraisal period 2008-2030 ($MtCO_2$)		3.5
Present value of costs (£m)		£113
Of which	*Training (and lost wage) costs*	*£113*
Present value of benefits (£m)		£530
Of which	*CO_2 savings*	*£135*
	Fuel Resource Cost Savings	*£395*
Net Present Value (£m)[1]		£417
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		-£82
Average value of CO_2 saved (£/tCO_2)		£39
Social benefit-cost ratio		4.7
Fuel saved in 2020 (m litres)		81
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.
Other non-quantified impacts		There could be potential time saving changes due to changes in acceleration and braking patterns. There could also be improved time savings via lower congestion. We have not attempted to quantify this impact.

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) <u>*Different fuel efficiency assumptions based on SAFED results*</u>

- An 8% fuel efficiency leads to an NPV of £311m and a CO_2 saving in 2020 of 0.15$MtCO_2$.
- A 12% fuel efficiency leads to an NPV of £523m and a CO_2 saving in 2020 of 0.23$MtCO_2$.

A144. As we would expect, an assumed lower fuel efficiency figure delivers a lower NPV and CO_2 saving and vice versa for higher fuel efficiency assumptions. This is because lower (higher) fuel efficiency assumptions mean lower (higher) fuel consumption and lower (higher) resource costs to bus operators as well as lower (higher) emission levels. It is clear that the NPV is quite sensitive to changes in assumptions relating to fuel efficiency.

b) *Different fuel price assumptions*

- Using oil price scenario 1 (the lowest oil price scenario) leads to an NPV of £326m and a CO_2 saving in 2020 of 0.19MtCO_2.
- Using oil price scenario 3 (the high oil price scenario) leads to an NPV of £548m and a CO_2 saving in 2020 of 0.19MtCO_2.

A145. The NPV is also sensitive to changes in the assumed price of oil. As oil prices increase, the opportunity cost of not investing in the SAFED programme increases as the resource benefits from improved fuel efficiency increase dramatically. The CO_2 saving is independent of changes in the price of oil and fuel consumption is assumed not to change. In reality this might not be the case. For example, it may be that an increasing price of fuel might cause people to switch from cars to buses which would increase overall bus CO_2 emissions but lower total road transport emissions.

c) *Different depreciation of benefits*

- A 10% annual loss in fuel consumption benefits leads to an NPV of £327m and a CO_2 saving in 2020 of 0.16MtCO_2.
- A 20% annual loss in fuel consumption benefits leads to an NPV of £148m and a CO_2 saving in 2020 of 0.11MtCO_2.
- A 50% annual loss in fuel consumption benefits after the end of three training courses from 2022 onwards leads to an NPV of £354m.

A146. The CO_2 savings of the SAFED programme are quite sensitive to what is assumed about how long the benefits last for each driver. We have assumed a 5% annual "loss" in the SAFED benefits per year per driver trained. An increase in this assumed "loss" in benefits significantly reduces the potential for CO_2 reductions.

Distributional impacts

A147. Figure A24 below illustrates the impact of the SAFED programme on different groups. The table shows that there is no impact on consumers. This is unlikely to be the case given the possible change in journey times and possible reductions in fares (or even increased service levels) as a consequence of the fuel savings. However, given the complexity of this issue we have not attempted to model this impact. The main impact is the resource saving on fuel to bus operators.

Figure A24: Summary of distributional analysis for SAFED for bus drivers

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms (bus operators)	£406m
	Consumers	n/a

Source: DfT analysis

Other considerations

A148. The proposed reforms to BSOG are likely to include incentives for bus operators to improve their fuel efficiency. It is possible that the SAFED programme will be part of a package of measures aimed at improving the fuel efficiency of buses alongside incentives for Low Carbon Emission Buses. In a world of high fuel prices the opportunity cost of not investing in the SAFED programme for bus operators increases. In addition, in a possible world where changes in BSOG are linked to fuel efficiency improvements then there will be a clear incentive (and need) for bus operators to invest in the SAFED programme.

G. Low Carbon Emission Buses

Description of policy

A149. Recent changes to the Bus Services Operators Grant (BSOG) include incentives for Low Carbon Emission Buses (LCEBs) equal to 6p per operated kilometre. On average, this is the amount of BSOG an operator would have "lost" had they not purchased a LCEB. Before the introduction of this incentive in April 2009, BSOG implicitly reduced the incentive for bus operators to invest in a LCEB given the reduction in BSOG an operator would have received. In addition, the DfT recently announced a £30 million grant over the next two years to support the introduction of LCEBs. This grant is open to bus operators to bid for the additional cost of a LCEB compared to a standard diesel bus and further supports the BSOG incentives aimed at stimulating the market for LCEBs.

A150. The modelling of LCEB for this work assumes a particular uptake of LCEBs which is driven in part by the existence of these incentives. This assumed uptake determines the potential impact of an increased uptake of LCEBs on bus operators.

A151. Our broad estimates of the likely costs of LCEB are from discussions with the Low Carbon Vehicle Partnership (LCVP) who have also advised on purchase costs and how they might change overtime. The key assumptions rest with purchase costs and future fuel duty and BSOG changes.

Key points to note

- An LCEB is "low carbon" as it is generally considered to be a hybrid bus which combines a conventional engine and an electric motor. These buses have the potential to produce at least a 30% reduction in greenhouse gas emissions compared to a Euro III standard diesel bus. However, an electric bus also meets the LCEB definition but with added emission benefits.
- As part of the changes being made to the BSOG - which is a payment to operators to offset a high proportion of the fuel duty costs incurred - additional BSOG is being made available to operators who purchase and operate LCEBs. The definition adopted for an LCEB is a bus that is able to achieve the LCEB target for greenhouse gas emissions, which is equivalent to a 30% reduction in its greenhouse gas emissions compared to a current Euro 3 diesel bus of the same total passenger capacity.
- In general, an LCEB is currently relatively expensive compared to a standard diesel bus, even accounting for the potential fuel cost savings associated with an LCEB. Relatively few bus operators have therefore invested in an LCEB so far. However, with the BSOG incentive for LCEBs taking effect from April 2009, the £30m grant scheme and the Transport for London (TfL) plans, we expect purchase costs to fall in the next few years as the manufacturing of LCEBs develops and economies of scale are achieved. TfL has recently announced that several hundred hybrid buses will be in operation by 2012. The fall in purchase costs will make the commercial attractiveness of an LCEB much stronger. This key assumption (and future changes in fuel prices) drives the potential for take-up of LCEBs.

Key assumptions and uncertainties

A152. We have assumed an appraisal period that runs from 2009 to 2036. This appraisal period has been chosen because it is assumed that a bus has a 15 year life. Given an appraisal period for the policy to 2022, we need to assess all costs and benefits of LCEBs that have been purchased up to this point. The last set of buses purchased in 2022 therefore need to have their costs and benefits assessed for the full life cycle of the bus i.e. 15 years from 2022 (2036).

A153. The assumption is that there is currently a very small number of LCEBs (around 65 buses, equal to 0.15% of the bus fleet). This is assumed to rise to 4% of the fleet by 2015 (around 1,700 LCEBs) and increasing to 34% by 2022 (equal to around 14,630 LCEBs). All future costs and benefits have been discounted into 2009 prices and values.

Purchase costs

A154. The current purchase costs of an LCEB is assumed to be £230,000 (£100,000 more than a standard diesel bus) but are assumed to fall to £185,000 in 2012, given that we are expecting higher demand to result in some reduction in purchase costs. The £230,000 assumption has been cited by a bus manufacturer as a current cost, while the £185,000 assumption is a mid-estimate taken from the LCVP cost estimate of LCEBs, once a small amount of mass production is achieved. We have also assumed that in 2019, the purchase costs of an LCEB fall to £150,000 as further economies of scale in production are achieved. This is also an estimate from the LCVP and 2019 represents a reasonable estimate of when this is likely to be achieved. The reduction is assumed to be a step change rather than a gradual reduction as per advice from the LCVP.

Fuel efficiency

A155. A further assumption is that an LCEB is 30% more fuel efficient than a standard bus i.e. it consumes 30% less fuel per km than a standard bus. Using published data on total bus kilometres in 2007/08 and the assumption that there are 26,500 buses outside London, we can calculate the implied average kilometres driven per average bus (around 65,000 per year). We have applied this assumption to all of the UK including London, which implies there are broadly around 43,000 buses operating local services.

Uptake of LCEBs

A156. We have assumed a small uptake of LCEBs initially, given TfL plans and LCEB trials. There is therefore likely to be a small uptake before purchase costs fall, partly as a result of the incentives for LCEBs and given TfL's plans. We have assumed that by 2014, LCEBs represent 3% of the bus fleet. Purchase costs are assumed to fall in 2019, greatly enhancing the commercial attractiveness of LCEBs. To account for a more significant increase in LCEBs, we have assumed the uptake of LCEBs as a share of the bus fleet to be 20% by 2020 and 34% by 2022.

A157. We have made allowance for the SAFED bus driver training scheme so all benefits have been calculated as cumulative and over and above those from the SAFED programme.

A158. We have not made any allowances for rebound effects. This is because we do not expect large increases in bus services over the next few years. In addition, the marginal cost of operating additional bus services is likely to be significantly more than the marginal benefits of operating additional services in the presence of lower fuel costs, making rebound effects from bus service changes less likely. There are therefore only assumed to be direct impacts associated with the policy.

Results of the cost-benefit analysis

A159. The impact of an increasing uptake of LCEBs has been assessed against a counterfactual of a 'do nothing' scenario that involves purchasing a stand diesel bus. The main results of our analysis are given in Figure A25 below. It is estimated that the future LCEB would result in an annual CO_2 saving of **0.17MtCO_2 in 2020** at a lifetime **net benefit of £7/tCO_2** saved.

A160. The costs of the policy mainly come from the cost of new LCEBs while the benefits are simply the resource cost savings from fuel. In respect of air quality standards, new buses are required to meet certain criteria on air quality emissions and these are projected to become tighter overtime. Although the assumption being made is that new LCEBs will meet the same emission standards as new Euro V engines, we do expect there to be some air quality benefits, particularly if electric buses are rolled out on any significant scale. However, the complications associated with measuring this impact means this has not been quantified.

Figure A25: Summary of central case results for Low Carbon Emission Buses

		Direct impacts only
Impact on annual CO_2 in 2020 (MtCO_2)		0.2
Impact on other greenhouse gases in 2020 (MtCO_2e)		Negligible
Savings in 1st budget period 2008-2012 (MtCO_2)		0.0
Savings in 2nd budget period 2013-2017 (MtCO_2)		0.2
Savings in 3rd budget period 2018-2022 (MtCO_2)		0.9
Cumulative savings over appraisal period 2008-2036 (MtCO_2)		4.9
Present value of costs (£m)		£396
Of which	*Purchase costs*	*£396*
Present value of benefits (£m)		£611
Of which	*CO_2 saving*	*£167*
	Fuel Resource Cost Savings	*£444*
Net Present Value (£m)[1]		£215
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		-£7
Average value of CO_2 saved (£/tCO_2)		£36
Social benefit-cost ratio		1.7
Fuel saved in 2020 (m litres)		71
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.
Other non-quantified impacts		Positive impacts on innovation and security of supply.

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) *<u>Different fuel efficiency (lower and upper estimates of potential efficiency gains of LCEB)</u>*

- A 20% fuel efficiency improvement leads to an NPV of £8.8m and a CO_2 saving in 2020 of 0.1MtCO_2.
- A 40% fuel efficiency improvement leads to an NPV of £421m and a CO_2 saving in 2020 of 0.2MtCO_2.

A161. The 20% and 40% fuel efficiency sensitivity assumptions are the lower and upper estimates the evidence suggests that LCEBs are able to achieve (with our central estimate being 30%). As we would expect, a reduction in the assumed fuel efficiency of an LCEB by around a third to 20% leads directly to a reduction in the potential CO_2 benefits by approximately 30%, and vice versa for an assumed higher level of fuel efficiency. It is also noticeable that the NPV is highly sensitive to changes in the assumed fuel efficiency of LCEBs. This is because the commercial attractiveness of an LCEB depends critically upon the relationship between the cost and potential future resource cost savings in fuel.

b) *<u>Different purchase costs</u>*

- A 5% higher purchase cost in 2010 of an LCEB leads to an NPV of £180m and a CO_2 saving in 2020 of 0.2MtCO_2.
- A 5% lower purchase cost of an LCEB in 2010 leads to an NPV of £250m and a CO_2 saving in 2020 of 0.2MtCO_2.

A162. As well as the assumed fuel efficiency of an LCEB, the key decision an operator faces at the margin will be the relative purchase cost of an LCEB compared to a standard diesel bus. The sensitivity check on different purchase costs of an LCEB shows that the commercial decision to invest in an LCEB – implicitly captured by the NPV – is highly sensitive to assumed changes in purchase costs. A 5% higher purchase cost results in a negative NPV, while a 5% lower cost dramatically increases the NPV. The potential CO_2 savings are independent of this.

Distributional impacts

A163. The table below does not show an impact on consumers, although in practice there is a possible reduction in fares (or even increased service levels) as a consequence of the fuel savings. However, given the complexity of this issue we have not attempted to model this impact. The main impact shown is therefore the resource saving on fuel to bus operators.

Figure A26: Summary of distributional analysis of Low Carbon Emission Buses

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms (bus operators)	£247m
	Consumers	n/a

Source: DfT analysis

Other considerations

A164. The analysis makes no assumption about rebound effects and is highly dependent on the assumed change in purchase costs of LCEBs. It is also dependent on the average LCEB achieving a 30% fuel efficiency saving and on future trends in fuel prices.

H. Illustrative Rail Electrification

A165. The illustrative CO_2 savings presented in the evidence base above are derived from our estimate that electrifying a typical main line carrying a relatively high level of passenger traffic would deliver a reduction in (diesel) emissions of approximately 20,000 tonnes of CO_2 per 100 single track kilometres electrified. The emissions savings from electrification of an illustrative 750 single track kilometres of rail line is therefore estimated to amount to 0.15 $MtCO_2$ in 2020. The emissions savings that may be generated from electrifying a specific rail route will depend heavily on its traffic density and rolling stock characteristics. The most cost-effective routes for electrification will be the busier of the remaining diesel operated lines, where the cost savings from running electric trains can offset the additional infrastructure costs.

A166. The emissions savings presented do not take account of the increase in emissions from an increase in electricity use, and therefore reflect the emissions reductions that would occur in the non-traded sector. In the traded sector, the cap on emissions ensures that any increase in emissions is offset by reductions made elsewhere in the trading scheme. There is therefore no net increase in traded sector emissions as a consequence of electrification.

A167. Electric trains typically emit between 20% and 35% less CO_2 emissions than equivalent diesel trains on the basis of the current electricity generation mix. As the generation mix becomes less carbon intensive over time, this performance will improve still further. In addition, the use of regenerative braking enables many electric trains to re-use the energy that would otherwise have been lost when braking. This system, already in widespread use on parts of the network, can reduce overall energy consumption and CO_2 emissions by a further 25%.

<u>Unquantified measures</u>

A168. In addition to the measures outlined above, there are a number of measures included within the Strategy which we have not been able to model at this time because of a lack of data, for example. For measures relating to road transport, some of these will contribute towards the achievement of the savings estimated above. For example, the ACT ON CO_2 campaign – the cross-government campaign that provides information about climate change and advice to consumers about easy, achievable ways in which they can reduce their emissions – provides advice to consumers about buying the most fuel efficient car to meet their needs. The potential emissions savings from this would therefore be expected to contribute towards the achievement of the EU new car CO_2 regulation targets.

A169. Conversely, there may be other road transport measures in the Strategy that could result in additional emissions savings. For example, the ACT ON CO_2 campaign also provides advice on the steps that drivers can take to drive their car more efficiently, such as driving more smoothly. This would generate additional savings under option 2 (although they would not be additional to the eco-driving estimate set out under option 3).

A170. Measures relating to aviation and shipping would also produce additional savings to the total for the Strategy set out in the evidence base above. These measures are outlined below, and more information can be found in the Carbon Reduction Strategy for Transport.

Aviation measures

A171. Emissions from domestic aviation will be counted towards the carbon budget for the non-traded sector in the first budget period (2008 – 2012). However, these emissions are expected to become part of the traded sector when aviation joins the EU ETS in 2012. Forecast emissions in the baseline from domestic aviation are consistent with the assumptions used to produce the aviation forecasts set out in DfT (2009), *"UK Air Passenger Demand and CO_2 Forecasts"*. Hence any expected improvements in fuel efficiency as a result of, for example, the existing ACARE targets (e.g. from improved technology of new aircraft entering the fleet or improvements to Air Traffic Management) are included in the baseline. Also included is the impact of capacity constraints at airports, taking account of any additional capacity supported by the Air Transport White Paper (2003).

A172. We are taking action in a number of areas to encourage and promote the uptake of more fuel-efficient aircraft technology. The UK has also adopted a target to reduce emissions from UK aviation to 2005 levels by 2050. Given the international nature of the sector, we are pressing for the inclusion of international aviation in the global deal being negotiated at Copenhagen later in 2009, and we are promoting international emissions trading mechanisms as a key policy lever. We have played a leading role in the decision to include CO_2 emissions from aviation in the EU Emissions Trading System from 2012.

A173. Domestic aviation emissions are included within the UK carbon budgets. This sector emits only a very small proportion of the UK's emissions – less than 0.5% of total UK greenhouse gas emissions. However, it is nonetheless important to consider ways in which emissions from this sector could be reduced. Work commissioned from The Centre for Air Transport and the Environment at Manchester Metropolitan University and Cranfield University by the Department for Transport in 2008 indicates that there are a range of possible options[40].

A174. This particular study considered the scope for reducing domestic aviation emissions through engine and airframe technology, operational improvements and fleet management. This demonstrated that although the scope for reductions is dependent on a broad range of factors, including oil prices, the pace of technology development and ability to uptake new technologies – and their cost, there is scope for notable reductions at relatively low cost.

Shipping measures

A175. We are working within the International Maritime Organization (IMO) on technical and operational measures to reduce CO_2 emissions from ships, such as:

a. an Energy Efficiency Design Index for new ships, which would rate ship designs on their energy efficiency, allowing ship owners to choose the most energy efficient ship; and
b. a voluntary Energy Efficiency Operational Index for current ships, and a range of voluntary operational and technological improvements. Measures being discussed at the IMO include harnessing wind power, alternative fuels, and reduced speeds to reduce the environmental impact of the sector.

A176. Shipping, like aviation, is a global industry, and so we are working with our international partners and within international fora such as the IMO and the UN Framework Convention on Climate Change (UNFCCC) to drive action to reduce emissions from the sector. The UK is pushing for international shipping to be included in any global deal agreed at

[40] Available at http://www.dft.gov.uk/pgr/aviation/environmentalissues/carbonreductionfutures

Copenhagen in December, as we believe that international shipping should be set a global sector-level target. We will also work within the IMO to develop a new convention to deal with greenhouse gas emissions from ships through an economic instrument such as an emissions trading scheme at a global level.

A177. Until a truly global solution can be found, or should progress within the IMO prove too slow, we will continue to look at other options, notably those proposed at EU level, such as to include shipping emissions in the EU Emissions Trading System (EU ETS).

Option 3: Additional abatement identified by the Committee on Climate Change

A178. The following measures were modelled for option 3:

- an extension to the Smarter Choices programme;
- eco-driving training for existing licence holders; and
- speed reduction and enforcement at 60mph.

A. Extension of the Smarter Choices Programme

Description of policy

A179. This describes the appraisal of a rolling out of the Smarter Choices programme to all urban areas in the UK. Smarter Choices refer to alternative methods in car-usage reduction policy. Emphasis is placed on persuasion rather than fiscal measures in an attempt to better inform the road-user into using alternative, more sustainable modes of transport. The fundamental objective is to reduce car dependency, thereby achieving lower traffic levels and lower emissions. For the purposes of this analysis, Smarter Choices is not assumed to influence choice of vehicle or driving techniques.

Key points

- CO_2 savings come from the reduction in vehicle kilometres which result from the implementation of Smarter Choices measures in urban areas[41].
- It is assumed that the policy is in place from 2009 until 2020 in urban areas in the UK.
- The potential benefits and costs of implementing Smarter Choices on a national scale are difficult to determine and subject to much uncertainty. As a result this analysis should only be considered an indication of the scale of emissions reductions that could be achieved from this policy measure and the costs of such a policy.
- The central scenario is estimated to save **0.94MtCO_2 in 2020** at a **net benefit of about £74/tCO_2**. These results are very sensitive to the assumptions made on the value of congestion and the costs of implementing such measures.
- The CO_2 savings from Smarter Choices are dependent upon there being in place demand side measures which help lock in the benefits from any Smarter Choices initiative.

Key assumptions and uncertainties

A180. The modelling assumes that Smarter Choices is rolled out nationally in urban areas. The key piece of evidence upon which much of the analysis is based is a 2005 report, *"Smarter Choices – Changing the Way We Travel"*[42].

[41] It assumes that the vehicle kilometre reductions originate only in urban areas, not that the vehicle kilometre reductions only occur for drivers who live in urban areas.

A181. The key factors influencing the cost of this policy and its impact on CO_2 emissions are set out below. These assumptions do not prejudge decisions on the scope or scale of potential policy measures in this area, but are used merely for illustrative purposes.

Baseline

A182. The baseline assumes there is an EU-wide CO_2 target for new cars of 95gCO_2/km by 2020 and that the 130gCO_2/km target is met in 2015. It is also assumed that 'complementary measures' and a national eco-driving initiative are in place which will all further reduce the real world CO_2 emissions of vehicles. Biofuels are assumed to make up 10% (by energy) of transport fuel used. The latest population forecasts, GDP forecasts and oil price forecasts are used in the baseline.

Reductions in traffic

A183. Figure A27 below compares the average assumptions used in the modelling with the estimated behavioural changes presented in the original Smarter Choices report (2005).

Figure A27: Comparison of behavioural change assumptions from Smarter Choices measures

% Change	Report (2005)		DfT Modelling (2009)
	High Intensity scenario	Low Intensity scenario	
Car trips in 2020	11%	2-3%	7%
Car km in 2020	11%	2-3%	3.7%

A184. The 2005 report assumed that the change in car kilometres would equal the change in car trips. For the latest modelling, we used DfT's National Transport Model (NTM) to estimate the change in car kilometres for a given change in car trips. The NTM predicted that most of the substitution in car journeys would be of shorter distance, so the change in kilometres would be lower than the change in the number of car trips. The change in vehicle kilometres varies year on year, increasing until 2020.

A185. Smarter Choices policy is likely to be targeted towards urban areas which have strong public transport links and a relatively large population. In light of this we have assumed that the reduction in vehicle kilometres occurs only in urban areas. The table below outlines the reduction in vehicle kilometres considered within the model.

Figure A28: Table showing assumed reduction in vehicle kilometres

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Urban areas	2.6 %	2.6 %	2.7 %	2.9 %	3.0 %	3.1 %	3.2 %	3.3 %	3.4 %	3.5 %	3.6 %	3.7 %	3.8 %	3.9 %

Source: DfT analysis

[42] Available at http://www.dft.gov.uk/pgr/sustainable/smarterchoices/ctwwt/.

Costs of a Smarter Choices scheme

A186. The cost of the scheme is based on the cost of implementing Smarter Choices measures in the Sustainable Travel Towns of Worcester, Peterborough and Sutton. Using this data an average cost per head per scheme is calculated. The cost of the Worcester scheme was higher at £16.13 per head than the costs of the Peterborough and Sutton schemes. To reflect the potential additional costs associated with implementing the policy nationwide we have assumed that the costs per head would be equivalent to the costs in Sutton which represents the central estimate of the three towns. Our analysis therefore assumes that the costs of the case study areas in Worcester, Sutton and Peterborough are transferable nationwide.

A187. These yearly costs per head are then multiplied by yearly urban population UK forecasts from the ONS to obtain the total costs of the scheme. This assumes therefore that the Smarter Choices measures are in place across all urban areas of the country. It is assumed that the costs of the scheme increase by 2.0% per annum.

Benefits of a Smarter Choices scheme

A188. The dominant monetised benefit is the reduction in congestion in urban areas. To calculate this we have used the NTM’s estimate of the congestion cost per kilometre in urban areas which has been derived using the NTM modelling of the congestion cost arising from the EU new car CO_2 regulation. Other monetised benefits include fuel savings, reductions in CO_2, a fall in air quality pollutant emissions resulting from a fall in vehicle kilometres and the impacts on infrastructure, accidents and noise. There could also be significant health benefits associated with this type of policy (from an increase in walking and cycling), although these have not been monetised. To ensure that the reduction in vehicle kilometres originating from a Smarter Choices programme is sustained over the long-term, there needs to be complementary demand side measures in place. This modelling implicitly assumes that demand side measures such as congestion charging and parking controls are in place, which lock-in the fall in vehicle kilometres arising from the Smarter Choices measures.

Rebound effect

A189. It has been assumed that the reductions in traffic are net of any rebound effect – we have assumed that Smarter Choices measures do not result in a rebound effect.

Results of the cost-benefit analysis

A190. The main results of our analysis are given in Figure A29 below. The central scenario is estimated to save **0.9MtCO_2 in 2020** at a **net benefit of £74/tCO_2**. However, given the uncertainty surrounding the assumptions used (as described above), these impacts are only speculative, especially the estimate of costs.

A191. The costs of the measure arise from the estimated implementation cost of the policy. The benefits arise from fuel-cost savings, CO_2 savings, congestion benefits, reduced emissions of air quality pollutants and the effect on accidents, infrastructure and noise. Reducing congestion is treated as a direct benefit here as the direct impact of the policy is to reduce vehicle kilometres.

Figure A29: Summary of central case results of extending the Smarter Choices Programme

		Direct impacts only		
		Central SPC	**High SPC**	**Low SPC**
Impact on annual CO_2 in 2020 ($MtCO_2$)		0.94	0.94	0.94
Impact on other greenhouse gases in 2020		Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		3.2	3.2	3.2
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		4.4	4.4	4.4
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		4.7	4.7	4.7
Cumulative savings over appraisal period ($MtCO_2$)		12.4	12.4	12.4
Present value of costs (£m)		£5,960	£5,960	£5,960
Of which	*Policy Implementation Cost*	*£5,960*	*£5,960*	*£5,960*
Present value of benefits (£m)		£7,435	£7,712	£7,158
Of which	*Congestion*	*£3,679*	*£3,679*	*£3,679*
	CO_2 savings	*£555*	*£832*	*£277*
	Fuel Resource Cost savings	*£1,644*	*£1,644*	*£1,644*
	Air Quality Pollutant Savings	*£77*	*£77*	*£77*
	Infrastructure, Accidents and Noise	*£1,480*	*£1,480*	*£1,480*
Net Present Value (£m)[1]		£1,475	£1,753	£1,197
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		-£74.2	-£74.2	-£74.2
Average value of CO_2 saved (£/tCO_2)		£45	£67	£22
Social benefit-cost ratio		1.25	1.29	1.20
Fuel saved in 2020 (m litres)		432	432	432
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.		
Other non-quantified impacts		Health benefits. Fuel costs of mode shift to public transport		

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) *Impact of higher oil prices*

A192. Assuming higher oil prices in our analysis makes a significant difference to the cost effectiveness of the policy but only has a marginal impact on the CO_2 savings. The large impact on cost effectiveness is due to the changes in the implied congestion price. In oil price scenarios 3 and 4 there is less traffic on the road and therefore the implicit price of congestion is lower in these scenarios. A major benefit of Smarter Choices is the reduction in congestion so, combined with a lower implicit value of congestion, implies that under the higher oil price scenarios the policy becomes less cost-effective. When DECC's scenario 3 oil price is used the CO_2 savings are 0.97MtCO_2 and the cost effectiveness is a net benefit of £10/tCO_2, while under DECC's oil price scenario 4 the CO_2 savings are 0.9MtCO_2 and the cost effectiveness is a net cost of £5/tCO_2.

b) *Impact of changing the cost assumptions*

A193. In our central case we have assumed that the cost of the policy is £8.96 per head per year. If we revised this to the average cost per head of the three sustainable travel towns of £10.62 then the policy would have a net cost of £15/tCO_2. Alternatively, increasing the cost of the policy to £16.13 per head (consistent with the costs sustained in the Worcester sustainable travel town) would make the policy have a net cost of £311/tCO_2. The cost-effectiveness of Smarter Choices measures is therefore very sensitive to the cost of implementing the policy.

c) *Impact of higher/lower congestion benefits*

A194. We have calculated congestion costs based on the implied congestion price used in the NTM modelling of the costs of congestion associated with the EU new car CO_2 regulation. The results of the Smarter Choices modelling are very sensitive to this pricing assumption. For instance, using a congestion price of 6.2p per kilometre in 2015 and 8.6p per kilometre in 2025 would result in the policy having a net benefit of £151/tCO_2 compared with £74/tCO_2 if we used the congestion price implied in our central scenario of 4.9p per kilometre in 2015 and 6.8p per kilometre in 2025.

d) *Impact of a greater/smaller reduction in vehicle kilometres*

A195. The original 2005 Smarter Choices report identified high and low 'intensity' scenarios to look at the impact of pursuing Smarter Choices measures with differing degrees of intensity (and therefore the resulting reduction in car trips and kilometres). Using the high and low scenarios significantly changes the results: the high scenario increases the CO_2 savings to 1.46MtCO_2 with a net benefit of £399/tCO_2; the low scenario reduces the CO_2 savings to 0.43MtCO_2 with a net benefit of £37/tCO_2.

Distributional impacts

A196. The impacts of this measure on two groups in society (firms and consumers) have been estimated. The policy results in a net benefit for both groups. The public are assumed to save on fuel costs and to benefit from a reduction in CO_2 emissions, congestion and an improvement in air quality. Firms are expected to benefit from reduced fuel costs and congestion.

Figure A30: Summary of distributional analysis of extending the Smarter Choices programme

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	£3,152m
	Consumers	£5,988m

Source: DfT analysis

Other considerations

A197. There is an inherent difficulty with estimating the national costs of this type of policy. Due to different circumstances across urban areas the costs which need to be incurred to achieve the same level of return across different urban areas are likely to vary significantly. While the funding allocation to local authorities would be finite, the benefits which result from this funding would be very uncertain. Therefore assuming a fixed rate of return from spending on Smarter Choices would be incorrect as it would vary significantly across different urban areas and we do not have sufficient data to support such a conclusion.

A198. Furthermore, one could also envisage economies of scale from implementing Smarter Choices policy nationally. For example, national advertising campaigns are cheaper than having a series of local campaigns and the messages are more likely to spread through word of mouth if the policy is repeated on a national scale. This may imply that using cost estimates originating from a series of local Smarter Choices initiatives as done in this modelling may overestimate the total costs.

A199. There are three main distinctions made between the type of roads travelled on. These are urban roads, rural roads and motorways. As noted above, we assume that Smarter Choices only has an impact on trips in urban areas. However, it is unclear whether we should define motorways as urban or rural. For the purposes of this modelling we have assumed that motorway travel is not influenced by Smarter Choices policy as it is unlikely that these measures will be able to change motorway behaviour sufficiently.

B. Eco-driving training for existing driving licence holders

Description of policy

A200. 'Eco-driving' training is the provision of lessons which aim to encourage more fuel efficient driving. The results presented here represent an assessment of the potential emissions savings from training 1% of existing drivers per annum in eco-driving techniques.

Key points to note

- CO_2 savings come from driving at a more efficient speeds, avoiding unnecessary braking and accelerating, keeping tyres inflated to optimal levels and minimising the use of auxiliary equipment. There may therefore be some overlap with savings from other potential policy measures e.g. tyre pressure monitoring systems, gear shift indicators and more efficient air conditioning.
- We assume that 1% of existing drivers are trained per year (around 350,000 drivers) at a cost of around £60 per driver. New drivers are excluded from the analysis since they already receive eco-driving lessons as part of their driving test preparation.
- Delivery of the CO_2 savings would rely on sufficient funding to subsidise lessons; ensuring sufficient instructors were trained and available; and securing sufficient uptake, especially amongst high mileage drivers.
- There is some evidence available on the average reduction in fuel consumption immediately following training. However, there is only limited data on the longer term effects of training.
- The central scenario is estimated to save **0.15MtCO_2 in 2020** at a **net benefit of £45/tCO_2**. However, these results are very sensitive to the assumptions made on cost and impact of training.

Key assumptions and uncertainties

A201. The model estimates the costs and benefits of an eco-driving training programme in place from 2010 to 2020. The cost of training drivers is assumed to accrue from 2010 to 2020. The benefits of training are assumed to continue for an additional 12 years (to 2032).

A202. The key factors influencing the cost of this policy and its impact on CO_2 emissions are set out below. These assumptions do not prejudge decisions on the scope or scale of potential policy measures in this area, but are used merely for illustrative purposes.

Baseline

A203. The baseline assumes there is an EU-wide CO_2 target for new cars of 95gCO_2/km by 2020. It is also assumed that 'complementary measures' (e.g. gear shift indicators, tyre pressure monitoring and more efficient air conditioning) are in place which will further reduce the real world CO_2 emissions of vehicles. Biofuels are assumed to make up 10% (by energy) of transport fuel used.

A204. The model underlying the analysis works by using assumptions on car efficiency, biofuel use and annual kilometres driven by vehicles of different ages to forecast annual fuel consumption and CO_2 emissions from petrol and diesel cars. Baseline forecasts of car fuel consumption, CO_2 emissions and vehicle kilometres travelled are calibrated to the National Transport Model (given the above assumptions of efficiency and biofuel use).

CO_2 savings from eco-driving

A205. Evidence on CO_2 savings from eco-driving is limited and based on a small number of case studies. The Driving Standards Agency (DSA) found that eco-driving leads to an average 8.5% improvement in fuel efficiency for drivers after two hours of training. Other studies have indicated that drivers could achieve efficiency savings of as much as 10-15%. However, these studies tend to look at savings immediately after training. There is much less evidence on the extent to which these savings are maintained over time. We might expect that over time drivers revert to their previous driving style and the efficiency gains to decline.

A206. Assumptions in the DfT model are based on estimates from TNO (2006)[28]. They estimate that depending on driving style, drivers may save between 5% and 25% fuel directly after received instructions or lessons. However, they find that the average reduction in practice is more in the order of 5-10% and tends to reduce over time. They estimate that the long term effect of eco-driving is a fuel consumption reduction of around 3%.[43]

A207. To test the sensitivity of the results, we have also considered a more optimistic scenario where the long term effect is to reduce fuel consumption by 5% on average; and a more pessimistic scenario where fuel consumption is only reduced by 1%.

A208. These fuel consumption savings relate to a percentage reduction in 'real world' fuel consumption i.e. they would not affect a vehicle’s official CO_2 figures as produced by the Type Approval process. For any given vehicle, 'real world' emissions tend to be on average around 15% higher than the official gCO_2/km figure. However, if we were to apply a 15% uplift to fuel consumption figures of all cars and model the amount of fuel consumed, this would be significantly higher than actual fuel used (as measured by fuel duty receipts). The most likely reason for this is that more efficient vehicles tend to drive more, on average, than less efficient vehicles. This is supported by evidence from the National Travel Survey.

A209. We build this assumption into our modelling by weighting gCO_2/km figures by kilometres driven in a given year i.e. assuming new cars are driven more than older cars. By using this method, estimates of total fuel consumption are more in line with actual fuel used (as measured by fuel duty receipts). In this way, we can infer that the average gCO_2/km figure we use in the model broadly reflects the average car kilometre driven in the 'real world'. To estimate the impact of eco-driving training, we therefore apply the percentage reduction directly to the gCO_2/km figure rather than applying an uplift first.

A210. Reductions in fuel consumption come from driving at a more efficient speed, avoiding unnecessary braking and accelerating, pumping up tyres and minimising the use of auxiliary equipment. There may therefore be some overlap with savings from other potential policy measures, some of which, like tyre pressure monitoring systems and gear shift indicators are already included in the baseline. When looking at the cumulative impact of eco-driving training, the model may therefore slightly overestimate potential CO_2 savings.

Uptake of training

A211. We have considered a scenario where 1% of existing licence holders (around 350,000 drivers) receive training in eco-driving techniques each year. This scenario is purely illustrative and assumes that subsidising lessons is sufficient to ensure uptake and that no additional incentives are required. New drivers (those passing their driving test after 2009)

[43] This is calculated by: achievable effect (10%) x effectiveness (35%) x durability (90%) = achieved effect (3%)).

are excluded from the modelling since these drivers are expected to receive eco-driving training as part of their test preparation.

Costs of eco-driving training

A212. The cost per driver is assumed to be around £60. This is taken from the mid-point of the range given in TNO (2006), converted from Euros. As sensitivity analysis we have also considered a lower cost scenario where the training cost per driver is around £40; and a higher cost scenario where the training cost per driver is around £80. There is also assumed to be a small additional cost associated with training additional instructors to cope with the increased demand. We assume a one-off cost of £140 per instructor in 2010.

Rebound Effect

A213. Unlike our modelling of other measures which reduce fuel costs, the eco-driving model assumes no rebound effect. In other words, we assume that motorists who choose to undertake eco-driving training will not respond to the reduction in fuel costs by driving more. If they were to drive more, the CO_2 savings from eco-driving would be lower.

Results of cost-benefit analysis

A214. The main results of our analysis are given in Figure A31 below. The central scenario is estimated to save **0.15MtCO_2 in 2020** at a **net benefit of £45/tCO_2**. However, since take-up and impact on driver behaviour is uncertain, these impacts are only speculative.

A215. The costs of the measure arise from the cost of the lessons themselves, and the costs of training additional driving instructors. The benefits arise from fuel-cost savings and CO_2 emissions savings.

Figure A31: Summary of central scenario results for extending eco-driving lessons for existing car licence holders

		Direct impacts only		
		Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		0.15	0.15	0.15
Impact on other greenhouse gases in 2020 ($MtCO_2e$)		Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		0.1	0.1	0.1
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		0.5	0.5	0.5
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		0.7	0.7	0.7
Cumulative savings over appraisal period ($MtCO_2$)		1.7	1.7	1.7
Present value of costs (£m)		£167	£167	£167
Of which	*Cost of lessons*	*£161*	*£161*	*£161*
	Cost of training additional instructors	*£6*	*£6*	*£6*
Present value of benefits (£m)		£319	£355	£282
Of which	*CO_2 savings*	*£73*	*£109*	*£36*
	Welfare benefit from lower cost of driving per km	*£246*	*£246*	*£246*
Net Present Value (£m)[1]		£152	£188	£115
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		-£45	-£45	-£45
Average value of CO_2 saved (£/tCO_2)		£42	£62	£21
Social benefit-cost ratio		1.9	2.1	1.7
Fuel saved in 2020 (m litres)		67	67	67
Impact on Renewable Energy Target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.		
Other non-quantified impacts		Positive impacts on safety. Positive impact on security of supply. Reduction in vehicle wear and tear from fewer stops and less gear changes.		

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Sensitivity analysis

a) *Impact of different oil price scenarios*

A216. As set out in the main impact assessment, DECC have developed four oil price scenarios. The main results presented in the table above use the *timely investment, moderate demand* scenario (scenario 2). Different oil price scenarios do not generate a marked difference in the estimate of CO_2 savings in 2020 for eco-driving. However, they do impact on the cost-effectiveness estimate (as the value of the fuel savings is changed). Using the *low global energy* scenario (scenario 1), the cost-effectiveness results falls to a net benefit of £14/tCO_2. The higher oil price scenarios 3 and 4 (“high demand, producers’ market power” and “high demand, significant supply constraints” scenarios) generate cost-effectiveness results of a net benefit of £97/tCO_2 and £155/tCO_2 respectively.

b) *Impact of a higher/lower training costs*

A217. In their modelling, TNO (2006) assume that the cost of half a day of eco-driving lessons would range from around €50 to €100 and that the cost of training instructors would be between €150 and €200. We have taken the mid-point of these estimates as our central case, but also look at the upper and lower end of the ranges as a sensitivity (£56 per lesson within a range of £37 to £74; and £130 for training an instructor within a range of £111 to £148).

A218. If costs are at the lower end of the range, the cost-effectiveness estimate improves from a net benefit of £45 per tonne of CO_2 saved to a net benefit of £76/tCO_2. If costs are at the higher end of the range, the estimate of cost per tonne of CO_2 saved reduces to a net benefit of £14/tCO_2.

A219. Because the model assumes the cost of lessons is met in full through exchequer funding, changing the cost of lessons does not affect uptake in the model. If lessons were only part subsidised or funded by the driver then we might expect levels of uptake to vary according to the cost of lessons.

c) *Impact of a greater/smaller reduction in fuel consumption*

A220. There is considerable uncertainty surrounding the long term effect of eco-driving training i.e. to what extent trained drivers continue to drive in a fuel efficient way following training. Our central case assumes a 3% reduction in fuel consumption in the long run. As sensitivity analysis we have also considered a more optimistic scenario where the long term effect is to reduce fuel consumption by 5% on average; and a more pessimistic scenario where fuel consumption is only reduced by 1%.

A221. In the more pessimistic scenario, estimated CO_2 savings fall from 0.15MtCO_2 in 2020 to 0.05MtCO_2 and the cost rises to a net cost of £146/tCO_2. In the more optimistic scenario, estimated CO_2 savings increase to 0.25MtCO_2 in 2020 and the cost per tonne of CO_2 saved becomes a net benefit of £83/tCO_2.

Distributional impacts

A222. The policy results in a net benefit for consumers and firms. Consumers and firms are assumed to save on fuel costs. We split the benefits between firms and consumers using the proportion of vehicle kilometres driven by company cars (assumed to be firms) and non-company cars (assumed to be consumers). The value of the CO_2 saved is allocated to consumers.

Figure A32: Summary of distributional analysis for eco-driving lessons for existing car licence holders

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	£161m
	Consumers	£648m

Source: DfT analysis

Other considerations

A223. In this initial analysis we have focused on modelling an illustrative scenario, where a proportion of existing drivers are trained in eco-driving techniques each year. We have not attempted to differentiate between drivers, for example focusing on drivers who are particularly high mileage or most likely to change their driving behaviour. Targeting an eco-driving programme in this way could result in higher CO_2 savings than we have estimated.

C. Speed Limit Reduction and Enforcement

Description of policy

A224. This note provides a summary of the appraisal of measures that seek to fully enforce speed limits on existing 60mph roads and reduce speed limits on 70mph to 60mph with full enforcement of speed limits.

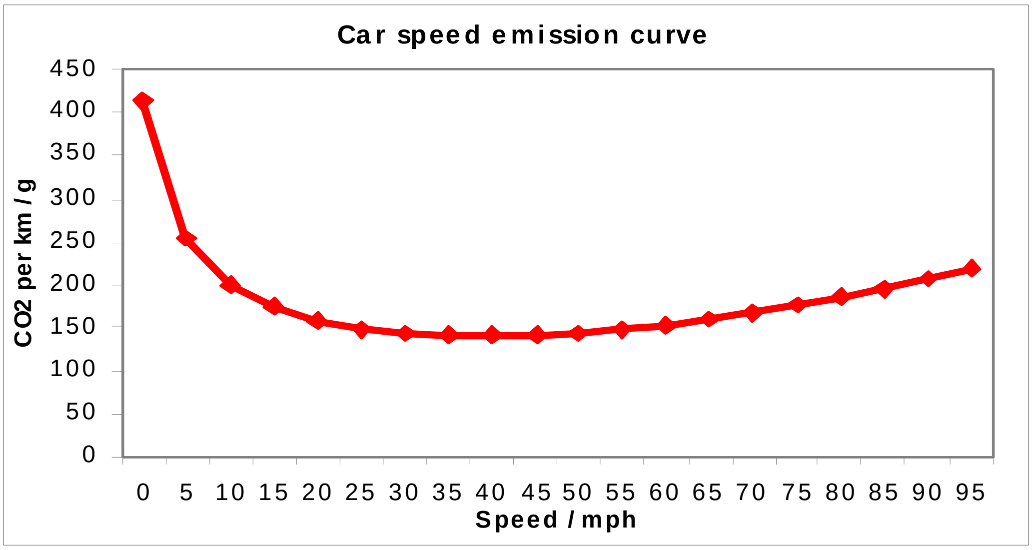
Key points

- Given that optimal engine efficiency is achieved at around 50mph, any modification of driver behaviour that moves the speed of vehicles towards this level will reduce CO_2 emissions. This is the basic environmental rationale for a speeds control policy.
- Reducing and subsequently enforcing a 60mph speed limit is made possible by the recently developed SPECS3 average speed camera technology which offers a means of effectively monitoring vehicle speeds.

Measures of speeding and speed emission curves

A225. The average speed of drivers over the speed limit is a weighted average of the speed of vehicles exceeding the speed limit. The distance travelled by speeders is a measure of how many vehicle kilometres are driven above the speed limit. The impact of speed on engine efficiency is a non-linear relationship, with disproportionately greater impacts as travelling speed moves further away from the optimum level of around 50mph. This can be seen in an example speed emissions curve in Figure A33 below.

Figure A33: Example speed emissions curve for a car



Compliance

A226. The model assumes full compliance with the speed limit is achieved through the deployment of SPECS3 average speed cameras across the relevant stretches of the network. The cost of rolling out the system comprises the capital cost of purchasing and installing the technology, along with an annual maintenance charge. The costs are based on current figures gathered in consultation with the Highways Agency. The model assumes that 100% compliance would be achieved through this system.

Value of time

A227. When the speed of motorists exceeding the speed limit is reduced it will impact on the time it takes for drivers to reach their destination. There is thus a time cost involved in forcing compliance with the speed limit. The value assigned to this increase in journey time is in line with WebTag guidance[44]. However, in the scenario considered, only the time cost of reducing the speed limit has been included. Those drivers currently travelling above this speed limit are engaged in an illegal activity. To include the time cost that will accrue to these drivers if the speed limit is enforced would thus be to value the gain they are currently making from illegal activity, and is therefore not included.

Reduction in road accident related casualties

A228. Forcing compliance with the speed limit is likely to give rise to a road safety benefit. There are two reasons why this may come about. Firstly, lower driving speeds allow for increased driver reaction time, which is likely to reduce the number of collisions. Secondly, where collisions do occur, the severity of the impact will be reduced by lower driving speeds. The speed-safety relationship used is taken from a 2004 paper authored at the Institute of Transport Economics[45]. The approach uses a power model of the speed-safety relationship, with the reduction in average speed determining how far pre-policy casualty levels are reduced. Estimates of the reduction in casualties precipitated by a reduction in the average speed of vehicles are converted into monetary estimates on the basis of the Highways Economics Note 1 guidance published by the DfT[46].

Fleet composition / travel projections

A229. Fleet composition and travel projections which feed into the distance travelled by motorists exceeding the speed limit are provided by the National Atmospheric Emissions Inventory (NAEI) and the NTM respectively. The NTM forecasts assume a variety of other measures are already in place to reduce CO_2 emissions.

Results of the cost-benefit analysis

A230. The main results of our analysis are given in the table below. It is estimated that this measure would result in an annual CO_2 saving of **1.4MtCO_2 in 2020** at a lifetime **net cost of £306/tCO_2** saved.

A231. The benefits from the policy come from lower levels of accidents and reduced fuel costs. Some smaller benefits also accrue from the CO_2 emissions saving, which become more significant as higher values are assigned to these emissions. There is only a small air quality benefit. The major costs are related to increases in journey time, which dominate all other factors considered in the analysis. The estimates below do not include the private journey time costs of a reduction in speeding (down to 70mph) as this is an illegal activity.

[44] DfT (2009), WebTag Unit 3.5.6: Values of Time and Operating Costs, available at http://www.dft.gov.uk/webtag/webdocuments/3_Expert/5_Economy_Objective/3.5.6.htm#t01

[45] Elvik, R., et al. (2004) "*Speed and Road Accidents: An Evaluation of the Power Model*", Institute of Transport Economics.

[46] DfT (January 2007), Highways Economics Note 1, available at http://www.dft.gov.uk/pgr/roadsafety/ea/pdfeconnote105.pdf

Figure A34: Summary of central case results for speed reduction and enforcement at 60mph

		Direct impacts only		
		Central SPC	High SPC	Low SPC
Impact on annual CO_2 in 2020 ($MtCO_2$)		1.4	1.4	1.4
Impact on other greenhouse gases in 2020 ($MtCO_2e$)		Negligible	Negligible	Negligible
Savings in 1st budget period 2008-2012 ($MtCO_2$)		4.4	4.4	4.4
Savings in 2nd budget period 2013-2017 ($MtCO_2$)		7.4	7.4	7.4
Savings in 3rd budget period 2018-2022 ($MtCO_2$)		7.2	7.2	7.2
Cumulative savings over appraisal period ($MtCO_2$)		19.1	19.1	19.1
Present value of costs (£m)		£13,394	£13,394	£13,394
Of which	*Journey time*	*£12,284*	*£12,284*	*£12,284*
	Compliance (SPECS3)	*£1,110*	*£1,110*	*£1,110*
Present value of benefits (£m)		£8,385	£8,811	£7,960
Of which	*CO_2 savings*	*£851*	*£1,276*	*£425*
	Air quality	*£89*	*£89*	*£89*
	Fuel resource cost savings	*£2,556*	*£2,556*	*£2,556*
	Safety	*£4,889*	*£4,889*	*£4,889*
Net Present Value (£m)[1]		-£5,008	-£4,583	-£5,433
Cost-effectiveness: Net cost per tonne of CO_2 saved (£/tCO_2)[2]		£307	£307	£307
Average value of CO_2 saved (£/tCO_2)		£45	£67	£22
Social benefit-cost ratio		0.63	0.66	0.59
Fuel saved in 2020 (m litres)		647	647	647
Impact on renewable energy target		Small beneficial impact on renewable obligations since a reduction in total fuel use means a smaller volume of biofuel required.		
Other non-quantified impacts		Positive impact on security of supply		

[1] A positive NPV indicates that the policy has a net benefit overall (i.e. the benefits outweigh the costs).
[2] A negative cost-effectiveness value indicates a net benefit per tonne of CO_2 saved.
Source: DfT analysis

Distributional impacts

A232. The costs and benefits estimated in the analysis have been disaggregated across two groups in society – firms and consumers. Both firms and consumers suffer from increases in journey time from a reduction in speed limits from 70mph to 60mph. For firms this time cost is only partially offset by the benefits of improved safety and reduced fuel costs. For consumers there is an overall benefit from improved safety, fuel costs, CO_2 savings and improvements in air quality. The NPV estimates below do not include the private journey time costs of a reduction in speeding as this is an illegal activity.

Figure A35: Summary of distributional analysis for speed reduction and enforcement at 60mph

Lifetime Distributional Impacts, NPV (£m, 2009 prices)		
Including indirect impacts	Firms	-£1,494m
	Consumers	£2,037m

Source: DfT analysis

Annex B – Sustainable Development Assessment

B1. The goal of sustainable development is to enable all people throughout the world to satisfy their basic needs and enjoy a better quality of life, without compromising the quality of life of future generations. To this end, the Government is committed to the five principles of sustainable development as set out in *"Securing the Future – UK Government Sustainable Development Strategy"* (2005)[47]:

- Living within environmental limits;
- Achieving a sustainable economy;
- Ensuring a strong, healthy and just society;
- Promoting good governance; and
- Using sound science responsibly.

B2. The Climate Change Act (2008) requires our policies and proposals for meeting carbon budgets to contribute to sustainable development. The policies within our Carbon Reduction Strategy therefore need to be underpinned by these principles, which means integrating social, environmental and economic objectives.

B3. Earlier this year the Department for Transport (DfT) published its Sustainable Development Action Plan, April 2009 – March 2010[48], which describes how the principles of sustainable development are integrated into the work of the Department, in our policy, operations and activity. The Action Plan noted that a good transport system is vital for a prosperous economy – delivering goods, services and increasing accessibility. At the same time, it also recognised the negative impacts that transport can have in terms of congestion, noise, local air quality issues and greenhouse gas emissions, and reaffirmed our commitment to reducing these. The DfT has an important role to play in delivering sustainable development. Our objective is to have a modern transport system that works for everyone and maximises the benefits whilst minimising these negative impacts.

B4. The five principles of Sustainable Development are closely aligned to the DfT's Strategic Objective to reduce transport's emissions of greenhouse gases, with the desired outcome of tackling climate change. A package of measures that contributes towards delivering the UK's burden share of global climate change mitigation, that is consistent with continued economic growth and that distributes the costs fairly, goes a great deal of the way towards delivering a package that is consistent with sustainable development.

B5. Considering first the principle of using sound science responsibly, there is increasing scientific evidence that the earth is getting warmer, and that man-made emissions of greenhouse gases are the primary cause of climate change observed over the last century. The world's leading climate scientists recently reaffirmed that the role of human activities in the observed changes is now clearer than ever and much greater than any natural factors[49]. Science has a crucial role to play in providing the necessary evidence to understand, predict and prepare for the changes that are likely to happen as a result of climate change.

B6. A key aim of the Carbon Reduction Strategy for Transport is to ensure that we live within environmental limits, respecting the limits of the planet's environment, resources and biodiversity. The Strategy is expected to significantly reduce greenhouse gas emissions

[47] Available at http://www.defra.gov.uk/sustainable/government/publications/uk-strategy/
[48] Available at http://www.dft.gov.uk/about/howthedftworks/sda/secsusdevactplan09/sustainactplan.pdf
[49] Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007), available through http://www.ipcc.ch/.

from the transport sector, which will contribute towards the UK's goal of avoiding dangerous levels of climate change.

B7. Supporting a shift to new technologies and decarbonising transportfuels will also support the achievement of a sustainable economy, and is well-aligned with our goal to support economic competitiveness and growth. Both will re-shape transport energy use in the UK, reducing our dependence on oil in the long term and increase our resilience to oil price shocks.

B8. However, the transition to low carbon technology will involve bringing forward investment that otherwise would only occur when oil prices are high and expected to remain high. This means that some measures impose net costs on business and consumers. The mix of policy instruments used in this strategy, and the way those policy instruments are designed, is specifically aimed at supporting national economic competitiveness and growth by minimising regulatory burdens. Using prices to encourage a shift to lower carbon transport allows transport providers and users to respond flexibly to the incentives they face. This ensures that emissions savings are made at least cost to the economy.

B9. Promoting low carbon travel choices is a key part of our efforts to tackle congestion in urban areas and on inter-urban roads. Tackling congestion supports national economic competitiveness and growth by reducing journey times, and improving the reliability of journey times.

B10. The Strategy will have links to creating a healthy society in that new transport technology and low carbon fuels will potentially have impacts on air quality. There are potential risks and benefits – for example, a shift to diesel vehicles could have adverse air quality impacts, whereas a shift to electric or hybrid vehicles could have air quality benefits. Promoting low carbon travel choices is expected to deliver air quality improvements, by reducing traffic volumes and promoting eco-driving. Similarly, an increase in walking and cycling could have air quality benefits where this replaces car travel, and will also have a positive effect on health. We have sought to minimise the risks to air quality through careful design of policy instruments – and will monitor the impacts closely.

B11. The Strategy helps to support a just society, as provision of affordable, accessible public transport, and broadening the range of transport choices available, are important tools for delivering a fairer society. For example, the nationwide concessionary fares scheme, introduced in April 2008, has given free bus travel nationwide to all people aged 60 and over, as well as to many disabled people. Some 11 million people are now eligible for this free travel in England. The concession recognises the importance of public transport for older people and the role that access to transport has to play in tackling social exclusion and maintaining well-being. Quality of life benefits are also expected from the development of sustainable travel solutions, particularly in urban areas – by reducing traffic volumes and noise from traffic.

Annex C – Health Impact Assessment

Will your policy have a significant impact on human health by virtue of its effects on the wider determinants of health?

C1. The Strategy is expected to have an impact on human health by virtue of its effects on transport and the environment. These impacts include changes in air quality, in the number of accidents, and an increase in physical activity from an increase in the number of journeys undertaken by bicycle or on foot.

Will there be a significant impact on any of the following lifestyle related variables?: physical activity; diet; smoking, drugs, or alcohol use; sexual behaviour; accidents and stress at home or work.

C2. There is expected to be an increase in the level of accidents as a result of the Strategy, due to the anticipated increase in mileage driven.

C3. There is expected to be a positive impact on physical activity in terms of an increase in cycling and walking. These activities can also improve mental wellbeing and reduce stress levels.

Are the potential positive and/or negative health and well-being effects likely to cause changes in contacts with health and/or care services, quality of life, disability or death rates?

C4. The Strategy is expected to have a modest impact on air quality. Despite significant improvements over time (for example, through implementation of tough 'Euro standards' for new vehicles), road transport remains a key source of both air pollutants particulate matter (PM_{10}) and nitrogen dioxide (NO_2). Both short-term and long-term exposure to ambient levels of PM_{10} are consistently associated with respiratory and cardiovascular illness and mortality as well as other ill-health effects. NO_2 emissions are also associated with adverse effects on human health, and at high levels can cause inflammation of the airways. Long-term exposure may affect lung function and cause respiratory symptoms. NO_2 also enhances the response to allergens in sensitive individuals.

C5. Assessing exposure is key to determining the likely health impacts resulting from emissions of air quality pollutants. Unpopulated areas are much less of a concern from an air quality perspective, although air pollutants can travel significant distances. EU Directive limit values do not apply in areas where members of the public do not have access and there is no fixed habitation. The impact of the Strategy on human health will therefore depend on the number of the local population that are within the areas where air quality is reduced.

C6. There is expected to be a change in the level of accidents as a result of the Strategy, due to the expected increase in mileage driven. However, we have not been able to determine the number of additional injuries, for example, and therefore the potential increase in the level of contact with health services.

C7. In terms of increasing physical activity, when all sources of activity are considered, only about 37% of men and 24% of women meet the Chief Medical Officer's minimum recommendations for activity in adults and are sufficiently active to benefit their health[50]. Walking and cycling can significantly improve people's level of fitness, and one advantage

[50] Department of Health (2005), *"Choosing activity: a physical activity action plan"*, available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4105354

that these activities have over other forms of exercise is that they can also easily become part of everyday activity. The health benefits of regular cycling – as for any regular physical activity – include reduced risk of developing high blood pressure, diabetes, and certain cancers. It can help control weight, build and maintain healthy bones, muscles and joints and reduces the risk of dying from heart disease.

Are the potential positive and/or negative health and well-being impacts likely to affect specific sub groups disproportionately compared with the whole population?

C8. One of the most important factors contributing to air quality exceedences in the UK is the impact of emissions from road transport. Whilst other sources can give rise to significant emissions, these are typically released at higher levels often outside urban areas. At the street level, it is the emissions from low level sources, such as road transport, which have the most significant impact on ambient concentrations.

C9. Where reductions in air pollutants occur in urban areas, they are likely to result in health benefits for the local population; for example, when there is a reduction in car travel (either because of a shift to public transport, to walking and cycling, or a reduction in overall travel). Those living near train lines used by diesel trains will also benefit from an overall improvement in air quality as biodiesel becomes a greater proportion of the fuel used.

C10. We would not expect the change in the level of accidents to impact on a specific sub group of the population.

C11. It might be envisaged that younger people would be more likely to switch from car trips to walking and cycling, and this group would therefore receive the benefits from this increase in physical activity. Urban populations may also be more likely to increase their levels of walking and cycling than those living in rural areas, due to a greater level of amenities available within walking or cycling distance.

Are there likely to be public or community concerns about potential health impacts of this policy change?

C12. We do not expect there to be public or community concerns about the potential health impacts of the Strategy.

Annex D – Race Equality Assessment

Availability of evidence

D1. We have found only limited data relating to ethnicity and travel; for example, we not been able to find any quantitative or qualitative evidence on car purchase behaviour of different ethnic groups, and nor have we seen any evidence that quantitatively or qualitatively disaggregates fuel consumption patterns by racial group.

D2. The Department for Transport's National Travel Survey (NTS) does collect data on car availability and car licence holding by ethnic group[51]. Whilst this provides some valuable data on the personal car access of different groups, it does not enable a full assessment of the impact of the Strategy on different ethnic groups to be undertaken.

Relevance of the policy to the race equality duty

Will the proposed policy involve, or have consequences for UK consumers?

D3. UK consumers will benefit from the Strategy to the extent that they form part of the global population at risk from impacts of climate change (such as increased climate variability and more frequent extreme weather events).

D4. Other impacts on consumers that are expected as a result of the Strategy are:

- an increase in the purchase price of new cars as the costs of new technology are passed on to consumers, but a saving on running costs such that the increase in purchase price is likely to be recouped in about 5 years as a result of lower fuel costs;
- a slight increase in fuel prices at the pump due to the higher cost of biofuels being blended with conventional fuel as a result of the RES target;
- an improvement in public transport from greater levels of investment;
- potentially lower bus fares as bus operators pass on the reduction in (fuel) costs as a result of low carbon buses and SAFED training for bus drivers; and
- encouragement to undertake more trips by bike or on foot, for example as a result of investment in cycle training ("bikeability") and cycling infrastructure, and cycling demonstration towns.

Could these consequences differ according to people's racial group, for example, because they have particular needs, experiences or priorities?

D5. These consequences would only differ according to racial group if people's transport decisions are influenced by their group; for example, if the type of new car purchased is influenced by the race of the purchaser then racial groups who tend to buy vehicles which, under the regulation, will face a greater increase in purchase price may be disproportionately affected. However, these groups would also benefit from reduced fuel costs (as a result of efficiency improvements). Analysis suggests that these fuel cost savings would more than outweigh the increase in purchase price. We do not have data linking car purchase choice with racial group and so have not been able to explore this further.

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[51] See the DfT National Travel Survey webpage, available at: http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/.

D6. The data that is available from the NTS suggests that about 82% of White British respondents are in households with access to a car[52]. This compares to 79% of Pakistani respondents; 63% of Caribbean and 53% of African respondents. To the extent that this can be taken to imply that certain ethnic groups rely more heavily on non-car modes, these groups will benefit from the investment in public transport, walking and cycling.

Is there any reason to believe that people could be affected differently by the proposed policy, according to their racial group, for example in terms of access to a service, or the ability to take advantage of proposed opportunities?

D7. See above.

Is there any evidence that any part of the proposed policy could discriminate unlawfully, directly or indirectly, against people from some racial groups?

D8. No.

Is there any evidence that people from some racial groups may have different expectations from the policy in question?

D9. No.

Is the proposed policy likely to affect relations between certain racial groups, for example because it is seen as favouring a particular group or denying opportunities to another?

D10. No.

[52] Data is the average over 2004 to 2007 for persons aged over 17, taken from the 2007 NTS, available at http://www.dft.gov.uk/pgr/statistics/datatablespublications/personal/mainresults/nts2007/.

Annex E – Disability Equality Assessment

Availability of evidence

E1. A 2007 report by TRL[53] commissioned by the Department for Transport estimated that the number of licensed disabled drivers in the UK was around 1.9 million (approximately 20% of the 9.5 million disabled adults believed to be living in Great Britain and around 6% of the 34 million licensed drivers in the UK). Around 1.7 million disabled drivers are thought to be current, active drivers. These figures were based on the DVLA Driver Medical Group (DMG) database which contains details of drivers who have notified the DVLA of a medical condition. These estimates therefore cover a wide range of disabilities.

E2. The report also looks at alternative datasources. For instance, around 2.3 million people in the UK hold a Blue Badge (although these are not all necessarily drivers). Blue Badges are available to severely disabled people including those who are unable to walk or who have very considerable difficulty in walking, those who are registered blind, those with a severe disability in both arms, as well as children under the age of 2 with specific medical conditions. The Blue Badge data suggested that around 51,000 drivers (0.2% of total licence holders) held a licence that restricted them to using adapted vehicles.

E3. The National Travel Survey also collects data on health-related travel difficulties.

Relevance of the policy to the Disability Equality Duty

Will the regulation involve, or have consequences for UK consumers?

E4. UK consumers will benefit from the Strategy to the extent that they form part of the global population at risk from impacts of climate change (such as increased climate variability and more frequent extreme weather events).

E5. Other impacts on consumers that are expected as a result of the Strategy are:

- an increase in the purchase price of new cars as the costs of new technology are passed on to consumers, but a saving on running costs such that the increase in purchase price is likely to be recouped in about 5 years as a result of lower fuel costs;
- a slight increase in fuel prices at the pump due to the higher cost of biofuels being blended with conventional fuel as a result of the RES target;
- an improvement in public transport from greater levels of investment;
- potentially lower bus fares as bus operators pass on the reduction in (fuel) costs as a result of low carbon buses and SAFED training for bus drivers; and
- encouragement to undertake more trips by bike or on foot, for example as a result of investment in cycle training ("bikeability") and cycling infrastructure, and cycling demonstration towns.

Could these consequences differ for disabled people?

E6. The impacts of climate change, and in particular, higher maximum temperatures and heat waves, could have a greater adverse effect on older or more sensitive groups of the population, including disabled people.

E7. The NTS suggests that in 2005, 14% of adults experienced mobility difficulties going out on foot and/or using local buses; 7% have problems with both, 7% with going out on foot

[53] TRL (September 2007), Published Project Report PPR287, "Data gathering on disability and driving statistics: Summary Report", available at http://www.dft.gov.uk/transportforyou/access/research/drivingandstatisticssummary.pdf.

only and 1% with using local buses only. Two thirds of respondents with a mobility difficulty said that they do not have difficulty getting in or out of a car. However, the NTS findings suggest that people with mobility difficulties are more than twice as likely as those without to live in a household with no car, regardless of their age. 48% of people with mobility difficulties aged 17 and over hold a full driving licence, compared to 75% of those without mobility difficulties. So it is not clear whether disabled people are in general more reliant on cars for their personal mobility than people without mobility difficulties.

E8. People with mobility difficulties who are more reliant on cars for their personal mobility may be affected by the EU new car CO_2 regulation and the biofuels target. Higher upfront costs of new cars as a result of the EU new car CO_2 regulation may discourage some new car purchases. However, special purpose vehicles, including vehicles built specifically to accommodate wheelchair use inside the vehicle, are excluded from the scope of the regulation. Other types of vehicles purchased by disabled people will be covered by the regulation. Any increase in purchase price as a result of the regulation is expected to be recouped in fuel savings within about 5 years. Reducing fuel costs for disabled motorists could therefore have a positive impact on their ability to access employment, health, shopping, leisure and educational opportunities. As such, we do not expect the regulation to impact on disability equality[54]. Any reduction in fuel costs due to improved fuel efficiency will be partially offset by an increase in fuel prices as a result of the increased use of biofuels.

E9. Greater investment in public transport should therefore benefit those with mobility difficulties without access to a car. In relation to rail, over £10 billion will be invested in enhancing capacity between 2009 and 2014, with overall Government support for the railways over this period totalling £15 billion. In relation to buses, over the last 10 years investment in bus services has increased to around £2.5 billion a year, more than double the level of support 10 years ago[55]. The new nationwide concessionary fares scheme that was introduced in April 2008 provides free bus travel nationwide to everyone over 60 and to many disabled people. 11 million people are eligible for this free travel in England. The cost is around £1 billion a year.

Is there any reason to believe that disabled people could be affected differently by the proposed policy, for example in terms of access to a service, or the ability to take advantage of proposed opportunities?

E10. See above.

Is there any evidence that any part of the proposed policy could discriminate unlawfully, directly or indirectly, against disabled people?

E11. No.

Is there any evidence that disabled people may have different expectations from the policy in question?

E12. No.

[54] More information is provided in the UK Impact Assessment for the EU new car CO_2 regulation, available at http://www.dft.gov.uk/consultations/closed/co2emissions/fia.pdf.
[55] This figure includes local authority capital expenditure on bus infrastructure.

Annex F – Gender Impact Assessment

Availability of evidence

F1. The National Travel Survey (NTS) is the main source of information about differences in travel behaviour between men and women. Data from the survey suggests that, on average, women make slightly more trips than men but travel much less far. in 2006 women made 1,060 trips per person per year on average compared with 1,014 for men. However, the average trip length is much longer for men than women, at 7.9 miles compared with 6.0 miles respectively. Therefore, on average, men travel much further than women.

F2. In 2006, women made 36% of all their trips as car drivers. This proportion has increased from 31% in 1995/97 but is still lower than for males (48%). Men also make about twice as many trips by bicycle as women. However, women are still more likely to make trips on foot, by bus and by taxi than men.

F3. In terms of trip purpose, in 2006, 23% of all trips by women were for shopping and 6% were for escort education, compared with 19% and 2% respectively for men. Conversely, commuting and business accounted for a higher proportion of trips among men (22%) than women (15%).

F4. However, as travel patterns change the differences between men and women is narrowing – between 1995/97 and 2006, the average number of business trips per person per year by women increased by 46% compared with a fall among men of 26%. Over the same period commuting trip rates fell by 4% among women but by 12% among men.

F5. Differences in travel patterns between men and women are strongly influenced by their access to a car and by their roles in society. As these factors change over time, the differences in travel patterns are reducing.

Relevance of the policy to the gender equality duty

Will the target involve, or have consequences for UK consumers?

F6. UK consumers will benefit from the Strategy to the extent that they form part of the global population at risk from impacts of climate change (such as increased climate variability and more frequent extreme weather events).

F7. Other impacts on consumers that are expected as a result of the Strategy are:
- an increase in the purchase price of new cars as the costs of new technology are passed on to consumers, but a saving on running costs such that the increase in purchase price is likely to be recouped in about 5 years as a result of lower fuel costs;
- a slight increase in fuel prices at the pump due to the higher cost of biofuels being blended with conventional fuel as a result of the RES target;
- an improvement in public transport from greater levels of investment;
- potentially lower bus fares as bus operators pass on the reduction in (fuel) costs as a result of low carbon buses and SAFED training for bus drivers; and
- encouragement to undertake more trips by bike or on foot, for example as a result of investment in cycle training (“bikeability”) and cycling infrastructure, and cycling demonstration towns.

Could these consequences differ between genders?

F8. Whilst the data available suggests that women make fewer trips as car drivers than men, we do not have data about who pays the purchase price and running costs of vehicles. We are therefore not able to determine whether measures which impact on the cost of purchasing a car and fuel costs will have different consequences between the genders.

F9. The data available also suggests that women make more trips by bus and on foot than men. Any measures which impact on bus fares or service provision may therefore provide more of a benefit to women, although it may also encourage a greater number of men to make use of public transport. Conversely, the data suggests that men make more trips by bicycle than women. The benefits from any investment in cycling could therefore be felt more by men than by women, although again, this investment may encourage more women to undertake a greater number of trips by bicycle.

Is there any reason to believe that people could be affected differently by the proposed policy, according to their gender, for example in terms of access to a service, or the ability to take advantage of proposed opportunities?

F10. See above.

Is there any evidence that any part of the proposed policy could discriminate unlawfully, directly or indirectly, against people from different genders?

F11. No.

Is there any evidence that people from different genders may have different expectations from the policy in question?

F12. No.

Annex G – Rural Proofing

Will the policy affect the availability of public and private services?

G1. No.

Will the policy rely on existing service outlets, such as schools, libraries and GP surgeries?

G2. No.

Will the policy rely on the private sector or a public-private partnership?

G3. No.

Will the cost of delivery be higher in rural areas where clients are more widely dispersed and economies of scale can be harder to achieve?

G4. No.

Will the policy rely on local institutions for delivery?

G5. No.

Will the policy affect travel needs or the ease/cost of travel?

G6. Any measure that affects the cost of purchasing or running a car will potentially have a larger impact on rural communities since there tend to be fewer alternatives to private transport and therefore a greater dependence on cars. However, analysis suggests that on average, the additional upfront cost of purchasing a more efficient vehicle as a result of the EU new car CO_2 regulation will be recouped in fuel savings in around 5 years. This would suggest that the regulation would have a beneficial impact on rural communities, particularly for those individuals who tend to do above average mileage (who would tend to save more fuel).

G7. Fares on local bus services may also be reduced, if bus operators pass on the reduced fuel cost to consumers.

Does the policy rely on infrastructure (e.g. broadband ICT, main roads, utilities) for delivery?

G8. In relation to the use of biofuels, distributional problems have the potential to be an issue for particularly remote rural areas that are serviced by marine tankers. The chemical properties of hydrocarbon petrol and ethanol are such that they do not bond particularly well at the molecular level, and can easily be encouraged to separate with the addition of water. This is known as Phase separation. It is problematic because standard marine tankers do not keep moisture from coming into contact with the fuel adequately. Thus in remote areas of the country that are supplied primarily by these means, such as the Highlands and Islands in Scotland, may not be able to take the same biofuel blend as the rest of the country.

G9. This distributional issue is currently being investigated by the Department for Transport, where the evidence base needed to assess the implications of biofuel blending is currently being gathered.

Will delivery of the policy be challenging at the 'edges' of administrative areas?

G10. No.

Is the policy dependant on new buildings or development sites?

G11. No.

Does the policy rely on communicating information to clients? How will clients access information in rural areas, where there are fewer (formal) places to obtain advice and information?

G12. Certain measures in the Strategy rely on providing information to consumers, such as the Act on CO_2 campaign and car labelling. However, the Act on CO_2 campaign makes use of the internet through its website and electronic newsletter; as well as TV, radio and press advertising and a poster campaign. It does not therefore rely solely on 'formal' places to provide advice that are likely to be inaccessible to those in rural areas. Information on car labels can be obtained both on the internet and at car showrooms, at the point of purchase.

Will the policy impact on rural businesses, including the self employed? Will the policy affect land-based industries and, perhaps, rural economies and environments? How will the policy affect agriculture and/or local mining, extraction and water industries (which have a particular importance in many rural areas)? Will there be a knock-on effect on the environment?

G13. Based on the scenarios assessed for the UK Renewable Energy Strategy, the UK may require between 5 billion – 7.5 billion litres of biofuel in 2020. This may be supplied domestically, imported or, most likely, a combination of the two. It has been estimated that during this period over £3 billion will be invested in biofuel production within the UK. This is estimated to create or secure 2,600 agricultural jobs and over 800 industrial jobs.

G14. The wider environmental impacts of the Strategy are given in the evidence base above.

Will the policy affect people on low wages or in part-time or seasonal employment? Wages tend to be lower on average in rural areas and a higher proportion of the workforce relies on part-time or seasonal employment. Will it affect the type of businesses that tend to pay low wages or offer seasonal/part time work (e.g. agriculture, tourism)?

G15. Any increase in the purchase price of a vehicle as a result of the EU new car (or potential van) CO_2 regulation may discourage some purchasers, particularly those constrained by low incomes. However, low income households tend not to participate in the new car market. Further, analysis suggests that on average, the additional upfront cost of purchasing a more efficient vehicle will be recouped in fuel savings in around 5 years.

G16. The potential impact of the Strategy on the agricultural sector is set out in para G13 above.

Will the policy target disadvantaged people or places? How will this work in rural areas where disadvantage is rarely concentrated?

G17. The Strategy is not intended to target disadvantaged people or places – the impact of climate change is not specific to certain groups or geographical locations, and therefore the Strategy is not specifically targeted.