**Transport and
Environmental
Policy
Research**

Carbon impact of HS2:
Overview of relevant policy issues and advice on modelling assumptions

Final Report

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1. INTRODUCTION

This report was commissioned from Transport and Environmental Policy Research (TEPR)[1] by Greengauge 21. Greengauge 21, along with a number of environmental NGOs, including the Campaign to Protect Rural England (CPRE), the Campaign for Better Transport (CBT) and the Royal Society for the Protection of Birds (RSPB), believe that HS2[2], and high-speed rail (HSR) more generally, needs to contribute to reducing the UK's carbon dioxide (CO_2) emissions in line with the overall targets in the Climate Change Act 2008.

It is worth noting that CO_2 is only one of six greenhouse gases (GHGs) covered by the UK Climate Change Act 2008[3] (these GHGs are the same six that are covered by the Kyoto Protocol[4]). However, the vast majority of transport's direct GHG emissions are CO_2[5]. Hence, in relation to transport, "CO_2" and "GHG" are sometimes used interchangeably. The main exception to this is in relation to aviation, where the effect of non-CO_2 emissions on climate change appears to be significant. Current understanding suggests that the net impact of these non-CO_2 effects, including the impacts of emissions of water vapour and nitrogen oxides (NO_x) in the atmosphere, is an additional warming effect. If this additional effect is taken into account, the total climate effects of aviation could be double that which is attributable to aviation's CO_2 emissions alone[6].

Additionally, it is worth noting that GHG emissions from international aviation (and shipping) are not included in national GHG reduction targets under the Kyoto Protocol and are not currently included in the carbon budgets developed under the Climate Change Act 2008[7]. However, the Committee on Climate Change (CCC) has advised the Government to accept "the principle" of including these emissions in the carbon budgets and will make recommendations on how this might be done[8].

This report has been commissioned as part of a wider study that will consider more broadly how net CO_2 emissions from HS2 will be influenced by:

(a) The railway's design, configuration and operation; and
(b) The wider policy context.

The aim of the wider study will be to identify objectively the key factors that will determine HS2's contribution to reductions in the UK's CO_2 emissions. The study covers a number of factors, including:

i) The relative user costs of road, air and rail under different **oil prices.**
ii) The implications of **Government policies** (actual or proposed) that would impact on the carbon emissions of HS2.
iii) HS2 **operating speed and service pattern assumptions**.

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[1] Contact: ian.skinner@tepr.co.uk; see www.tepr.co.uk
[2] High Speed 2, the proposed new high-speed railway line between London and the West Midlands
[3] See Climate Change Act 2008 at http://www.legislation.gov.uk/ukpga/2008/27/section/24
[4] This is the international agreement that sets the UK's GHG reduction target for 2008 to 2012. See Annex A of the UNFCCC (1998) Kyoto Protocol to the United Nations Framework Convention on Climate Change; see http://unfccc.int/resource/docs/convkp/kpeng.pdf
[5] 98.7% according to EEA (2011) *"Greenhouse gas emissions in Europe: A retrospective trend analysis for the period 1990-2008"* EEA Report No 6/2011
[6] This takes account of the fact that there are also some cooling effects. There is considerable uncertainty about these additional impacts, e.g. see Box 3.2 in DfT (2011) *UK Aviation Forecasts* and Ulbina Environmental Consulting (2011) *"Aviation and Climate Change Policy in the UK"* A report for AirportWatch
[7] See EEA (2011) and Article 30 of the UK Climate Change Act 2008; note, however, that the Kyoto Protocol requires that these emissions are reported, and that Article 10 of the Act requires that the "estimated amount of reportable emissions" from international aviation and shipping be "taken into account" in connection with carbon budgets.
[8] CCC (2010) *The Fourth Carbon Budget: Reducing emissions through the 2020s*

iv) **Station location**.
v) Strategies for the **re-use of liberated classic line capacity** for both passengers and freight.

The aim of the work commissioned from TEPR was to provide input on Government, European and international policies and other factors that are likely to affect the carbon impacts of HSR relative to other modes of transport through to 2050. It contains two elements:

1. Policy and other issues that may influence the carbon case for HSR and other competing modes of transport (car, air) through to 2050. This is the subject of Section 2, below.
2. Advice on the assumptions that will underpin the separate analysis of HS2 CO_2 emissions, which are set out in Section 3.

This document is the final report and takes account of issues raised by the project steering group on an earlier version of the report.

2. OVERVIEW OF THE RELEVANT POLICY ISSUES

As this report focuses on the policies that might have an impact on the CO_2 emissions associated with HS2, the focus was on UK, European and international policies that potentially affect the CO_2 emissions of road, rail and air travel in the UK, for both passenger and freight transport. Freight transport was included within the scope of the report, as the scope of the wider project covered the potential re-use of freed capacity on existing rail lines for both passenger and freight travel. Similarly, as the scope of the wider project includes aspects such as the location of railway stations, policies that affected local, as well as inter-urban, travel were covered.

For the sake of clarity and to ensure as far as possible a comprehensive coverage, the policy assessment and review presented below was undertaken in order to identify and assess policies that impact on various elements of the transport system. In other words, the assessment reviewed, in turn, policies that affect the:

- **Carbon intensity** of fuels[9] used in the transport sector;
- **Fuel efficiency** of transport vehicles;
- **Use of vehicles,** including policies that focus on improving the utilisation of vehicles; and
- **Capacity and location** of transport infrastructure.

These are covered, respectively, in Sections 2.2 to 2.5, below. As a comparison, in their review of the GHG implications of HS2, Booz and Temple (2011)[10] noted that the potential Government policies to reduce GHG emissions from motor vehicles included:

- Reducing the fossil carbon content of transport fuel;
- Improving the fuel efficiency of vehicles;
- Increasing the care that people take over fuel consumption while driving; and
- Promoting the adoption of hybrid and electric vehicles.

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[9] For vehicles that use electricity, such as electric rail or electric cars, it is strictly more accurate to talk about "energy" and "energy efficiency" rather than "fuel" and "fuel efficiency", as electricity is an energy carrier rather than a fuel. However, for the purposes of simplicity, "fuel" and "fuel efficiency" are used within this report.
[10] Booz & co and Temple (2011) *HS2 to the West Midlands – Appraisal of Sustainability: Appendix 2 – Greenhouse Gas Emissions*

In order to set the wider policy context, Section 2.1 begins the overview of policies by outlining the wider strategic policy framework in which the reduction of GHG emissions more generally, and in the transport sector in particular, will take place.

In the sections that follow, quantitative information that indicates the potential CO_2 reduction, or the potential development of standards or requirements, is provided where this exists. More broadly, where there is a lack of policy detail, but an indication of what policies might be needed, e.g. to meet longer-term targets, these will also be mentioned. It is important to note, however, that detailed policies are rarely developed for the longer-term. For example, many of the policies currently in place do not look any farther ahead than 2020. In the period from 2020 to 2050, which is the date generally used for the longer-term strategic framework, there is less policy detail. In this respect, the report draws on the policy assumptions of scenarios that have been undertaken to assess the potential for GHG emissions reductions from transport in the longer-term. The identification and overview of the policies presented in the following sections is based on a review of the policies in relevant documents, including:

- UK and EU transport strategy documents, including the work of the CCC.
- Specific policy proposals in the UK and EU, including impact assessments.
- Consultancy, academic and other reports looking at the potential policies for reducing transport's CO_2 emissions.

2.1 Strategic policy framework for GHG reduction

In February 2011, the EU's Heads of State reconfirmed the EU objective of reducing GHG emissions by 80% to 95% by 2050 compared to 1990 levels. This is in line with reductions that the Intergovernmental Panel for Climate Change believes are necessary from developed countries[11]. In response, the European Commission has developed a low carbon road map that sets out a high level strategy for delivering such a reduction by 2050[12]. This analysis foresees that in order to meet the 2050 target GHG emissions would have to be 40% lower than 1990 levels by 2030 and be 60% lower by 2040. In relation to transport, the European Commission published a White Paper in early 2011 that envisages a 60% cut in GHG emissions from transport by 2050, as analysis suggests that deeper cuts are achievable in other sectors. By 2030, the goal will be to reduce transport's GHG emissions to around 20% below their 2008 levels[13].

In the UK, the CCC is advising the UK Government on how to reach similar targets. In doing this, the CCC proposes interim carbon budgets of which four have now been set[14]. The ultimate target recommended by the CCC is that the UK set a GHG reduction target of at least 80% by 2050 compared to 1990 levels. The CCC's initial proposals for interim budgets are consistent with achieving a 34% GHG reduction by 2020. The ultimate target, as well as these interim budgets, have been accepted by the Government and have been included in relevant legislation. In 2010, the CCC updated its advice on the second and third interim budgets with the new proposals being consistent with a 2020 reduction target of 37% compared to 1990 levels. The CCC's proposals for the fourth budget period were consistent with a GHG emissions reduction of 50% by 2025; it also

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[11] See, for example, the introduction to the EU's low carbon road map, COM (2011) 122 *A Roadmap for moving to a competitive low carbon economy in 2050*; at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0112:FIN:EN:PDF

[12] COM (2011) 122

[13] Note that this level would still be above 1990 levels; see COM (2011) 144 *Roadmap to a Single European Transport Area – Towards a competitive and resource-efficient transport system;* see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:EN:PDF

[14] The first four budgets cover the following periods: 2008-12, 2013-17, 2018-22 and 2023-2027, respectively.

recommended an indicative reduction target of 60% by 2030[15]. The fourth budget, as proposed by the CCC, has also now been included in the relevant legislation.

Whilst not setting a target as such for the transport sector, the CCC's "Medium Abatement" scenario (effectively their "central case") would deliver a 43% reduction in GHG emissions below 2008 levels from surface transport by 2030. By 2050, the CCC estimates that an emissions reduction of more than 90% will be needed from surface transport in order to meet the economy-wide 80% reduction target. As noted above, GHG emissions from international aviation are not currently included within the carbon budgets, although the CCC has advised the Government to do so[16]. After it has completed its review of GHG emissions from international shipping (which are also currently not included), the CCC will make recommendations on how the budgets would need to be adjusted to take account international transport GHG emissions[17].

2.2 Policies that affect the carbon intensity of transport fuels

Currently the vast majority of transport fuel used in the UK is derived from oil, e.g. petrol and diesel in road transport, and kerosene in aviation. The main exception is rail transport, which also uses electricity, while a small amount of biofuels is used by road transport[18]. In the future, as a result of the longer-term GHG reduction objectives (see Section 2.1), it is likely that the use of fuel derived from sources other than oil will increase in the transport sector. In the short- to medium-term, this is likely to mean increases in the use of biofuels and electricity, while hydrogen is a potential medium- to long-term option. If such fuels are to contribute to reducing transport's GHG emissions, biofuels need to be "sustainable" and electricity and hydrogen need to be produced from zero, or at least very low, carbon sources[19].

There are, however, many challenges to ensuring that these alternative fuels and energy sources are sustainable and low carbon. The use of low carbon electricity (and/or hydrogen) in the transport sector requires the decarbonisation of the electricity (and/or hydrogen) supply industries (see Sections 3.3 and 3.4). The extent of any GHG benefits from using biofuels varies according to the feedstock (e.g. wheat, rapeseed, waste products) that is used to produce the biofuels, the direct land use change that occurs from planting the biofuel feedstock and the associated emissions, the processing and transport emissions, as well as the use of the by-products of production[20]. Additionally, an issue that is gaining increasing prominence in relation to the GHG reduction potential of biofuels is the potential impact of indirect land use change (ILUC), which can be large and variable[21].

In the context of decarbonising transport fuels, it is also worth noting that the use of "unconventional" sources of oil, e.g. oil sands and oil shale, instead of conventional crude oil has the potential to increase the carbon content of transport fuel. For example, the European Commission is reported to be considering an amendment to existing legislation that would effectively count transport fuels derived from oil sands as having a 22% higher carbon intensity than fuel produced from conventional crude oil[22].

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[15] CCC (2010)
[16] The Government needs to make a decision on whether or not to include GHG emissions from international aviation in the carbon budgets in 2012.
[17] CCC (2010)
[18] 3.3% in 2009/10, according to the DfT: see http://www.dft.gov.uk/topics/sustainable/biofuels/use-supply/
[19] See, for example, the conclusions of The King Review of low-carbon cars (2007) *Part I: The potential for CO_2 reduction*, TSO, London.
[20] For example, see AEA (2008) *"Review of work on the environmental sustainability of international biofuels production and use"* Report for DEFRA
[21] For example, see E4Tech (2010) *"A causal descriptive approach to modeling the GHG emissions associated with the indirect land use impacts of biofuels"* Report for DfT
[22] The figure being considered for the carbon intensity of fuel derived from conventional crude oil is 87.5gCO_2 per megajoule (MJ), whereas the figure being considered for oils sands is 107gCO_2/MJ; see *"Larger footprint for fuel from oil sands",* ENDS Report, Issue 441, October 2011, p53

The relevant UK targets with respect to increasing the use of renewable energy, generally, and in the transport sector in particular, are based on the requirements of EU legislation. Under the EU's 2009 Renewable Energy Directive (also known as the RED)[23], the UK has to deliver 15% of its energy consumption from renewable resources by 2020. In addition, the RED sets each Member State a minimum target of 10% for the proportion of final energy consumption used by transport that should come from renewable sources by 2020.

Another relevant piece of EU legislation is the Fuel Quality Directive (FQD), which sets quality standards for a range of liquid transport fuels[24]. A 2009 amendment to this Directive included a target for the reduction of lifecycle GHG emissions of these fuels of at least 6% by the end of 2020 (compared to 2010)[25]. In response to concerns about the sustainability of some biofuels, the RED and FQD contain the same set of sustainability criteria that biofuels must satisfy in order to be counted towards the respective targets, including a requirement that they deliver 35% of GHG savings compared to fossil fuels.

There are a number of overlaps between the requirements of the RED in relation to transport and the requirements of the FQD to the extent that meeting one target could mean that a Member State meets the target of the other Directive. However, this is not necessarily the case, due to the way in which the two Directives operate. One issue of relevance to this report is the different modal coverage in each Directive. For example, "sustainable" biofuels that are used in the maritime and aviation sectors are included in the calculation of transport energy from renewable sources in the RED, but these cannot be taken into account to meet the GHG savings target of the FQD[26].

In its National Renewable Energy Action Plan (NREAP) submitted under the RED[27], the UK presented an illustration of the way in which its transport target could be met[28]. This anticipated that the transport target would largely be met through increasing the use of biofuels in transport. The use of renewable electricity in transport would amount to around 6% of the total renewable energy needed to meet the target and most of this would be used by "non-road" transport[29].

However, the 2011 UK Renewable Energy Roadmap takes a more cautious approach to biofuels – noting that the existing RED (and FQD) sustainability criteria do not address some important sustainability concerns, such as ILUC[30]. The European Commission was supposed to have reported by the end of 2010 on a review of ILUC, and to make a proposal to amend the Directive, as appropriate, in order to ensure that the use of biofuels delivered GHG reductions while taking account of ILUC. However, a proposal has

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[23] Directive 2009/28/EC on the promotion of the use of energy from renewable sources; see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF.

[24] Directive 98/70/EC relating to the quality of petrol and diesel fuels; as amended by Directive 2009/30/EC; see http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0088:0113:EN:PDF

[25] Additionally, in order to potentially increase this figure to 10%, there are two indicative targets of 2% that can be achieved through, for example, the use of carbon, capture and storage or through the use of credits purchased through the Kyoto Protocol's Clean Development Mechanism.

[26] For a discussion of the relevant issues, see Skinner I and B Kretschmer (2010) *The interactions between European policy drivers for increasing the use of biofuels in transport* Paper prepared under the Biomass Futures project; see http://www.tepr.co.uk/files/tepr/home/RED_and_FQD.pdf

[27] The UK NREAP can be found at: http://ec.europa.eu/energy/renewables/transparency_platform/doc/national_renewable_energy_action_plan_uk_en.pdf

[28] This was based on the results of the lead scenario of the previous government's UK Renewable Energy Strategy.

[29] Hence, in this illustration around 94% of the target would be achieved through the use of sustainable biofuels; see Table 12 of UK NREAP.

[30] DECC (2011) *UK Renewable Energy Roadmap*; see http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/renewable-energy/2167-uk-renewable-energy-roadmap.pdf

not yet been forthcoming, while concerns over the sustainability of biofuels if ILUC is ignored have been increasing[31]. The way in which Directives such as the RED and FQD account for the GHG emissions of biofuels, i.e. that they implicitly assume that there are no GHG emissions from the combustion of biofuels, has also been criticised, as it neglects that harvesting biomass can decrease the amount of carbon stored in soil and plants[32].

In the course of 2011, the Government consulted on the implementation of the RED and FQD, but for the moment the target levels for the amount of biofuels to be used in transport is to remain 5% for 2013/14 and beyond. This requirement is set by the Renewable Transport Fuel Obligation (RTFO), which sets an obligation on road transport fuel suppliers. A UK Bioenergy Strategy is expected to be published before the end of 2011. There is no policy that directly aims to decarbonise aviation fuels, although the inclusion of aviation in the EU emissions trading scheme could have an indirect effect (see Section 2.3).

More generally, the UK Renewable Energy Roadmap focuses on actions to increase the amount of renewable energy in the UK in the period up to 2020 with the aim of meeting the 2020 RED target. The Roadmap notes that the CCC has advised the Government that by 2030 between 30% and 45% of all energy consumed in the UK could be from renewable sources. The UK Government is planning to respond to the CCC's advice by the end of 2011[33]. Such developments could improve the GHG performance of rail that uses electricity, as an increasing proportion of UK electricity comes from renewable sources.

The RED requires the European Commission to present a Renewable Energy Roadmap for the post-2020 period in 2018. As noted in Section 2.1, the EU has an objective that requires further reductions in GHG emissions beyond 2020, so it is likely that there will be additional renewable targets for Member States in the post-2020 Renewable Energy Roadmap. Even in the absence of a target beyond 2020 in a revised RED, the UK is very likely to continue to take action to decarbonise its power generation, and increase the amount of biofuels used if their sustainability issues can be overcome, as a result of its domestic commitments.

2.3 Policies that affect vehicle efficiency

The fuel efficiency requirements for new passenger cars and new vans are set in EU Regulations. For new passenger cars, the "passenger car CO_2 Regulation" sets an average target of 130gCO_2/km[34] to be met by manufacturers by 2015[35]. The Regulation also sets an average target for 2020 of 95gCO_2/km, although the details of how the target is to be achieved have yet to be agreed. A similar "van CO_2 Regulation" aims to reduce CO_2 emissions from vans to an average of 175gCO_2/km by 2017 and then to

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[31] JRC (2011) *"Estimate of GHG emissions from global land use change scenarios"* JRC Technical Note EUR 24817; see http://re.jrc.ec.europa.eu/bf-tp/download/Technical_Note_EU24817.pdf

[32] For example, European Environment Agency Scientific Committee (2011) *Opinion of the EEA Scientific Committee on Greenhouse Gas Accounting in relation to Bioenergy*; see http://www.eea.europa.eu/about-us/governance/scientific-committee/sc-opinions/opinions-on-scientific-issues/sc-opinion-on-greenhouse-gas

[33] DECC (2011)

[34] There are no assumptions with respect to the uptake of biofuels underlying this figure, or underlying any of the other figures quoted in this report for the fuel efficiency of cars, vans and heavy goods vehicles. The current figures for the fuel efficiency of cars and vans are measured on the basis of existing test cycles (see footnote 38), which are based on standardised fuels that do not contain biofuels. In order to enable comparison with the current figures, future figures are implicitly estimated on the same basis even though in order to reach future targets, e.g. those proposed by the CCC for 2030, a significant proportion of the vehicles would have to be electric.

[35] Regulation (EC) 443/2099 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles

147gCO_2/km by 2020[36]. To date, no similar legislation exists for other modes and there are no commitments, e.g. in the Regulations themselves, to develop targets beyond 2020. However, this is not to say that there will not be stricter targets for cars and vans and that legislation for other modes will not be forthcoming, e.g. one of the initiatives in the Commission's 2011 Transport White Paper was to develop appropriate standards for the CO_2 emissions of vehicles in all modes[37].

It is important to note that the targets in the existing Regulations are measured according to the existing test cycles[38], which do not reflect real world emissions as well as might be expected. For example, an analysis of fuel consumption data of a group of business drivers in the Netherlands found that real world CO_2 emissions were, on average, 18% higher for diesel cars and 16% higher for petrol cars than the emissions as measured on the test cycle[39]. This has implications when identifying the real world impacts of the respective legislation.

A 2011 report on progress towards the targets in the passenger car CO_2 Regulation suggested that the average new car in the EU-27 in 2010 had CO_2 emissions of 140.3g/km, which was a 3.7% improvement on the 2009 figure of 145.7g/km. In the UK, the improvement was slightly better than average as a 3.8% improvement saw the average CO_2 emissions of new cars decline from 150g/km to 144g/km[40]. This is consistent with SMMT figures for the UK[41].

In its "Medium Abatement" scenario for 2030, the CCC assumes that the efficiency of conventional cars improves to 80gCO_2/km[42] and that of conventional vans would be 120gCO_2/km. In order to reinforce UK action to meet the fourth carbon budget, the CCC argues that the UK Government should push for targets to be set under the existing EU Regulations for 2030 of around 50gCO_2/km for cars and 80gCO_2/km for vans[43].

As yet, as noted above, there is no EU level GHG reduction target for heavy goods vehicles (HGVs), although standards have been developed and implemented elsewhere, e.g. Japan and the USA, so could potentially be developed in the EU[44].

For aviation, the International Civil Aviation Organization (ICAO) and its member countries, including the UK, are developing a regulatory CO_2 emissions standard for new aircraft with the aim of having this in place by 2013[45]. In the EU, the inclusion of aviation in the EU's emissions trading system (ETS) from 2012 has the potential to incentivise airlines to take action to reduce their GHG emissions, which could include more efficient aircraft, but also changes in operational practices. However, DECC's impact assessment of the relevant UK Regulations assume that there will be no GHG

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[36] Regulation (EU) 510/2011 setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO_2 emissions from light-duty vehicles
[37] See Initiative 26 in Annex I of COM (2011) 144
[38] These are standardised procedures that each vehicle has to pass before it is allowed to be put on sale in the EU, which includes the measurement of emissions.
[39] TNO (2010) Passenger car CO_2 emissions in tests and in the real world – an analysis of business use data. Report no: MON-RPT-2010-00114, prepared for the Dutch Ministry of Housing, Spatial Planning and the Environment.
[40] Transport and Environment (2011) *How clean are Europe's cars? An analysis of carmaker progress towards EU CO_2 targets in 2010*
[41] SMMT (2011) New car CO_2 Report 2011
[42] There is a limit to how far the efficiency of vehicles using conventional internal combustion engines can be improved, but there is debate about what this limit is. CCC (2010) reported that some industry participants suggested that it could be as low as 60gCO_2/km, but 80gCO_2/km is a more commonly mentioned figure.
[43] By "conventional" cars and vans, the CCC means those using internal combustion engines, i.e. not electric vehicles. The EU targets that it proposes do include electric vehicles, which is the reason for the differences in the figures presented in this paragraph.
[44] See, for example, AEA and Ricardo (2011) *Reduction and testing of greenhouse gas emissions from heavy duty vehicles: Lot 1 - Strategy*, for European Commission; see http://ec.europa.eu/clima/policies/transport/vehicles/docs/ec_hdv_ghg_strategy_en.pdf
[45] DfT (2011) *Developing a sustainable framework for UK aviation: Scoping document*

emissions abatement in aviation before 2020, as a result of an anticipated low level of fleet replacement[46]. A recent independent analysis reached a similar conclusion, i.e. that prior to 2020, GHG emissions abatement resulting from the inclusion of aviation in the EU ETS will largely (around 93%) occur in other ETS sectors[47].

For rail, the CCC's "Extended Ambition" scenario to 2020 assumes a small GHG emissions reduction resulting from improved efficiency, including new trains, but also through other ways of saving energy. In the medium term, the CCC believes that there is scope for further GHG reduction through the further electrification of rail, as even with the current electricity mix in the UK, CO_2 emissions per passenger kilometre from electric trains are two-thirds that from diesel trains. In the longer term, there is the potential for further reductions from electric trains, as the power generation sector decarbonises (see Section 3.3), although it may not be possible to deliver a 100% electrification of the railway system. However, the CCC believes that there are many uncertainties in relation to the possibility of further electrifying the UK rail network, so do not rely on emissions reductions from further electrification and from high speed rail in their transport scenarios[48].

2.4 Policies that affect vehicle use

There are a number of potential policy options that could reduce transport's CO_2 emissions by affecting the way in which a vehicle is used. For example, a recent report that looked at the potential social and distributional impacts of transport policies that could be put in place by the Department for Transport (DfT) to reduce CO_2 emissions from passenger transport, included (in addition to policies mentioned in previous sections):

- Congestion charging, local road pricing schemes and parking charges;
- Investment in public transport and cycling infrastructure;
- Smarter choices;
- Car clubs and car sharing; and
- Information and training on eco-driving.

The report noted that other policies, such as fuel and vehicle taxation and the regulation of speeds, also had the potential to be used to reduce transport's CO_2 emissions[49]. Other reports have also identified a similar wide range of policies that could be used to reduce transport's CO_2 emissions[50]. Ultimately, the impact on CO_2 emissions of many of these policies depends on the level of any charges or taxes, the extent of any resources or investment allocated, as well as the location and design of any local measures. There is also the potential that some of these policies, e.g. car clubs, as well as some of the potential technological developments, e.g. electric vehicles, could influence the way in which cars are owned and used, but it is not possible at this stage to identify the impact on transport's CO_2 emissions of such developments.

On the basis of the assumptions used in a report for the European Commission that explored scenarios to reduce the EU's transport GHG emissions out to 2050, higher GHG

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[46] Department of Energy and Climate Change (2010) *Impact Assessment: Aviation Greenhouse Gas Emissions Trading Scheme Regulations*; see: http://www.legislation.gov.uk/uksi/2010/1996/pdfs/uksiem_20101996_en.pdf

[47] Faber J and L Brinke (2011) *The Inclusion of Aviation in the EU Emissions Trading System: An Economic and Environmental Assessment*; ICTSD Programme on Trade and Environment; Trade and Sustainable Energy Series; Issue Paper No. 5; International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org.

[48] CCC (2010)

[49] AEA, TTR and TSU (2011) *Knowledge Review of Social and Distributional Impacts of Climate Change Policy Options* for Department for Transport.

[50] For example, UK ERC (2009) *What policies are effective at reducing carbon emissions from surface transport?* ISBN 1 903144 0 7 8

reductions were delivered from pricing and taxation policies than from other types of policy listed above[51].

It is possible to identify potential GHG reduction benefits of some of the policies that would target vehicle use. For example, tests for the European Environment Agency (EEA) on the potential GHG reduction from reducing speed limits estimated that a reduction in speed limits from 120km/h (around 75mph) to 110km/h (68mph) could theoretically deliver savings of between 12% and 18% for existing cars. However, with more realistic assumptions the analysis suggested that, while there would still be savings, these would be more likely to be between 2% and 3%[52]. Generally speaking, for cars the most efficient speeds from a CO_2 emissions perspective are between 50km/h (around 31mph) and 90km/h (56mph), after which CO_2 emissions per kilometre tend to increase[53]. Speed reduction also has the potential to reduce CO_2 emissions from commercial vehicles. For example, a reduction in speed from 90km/h to 80km/h (50mph) for a 40 tonne truck could lead to a 6% reduction in fuel consumption[54]. However, it is important to note that reduced speeds would increase travel times[55]. For freight transport, the resulting longer journey times by road could increase the number of trucks needed to move similar amounts of freight or result in a shift from road to rail.

In its transport scenarios, the CCC includes a number of non-technical transport measures in its "Extended Ambition" scenario to 2020, i.e.:

- The roll-out of Smarter Choices in all UK towns and cities could reduce car kilometres by more than 5%.
- 10% of car and van drivers and all HGV drivers trained in eco-driving by 2020.
- Strict enforcement of the 70mph speed limit on motorways.

Additionally, in its more ambitious "Stretch Ambition" scenario, the CCC also includes policies that are "likely to be cost-effective in reducing emissions, but where political considerations may pose a significant barrier", i.e.:

- Road pricing, if it is introduced in addition to existing fuel duty, could result in significant GHG emissions reductions, mainly from a reduction in distances travelled. The CCC notes that between 2020 and 2030, road pricing should be "seriously considered".
- Reducing speed limits from 70mph to 60mph would deliver GHG emissions reductions as a result of fuel efficiency improvements.

Additionally, between 2020 and 2030, the CCC's "Medium Abatement" scenario assumes that truck kilometres can be reduced by 6.5% as a result of improved logistics, but notes that the potential is uncertain and could range from nothing to double this figure. The CCC also estimated that the affect of the high speed rail proposals on surface transport emissions (i.e. the increase in emissions from electricity generation and any reduced car emissions resulting from modal shift) would be negligible[56]. In their review of the GHG implications of HS2, Booz and Temple (2011) reached similar conclusions[57].

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[51] Skinner I, van Essen H, Smokers R and Hill N (2010) *Towards the decarbonisation of EU's transport sector by 2050* Final report for the European Commission; see http://www.eutransportghg2050.eu/cms/assets/EU-Transport-GHG-2050-Final-Report-22-06-10.pdf

[52] http://www.eea.europa.eu/themes/transport/speed-limits

[53] See the third slide of Ligterink, N (2011) *"NEDC is OK"*, presentation at LowCVP Life-cycle CO_2 Assessment seminar, 14 November, London; see http://lowcvp.org.uk/assets/presentations/1615%20LigterinkNE.pdf

[54] AEA and Ricardo (2011)

[55] Although this could be marginal, e.g. the work for the EEA suggested that reducing speeds from 120km/h to 110km/h would add no more than 9 minutes to a 200km (125 mile) trip.

[56] CCC (2010)

[57] Booz & co and Temple (2011) *HS2 to the West Midlands – Appraisal of Sustainability: Appendix 2 – Greenhouse Gas Emissions*

The current UK Coalition Government is not considering a national road pricing scheme for cars on existing roads, or even making any preparations for such a scheme, in the lifetime of the current Parliament (i.e. until at least 2015)[58]. The Government has also announced that it intends to launch a consultation on the possibility of increasing the speed limits on motorways to 80mph[59]. The DfT acknowledges that such a change would increase CO_2 emissions, but disagrees with the CCC as to the extent of the increase. While the CCC estimates that the change would increase annual CO_2 emissions by 2.2 million tonnes a year, the DfT estimates that the increase would be less than a third of this figure[60].

In its 2011 White Paper, the European Commission set out a number of potential policies that it will consider in relation to transport taxes and charges. These include mandatory infrastructure charging for heavy goods vehicles, which would cover the costs of noise and pollution by 2016 (this is currently voluntary) and extending this to all road transport by 2020, as well as extending the coverage of the charge to cover the costs of congestion and, potentially, CO_2[61]. The Commission also proposes to ensure that the costs of local air and noise pollution for other modes, including aviation, are internalised by 2020[62]. However, based on experience with previous European legislation on transport taxes and charges, it is far from certain that these proposals will become law in the form proposed. The Commission is also considering the inclusion of eco-driving requirements in future revisions of the driving licence Directive.

2.5 Policies that affect the capacity of transport infrastructure

In relation to the capacity of transport infrastructure, the most important issue of relevance in the context of this report relates to airport capacity. Heathrow already operates daily at close to 100% of its potential capacity, as does Gatwick in the peak summer period[63]. By 2030, it is predicted that other South East airports, as well as those in Manchester and Birmingham, will also be operating close to or at capacity[64]. More widely, it has been projected that nearly half of the main airports in the EU will be heavily congested by 2025 without additional capacity[65]. However, citing environmental constraints, the current UK Coalition Government cancelled the plans of its predecessor to expand runway capacity at Heathrow airport and confirmed that it would refuse permission for additional runways at Gatwick and Stansted airports[66]. Hence, at least for the life-time of this Parliament (until 2015), it would appear that there will be no expansion of airport capacity in South East England.

There is an important link between airport capacity and high speed rail. As has been noted by the CCC, high speed rail has the potential to contribute to reducing the UK's GHG emissions with two important caveats. First, there needs to be a low carbon electricity system (see Section 3.3) and second, any landing and take-off slots released at capacity-constrained airports as a result of a reduction in domestic flights were withheld[67]. This is consistent with the conclusion of Booz and Temple (2011). In their

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[58] See http://www.dft.gov.uk/publications/road-pricing-demonstrations-project
[59] See http://www.dft.gov.uk/news/press-releases/dft-press-2011100
[60] Note that even the DfT's estimated increase is equivalent to around 1% of the total annual emissions of cars, small vans and motorcycles in the UK; see *"Speed limit rise would increase CO_2 emissions",* ENDS Report, Issue 441, October 2011, pp34-35
[61] CO_2 would be covered unless it is included within a previous amendment to amend a Directive that sets minimum tax rates for energy products, which has already been proposed.
[62] COM (2011) 144
[63] DfT (2011) *South East Airports Taskforce: Report*; see http://assets.dft.gov.uk/publications/south-east-airports-taskforce-report/south-east-airports-taskforce-report.pdf
[64] CAA (2011) *Response to the Department for Transport Consultation: Developing a Sustainable Framework for UK Aviation*
[65] Eurocontrol (2004) *Challenges to Growth*; see http://www.eurocontrol.int/eatm/gallery/content/public/library/CTG04_report.pdf
[66] DfT (2011) *Developing a sustainable framework for UK aviation: Scoping document*
[67] CCC (2010)

most optimistic scenario of the GHG implications of HS2, they concluded that HS2 could deliver significant savings as a result of fewer domestic flights if the landing and take-off slots that would be freed up remain unused. In their "Worse Case" scenario, these freed up slots would instead be used by international flights resulting in potentially significant increases in GHG emissions[68]. There is clearly a risk that any airport landing and take-off slots freed up by HS2 would indeed be used instead for international flights[69].

Neither the CCC nor Booz and Temple attempted to estimate the impact on GHG emissions if the slots potentially freed up at capacity-constrained airports by HS2 were instead used by long-haul, international flights. Clearly there are many assumptions that would need to be made in order to make such an estimate and it is not possible within the scope of this report to do so. However, it is expected that aviation will continue to grow, e.g. the CCC believes that it would be possible to let aviation demand increase by 60% by 2050 and still meet the previous Government's target of bringing aviation's GHG emissions back to 2005 levels by 2050[70]. Hence, it is unlikely that any slots released at Heathrow as a result of HS2 would remain unused. Similarly, if airport capacity was increased in the South East, there is clearly the potential for more flights – both short- and long-haul. CCC notes that the increase in demand that they think is possible is far less than that which would result without policies to constrain demand (e.g. limits on airport capacity or carbon pricing)[71].

In the medium- to long-term, it might be possible that an extended HSR network could interact with regional airports in a way that leads to fewer CO_2 emissions. However, it is beyond the scope of this report to assess what such a transport network might look like, or how it could deliver reduced CO_2 emissions. Additionally, as noted by Booz and Temple (2010), CO_2 emissions will also be caused by the construction of transport infrastructure, as well as by the extraction and transport of the materials used. Embedded emissions are being considered elsewhere in the wider study, so will not be considered further within this report.

The importance of integrating land use planning and transport policy in contributing to reduced CO_2 emissions from transport has been highlighted by the CCC. They note that the ongoing review of the planning framework is an opportunity to take better account of transport emissions in planning decisions[72]. In this respect, they recommend the development of integrated land use and transport planning strategies[73]. Other reports have reached similar conclusions[74]. Experts consider that land use policy would be most favourable to reducing CO_2 emissions if it favoured higher densities, active and attractive local communities and had amenities in walking distance, and which were well served by public transport. Additionally, urban brown field development should be favoured over ex-urban green field development[75], which could also be beneficial from a carbon perspective. In response to the Government's 2011 consultation on its proposed National Planning Policy Framework, a number of transport organisations have called for

[68] Booz & co and Temple (2011) *HS2 to the West Midlands – Appraisal of Sustainability: Appendix 2 – Greenhouse Gas Emissions*
[69] For example, see "*High-speed rail set to boost UK emissions from aviation*", ENDS Report, Issue 434, March 2011, pp34-36.
[70] Although this target has not been accepted by the current Coalition Government, the CCC's analysis that has been published to date assumes that this is the target; see CCC (2009) *Meeting the UK aviation target options for reducing emissions to 2050*
[71] CCC (2009)
[72] http://www.theccc.org.uk/sectors/surface-transport/land-use-and-transport-planning
[73] CCC (2010)
[74] Transport for Quality of Life (2011) *Thriving Cities: Integrated land use and transport planning* Report for PTEG
[75] Goodwin, P (2009) Report of CCC Expert Workshop *Land Use Aspects of Transport's Contribution to Climate Change*; see http://downloads.theccc.org.uk/CCC_land_use_transport_report.pdf

the reduction of GHG emissions and the promotion of a low carbon economy to be one of the core principles and objectives for the framework[76].

3. ADVICE ON THE MODELLING ASSUMPTIONS

This section of the report provides advice on the modelling assumptions that could be used in the wider study. The advice is based on a review of assumptions and estimates of potential future changes that have been made in other relevant reports. The assumptions used in the previous modelling work by ATOC are presented in Table 1. This report reviews these assumptions in Section 3.1, below.

Table 1: List of assumptions used in ATOC 2009 analysis

	Year[1]	Assumption	Notes
Car travel*			
CO_2 emissions per vehicle-km (King Review/CCC scenario)	2008 2025 2040 2055	158 gCO_2/veh-km** 95 57 6	The figures assume that all new cars by 2055 are electric, with energy consumption of 0.2kWh per vehicle-km.
Carbon emissions per vehicle-km ('continuation of current trends' scenario)	2008 2025 2040 2055	158g CO_2/veh-km 112.1 82.8 61.1	Forecasts assume new car emissions fall by 2% per annum. The figures assume no widespread take-up of electric cars but significant hybrid penetration.
Average car occupancy	All years	30% occupancy 5 seats per car	Based on National Travel Survey.
Short-haul aviation			
CO_2 emissions per vehicle-km	2008 2025 2040 2055	14.9 $kgCO_2$/aircraft-km 9.7 7.5 6.4	Based on A319 on a 300-600 km sector.
Seat per aircraft	All years	156	Based on Easyjet's seating capacity (higher than standard)
Average load factor	All years	85%	Based on Easyjet average
Rail travel			
Carbon intensity of electricity generation	2006 2020 2030 2050	560 gCO_2/kWh 310 Approx 80 Approx 40	Based on CCC forecasts

Source: ATOC (2009)[77]

Notes: * Two scenarios were developed for car travel: the first assumed that the reductions considered possible by the King Review would be met; the second scenario assumed more modest improvements in line with historical performance. ** This is based on average *new* car emissions.

[76] Chartered Institution of Highways and Transportation et al (2011) *Consultation on National Planning Policy Framework (NPPF) Summary of key responses – Joint submission*
[77] See http://www.greengauge21.net/wp-content/uploads/Energy-Consumption-and-CO2-impacts.pdf for rationale underpinning the assumptions.

The modelling to be undertaken as part of the wider study will be broader in scope than the previous modelling. Consequently, this report also aims to provide advice on the additional assumptions that need to be made as part of this broader modelling. In this respect, the report focuses on the following issues in Sections 3.2 to 3.6, respectively:

- Range of potential future oil prices (or fuel prices for road transport).
- Carbon intensity of electricity generation and changes over time.
- Carbon intensity of other fuel sources.
- Take-up of low carbon vehicles.
- Improvements in air transport energy efficiency and costs.

Section 3.7 reviews some additional assumptions of relevance, i.e.:

- Factors to adjust the assumptions above on CO_2 emissions for aviation in order to take into account other greenhouse gas effects, e.g. radiative forcing.
- Carbon emissions per vehicle-km for HGVs.

On the basis of the review of these issues, Section 3.8 provides advice on the assumptions that could be used in the modelling work, including potential alternative scenarios.

Before reviewing the various assumptions, it is first important to discuss the potential timescales for the modelling. It has been suggested that the modelling in the wider study might consider a time frame beginning with information on the current situation and end in 2050. Ending in 2050 would be consistent with the strategic targets (see Section 2.1), while beginning in 2010 would also make sense, as data is now available in most cases. This would also mean that the modelling would cover 40 years, which would be tidier to present, and that intermediate assessments could be undertaken for 2020, 2030 and 2040, which would also be consistent with other approaches. Hence, in the sections that follow, it is assumed that the focus will be on these 10 yearly intervals from 2010 to 2050.

3.1 Assumptions used in previous modelling

When modelling the CO_2 emissions from new cars into the future, care must be taken when considering what figure to use for CO_2 emissions. The assumptions used in ATOC's 2009 analysis used the UK's new passenger car CO_2 emissions figure, as reported by the SMMT and as measured by the test cycle. As noted in Section 2.3, real world GHG emissions tend to be higher than test cycle emissions by on average between 16% and 18%, so in order to reflect actual GHG emissions from new cars, it would be useful to increase the test cycle emissions by a factor of around 17%[78]. As was also noted above, in 2010 the average test cycle CO_2 emissions from new passenger cars in the UK were 144gCO_2/km. Note that the annual rate of improvement in the latest SMMT report was 3.5% between 2009 and 2010, which amounted to a 20.3% reduction since 2000[79].

Looking to the future, the 2008 King Review considered that, by 2030, GHG emissions from new cars (as measured on the test cycle) could be half what they were then. The report mentioned the UK average CO_2 emissions from 2006, which were 167gCO_2/km, so concluded that by 2030, CO_2 emissions from new cars could be around 80gCO_2/km[80]. The King Review also recommended that the EU should adopt a target of 100gCO_2/km by 2020[81]. As was noted in Section 2.3, the 2009 passenger car CO_2 Regulation

[78] Note that a new test cycle is being developed that should address the current discrepancy between test cycle and real world CO_2 emissions, but this will not be in place for a number of years.
[79] SMMT (2011)
[80] The King Review of low-carbon cars (2007) *Part I*
[81] The King Review of low-carbon cars (2007) *Part II: Recommendations for action*, TSO, London.

subsequently set a more stringent target for 2020 of 95gCO_2/km for cars and the CCC have called for a European target of around 50gCO_2/km for cars for 2030.

Moving beyond 2030, if the economy-wide GHG reduction ambitions for the UK and EU are to be achieved, CO_2 emissions from cars and other transport vehicles will need to continue to improve, so it makes sense to assume that there will be continuing requirements to reduce CO_2 emissions from new cars beyond 2030. The King Review assumed that, if "substantial progress" could be on some the challenges with existing technologies and if a decarbonised power sector supplies a large proportion of road transport's energy demand, per kilometre reductions of 90% could be achievable for cars by 2050[82]. Recent work on future GHG reduction scenarios for EU transport in a project entitled *"EU Transport GHG: Routes to 2050"* assumed that GHG emissions from cars, vans and motorcycles could be reduced by 90% by 2050 compared with 2010[83,84].

Given that there are aspirations at the UK and EU levels to significantly reduce GHG emissions by 2050 (see Section 2.1), it is likely that significant reductions in GHG emissions from new vehicles will be achieved. However, if it is desired to undertake two scenarios for this factor, as was done in the previous modelling exercise, then an option would be to retain the previous assumption of an annual improvement of 2% in the CO_2 emissions of new passenger cars up to 2050. However, this assumption is probably consistent with a broader assumption that there is no policy to reduce CO_2 emissions from cars beyond 2020, rather than with a policy failing to deliver. Given the likelihood that there will be a policy to reduce CO_2 emissions from passenger cars beyond 2020, an alternative option might be to assume an annual reduction of 3%.

The SMMT estimates that average CO_2 emissions across *all cars in use* in the UK in 2009 were 172.8gCO_2/km, which was a 1.3% decrease on the previous year. This amount exceeded the average CO_2 emissions of new cars in 2009 by 15.6%[85]. Note that the difference between average CO_2 emissions of new cars and all cars appears to be variable as in 2008 the figure for all cars was only 10.8% above the average for new cars[86]. The *"Routes to 2050"* referred to above assumed that the GHG emissions of the average car in the fleet across the EU were 10.7% higher than those of new cars in 2010[87].

The National Travel Survey is a good source of occupancy rates for passenger cars. The 2010 version notes that car occupancy rates have been relatively stable at 1.6 occupants per car since the mid-1990s[88], but that occupancy varies and is as low as 1.2 for business and commuting travel[89].

The other assumptions from the previous modelling relating to short-haul aviation and rail travel are covered respectively in Sections 3.6 and 3.3 below.

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[82] The King Review of low-carbon cars (2007) *Part I*

[83] A linear reduction between 2010 and 2050 was assumed. Note that these were actually reductions in life cycle GHG emissions, i.e. GHG emissions from vehicles in use, as well as from the GHG emissions released from producing and supplying the energy or fuel.

[84] Hill N, M Morris and I Skinner (2010) *SULTAN: Development of an Illustrative Scenarios Tool for assessing the potential impacts of measures on EU Transport GHG* Report for the European Commission; see http://www.eutransportghg2050.eu/cms/assets/EU-Transport-GHG-2050-Report-VII-SULTAN-Illustrative-Scenarios-Tool-04-06-10-FINAL.pdf

[85] SMMT (2011) New car CO_2 Report 2011

[86] SMMT (2010) New car CO_2 Report 2010

[87] Hill et al (2010)

[88] Hill et al (2010) also use an average occupancy rate for cars of around 1.6. They also assume a capacity of five seats per car.

[89] DfT (2011) National Travel Survey: 2010 – Statistical release, 28 July 2011; see http://assets.dft.gov.uk/statistics/releases/national-travel-survey-2010/nts2010-01.pdf

3.2 Range of potential oil prices (or fuel prices for road transport)

The CCC uses oil prices corresponding to scenarios developed by DECC and published in 2010. In DECC's central scenario, oil prices rose from $72/barrel in 2010 to $82/barrel and $92/barrel in 2020 and 2030, respectively. On the basis of these figures, DECC and the DfT forecast that petrol prices could increase from 110p/litre in 2010 to 128p/litre by 2030, while diesel prices could increase from 115p/litre to 131p/litre over the same period[90]. More recently, in its aviation forecasts DfT assumed that oil prices in 2010 were $70 before rising to $90 a barrel in 2030[91]. In its most recent projections, DECC revised its central oil price assumptions upwards to $81/barrel in 2010 rising to $118/barrel in 2020 and $128/barrel in 2030 (in 2011 prices). The report also has assumptions for oil price ranges up to 2030, with crude oil prices under a "High Prices" scenario reaching $134/barrel by 2020 and $168/barrel by 2030. Under the report's "Low Prices" scenario, the price of a barrel of oil increases to only $91/barrel by 2020 and falls to $74/barrel by 2030[92].

Internationally, projections of future oil prices are more in line with the more recent DECC assumptions, e.g. earlier this year the International Energy Agency (IEA) was using an oil price of $110/barrel in 2020 and $130/barrel by 2030 and $135/barrel by 2035 for its policy scenarios. At the same time, the US Energy Information Administration was assuming slightly lower prices ($108 by 2020, increasing to $123 by 2030 and $125 by 2035). More recently, the IEA has assumed an oil price of $120/barrel in 2035 in its "New Policies" scenario[93]. Other assumptions tend to be lower than those used by the IEA and US EIA, e.g. these can range from around $80/barrel to nearly $120 in 2030[94]. However, it is clear that assumptions about future oil prices vary significantly and even change from year to year.

3.3 Carbon intensity of electricity generation and changes over time

As noted in Section 2, the decarbonisation of the power generation is important if HSR is going to contribute to a future low carbon transport system. Under the CCC's "High Abatement" scenario, the carbon intensity of power generation could be as low as 40gCO_2/KWh by 2030, while under its "Low Abatement" scenario, the equivalent figure would only be 130gCO_2/KWh[95]. Table 2 shows the CCC's assumptions under its "Medium Abatement" scenario, which are slightly different from the assumptions used in ATOC's earlier modelling (see Table 1).

Table 2: Key CCC assumptions for the power sector in their economy-wide "Medium Abatement" scenario

	2008	2020	2025	2030
Demand (TWh)	319	325	355	425
gCO_2/kWh	544	320	150	50
Low carbon capacity (GW)	16	26	33	58

Source: CCC (2010), Table 3.5

90 CCC (2010)
91 These were in line with DECC's Scenario 2 and were are 2008 prices; see DfT (2011) *UK aviation Forecasts*
92 DECC (2011) *"Updated energy and emissions projections 2011"*; see http://www.decc.gov.uk/assets/decc/11/about-us/economics-social-research/3134-updated-energy-and-emissions-projections-october.pdf
93 In its 2011 World Energy Outlook; see http://www.iea.org/weo/docs/weo2011/factsheets.pdf
94 See Table 13 of US EIA (2011) *Annual Energy Outlook 2011 with projections to 2035*; see http://www.eia.gov/forecasts/aeo/pdf/0383(2011).pdf
95 CCC (2010), Table 3.5

Booz and Temple note that the UK Government is committed to reducing the carbon intensity of electricity generation to between 14% and 40% of today's levels by 2050[96], which is not as ambitious as the rate of decarbonisation assumed in Table 2.

It is worth noting that the CCC suggests that rate of decarbonisation of the power sector could be delivered by a mix of technologies, such as renewable (e.g. wind and marine), coal and gas CCS and nuclear. The CCC's assumptions are based to some extent on where it considers the most cost-effective application of a particular technology might be. In the case of biomass, this is assumed to be in the industrial sector rather than in power generation, although it does not rule out the use of biomass for power generation in the longer-term.

At the EU level, the *"Routes to 2050"* project also assumed that electricity supply will need to be virtually decarbonised by 2050 (see Table 3)[97]. The figures are lower – at least initially – than the CCC's figures, as more low carbon energy sources are already used in other EU countries.

Table 3: Assumptions underlying decarbonisation of the EU's electricity generation[98]

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Carbon intensity ($kgCO_2$/MWh)	306	264	232	213	150	116	59	33	22
Indirect GHG (tCO_2e/MWh)	42	36	32	29	20	16	8	4	3
Total GHG (tCO_2e/MWh)	**348**	**300**	**264**	**242**	**170**	**132**	**67**	**37**	**25**

3.4 Carbon intensity of other fuel sources

As noted in Section 2.2, in addition to electricity, which was discussed in the previous section, the other likely alternative fuels and energy sources of a future low carbon transport system are biofuels and hydrogen.

The main way of decarbonising fossil fuels is through increasing the proportion of biofuels that is blended with such fuels[99]. However, as has been discussed, there are concerns about the potential of such fuels to deliver GHG reductions, particularly due to concerns about ILUC. The CCC reflects such concerns in its assumptions as it limits the uptake of biofuels to 8% (by energy, which is around 2.7 million tonnes of oil equivalent (Mtoe)) of total liquid fuel consumption by 2020 and assumes no change in this figure in two of its scenarios to 2030[100]. In its scenarios, the CCC assumes that biofuels have no GHG emissions in line with practice elsewhere, but acknowledges that there is a lot of uncertainty over the sustainability of biofuels, e.g. for the reasons discussed in Section 2.2.

The EU-level *"Routes to 2050"* project also restricted the potential use of biofuels in its scenarios as a result of similar sustainability concerns. It assumed that the well-to-wheel

[96] Booz & co and Temple (2011)
[97] These were based on the assumptions used by EURELECTRIC, the EU level industry body, in its modelling of ways of meeting an EU reduction target of 75%.
[98] Taken from Table 18 of Hill et al (2010)
[99] There is some potential to reduce the GHG emissions associated with producing the fossil fuels used in transport. The minimum 6% reduction in GHG intensity required by the FQD (see Section 2.2) can be increased to 10% by reducing *inter alia* reducing such production emissions. Such options are not discussed further in this report. However, it is also worth noting that increased use of oil from "unconventional" sources has the potential to increase the amount of GHG emitted in the course of the production of fossil fuels.
[100] CCC (2010); these are consistent with recommendations of the Gallagher Review.

GHG savings from biofuels increased from an average lifecycle GHG emissions reduction of 40% compared to the equivalent conventional fuel in 2010 to 85% by 2050[101].

With respect to modelling the GHG emissions associated with biofuels, an alternative to restricting the maximum potential biofuels that can be introduced would be to model the change in carbon intensity of transport fuels. As noted in the previous paragraph, the EU-level "*Routes to 2050*" project assumed that biofuels delivered a 40% lifecycle GHG saving compared to conventional fuels in 2010. In the UK, the average saving for the biofuels used between April 2010 and April 2011 was estimated to be 58%, although there were variations by feedstock and the country in which the biofuels were produced. This was an improvement on the previous two years in which the average estimated savings were 46% (for 2008/9) and 51% (for 2009/10). However, these figures did not necessarily include all emissions from direct land use change and excluded emissions from ILUC[102]. With respect, to ILUC a recent report[103] concluded that, if the estimates put forward by Member States in their NREAPs (see Section 2.2) were achieved, the increased demand for biofuels would cause ILUC GHG emissions of about 36gCO_2/MJ[104]. If this were applicable to the biofuels used in the UK between 2010 and 2011, it would virtually cancel out any GHG benefits.

While hydrogen is a potential low carbon transport fuel of the future, it is not used today at any significant level. However, as with electricity, if hydrogen is going to be a source of energy for a future low carbon transport system, it will need to be largely decarbonised[105]. The rate of decarbonisation of hydrogen is highly uncertain and depends on the way in which the hydrogen is produced. Whilst recognising the uncertainties involved, the "*Routes to 2050*" project made some assumptions about the rate of decarbonisation for hydrogen (see Table 4)[106].

Table 4: Assumptions underlying decarbonisation of the EU's hydrogen generation[107]

	2010	2015	2020	2025	2030	2035	2040	2045	2050
Carbon intensity (kgCO_2/MWh)	322	326	320	310	253	193	83	46	31
Indirect GHG (tCO_2e/MWh)	32	33	34	35	30	24	11	6	4
Total GHG (tCO_2e/MWh)	**354**	**359**	**354**	**346**	**282**	**217**	**94**	**52**	**35**

3.5 Take-up of low carbon vehicles

As a result of concerns about the sustainability of biofuels, CCC's decarbonisation of transport fuels relies largely on the increased use of electric vehicles and a rapid decarbonisation of the electricity supply sector. In this respect, the CCC notes that the importance of the early decarbonisation of the power sector and the large scale use of low carbon electricity in transport (as discussed in Section 3.3). By 2020, the CCC assumes (in "Extended Ambition" scenario) that 1.7 million cars and 130,000 vans are

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101 See Tables A15 and A16 of Hill et al (2010) for the interim assumptions.
102 DfT "RTFO Quarterly Report 12: 15 April 2010 – 14 April 2011"; see http://assets.dft.gov.uk/statistics/releases/biofuels_april_2011/rtfoaug2011.pdf
103 JRC (2011)
104 This is potentially significant, e.g. compared to the carbon intensity figure of 87.5gCO_2/MJ that is being considered for fuel derived from conventional crude oil (see footnote 22)
105 As noted by CCC (2010), which discusses some potential low carbon sources, but does not discuss potential rates of decarbonisation for hydrogen.
106 These were based on the assumptions used by EURELECTRIC, the EU level industry body, in its modelling of ways of meeting an EU reduction target of 75%.
107 Taken from Table 19 of Hill et al (2010)

electric or plug-in hybrid, which would equate to a market share of 16% and lead to 5% and 4% of the respective fleets being made up of these vehicles.

Looking towards 2030, under its "Medium Abatement" scenario the CCC foresees that 60% of new cars could be electric (accounting for 31% of the total fleet) of which 30% are battery electric with the remainder bring plug-in hybrid cars. Similarly, under this scenario, the proportion of new vans that could be electric by 2030 is also 60% (29% of the fleet), but a higher proportion – 87.5% - of vans would be plug-in hybrid vans. Under the same scenario, the uptake of hydrogen is limited to buses. Low-carbon hydrogen buses begin to enter the fleet around 2021 and by 2030 will have a 50% market share of new buses, but would still be only around 5% of the total fleet by that time. The CCC believes that the potential for widespread use of electric HGVs is limited, and therefore note that biofuels are important to decarbonise HGVs. In its "High Abatement" scenario, in addition to buses, there is some uptake of hydrogen for cars, vans, HGVs and coaches from 2025.

Between 2030 and 2050, the take up of alternatively-fuelled vehicles will depend on the path that has been taken to 2030. If there has been a strong uptake of electric vehicles, then all new cars and vans could be pure electric vehicles by 2035 or, if electric vehicles had not been as successful as this, there could be more hydrogen-powered cars and vans. HGVs could run on low carbon hydrogen, with any residual need for liquid fuels (e.g. for plug-in hybrid cars, non hydrogen HGVs) coming from biofuels[108].

The EU-level *"Routes to 2050"* project developed some more detailed assumptions about the proportion of new cars, vans, buses and HGVs that would use different fuels between 2010 and 2050. The figures for cars can be found in Table 5; it is interesting to note that the total market share for electric and plug-in vehicles is less than the CCC assumption at around 40%.

Table 5: Split of new car sales by fuel type[109]

	2010	2020	2030	2040	2050
Petrol	47.4%	28%	14%	7%	1%
Diesel	51.7%	18%	14%	7%	1%
Hybrid petrol	0%	20%	17%	12%	4%
Hybrid diesel	0%	16%	16%	10%	4%
Plug-in hybrid petrol	0%	7%	11%	18%	12%
Plug-in hybrid diesel	0%	6%	12%	17%	12%
Electric	0%	3%	10%	18%	35%
Fuel cell (hydrogen)	0%	0%	5%	10%	30%
Gases[110]	0.8%	2%	1%	1%	1%

When a vehicle is described as a low carbon vehicle, this is often considered to refer to a vehicle that emits (or has the potential to emit) less CO_2, either as a result of the fuel that it directly uses or as a result of it using a low carbon energy source, such as low carbon electricity. However, such low carbon vehicles can be the cause of higher levels of CO_2 emissions in the course of their production. For example, a recent report[111] for the Low Carbon Vehicle Partnership suggested that the proportion of CO_2 emissions

[108] CCC (2010)
[109] Table A20 of Hill *et al* (2010); subsequent tables show take up rates for other types of vehicle.
[110] Liquefied Petroleum Gas (LPG) and Compressed Natural Gas (CNG)
[111] Ricardo (2011) *"Preparing for a lifecycle CO_2 measure"* Report for the LowCVP; see http://www.lowcvp.org.uk/assets/reports/RD11_124801_5%20-%20LowCVP%20-%20Life%20Cycle%20CO2%20Measure%20-%20Final%20Report.pdf

resulting from the production phase of a mid-size electric car could be twice the equivalent figure for a petrol car[112].

3.6 Improvements in air transport energy efficiency and costs

ICAO has adopted a goal of achieving an annual 2% improvement in fuel efficiency between 2009 and 2020 and has set an aspirational world-wide objective of stabilising emissions from international civil aviation from 2020. For 2020, the Advisory Council for Aeronautics Research in Europe (ACARE) has set a target for the industry of achieving a 50% reduction in CO_2 emissions per seat kilometre, compared with equivalent new aircraft entering service in 2000. This would be achieved by both technical developments and improvements in operational efficiency[113].

CCC concluded that the evolutionary innovation of aircraft technology could lead to fuel efficiency improvements in new aircraft of between 35% and 45% by 2025, whereas more radical technologies could deliver savings of up to 60% by 2050 compared to 2006. Additionally, there is the potential for improvements of between 6% and 13% per flight as a result of improvements in air traffic management. Hence, the CCC estimates that there is the potential for an annual improvement in fleet fuel efficiency per seat-kilometre of between 0.8% and 1.5%[114].

On the basis of a review of the available evidence, the EU-level *"Routes to 2050"* project assumed an annual improvement in new aircraft efficiency of 1.5% compared to a business as usual annual improvement of 1%[115].

In its revised aviation forecasts, DfT assumes in its central forecast that between 2010 and 2030, the annual average fuel efficiency important of aircraft will be 0.4% delivering a 10% improvement over the 20 years. From 2030 to 2040, an annual improvement of 1% is assumed rising to 2% in each year of the following decade. In its central scenario, DfT assumes that no improvements in fuel efficiency result from operational improvements, but that that there is an increasing amount of biofuels used in aviation. The assumptions are summarised in Table 6[116].

In its forecasts, DfT assumes that air fares increase (or decrease) in line with airline costs. These consist of fuel costs, where the strong relationship between kerosene and oil prices is assumed to continue[117], and non-fuel costs, which include taxes. In this respect, Air Passenger Duty is assumed to remain constant in real terms, while airlines are assumed to pass on the costs of their EU allowances to passengers. The forecasts use DECC projections for the price of traded carbon, which assume that this will increase from £14.1tCO_2e (2009 prices) in 2010 to possibly £200tCO_2e by 2050, with lower and upper bounds of £100tCO_2e either way. Finally, the assumptions relating to changes in other non-fuel costs are given in Table 7[118].

In its reference scenarios, CCC assumes that average load factors increase from around 75% in 2005 to 85% by 2050[119]. DfT assumes that there are load factor ceilings of 80% for domestic and other short-haul flights and 90% for long-haul flights[120].

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[112] Note that the lifecycle CO_2 emissions of a mid-size electric car would still be less than that of a similar size petrol car in spite of the higher proportion of CO_2 emissions emitted in the course of production.
[113] DfT (2011) *Developing a sustainable framework for UK aviation: Scoping document*
[114] CCC (2009)
[115] See Appendix 2 of Hill *et al* (2010)
[116] DfT (2011) *UK aviation Forecasts*; note that Table 3.3 has potential improvements in fuel efficiency for different types of aircraft.
[117] It is assumed that the levels of biofuels assumed would not have a net impact on costs.
[118] DfT (2011) *UK aviation Forecasts*
[119] CCC (2009)
[120] DfT (2011) *UK aviation Forecasts*

Table 6: Summary of assumptions in DfT aviation forecast scenarios

	Low	Central	High
Regulatory CO_2 standards		None	
Retirement age		22 years	
Retro-fitting		None	
2020 Generation (cf 2000 type)	19.5 to 23.5% fuel burn improvement	17.5 to 21.5% fuel burn improvement	15.5 to 19.5% fuel burn improvement
2030 Generation	28.5 to 31.5% fuel burn improvement	24.5 to 27.5% fuel burn improvement	20.5 to 23.5% fuel burn improvement
2040 Generation	35.0 to 37.0% fuel burn improvement	29.5 to 31.5% fuel burn improvement	24.0 to 26.0% fuel burn improvement
Air Traffic Management gains	1% gain by 2050	None	4% deterioration
Airline operational efficiency improvements	0.25% extra efficiency each year	None	0.25% less efficiency each year
Biofuel use	None	0.5% in 2030 rising to 2.5% by 2050	1% in 2030 rising to 5% by 2050

Table 7: Annual changes in other non-fuel costs

	2008 to 2010	2011 to 2015	2016 to 2030	2030 to 2050
Short-haul	-1.4%	-1.1%	-0.7%	0%
Long-haul	-1.7%	-1.4%	-1.0%	0%

3.7 Comments on other assumptions

This section provides advice on other assumptions of relevance to the modelling as presented in Box 1.

Box 1: Assumptions covered in this section

Other assumptions on which advice was sought:

- Factors to adjust the assumptions above on CO_2 emissions for aviation in order to take into account other greenhouse gas effects, e.g. radiative forcing.
- Carbon emissions per vehicle-km for HGVs.

As was noted in Section 1, the effect on non-CO_2 emissions from aviation appears to be significant. A "comprehensive updated assessment" of the impact of aviation on climate change has suggested that the inclusion of these non-CO_2 elements could double the effect of aviation's impact on climate change[121].

In relation to the CO_2 emissions from HGVs, the CCC assumes that the efficiency of conventional trucks improves by 8% to 2020, while in its "Medium Abatement" scenario it assumes a 15% to 30% efficiency improvement for conventional trucks between 2020 and 2030. This reduces CO_2 emissions from the average new conventional HGV from

[121] See Box 3.2 in DfT (2011) *UK aviation Forecasts* and Ulbina Environmental Consulting (2011)

799gCO_2/km in 2008 to 750gCO_2/km in 2020 and to 660gCO_2/km in 2025 and 580gCO_2/km in 2030[122].

In the EU-level *"Routes to 2050"* project, it was assumed that GHG emissions from trucks reduced by around 20% between 2010 and 2020. From 2020, it was assumed that a reduction of 90% on 2010 levels was possible for trucks weighing less than 16 tonnes, which was consistent with the assumption for other vehicles (see Section 3.1), but that only an 80% reduction on 2010 levels was possible for larger trucks[123]. These assumptions lead to much greater gCO_2/km emissions reductions than those of the CCC.

3.8 Advice on the modelling assumptions

As noted at the beginning of Section 3, it is recommended that the modelling be undertaken for the period 2010 to 2050 with interim assessments undertaken for 2020, 2030 and 2040.

On the basis of the discussion in Section 3.1, it is suggested that the following assumptions could be used for the modelling:

- For CO_2 emissions from new cars (including conventional and alternatively-fuelled cars, such as electric cars), the following figures for test cycle CO_2 emissions could be multiplied by 1.17 to deliver real world emissions for each year:
    a. 2010: 144gCO_2/km (actual 2010 emissions in the UK).
    b. 2020: 95gCO_2/km (the EU target for 2020).
    c. 2030: 70gCO_2/km (half the 2010 figure) or 50gCO_2/km (the CCC recommendation).
    d. 2040: 45gCO_2/km or 30gCO_2/km (depending on the figure chosen for 2030).
    e. 2050: 14gCO_2/km (10% of the 2010 figure).
- In order to test the implications of policy to reduce CO_2 emissions from new passenger cars failing to deliver, an alternative scenario could assume an annual improvement of 3%.
- For all cars, it appears to be appropriate to assume that average CO_2 emissions of the fleet are around 10% higher than average new car CO_2 emissions. This could change, as the rate of improvement in the efficiency of new cars increases.
- For cars, the following assumptions used in the previous modelling should be retained:
    a. Average occupancy of 1.6.
    b. Maximum number of seats is 5.

From the discussion in Section 3.2, it is clear that assumptions about future oil prices can vary from year-to year. In this respect, it probably makes most sense to:

- Use the most recent DECC assumptions for oil prices of \$81/barrel for 2010, \$118/bbl in 2020 and \$128/bbl in 2030. Few existing projections go beyond 2030, but the projections that exist to 2035 assume a declining rate of increase post 2030.
- As alternatives, DECC's ranges could be used, i.e.:
    1. High oil price scenario: \$134/barrel in 2020 and \$168/barrel in 2030.
    2. Low oil price scenario: \$91/barrel in 2020 and \$74/barrel in 2030.

In relation to changes to the carbon intensity of electricity in the UK, from Section 3.3 it appears that it would make sense to:

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[122] CCC (2010), Table 3.5
[123] See Appendix 2 of Hill *et al* (2010)

- Use the assumptions of the CCC's "Medium Abatement" scenario (see Table 2), with an assumption that, by 2050, the carbon intensity of the UK electricity supply sector would be the level assumed by the CCC in its "High Abatement" scenario for 2050, i.e. 40gCO_2/KWh.
- In order to assess the implications of a less ambitious decarbonisation scenario for the UK power sector, it could be assumed that the carbon intensity of 130gCO_2/KWh assumed in the CCC's "Low Abatement" scenario is reached by 2030, with a corresponding higher figure for 2050.

In relation to the carbon intensity of other potential future alternative fuels and energy sources, on the basis of the discussion of Section 3.4, the following assumptions could be made:

- Given the concerns over the sustainability of biofuels, it would seem prudent to follow the assumptions of the CCC and limit the take up of biofuels in the UK to around 2.7Mtoe (or 8%) of total liquid fuel consumption by energy by 2020 and assume no increase in this figure beyond 2020.
- In order to model the reductions in the carbon intensity of conventional fuels as a result of the use of biofuels, there are a number of options:
    1. In order to be consistent with the CCC, it could be assumed that biofuels have no GHG emissions, i.e. that they deliver 100% GHG reductions compared to conventional fuels. This might be consistent with the approach taken elsewhere, including in various EU Directives, but is not necessarily accurate.
    2. Take the GHG savings for the biofuels used in the UK for 2010, i.e. 58% and assume that this figure improves going forward, e.g. the EU-level *"Routes to 2050"* project assumed that 85% savings might be achieved by 2050. However, this does not take account of ILUC.
    3. In 2010/11, it is possible that taking account of ILUC would have cancelled out the estimated GHG savings from biofuels in the UK (see Section 3.4). Hence, it could be assumed that in 2010, there were no GHG savings from biofuels in the UK. It is difficult to project forward how any GHG emissions as a result of ILUC might change. It is very likely that some policy action will be taken to take account of ILUC, but whether this will lead to a capping of the amount of biofuels used, or a solution that guarantees GHG reductions from biofuels, is not clear at this point. However, a scenario could assume that the GHG reductions (excluding ILUC) from biofuels proposed in option 2 are achieved, i.e. 58% in 2010 improving to 85% by 2050. It could then take account of ILUC by applying the ILUC GHG increase (see Section 3.4) in 2010 and in all years until 2050. Even though this factor is likely to change, it is not clear what any other assumption could be at this stage. This would cancel out any GHG benefits for 2010, but deliver slight GHG reductions into the future. In order to take account of ILUC, this option would appear to be the most appropriate to use in the modelling.
- If a decarbonisation assumption needs to be made for hydrogen, the figures assumed for the EU in Table 4, could be increased by an appropriate factor to deliver potential GHG emissions from hydrogen production in the UK.

In relation to the take up of low carbon vehicles, the discussion of Section 3.5 suggests that the assumptions used by the CCC could be applied, i.e.:

- 60% of new cars and vans are electric by 2030 (of which 30% of cars and 12.5% of vans are battery electric), which could increase to all new cars by 2050.
- 50% of new buses to be hydrogen by 2030, with an increasing proportion to 2050.

Whether it would make sense to model the CO_2 emissions embedded in cars would depend on the details and the desired complexity of the model.

In relation to assumptions relating to aviation, the discussion of Section 3.6 suggests that it would make sense to use the following assumptions:

- Fuel efficiency improvements of around 40% for new aircraft could be achieved by 2025 with perhaps 60% improvements on 2006 by 2050, according to the CCC. It is worth noting that the recent DfT aviation forecasts assume that lower rates of efficiency will be achieved than the CCC, at least in the short-term.
- The DfT cost projections set out in and around Table 7.
- The assumptions relating to seats per aircraft and average load factor based on EasyJet's figures appear to make sense. The load factor is higher than the "ceiling" used by the DfT, but if the EasyJet figure is an actual figure, then it could be retained.

The discussion of Section 3.7 suggests that:

- The climate impacts of aviation including its non-CO_2 impacts could be double the effect of aviation's CO_2 emissions alone.
- According to the CCC, the average CO_2 emission from trucks could decline from 799gCO_2/km in 2008 to:
    - 750gCO_2/km in 2020;
    - 660gCO_2/km in 2025; and
    - 580gCO_2/km in 2030.

  Beyond 2030, it would make sense to assume continuing decreases.

Finally, a scenario with respect to speed could be modelled in different ways that would deliver different outcomes, as was clear from the discussion in Section 2.4. However, the following high level assumptions might be made:

- A 10mph increase from 70mph could increase fuel use by around 3%[124].
- A 10mph decrease from 70mph could reduce fuel use by around 2%[125].

As noted above, and as is clear from the way in which the assumptions are presented, the proposed assumptions are based on a review of relevant reports. In this report, one of the important wider assumptions is that policy develops over the next 40 years in order to deliver the objectives of decarbonising the economy by 2050, as set out in Section 2.1. However, when looking forward to 2050, it is clearly possible to make a number of different assumptions about what might happen. In this respect, the exploration of scenarios based on different assumptions, as proposed in this section, is important.

In order to achieve such high levels of CO_2 emissions reduction from transport, a wide range of policies will have to be implemented, such as those discussed in Section 2. However, as was clear from this discussion, there are still many challenges and uncertainties about the way in which a low carbon economy, and a low carbon transport system, can be achieved. The approach that has been taken to the discussion of the policies and to the advice on modelling assumptions has been to focus on different

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[124] This figure is based on taking the EEA's maximum figure of 3% for the likely savings from reducing maximum speed limits from 75mph to 68mph. Taking the EEA's maximum is justified on the basis that the proposed assumption would apply to 10mph, rather than just 7mph as in the EEA's example (see Section 2.4).
[125] This figure is based on taking the EEA's minimum figure of 2% for the likely savings from reducing maximum speed limits from 75mph to 68mph. The reason for taking the EEA's minimum figure in this case is that the link between speed and CO_2 emissions is not linear; see Ligterink (2011) referred to in footnote 53 in Section 2.4.

elements of the transport system. In turn, this has focused on: decarbonising the fuel (or energy source) used; improving the fuel/energy efficiency of vehicles; improving the efficiency (from a CO_2 perspective) of the way in which vehicles are used; and infrastructure policies. If the modelling were to take a similar approach, then the contributions of different types of policies could be identified.

4. SUMMARY

From the overview of the policy and other issues, it can be seen that:

- There is a long-term policy strategic policy framework – both at the UK and EU levels – that requires economy-wide GHG reductions of more than 80% by 2050. Transport will have to reduce its GHG emissions significantly in order to contribute to these reductions.
- There are currently targets to increase the proportion of fuel from renewable sources in the transport sector, as well as for some decarbonisation of transport fuels, up to 2020. Given the longer-term GHG reduction commitments, it is likely that there will be continued action to decarbonise the fuel/energy used by transport beyond 2020. This could be from increased use of renewable electricity and/or increased use of biofuels, if the sustainability issues of the latter can be addressed, as well as potentially, in the longer-term, low carbon hydrogen.
- There are efficiency standards for cars and vans up to 2020, which are set at the European level. Standards for aircraft could be in place internationally by 2013, while efficiency standards for other vehicles, starting with trucks, might be expected. Again, given the long-term GHG reduction commitments, it is likely that standards will be made more stringent beyond 2020.
- A range of other policies can contribute to reducing the GHG emissions of vehicles in use, e.g. investment in and support for less GHG intensive modes, smarter choices, eco-driving, speed and planning policies, as well as taxation and charging.
- Land use policies, as well as the availability and capacity of infrastructure, can also have important implications for transport's CO_2 emissions.

The advice on the assumptions that could be used in the modelling to be undertaken in the wider study, which were presented in Section 3.8, is based on a review of relevant policy documents and reports. In this way, the advice is based on work undertaken by, and for, a number of different organisations with the aim of providing an objective perspective on the potential assumptions that might be used.