SULTAN modelling to explore the wider potential impacts of transport GHG reduction policies in 2030

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Abbreviation	Description
BEV	Battery Electric Vehicle
CI engines	Compression-ignition engines
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
ECF	European Climate Foundation
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse gas
HDV	Heavy Duty Vehicle
HEV	Hybrid Electric Vehicle
ICCT	International Council for Clean Transportation
ICE	Internal Combustion Engine
LCV	Light Commercial Vehicle
LDV	Light Duty Vehicle (i.e. cars and LCVs)
NEDC	New European Driving Cycle
OEM	Original Equipment Manufacturer
PHEV	Plug-In Hybrid Vehicle
R&D	Research and Development
REEV	Range Extended Electric Vehicle
RWC	Real World Cycle
SI engines	Spark-ignition engines
WLTC	Worldwide harmonized Light vehicles Test Cycle
WLTP	Worldwide harmonized Light vehicles Test Procedure

1 Introduction

The European Climate Foundation (ECF) commissioned Ricardo-Energy & Environment to build upon its previous work for ECF and the European Commission using the SULTAN model to give a high level assessment of the impacts of different policy decisions on transport GHG emissions.

Road transport accounts for more than a fifth of the EU's greenhouse gas (GHG) emissions and over two-thirds of its 'domestic' transport emissions. The EU's climate and energy policy framework for 2030, which has been agreed by Member States (MS), sets an economy-wide GHG reduction target of 40% compared to 1990 levels by 2030. This target is split between the ETS and non-ETS sectors and translates to a reduction of 30% for non-ETS sectors by 2030 (compared to 2005).

The exploration of different scenarios for delivering GHG reductions by 2050 (as well as intermediate objectives) was the subject of the two *'Routes to 2050'* projects undertaken for DG CLIMA between 2009 and 2012. These studies were both led by AEA (now Ricardo Energy & Environment). On the basis of a review and validation of the GHG reduction potential of a range of technical and non-technical options, an illustrative scenarios tool (SULTAN) was developed during these projects, which were used to identify the potential contribution of different options to meeting the long-term GHG reduction target (i.e. 60% reduction in direct emissions from all transport by 2050). The focus of the second '*Routes to 2050*' project was on identifying in more detail how the 60% GHG reduction target could be met. This was undertaken by the development of various illustrative scenarios in SULTAN that enabled different options for delivering the 60% GHG reduction target to be explored, along with their trade-offs.

Previous work by Ricardo Energy & Environment for the European Climate Foundation (ECF) further built upon this work in an analysis of the economic benefits of reduction in emissions from light duty vehicles (LDVs) (ECF, 2013), focusing on alternative trajectories for LDV decarbonisation.

The objective of this new project is to help ECF develop an enhanced understanding of the wider potential impacts of transport GHG reduction policies in 2030, as well as their possible significance in a critical path to GHG reductions to 2050. This work builds on the previous project work for DG CLIMA and ECF by using the SULTAN modelling tool to scope scenarios for emissions reductions in transport for 2030, and to explore how these might contribute to meeting the emissions reductions foreseen under the EU's climate and energy policy framework.

In addition to carrying out updates to the model baseline scenario, the work required the development a series of additional scenarios in SULTAN, including the following:

1. Exploration of the contribution of advanced low-carbon fuels until 2030;
2. Exploration of the contribution of road vehicle CO_2 standards until 2030;
3. Exploration of additional policy options not already covered previously in SULTAN;
4. Policy packages for road transport GHG reduction consistent with 2030 non-ETS climate ambition.

As part of this project, a workshop was also held in Brussels in December 2015 with transport policy experts. This workshop was used to discuss and agree the relevant assumptions and scenarios for the SULTAN modelling. The findings from this workshop have therefore directly shaped the development of the scenarios and the results presented in this report.

The following sections provide a summary of the work completed under this project.

Additional supporting information on scenario definitions is provided in Appendix 1.

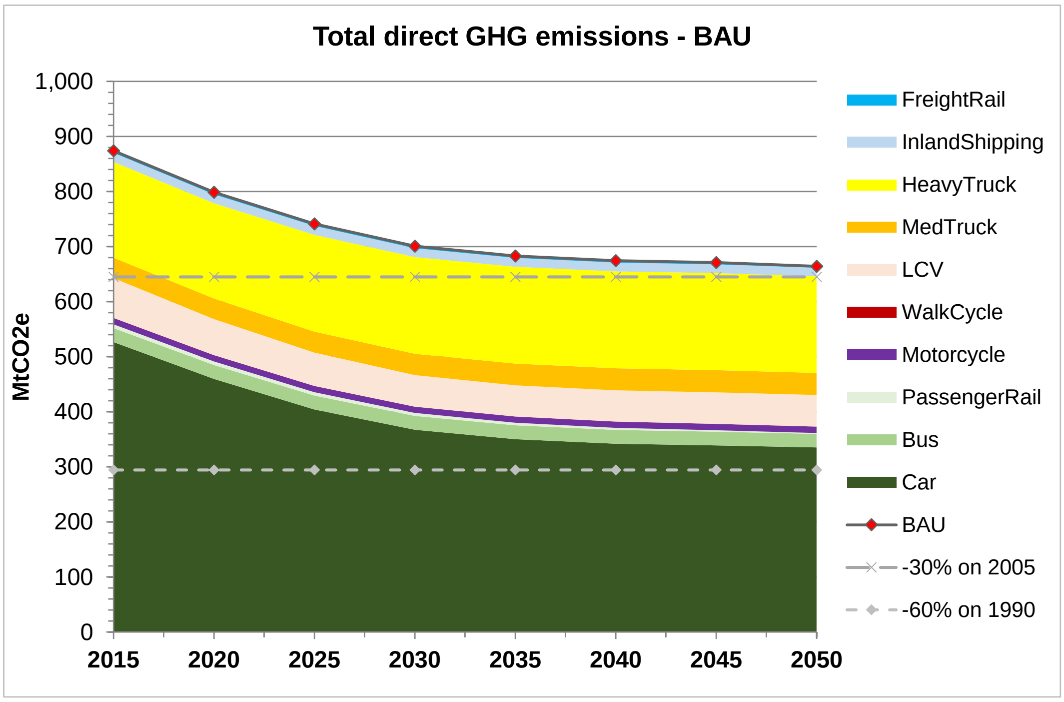
2 Updating the model baseline scenario

2.1 The original baseline scenario

The previously updated SULTAN reference scenario (AEA, 2012) covered all transport modes. However, the scope of this new work for ECF is limited to the non-ETS transport sectors (that are also covered by the Effort Sharing Decision), i.e. transport by road, rail and inland waterways only. The SULTAN baseline scenario was last updated in 2011 and is presented in Figure 2.1 below for these transport modes.

Since this baseline was last updated, the European economy has begun to recover – in some Member States more than others – and the impact of this on the transport sector therefore needs to be reflected in the baseline. Additionally, there have been developments in biofuels policy and in the understanding of the difference between test-cycle and real-world fuel consumption from LDVs in the last few years. As part of this project it was therefore important to make a number of amendments to the previous SULTANs baseline/reference scenario to reflect the latest information available. These amendments are discussed and summarised in the following report section (2.2).

Figure 2.1: The SULTAN baseline scenario developed under the *Routes to 2050* projects for DG CLIMA



Source: SULTAN 2012 baseline, from the EU Transport GHG: Routes to 2050 II project (AEA, 2012)

2.2 The updated baseline scenario

As discussed in the previous section, it was desirable to make a number of amendments to the original SULTAN baseline scenario to better reflect the change in economic conditions since this scenario was originally developed, as well as a number of other changes in policy improvements in understanding.

2.2.1 Adjustment for revised activity growth forecasts

Earlier SULTAN modeling used assumptions from EC modelling that were based on economic activity that have transpired to be over-optimistic, because the EU economic recovery has occurred later than predicted. This modeling exercise has therefore adjusted the previous baseline using updated economic projections, corrected downwards, and then projected forwards using ECFIN projections in the “Aging Report 2015” (European Commission, 2015). A comparison of the GDP growth projections upon which the original and updated SULTAN baseline activity forecasts are based is summarized in Table 2.1 below.

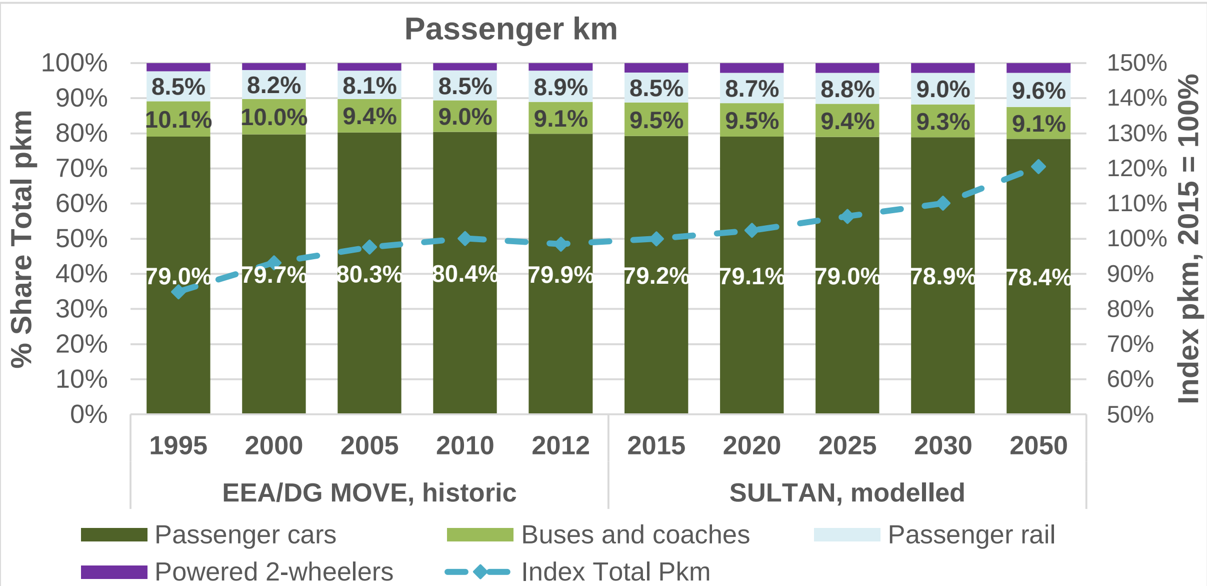
Table 2.1: Summary of the action of different elements on the SULTAN baseline scenario

GDP	2010	2015	2020	2025	2030	2035	2040	2045	2050
Original SULTAN baseline									
GDP growth p.a.	2.20%	2.20%	1.60%	1.60%	1.60%	1.60%	1.60%	1.60%	1.60%
GDP index	100%	111%	124%	135%	146%	158%	171%	185%	200%
Updated assumption based on 2015 Aging Report									
GDP growth p.a.	1.02%	1.10%	1.40%	1.40%	1.50%	1.50%	1.40%	1.40%	1.40%
GDP index	100%	105%	111%	119%	128%	138%	148%	159%	170%

The share of passenger and freight activity between different modes was also discussed at the expert workshop in December 2015. It was agreed that modal share should remain approximately constant over time, reflecting more recent trends in EEA data on this. Historic data for passenger transport has shown a small reduction in the share for cars in recent years, and the small further reduction in future years in the current baseline appears reasonable in this context. Historic freight data shows that the desired shift of freight from road to rail has not transpired, and in fact has reversed somewhat. However, given the foreseen implementation of a package of supporting policies (Shift2Rail), modal shift could be argued to remain unchanged in the baseline scenario over time (European Commission, 2015b).

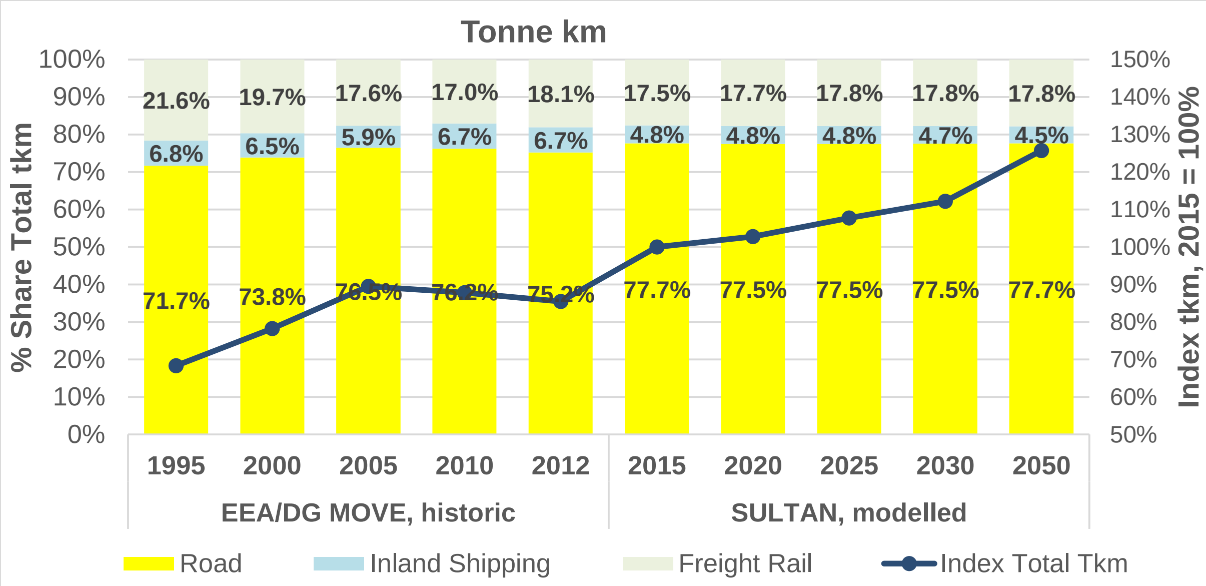
A comparison of the breakdown of transport activity by passenger and freight transport mode from European statistics and the overall level of activity indexed to 2015 is summarised for the updated SULTAN baseline in the following Figure 2.2 and Figure 2.3.

Figure 2.2: Historic and modelled modal share for EU passenger transport, and indexed activity



Source: Historic data is from the EEA's TERM 2014 report (EEA, 2014), page 23, box 2.7.

Figure 2.3: Historic and modelled modal share for EU freight transport, and indexed activity



Source: Historic data is from the EEA's TERM 2014 report (EEA, 2014), page 24, box 2.78.

2.2.2 Adjustment for biofuels to lower uptake rates and inclusion of ILUC

In previous SULTAN modeling, biofuels were assumed to reach 10% of liquid fuels consumption. In 2015 the EU made a decision in 2015 to cap food-based biofuels at 7% and set a 0.5% target for advanced low-ILUC biofuels (European Commission, 2015a). The Commission's Energy Union Strategy also stated that there will be no further biofuels policy (European Commission, 2015c). Therefore, it was agreed at the expert workshop that the baseline scenario should hold 1G biofuels constant at 7% during the period 2020-2050, with advanced zero-ILUC biofuels reaching 0.5% in 2020 and held constant thereafter.

There is currently high uncertainty over the GHG benefits of 1G biofuels, especially with regard to ILUC (indirect land use change). It was therefore also agreed at the expert workshop that this project should explore two scenario variants for 1G biofuels:

1) In the baseline, 1G food-based biofuels should increase from the 2015 level (bioethanol at ~3.4% of petrol demand and biodiesel at ~5.3% of diesel demand) to 7% overall in 2020, with no further expansion thereafter. Advanced waste-based biofuels should reach 0.5% in 2020, with no further expansion thereafter. In the baseline ILUC should also be included at levels demonstrated by the latest modeling (European Commission, 2015a), (although this does not show up in the current modeling project because the EU ESD only takes account of direct emissions) (EC JRC/IFPRI, 2014); and
2) In a 'New Fuels' scenario where: (a) 1G biofuels should be held constant at their 2015 levels (as indicated above), and (b) with any further growth from current levels avoiding ILUC through the implementation of EU policies to promote sustainable low-carbon liquid fuels, such as waste-based fuels or low-carbon synthetic fuels, up to a level of 4% in 2030. This is consistent with the findings of the ECF's "Wasted" study, which considered the potential sustainable availability of wastes and residues in 2030 (ECF, 2014). In total, the "New Fuels" scenario models a combined 9% share of biofuels and low-carbon liquids in 2030.

It is also anticipated that biogas/biomethane will be required for meaningful GHG savings from gas-fuelled HDVs (heavy duty vehicles, i.e. trucks, buses and coaches) in the medium-long term. The share of biogas use in such vehicles should therefore be in-line with the overall objectives, but should reflect latest evidence on availability of bio-resources (ICCT/IEEP/NNFC, 2014).

The SULTAN baseline scenario has therefore been updated to be consistent with these revisions, with the share of 1G biofuels capped to 7% and incorporating central Commission estimates for ILUC on these biofuels (i.e. ~12.5 gCO_2e/MJ for bioethanol from cereals and sugar feedstocks, and 55 gCO_2e/MJ for biodiesel from oil crops) (European Commission, 2015a). However, it should be

emphasised that these emissions are not visible in the current analysis, as they are not accounted in national inventories under the EU ESD, which only measure direct emissions. Emissions savings from biofuels measured in this analysis should therefore be treated with caution.

2.2.3 Adjustment to assumptions on real-world vs test-cycle CO_2 emissions

The gap between laboratory/test-cycle CO_2 figures and real-world performance was represented in the SULTAN model previously by up to a 20% uplift for LDV fuel consumption (compared to NEDC). Recent evidence suggests that this gap has grown to around 36% and even after the introduction of the WLTP testing procedure this gap will persist, and possibly keep growing to as much as 50% (ICCT/Element Energy, 2015). Due to the associated uncertainties, it was therefore agreed at the expert workshop held in in December 2015 to use a 36% uplift in the baseline scenario during the period 2015-2050.

2.2.4 Amendments to the Survival rate function across all vehicle types

The assumptions used in the previous SULTAN baseline were based on an analysis of datasets from models used in European Commission impact assessments at the time (i.e. TREMOVE version 3.3.2, and the PRIMES-TREMOVE model). Since this work was completed, updated and improved historical datasets have been developed in work for the European Commission as part of the TRACCS project (Emisia, 2013). Analysis of these datasets has allowed for improvements to the survival functions used in SULTAN, resulting in a closer match between derived new vehicle registrations and those seen in European statistical datasets (such as those from Eurostat or ACEA). Previously the SULTAN model somewhat over-estimated new vehicle registrations, meaning options involving improvements to new vehicle efficiency showed faster benefits on the overall fleet efficiency than would be seen in reality.

2.2.5 Other potential amendments identified that were not implemented

In addition to the changes noted above, recent analysis for the European Commission has shown that average annual mileage per vehicle is substantially higher in the first few years of a car’s life than in later years (Ricardo-AEA, 2014). However, due to resource constraints in this project and the high-level nature of this modelling project, it has not been possible to factor this in (as it would require further development of the SULTAN tool itself to enable this). This should be seen as an area for potential improvement, and could be seen to somewhat improve the effectiveness of options improving new vehicle efficiency.

2.2.6 Results of the SULTAN baseline adjustments

A summary of the significance of the impact on future transport GHG emissions for 2030 in the revised SULTAN baseline, compared to the previous baseline, is shown in Table 2.2 below. The resulting direct GHG emissions profile in the revised baseline (BAU-15) is also provided in Figure 2.4 below, with a comparison to the original baseline (BAU)

Figure 2.4: Updated SULTAN baseline scenario (BAU-15) in comparison to the original baseline (BAU)

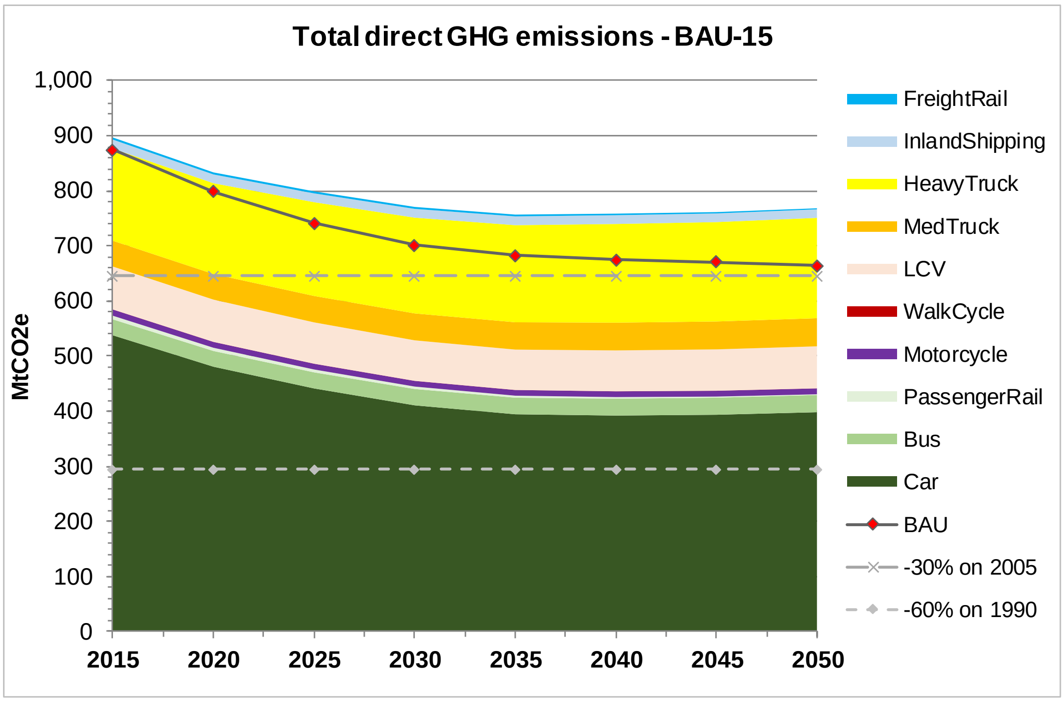


Table 2.2: Summary of the action of different elements on the SULTAN baseline scenario

Baseline revision	GHG impact in baseline
Adjustment of activity based on change in GDP forecasts for EU	↓
Amendment to the assumptions for baseline biofuel use	↑
Revision to the assumed real-world energy consumption of LDVs	↑↑
Amendments to the survival functions for all vehicle types	↑

3 Scenario development and results

Following the updates to the model baseline, the main project work for ECF involved carrying out a number of updates to the previously developed individual scenarios and the development of a number of new scenarios and scenario packages. The work completed in this phase of the work is summarised in the sections below, together with a summary of the SULTAN scenario modelling output results.

3.1 Definition of individual scenarios

A range of individual scenarios were developed previously as part of the *'Routes to 2050'* projects for DG Climate Action (AEA, 2010) (AEA, 2012). It was only possible to revisit a few of the most important scenarios in detail within the resources of this project, including the assumptions for biofuels and alternative trajectories for road vehicle CO_2 emission standards. In addition, a new scenario based on the potential from uptake of C-ITS technologies was also developed. The following Table 3.1 provides a summary of the individual scenarios defined in SULTAN as part of the previous and current work, with further details provided on the definition of the scenarios in the next subsections of this report. Further details on the definition of some of these scenarios is also provided in Appendix 1.

Table 3.1: Summary list of the individual illustrative scenarios defined in SULTAN for the previous 'Routes to 2050 II' project

ID	Individual illustrative scenarios defined in SULTAN	Area	Action*
1	**Improve GHG intensity of conventional fuels (e.g. via biofuels)**	**A**	**EU**
2	**Mandatory new vehicle emission targets**	**B**	**EU**
	(i) Central ambition targets for LDVs and HDVs		
	(ii) Low ambition targets for LDVs and HDVs		
	(iii) High ambition targets for LDVs and HDVs		
3	Package of cycling and walking improvement measures (walk/cycle)	C	MS
4	Improved spatial planning (road and rail)		Mixed/MS
5	Package of mobility management measures incl. improved public transport		MS
6	Improved freight intermodality (road, rail and inland shipping)		Mixed/MS
7	Improved road speed enforcement (road)	D, (E)	MS
8	Harmonised EU motorway speed limit (road)		Mixed/MS
9	Fuel-efficient driver training (road, rail)		MS
10	Company car tax reform (cars)	(A, B, C, D,) E	Mixed/MS
11	CO_2 price tax (all modes, based on central/low/high CO_2 costs))		Mixed/MS
12	Non-CO_2 price tax (road, internalise cost of NOx, PM and energy security		Mixed/MS
13	Equivalent duty and VAT rates for fuels		Mixed/MS
14	Implement maritime fleet efficiency measures	B, D	Mixed
15	*Deployment of Communicating Intelligent Transport Systems (C-ITS)*	*B*	*EU*

Notes:

(A) Decarbonising energy carriers (i.e. reducing the GHG intensity of transport energy);
(B) Improving vehicle efficiency (i.e. improving the technical energy efficiency of new vehicles);
(C) Efficient organisation of transport system (i.e. improving the structural efficiency of the transport system via modal shift, co-modality and spatial planning);
(D) Improving vehicle use (i.e. using vehicles more efficiently by improving operational efficiency);
(E) System efficiency (e.g. improving the economic efficiency of transport via economic instruments, by internalising selected external costs, removing subsidies and creating a level playing field).

Many of the scenario options will affect more than one category to a greater or lesser extent, however they have been grouped in the above table into their primary category area of action.

* EU = feasible for action at EU-level; MS = only feasible for meaningful action at Member State or local level; Mixed = feasible for action with a mix of EU- and MS-level actions; Mixed/MS = while action could be mixed, MS action is arguably most important.

RED bold = significant updates needed for this project; *GREEN italics* = newly added for this project; **GREY** = not relevant or significant for this project / 2030 time-horizon.

3.1.1 New biofuels

As discussed in earlier Section 2.2.2, a 'new biofuels' scenario was defined on the following basis:

1) In the baseline, 1G food-based biofuels should increase from the 2015 level (i.e. bioethanol at 3.4% of petrol demand and biodiesel at 5.3% of diesel demand) up to 7% overall in 2020, with no further expansion thereafter. Advanced waste-based biofuels should reach 0.5% in 2020, with no further expansion thereafter. In the baseline ILUC should be included at levels demonstrated by the latest modeling (European Commission, 2015a), (although this does not show up in the current modeling project because the EU ESD only takes account of direct emissions) (EC JRC/IFPRI, 2014); and
2) In a 'New Fuels' scenario where: (a) 1G biofuels should be held constant at their 2015 levels (as indicated above), and(b) with any further growth from current levels avoids ILUC through the implementation of EU policies to promote sustainable low-carbon liquid fuels, such as waste-based fuels or low-carbon synthetic fuels, up to a level of 4% in 2030. This is consistent with the findings of the ECF's "Wasted" study, which considered the potential sustainable availability of wastes and residues in 2030 (ECF, 2014). In total, the "New Fuels" scenario models a combined 9% share of biofuels and low-carbon liquids in 2030.
3) Where gas-fueled vehicles are deployed, it is assumed that the share of biomethane used by these vehicles in 2030 will be at least 20% (and rising to 50% by 2050).

3.1.2 Vehicle GHG emission standards

The following sections provide a summary of the main assumptions used in defining the central-, low- and high-ambition scenarios for new vehicle GHG emission standards for LDVs and HDVs. The definition of for these scenarios was also discussed at the expert workshop held in December 2015.

Improvements in the fuel efficiency for different powertrain technologies were informed by the technical potential for these improvements estimated in recent work for the Commission by Ricardo Energy & Environment for LDVs (Ricardo Energy & Environment, 2016 (forthcoming)), and by previous analysis on the cost-effectiveness of fuel efficiency improvements of HDVs (CE Delft, 2012).

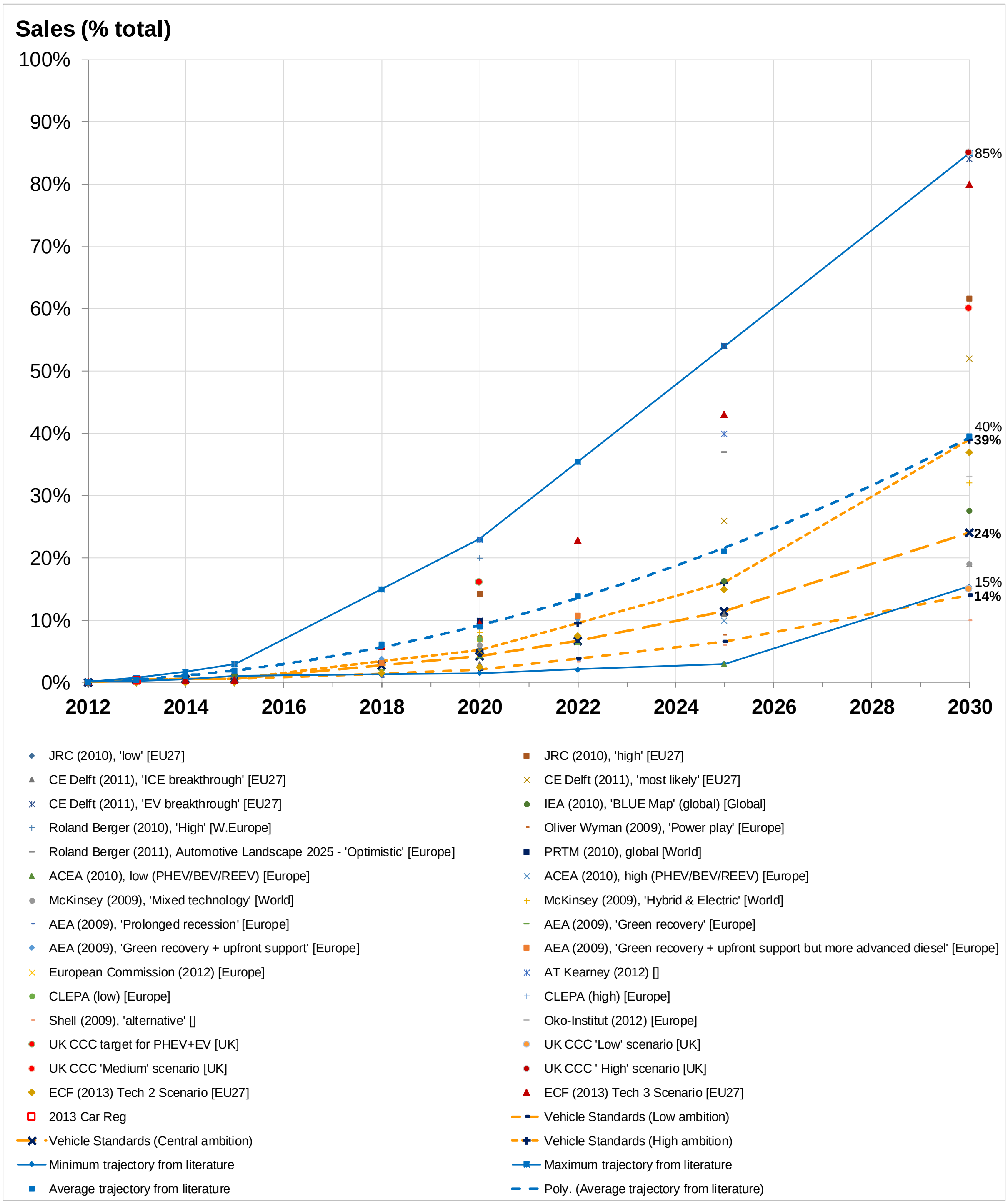
The deployment rates for alternative powertrain technologies for LDVs was informed by previous work by Ricardo Energy & Environment for ECF (ECF, 2013) and also recent work for the Commission (Ricardo Energy & Environment, 2016 (forthcoming)).

A comparison of the uptake rates assumed for advanced xEVs[1] in passenger cars with scenarios from literature is provided Figure 3.1. This shows that the assumptions used on the projected deployment of such vehicles falls within the central to low part of the range from the literature. The uptake rates in the high ambition new vehicle emission standards scenario are similar to those in the Tech 2 scenario developed and validated with a range of industry stakeholders in previous work on the wider economic impacts of LDV decarbonisation (ECF, 2013).

Further details on the definition of these scenarios is also provided in Appendix 1.

[1] Advanced xEVs are defined to include PHEVs, REEVs, BEVs and FCEVs

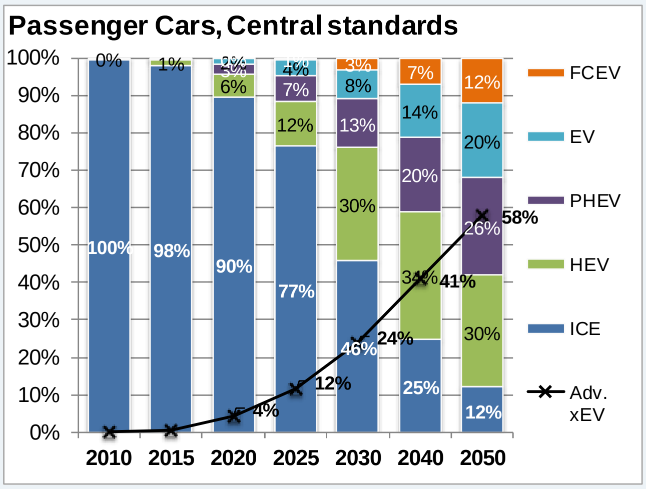
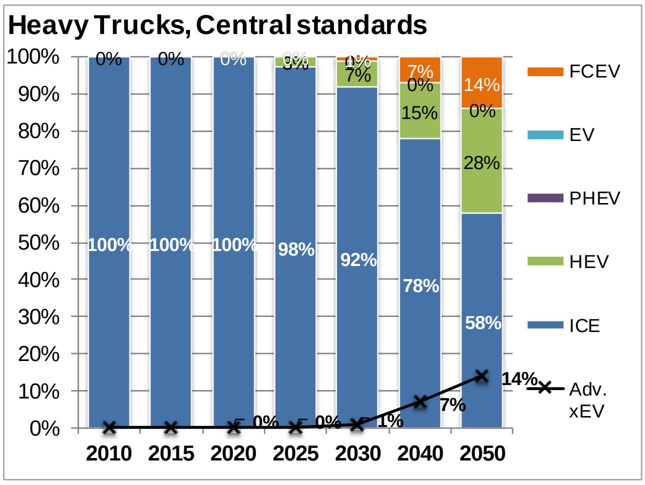
Figure 3.1: Comparison of project scenario assumptions for advanced xEV deployment for passenger cars with a range of scenarios, forecasts and projections from the literature



3.1.2.1 Central ambition

A summary of the assumptions used to define the central ambition vehicle GHG emission standards for LDVs and HDVs is provided in the following Table 3.2.

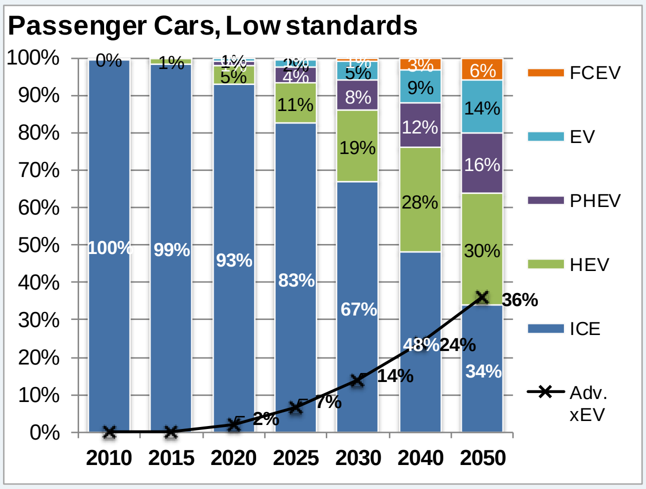
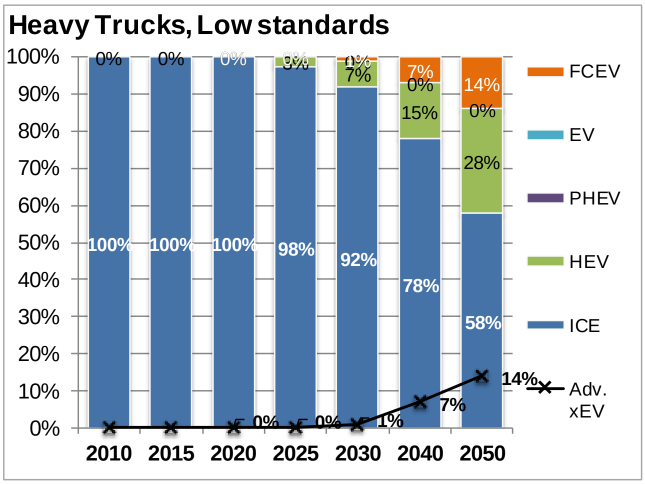
Table 3.2: Overview of assumptions for the central ambition vehicle emission standards scenario

	Rate of improvement	Deployment of alternative powertrain technologies
LDVs	Consistent with improvements for meeting target of **78 gCO_2/km** by 2025 for passenger cars, extrapolated forwards into the future. By 2030, this reaches a value of ~60g/km CO_2. Improvements to conventional powertrain technologies are taken to a significant proportion of their maximum potential by 2030. Improvements for LCVs beyond 2020 are assumed at a similar rate as for cars. By 2025, 2030, this reaches a value of ~121g/km, ~95g/km CO_2 respectively. Deployment of advanced xEVs is at moderate levels, with similar levels of deployment in cars and LCVs.	
HDVs	Consistent with the 100% uptake of all fuel efficiency improvement technology with 3-year payback by 2030 for all modes, for example as a result of CO_2 standards. [Equivalent to improvements vs 2015 vehicles of ~16% for buses, ~19% for medium trucks, and ~30% for heavy trucks.] It is assumed that alternative powertrain technologies are deployed at higher rates for medium trucks and significantly higher rates for buses, reflecting a combination of a higher share of urban driving and earlier cost-effectiveness.	

3.1.2.2 Low ambition

A summary of the assumptions used to define the low ambition vehicle GHG emission standards for LDVs and HDVs is provided in the following Table 3.5.

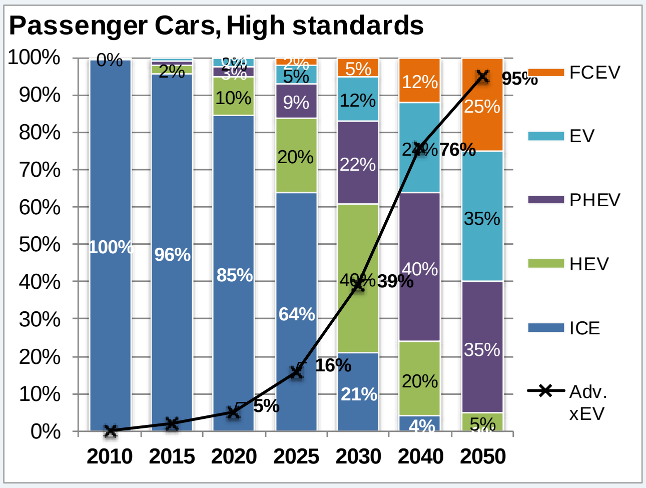
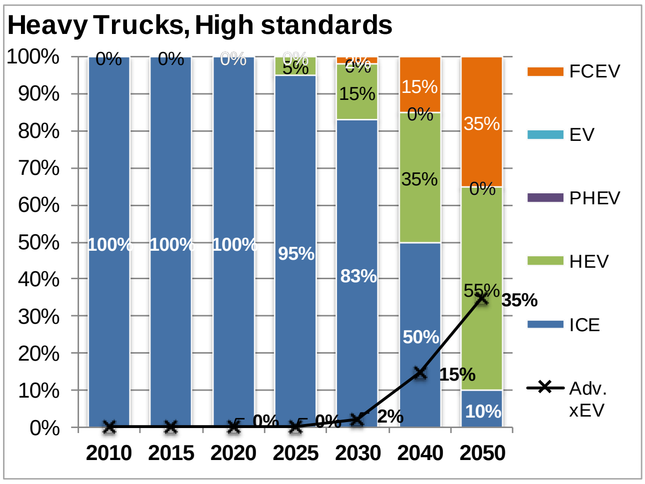
Table 3.3: Overview of assumptions for the low ambition vehicle emission standards scenario

	Rate of improvement	Deployment of alternative powertrain technologies
LDVs	Consistent with improvements for meeting target of **88 gCO_2/km** by 2025 for passenger cars, extrapolated forwards into the future. By 2030, this reaches a value of ~80g/km CO_2. Improvements to conventional powertrain technologies are taken to a moderate proportion of their maximum potential by 2030. Improvements for LCVs beyond 2020 are assumed at a similar rate as for cars. By 2025, 2030, this reaches a value of ~136g/km, ~125g/km CO_2 respectively. Deployment of advanced xEVs is at lower levels, with similar levels of deployment in cars and LCVs.	
HDVs	Consistent with the fuel efficiency improvement technology at half the maximum cost-effective reduction potential by 2030 for all modes. [Equivalent to improvements vs 2015 vehicles of ~11% for buses, ~11% for medium trucks, and ~21% for heavy trucks.] As for the central scenario, it is assumed that alternative powertrain technologies are deployed at relatively higher rates for medium trucks and for buses.	

3.1.2.3 High ambition

A summary of the assumptions used to define the high ambition vehicle GHG emission standards for LDVs and HDVs is provided in the following Table 3.6.

Table 3.4: Overview of assumptions for the high ambition vehicle emission standards scenario

	Rate of improvement	Deployment of alternative powertrain technologies
LDVs	Consistent with improvements for meeting target of **68 gCO_2/km** by 2025 for passenger cars, extrapolated forwards into the future. By 2030, this reaches a value of ~42g/km CO_2. Improvements to conventional powertrain technologies are taken to most of their maximum potential by 2030, and advanced xEVs are deployed at a faster rate. Improvements for LCVs beyond 2020 are assumed at a similar rate as for cars. By 2030, this reaches a value of ~108g/km, ~69g/km CO_2 respectively. Deployment of advanced xEVs is higher, with similar levels of deployment in cars and LCVs. This scenario is similar to the Tech 2 scenario from previous work on the wider economic impacts of LDV decarbonisation (ECF, 2013).	
HDVs	Consistent with the 100% uptake of all fuel efficiency improvement technology with *lifetime* payback by 2030 for all modes. [Equivalent to improvements vs 2015 vehicles of ~27% for buses, ~19% for medium trucks, and ~41% for heavy trucks.] As for the central scenario, it is assumed that alternative powertrain technologies are deployed at relatively higher rates for medium trucks and for buses.	

3.1.3 Deployment of C-ITS

Work led by Ricardo Energy & Environment on C-ITS for the Commission used as input to the final report of the C-ITS platform explored the impacts of a range of deployment scenarios for C-ITS technologies (European Commission, 2015d). Significant net economic benefits were calculated to result from the rapid deployment of all available technological options (Scenario E from the analysis, (European Commission, 2015d)). This has been used to inform the development of assumptions on the potential fleet-level fuel efficiency benefits from C-ITS technologies up to 2030, which are summarised in Table 3.5 below.

Table 3.5: Overview of assumptions for the fleet-level fuel consumption reductions through rapid C-ITS deployment in Europe

	2015	2020	2025	2030	2040	2050
Passenger cars	0.0%	0.0%	0.5%	1.0%	2.4%	2.4%
Buses	0.0%	0.0%	0.8%	1.7%	4.5%	4.5%
LCVs	0.0%	0.0%	0.4%	0.8%	2.2%	2.2%
Medium and heavy trucks	0.0%	0.0%	0.6%	0.9%	3.4%	3.4%

Notes: Reductions to 2030 are based on Scenario E (from (European Commission, 2015d)); reductions from 2040 onwards are based on the maximum reductions from Scenario E (high case).

3.1.4 Other individual scenarios

The definitions of the other individual scenarios were assumed to be essentially unchanged versus their implementation in the *Routes to 2050* projects (AEA, 2010) (AEA, 2012), with the exception of the implementation of a 5-year delay in their application. This delay was implemented to reflect the time that has passed since their original definition (in 2010) and the fact that in most cases it is judged that relatively little progress has been made in the areas identified, compared to the identified potential.

3.2 Definition of scenario packages

Four scenario packages were developed as part of this work reflecting different levels of ambition and whether policy action was primarily necessary at the EU or Member State (MS) level, and were defined and agreed in discussion with the European Climate Foundation. The objective was to explore both what different packages might contribute to reducing transport emissions, as well as to what extent they might contribute to achieving the overall 30% reduction target for all non-ETS sectors.

These packages were built based on a combination of the assumptions used to characterise the individual scenarios (as discussed in Section 3.1) and included the following Table 3.6. It is assumed that C-ITS technologies are deployed at a rapid rate in all scenarios where they are included. Recent work by Ricardo Energy & Environment for DG MOVE to support the C-ITS Platform and its' final report (European Commission, 2015d) has found very significant net economic benefits would result from this, primarily attributed to safety improvements (resulting in reduced accidents), but also with lower-level benefits from reduced fuel consumption and air pollutant emissions.

Table 3.6: Overview of the modelled scenario packages

Scenario # and name		Individual measures included
1	**EU-level policies**	Central ambition vehicle emission standards for LDVs and for HDVs; new biofuels (i.e. free from ILUC impacts); significant and rapid deployment of C-ITS technologies.
2	**MS-level policies**	Improvements to public transport, walking and cycling, and to freight intermodality; fuel efficient driver training; internalisation of external costs; speed enforcement and harmonisation; revisions to company-car taxation policies.
3	**Low ambition mixed**	Low ambition vehicle emission standards for LDVs, new biofuels; significant and rapid deployment of C-ITS technologies.
4	**All options**	Implementation of all available EU- and MS-level measures at their maximum levels.

3.3 Results of the scenario modelling analysis

In the following subsections the results from the SULTAN scenario modelling exercise are presented for individual scenarios (Section 3.3.1) and for a range of scenario packages (Section 3.3.2).

3.3.1 Individual scenarios

The following Figure 3.2, Figure 3.3 and Figure 3.4 provide a summary of the output results from the modelling of the scenarios for individual measures, showing (a) the total GHG emissions in 2030 by transport mode (Figure 3.2), (b) the level of potential reduction in 2005 emissions from the transport sector (Figure 3.3), and (c) the level of potential contribution to the overall target of 30% reduction in 2005 emissions from all non-ETS sectors (Figure 3.4). The results show that the different individual measures might reduce emissions by between, 0.75% and 15.3% of emissions from transport relative to the baseline scenario for 2030, and individual contribute between 5.2% and 9.0% to GHG emissions reductions from all sectors versus 2005 levels.

The data tables behind the charts presented here are provided in Appendix 2 of this report.

Figure 3.2: Direct GHG emissions from transport for different scenarios for 2030, by mode

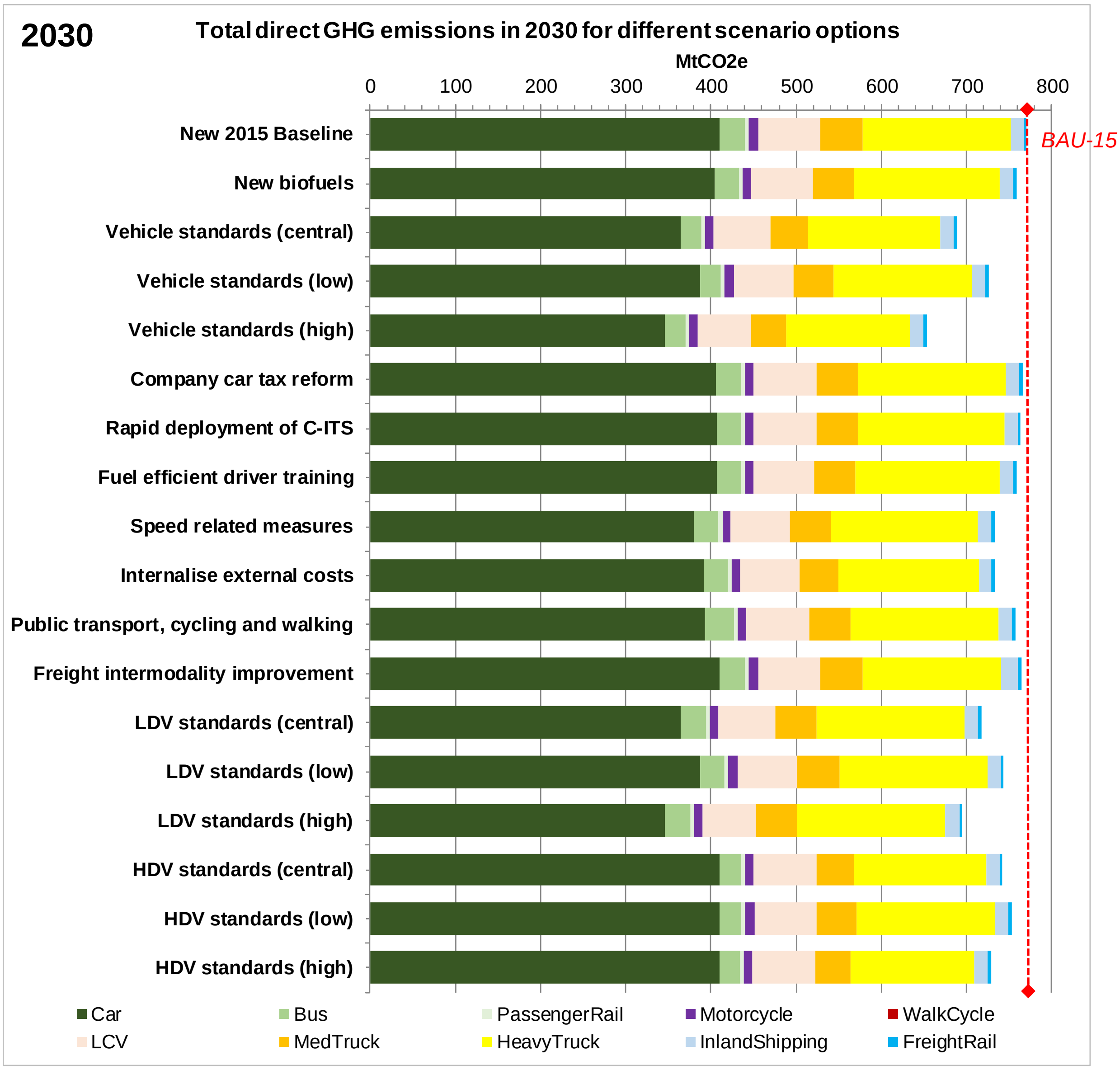


Figure 3.3: Contribution of transport to the overall reductions required on non-ETS GHG emissions from the transport sector for 2030, for different scenario options

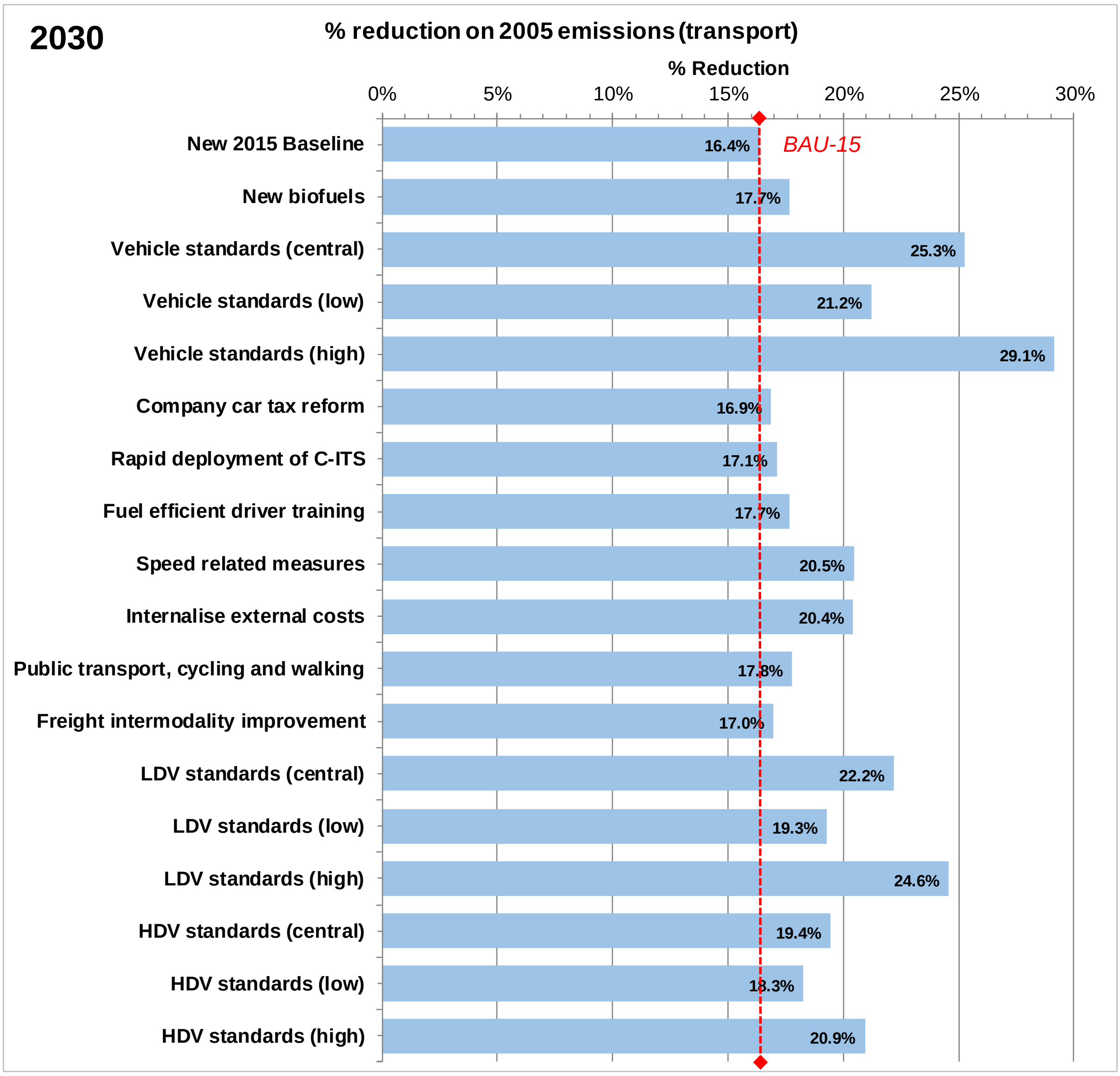
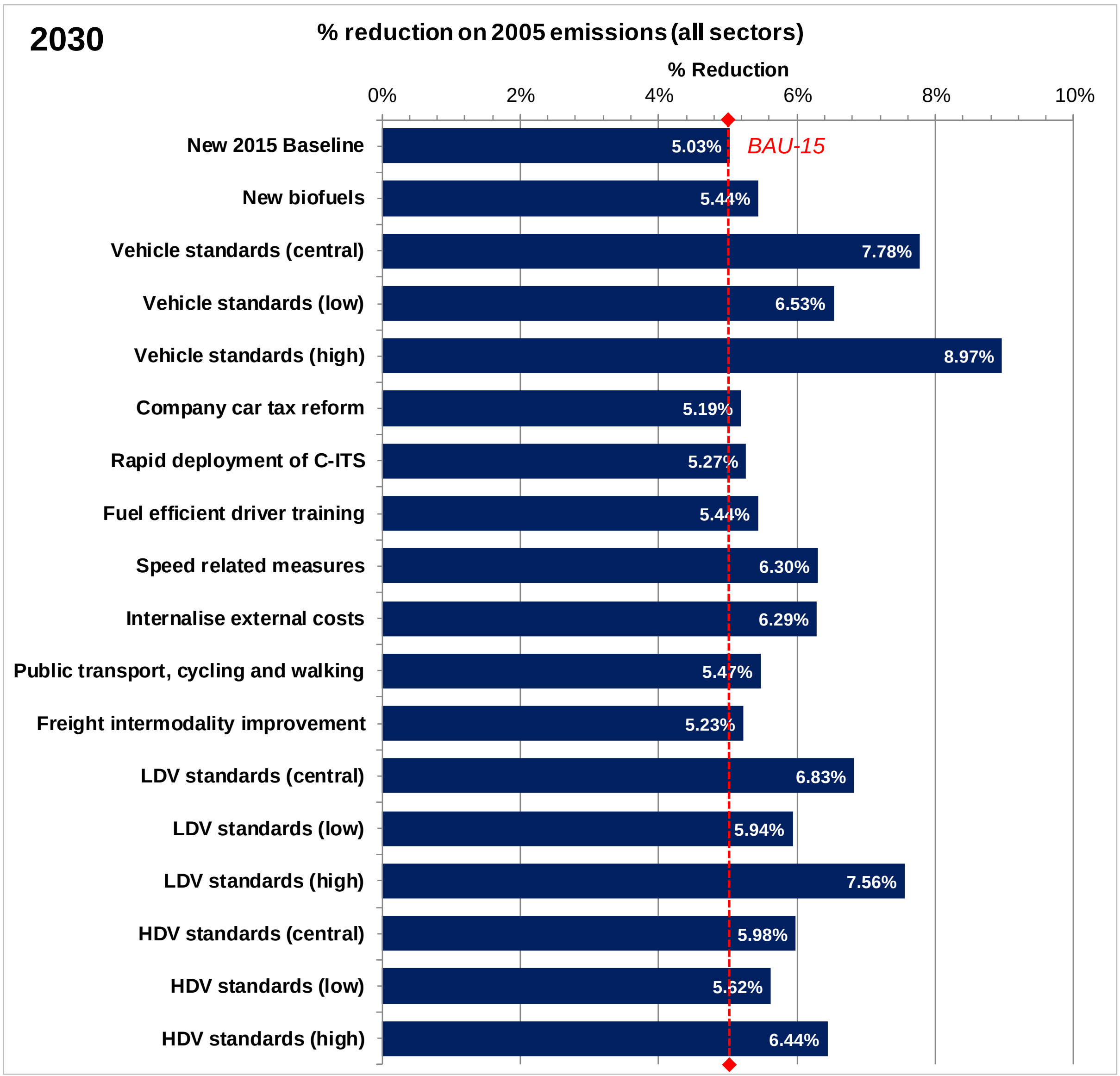


Figure 3.4: Contribution of transport to the overall reductions required on non-ETS GHG emissions from all sectors for 2030, for different scenario options



3.3.2 Scenario packages

The following Figure 3.5 provides a summary of the output results from the modelling of the different scenario packages. The three levels of new vehicle emissions standard scenarios are also presented for comparison. Figure 3.6 also provide a summary of the breakdown in emissions by transport mode in 2030, and Figure 3.7 provides a summary the level of potential contribution to the overall target of 30% reduction in emissions from all non-ETS sectors. The data tables behind the charts presented here are provided in Appendix 2 of this report.

The results show that the overall potential contributions of EU-level and MS-level policy options is similar in the 2030 horizon, and that transport could potentially contribute significantly to the overall targeted reduction in 2030 GHG emissions using a combination of such options. The results also underline the significance /importance of strong new vehicle emissions standards in achieving significant reductions in emissions from the transport sector. The package of EU-measures -- central scenarios for LDV and HDV standards and a limited expansion of zero-ILUC liquid fuels – would reduce transport emissions by 27% in 2030 compared to 2005. A package of all policy measures would achieve a 12.5% reduction in 2030 relative to the 2005 total ESD emissions, going a long way towards the EU's declared 30% reduction.

Looking beyond 2030, the results presented also suggest that a combination of central-high level ambition in both EU-level and MS-level policy actions are likely to be necessary to achieve GHG emission reduction savings compatible also with the longer-term target of 60% reduction in direct GHG emissions from transport by 2050. Given reductions at this level from international aviation and shipping (also included in the long-term target) will be even harder to achieve, this would suggest a higher level of ambition using all available options for the non-ETS transport sector might be necessary.

Figure 3.5: Timeseries trajectory for direct GHG emissions for various scenario packages in comparison to the baseline scenario (BAU-15)

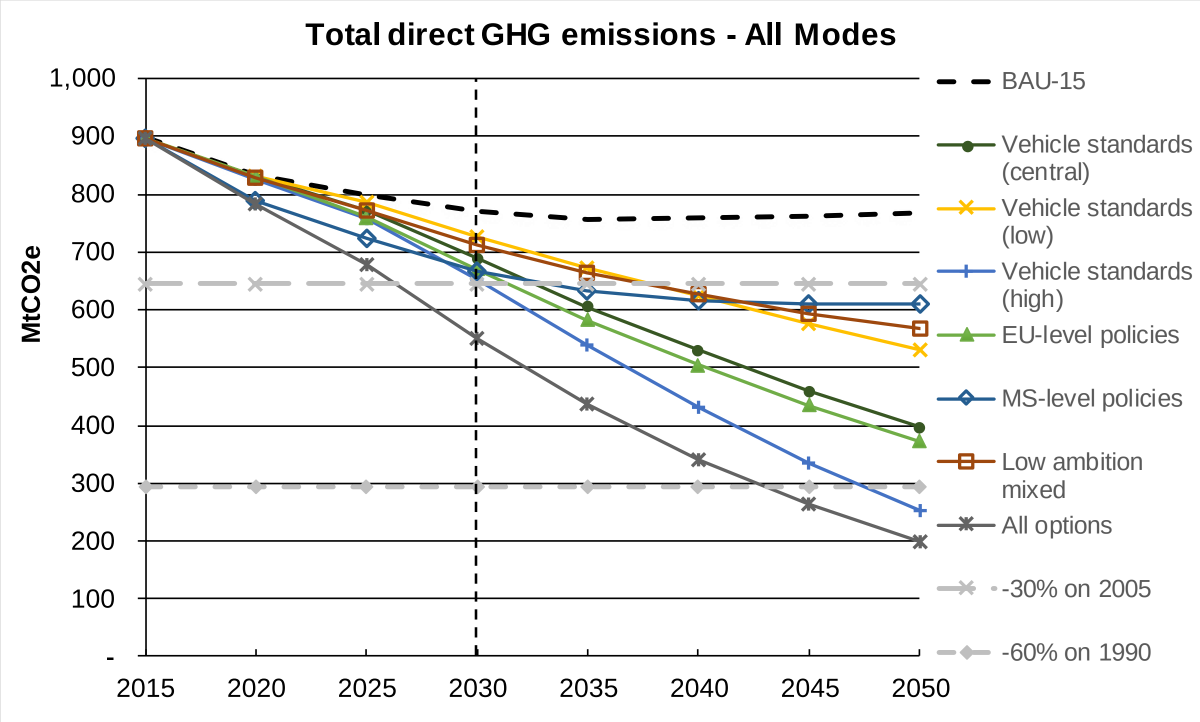


Figure 3.6: Direct GHG emissions reductions from transport for different scenarios for 2030

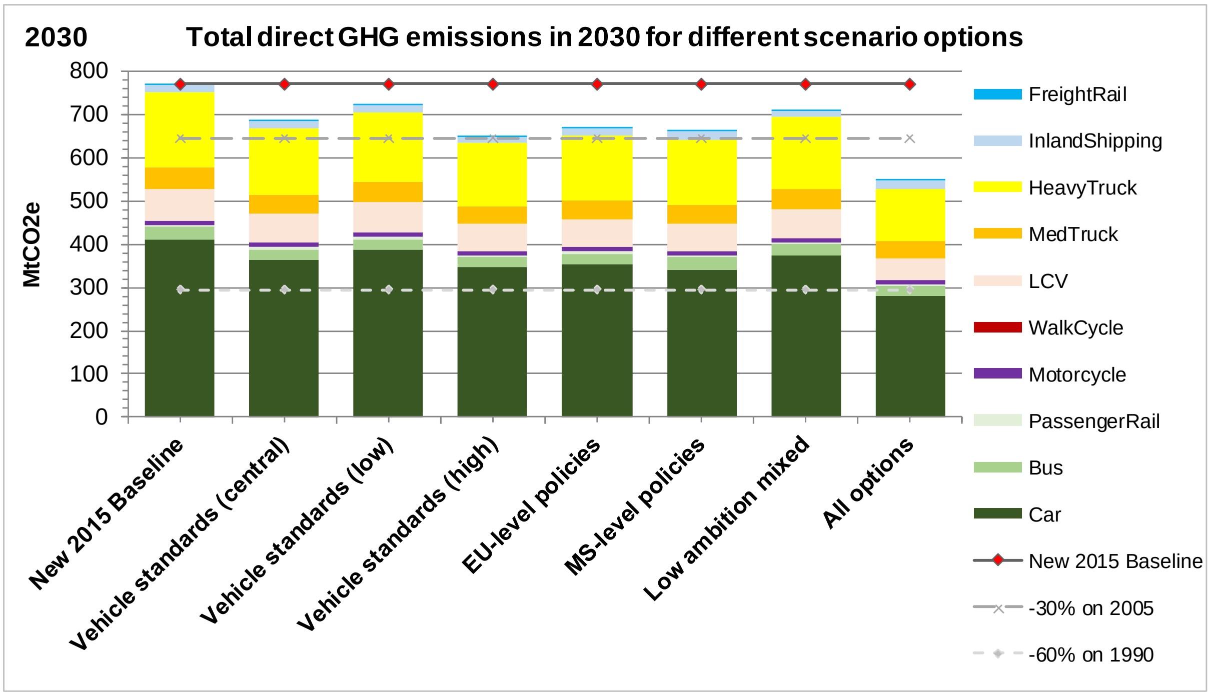
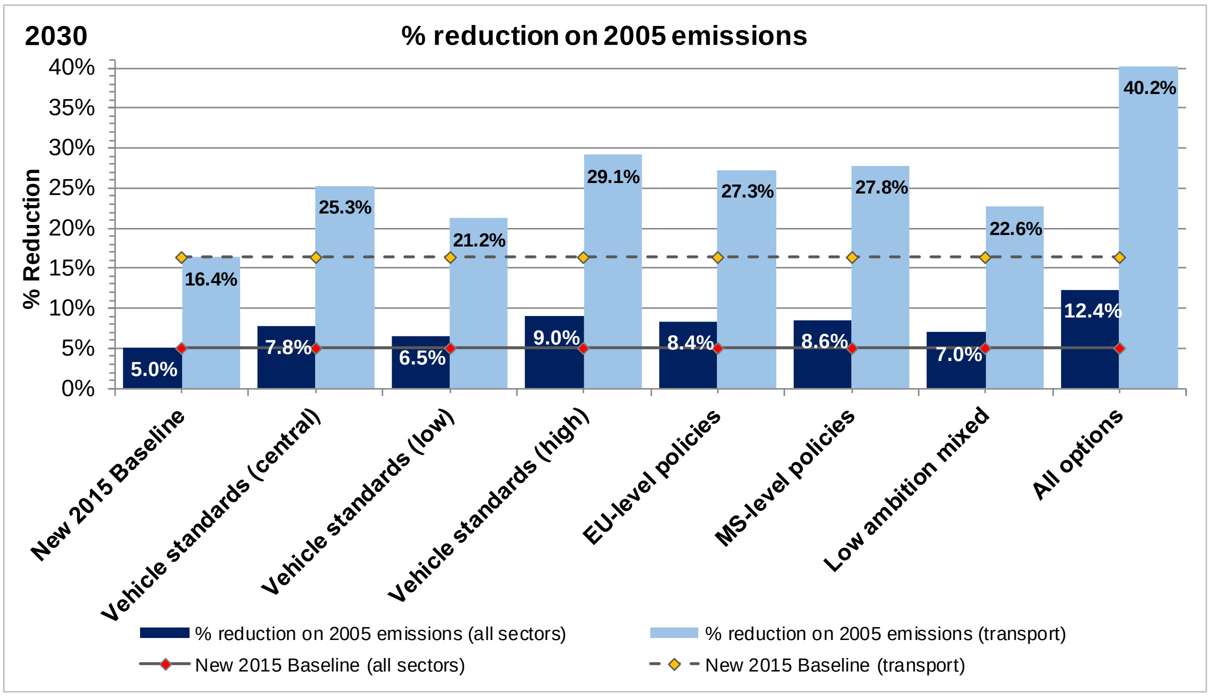


Figure 3.7: Contribution of transport to the reductions in (a) all sector GHG emissions (b) transport sector GHG emissions for 2030, for different scenario options



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Appendices

Appendix 1: Further details on the definition of scenarios in SULTAN

Appendix 2: Modelling output results tables for figures in the main report

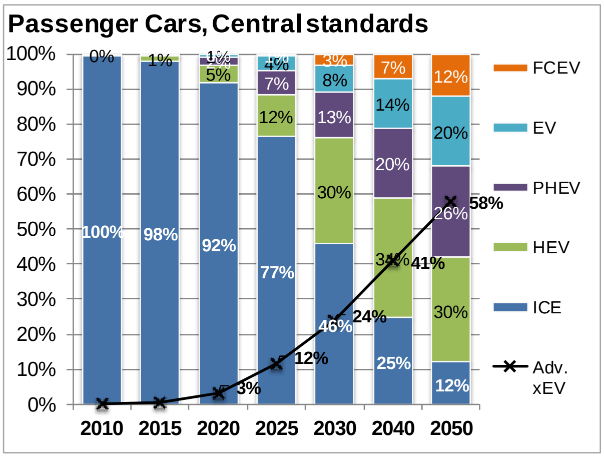
A1 Appendix 1 – Further details on the definition of scenarios in SULTAN

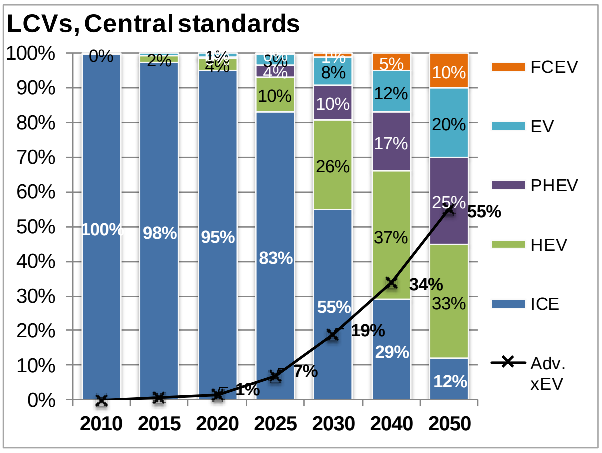
Additional details are provided below on the assumptions for individual scenarios. Most have been adapted directly from those developed in previous work for the European Commission (AEA, 2010).

A1.1 Vehicle emission standards

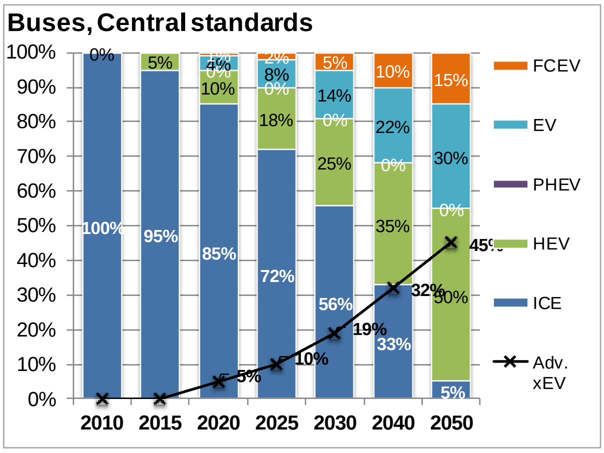
Table A1: Powertrain deployment assumptions for the central vehicle emissions standards scenarios

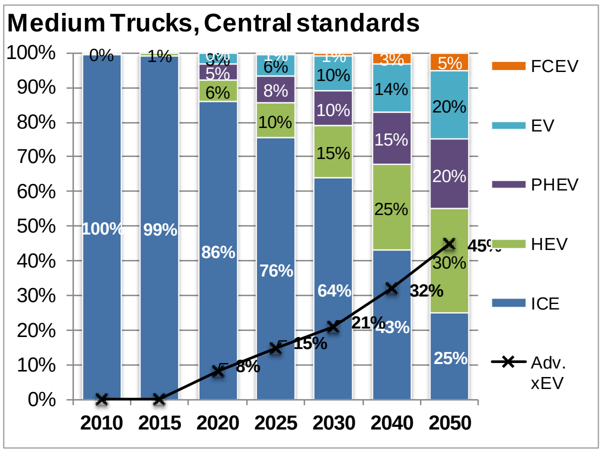
Light duty vehicles





Heavy duty vehicles





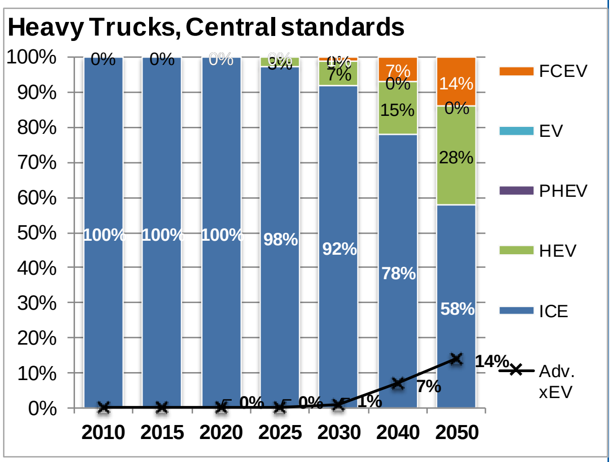
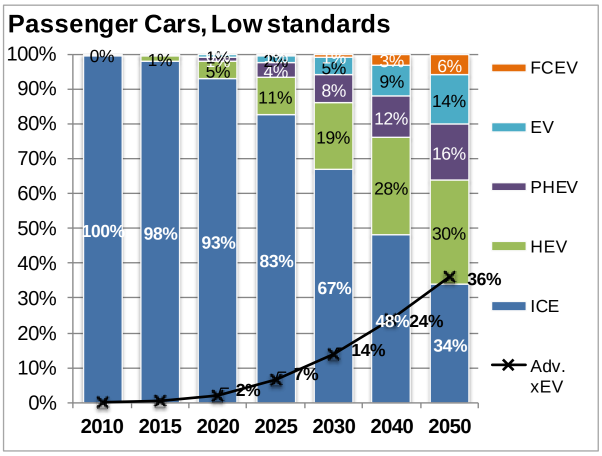
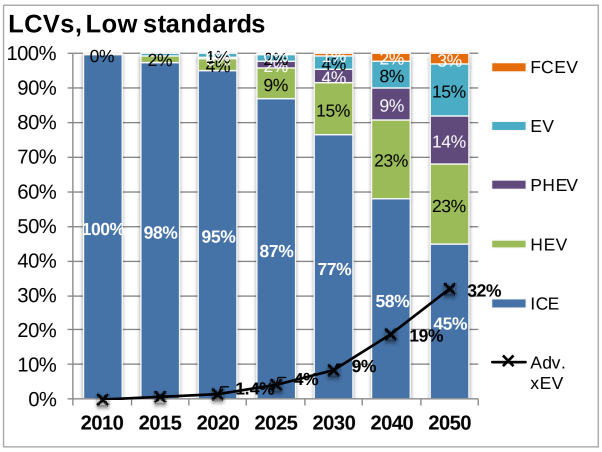


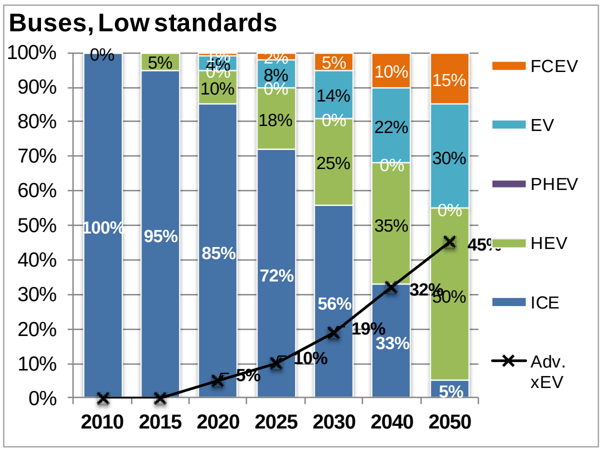
Table A2: Powertrain deployment assumptions for the low vehicle emissions standards scenarios

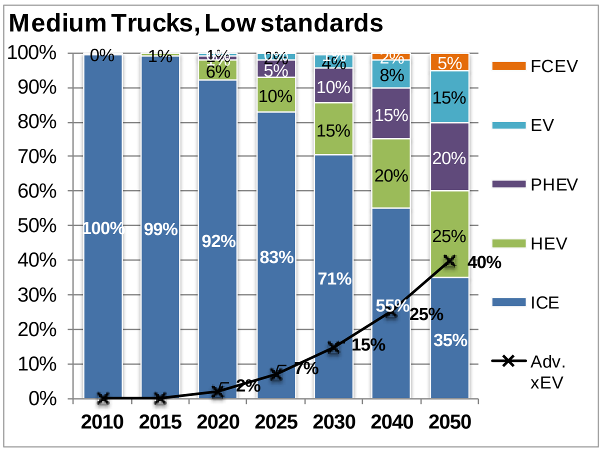
Light duty vehicles





Heavy duty vehicles





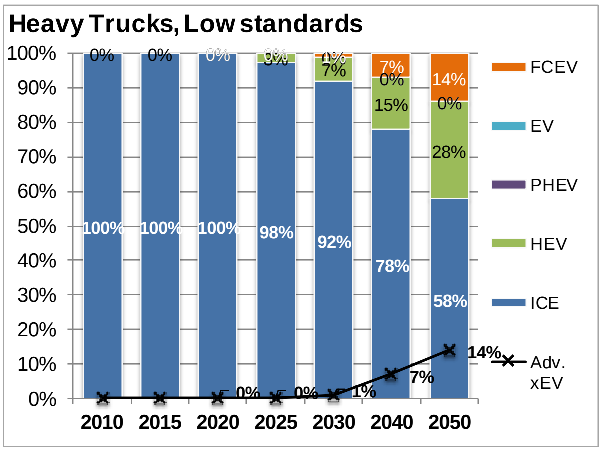
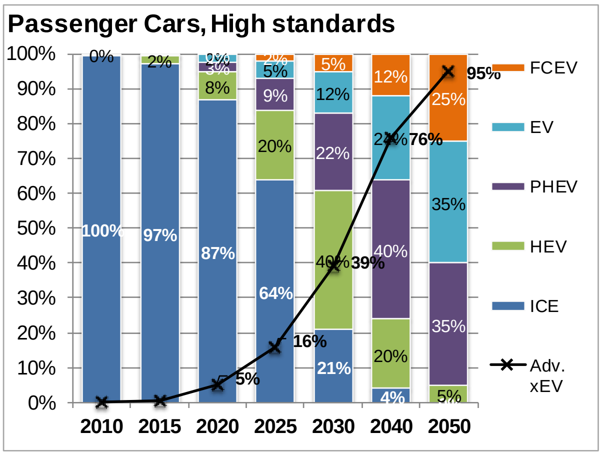
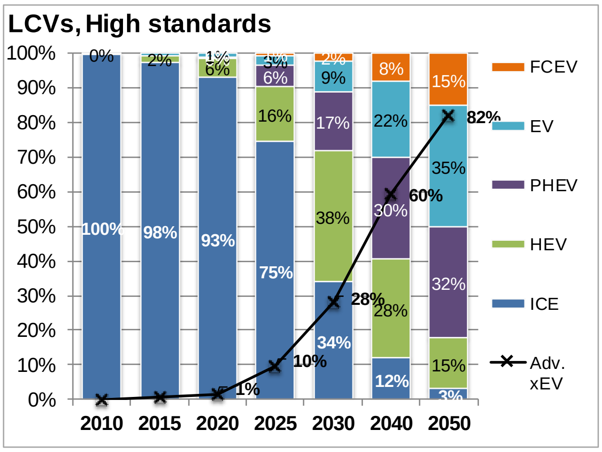


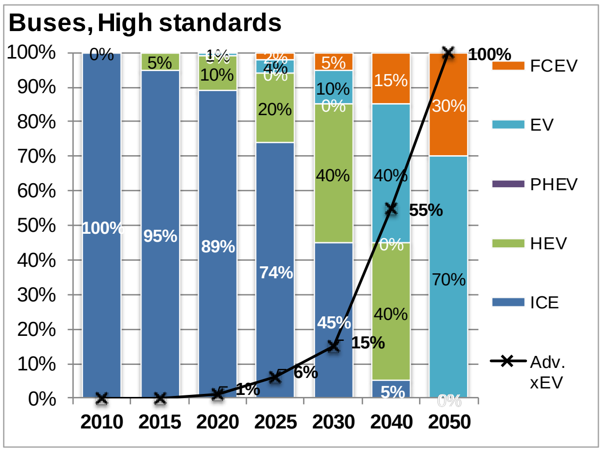
Table A3: Powertrain deployment assumptions for the high vehicle emissions standards scenarios

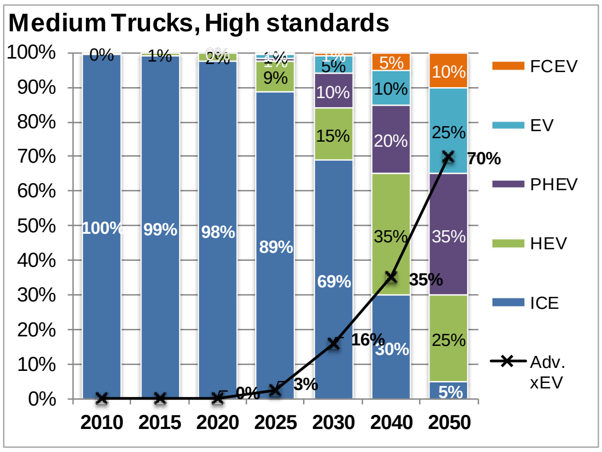
Light duty vehicles

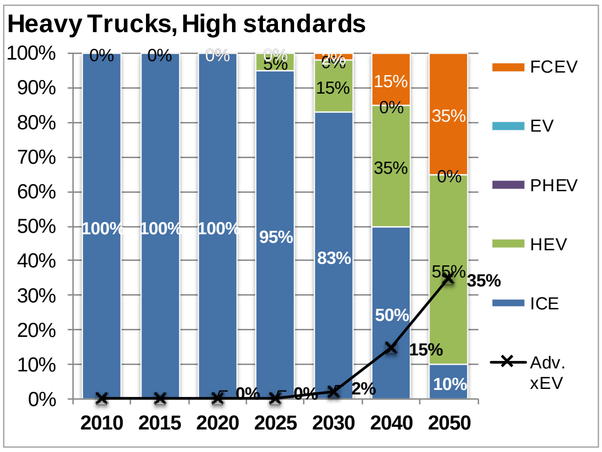




Heavy duty vehicles







A1.2 Public transport, cycling and walking improvement measures

- Assumptions for modal shift in demand for scenario summarised in Table A4 and Table A5;
- Impacts on stock changes resulting from changes in demand are estimated also.

Table A4: Assumptions on modal shift from cars to other modes for different road types

Modal Shift - Urban	2015	2020	2025	2030	2040	2050
FROM:						
Car		2.0%	5.0%	8.0%	14.0%	20.0%
TO:						
Bus		40.0%	40.0%	40.0%	40.0%	40.0%
Passenger Rail		10.0%	10.0%	10.0%	10.0%	10.0%
Motorcycle		0.0%	0.0%	0.0%	0.0%	0.0%
Walk/Cycle		50.0%	50.0%	50.0%	50.0%	50.0%
	0.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Modal Shift - Non-Urban	2015	2020	2025	2030	2040	2050
FROM:						
Car		1.0%	2.0%	3.0%	6.0%	8.0%
TO:						
Bus		35.0%	35.0%	35.0%	35.0%	35.0%
Passenger Rail		50.0%	50.0%	50.0%	50.0%	50.0%
Motorcycle		0.0%	0.0%	0.0%	0.0%	0.0%
Walk/Cycle		15.0%	15.0%	15.0%	15.0%	15.0%
	0.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Modal Shift - Motorway/Met	2015	2020	2025	2030	2040	2050
FROM:						
Car		1.0%	2.0%	3.0%	6.0%	8.0%
TO:						
Bus		40.0%	40.0%	40.0%	40.0%	40.0%
*Passenger Rail**		60.0%	60.0%	60.0%	60.0%	60.0%
Motorcycle		0.0%	0.0%	0.0%	0.0%	0.0%
Walk/Cycle						
	0.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

* added to passenger rail non-urban

Table A5: Split of new vehicle sales by powertrain (%) for rail reflecting increase in HSR

	2015	2020	2025	2030	2040	2050
Diesel	25%	15%	8%	1%	1%	1%
CR Electric	70%	73%	72%	79%	79%	79%
HSR Electric	5%	12%	20%	20%	20%	20%
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

Notes: CR = conventional rail, HSR = high-speed rail

A1.3 Improved freight intermodality

- Assumptions for modal shift in demand for scenario summarised in Table A6;
- Impacts on stock changes resulting from changes in demand are estimated also.

Table A6: Assumptions on modal shift for improved freight intermodality

Modal Shift (all roads)	2015	2020	2025	2030	2040	2050
FROM:						
LCV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Medium Truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Heavy Truck	0.0%	1.0%	3.0%	6.0%	10.0%	15.0%
TO:						
Inland Shipping		30.0%	30.0%	30.0%	30.0%	30.0%
Freight Rail		70.0%	70.0%	70.0%	70.0%	70.0%
		100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**

A1.4 Speed related measures for road vehicles

These include (a) improved speed enforcement and (b) reduction of average motorway speeds.

- Elasticity of speed change to demand change is assumed to be 100% for passenger modes and 25% for freight modes

Table A7: Assumptions on impacts of speed enforcement on average speed, and reduction in average motorway speed limits

	Motorway		Urban		Nonurban	
	LDVs	HDVs	LDVs	HDVs	LDVs	HDVs
Current Average Speed Limit (kph):	123	82	49	49	95	70
Reduction in Av. Speed (kph):	105	78	45	47	88	67
Speed Enforcement %Change	-15.2%	-4.8%	-8.0%	-4.0%	-8.0%	-4.0%
New Harmonised Speed Limit (kph):	110	80				
Total % Change	**-15.2%**	**-4.8%**	**-8.0%**	**-4.0%**	**-8.0%**	**-4.0%**

Table A8: Average % efficiency improvement due to speed change for road transport modes

All roads	2015	2020	2025	2030	2040	2050
Car	2.7%	3.0%	3.2%	3.3%	3.4%	3.5%
Bus	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%	-1.0%
Motorcycle	2.5%	2.7%	2.9%	2.9%	3.0%	3.0%
LCV	8.3%	8.4%	8.5%	8.5%	8.6%	8.8%
Medium Truck	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%
Heavy Truck	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
% Application	**2015**	**2020**	**2025**	**2030**	**2040**	**2050**
Car	0.0%	20.0%	40.0%	60.0%	100.0%	100.0%
Bus	0.0%	20.0%	40.0%	60.0%	100.0%	100.0%
Motorcycle	0.0%	20.0%	40.0%	60.0%	100.0%	100.0%
LCV	0.0%	20.0%	40.0%	60.0%	100.0%	100.0%
Medium Truck	0.0%	20.0%	40.0%	60.0%	100.0%	100.0%
Heavy Truck	0.0%	20.0%	40.0%	60.0%	100.0%	100.0%

A1.5 Fuel efficient driver training

Table A9: Assumptions on impact of fuel efficient driver training used in the definition of the scenario

Saving for driver training	2015	2020	2025	2030	2040	2050	% decline in effectiveness per year
Car	4.07%	3.68%	3.32%	3.00%	2.45%	2.01%	2.0%
Bus	4.25%	3.84%	3.47%	3.14%	2.56%	2.09%	2.0%
Passenger Rail	4.52%	4.09%	3.69%	3.34%	2.73%	2.23%	2.0%
Motorcycle	4.07%	3.68%	3.32%	3.00%	2.45%	2.01%	2.0%
LCV	6.51%	5.88%	5.32%	4.81%	3.93%	3.21%	2.0%
Medium Truck	3.89%	3.51%	3.18%	2.87%	2.35%	1.92%	2.0%
Heavy Truck	3.89%	3.51%	3.18%	2.87%	2.35%	1.92%	2.0%
Inland Shipping	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.0%
Freight Rail	2.71%	2.45%	2.22%	2.00%	1.64%	1.34%	2.0%

Notes: Decline in effectiveness of driver training is assumed (from 2010 starting point), due to technology performance being increasingly insensitive to driver/driving style either intrinsically (e.g. electric vehicles) or through technologically helping to optimise driving style automatically. This is already applied at the level indicated to periods after 2010 in the above table.

Table A10: Assumptions the level of application of fuel efficient driver training used in the definition of the scenario

% drivers /fleet covered	2015	2020	2025	2030	2040	2050	% drivers trained per year
Car	0.0%	10.0%	20.0%	30.0%	50.0%	70.0%	2.0%
Bus	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%
Passenger Rail	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%
Motorcycle	0.0%	10.0%	20.0%	30.0%	50.0%	70.0%	2.0%
LCV	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%
Medium Truck	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%
Heavy Truck	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%
Inland Shipping	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%
Freight Rail	0.0%	25.0%	50.0%	75.0%	100.0%	100.0%	5.0%

Notes: % of drivers trained per year has been used to derive the figures in the main body of the table.

A1.6 Reform of company car tax

Table A11: Assumptions used in the definition of the scenario on reforming company car tax

Assumed to be in BAU	2015	2020	2025	2030	2040	2050
Company Cars % Fleet	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
Company Cars % New Vehicles	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Increase in total EU fleet numbers	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
Company Cars increased fuel consumption	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
Increased annual km	1,200	1,200	1,200	1,200	1,200	1,200
% total annual km	10.3%	10.3%	10.3%	10.3%	10.3%	10.3%

Application	2015	2020	2025	2030	2040	2050
Implementation of reform	0.0%	50.0%	100%	100%	100%	100%
Change in total car demand (1)	0.00%	-0.77%	-1.55%	-1.55%	-1.55%	-1.55%
Improvement to new car efficiency (2)	0.0%	1.4%	2.8%	2.8%	2.8%	2.8%
Change in new car stock growth	0.0%	-2.5%	-5.0%	-5.0%	-5.0%	-5.0%

Notes:

(1) Based on reduction in annual km from company cars averaged out across whole fleet at level of implementation for the year
(2) Company car improvement in efficiency applied to % of new fleet that are company cars at level of implementation for the year

A1.7 Internalisation of external costs

- CO_2 prices/tax using the EC IMPACT study damage costs, central case.
- Tax is applied as an addition to existing duty levels based on carbon intensity of the energy carrier.
- NOx and PM prices/tax using damage costs based on EC IMPACT study figures.
- NOx and PM taxes applied as an addition to existing duty levels based on average NOx and PM emissions of the energy carrier (i.e. emissions weighted by relative activity for different modes).
- Energy security price/tax applied as additive to basic duty level at 0.145 €cents/MJ (~5 €cents/litre) for all conventional road transport fuels (i.e. excluding hydrogen and electricity).

Table A12: Fuel price elasticities used in the definition of illustrative scenarios modelled in SULTAN

Mode	Elasticity
Car	-0.54
Bus	-0.38
Passenger Rail	-0.24
Motorcycle	-0.41
LCV	-0.30
Medium Truck	-0.30
Heavy Truck	-0.30
Inland Shipping	-0.18
Freight Rail	-0.24

Source: UK MARKAL ED model (AEA, 2008)

Table A13: Proportion of fuel price response split between demand reduction and new vehicle efficiency

% Allocated to demand reduction	2015	2020	2025	2030	2040	2050
Car		40.0%	40.0%	40.0%	40.0%	40.0%
Bus		50.0%	50.0%	50.0%	50.0%	50.0%
Passenger Rail		90.0%	90.0%	90.0%	90.0%	90.0%
Motorcycle		40.0%	40.0%	40.0%	40.0%	40.0%
LCV		67.0%	67.0%	67.0%	67.0%	67.0%
Medium Truck		67.0%	67.0%	67.0%	67.0%	67.0%
Heavy Truck		67.0%	67.0%	67.0%	67.0%	67.0%
Inland Shipping*		90.0%	90.0%	90.0%	90.0%	90.0%
Freight Rail		90.0%	90.0%	90.0%	90.0%	90.0%

Source: Estimates agreed with project partners in the absence of a quantitative data source.

Speed-Demand Response

Demand response to speed reduction measures is assumed 1:1 for passenger modes (i.e. 1% reduction in pkm for every 1% reduction in speed) and 1:4 for freight modes (i.e. 0.25% reduction in tkm for every 1% speed reduction).

External Costs

The assumptions on the external costs of CO_2, NOx and PM emissions are based on information from the EC's IMPACT project and are summarised in Table A14 and Table A15. In addition an indicative figure for energy security from the IMPACT handbook of approximately 5 €cent/litre has also been utilised.

Table A14: External costs of climate change from IMPACT project (in €/tonne CO_2), expressed as single values for a central estimate and lower and upper values

Year of application	2010	*2015**	2020	2030	2040	2050
Central value	25	*32.5*	40	55	70	85

*Notes: * interpolated from IMPACT study values for 2010 and 2020*

Table A15: External costs of NOx and PM used in defining illustrative scenarios

External costs of NOx and PM		2010	2015	2020	2030	2040	2050
EU27 NOx	**All**	7,424	8,642	9,261	9,650	10,102	10,228
EU27 PM	**Non-urban**	89,571	98,629	96,427	92,328	86,539	75,267
EU27 PM	**Urban**	251,282	279,002	275,397	262,014	236,852	180,868

Source: Based on weighted average of figures from IMPACT project (in 2000€/tonne pollutant), corrected for GDP growth in future years with elasticity of 0.5.

A2 Appendix 2 – Modelling output results tables for figures in the main report

Table A16: Underlying data for Figure 3.2: Direct GHG emissions from transport for different scenarios for 2030, by mode

	Car	Bus	Passenger Rail	Motor -cycle	Walk /Cycle	LCV	Medium Truck	Heavy Truck	Inland Shipping	Freight Rail	Total direct GHG emissions
New 2015 Baseline	410.7	29.6	4.4	10.3	0.0	73.6	48.8	173.8	16.0	3.5	**770.9**
New biofuels	403.8	29.1	4.4	10.1	0.0	72.4	48.0	171.0	15.7	3.5	**758.0**
Vehicle standards (central)	364.2	24.6	4.4	10.3	0.0	66.4	43.9	155.2	16.0	3.5	**688.6**
Vehicle standards (low)	386.7	25.4	4.4	10.3	0.0	70.6	45.9	163.2	16.0	3.5	**726.1**
Vehicle standards (high)	346.3	23.8	4.4	10.3	0.0	62.5	41.7	144.6	16.0	3.5	**653.1**
Company car tax reform	405.9	29.6	4.4	10.3	0.0	73.6	48.8	173.8	16.0	3.5	**766.0**
Rapid deployment of C-ITS	406.8	29.1	4.4	10.3	0.0	73.1	48.4	172.2	16.0	3.5	**763.8**
Fuel efficient driver training	407.0	28.9	4.3	10.2	0.0	71.0	47.8	170.0	16.0	3.5	**758.8**
Speed related measures	380.3	29.1	4.4	9.6	0.0	68.9	48.5	172.7	16.0	3.5	**733.0**
Internalise external costs	391.7	28.1	4.4	10.0	0.0	69.8	46.2	164.3	15.3	3.4	**733.2**
Public transport, cycling and walking	393.1	33.8	4.7	10.3	0.0	73.6	48.8	173.8	16.0	3.5	**757.6**
Freight intermodality improvement	410.7	29.6	4.4	10.3	0.0	73.6	48.8	163.5	20.0	3.9	**765.1**
LDV standards (central)	364.2	29.6	4.4	10.3	0.0	66.4	48.8	173.8	16.0	3.5	**717.1**
LDV standards (low)	386.7	29.6	4.4	10.3	0.0	70.6	48.8	173.8	16.0	3.5	**743.8**
LDV standards (high)	346.3	29.6	4.4	10.3	0.0	62.5	48.8	173.8	16.0	3.5	**695.2**
HDV standards (central)	410.7	24.6	4.4	10.3	0.0	73.6	43.9	155.2	16.0	3.5	**742.4**
HDV standards (low)	410.7	25.4	4.4	10.3	0.0	73.6	45.9	163.2	16.0	3.5	**753.1**
HDV standards (high)	410.7	23.8	4.4	10.3	0.0	73.6	41.7	144.6	16.0	3.5	**728.7**

Table A17: Underlying data for Figure 3.3 and Figure 3.4 - Contribution of transport to reductions in 2005 GHG emissions from the transport sector and from all sectors for 2030, for different scenario options

	% reduction on 2005 emissions (all sectors)	*% reduction on 2005 emissions (transport)*
New 2015 Baseline	5.03%	16.35%
New biofuels	5.46%	17.75%
Vehicle standards (central)	7.78%	25.28%
Vehicle standards (low)	6.53%	21.22%
Vehicle standards (high)	8.97%	29.14%
Company car tax reform	5.19%	16.88%
Rapid deployment of C-ITS	5.27%	17.12%
Fuel efficient driver training	5.44%	17.67%
Speed related measures	6.30%	20.47%
Internalise external costs	6.29%	20.44%
Public transport, cycling and walking	5.47%	17.79%
Freight intermodality improvement	5.23%	16.98%
LDV standards (central)	6.83%	22.18%
LDV standards (low)	5.94%	19.29%
LDV standards (high)	7.56%	24.56%
HDV standards (central)	5.98%	19.45%
HDV standards (low)	5.62%	18.28%
HDV standards (high)	6.44%	20.93%

Table A18: Underlying data for Figure 3.5: Timeseries trajectory for direct GHG emissions for various scenario packages in comparison to the baseline scenario (BAU-15)

	Direct GHG emissions, $MtCO_2e$							
	2015	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
BAU-15	897.8	834.3	799.9	771.6	757.7	759.4	762.2	769.2
Vehicle standards (central)	897.7	830.6	771.1	689.3	606.0	530.0	459.2	396.6
Vehicle standards (low)	897.7	832.6	785.1	726.8	671.3	623.4	575.3	530.1
Vehicle standards (high)	897.5	827.3	757.8	653.7	540.5	431.9	333.9	251.8
EU-level policies	897.7	830.2	760.5	670.9	583.3	503.8	434.4	372.9
MS-level policies	897.8	790.0	724.7	666.1	633.6	615.4	610.7	609.0
Low ambition mixed	897.8	828.8	772.6	713.6	665.3	626.1	594.6	567.1
All options	897.5	783.5	679.0	551.9	438.3	339.2	263.0	199.6

Table A19: Underlying data for Figure 3.6: Direct GHG emissions reductions from transport for different scenarios for 2030

	Direct GHG emissions, $MtCO_2e$							
	New 2015 Baseline	*Vehicle standards (central)*	*Vehicle standards (low)*	*Vehicle standards (high)*	*EU-level policies*	*MS-level policies*	*Low ambition mixed*	*All options*
Car	410.7	364.2	386.7	346.3	354.4	340.0	372.9	279.4
Bus	29.6	24.6	25.4	23.8	23.7	30.7	28.0	23.7
Passenger Rail	4.4	4.4	4.4	4.4	4.4	4.5	4.3	4.5
Motorcycle	10.3	10.3	10.3	10.3	10.1	9.2	10.0	9.1
Walk/Cycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LCV	73.6	66.4	70.6	62.5	64.8	62.9	66.4	52.2
Medium Truck	48.8	43.9	45.9	41.7	42.8	44.9	46.6	37.4
Heavy Truck	173.8	155.2	163.2	144.6	150.9	150.3	165.7	122.6
Inland Shipping	16.0	16.0	16.0	16.0	15.7	19.1	15.7	18.8
Freight Rail	3.5	3.5	3.5	3.5	3.5	3.8	3.4	3.7
Total direct GHG emissions	**770.9**	**688.6**	**726.1**	**653.1**	**670.3**	**665.4**	**712.9**	**551.4**

Table A20: Underlying data for Figure 3.7: Contribution of transport to the reductions in (a) all sector GHG emissions (b) transport sector GHG emissions for 2030, for different scenario options

	% Reductions in GHG Emissions							
	New 2015 Baseline	*Vehicle standards (central)*	*Vehicle standards (low)*	*Vehicle standards (high)*	*EU-level policies*	*MS-level policies*	*Low ambition mixed*	*All options*
% reduction on 2005 emissions (all sectors)	5.03%	7.78%	6.53%	8.97%	8.39%	8.55%	6.97%	12.36%
% reduction on 2005 emissions (transport)	16.35%	25.28%	21.22%	29.14%	27.27%	27.79%	22.64%	40.17%

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