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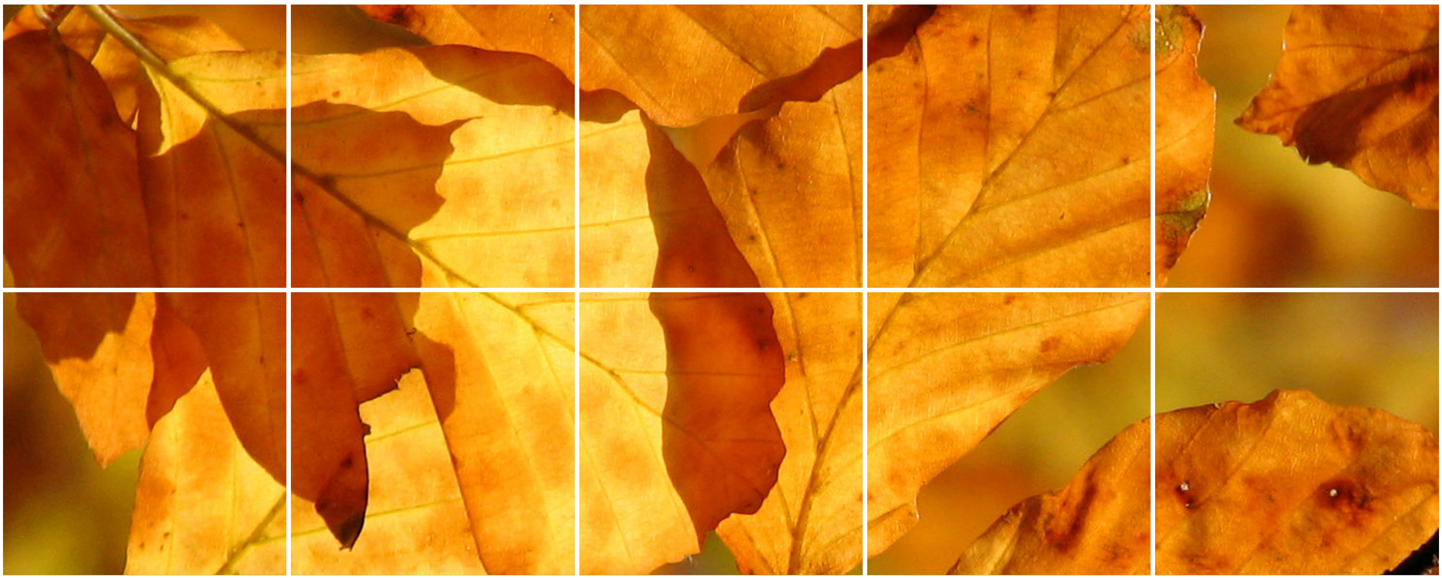

Assessment of options for the legislation of CO_2 emissions from light commercial vehicles

Final Report - Update

Association ASPEN

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Institute for Applied Ecology

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1 Introduction

This report is an updated version of the "Assessment of options for CO_2 legislation for light commercial vehicles" published in December 2008. In a review of the work some calculation errors have been discovered in the spreadsheet that was used to construct the cost curves for CO_2 emission reduction in light commercial vehicles (see section 4.1). The errors affected the CO_2 reduction potential estimated for various packages of measures. This error has been corrected and assessments have been redone. Updated results are presented in this report.
It should be noted that the underlying assumptions on potential and costs of technological measures have remained unchanged. The main effect of the correction is that it leads to lower costs for reaching the various target levels assessed in this report.

1.1 Context of the project

In COM(2007) 19[1] and SEC(2007) 60[2] the European Commission has outlined its plans for a new Community Strategy for reaching the EU objective of reducing CO_2 emissions from new passenger cars to 120 g/km in 2012. The Commission proposes an Integrated Approach. The main element of this approach is a regulatory framework for reducing the CO_2 emissions of the average new car fleet to 130 g/km by means of improvements in vehicle technology. To bridge the gap between this new car fleet average and the 120g/km goal the Integrated Approach comprises the following additional elements:
- setting minimum efficiency requirements for air-conditioning systems;
- compulsory fitting of accurate tyre pressure monitoring systems;
- setting maximum tyre rolling resistance limits in the EU for tyres fitted on passenger cars and light commercial vehicles;
- the use of gear shift indicators;
- fuel efficiency progress in light commercial vehicles with the objective of reaching 175 g/km CO_2 by 2012 and 160g/km CO_2 by 2015;
- increased use of biofuels maximizing environmental performance.

Together these elements are intended to achieve a net CO_2 emission reduction that is equivalent to the impact of reducing the new vehicle fleet average from 130 to 120 g/km. In December of 2007 the Commission has presented a detailed proposal[3] and accompanying Impact Assessment[4] for the regulatory framework to achieve a new car fleet average of 130 g/km.

In December 2008 the European Parliament and Council have reached agreement through a co-decision procedure on the details of the CO_2 legislation for passenger cars, laid down in Regulation No 443/2009[5]. Some important elements of the agreement are:
- Limit value curve: the fleet average to be achieved by all cars registered in the EU is 130 grams per kilometre (g/km). A so-called limit value curve implies that heavier cars are allowed higher emissions than lighter cars while preserving the overall fleet average. Manufacturers will be given a target based on the sales-weighted average mass of their vehicles.

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[1] COM(2007) 19: Results of the review of the Community Strategy to reduce CO_2 from passenger cars and light commercial vehicles, 7.2.2007

[2] SEC(2007) 60, Impact Assessment, accompanying document to COM(2007) 19, 7.2.2007

[3] COM(2007) 856, Proposal for a Regulation of the European Parliament and of the Council 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, 19.12.2007

[4] SEC(2007) 1723, Proposal from the Commission to the European Parliament and Council for a Regulation to reduce CO_2 emissions from passenger cars, DRAFT Impact Assessment, 19.12.2007

[5] REGULATION (EC) No 443/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 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, see: http://ec.europa.eu/environment/air/transport/co2/co2_home.htm

- Phasing-in of requirements: in 2012 65% of each manufacturer's newly registered cars must comply on average with the limit value curve set by the legislation. This will rise to 75% in 2013, 80% in 2014, and 100% from 2015 onwards.
- Long-term target: a target of 95g/km is specified for the year 2020. The modalities for reaching this target and the aspects of its implementation will have to be defined in a review to be completed no later than the beginning of 2013.

This report presents results of analyses carried out by CE Delft, in collaboration with TNO, in support of the development by the European Commission of a proposal for regulation of the CO_2 emissions from new light commercial vehicles (LCVs).

1.2 Objective of the work

As mentioned above, in the Commission Strategy (COM(2007) 19) light commercial vehicles are expected to provide part of the CO_2 emission reduction required to bridge the gap between the proposed 130 g/km average for new passenger cars and the overall target of 120 g/km (equivalent). Proposed targets are a sales weighted average for new vehicles of 175 g/km in 2012 and of 160 g/km in 2015. The Commission's intention is to set up the legislation along similar lines as was done for the proposal for passenger cars (see COM(2007) 856), on the basis of an overall sales weighted target translated to the level of manufacturers using a utility-based limit function.

The objective of the work, reported in this document, has been to support the Commission (DG Environment) in the assessment of the impacts of different regulatory approaches for CO_2 emissions of light commercial vehicles on manufacturers in particular (incl. distributional impacts, i.e. distribution of reduction efforts and associated costs over the various manufacturers) and on society in general, with a focus on the quantitative assessment of absolute and relative retail price and manufacturer cost increases and associated fuel (cost) savings resulting from the application of technical measures to reduce the CO_2 emissions of light commercial vehicles.

The Commission has requested detailed assessment of the variants and scenarios indicated in Table 1.1. The definition of utility-based limit functions with different slope values is explained in Chapter 5. A target based on percentage reduction means that all manufacturers in the target year have to reduce the sales-averaged CO_2 emissions of their new vehicles compared to the reference year (e.g. 2007) by the same percentage, which is defined by the ratio of the overall target value for the target year and the overall sales-weighted average CO_2 emissions in the reference year. Considerations on the scenario assumptions with respect to autonomous mass increase can be found in section 4.3

Table 1.1 Legislative variants and AMI scenarios assessed in this report

target value [g/km]	target year	target types	slope values	autonomous mass increase assumptions
175	2012	utility-based limit function for mass and pan area percentage reduction	0 – 120% n.a.	0.0 – 1.5% p.a. 0.0 – 1.5% p.a.
175	2015	utility-based limit function for mass and pan area percentage reduction	0 – 120% n.a.	0.0 – 1.5% p.a. 0.0 – 1.5% p.a.
160	2015	utility-based limit function for mass and pan area percentage reduction	0 – 120% n.a.	0.0 – 1.5% p.a. 0.0 – 1.5% p.a.

The assessment for 2012 and 2015 is based on (static) cost curves for the year 2012 derived from the cost data collected in [TNO 2006] for technologies that can be used to reduce CO_2 emissions from vans. Possible effects of developments in technology and costs are ignored for this short term time horizon. The assessment of a long term target for 2020, using cost curves including new technologies becoming available after 2012 and cost reductions caused by learning effects, is carried out and reported separately[6].

1.3 Definition of light commercial vehicles

To align the scope of the proposal for regulation of the CO_2 emissions of new light commercial vehicles with that of the Euro 5/6 legislation, the regulation is intended to cover N1, N2 and M2 vehicles with a reference mass not exceeding 2610 kg. Further definitions are given in chapter 2.

Wherever this report makes reference to “N vehicles”, “N-type” vehicles, “light commercial vehicles” or “vans” it should be read as “light commercial vehicles including N2 and M2 vehicles with a reference mass not exceeding 2610 kg”.

1.4 Project history

The assessments presented in this report build in part on previous work carried out by the present consortium members CE Delft and TNO in collaboration with IEEP and LAT. This work has been reported in the following documents:

- [IEEP 2007]: *Service Contract on possible regulatory approaches to reducing CO_2 emissions from cars: Study on the detailed design of the regulation to reduce CO_2 emissions from new passenger cars to 130 g/km in 2012*, carried out by IEEP, CE Delft and TNO on behalf of the European Commission (DG ENV, contract nr. 070402/2006/452236/MAR/C3) in 2007
- [TNO 2006]: *Service Contract to review and analyse the reduction potential and costs of technological and other measures to reduce CO_2 emissions from passenger cars*, carried out by TNO, IEEP and LAT on behalf of the European Commission (DG Enterprise, contract nr. SI2.408212) in 2006.
- [TNO 2004]: *Service Contract on the policies for reducing CO_2 emissions from light commercial vehicles*, carried out by TNO, IEEP and LAT on behalf of the European Commission (DG Environment) in 2003-4.

A first assessment of CO_2 reduction potentials, costs and possible regulatory approaches has been made in [TNO 2004]. Further analysis, based on updated cost curves, is provided in chapter 8 of [TNO 2006]. The Commission’s intention is to develop a regulatory framework for light commercial vehicles along similar lines as used for passenger cars. However, due to a lack of data on sales numbers and utility parameter values per vehicle model, so far it was not possible to analyse concrete options for light commercial vehicles in the same level of detail as applied to M1 vehicles. Some conclusions from [IEEP 2007] and previous studies have been summarized in Annex A.

As part of the current project a detailed sales database on light commercial vehicle registrations has been purchased, which does allow a detailed cost analysis of regulatory options similar to the assessment carried out for M1 vehicles (see [IEEP 2007]).

1.5 Approach

The approach for assessing options for regulating CO_2 emissions of light commercial vehicles has been as follows:

- purchase of suitable database;
- analysis of the database;
- adjustments of the database to remove or repair anomalous data or to insert missing data;
- definition of utility-based limit functions on the basis of the light commercial vehicle database using the methodology outlined in Technical Note 8 of [IEEP 2007];

[6] *Assessment with respect to long term CO_2 emission targets for passenger cars and vans*, by TNO and CE Delft, July 2009. See: http://ec.europa.eu/environment/air/transport/co2/pdf/Report%20LT%20targets.pdf

- use of the database to calculate per manufacturer per N vehicle class (class I, II and III) and fuel type (petrol and diesel) the total sales, average CO_2 emissions and average values of candidate utility parameters (mass and pan area);
- input of these data into the cost assessment model as developed for M1 vehicles (see [IEEP 2007]);
- further adaptations of the cost assessment model to the assessment of costs for N vehicles, incl. the use of dedicated cost curves (derived from [TNO 2006]);
- assessment of costs and distributional impacts for various considered regulatory approaches, specifically utility-based limit functions with different slopes;
- analysis of various aspects such as perverse incentives resulting from the use of various utility-based limit functions and possibilities for integrating / harmonizing the regulation for M1 and N vehicles.

1.6 Project Team

This report is a deliverable from the project “Impacts of regulatory options to reduce CO_2 emissions from cars, in particular on car manufacturers” [7]. This project has been carried out by a consortium of consultants consisting of CE Delft, TNO, Öko-Institut and AEA. Project leader has been Richard Smokers[8] of CE Delft. The project team also comprises Gerdien van de Vreede and Femke Brouwer of CE Delft, Gerben Passier, René van Asch, Janneke van Baalen, Amber Hensema and Ruben Sharpe of TNO, and Wiebke Zimmer of the Öko-Institut. The project is part of a Framework Contract between DG-ENV and the Aspen Association (contract nr. ENV.C.5/FRA/2006/0071). The Aspen Association is a consortium led by AEA. As such AEA has been responsible for administrative project management. The Technical Manager responsible for the technical quality of the delivery to the Commission has been Ian Skinner, the administration of the sub-contract has been the responsibility of Grace Gordon, the ASPEN Business Manager.

1.7 Structure of this report

This report is structured as follows:
- Chapter 2 deals with definitions of light commercial vehicle categories and price vs. cost definitions;
- In chapter 3 we describe the results of the analysis, elaboration and filtering of the LCV registration database that was used to provide input to the cost assessment model;
- The development of cost curves for CO_2 reduction in LCVs and of the cost assessment model is described in chapter 4;
- In chapter 5 utility-based limit functions for light commercial vehicles are defined;
- Results of the cost assessment for regulating CO_2 emissions of light commercial vehicles are presented in chapter 6;
- Chapter 7 analyses possibilities for and impacts of perverse incentives and gaming with respect to the CO_2 regulation for light commercial vehicles;
- In chapter 8 the possibilities for pooling the targets for M1 and light commercial vehicles are explored;
- Conclusions from the previous chapters are summarized in chapter 9;
- Additional information on results from previous analyses, on the modelling methodology for assessment of costs and distributional impacts, on 2007 input data and on other representations of the assessment results can be found in the Annexes A tot D.

[7] A Service Request under the Framework contract for atmospheric emissions ENV.C.5/FRA/2006/0071

[8] Currently at TNO Science & Industry, Delft, the Netherlands

2 Definitions

2.1 Definition of N1, N2 and M2 vehicles and mass classes

Definitions of N1 vehicles and N1 vehicle classes are given in Directives 70/156/EEC and 2004/3/EC:

- N1 vehicles are motor vehicles with at least four wheels designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes.
- Classes of N1 vehicles (for the purpose of emission legislation) are defined on the basis of reference mass:
  - Class I: reference mass ≤ 1305kg
  - Class II: 1305 kg < reference mass ≤ 1760 kg
  - Class III: reference mass > 1760 kg

To align the scope with that of the Euro 5/6 legislation the regulation is intended to cover N1, N2 and M2 vehicles with a reference mass not exceeding 2610 kg. This is further extended to those vehicles with reference mass up to 2840 kg of which other model variants are type approved as N1, N2 or M2 with reference mass below 2610 kg.

In Directive 70/156/EEC N2 and M2 vehicles are defined as:

- Category N2: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3,5 tonnes but not exceeding 12 tonnes.
- Category M2: Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes.

With respect to N2 and M2 vehicles the legislation is intended to apply only to vehicles with reference mass smaller than 2610 kg. For this reason the class definition for N1 vehicles will be used for all vehicles in the database for the purpose of the cost analysis presented in chapter 6.

2.2 Definition of reference mass in relation to kerb weight and mass in running order

The definition of mass used in the Monitoring Mechanism and in the legislation on the CO_2 emissions from cars (Regulation (EC) No 443/2009) is "mass in running order" which is the mass of the empty vehicle plus 75kg for the driver (Directive 2007/46/EC, Annex I, paragraph 2.6 and associated explanatory note (o)).

The present report is not using mass in running order but reference mass. In Directives 80/1268/EC and 70/220/EC reference mass is defined as:

- reference mass is mass of the vehicle in running order less the uniform mass of the driver of 75 kg and increased by a uniform mass of 100kg.

Reference mass is thus equal to mass in running order + 25 kg. Mass in running order includes the weight of a nominal driver, spare wheel, fluids and fuel.

Vehicle registration databases do not contain information on reference mass. Instead usually kerb weight is specified. Kerb weight is the total weight of a vehicle with standard equipment, all necessary operating consumables (such as motor oil and coolant), a full tank of fuel, and not loaded with either passengers or cargo. The definition of kerb weight as used in practice, however, is found to be unclear or at least not consistent. Some manufacturers report kerb weight including the nominal 75 kg mass of the driver, while other manufacturers report kerb weight as empty weight without driver.

From the database used for the assessment (see chapter 3) it is not possible to decided which manufacturer uses which definition. In consultation with the Commission Services we have therefore used an approximate definition for translating the kerb weight figures in the database into reference mass:

reference mass = kerb weight + 60kg.

2.3 Relation between manufacturer costs and retail price for light commercial vehicles

Cost curves for N vehicles (see chapter 4 and [TNO 2006]) are defined on the basis of CO_2 reduction potentials for various CO_2 reduction options and information on manufacturer costs for these options. For the Impact Assessment, to be carried out by the Commission Services, it is necessary to express additional costs of CO_2 reduction measures in terms of retail price increase. In this way the price increase can also be compared to the base price of the complete vehicle (for which manufacturer costs are not known).

To assess the impact of meeting a CO_2 reduction target on the price that users pay for vans therefore a translation factor is needed to convert a manufacturer cost increase into a price increase.

Table 1 presents VAT and total vehicle purchase tax levels in European countries for 2008 as well as sales numbers for passenger cars and vans for 2006. All numbers are derived from ACEA publications ([ACEA 2008a] and [ACEA 2008b]).

Based on this overview it is assessed that the sales-weighted average total tax on vans in Europe is 30% of the price exclusive of tax (or equivalently 23% of the sales price including taxes). Owners of vans are almost always companies, which de facto do not pay VAT. The net average tax on vans therefore is around 11% of the price exclusive of tax (or equivalently 7% of the sales price including taxes).

In the assessment of the costs of technological measures applied to reduce CO_2 emissions the translation from additional costs to the manufacturer to retail price increase involves a mark-up, which includes possible margins for the manufacturer, importers and dealers and various taxes (vehicle purchase tax and VAT). To be consistent with [IEEP 2007] and the practices used by the Commission Services for Impact Assessments the translation from additional manufacturer costs for CO_2 reduction measures to sales price increase in this report only includes taxes, i.e. no manufacturer and dealer margins are assumed for these measures. For the case of N vehicles (vans) this gives a translation factor of 1.11 to convert additional manufacturer costs into retail price increase exclusive of VAT.

Table 2.1 Calculation of average tax levels for passenger cars and vans in the EU, based on information from [ACEA 2008a] and [ACEA 2008b]

	new vehicle registrations		tax	
country	**passenger cars**	**vans < 3,5 t**	**VAT**	**total tax**
Austria	308594	30379	20.0%	30.0%
Belgium	526141	60393	21.0%	25.0%
Czech republic	123987	4941	19.0%	19.0%
Denmark	154374	65349	25.0%	156.0%
Estonia	25582	3717	18.0%	18.0%
Finland	145659	16561	22.0%	53.0%
France	2000549	439273	19.6%	23.0%
Germany	3467961	197548	19.0%	19.0%
Greece	267669	23774	19.0%	59.0%
Hungary	187676	21604	25.0%	44.0%
Ireland	178766	39609	21.0%	57.0%
Italy	2324635	217775	20.0%	23.0%
Latvia	25582	2624	18.0%	20.0%
Lithuania	14234	4296	18.0%	18.0%
Luxembourg	50837	3083	15.0%	15.0%
Netherlands	483979	63850	19.0%	55.0%
Poland	238993	40119	22.0%	25.0%
Portugal	194702	64482	21.0%	58.0%
Slovakia	59084	19504	19.0%	19.0%
Slovenia	59578	6064	20.0%	29.0%
Spain	1499032	409465	16.0%	26.0%
Sweden	282766	39702	25.0%	25.0%
United Kingdom	2344864	329691	17.5%	17.5%
tax as share of pre-tax price				
average VAT	19.2%	19.0%		
average total tax	26.2%	30.2%		
average vehicle tax excl. VAT	7.0%	11.2%		
tax as share of price incl. tax				
average VAT	16.1%	16.0%		
average total tax	20.8%	23.2%		
average vehicle tax excl. VAT	4.7%	7.2%		

3 Database for light commercial vehicles

3.1 Purchase of the light commercial vehicles database

A detailed assessment of cost impacts for various manufacturers requires input data on sales, average Type Approval CO_2 emissions, mass and other vehicle parameters per manufacturer per class and fuel type. In previous projects on M1 vehicles such data have been derived from commercially available vehicle sales databases.

After interaction with various possible suppliers to assess the availability of sales databases on light commercial vehicles JATO has been selected as supplier of the database to be used as input for the detailed cost assessment. JATO has supplied two datasets:

- the 2007 “Vols database” containing vehicle registration data and limited technical information (but containing CO_2 combined, kerb weight, payload, overall length, overall width, overall height, wheelbase, cargo volume, sales) for 20 European countries[9] in 2007;
- the 2007 “Specs database” containing extensive technical data for all vehicles registered in 20 countries in 2007 but no sales data (included in addition to the Vols database: base price, CO_2 and fuel consumption for urban, extra-urban and combined, front and rear track width, and cargo space dimensions).

For 9 countries[10] for which vehicle models are labelled with a Unique Identity number JATO has established a coupling between the Vols and the Specs database so that for these countries the Specs database will also contain sales volumes. This enables the estimation of average price per segment per manufacturer.

3.2 Analysis, elaboration and filtering of the database

The JATO light commercial vehicle databases are vehicle registration databases. This means that they contain all vehicles registered as vans under national law. As a consequence they also contain a large number of passenger cars registered as vans. As the CO_2 legislation for light commercial vehicles is to apply only to vehicles type approved as N1, N2 or M2 vehicles (with reference mass < 2610 kg), all vehicles type approved as M1 need to be excluded from the database. As a label with type approval category is not included in the database the identification of M1 vehicles was done by hand, using information from internet and expert knowledge/judgement. For some categories (mainly large SUVs, but also some passenger car derived vans) it was difficult to decide which entries are type approved as N1 or M1.

Another problem with the databases was that for a large number of entries (specific model variants sold in a given country) CO_2 and/or mass and size data were missing. For CO_2 this is largely resulting from the fact that reporting CO_2 emissions for N1 vehicles, as measured on the Type Approval test, has only become mandatory for new models since the adoption of Directive 2004/3/EC (amending Directive 80/1268/EEC) in 2004. Furthermore some heavier N1 vans as well as many N2 vans have engines that are type approved under HD legislation, so that no CO_2 data are available either[11]. The absence of mass data and other vehicle specifications is likely resulting from omissions in national registration databases. This problem has been solved by determining for all vehicle models on the basis of data on CO_2 and mass as available in the database, the average CO_2 emission, average mass and (if statistically significant) the linear

[9] EU countries: Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Ireland, Italy, Slovenia, Spain, Sweden, the Netherlands, Czech Republic, Portugal, Poland, Greece, Hungary + non-EU countries: Norway, Switzerland

[10] France, Germany, Great Britain, Spain, Czech Republic, Portugal, Greece, Hungary.

[11] It should be noted that this is a temporary problem as from 2010 all new type approvals of N1, N2 and M2 must use the light duty system. CO_2 data will thus be fully available from 2010 onwards.

regression of CO_2 as function of mass. This information has been used to fill the gaps in the database for all entries for which CO_2 and/or mass data were missing. The limited number of vehicles for which missing data could not be corrected have been excluded from the database.

To calculate sales, average CO_2 emissions, average mass and pan area per manufacturer per segment a database has been elaborated based on the Vols database purchased from JATO with sales data of vehicles registered as vans / light commercial vehicles in 2007 in 18 EU member states. In elaboration and filtering the data the following steps have been taken:

- All entries have been labelled as either being type approved as N, as M1 (including small buses up to 9 seats) or as M2 (small and midi-buses with more than 9 seats):
  - Labelling was based on internet information and expert judgement.
  - All small van-type vehicles (e.g. Citroën Berlingo, Renault Kangoo, Fiat Doblo) are considered N1, even though these sales may include vehicles type approved as M1 (but this could not be identified from the database information).
  - If the variant identification contained information on the number of seats or contained the word “bus” this was used to determine whether the vehicle is a mini/midibus falling under the M1 resp. M2 category.
  - All campers (as far as these could be identified on the basis of model or variant name) have been labelled as M. These entries generally contained no CO_2 data and were deleted from the database.
  - For all pick-up vehicles (is apparent from the variant name or a marketing segment label available in the JATO database) have been considered to be type approved as N1.
  - All SUVs, except pick-up versions, have been assumed to be type approved as M1.
- All entries not labelled as N or M2 midi-buses have been deleted from the database.
- Registrations for Switzerland and Norway have been excluded from the database. Data from these countries have been used, though, to generate data used for filling gaps in the CO_2 and vehicle mass data for other countries.
- All remaining entries have been labelled class I, II or III based on reference mass (calculated from kerb weight according to the definition given in section 2.2).
- All remaining vehicles with fuels other than petrol and diesel (LPG / CNG / electricity / hydrogen) have been excluded from the database used for determining inputs for the cost assessment model.

3.3 Results from the database analysis

Table 3.1 presents and overview of the shares in total sales of vehicles from different categories, classes and fuels in the complete JATO Vols database. The share of different fuels in the N and M vehicles included in the database is given in Table 3.2.

As can be seen from Table 3.2 the share of petrol vehicles in the JATO database is found to be much smaller than the 34.2% share used in previous analyses ([TNO 2006] and [IEEP 2007]). These shares were based on data presented in the 2004 N1 study by TNO/LAT/IEEP [TNO 2004]. The results from [TNO 2004] are presented in Table 3.3 below. For the share of different mass classes the results from [TNO 2004] were based on analysis of data obtained from Member State registration bodies and from the [RAND 2003] study. The division over fuels used in [TNO 2004] was taken from TREMOVE.

The low share of petrol vehicles in the new data will have significant implications for the costs of meeting the proposed targets (175 g/km in 2012 and 160 g/km in 2015) as the necessary reductions will now all have to be established in diesel vehicles for which the cost curves are steeper (resulting in higher costs for the same absolute level of reduction).

Table 3.1 Shares in total sales of different vehicle types / classes / fuels from the JATO database

fuel	class	N	M	camper	unknown	total
petrol	I	1.29%	0.18%	0.00%	0.00%	1.47%
	II	0.32%	0.10%	0.00%	0.00%	0.42%
	III	0.18%	0.02%	0.00%	0.00%	0.21%
	unknown	0.05%	0.16%	0.00%	0.34%	0.55%
diesel	I	13.96%	6.45%	0.00%	0.00%	20.41%
	II	20.87%	1.99%	0.00%	0.00%	22.86%
	III	48.55%	2.30%	0.00%	0.00%	50.85%
	unknown	0.11%	0.76%	0.53%	0.26%	1.67%
CNG	I	0.08%	0.01%	0.00%	0.00%	0.08%
	II	0.31%	0.00%	0.00%	0.00%	0.31%
	III	0.01%	0.00%	0.00%	0.00%	0.02%
	unknown	0.03%	0.00%	0.00%	0.00%	0.03%
LPG	I	0.01%	0.01%	0.00%	0.00%	0.02%
	II	0.00%	0.00%	0.00%	0.00%	0.00%
	III	0.00%	0.00%	0.00%	0.00%	0.00%
	unknown	0.02%	0.00%	0.00%	0.00%	0.03%
electric	I	0.00%	0.00%	0.00%	0.00%	0.00%
	II	0.00%	0.00%	0.00%	0.00%	0.00%
	III	0.00%	0.00%	0.00%	0.00%	0.00%
	unknown	0.01%	0.00%	0.00%	0.02%	0.03%
hydrogen	unknown	0.00%	0.00%	0.00%	0.00%	0.00%
unknown	I	0.00%	0.00%	0.00%	0.00%	0.00%
	II	0.00%	0.00%	0.00%	0.00%	0.00%
	III	0.00%	0.00%	0.00%	0.00%	0.00%
	unknown	0.54%	0.37%	0.00%	0.13%	1.04%
total		86.36%	12.35%	0.54%	0.76%	100.00%

Table 3.2 Share of different fuels in N- and M-type vehicle sales in the JATO database

	N	M
petrol	2.1%	3.8%
diesel	96.7%	93.1%
CNG	0.5%	0.1%
other	0.7%	3.1%
total	100.0%	100.0%

Table 3.3 Share of different fuels and classes in sales of N-type vehicles according to [TNO 2004]

TNO 2004	petrol			diesel		
	I	II	III	I	II	III
share of sales per class[1]	27.5%	33.0%	39.5%	27.5%	33.0%	39.5%
share of sales per fuel[2]	34.1%	34.1%	34.1%	65.9%	65.9%	65.9%
share of sales per fuel per class	9.4%	11.3%	13.5%	18.1%	21.7%	26.0%

[1]) based on data from Member State registration bodies and RAND 2002

[2]) based on TREMOVE

For the detailed cost assessment vehicles on LPG, CNG, electricity and hydrogen have been excluded from the database. Due to their insignificant sales numbers they do not influence the averages determined for 2007. Furthermore cost curves are only available for petrol and diesel vehicles.

3.4 Input data on sales of light commercial vehicles on petrol and diesel in different classes

Table 3.4 presents the average CO_2 emissions, reference mass and pan are per segment derived from the light commercial vehicle database for 2007.

Table 3.4 Average CO_2 emissions, reference mass and pan area per segment for 2007

	petrol I	petrol II	petrol III	diesel I	diesel II	diesel III	average
reference mass	1110	1455	1958	1191	1556	1975	1731
pan area	6.7	7.7	9.7	7.0	8.4	10.6	9.4
CO2	165	198	271	144	179	231	203
sales	20,992	6,590	3,761	287,710	429,805	998,287	1,747,145

The Table 3.5 below summarizes the input data with respect to sales for the various manufacturers included in the model:

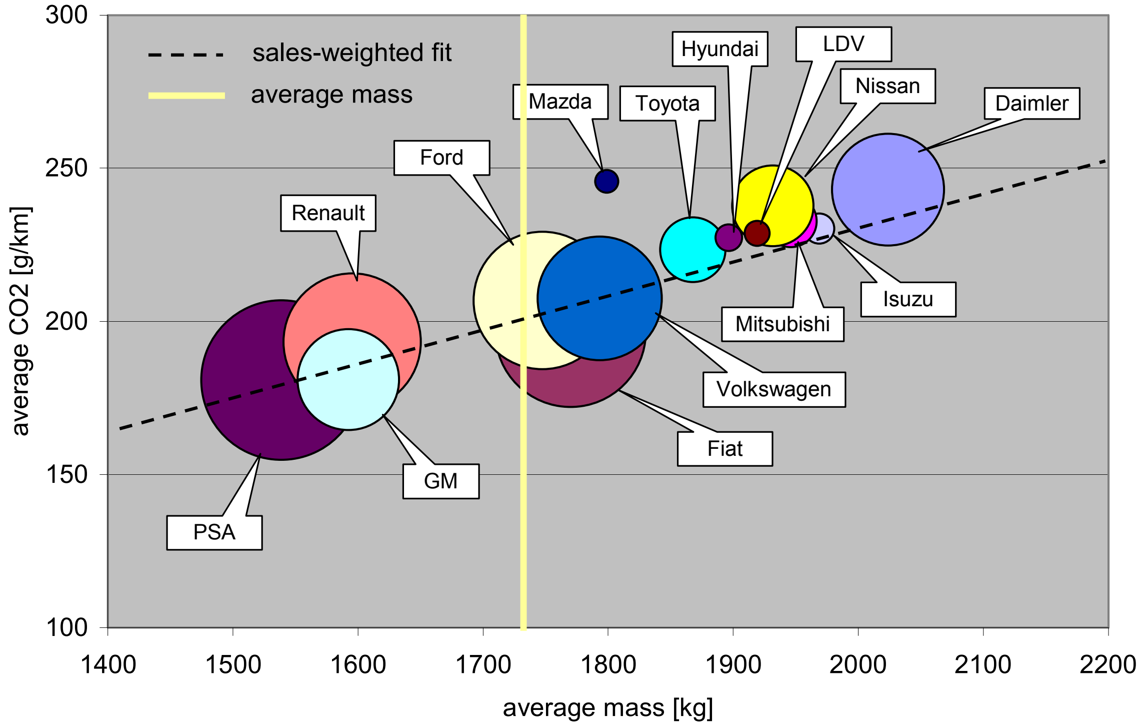
- Only manufacturers with sales > 5000 have been included in the model.
- Petrol vehicle sales below 20 vehicles per segment have been set to zero.
- Data are graphically illustrated in "bubble graphs" (see Figure 1).

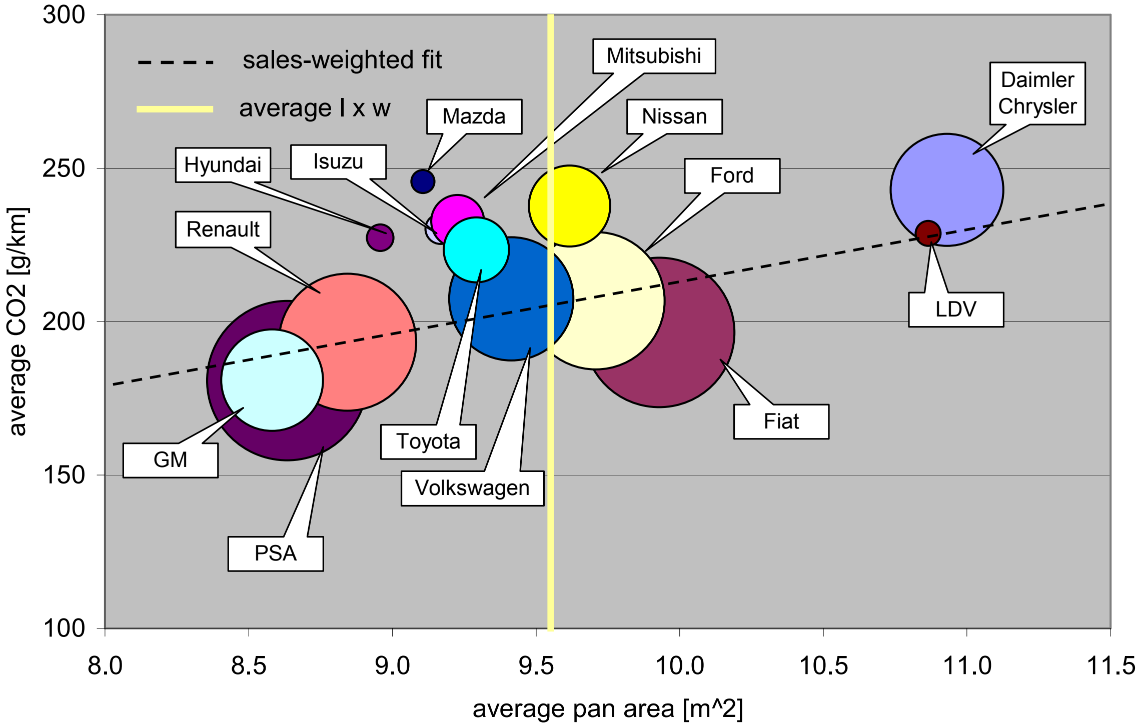
A complete overview of the average CO_2, mass and pan area per manufacturer per segment is included in Annex C.

Table 3.5 Average CO_2 emission, reference mass and pan area, and sales per segments in 2007 for all manufacturers in the cost assessment model

	2007-data									
manufacturer	CO2	mass	pan are	sales						
	[g/km]	[kg]	[m^2]							
	avg.	avg.	avg.	p,I	p,II	p,III	d,I	d,II	d,III	total
ACEA										
Daimler	243	2024	10.9	0	35	365	0	4623	151677	156700
Fiat	196	1770	9.9	6308	532	0	28401	75819	168481	279541
Ford	207	1748	9.7	147	376	962	2358	116737	114927	235507
GM	181	1592	8.6	1428	351	906	30483	45157	49920	128245
PSA	181	1539	8.6	6830	399	0	131167	66020	112850	317266
Renault	193	1595	8.8	5164	1597	278	87669	28367	110797	233872
Volkswagen	207	1793	9.4	747	3132	1093	1882	71094	112716	190664
JAMA										
Isuzu	230	1969	9.2	0	0	0	0	422	11127	11549
Mazda	246	1799	9.1	0	0	0	876	622	5225	6723
Mitsubishi	233	1946	9.2	0	0	0	460	137	34078	34675
Nissan	238	1932	9.6	363	65	119	4363	12604	64649	82163
Toyota	223	1868	9.3	0	0	0	51	6680	46508	53239
KAMA										
Hyundai	227	1897	9.0	0	96	0	0	1510	7448	9054
Other										
LDV	229	1919	10.9	0	0	0	0	13	7884	7897
total / average	203	1731	9.4	20987	6583	3723	287710	429805	998287	1747095
share				1.2%	0.4%	0.2%	16.5%	24.6%	57.1%	

Figure 1 **Average CO_2 emissions as function of reference mass and pan area for various manufacturers selling light commercial vehicles in Europe. The size of the bubbles indicates the sales volume.**





The bubble graph for reference mass in Figure 1 shows 4 clusters:
- One cluster below the overall average mass with 3 European manufacturers;
- One cluster with 3 European manufacturers around the overall average mass.
- A cluster with Japanese and Korean manufacturers above the overall average mass and also above average CO_2 emissions.
- Daimler with the highest average mass.

The bubble graph for pan area in Figure 1 shows much more scatter, both in the division of manufacturers over the x-axis (average pan area) as well as in CO_2 emissions with respect to the sales-weighted fit for 2007.

A general observation is that the market for light commercial vehicles is dominated by European manufacturers. Japanese and Korean manufacturers have much lower sales. As a consequence the sales-weighted least square fits, that are used as a basis for the utility-based limit functions, are dominated by the characteristics of these European manufacturers.

3.5 Possible impacts of uncertainties with respect to the database

3.5.1 Pick-up SUVs

Mazda (and to a lesser extent Hyundai for pan area) appears to be an outlier in Figure 1. Closer analysis of the JATO database shows that all sales included as N-type vehicles for Mazda are pick-up SUVs with relatively high CO_2 emissions. These vehicles are also included in the sales of various other, mainly Japanese and Korean, manufacturers. At this stage it is not clear whether such pick-up vehicles are actually type-approved as N1.

It should be emphasized that, due to the small sales volumes, excluding the relatively small Mazda sales and pick-up SUVs from other manufacturers from the analysis:
- will have negligible impact on the definition of the 2007 sales-weighted least squares fit through the data, and
- will thus have negligible impact on the definition of utility-based limit functions for 2012 or 2015, and
- will therefore have negligible impact on the costs for meeting the various targets for other manufacturers.

3.5.2 Multi-stage vehicles

Multi-stage vehicles are vans that are sold and leave the factory as chassis-cabin combinations. These vehicles receive a dedicated build-up after the vehicles are sold by the OEM to customers, built to customer specifications by “final stage” manufacturers. Chassis-cabin combinations from OEMs are also sold to builders of campers, who sell the completed vehicles under their own brand names.

The database as purchased from JATO does not allow identification of vehicles as multi-stage. It is expected that many multi-stage vehicles in the 2007 database will not have information on CO_2 emissions, as these only need to be measured for this vehicle category from January 2009 onwards[12]. If type approval CO_2 data are available, they are measured on the vehicle without build-up and therefore are not representative of the emissions of these vehicles in-use (with build-up). CO_2 emissions of the vehicle with build-up will be higher than those of the vehicle without build-up due to a higher mass and higher air drag coefficient. The fact that multi-stage vehicles

[12] For these vehicles CO_2 emission values in the model database have been estimated on the basis of analysis of CO_2 and mass data from variants of the same model or other models of the same manufacturer in that class.

appear in the database with a lower CO_2 figure than with build-up is at least partly compensated by the fact that also the registered mass is lower.

It is clear that the issue of how to adequately deal with multi-stage vehicles can not be resolved at this stage. It would be preferable to amend the type approval legislation in such a way that for these vehicles a CO_2 figure is measured that is more representative of the CO_2 emissions of the vehicles with build-up. This could be done by simulating some default build-up in the rollerbench setting for the testing of chassis-cabin combinations. If such an amendment would be realised, then the definition of a CO_2 limit function should be based on a database that for multi-stage vehicles includes CO_2 emission data for vehicles with (simulated) build-up. If such amendments are not made before the target year of the legislation the CO_2 limit function should be based on a database that for multi-stage vehicles includes CO_2 emission data for vehicles without build-up (as is the case in the present database).

However, the share of multi-stage vehicles is only around 8% of the total LCV sales[13]. The fact that the highest sales of multi-stage vehicles will be in class III may to some extent influence the level and slope of the 2007 sales-weighted least squares fit through the data. This in turn has an influence on the absolute slope of the 100% (relative) slope variant of the utility based limit function for 2012 or 2015. But as the lower CO_2 emission figures of these vehicles are accompanied by lower mass figures also, this effect is considered to be relatively small. For this reason the uncertainties with respect to multi-stage vehicles are considered not to prohibit the definition of an appropriate limit function for the CO_2 legislation for LCVs.

3.6 Price data

Table 3.6 presents an overview of base price (retail price excl. VAT) per segment per manufacturer derived from the JATO Specs database. Overall sales-weighted averages have been calculated using the sales data in the Specs database for 9 EU countries and the sales data in the Vols database for 18 EU countries. Comparison of these averages indicates that the price data included in the Specs database for 9 EU countries are very well representative for the 18 EU countries in the JATO Vols database from which sales and average CO_2, mass and pan area figures have been obtained.

Table 3.6 Overview of base price (retail price excl. VAT) per segment per manufacturer derived from the JATO Specs database. Overall sales-weighted averages have been calculated using the sales data in the Specs database for 9 EU countries and the sales data in the Vols database for 18 EU countries.

	petrol I	petrol II	petrol III	diesel I	diesel II	diesel III	average Specs	average Vols
Daimler		20644	23325		23266	26719	26694	26608
Fiat	8406	11376	14159	10810	15316	26242	20569	21279
Ford	9214	21197	18626	10291	17875	25617	20886	21580
GM	11685	14676	20246	13840	17774	23868	18725	19152
Hyundai		12105			14347	18271	17655	17545
Isuzu					14212	22288	21949	21993
LDV					26640	24203	24214	24207
Mazda				15723	14130	20451	19044	19250
Mitsubishi				11489	13501	23851	23606	23643
Nissan	11163	17355	19533	14191	20110	25529	23892	24017
PSA	12177	15114	20127	14299	17410	23445	18018	18155
Renault	12143	14853	21809	13754	20582	25111	19561	19944
Toyota	8491	14277			15840	21945	21204	21156
Volkswagen	9820	12963	19362	10823	15679	25001	21408	21095
average Specs	10908	14069	19958	13641	17273	25091	20714	
average Vols	10878	14057	19912	13680	17226	25064		21038

[13] Information from industry sources.

4 Update of cost curves and development of cost assessment model for light commercial vehicles

4.1 Update of the cost curves for light commercial vehicles

The methodology for defining cost curves for light commercial vehicles has been worked out in Chapter 8 of [TNO 2006]. This methodology is based on information on the relative CO_2 reduction potential (% reduction) and additional costs (€) for a large number of technological CO_2 reduction options (see Tables 8.2 and 8.3 of [TNO 2006]) that can be applied to baseline light commercial vehicles (reference year 2002). For each segment (class / fuel) a number of packages is assembled containing a combination of various options for which overall reduction potential and costs are estimated. The overall relative CO_2 reductions are then applied to the average CO_2 emission per segment of the 2002 baseline vehicles.

In this report the same methodology is used, but the fact that analysis of the JATO database delivers average CO_2 emission figures for the reference vehicles that may be different than the reference data used in [TNO 2006] requires that the cost curves are updated.

Furthermore the low petrol share will lead to much higher reductions in diesels than was the case in previous assessments. The total reduction potential for diesel, however, is smaller than for petrol. To correctly assess the feasibility of the proposed targets in light of the new petrol / diesel shares it is necessary to take proper account of the maximum reduction potentials for the different segments. This was not necessary in the assessment based on the petrol / diesel share as taken from [TNO 2004], as the division of reduction efforts over petrol and diesel led to smaller required reductions in the diesel segment.

The assessment for 2012 and 2015, as reported in chapter 6, is thus based on (static) cost curves for the year 2012 derived from the cost data collected in [TNO 2006] for technologies that can be used to reduce CO_2 emissions from vans in the 2012 – 2015 timeframe. Possible effects of developments in technology and costs are ignored for this short term time horizon. The assessment of a long term target for 2020, using cost curves including new technologies becoming available after 2012 and cost reductions caused by learning effects, is carried out separately and will be reported at a later stage.

Note that the cost curves presented in this section have been updated compared to those published in a previous version of this report issued December 2008. In a review of the work some calculation errors have been discovered in the spreadsheet that was used to construct the cost curves for CO_2 emission reduction in light commercial vehicles. The errors affected the CO_2 reduction potentials estimated for various packages of measures. This error has been corrected and assessments have been redone. Updated results are presented in this report. It should be noted that the underlying assumptions on potential and costs of technological measures have remained unchanged. The main effect of the correction is that it leads to lower costs for reaching the various target levels assessed in this report.

4.1.1 2002 Baseline vehicles

As explained above the starting point for the determination of cost curves are the 2002 reference vehicles. JATO data only provide information on 2007 vehicles. To obtain 2002 reference data that are consistent with the 2007 averages determined from the database it is therefore necessary to make assumptions on the development of CO_2 emissions in N-type vehicles between 2002 and 2007.

Analysis of the 2002 and 2006 data in the model for M1 vehicles shows that in that time interval manufacturers must have applied CO_2 reduction technologies to petrol vehicles that in the absence of autonomous mass increase (AMI) would have resulted in on average 5.5 - 6% CO_2 reduction. For diesel vehicles this is about 3.5%. In this analysis per manufacturer account has been taken of changes in average mass and resulting impacts on CO_2.

Manufacturers will at least to some extent have actively applied efficiency improvements to M1 vehicles in the context of the voluntary agreements. As these agreements do not apply to light commercial vehicles it has been assumed that the amount of CO_2 reduction measures applied in vans is smaller, and (in the absence of appropriate data) this reduction has been set to 3.5% for petrol vehicles and 2.5% for diesel vehicles over the complete 2002-2007 period.

Table 4.1 Determination of the CO_2 emissions of 2002 reference vehicles on the basis of average CO_2 emissions, reference mass and pan area per segment for 2007 and assumed levels of applied CO_2 reduction measures between 2002 and 2007.

		petrol I	petrol II	petrol III	diesel I	diesel II	diesel III	average	
2007	reference mass	1110	1455	1958	1191	1556	1975	1731	[kg]
	pan area	6.7	7.7	9.7	7.0	8.4	10.6	9.4	[m^2]
	CO_2	165.1	198.3	271.3	144.4	178.6	230.9	203.0	[g/km]
	sales	20,992	6,590	3,761	287,710	429,805	998,287	1,747,145	#
CO2 reduction 2002-2007		3.5%	3.5%	3.5%	2.5%	2.5%	2.5%	2.52%	
2002	CO_2	171.1	205.5	281.3	148.1	183.2	236.8	208.2	[g/km]

4.1.2 Technology packages

In order to properly determine the maximum reduction potential available in the various N segments the amount of technology packages used to construct the cost curves has been extended from 4 to 5. The 5th package represents the maximum reduction potential. The contents of the first 4 packages have been altered somewhat. The new packages are presented in Table 4.2 (see also Tables 8.4. and 8.5 in [TNO 2006]).

To create better consistency with the approach for M1 vehicles in [IEEP 2007] the business-as-usual (BAU) package, which was defined in [TNO 2006] to describe autonomous application of a limited level of CO_2 reduction measures, has been "emptied". No baseline autonomous trend for CO_2 reduction has been assumed anymore. Instead of that, in the cost analysis two alternative baselines have been used for scenarios with autonomous mass increase, one assuming that costs for maintaining 2007 CO_2 levels (i.e. costs for cancelling the CO_2 impacts of the assumed level of AMI) are attributed to the Commission's CO_2 policy for light commercial vehicles and one in which these costs are not attributed to the policy.

Table 4.2 Technology packages used to determine the cost curves for light commercial vehicles on petrol and diesel

		Class I						Class II						Class III					
Petrol	technology	BAU	Pk1	Pk2	Pk3	Pk4	Pk5	BAU	Pk1	Pk2	Pk3	Pk4	Pk5	BAU	Pk1	Pk2	Pk3	Pk4	Pk5
Engine	Reduced engine friction losses		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	DI / homogeneous charge (stoichiometric)		x						x						x				
	DI / Stratified charge (lean burn / complex strategies)			x	x	x	x			x	x	x	x			x	x	x	x
	Medium downsizing with turbocharging				x	x					x	x					x	x	
	Strong downsizing with turbocharging						x						x						x
	Variable Valve Timing			x	x					x	x					x	x		
	Variable valve control					x	x					x	x					x	x
	Optimised cooling circuit				x						x						x		
	Advanced cooling circuit+ electric water pump					x	x					x	x					x	x
Trans-mission	Optimised gearbox ratios		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	Piloted gearbox			x	x	x	x			x	x	x	x			x	x	x	x
Hybrid	Start-stop function			x						x						x			
	Start-stop + regenerative braking				x						x						x		
	Mild hybrid (motor assist)					x						x						x	
	Full hybrid (electric drive)						x						x						x
Body	Improved aerodynamic efficiency		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	Mild weight reduction			x						x						x			
	Medium weight reduction				x						x						x		
	Strong weight reduction					x	x					x	x					x	x
Other	Low rolling resistance tyres		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	Electrically assisted steering (EPS, EPHS)					x	x					x	x				x	x	x

		Class I						Class II						Class III					
Diesel	technology	BAU	Pk1	Pk2	Pk3	Pk4	Pk5	BAU	Pk1	Pk2	Pk3	Pk4	Pk5	BAU	Pk1	Pk2	Pk3	Pk4	Pk5
Engine	Reduced engine friction losses		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	Mild downsizing			x						x						x			
	Medium downsizing				x	x	x				x						x		
	Strong downsizing											x	x					x	x
	Optimised cooling circuit					x						x						x	
	Advanced cooling circuit+ electric water pump						x						x						x
	Exhaust heat recovery											x	x					x	x
Trans-mission	6-speed manual/automatic gearbox																		
	Piloted gearbox				x	x	x				x	x	x				x	x	x
Hybrid	Start-stop function			x						x						x			
	Start-stop + regenerative braking				x						x						x		
	Mild hybrid (motor assist)					x						x						x	
	Full hybrid (electric drive capability)						x						x						x
Body	Improved aerodynamic efficiency		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	Mild weight reduction			x						x						x			
	Medium weight reduction				x						x						x		
	Strong weight reduction					x	x					x	x					x	x
Other	Low rolling resistance tyres		x	x	x	x	x		x	x	x	x	x		x	x	x	x	x
	Electrically assisted steering (EPS, EPHS)					x	x					x	x					x	x

4.1.3 Updated cost curves

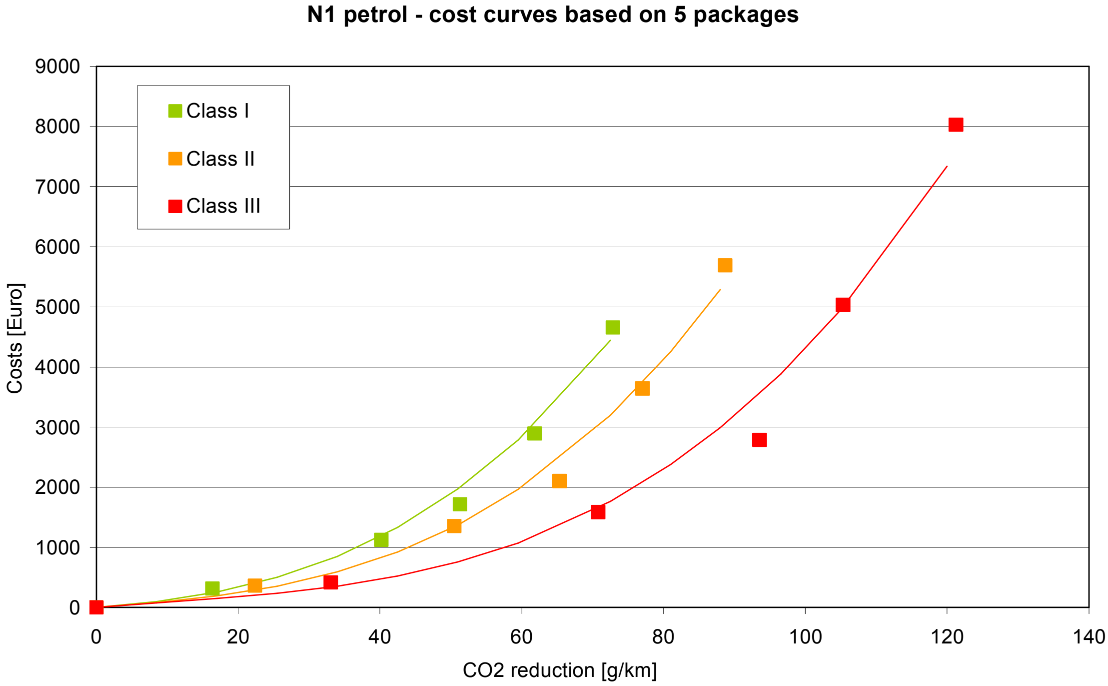
For each package indicated in Table 4.2 the overall CO_2 reduction and additional costs have been taken into account. For CO_2 reduction a correction has been made to account for the fact that the reduction potentials of individual options cannot simply be combined to achieve the total reduction for a package of options:

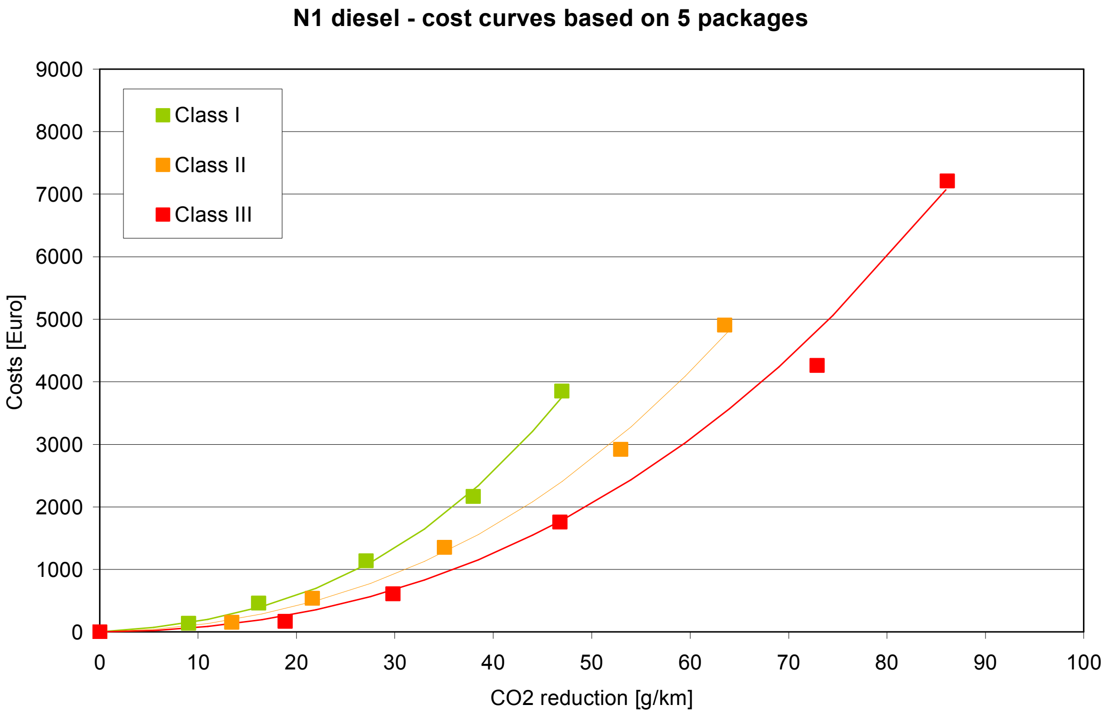
$$CO_2^{combined} = correction\_factor \times CO_2^{baseline} \times \prod_{i=1}^{n} (1 - \delta_i)$$

with δ_i the relative CO_2 emission reduction (in %) of technological option i in the package. For petrol vehicles the correction factor in the above formula was chosen to gradually decrease from 0.95 for package 1 to 0.80 for packages 4 and 5. For diesel vans the correction factor decreases from 0.95 for package 1 to 0.85 for packages 4 and 5. The reason for the difference is the higher number of measures affecting part load efficiency in the packages for petrol vehicles.

This analysis results in the updated cost curves as described in Figure 2 and Table 4.3.

Figure 2 Updated cost curves for light commercial vehicles





The cost curves in Figure 2 are 3rd order polynomials ($y = ax^3 + bx^2 + cx$, with y is costs and x is CO_2 reduction). The coefficients are given in Table 4.3. The cost curves for large vehicles are assumed to apply to large N1 vehicles as well as to N2 and M2 vehicles with reference mass below 2610 kg.

Table 4.3 Coefficients of the updated cost curves and maximum reduction potentials per segment

manufacturer costs

		p,I	p,II	p,III	d,I	d,II	d,III
a	x^3	0.0065	0.0062	0.0048	0.0200	0.0065	0.0040
b	x^2	0.250	0.035	-0.150	0.550	0.700	0.600
c	x	9.00	9.00	10.00	10.00	4.00	1.00

retail price (excl. VAT)

		p,I	p,II	p,III	d,I	d,II	d,III
a	x^3	0.0072	0.0069	0.0053	0.0222	0.0072	0.0044
b	x^2	0.278	0.039	-0.167	0.611	0.777	0.666
c	x	9.99	9.99	11.10	11.10	4.44	1.11

max. reduction potential [g/km]	73	89	121	47	64	86

4.1.4 Considerations on economies of scale and learning effects

According to learning curve theory, costs decrease with increasing cumulative production as a result of product and production innovation and economies of scale. Cost curves therefore are not static but in principle evolve over time.

Similarly to what has been done for M1 vehicles in [TNO 2006], the costs of various technologies underlying the cost curve for N-type vehicles have been estimated under the assumption that they apply to a level of production that would be achieved if the technology is widely applied to new vehicles in 2012/2015 to meet the target for that year. These cost estimates therefore implicitly already incorporate a certain level of learning effects.

In the analysis presented in this report the same cost curves are used for 2012 and 2015. As the 160 g/km target for 2015 is significantly lower than the 175 g/km target for 2012 other technologies need to be applied for meeting 2015 target than for meeting the 2012 target. As far as learning effects are concerned, the costs of these technologies do not decrease if they are not applied. As a consequence the costs of advanced technologies necessary to meet the 2015 target of 160 g/km are the same as they would have been in 2012 in case these technologies would have been necessary to meet the same target in 2012. The same reasoning applies to comparison of the 175 g/km for 2012 and 2015. Therefore, no learning effects need to be applied for generating the 2015 cost curve.

4.2 Development of the cost assessment model for light commercial vehicles

For analysing distributional impacts a cost assessment model for light commercial vehicles has been derived on the basis of the model for M1 vehicles as used for [IEEP 2007]. The main modifications are:

- input of 2007 data per manufacturer for N-type vehicles derived from the JATO database;
    - Only manufacturers selling more than 5000 vehicles p.a. have been included in the model;

- determination of 2002 CO_2 data per manufacturer on the basis of average reduction percentages for 2002-2007 as indicated in Table 4.1;
- input of updated cost curves for N-type vehicles;
- modification of the cost optimisation algorithm to take account of ceilings in the cost curves (maximum reduction potentials, see Table 4.3);
- include possibility to extend the calculation to a target year beyond 2012.

For the assessment the following assumptions have been made:
- sales numbers per manufacturer per segment are the same for 2002, 2007, 2012 and 2015;
- no shift from petrol to diesel.

4.3 Considerations on scenarios for autonomous mass increase in vans

Upon request by the Commission analyses have been made for three different assumptions with respect to autonomous mass increase (AMI):
- AMI = 0.0% p.a.
- AMI = 0.82% p.a.
- AMI = 1.5% p.a.

Results presented in this report focus on the AMI = 0.0% and 1.5% p.a. scenarios.

Autonomous mass increase can be caused by different mechanisms:
- The average mass within a vehicle class can increase as a result of the application e.g. of more safety features or features adding luxury, comfort and/or performance. This mechanism is certainly seen in passenger cars and is also conceivable for vans to some extent.
- The overall average mass (over all classes) can increase due to a trend in sales towards vehicles in higher classes, which are generally heavier and in the case of passenger cars also more luxurious classes and better performing. In the case of passenger cars this increased performance (power-to-weight ratio) and luxury (energy consuming accessories) leads to additional CO_2 emissions on top of the effects of mass increase as such. For vans this additional effect is considered less relevant as the power-to-weight ratio does not increase with increasing vehicle mass or size. Furthermore buyers of vans are expected to be more rational and to attach less value to luxury features.

For LCVs a shift towards higher classes is not necessarily something to be counteracted from a CO_2 emissions point of view, if the use of larger vans leads to lower CO_2 emissions per tonkm.

In the modelling for LCVs, vehicle classes are defined on the basis of mass. Sales per class are kept constant between 2007 and 2012 / 2015, so that no shift towards larger classes is modelled. The applied AMI value thus solely relates to possible mass increases within each class. In the case of the assessment for M1s vehicle classes were based on grouped marketing classes rather than weight classes. This means that the AMI value as used in the case of M1s can be considered to represent both an increase in mass with a class as well as a gradual shift to larger vehicles.

For light commercial vehicles no information is available on actual AMI trends. Therefore the above listed three scenarios have been chosen with the same AMI values as for the analysis of M1 vehicles for reasons of symmetry and comparability. For a combination of reasons as mentioned above the AMI = 2.5% p.a. scenario analysed for M1 is not considered realistic for light commercial vehicles.

5 Definition of utility-based limit functions for light commercial vehicles

5.1 Introduction

Based on results of the analysis of the JATO 2007 Vols database utility-based CO_2 limit functions can be defined for light commercial vehicles. With the available data only functions based on mass and on pan area can be analysed. Information on wheel base and track width coupled to sales volumes is only available for a limited number of countries. An assessment for a footprint-based limit function is therefore not made at this stage.

For light commercial vehicles we have defined the mass-based limit function on the basis of reference mass[14]. There is only one problem with this, which relates to the translation between data on kerb weight in the database and reference mass. As indicated in section 2.2 some manufacturers report kerb weight as weight in running order including a nominal 75 kg for the driver and 25 kg "luggage", while other manufacturers report kerb weight without the 75 kg for the driver. From the information in the database it cannot be decided how individual data are defined. For this reason the following translation from kerb weight to reference mass has been used:

reference mass = kerb weight + 60 kg.

This is in between the 25 kg and 100 kg additional mass depending on the two definitions.

CO_2 limit functions based on reference mass and pan area need to be defined for different target values for 2012 and 2015 in function of different assumed levels of autonomous mass increase (AMI). Furthermore it will be evaluated to what extent the mass-based limit function for light commercial vehicles can be aligned with the already proposed limit function for M1 vehicles.

5.2 Procedure for defining limit functions

The overall procedure is identical to the one used for M1 vehicles in [IEEP 2007]:
- Definition of a sales-weighted least squares fit a U + b through the CO_2 vs. mass and CO_2 vs. pan area data for the reference year 2007;
- Calculation of the 100% target line by multiplying the slope a and intercept b with the ratio of the CO_2 target and the 2007 average CO_2 value. This 100% target line goes through the point (<U>, CO_2 target value) with <U> the average utility (mass or pan area);
  - In the case of mass as utility this ratio is corrected to take account of the shift in average mass between 2007 and the target year (2012 or 2015).
- Define various slope percentages by multiplying the a-value for the 100% slope with the slope percentage and adjusting the intercept b in such a way that the new slope function equals the CO_2 target value for the average utility value in the target year.

5.2.1 Sales-weighted least square fit through the 2007 data

The sales-weighted least squares fit through the 2007 data for CO_2 as function of reference mass or pan area are calculated on all N-type vehicles in the database running on petrol and diesel. As a sensitivity analysis the limit functions have also been defined including the CNG vehicles in the

[14] For M1 vehicles the mass-based limit functions were defined in [IEEP 2007] on the basis of kerb weight. The limit function in the Commission proposal was subsequently adjusted to account for the use of mass in running order.

database. In the filtering of vehicles in the database (with respect to them being type approved as N-type or not) a major uncertainty related to the more practical and larger SUVs such as the Landrover Defender and the Toyota Landcruiser. As additional sensitivity analysis least squares fits have also been determined for the situation in which these types of vehicles were considered N1s. Results are depicted in Table 5.1 and Figure 3.

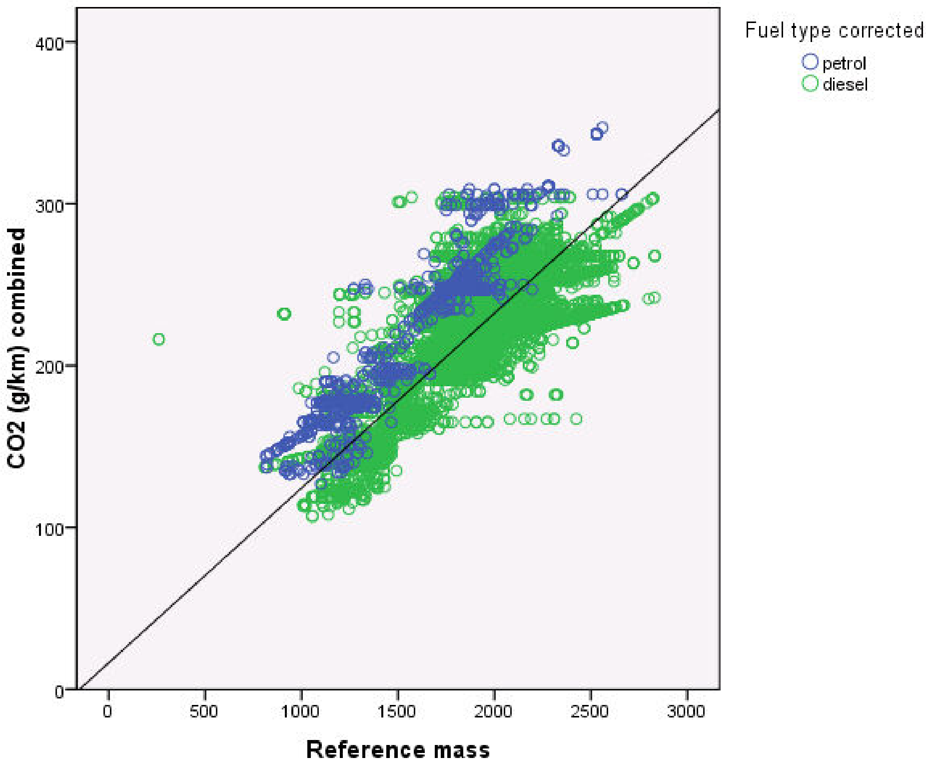
Table 5.1 Sales-weighted least squares fit through the CO_2 vs. reference mass or pan area data in the 2007 light commercial vehicle database

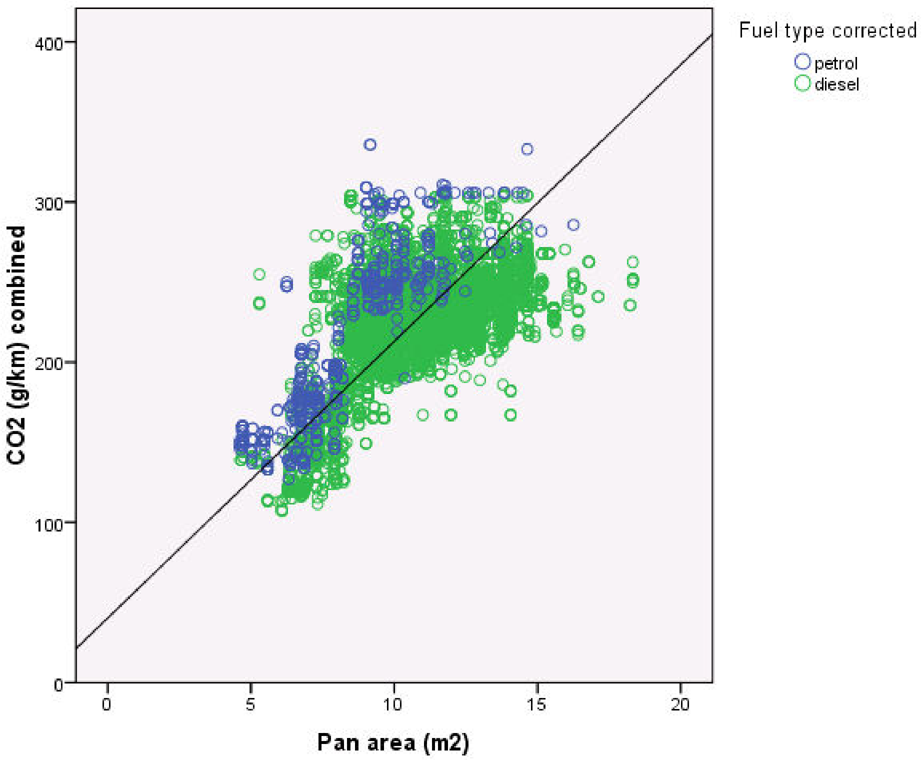
	including				
	CNG	PSUV	**a**	**b**	**R^2**
2007 sales weighted fit CO2(reference mass)	x	x	0,1085	15,591	0,824
2007 sales weighted fit CO2(reference mass)		x	0,1083	15,999	0,824
2007 sales weighted fit CO2(reference mass)	x		0,1081	15,930	0,833
2007 sales weighted fit CO2(reference mass)			0,1079	16,334	0,833

	including				
	CNG	PSUV	**a**	**b**	**R^2**
2007 sales weighted fit CO2(pan area)	x	x	17,0708	42,557	0,630
2007 sales weighted fit CO2(pan area)		x	17,0292	43,013	0,628
2007 sales weighted fit CO2(pan area)	x		17,3184	39,767	0,659
2007 sales weighted fit CO2(pan area)			17,2792	40,198	0,657

Whether or not CNG vehicles or large SUVs are included in the analysis is shown to have very limited impact on the regression lines. Given these small differences, and given the fact that due to the small sales numbers Landrover/Jaguar (now owned by Tata) will not be included in the detailed cost assessment, it has been decided to base the limit functions on the database excluding CNG vehicles and large SUVs. The resulting regressions for reference mass and pan area are depicted on the next page.

Figure 3 Sales-weighted least squares fit through the CO_2 vs. reference mass or pan area data in the 2007 light commercial vehicle database (for petrol and diesel only and excl. large SUVs except pick-up versions)





5.2.2 Definition of limit functions

Limit functions for pan area and reference mass depend on the target value and in the case of reference mass also on the assumed amount of autonomous mass increase (AMI) and the target year. Results are presented below for:
- target levels 175 and 160 g/km
- AMI values of 0.0%, 0.82% and 1.5% p.a. (for mass based limit only)
- target years 2012 for 175 g/km and 2015 for 175 and 160 g/km (for mass based limit only)

The choice of AMI values has been discussed in section 4.3. For pan area the limit function is not affected by the choice of AMI value (but the results in terms of costs for meeting the target are).

Resulting utility-based limit functions are presented in Table 5.2 to Table 5.4 for reference mass as utility parameter and Table 5.5 for pan area. It is recalled that for use in the legislation, the formula needs to be adapted so as to allow the use of mass in running order, which is 25 kg lower than the reference mass. As an example, the case of 100% slope and AMI = 0% p.a. leads to the following limit value formula:

$$\text{Limit value} = 175 + 0.0930 \times (M - M_0)$$

where M is the mass in running order and M_0 = 1706 kg.

Table 5.2 Limit functions for light commercial vehicles – based on reference mass as utility parameter, a target of 175 g/km and 2012 as target year

CO2(reference mass)				target year	2012	
AMI	0.00%		0.82%		1.50%	
target	175		175		175	
slope	a	b	a	b	a	b
2007 fit	0.1079	16.33	0.1079	16.33	0.1079	16.33
160%	0.1488	-82.48	0.1433	-83.31	0.1389	-83.98
140%	0.1302	-50.30	0.1254	-51.02	0.1215	-51.60
120%	0.1116	-18.11	0.1075	-18.73	0.1042	-19.23
100%	0.0930	14.07	0.0895	13.55	0.0868	13.14
90%	0.0837	30.17	0.0806	29.70	0.0781	29.33
80%	0.0744	46.26	0.0716	45.84	0.0694	45.51
70%	0.0651	62.35	0.0627	61.99	0.0608	61.70
60%	0.0558	78.44	0.0537	78.13	0.0521	77.88
50%	0.0465	94.54	0.0448	94.28	0.0434	94.07
40%	0.0372	110.63	0.0358	110.42	0.0347	110.26
30%	0.0279	126.72	0.0269	126.57	0.0260	126.44
20%	0.0186	142.81	0.0179	142.71	0.0174	142.63
10%	0.0093	158.91	0.0090	158.86	0.0087	158.81
0%	0.0000	175.00	0.0000	175.00	0.0000	175.00

Table 5.3 Limit functions for light commercial vehicles – based on reference mass as utility parameter, a target of 175 g/km and 2015 as target year

CO2(reference mass)				target year	2015	
AMI	0,00%		0,82%		1,50%	
target	175		175		175	
slope	a	b	a	b	a	b
2007 fit	0,1079	16,33	0,1079	16,33	0,1079	16,33
160%	0,1488	-82,48	0,1401	-83,80	0,1333	-84,83
140%	0,1302	-50,30	0,1226	-51,45	0,1166	-52,35
120%	0,1116	-18,11	0,1051	-19,10	0,0999	-19,87
100%	0,0930	14,07	0,0875	13,25	0,0833	12,61
90%	0,0837	30,17	0,0788	29,43	0,0750	28,85
80%	0,0744	46,26	0,0700	45,60	0,0666	45,09
70%	0,0651	62,35	0,0613	61,78	0,0583	61,33
60%	0,0558	78,44	0,0525	77,95	0,0500	77,56
50%	0,0465	94,54	0,0438	94,13	0,0416	93,80
40%	0,0372	110,63	0,0350	110,30	0,0333	110,04
30%	0,0279	126,72	0,0263	126,48	0,0250	126,28
20%	0,0186	142,81	0,0175	142,65	0,0167	142,52
10%	0,0093	158,91	0,0088	158,83	0,0083	158,76
0%	0,0000	175,00	0,0000	175,00	0,0000	175,00

Table 5.4 Limit functions for light commercial vehicles – based on reference mass as utility parameter, a target of 160 g/km and 2015 as target year

CO2(reference mass)				target year	2015	
AMI	0.00%		0.82%		1.50%	
target	160		160		160	
slope	a	b	a	b	a	b
2007 fit	0.1079	16.33	0.1079	16.33	0.1079	16.33
160%	0.1360	-75.41	0.1281	-76.62	0.1218	-77.56
140%	0.1190	-45.99	0.1121	-47.04	0.1066	-47.86
120%	0.1020	-16.56	0.0960	-17.46	0.0914	-18.17
100%	0.0850	12.87	0.0800	12.12	0.0762	11.53
90%	0.0765	27.58	0.0720	26.90	0.0685	26.37
80%	0.0680	42.29	0.0640	41.69	0.0609	41.22
70%	0.0595	57.01	0.0560	56.48	0.0533	56.07
60%	0.0510	71.72	0.0480	71.27	0.0457	70.92
50%	0.0425	86.43	0.0400	86.06	0.0381	85.76
40%	0.0340	101.15	0.0320	100.85	0.0305	100.61
30%	0.0255	115.86	0.0240	115.63	0.0228	115.46
20%	0.0170	130.57	0.0160	130.42	0.0152	130.31
10%	0.0085	145.29	0.0080	145.21	0.0076	145.15
0%	0.0000	160.00	0.0000	160.00	0.0000	160.00

Table 5.5 Limit functions for light commercial vehicles – based on pan area as utility parameter for 2012 and 2015 as target years

CO2(pan area)	target year		NA	
AMI	NA		NA	
target	175		160	
slope	a	b	a	b
2007 fit	17.2792	40.20	17.2792	40.20
160%	23.8848	-49.44	21.8376	-45.20
140%	20.8992	-21.38	19.1079	-19.55
120%	17.9136	6.67	16.3782	6.10
100%	14.9280	34.73	13.6485	31.75
90%	13.4352	48.76	12.2836	44.58
80%	11.9424	62.78	10.9188	57.40
70%	10.4496	76.81	9.5539	70.23
60%	8.9568	90.84	8.1891	83.05
50%	7.4640	104.86	6.8242	95.88
40%	5.9712	118.89	5.4594	108.70
30%	4.4784	132.92	4.0945	121.53
20%	2.9856	146.95	2.7297	134.35
10%	1.4928	160.97	1.3648	147.18
0%	0.0000	175.00	0.0000	160.00

5.3 Comparison with the proposed limit function for M1 vehicles

It appears worth investigating what the possibilities are for harmonizing the legislation for passenger cars and light commercial vehicles. In this context it is interesting to analyse to what extent the limit functions derived in the previous section for vans align with the limit function proposed for passenger cars.

The CO_2 limit function ($CO_2(m) = a\ m + b$) proposed by the European Commission for M1 vehicles in COM(2007) 856 is given in the table below. The limit function has a 60% slope and is expressed as function of kerb weight. It is valid for the AMI = 0.0% p.a.. The table also contains the same limit function expressed as function of reference mass, using the approximate translation (kerb weight + 60 kg) discussed above[15].

Table 5.6 CO_2 limit function (CO_2 (m) = a m + b, with m the average mass, a the slope of the limit function and b the y-axis intercept) for M1 vehicles as proposed in COM(2007) 856 for kerb weight and translated to a specification on the basis of reference mass

Mass-based CO2 limit function for M1 vehicles

	a	b
least squares fit through 2006 data	0.0934	38.700
60% slope based on kerb weight	0.0457	70.900
60% slope based on reference mass	0.0457	68.158

There is a significant amount of overlap in the vehicle models included in the M1 and N categories. Minibuses up to 9 seats are M1 but are generally based on N1 van platforms. Similarly small vans are usually derived from passenger car platforms. It is therefore interesting to investigate whether the CO_2 legislation for these two vehicle classes can be combined. An option would be the use of a single limit function for both classes.

[15] The assumed b-value in this assessment deviates slightly from the final value established in the agreement text (see footnote 14), but this has negligible impact on the outcome of the analysis as presented here.

In Table 5.7 below for a number of CO_2 targets for light commercial vehicles the slope percentage is determined for which the absolute slope (coefficient a) equals the absolute slope of the limit function for M1 vehicles. Subsequently the y-axis intercept (constant b = target – a $m_{average}$) is compared to see whether the line for N-type vehicles is below of above that for M1 vehicles. This is done only for the case of AMI = 0.0% p.a..

Table 5.7 Comparison of the limit function for M1 vehicles to limit functions defined for light commercial vehicles. ΔCO_2 is the difference in limit value for the same mass between the limit function for light commercial vehicles with target, slope and intercept indicated and the proposed limit function for M1 vehicles.

		a	b	
M1 60% slope[1]		0,0000	0,0	
N1 target	slope	a	b	ΔCO_2 [g/km]
175,0	49,2%	0,0457	95,9	27,7
160,0	53,8%	0,0457	80,9	12,7
147,3	58,4%	0,0457	68,2	0,0

[1]) based on reference mass = kerb weight + 60 kg

It can be concluded from this table that using the M1 limit function for light commercial vehicles too would be equivalent to setting a CO_2 target of 147 g/km for light commercial vehicles. This is clearly beyond the scope of the Commission's intentions and also beyond the currently available reduction potential.

For target values between 190 and 160 g/km the line with same absolute slope for light commercial vehicles is always above the limit function line for M1s. Apparently for a given mass the average CO_2 emissions of light commercial vehicles are higher than those of M1s.

Bringing M1 and light commercial vehicles under the same CO_2 limit function would thus increase the distance to target for manufacturers that sell significant amounts of light commercial vehicles, leading to higher costs of compliance for these manufacturers. Due to the dominance of diesel in light commercial vehicles the reduction potential for these vehicles is more limited than for M1s (with more affordable reduction potential in petrol vehicles), which increases the costs of compliance even further.

6 Results of the cost assessment for regulating CO_2 emissions of light commercial vehicles

6.1 Introduction

This chapter reports results of runs with the detailed cost assessment model for light commercial vehicles. These results are relevant for the following issues:
- Assessment of the level of stringency of the 175 g/km target for 2012 or 2015 and the 160 g/km target for 2015;
- Distributional impacts, i.e. distribution of the burden for reaching the target over the various manufacturers in function of target level and slope of the utility-based limit function;
- Average costs (absolute and relative to base price) for reaching the targets.

Calculations with the costs assessment model have been done for the 175 g/km target for 2012 and 2015 and the 160 g/km target for 2015 translated to manufacturer targets using:
- utility-based limit functions applied per manufacturer on the basis of reference mass and pan area;
- a uniform percentage reduction;
- three scenarios for the assumed level of autonomous mass increase:
    - 0.0% p.a. / 0.82% p.a. / 1.5% p.a.

The sections below present results of a limited number of the above described variants. For autonomous mass increase the focus is on the AMI = 0.0% p.a. scenario as this is also the case for which the proposed legislation for M1 vehicles is defined. To illustrate the effects of non-zero AMI the case of AMI = 1.5% p.a. is included in the results shown. For AMI = 0.82% p.a. effects of AMI on costs and distributional impacts will be roughly halfway the two presented cases.

In the presentation and analysis of results we focus on reference mass as utility parameter. For consistency with the M1 proposal this is the most relevant option. An analysis for pan area, however, is also reported. For values of the parameters that define the various limit functions see chapter 5. Most results in this chapter are for AMI = 0.0% as this will be the base case for the legislation (see also proposal for M1). Calculation with AMI = 1.5% are included to illustrate effects of AMI.

6.2 Level of stringency of the proposed targets

The low share of petrol vehicles found in the new JATO 2007 light commercial vehicle database is expected to lead to higher costs for meeting CO_2 reduction targets for light commercial vehicles than was calculated in previous assessments ([TNO 2006] and [IEEP 2007]). These previous assessments were based on information on the petrol/diesel shares for 2004 obtained from TREMOVE. The lower available reduction potential in diesel vehicles (see cost curves in Figure 2) furthermore leads to required reductions which are close to or in some cases at the maximum reduction potentials given by the cost curves for the 6 segments of light commercial vehicles. This is especially prominent for the proposed target of 160 g/km for 2015, as can be seen from Table 6.1 to Table 6.3 below.

The impact on the overall achieved average CO_2 emissions of various manufacturers not being able to meet their target is illustrated in Table 6.1 in which the average CO_2 emission in 2012 is given for various combinations of target level, target year, target type and AMI assumptions. The overall impact of manufacturers not meeting the target is rather limited due to the fact that this mostly happens to manufacturers with relatively small sales volumes. For mass as utility parameter all but one combination of target level and definition can be met in the case of AMI = 0.0% p.a. With AMI = 1.5% p.a. the 160 g/km target can not be met by all manufacturers in 2015, which is also the case for the 175 g/km for 2015 in case of a uniform target (slope = 0%). For pan area the 175 g/km can be met by all manufacturers in the absence of autonomous mass increase, but with the 160 g/km target some manufacturers "hit the ceiling" of the cost curves for this AMI scenario. For AMI = 1.5% p.a. meeting 175 g/km in 2012 is still possible for all manufacturers, but there are no “safe” slope values for which the target is still exactly met in 2015. For the percentage reduction option the targets of 175 and 160 g/km can be met in 2012 and 2015 in both AMI scenarios.

Table 6.1 Average CO_2 emission reached under various combinations of overall target level, slope of limit function or percentage reduction target and AMI assumption for reference mass and pan area as utility parameter

utility = reference mass			**2012 average CO2 emission**							
target	year	AMI	target definitions							
[g/km]		p.a.	0%	20%	40%	60%	80%	100%	120%	percentage
175	2012	0.0%	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
175	2015	0.0%	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
160	2015	0.0%	160.5	160.0	160.0	160.0	160.0	160.0	160.0	160.0
175	2012	1.5%	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
175	2015	1.5%	175.4	175.0	175.0	175.0	175.0	175.0	175.0	175.0
160	2015	1.5%	162.8	162.1	161.4	160.7	160.3	160.1	160.1	160.0

utility = pan area			**2012 average CO2 emission**							
target	year	AMI	target definitions							
[g/km]		p.a.	0%	20%	40%	60%	80%	100%	120%	percentage
175	2012	0.0%	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
175	2015	0.0%	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
160	2015	0.0%	160.5	160.2	160.2	160.1	160.1	160.1	160.1	160.0
175	2012	1.5%	175.0	175.0	175.0	175.0	175.0	175.0	175.0	175.0
175	2015	1.5%	175.4	175.1	175.1	175.1	175.1	175.1	175.1	175.0
160	2015	1.5%	162.8	162.4	162.0	161.7	161.3	161.1	161.1	160.0

< 1 g/km above target
1 - 2 g/km above target
> 2 g/km above target

Example cases in Table 6.2 and Table 6.3 below indicate for each manufacturer the percentage of the total reduction potential per segment that needs to be used for meeting the manufacturer-specific target set by the combination of the overall target level (in this case 175 and 160 g/km for a 60% and 100% slope and AMI = 0.0% as well as 175 and 160 g/km for a 100% slope and AMI = 1.5%) and the slope of the mass-based limit function. Fields highlighted in magenta indicate cases where the full potential is used. If this is the case in all segments in which a manufacturer sells N-type vehicles, the manufacturer is not able to meet the target.

From the tables it can be seen that Mazda has most difficulty in meeting the target. Closer analysis of the JATO database, as discussed in section 3.5, shows that all sales included as N in the model are pick-up SUVs with relatively high CO_2 emissions.

Table 6.2 Percentage of maximum reduction potential used in different segments per manufacturer for a mass-based limit function and target value = 175 g/km combined with a 60% or 100% slope in case of AMI = 0.0%. p.a. and for target value = 175 g/km combined with a 100% slope in case of AMI = 1.5%. p.a.

	175 g/km - 60% - AMI = 0.0% - 2012/15						175 g/km - 100% - AMI = 0.0% - 2012/15						175 g/km - 100% - AMI = 1.5% - 2015					
	per manu - utility						per manu - utility						per manu - utility					
manufacturer	% of max. reduction potential						% of max. reduction potential						% of max. reduction potential					
	p,I	p,II	p,III	d,I	d,II	d,III	p,I	p,II	p,III	d,I	d,II	d,III	p,I	p,II	p,III	d,I	d,II	d,III
ACEA																		
Daimler		81%	78%		73%	67%		76%	74%		67%	62%		86%	82%		78%	72%
Fiat	42%	45%		33%	33%	31%	47%	51%		39%	38%	36%	60%	61%		50%	50%	46%
Ford	60%	62%	62%	50%	50%	47%	67%	67%	66%	55%	57%	52%	78%	77%	75%	65%	68%	63%
GM	34%	39%	43%	27%	27%	26%	51%	54%	55%	42%	42%	39%	63%	64%	64%	52%	53%	49%
PSA	41%	45%		33%	33%	31%	62%	63%		51%	52%	48%	75%	74%		62%	64%	60%
Renault	56%	58%	59%	46%	47%	43%	72%	72%	70%	60%	62%	57%	84%	82%	79%	71%	74%	68%
Volkswagen	56%	58%	59%	46%	46%	43%	60%	61%	62%	49%	50%	46%	71%	71%	70%	60%	61%	57%
JAMA																		
Isuzu					61%	56%					56%	52%					68%	63%
Mazda				93%	100%	92%				96%	100%	96%				100%	100%	100%
Mitsubishi				63%	65%	60%				61%	62%	58%				70%	73%	68%
Nissan	87%	84%	81%	73%	77%	71%	84%	82%	79%	71%	74%	68%	96%	92%	87%	81%	86%	79%
Toyota				58%	60%	55%				59%	60%	56%				68%	71%	66%
KAMA																		
Hyundai		73%			63%	59%		72%			62%	58%		82%			74%	68%
Other																		
LDV					62%	57%					60%	55%					71%	65%
max reduction	72.9	88.7	121.3	47.0	63.5	86.1	72.9	88.7	121.3	47.0	63.5	86.1	72.9	88.7	121.3	47.0	63.5	86.1

Table 6.3 Percentage of maximum reduction potential used in different segments per manufacturer for a mass-based limit function and target value = 160 g/km combined with a 60% or 100% slope in case of AMI = 0.0%. p.a. and for target value = 160 g/km combined with a 100% slope in case of AMI = 1.5%. p.a.

	160 g/km - 60% - AMI = 0.0% - 2015						160 g/km - 100% - AMI = 0.0% - 2015						160 g/km - 100% - AMI = 1.5% - 2015					
	per manu - utility						per manu - utility						per manu - utility					
manufacturer	% of max. reduction potential						% of max. reduction potential						% of max. reduction potential					
	p,I	p,II	p,III	d,I	d,II	d,III	p,I	p,II	p,III	d,I	d,II	d,III	p,I	p,II	p,III	d,I	d,II	d,III
ACEA																		
Daimler		99%	92%		94%	87%		88%	84%		81%	75%		100%	97%		100%	92%
Fiat	65%	66%		54%	55%	51%	63%	64%		52%	53%	49%	82%	80%		69%	72%	66%
Ford	82%	80%	77%	69%	72%	66%	81%	80%	77%	68%	71%	65%	99%	95%	89%	84%	89%	82%
GM	59%	60%	61%	48%	49%	45%	66%	67%	66%	55%	56%	52%	85%	83%	79%	72%	75%	69%
PSA	66%	67%		55%	56%	52%	77%	76%		65%	67%	62%	97%	93%		82%	87%	80%
Renault	80%	78%	76%	67%	70%	64%	87%	85%	81%	73%	77%	71%	100%	100%	94%	90%	97%	89%
Volkswagen	77%	76%	74%	65%	67%	62%	74%	74%	72%	62%	64%	59%	92%	89%	85%	78%	83%	76%
JAMA																		
Isuzu					81%	75%					71%	65%					89%	82%
Mazda				100%	100%	100%				100%	100%	100%				100%	100%	100%
Mitsubishi				81%	86%	79%				73%	77%	71%				88%	95%	87%
Nissan	100%	100%	95%	91%	98%	90%	98%	94%	89%	83%	89%	82%	100%	100%	100%	100%	100%	100%
Toyota				76%	80%	74%				71%	74%	68%				86%	92%	85%
KAMA																		
Hyundai		91%			84%	78%		84%			77%	71%		99%			95%	88%
Other																		
LDV					82%	76%					74%	68%					92%	84%
max reduction	72.9	88.7	121.3	47.0	63.5	86.1	72.9	88.7	121.3	47.0	63.5	86.1	72.9	88.7	121.3	47.0	63.5	86.1

For the 160 g/km target a significant number of manufacturers will “hit the ceiling” of the cost curve in one or more segments. In other segments the share of the potential that is used by these manufacturers is generally above 70%. This means that these manufacturers will not be able to meet their individual targets without pooling (either with M1s or another manufacturer). Many manufacturers that are able to meet the 160 g/km target in 2015 use 70% to more than 90% of the reduction potential, which means that meeting the target requires implementation of mild or full hybrid power trains as well as strong weight reduction measures on all N-type vehicles sold in

2015. Given the uncertainties over the timing and level of long term targets for passenger cars, it is thus questionable whether 160 g/km in 2015 is a realistic policy option.

For 175 g/km all manufacturers except Mazda can reach their target without using the full reduction potentials in the diesel segments. Required reductions are in the order of 30 - 60% for many manufacturers and above that level for most Japanese manufacturers. With the exception of Daimler, it can be concluded that the targets are more difficult to achieve for Japanese manufacturers than for European manufacturers.

The share of the full reduction potential in petrol segments is generally higher than in the diesel segments. This should be considered less of an issue and can in fact be seen as an artefact of the modelling method. It is of course unlikely that manufacturers will apply very advanced technologies in segments where they sell so few vehicles. In fact, in many of these vehicles manufacturers will basically carry over power train technologies as used in passenger cars, which are on average less advanced under the 130 g/km target than the technologies at the upper end of the cost curve for vans on petrol. But at the same time these low sales also mean that applying less CO_2 reduction measures in petrol vehicles than indicated by the cost assessment model can easily be compensated by applying a little bit more CO_2 reduction in the diesel segments without seriously affecting the overall costs of meeting the target.

As can be seen from Table 6.2 and Table 6.3 assuming a non-zero AMI value will require larger reductions than in case of AMI = 0.0% p.a.. Given a certain legislative target, and possible adjustments of the limit curve to compensate effects of observed mass increase, this may be an incentive for manufacturers not to allow adverse trends in vehicle mass.

6.3 Distributional impacts for mass-based limit functions

6.3.1 Results for a target of 175 g/km in 2012

Figure 4 and Figure 5 present distributional impacts in terms of retail price increase per vehicle for the different manufacturers for the 175 g/km target for 2012 for different values of the slope of the mass-based limit function and for two different assumptions on autonomous mass increase: AMI = 0.0% resp. 1.5% p.a.. In addition to mass-based limit functions also results are displayed for the percentage reduction option. Under this option all manufacturers must reduce their sales-averaged CO_2 emissions by the same percentage, which based on is the ratio of the overall sales-averaged CO_2 emission in 2007 and the overall target for 2012 (1 – 175/203 = 13.8%).

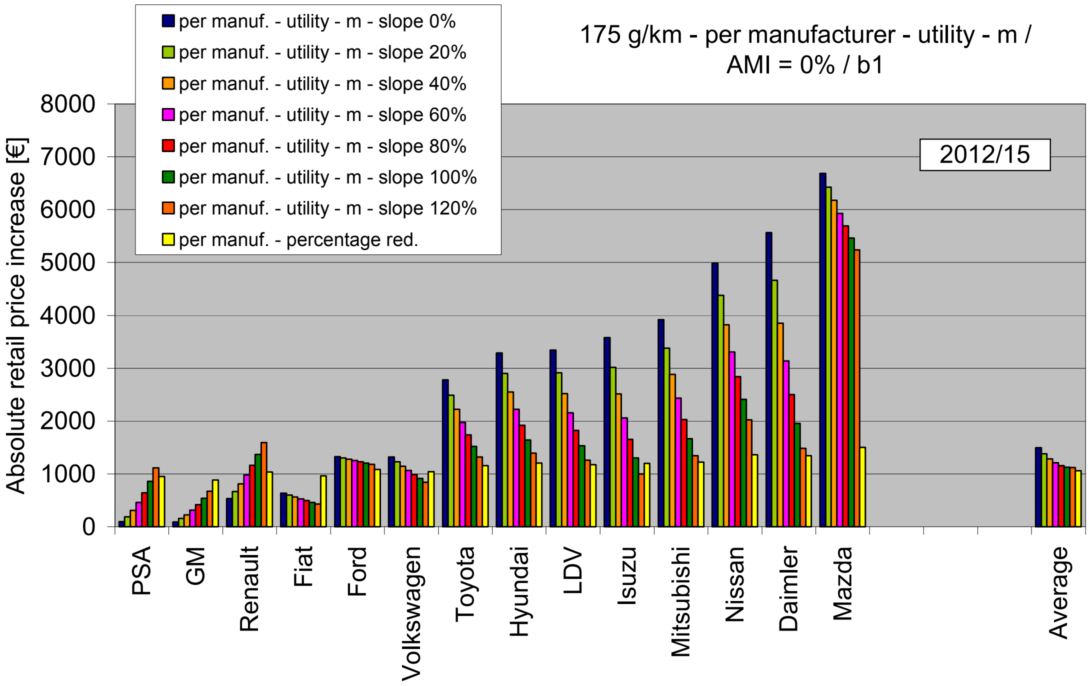
Manufacturers are listed according to increasing 2007 average CO_2 emissions. Costs are expressed as absolute price increase and as relative price increase (i.e. additional price divided by average base price). Retail price for light commercial vehicles is defined as price including all taxes except VAT. Average retail prices per manufacturer have been obtained from the JATO databases. For CO_2 reduction measures additional manufacturer costs are translated into retail price increase excl. VAT using a factor 1.11. This factor has been derived from an analysis of ACEA data (see section 2.3).

The results presented in Figure 4 are for the case of AMI = 0.0% p.a.. For AMI = 0.0% p.a. the results of the modelling methodology are independent of the year for which the target is set.

Results in Figure 5 are for the same target and slope values but apply to the situation in which AMI = 1.5% p.a.. In those cases where for a given manufacturer costs do not change with slope the manufacturer is applying 100% of the potential in those segments and is not able to meet the target. Additional costs are for the baseline “b1” (see section 2.2 of Note 6 on page 78 of the technical notes in [IEEP 2007]), in which it is assumed that the costs associated with applying

CO_2 reduction measures to compensate the effects of mass increase on CO_2 (i.e. to maintain CO_2 emission levels at the 2007 level in the absence of legislation) are not attributed to the costs of the CO_2 legislation. This is similar to the approach used for M1 vehicles.

Figure 4 Absolute and relative price increase for meeting a target of 175 g/km in 2012 / 2015 set by a mass-based limit function with various slope levels, with AMI = 0.0% p.a. and baseline b0 = b1



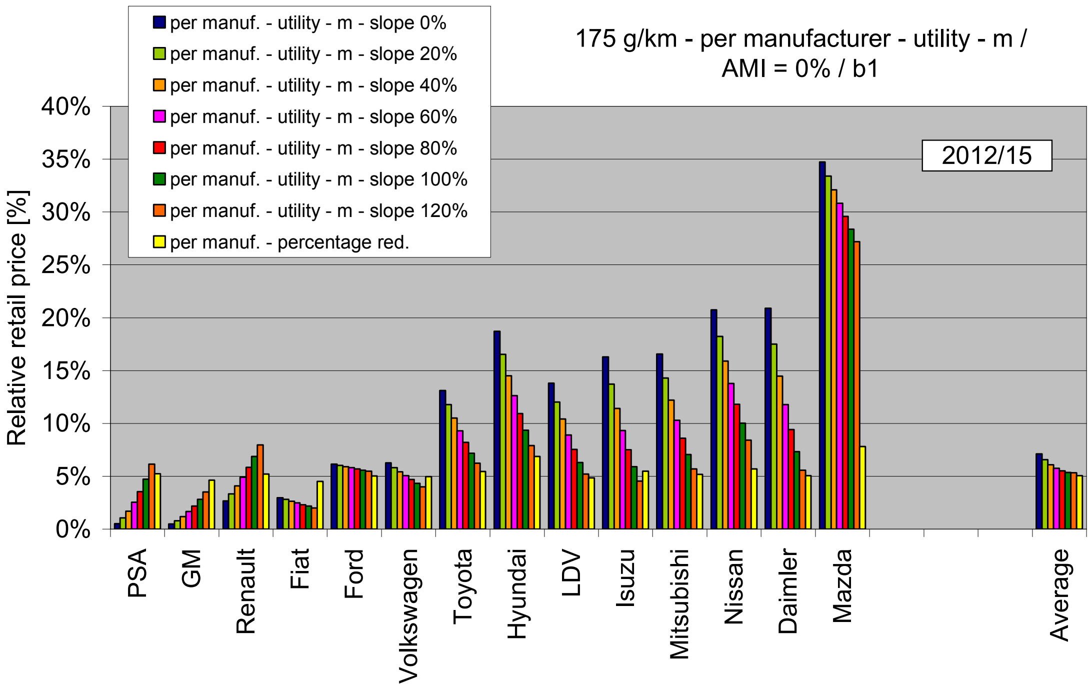
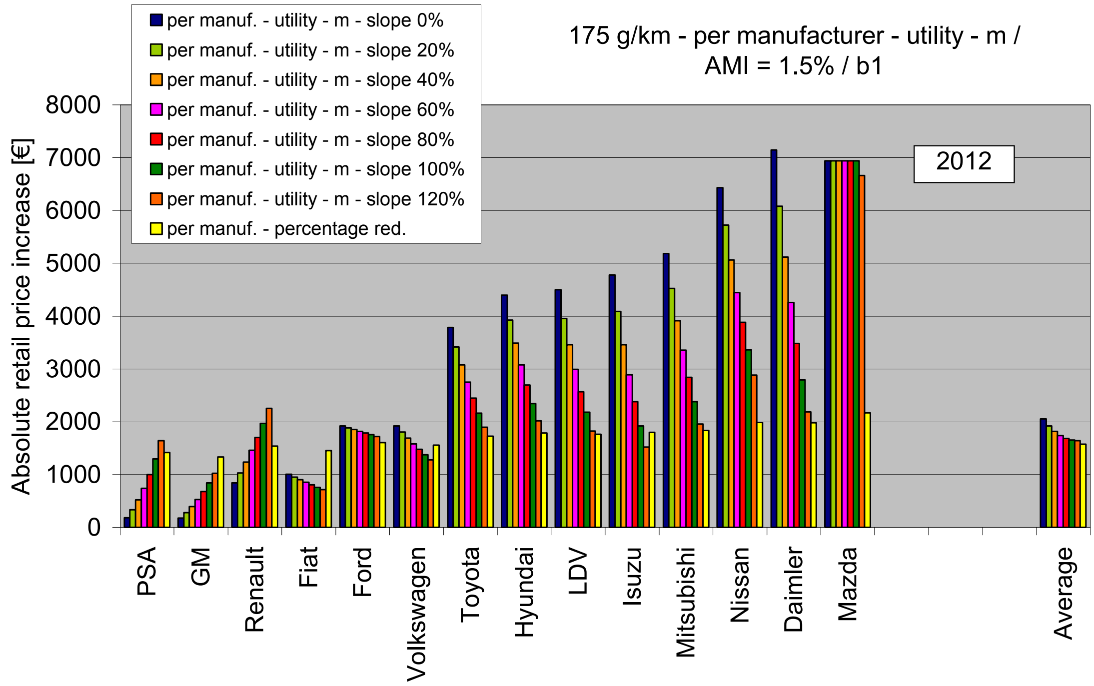
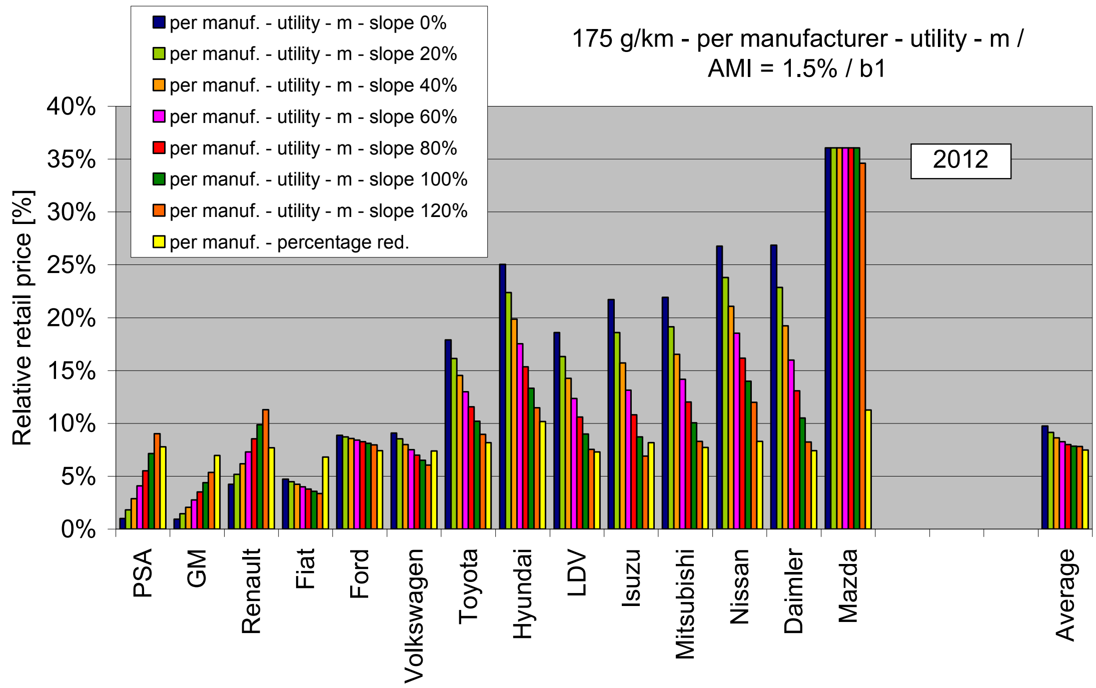


Figure 5 Absolute and relative price increase for meeting a target of 175 g/km in 2012 set by a mass-based limit function with various slope levels, with AMI = 1.5% p.a. and baseline b1 (cost for compensating AMI not attributed to the policy)





It is clear from the results that for light commercial vehicles the costs per manufacturer are much more sensitive to the slope of the limit function than is the case for M1 (see e.g. Figures 124 and 125 on page 234 of the technical notes in [IEEP 2007]). Also the difference in costs between manufacturers is much larger than for M1.

Costs are generally higher for Japanese and Korean manufacturers than for European manufacturers, with the exception of Daimler and LDV. Average costs are strongly dominated by the large European manufacturers.

Generally a higher slope of the mass-based limit function gives a more even distribution of costs over the different manufacturers. The most even distribution is obtained by the percentage reduction target.

Assuming AMI = 1.5% p.a. leads to significantly higher costs for meeting the target. For most slope values Mazda is “hitting the ceiling of the cost curves” and as a consequence is not able to meet its manufacturer-specific target.

6.3.2 Results for a target of 175 g/km in 2015

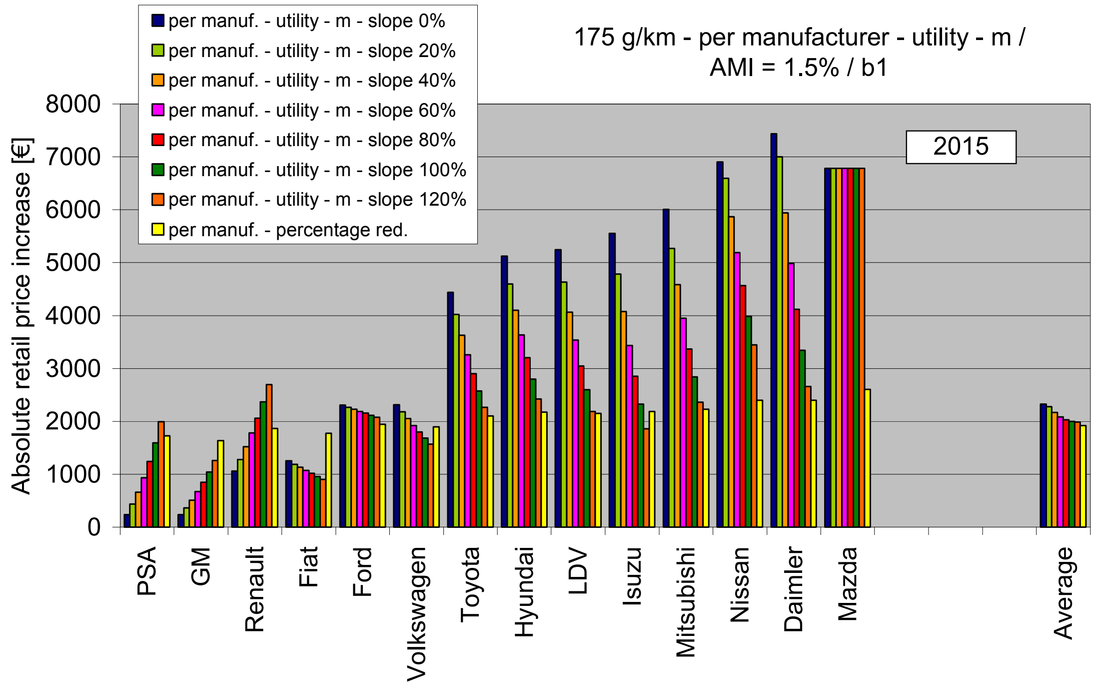
For AMI = 0.0% p.a. the costs of meeting a target are independent of the target year in the assessment methodology used here. The results for meeting 175 g/km in 2015 using a mass-based limit function under the assumption of zero autonomous mass increase are therefore identical to the results for 2012 depicted in Figure 4.

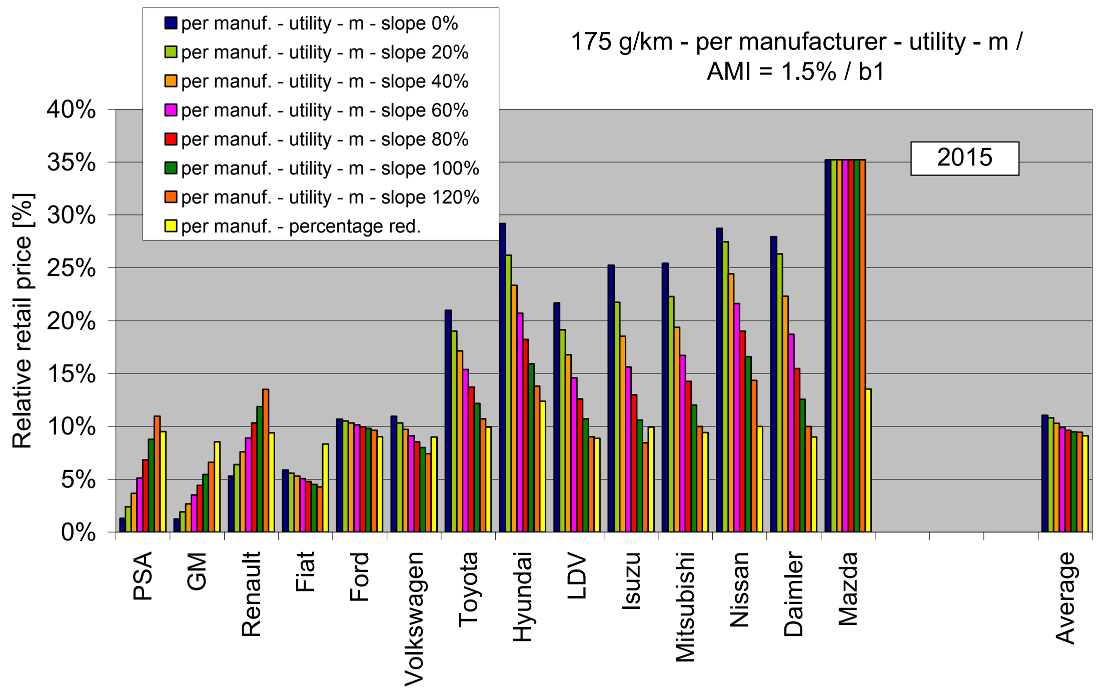
The costs for meeting 175 g/km in 2015 using a mass-based limit function in the case of AMI = 1.5% p.a. are depicted in Figure 5 below.

Comparing Figure 5 to Figure 4 one can see that for manufacturers that are able to meet the target in 2012 and 2015 the costs for meeting the target go up with shifting the target year from 2012 to 2015. Postponing the target year leads to a higher mass increase between 2007 and the target year. The CO_2 impacts of that have to be compensated by additional measures at the upper end of the cost curve which have increasing marginal costs.

For Mazda, which is not able to meet its target (which can be seen from the fact that costs do not change with the slope of the limit function) the costs appear to go down with shifting the target year from 2012 to 2015. This is the result of comparing the costs to baseline b1 (see section 2.2 of Note 6 on page 78 of the technical notes in [IEEP 2007]) in which the costs of applying CO_2 reduction measures to compensate the impacts of autonomous mass increase in the absence of a CO_2 legislation are not attributed to the CO_2 legislation. If a manufacturer reaches the “ceiling” of the cost curve the overall costs can not go up with increasing impact of AMI as a result of postponing the target year. But the costs for compensating this impact in the absence of CO_2 legislation, which are subtracted from the costs of meeting the target, do increase with postponing the target year.

Figure 6 Absolute and relative price increase for meeting a target of 175 g/km in 2015 set by a mass-based limit function with various slope levels, with AMI = 1.5% p.a. and baseline b1 (cost for compensating AMI not attributed to the policy)

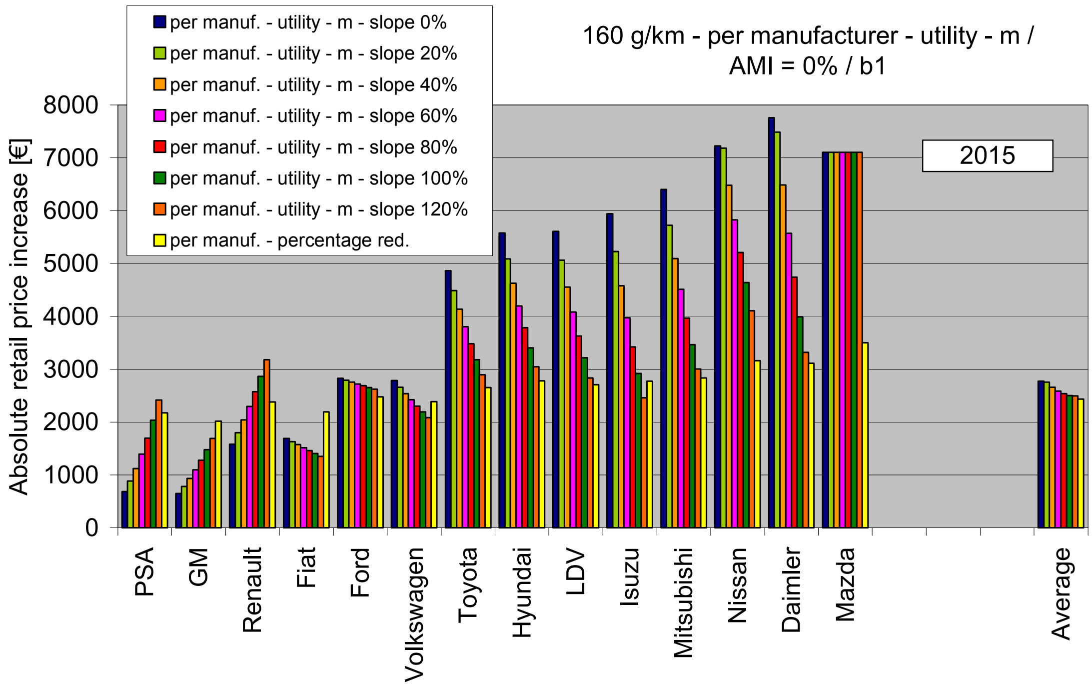




6.3.3 Results for a target of 160 g/km in 2015

Figure 7 and Figure 8 present distributional impacts in terms of retail price increase per vehicle for the different manufacturers for the 160 g/km target for 2012 for different values of the slope of the mass-based limit function and for two different assumptions on autonomous mass increase: AMI = 0.0% resp. 1.5% p.a.. In addition to mass-based limit functions also results are displayed for the percentage reduction option, in which all manufacturers must reduce their sales-averaged CO_2 emissions by the same percentage (for 2015: 1 – 160/203 = 21.2%).

Figure 7 Absolute and relative price increase for meeting a target of 160 g/km in 2015 set by a mass-based limit function with various slope levels, with AMI = 0.0% p.a. and baseline b0 = b1



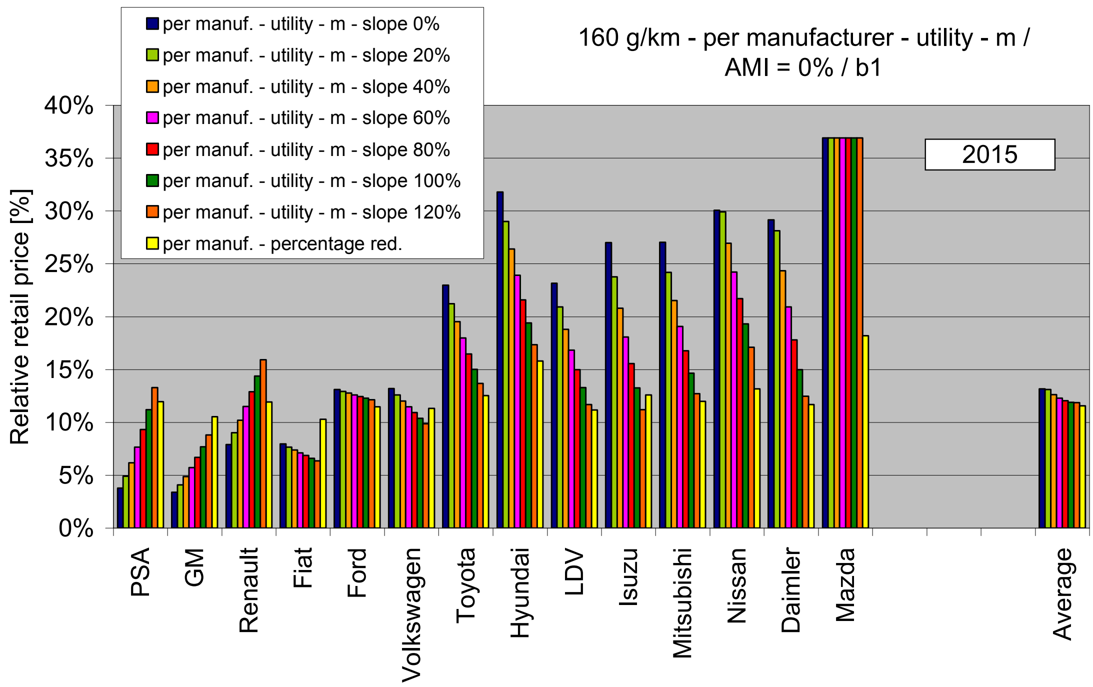
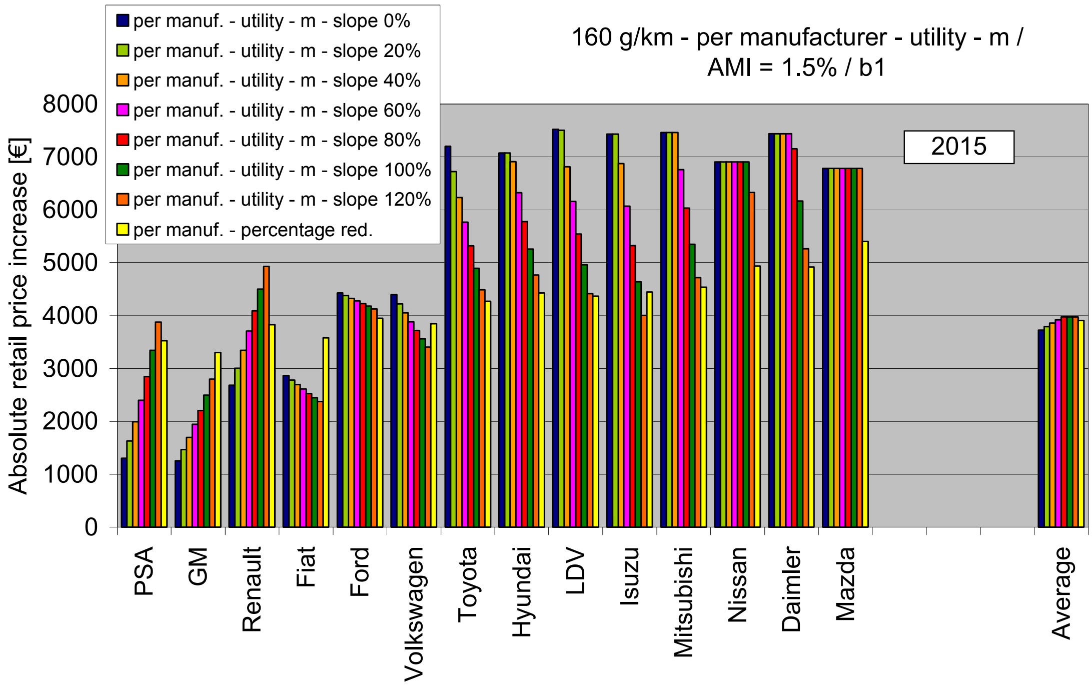


Figure 8 Absolute and relative price increase for meeting a target of 160 g/km in 2015 set by a mass-based limit function with various slope levels, with AMI = 1.5% p.a. and baseline b1 (cost for compensating AMI not attributed to the policy)



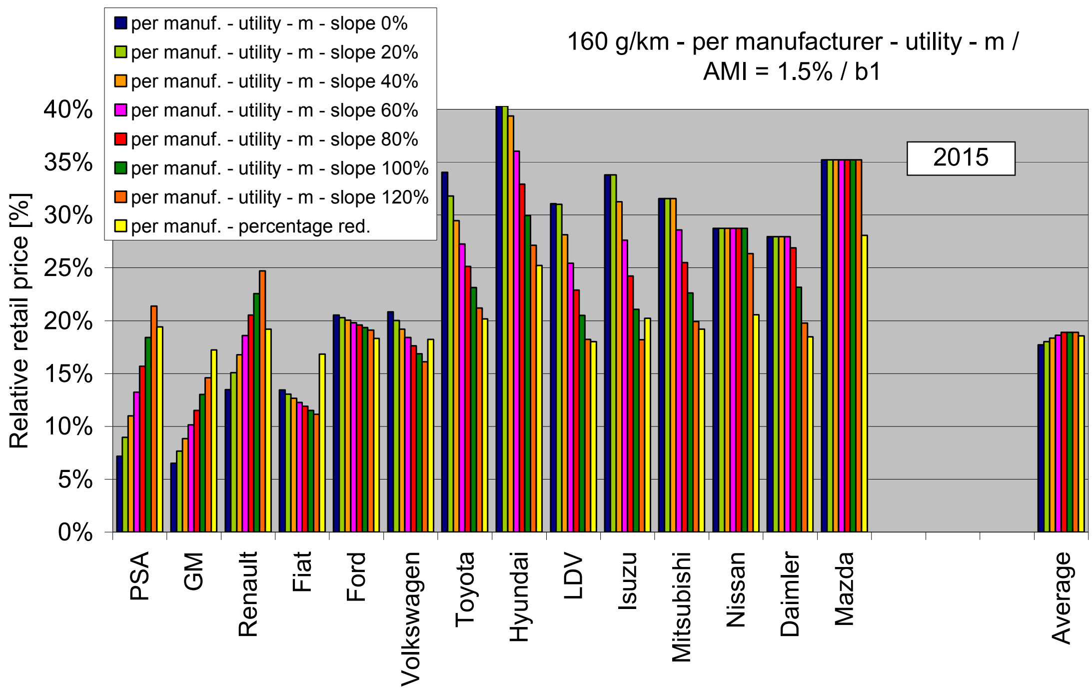


Figure 7 shows that already in the case of AMI = 0.0% p.a. still only Mazda will not be able to meet its targets. The average relative cost increase for this scenario is between 11.6% and 13.2% for this scenario. From Figure 8 it can be concluded that in the case of AMI = 1.5% p.a. many manufacturers will not be able to meet their target in 2015 for one or more slope values. Average relative cost increases for this scenario are between 17.7% and 18.9%.

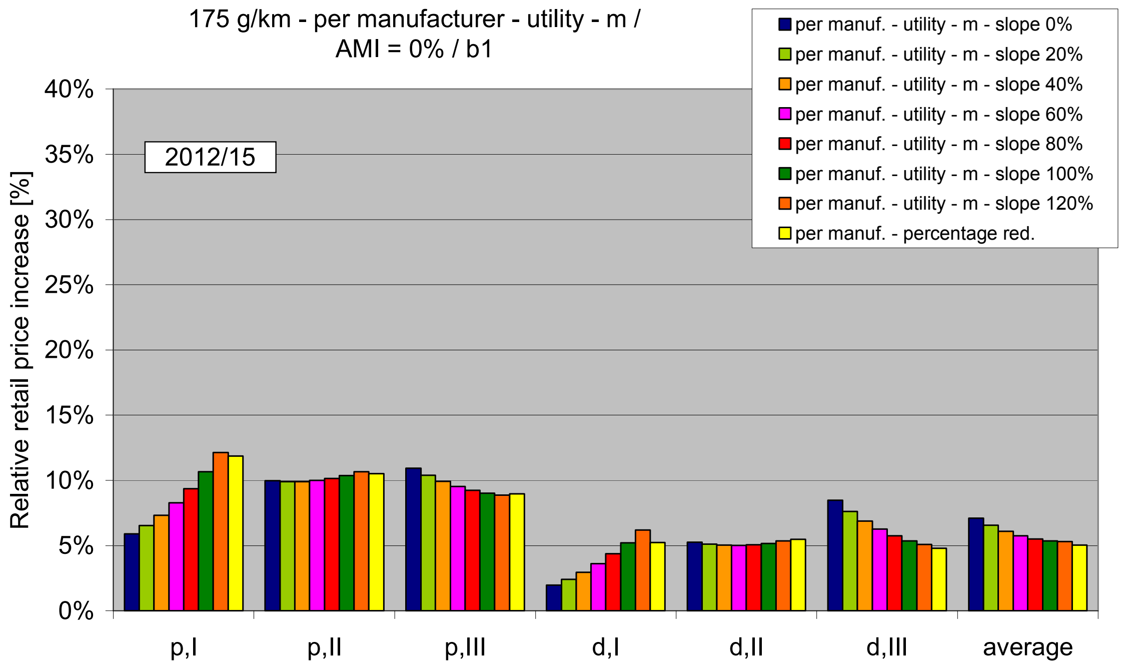
6.3.4 Division of costs over vehicle segments for mass-based limit functions

The division of costs over segments (fuel type and mass class) is illustrated in Figure 9 to Figure 12 for the 175 g/km target for 2012 and 2015 and the 160 g/km target for 2015, both in the case of AMI = 0.0% and 1.5% p.a.

The cost assessment model predicts relatively high CO_2 reductions and associated costs for petrol vehicles. Given the small share of petrol vehicles in light commercial vehicle sales (2%) it is not expected that manufacturers will actually apply such high levels of CO_2 reduction to petrol vehicles (in any case not more advanced technology than what is used in passenger cars). However, due to the low share limiting the amount of CO_2 reduction in petrol vehicles has little impact on the reductions to be achieved in diesel vehicles as well as on the average costs for meeting the target. For this reason this unrealistic effect on petrol vehicle has not been corrected in the model for the results presented here[16].

For vehicles of Class II and III the average price increase is not very sensitive to the slope of the limit function. For Class I vehicles the impact of slope is large. The most even distribution of costs over the three diesel segments is achieved at slope values of 80% or more.

Figure 9 Relative retail price increase per segment for meeting a target of 175 g/km in 2012 / 2015, a mass-based utility function with various slopes and AMI = 0.0% and baseline b0 = b1



[16] For the purpose of sensitivity analyses in TREMOVE also results have been provided to the Commission from simulations in which the maximum CO_2 reduction in petrol vehicles was limited to 50% of the maximum potential as given by the cost curves from Figure 2.

Figure 10 **Relative retail price increase per segment for meeting a target of 175 g/km in 2012, a mass-based utility function with various slopes and AMI = 1.5% and baseline b1 (cost for compensating AMI not attributed to the policy)**

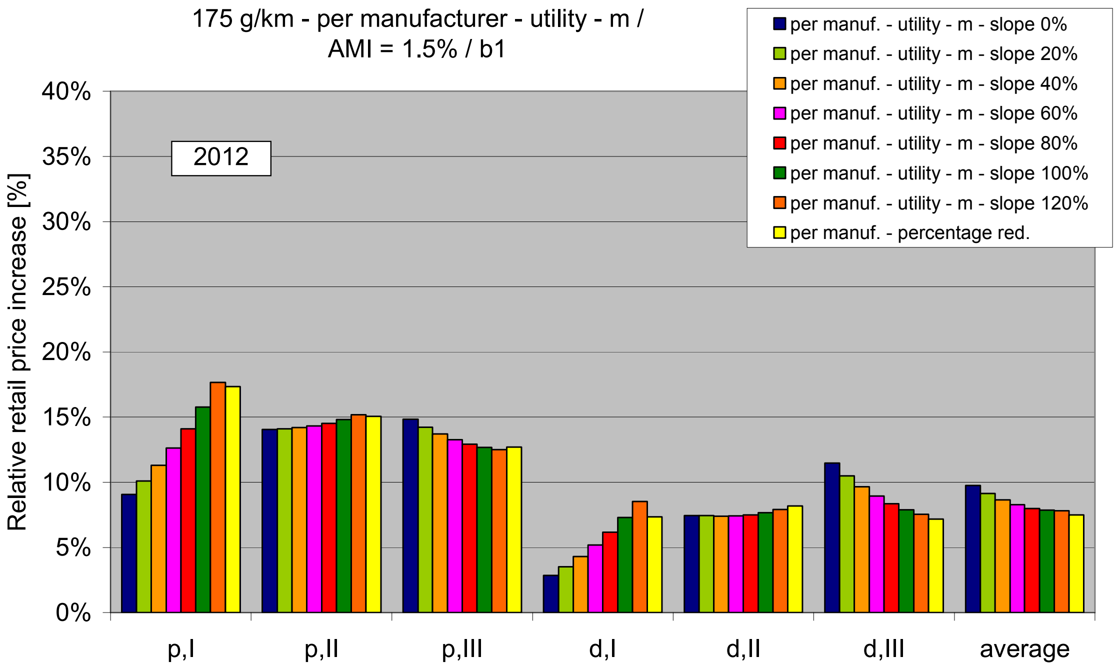


Figure 11 **Relative retail price increase per segment for meeting a target of 175 g/km in 2015, a mass-based utility function with various slopes and AMI = 1.5% and baseline b1 (cost for compensating AMI not attributed to the policy)**

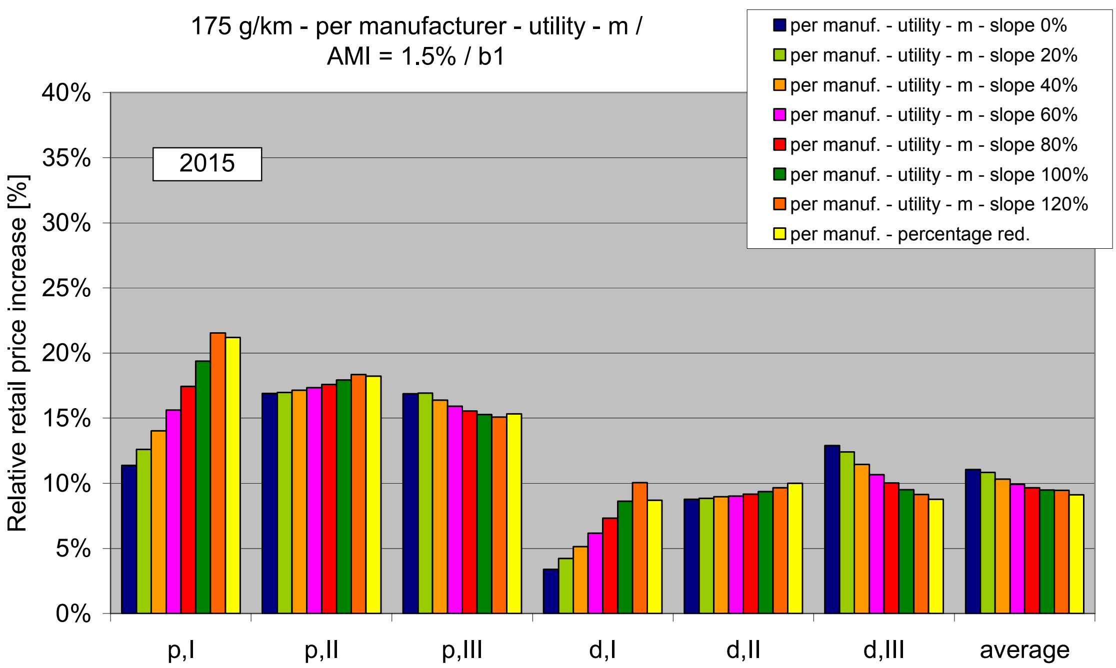


Figure 12 Relative retail price increase per segment for meeting a target of 160 g/km in 2015, a mass-based utility function with various slopes and AMI = 0.0% and baseline b0 = b1

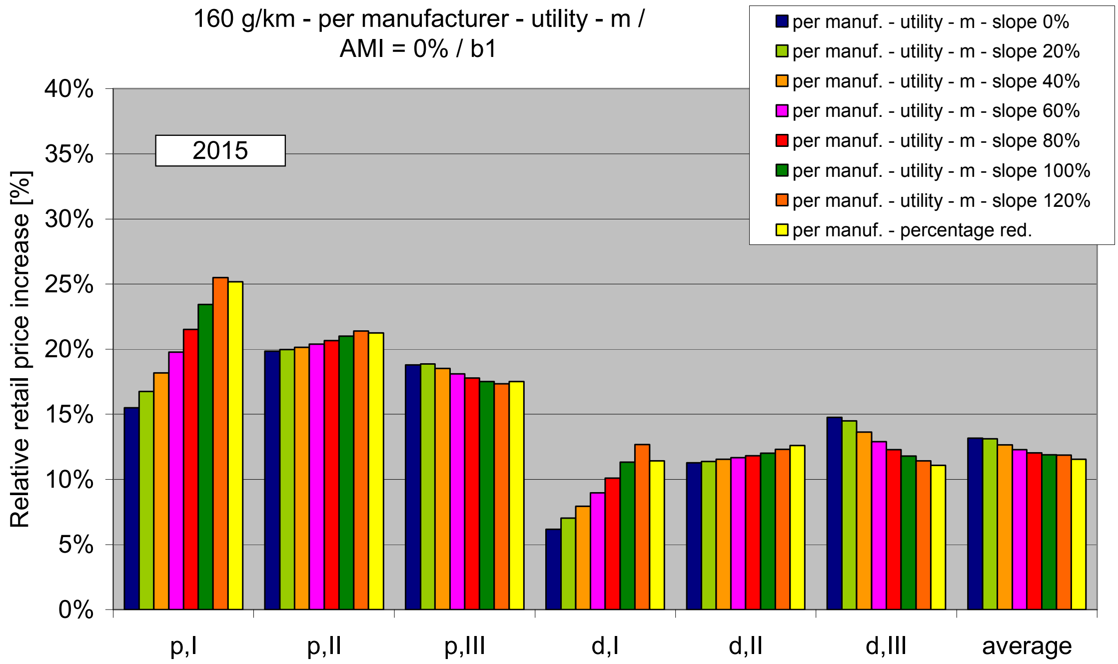
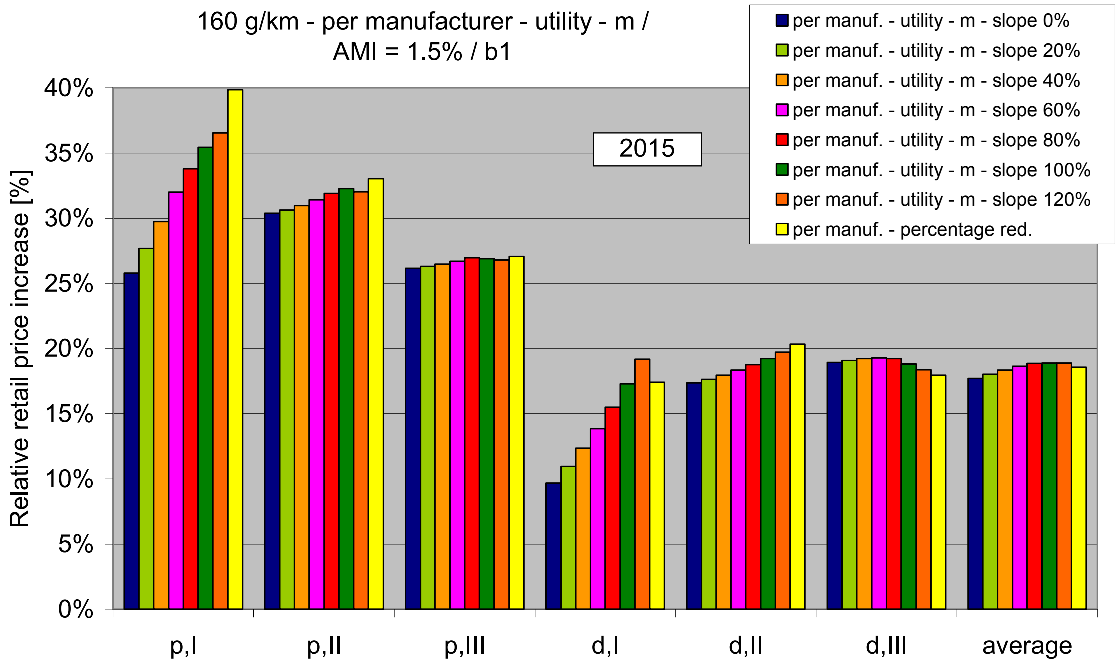


Figure 13 Relative retail price increase per segment for meeting a target of 160 g/km in 2015, a mass-based utility function with various slopes and AMI = 1.5% and baseline b1 (cost for compensating AMI not attributed to the policy)



6.3.5 Average costs for meeting targets combined with a mass-based limit function

The average retail price increases (excl. VAT) for meeting the target are presented in Table 6.4 below. Impacts on manufacturer costs (exclusive of all taxes) are indicated in Annex D. For the 175 g/km the relative price increase for the case of AMI = 0.0% p.a. is around 5 to 7%, which is of the same order of magnitude as the impact of the 130 g/km on M1 vehicles. Meeting 160 g/km in 2015 in the absence of AMI is about twice as expensive as meeting 175 g/km. For the 175 g/km target assuming AMI = 1.5% p.a. leads to costs which are a factor 1.5 to 1.8 higher than for the case of AMI = 0.0% depending on the target year.

Table 6.4 Overview of absolute and relative average price increase per segment for different target levels, different slopes of the mass-based limit function and different assumptions with respect to AMI relative to baseline b1 (cost for compensating AMI not attributed to the policy)

				2007-2012 add. absolute retail price per car [€]							**2007-2012** add. relative retail price per car [%]						
target	year	AMI	slope	p,I	p,II	p,III	d,I	d,II	d,III	average	p,I	p,II	p,III	d,I	d,II	d,III	average
175	2012 / 2015	0.0%	0%	641	1400	2183	269	906	2123	1498	5.9%	10.0%	10.9%	2.0%	5.3%	8.5%	7.1%
			20%	712	1392	2075	331	882	1909	1381	6.5%	9.9%	10.4%	2.4%	5.1%	7.6%	6.6%
			40%	797	1393	1982	406	867	1725	1285	7.3%	9.9%	9.9%	3.0%	5.0%	6.9%	6.1%
			60%	900	1404	1906	494	864	1570	1211	8.3%	10.0%	9.5%	3.6%	5.0%	6.3%	5.8%
			80%	1020	1425	1845	597	871	1444	1159	9.4%	10.1%	9.2%	4.4%	5.1%	5.8%	5.5%
			100%	1160	1457	1800	713	890	1346	1129	10.7%	10.4%	9.0%	5.2%	5.2%	5.4%	5.4%
			120%	1321	1500	1770	846	921	1276	1120	12.1%	10.7%	8.9%	6.2%	5.3%	5.1%	5.3%
			percentage	1291	1481	1792	717	945	1201	1062	11.9%	10.5%	9.0%	5.2%	5.5%	4.8%	5.0%
160	2015	0.0%	0%	1687	2791	3749	845	1943	3702	2771	15.5%	19.9%	18.8%	6.2%	11.3%	14.8%	13.2%
			20%	1824	2807	3766	962	1961	3635	2759	16.8%	20.0%	18.9%	7.0%	11.4%	14.5%	13.1%
			40%	1978	2833	3699	1087	1988	3415	2662	18.2%	20.2%	18.5%	7.9%	11.5%	13.6%	12.7%
			60%	2151	2867	3614	1226	2011	3231	2587	19.8%	20.4%	18.1%	9.0%	11.7%	12.9%	12.3%
			80%	2342	2905	3548	1380	2035	3080	2535	21.5%	20.7%	17.8%	10.1%	11.8%	12.3%	12.0%
			100%	2549	2951	3497	1550	2071	2958	2504	23.4%	21.0%	17.5%	11.3%	12.0%	11.8%	11.9%
			120%	2772	3008	3462	1736	2119	2864	2496	25.5%	21.4%	17.3%	12.7%	12.3%	11.4%	11.9%
			percentage	2740	2986	3496	1562	2172	2779	2431	25.2%	21.2%	17.5%	11.4%	12.6%	11.1%	11.6%
175	2012	1.5%	0%	987	1975	2963	393	1283	2879	2051	9.1%	14.1%	14.8%	2.9%	7.4%	11.5%	9.7%
			20%	1099	1983	2841	483	1282	2627	1923	10.1%	14.1%	14.2%	3.5%	7.4%	10.5%	9.1%
			40%	1228	1994	2737	588	1274	2417	1819	11.3%	14.2%	13.7%	4.3%	7.4%	9.6%	8.6%
			60%	1374	2012	2651	709	1277	2238	1740	12.6%	14.3%	13.3%	5.2%	7.4%	8.9%	8.3%
			80%	1534	2041	2582	845	1293	2091	1684	14.1%	14.5%	12.9%	6.2%	7.5%	8.3%	8.0%
			100%	1716	2081	2531	998	1322	1976	1653	15.8%	14.8%	12.7%	7.3%	7.7%	7.9%	7.9%
			120%	1921	2134	2496	1168	1365	1889	1644	17.7%	15.2%	12.5%	8.5%	7.9%	7.5%	7.8%
			percentage	1887	2117	2534	1005	1410	1800	1577	17.3%	15.1%	12.7%	7.3%	8.2%	7.2%	7.5%
175	2015	1.5%	0%	1238	2376	3365	465	1511	3232	2326	11.4%	16.9%	16.9%	3.4%	8.8%	12.9%	11.1%
			20%	1372	2387	3378	578	1523	3109	2279	12.6%	17.0%	16.9%	4.2%	8.8%	12.4%	10.8%
			40%	1526	2408	3272	702	1545	2869	2170	14.0%	17.1%	16.4%	5.1%	9.0%	11.4%	10.3%
			60%	1701	2438	3179	844	1555	2674	2086	15.6%	17.3%	15.9%	6.2%	9.0%	10.7%	9.9%
			80%	1897	2473	3106	1002	1577	2514	2028	17.4%	17.6%	15.6%	7.3%	9.2%	10.0%	9.6%
			100%	2108	2519	3050	1179	1613	2386	1996	19.4%	17.9%	15.3%	8.6%	9.4%	9.5%	9.5%
			120%	2343	2579	3012	1374	1663	2292	1989	21.5%	18.3%	15.1%	10.0%	9.7%	9.1%	9.5%
			percentage	2305	2563	3061	1190	1723	2198	1920	21.2%	18.2%	15.3%	8.7%	10.0%	8.8%	9.1%
160	2015	1.5%	0%	2806	4269	5220	1323	2993	4748	3728	25.8%	30.4%	26.1%	9.7%	17.4%	18.9%	17.7%
			20%	3010	4306	5249	1498	3039	4785	3792	27.7%	30.6%	26.3%	11.0%	17.6%	19.1%	18.0%
			40%	3234	4354	5286	1689	3095	4818	3859	29.7%	31.0%	26.5%	12.3%	18.0%	19.2%	18.3%
			60%	3480	4412	5331	1895	3159	4835	3921	32.0%	31.4%	26.7%	13.9%	18.3%	19.3%	18.6%
			80%	3677	4484	5385	2120	3230	4822	3972	33.8%	31.9%	27.0%	15.5%	18.8%	19.2%	18.9%
			100%	3857	4536	5369	2363	3313	4717	3974	35.5%	32.3%	26.9%	17.3%	19.2%	18.8%	18.9%
			120%	3975	4503	5345	2624	3397	4602	3973	36.5%	32.0%	26.8%	19.2%	19.7%	18.4%	18.9%
			percentage	4334	4641	5403	2383	3506	4499	3907	39.8%	33.0%	27.1%	17.4%	20.4%	17.9%	18.6%

For the 175 g/km and AMI = 0.0% target cost decrease with increasing slope. For the 160 g/km target for 2015 and both AMI assumptions this is the other way around.

In comparing the average costs for different targets and slopes it should be noted that not for all combinations all manufacturers are able to meet their targets as indicated in the analysis presented at the beginning of this chapter. In such cases this means that for the costs indicated above table the overall target is not entirely met. Costs of penalties for not meeting manufacturer targets are not included in these calculations.

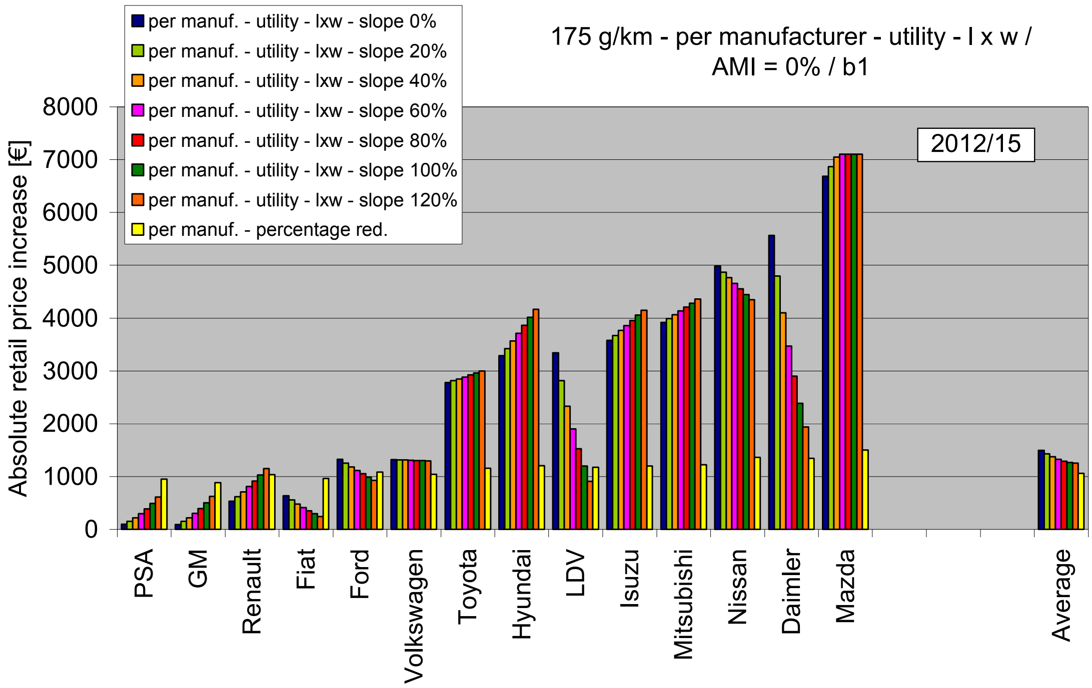
6.4 Distributional impacts for pan area-based limit functions

6.4.1 Results for a target of 175 g/km in 2012

Figure 14 and Figure 15 present distributional impacts in terms of retail price increase per vehicle for the different manufacturers for the 175 g/km target for 2012 for different values of the slope of the pan area-based limit function and for two different assumptions on autonomous mass increase: AMI = 0.0% resp. 1.5% p.a.. In addition to pan area-based limit functions also results are displayed for the percentage reduction option, in which all manufacturers must reduce their sales-averaged CO_2 emissions by the same percentage.

A comparison with the same scenarios (target value and AMI) for a mass-based limit function (see Figure 4 and Figure 5) shows that average costs are quite the same but that the distributional impacts are somewhat stronger for pan area than for mass.

Figure 14 Absolute and relative price increase for meeting a target of 175 g/km in 2012 and 2015 set by a pan area-based limit function with various slope levels, with AMI = 0.0% p.a. and baseline b0 = b1



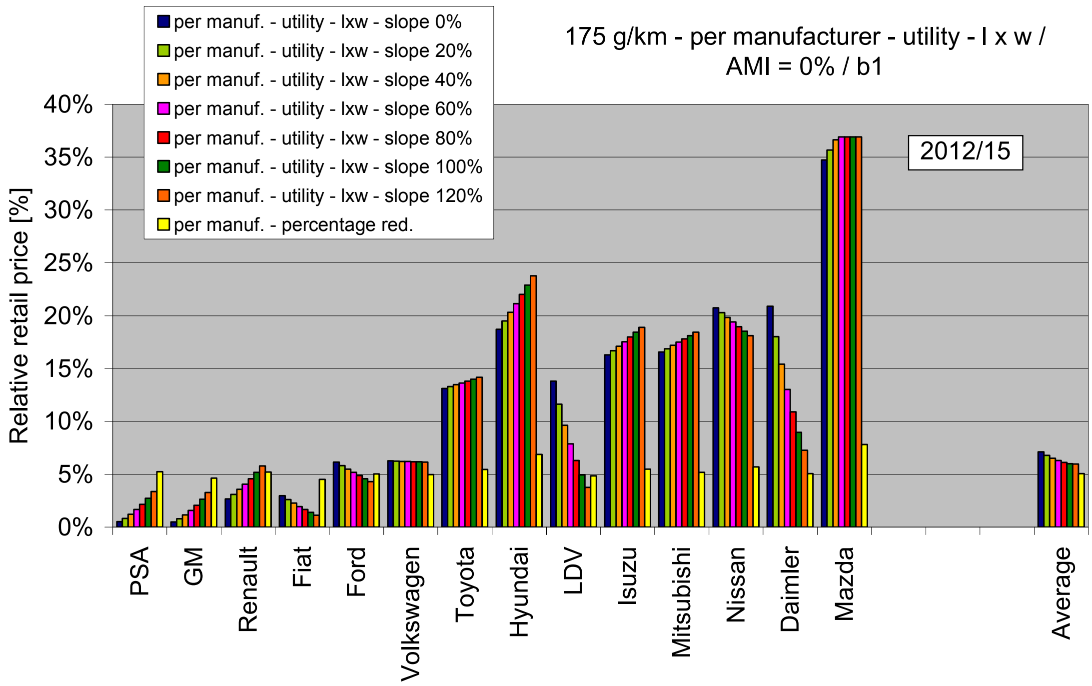
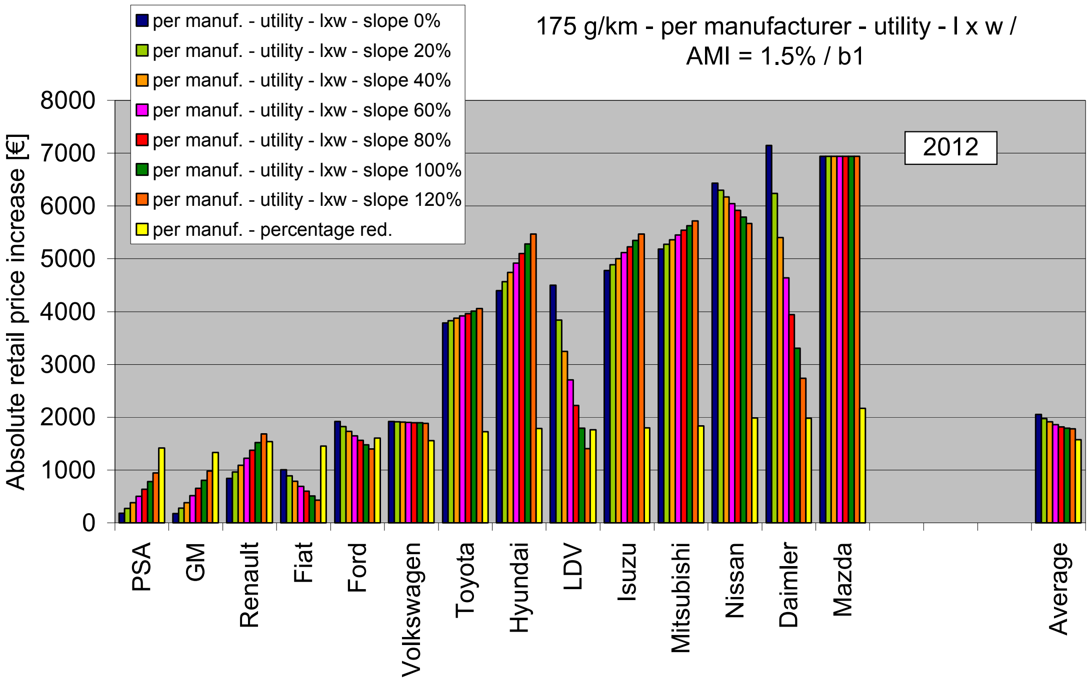
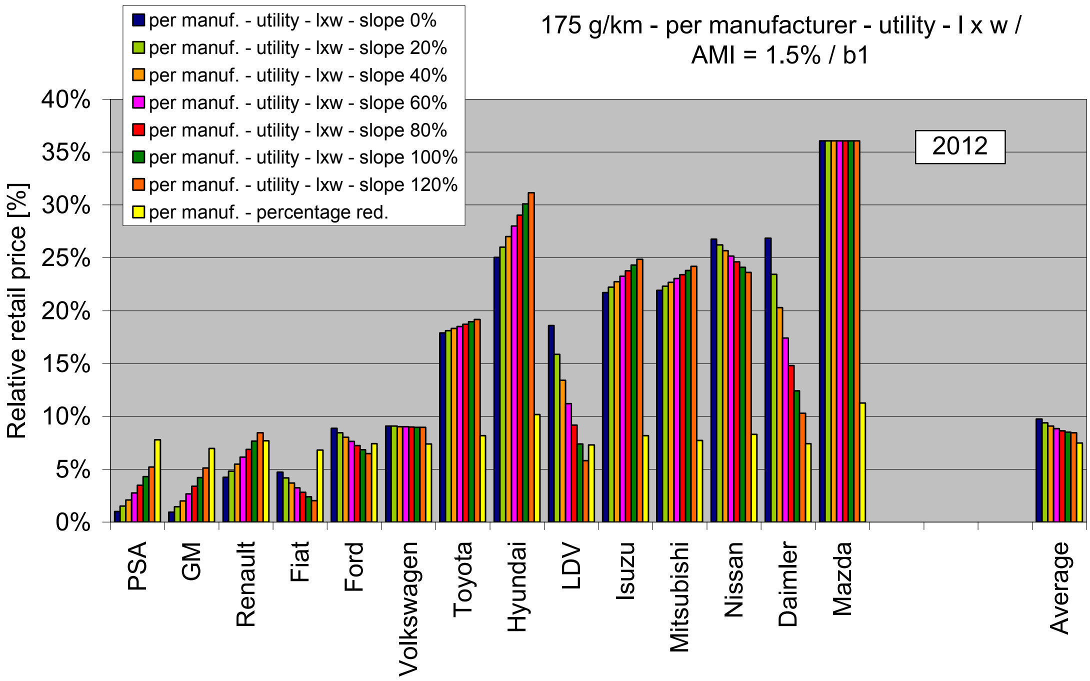


Figure 15 Absolute and relative price increase for meeting a target of 175 g/km in 2012 set by a pan area-based limit function with various slope levels, with AMI = 1.5% p.a. and baseline b1 (cost for compensating AMI not attributed to the policy)



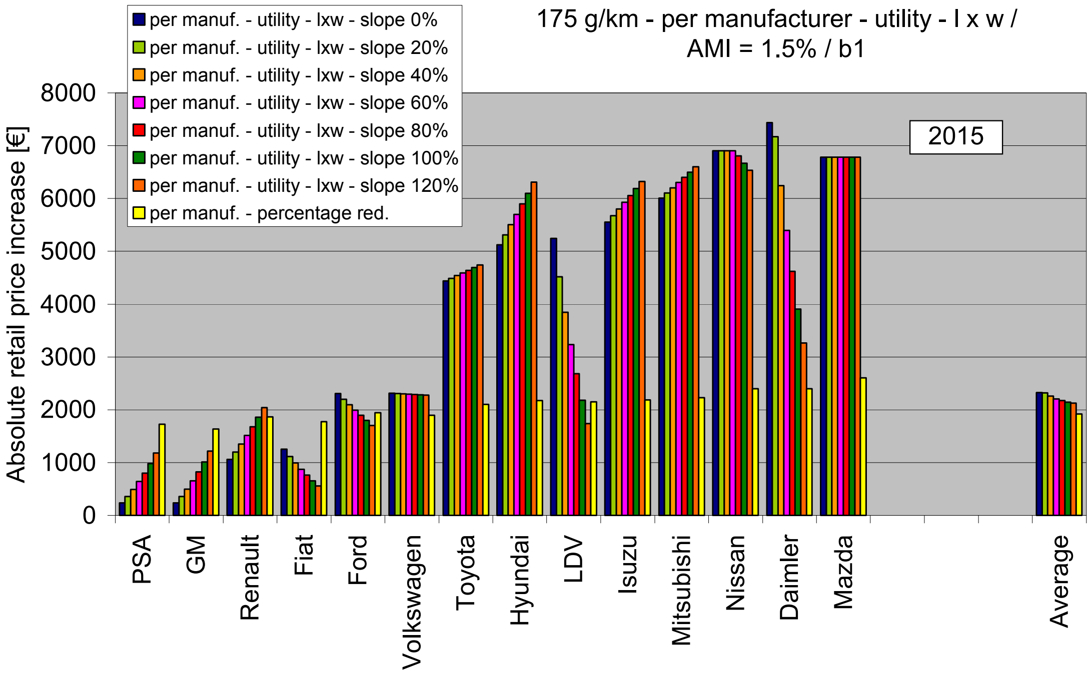


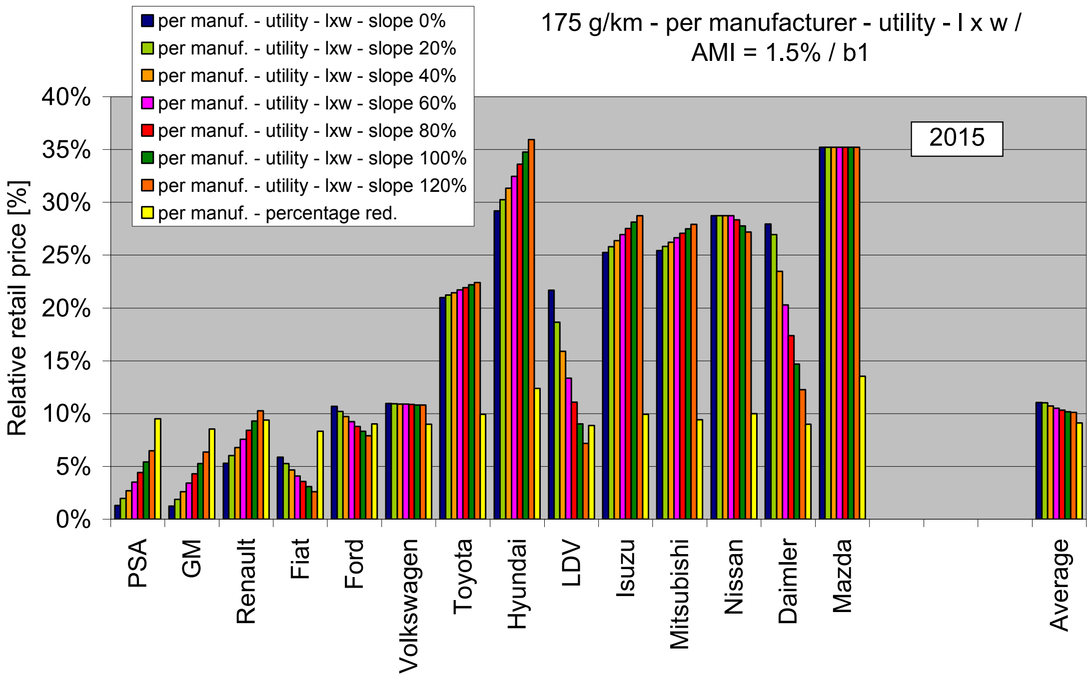
6.4.2 Results for a target of 175 g/km in 2015

For AMI = 0.0% p.a. the costs of meeting a target are independent of the target year in the assessment methodology used here. The results for meeting 175 g/km in 2015 using a pan area-based limit function under the assumption of zero autonomous mass increase are therefore identical to the results for 2012 depicted in Figure 14.

The costs for meeting 175 g/km in 2015 using a pan area-based limit function in the case of AMI = 1.5% p.a. are depicted in Figure 16 below.

Figure 16 Absolute and relative price increase for meeting a target of 175 g/km in 2015 set by a pan area-based limit function with various slope levels, with AMI = 1.5% p.a. and baseline b1 (cost for compensating AMI not attributed to the policy)



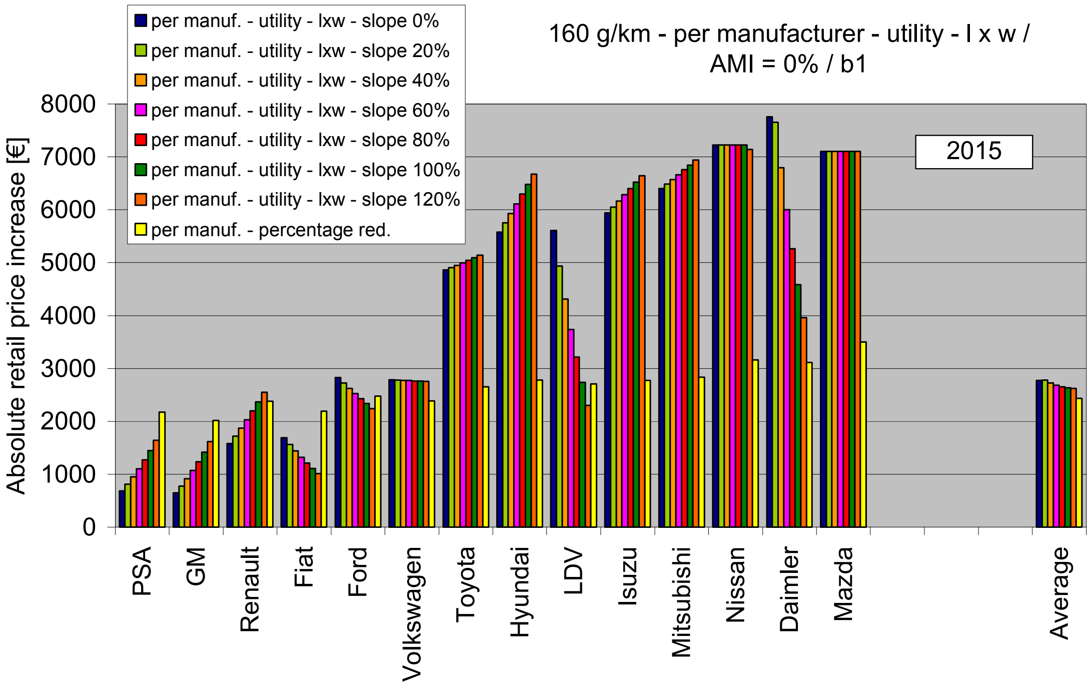


Similar to the case of a mass-based limit function, on can observe here that for manufacturers that are not able to meet the target (which can be seen from the fact that costs do not change with the slope of the limit function) the costs appear to go down with shifting the target year from 2012 to 2015. This is the result of comparing the costs to baseline b1 (see section 2.2 of Note 6 on page 78 of the technical notes in [IEEP 2007]) in which the costs of applying CO_2 reduction measures to compensate the impacts of autonomous mass increase in the absence of a CO_2 legislation are not attributed to the CO_2 legislation. If a manufacturer reaches the “ceiling” of the cost curve the overall costs can not go up with increasing impact of AMI as a result of postponing the target year. But the costs for compensating this impact in the absence of CO_2 legislation, which are subtracted from the costs of meeting the target, do increase with postponing the target year.

6.4.3 Results for a target of 160 g/km in 2015

Figure 17 and Figure 18 present distributional impacts in terms of retail price increase per vehicle for the different manufacturers for the 160 g/km target for 2015 for different values of the slope of the pan area-based limit function and for two different assumptions on autonomous mass increase: AMI = 0.0% resp. 1.5% p.a.. In addition to pan area-based limit functions also results are displayed for the percentage reduction option, in which all manufacturers must reduce their sales-averaged CO_2 emissions by the same percentage.

Figure 17 Absolute and relative price increase for meeting a target of 160 g/km in 2015 set by a pan area-based limit function with various slope levels, with AMI = 0.0% p.a. and baseline b0 = b1



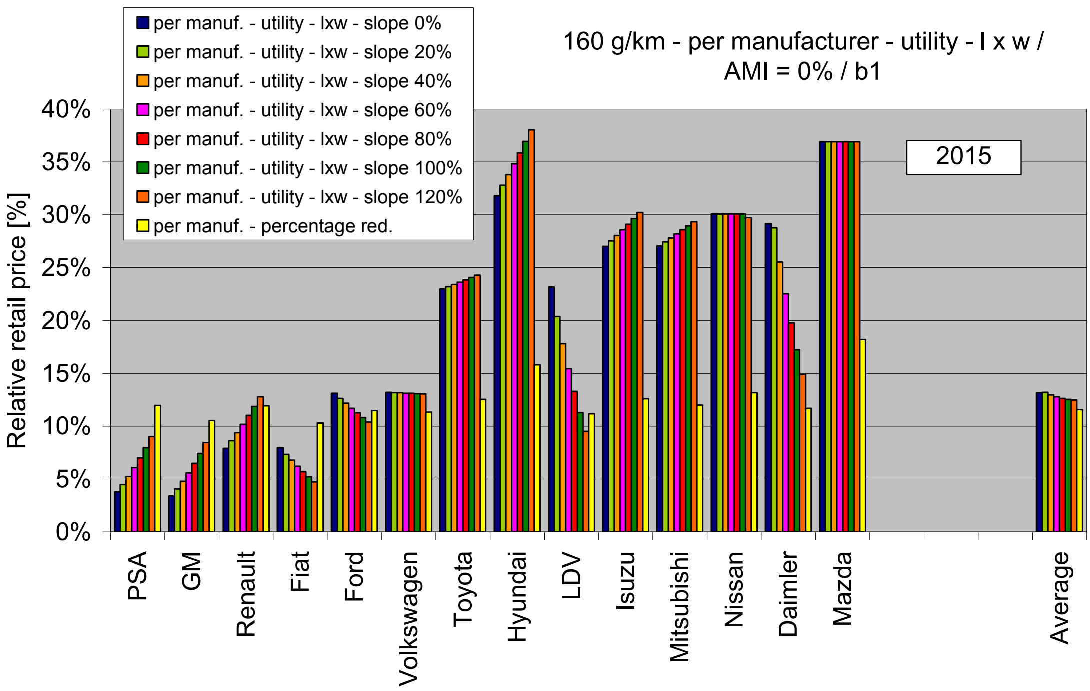
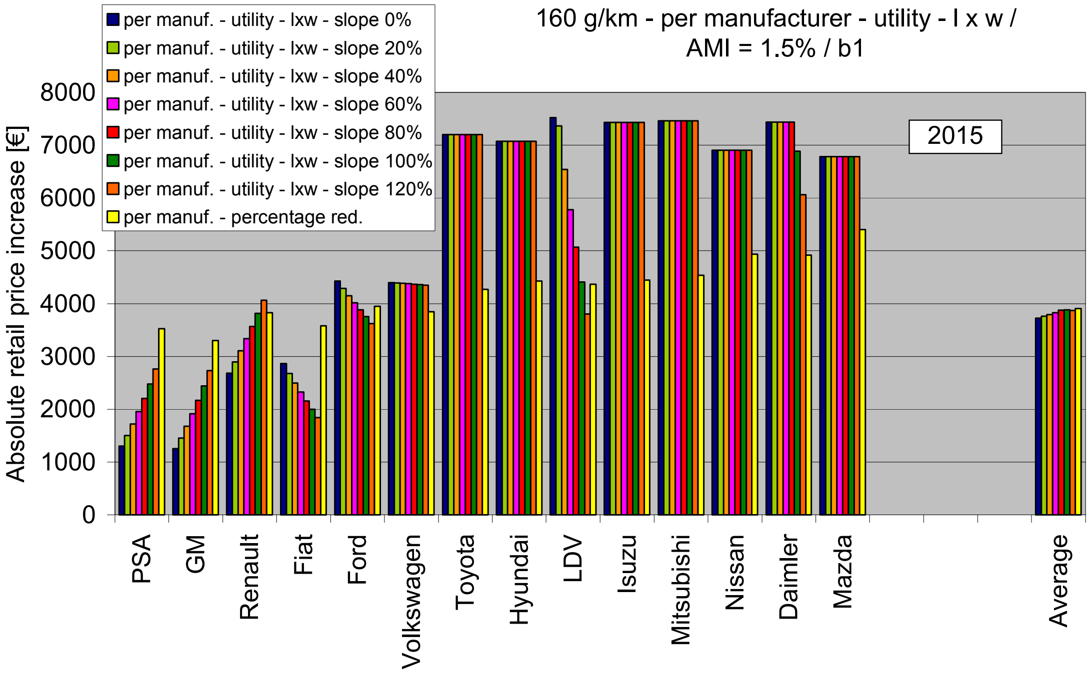
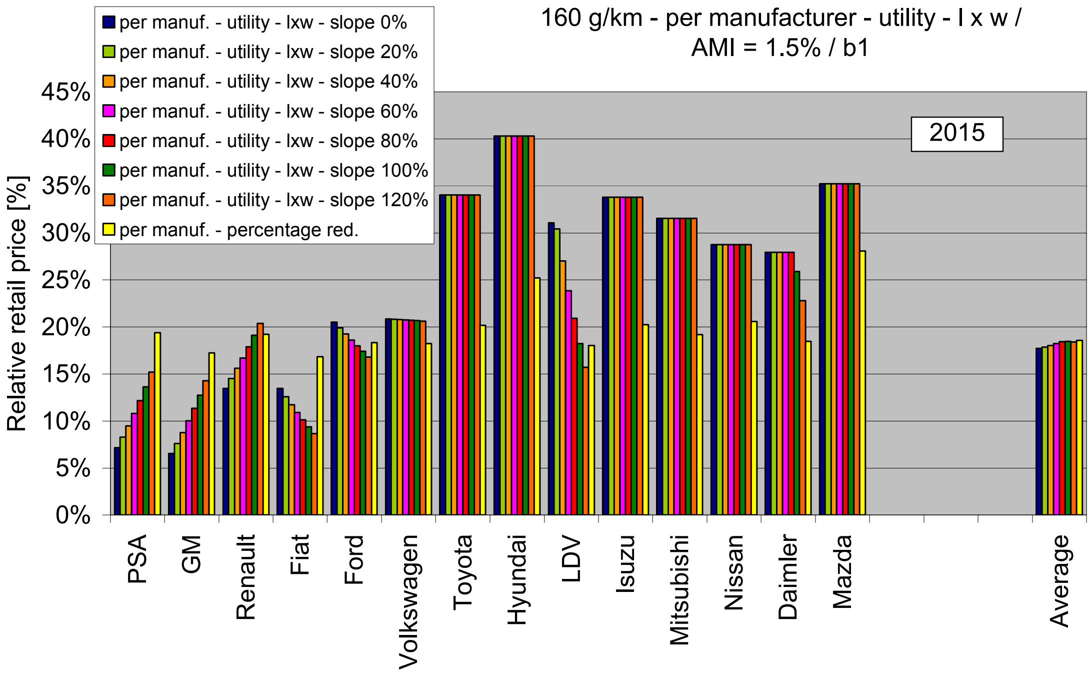


Figure 18 Absolute and relative price increase for meeting a 160 g/km target in 2015 set by a pan area-based limit function with various slope levels, with AMI = 1.5% p.a. and baseline b1 (cost for compensating AMI not attributed to the policy)





6.4.4 Division of costs over vehicle segments for pan area-based limit functions

The division of costs over segments (fuel type and mass class) is illustrated in Figure 19 to Figure 23 on the next pages for the 175 g/km target for 2012 and 2015 and the 160 g/km target for 2015, both in the case of AMI = 0.0% and 1.5% p.a.

Also here the cost assessment model predicts relatively high CO_2 reductions and associated costs for petrol vehicles, but similarly to the case of mass-based limit functions this does not significantly affect the reductions to be achieved in diesel vehicles or the average costs for meeting the target. For this reason this unrealistic effect on petrol vehicle has not been corrected in the model.

Also for pan area the average price increase for vehicles of Class II and III is not very sensitive to the slope of the limit function. For Class I vehicles the impact of slope is large. The most even distribution of costs over the three diesel segments is achieved at slope values of 80% or more.

Figure 19 Relative retail price increase per segment for a target of 175 g/km in 2012 and 2015, a pan area-based utility function with various slopes and AMI = 0.0% and baseline b0 = b1

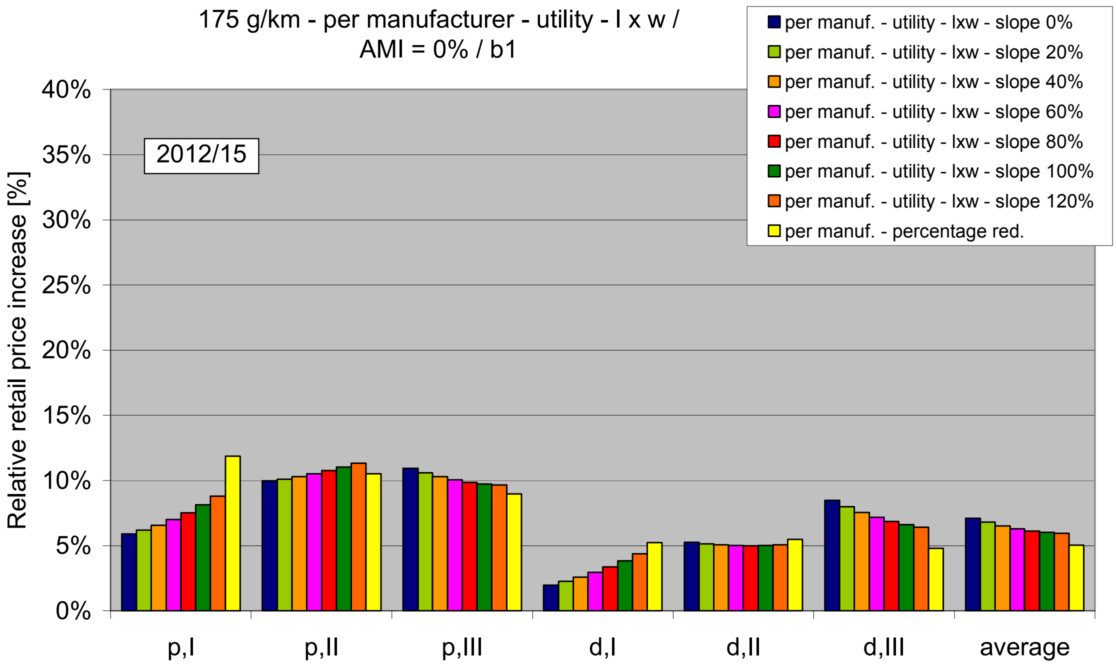


Figure 20 Relative retail price increase per segment for a target of 175 g/km in 2012, a pan area-based utility function with various slopes and AMI = 1.5% and baseline b1 (cost for compensating AMI not attributed to the policy)

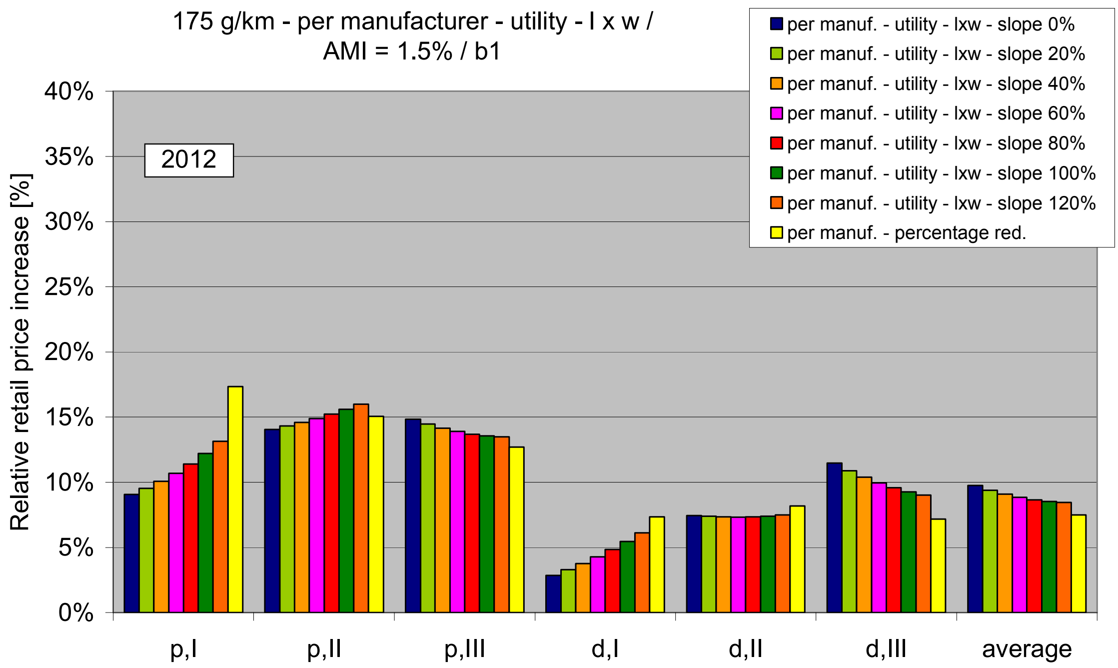


Figure 21 Relative retail price increase per segment for a target of 175 g/km in 2015, a pan area-based utility function with various slopes and AMI = 1.5% and baseline b1 (cost for compensating AMI not attributed to the policy)

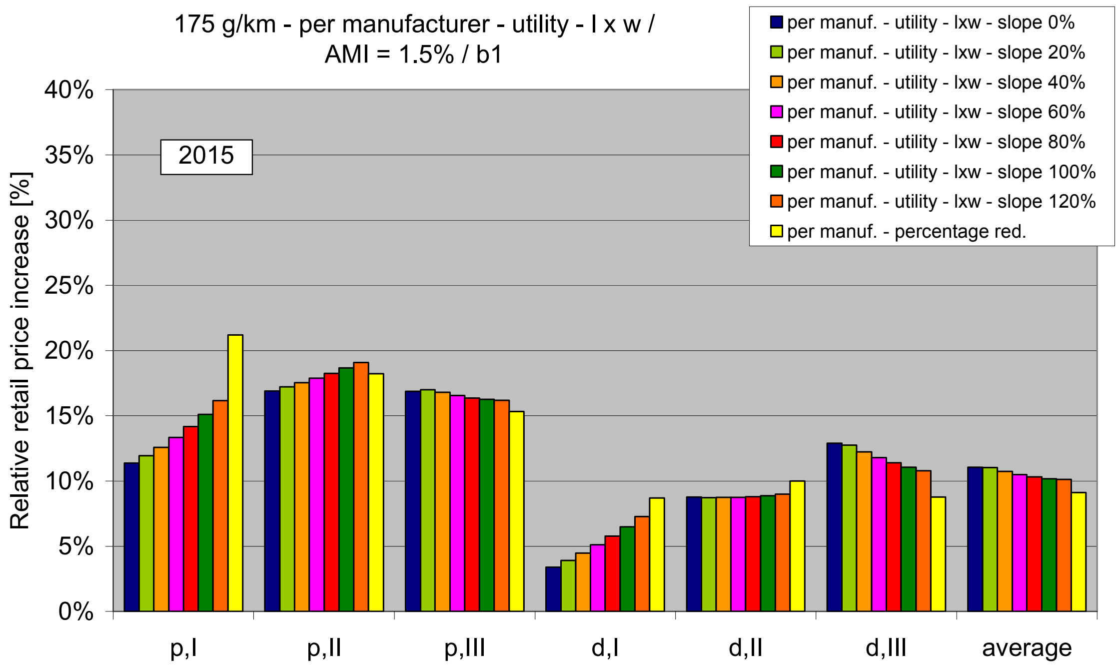


Figure 22 Relative retail price increase per segment for a target of 160 g/km in 2015, a pan area-based utility function with various slopes and AMI = 0.0% and baseline b0 = b1

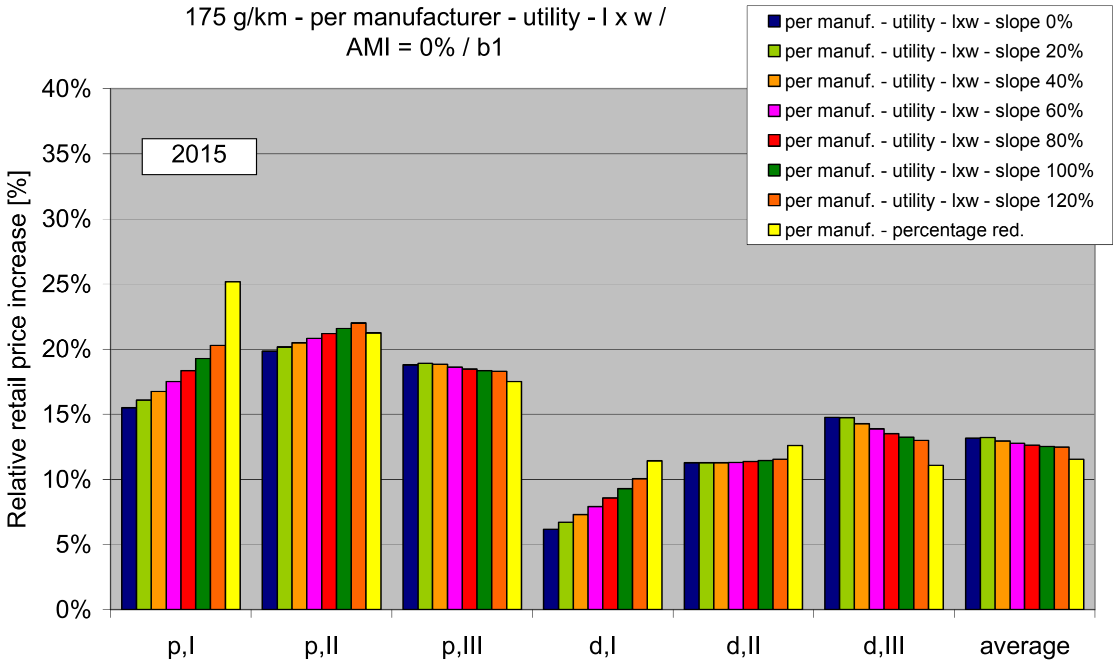
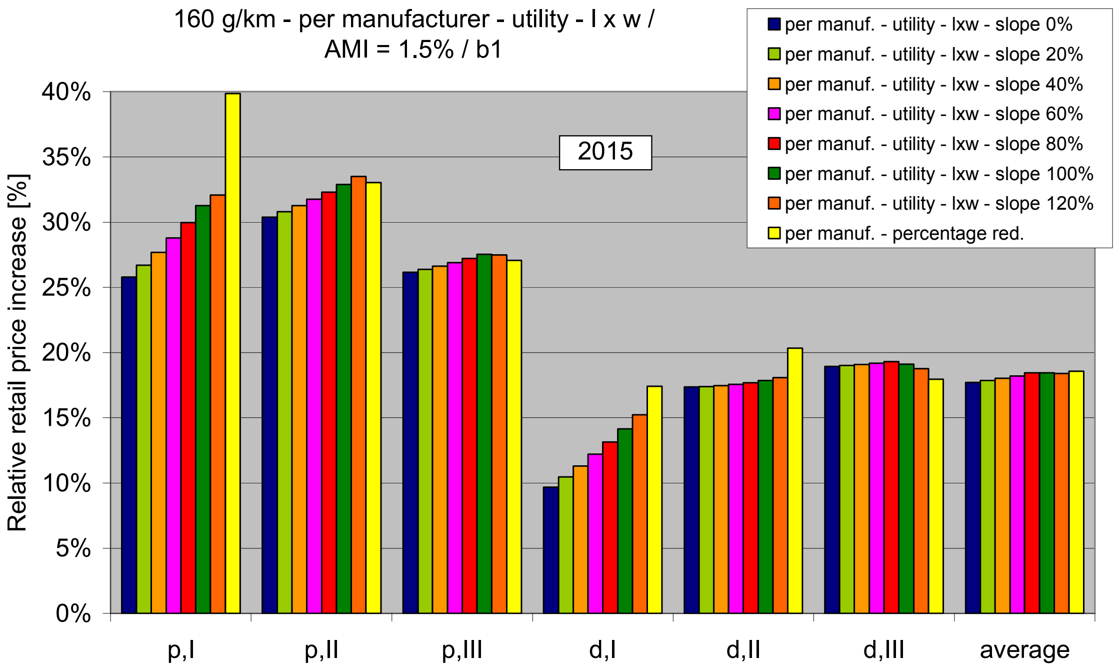


Figure 23 Relative retail price increase per segment for a target of 160 g/km in 2015, a pan area-based utility function with various slopes and AMI = 1.5% and baseline b1 (cost for compensating AMI not attributed to the policy)



6.4.5 Average costs for meeting targets combined with a pan area-based limit function

The average costs for meeting the target with a pan area based limit function are presented in Table 6.5 below. For the 175 g/km and AMI = 0.0% target cost decrease with increasing slope. For the 160 g/km target for 2015 and both AMI assumptions this is the other way around. In the case of 175 g/km and AMI = 1.5% p.a. the costs are not very sensitive to the slope of the limit function. Comparison with Table 6.4 for mass-based limit functions shows that the cost for meeting the target are generally somewhat higher for pan area than for mass.

Table 6.5 Overview of absolute and relative average price increase per segment for different target levels, different slopes of the pan area-based limit function and different assumptions with respect to AMI relative to baseline b1 (cost for compensating AMI not attributed to the policy)

				2007-2012/15 add. absolute retail price per car [€]							2007-2012/15 add. relative retail price per car [%]						
target	year	AMI	slope	p,I	p,II	p,III	d,I	d,II	d,III	average	p,I	p,II	p,III	d,I	d,II	d,III	average
175	2012 / 2015	0.0%	0%	641	1400	2183	269	906	2123	1498	5.9%	10.0%	10.9%	2.0%	5.3%	8.5%	7.1%
			20%	675	1422	2114	309	886	1999	1429	6.2%	10.1%	10.6%	2.3%	5.1%	8.0%	6.8%
			40%	714	1448	2056	355	872	1891	1372	6.6%	10.3%	10.3%	2.6%	5.1%	7.5%	6.5%
			60%	762	1478	2008	406	864	1798	1326	7.0%	10.5%	10.1%	3.0%	5.0%	7.2%	6.3%
			80%	819	1512	1970	464	862	1719	1290	7.5%	10.8%	9.9%	3.4%	5.0%	6.9%	6.1%
			100%	884	1551	1943	527	866	1655	1266	8.1%	11.0%	9.7%	3.9%	5.0%	6.6%	6.0%
			120%	958	1594	1926	597	875	1606	1253	8.8%	11.3%	9.6%	4.4%	5.1%	6.4%	6.0%
			percentage	1291	1481	1792	717	945	1201	1062	11.9%	10.5%	9.0%	5.2%	5.5%	4.8%	5.0%
160	2015	0.0%	0%	1687	2791	3749	845	1943	3702	2771	15.5%	19.9%	18.8%	6.2%	11.3%	14.8%	13.2%
			20%	1751	2833	3776	918	1941	3695	2780	16.1%	20.2%	18.9%	6.7%	11.3%	14.7%	13.2%
			40%	1823	2879	3761	996	1944	3576	2727	16.8%	20.5%	18.8%	7.3%	11.3%	14.3%	13.0%
			60%	1905	2928	3717	1081	1949	3475	2685	17.5%	20.8%	18.6%	7.9%	11.3%	13.9%	12.8%
			80%	1996	2980	3686	1173	1957	3390	2655	18.3%	21.2%	18.5%	8.6%	11.4%	13.5%	12.6%
			100%	2097	3034	3665	1270	1971	3321	2636	19.3%	21.6%	18.4%	9.3%	11.4%	13.2%	12.5%
			120%	2207	3094	3654	1374	1991	3259	2624	20.3%	22.0%	18.3%	10.0%	11.6%	13.0%	12.5%
			percentage	2740	2986	3496	1562	2172	2779	2431	25.2%	21.2%	17.5%	11.4%	12.6%	11.1%	11.6%
175	2012	1.5%	0%	987	1975	2963	393	1283	2879	2051	9.1%	14.1%	14.8%	2.9%	7.4%	11.5%	9.7%
			20%	1036	2012	2890	450	1275	2731	1974	9.5%	14.3%	14.5%	3.3%	7.4%	10.9%	9.4%
			40%	1095	2052	2826	514	1266	2603	1910	10.1%	14.6%	14.2%	3.8%	7.3%	10.4%	9.1%
			60%	1163	2093	2774	585	1263	2492	1859	10.7%	14.9%	13.9%	4.3%	7.3%	9.9%	8.8%
			80%	1242	2140	2734	662	1267	2399	1820	11.4%	15.2%	13.7%	4.8%	7.4%	9.6%	8.7%
			100%	1330	2191	2707	747	1275	2323	1794	12.2%	15.6%	13.6%	5.5%	7.4%	9.3%	8.5%
			120%	1429	2247	2691	839	1290	2263	1780	13.1%	16.0%	13.5%	6.1%	7.5%	9.0%	8.5%
			percentage	1887	2117	2534	1005	1410	1800	1577	17.3%	15.1%	12.7%	7.3%	8.2%	7.2%	7.5%
175	2015	1.5%	0%	1238	2376	3365	465	1511	3232	2326	11.4%	16.9%	16.9%	3.4%	8.8%	12.9%	11.1%
			20%	1298	2419	3391	536	1505	3197	2317	11.9%	17.2%	17.0%	3.9%	8.7%	12.8%	11.0%
			40%	1369	2465	3352	614	1506	3066	2257	12.6%	17.5%	16.8%	4.5%	8.7%	12.2%	10.7%
			60%	1450	2514	3304	699	1507	2957	2209	13.3%	17.9%	16.5%	5.1%	8.7%	11.8%	10.5%
			80%	1542	2566	3268	790	1514	2858	2171	14.2%	18.3%	16.4%	5.8%	8.8%	11.4%	10.3%
			100%	1644	2622	3245	889	1528	2773	2143	15.1%	18.7%	16.3%	6.5%	8.9%	11.1%	10.2%
			120%	1758	2684	3235	995	1549	2706	2129	16.2%	19.1%	16.2%	7.3%	9.0%	10.8%	10.1%
			percentage	2305	2563	3061	1190	1723	2198	1920	21.2%	18.2%	15.3%	8.7%	10.0%	8.8%	9.1%
160	2015	1.5%	0%	2806	4269	5220	1323	2993	4748	3728	25.8%	30.4%	26.1%	9.7%	17.4%	18.9%	17.7%
			20%	2904	4329	5264	1431	2997	4765	3758	26.7%	30.8%	26.4%	10.5%	17.4%	19.0%	17.9%
			40%	3012	4395	5314	1546	3007	4782	3791	27.7%	31.3%	26.6%	11.3%	17.5%	19.1%	18.0%
			60%	3130	4465	5371	1669	3023	4806	3831	28.8%	31.8%	26.9%	12.2%	17.6%	19.2%	18.2%
			80%	3260	4540	5433	1799	3047	4837	3878	30.0%	32.3%	27.2%	13.2%	17.7%	19.3%	18.4%
			100%	3401	4621	5497	1937	3077	4789	3883	31.3%	32.9%	27.5%	14.2%	17.9%	19.1%	18.5%
			120%	3489	4708	5489	2084	3114	4706	3870	32.1%	33.5%	27.5%	15.2%	18.1%	18.8%	18.4%
			percentage	4334	4641	5403	2383	3506	4499	3907	39.8%	33.0%	27.1%	17.4%	20.4%	17.9%	18.6%

6.5 Conclusions

6.5.1 Conclusions for mass-based limit functions

- The average retail price increase (excl. VAT) per vehicle for meeting the 175 g/km target for 2012 or 2015 in the absence of autonomous mass increase (AMI) is between € 1100 and € 1500 per vehicle depending on the slope of the limit function. This is equal to 5% - 7% of the new vehicle base price. Costs increase with decreasing slope of the limit function.
- With AMI = 1.5% p.a. the costs for meeting 175 g/km in 2012 increase to around 7.8% - 9.5% of the average 2007 vehicle price. For 2015 as target year this AMI scenario leads to a retail price increase of 9% - 11%.
- The average retail price increase (excl. VAT) per vehicle for meeting the 160 g/km target for 2015 in the absence of autonomous mass increase are between € 2500 and € 2800 per vehicle depending on the slope of the limit function. This is equal to 12% - 13% of the new vehicle base price. For this target the costs decrease with decreasing slope. With AMI = 1.5% p.a. these costs increase to €3700 to € 4000 or 18% - 19% of the vehicle base price. It should be noted here that the target is not entirely met in this scenario, and that the costs assessed here are exclusive of possible penalties for not meeting targets.
- This detailed cost analysis confirms the expectation that the low share of petrol vehicles found in the new JATO 2007 light commercial vehicle database leads to higher costs for meeting CO_2 reduction targets for light commercial vehicles than was calculated in previous assessments ([TNO 2006] and [IEEP 2007]). These previous assessments were based on information on the petrol/diesel shares for 2004 obtained from TREMOVE (see section 3.3).
- Due to the low petrol share almost all of the CO_2 reduction will be realised in diesel vehicles. In some cases the lower available reduction potential in diesel vehicles (compared to petrol) leads to required reductions which are close to, or at the maximum reduction potentials given by, the cost curves for the 6 segments of N-type vehicles. This is especially prominent for the proposed target of 160 g/km for 2015.
- All this leads to higher costs than originally projected for meeting the proposed targets and raises some important questions regarding the technical feasibility of the 160 g/km target for 2015. Based on the assessments presented here it appears that the 160 g/km target for 2015 can not be met by several manufacturers without some kind of pooling arrangement and requires large scale application of advanced technologies (e.g. mild and full hybridisation).
- The 175 g/km for 2012 or 2015 seems feasible for most European manufacturers but appears to require very large reduction levels for various Japanese and Korean manufacturers. This is at least partly due to the inclusion in the database of large pick-up SUVs, for which it is currently not clear whether these are type-approved as N1.
- For the 175 g/km target the average costs for meeting the target decrease with increasing slope of the mass-based limit function. Slope values between 80% and 120% lead to the most even distribution of costs over manufacturers. For 160 g/km in 2015 the costs increase with increasing slope.
- For vehicles of Class II and to a lesser extent Class III the average price increase is not very sensitive to the slope of the limit function. For Class I vehicles the impact of slope is large. The most even distribution of costs over the three diesel segments is achieved at slope values of 80% or more.

6.5.2 Conclusions for pan area-based limit functions

Many conclusions are the same for pan area and for mass-based limit functions. The main differences are:

- A comparison with the same scenarios (target value and AMI) for a mass-based limit function shows that the distributional impacts are somewhat more pronounced for pan area than for mass. With tight target levels or high autonomous mass increase more manufacturers may not be able to meet their specific targets without pooling.
- For the 175 g/km target the cost for meeting the target are somewhat higher for pan area than for mass.

6.5.3 Conclusions for percentage reduction

- As with M1 vehicles the percentage reduction option (all manufacturers obliged to reduce CO_2 emission by the same percentage) leads to the most even distribution of the burden for meeting the target over all manufacturers. The percentage reduction option also avoids the problem of manufacturers not being able to meet their target.

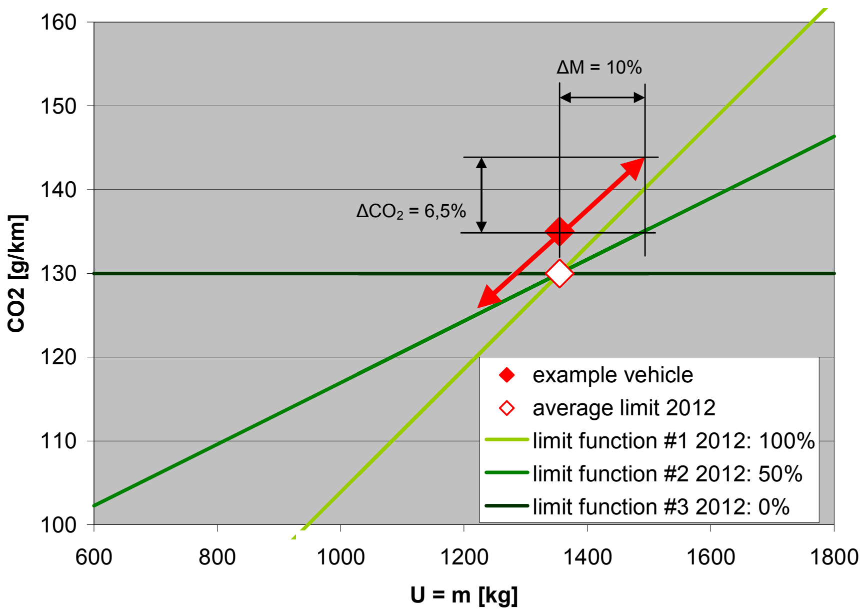
7 Considerations on perverse incentives and gaming with respect to the CO_2 regulation for light commercial vehicles

7.1 Introduction

A first assessment has been made of the possible perverse incentives and possibilities for gaming resulting from the use of mass as a utility parameter for the CO_2 limit function for light commercial vehicles. The same approach has been used as was applied to M1 vehicles in previous work (see Annex A to Technical Note 8 of [IEEP 2007]).

To assess the extent to which a mass-based limit function creates perverse incentives or creates opportunities for gaming one needs to look at the effects of mass increase or decrease on a vehicle's CO_2 emission and compare these effects with the effect of the same mass variation on the limit value set by the mass-based limit function. If adding weight to a vehicle moves the vehicle closer to the target line, the mass based limit function can be said to create a perverse incentive for manufacturers to game the legislation by making vehicles heaver or by selling heavier vehicles. This is illustrated in Figure 24 below (taken from [IEEP 2007].

Figure 24 Illustration of the effect of mass increase on CO_2 compared to the slope of the limit function



The extent to which an increase in mass moves vehicles closer to or further away from the target line is not the only factor that determines the strength of the perverse incentive created by the use of a mass-based limit function. Especially in the case of vans other factors may come into play. This is further explored in section 7.5.

7.2 Three types of gaming / perverse incentives

In [IEEP 2007] three main types of perverse incentives / gaming options are identified:

- Option 1 is a gaming option which is often referred to as the proverbial "brick in the boot". Manufacturers may simply add weight to the body-in white or other parts of the vehicle or may even add removable items to the vehicle (e.g. additional seats) that add weight on the type approval test but are removed from the car by most users. This added weight will lead to a loss of performance (due to lower power-to-weight ratio), but this could be acceptable if the added weight is limited. In the short term this may be a means of achieving a sales weighted CO_2 emission target at low costs, but in the longer run it would seem that heavier cars with reduced performance will be hard to sell. In the case of N-type vehicles this option goes at the expense of payload.
- Option 2 is to add mass to the car while at the same time applying compensating measures to engine and powertrain to maintain vehicle performance. If this brings a vehicle closer to the target line this target definition is said to create a perverse incentive for building heavier cars. This is the mechanism that also corresponds to the term autonomous mass increase where vehicle models get heavier over time due to e.g. additional passive safety measures and increased comfort. This autonomous mass increase (AMI) is taken into account in the modelling as an annual weight increase of all models within a given vehicle class. It is at present unclear to what extent there is an autonomous mass increase trend in N-type vehicles. A mass based limit function may however reward producing more luxurious or larger vans.
- Option 3 is the mechanism that corresponds to upward or downward market shifts, e.g. consumers buying on average larger and better performing cars or smaller and less performing cars. In case of an upward market shift this trend will also lead to an increase of the average mass of newly sold vehicles over time. Manufacturers can to some extent influence this trend by marketing and pricing strategies. This option is considered less relevant for N-type vehicles than for M1s as with LCVs the power-to-weight ratio and associated performance does not increase with increasing mass.

7.3 The relation between mass and CO_2

CO_2 emissions generally increase with increasing vehicle mass. The amount by which CO_2 emissions increase depends on whether measures are taken to compensate for loss of performance , and will thus be different for the three perverse incentives / gaming options identified above. In [TNO 2006] the following generalised formula is used to describe the impact of a (relatively small) mass increase/decrease on CO_2 emissions (and fuel consumption):

$$\Delta CO_2 / CO_2 = \gamma \times \Delta m / m \qquad (1)$$

The coefficient γ may have different values for the different gaming options. In the case of M1 vehicles [TNO 2006] found that for option 1 ("brick in the boot") $\gamma = 0.35$. For option 2 (mass increase while maintaining performance) it was found that $\gamma = 0.65$ for M1 vehicles. For option 3 the value of γ is higher than 0.65 in the case of M1 vehicles as increased mass in this case is accompanied by increased power-to-weight ratio also. Whether this is also the case for N-type vehicles needs to be further analysed. The value can be determined from the slope of the unweighted least squares fit through the CO_2 vs mass data in the reference year.

It is at moment unclear whether the same values for γ can be used for N-type vehicles. In principle N-type vehicles have larger frontal area and c_w than M1 vehicles of the same mass, so that the relative increase of CO_2 emissions as function of mass may be smaller. This means that the values of γ for the three options for gaming / perverse incentives may be somewhat smaller than for M1 vehicles. This may need to be further analysed in a later stage. For the moment we will use the values 0.65 and 0.35 for the analysis of perverse incentives for vans.

7.4 Comparison of the impacts of mass increase with the slope of the limit function

Table 7.1 below lists the slopes and y-axis intercepts for the 2007 sales weighted fit of CO_2 vs mass and 2012 limit functions based on an overall target of 175 g/km and various slopes.

Table 7.1 2007 sales weighted fit of CO_2 vs mass and 2012 limit functions (CO_2 limit value = a m + b, with m the average mass, a the slope of the limit function and b the y-axis intercept) based on an overall target of 175 g/km, AMI = 0.0% and various slope values

	a	b
2007 sales weighted least squares fit	0.1079	16.33
2012 100% limit function	0.0930	14.07
2012 80% limit function	0.0744	46.26
2012 60% limit function	0.0558	78.44
2012 40% limit function	0.0372	110.63
2012 20% limit function	0.0186	142.81

For the cases of γ = 0.65 and 0.35 in formula (1), Table 7.2 shows the ratios of the CO_2 v mass increase slopes (for points on the 2007 sales weighted least squares fit as well as on the 2012 limit functions for slopes ranging from 100% to 20%) compared to the 100% limit function slope. It is clear from this table that, under the assumption that formula (2) is valid and that γ = 0.65, gaming option 2 does not bring vehicles closer to the target line for limit function slopes of 60% and lower. In case γ = 0.35 the slope of the limit function needs to well below 40% in order not to reward mass increase as a means to bring vehicles closed to the target line. These conclusions remain valid also for smaller values of γ for the perverse incentives / gaming options 1 (down to γ = 0.58) and 2 (down to γ = 0.30).

The above is further illustrated in the graph in Figure 25 below, which shows the slopes of two sets of mass variations, all for the case of γ = 0.65:

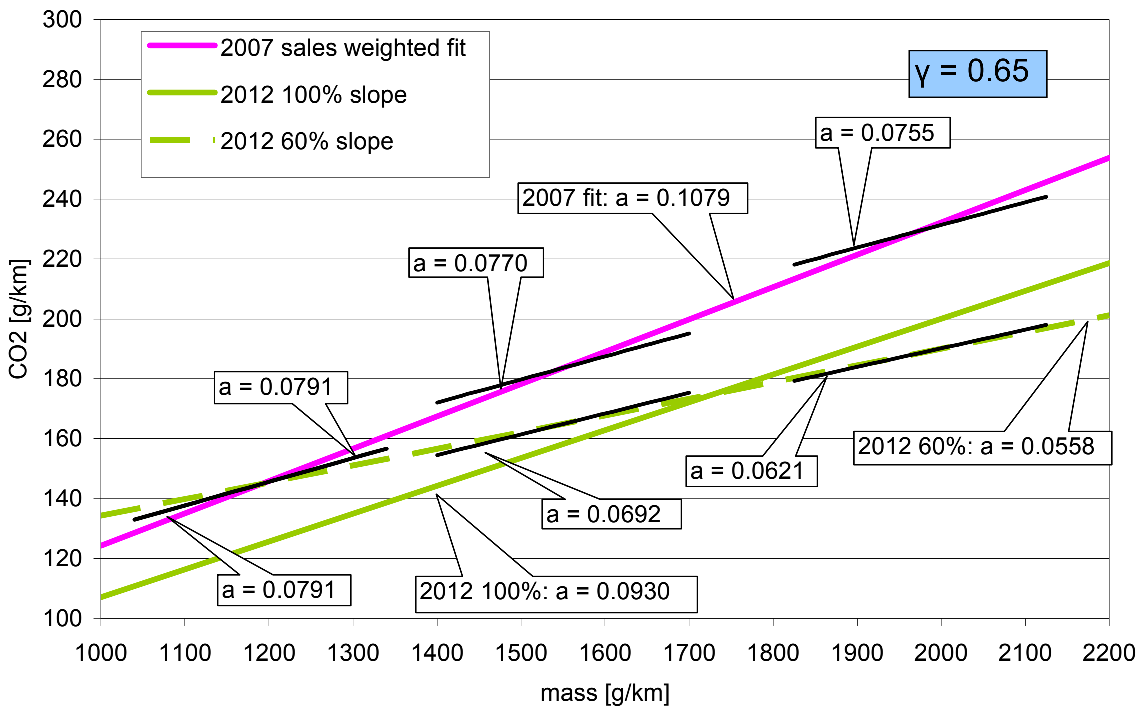
- one set of three examples of N-type vehicles that are on the line determined by the sales weighted fit of CO_2 against mass for all vehicles sold in 2007;
- one set of three examples of N-type vehicles that are on the line determined by the 60% mass-based limit function that yields an average of 175 g/km in 2012.

The example vehicles in the graph have mass values roughly equal to the average mass for class I, II and III N1 vehicles. For all vehicles that are above or on the 2012 limit function with 60% slope the relative increase of CO_2 with mass, associated with a value of γ = 0.65 in equation (1), is larger than the slope of the limit 60% function so that mass increase also increases the distance to target and is thus not perversely rewarded.

Table 7.2 Comparison of the slope associated with the CO_2 increase resulting from increased mass according to equation (1) and the slopes of various mass-based limit functions associated with a 2012 target of 175 g/km and AMI = 0.0% p.a.

2012 target = 175 g/km	m [kg]	CO_2 [g/km]	γ	slope [g/km/kg]	relative slope	γ	slope [g/km/kg]	relative slope
2007 sales weighted least squares fit	1190	144.8	0.65	0.0791	85%	0.35	0.0426	46%
	1550	183.6	0.65	0.0770	83%	0.35	0.0415	45%
	1975	229.5	0.65	0.0755	81%	0.35	0.0407	44%
2012 100% limit function	1190	124.7	0.65	0.0681	73%	0.35	0.0367	39%
	1550	158.2	0.65	0.0663	71%	0.35	0.0357	38%
	1975	197.7	0.65	0.0651	70%	0.35	0.0350	38%
2012 80% limit function	1190	134.8	0.65	0.0736	79%	0.35	0.0396	43%
	1550	161.6	0.65	0.0677	73%	0.35	0.0365	39%
	1975	193.2	0.65	0.0636	68%	0.35	0.0342	37%
2012 60% limit function	1190	144.8	0.65	0.0791	85%	0.35	0.0426	46%
	1550	164.9	0.65	0.0692	74%	0.35	0.0372	40%
	1975	188.6	0.65	0.0621	67%	0.35	0.0334	36%
2012 40% limit function	1190	154.9	0.65	0.0846	91%	0.35	0.0456	49%
	1550	168.3	0.65	0.0706	76%	0.35	0.0380	41%
	1975	184.1	0.65	0.0606	65%	0.35	0.0326	35%
2012 20% limit function	1190	164.9	0.65	0.0901	97%	0.35	0.0485	52%
	1550	171.6	0.65	0.0720	77%	0.35	0.0388	42%
	1975	179.5	0.65	0.0591	64%	0.35	0.0318	34%

Figure 25 Graphic illustration of the comparison of the slope associated with the CO_2 increase resulting from increased mass according to equation (1) and γ = 0.65 and the 60 % slope case for the mass-based limit function associated with a 2012 target of 175 g/km and AMI = 0.0% p.a.



7.5 Considerations on the likelihood of gaming in the case of LCVs

The likeliness of mass increase being used by manufactures as a means to reduce the amount of CO_2 reduction measures to be applied is considered significantly less in the case of N-type vehicles for the following reasons:

- In the case of option 1 (the brick in the boot) gaming goes at the expense of payload. This will not be acceptable to a large share of the vehicle users.
- In the case of option 2 engine power is also increased leading to a more expensive vehicle. Buyers of vans are expected to be more rational and more cost sensitive than buyers of passenger cars so that it is more difficult to sell them a car that is bigger or more expensive than what they actually need for their specific transport purpose.
- This reasoning applies even stronger to option 3, which is moreover considered not really applicable for vans as buyers do not expect better performance and luxury in larger vans.

Furthermore it can be seen from the analyses in chapter 6 that increasing the average mass of LCVs (i.e. inducing a positive AMI) leads to significantly increased costs for meeting the target, if the target function is adjusted to compensate for observed AMI. Due to the dominance of diesel in LCVs, counteracting impacts of AMI on CO_2 in LCVs requires more advanced and more expensive CO_2 reduction measures (at the upper end of the cost curve) to be applied than is the case for M1s in relation to the 130 g/km target. In the longer run gaming is thus not in the interest of LCV manufacturers.

7.6 Conclusions

From the above analysis on perverse incentives / gaming options the following conclusions can be drawn:

- As far as the numerical comparison between the impact of weight increase and the slope of mass-based limit functions is concerned, for light commercial vehicles the situation with respect perverse incentives for mass increase seems rather comparable to the case of M1 vehicles.
- A 60% slope looks safe to avoid rewarding perverse incentives / gaming options 2 and 3. Option 1 (the brick in the boot) can only be avoided with very low slopes below 30%.
- These conclusions remain valid also for smaller values of γ for the perverse incentives / gaming options 1 (down to $\gamma = 0.58$) and 2 (down to $\gamma = 0.30$).
- The likeliness of mass increase being used by manufactures as a means to reduce the amount of CO_2 reduction measures to be applied is considered significantly less in the case of N-type vehicles.

For the above reasons the advantages of using a slope of 80% or more, as identified in the cost assessment presented in chapter 6[17], can be considered to outweigh the possible perverse incentives for mass increase provided by higher slope values for the mass-based limit function.

[17] I.e. better attainability of the target, lower overall costs and a more equal distribution of costs over all manufacturers.

8 Possibilities for pooling the targets for M1 and light commercial vehicles

8.1 Introduction

As mentioned earlier it is interesting to explore possibilities to harmonize and integrate the approaches for M1 and light commercial vehicles (N1 plus N2 and M2 with reference mass below 2610 kg).

Bringing M1 and N-type vehicles under the same limit function is not a realistic option at this stage, as shown in section 5.3. Using the M1 limit function (130 g/km, 60% slope) for vans also would be equivalent to setting a CO_2 target of 147 g/km for the vans with a slope of 58%. For a possible future target based on footprint as utility parameter and actual CO_2 performance of vehicles (e.g. using a more representative driving cycle) such an integrated target setting, however, remains an option to be considered.

Using the same overall approach for M1s and LCVs, i.e. applying a utility-based limit function to determine targets per manufacturer albeit with possibly different utility parameters and slope values for the two vehicle categories, is already a first step in harmonization. In addition to that, allowing pooling of the efforts under separate targets (and resulting limit functions) for M1 and N-type vehicles may be an attractive option to integrate the legislation for M1s and LCVs. Such pooling of targets may also help to make the proposed 175 g/km target for 2012 and 2015 more flexible and feasible.

8.2 Pooling of the targets for M1 and N-type vehicles

Pooling of the targets for M1 and N-type vehicles would mean that manufacturers can compensate underachievement in one category (expressed in average g/km above target times total sales in that category) by an equivalent overachievement in the other category (expressed in average g/km below target times total sales in that category). The distance to target in M1s and Ns can be compared with different weights:

1) sales:

$$sales_{M1} \times \Delta CO2_{M1} + sales_{N} \times \Delta CO2_{N} = 0$$

2) total mileage (= sales x avg. annual mileage x avg. lifetime:

$$sales_{M1} \times mileage_{M1} \times lifetime_{M1} \times \Delta CO2_{M1} + sales_{N} \times mileage_{N} \times lifetime_{N} \times \Delta CO2_{N} = 0$$

For the analysis only option 1) is used, as possible differences in mileage for different vehicle categories are also not taken into account in the internal averaging per manufacturer and pooling between manufacturers that are allowed under the legislation for M1 vehicles.

8.3 Comparison of marginal costs for meeting various targets for light commercial vehicles and for meeting the proposed target for M1 vehicles

Table 8.1 below compares marginal costs per manufacturer for a 175 g/km target in 2012 / 2015 with different slope values for N-type vehicles with the marginal costs per manufacturer for meeting the 130 g/km target based on a 60% slope in M1 vehicles (AMI = 0.0% p.a. in both cases). This indicates for which manufacturers it may be profitable to do a bit less on N-type vehicles and to compensate this by extra reductions in their M1 vehicles.

Table 8.1 Comparison of marginal costs per manufacturer for a 175 g/km target in 2012 / 2015 with different slope values for N-type vehicles (assumed AMI = 0.0% p.a.) with the marginal costs per manufacturer for meeting the 130 g/km target based on a 60% slope in M1 vehicles

	N-type vehicles				M1 vehicles	
	target	175			target	130
	slope	60%	80%	100%	slope	60%
	N sales	marginal costs			M1 sales	marginal costs
manufacturer	[#]	[€/g/km]	[€/g/km]	[€/g/km]	[#]	[€/g/km]
ACEA						
Daimler	156700	124	108	94	913774	93
Fiat	279541	47	45	44	1115536	48
Ford	235507	76	75	74	1581958	65
GM	128245	37	43	49	1512436	64
PSA	317266	47	56	66	1998004	47
Renault	233872	70	77	84	1308043	51
Volkswagen	190664	68	65	63	2913713	62
JAMA						
Isuzu	11549	96	85	74		
Mazda	6723	190	186	181	243231	94
Mitsubishi	34675	106	96	85	107345	78
Nissan	82163	131	120	109	290743	63
Toyota	53239	95	88	82	820904	53
KAMA						
Hyundai	9054	102	94	86	490295	67
Other						
LDV	7897	99	90	81		

For almost all manufacturers the marginal costs for meeting their manufacturer-specific resulting from the overall targets and slope values for N-type vehicles are higher than the marginal costs for meeting the proposed M1 target. This means that, when pooling of targets is allowed, these manufacturers are likely to limit their CO_2 reduction efforts in N-type vehicles and to compensate this by applying more CO_2 reduction measures in M1 vehicles. The main exceptions from the above conclusion are Fiat and GM, which see lower marginal costs in Ns than in M1s for the 175 g/km target for light commercial vehicles for all three slope values.

Table 8.2 presents the net costs / benefits per N-type vehicle sold of achieving on average 1 g/km less reduction in N-type vehicles and compensating this by an equivalent reduction in M1 vehicles. These net cost / benefits are the cost reduction resulting from doing 1 g/km less in Ns (= - marginal costs for N x number of N-type vehicles) plus the cost increase resulting from reaching an equivalent reduction in M1s (= marginal costs for M1 x number of N-type vehicles), divided by the number of N-type vehicles sold. The most right hand column gives the cost increase per vehicle in the M1 category. This weighing on the basis of sales does not take account of the impact on CO_2 emissions of a possible difference in annual mileage between M1 and N-type vehicles. This could also be factored into the definition of equivalent reductions in both categories.

It is clear from the table that for almost all manufacturers pooling the targets for M1 and light commercial vehicles leads to a net cost reduction compared to the situation in which both targets have to be met separately. The cost increase in M1 vehicles resulting from lower reductions in vans is small compared to the average costs of meeting the 130 g/km target.

Table 8.2 Net cost / benefit per N-type vehicle sold per manufacturer for achieving 1 g/km less CO_2 reduction in N-type vehicles compensated by an equivalent reduction in M1 vehicles. The most right hand column gives the associated cost increase per vehicle in the M1 category.

	N-type vehicles				M1 vehicles	
	target	175			target	130
	slope	60%	80%	100%	slope	60%
	N sales	net cost reduction			M1 sales	cost increase
manufacturer	[#]	[€/veh.]	[€/veh.]	[€/veh.]	[#]	[€/veh.]
ACEA						
Daimler	156700	-30	-15	0	913774	16.0
Fiat	279541	2	3	5	1115536	12.1
Ford	235507	-11	-10	-9	1581958	9.7
GM	128245	27	21	15	1512436	5.4
PSA	317266	0	-9	-19	1998004	7.4
Renault	233872	-18	-26	-33	1308043	9.2
Volkswagen	190664	-7	-4	-1	2913713	4.0
JAMA						
Isuzu	11549					
Mazda	6723	-96	-91	-86	243231	2.6
Mitsubishi	34675	-28	-17	-7	107345	25.3
Nissan	82163	-68	-57	-46	290743	17.9
Toyota	53239	-42	-35	-29	820904	3.4
KAMA						
Hyundai	9054	-36	-27	-19	490295	1.2
Other						
LDV	7897					

8.4 Optimum division per manufacturer of the reduction efforts in M1 and light commercial vehicles when pooling is allowed

The analysis presented above does not yet allow the determination of the optimum division of efforts in N-type and M1 vehicles. Such analysis requires marginal cost curves per manufacturer. These have been derived from the cost assessment models for M1 and N-type vehicles.

The graphs in Figure 26 and Figure 27 below present the results for the case of a 175 g/km target for N-type vehicles implemented with a mass-based limit function with a 100% slope for the AMI = 0.0% p.a. scenario. This target is pooled with the targets resulting from the proposed 130 g/km target for M1 vehicles with a mass-based limit function with 60% slope and AMI = 0.0%.

- Figure 26 expresses the marginal costs per manufacturer for N-type and M1 vehicles as function of the difference between the achieved average CO_2 emissions in N-type vehicles (distance to target). When a manufacturer pools the targets for M1 and N-type vehicles the distance to target for M1 vehicles is $\Delta CO2_{M1} = - (sales_N / sales_{M1}) \times \Delta CO2_N$.
- Figure 27 expresses the marginal costs per manufacturer for N-type and M1 vehicles as function of the difference between the achieved average CO_2 emissions in M1 vehicles (distance to target). Equivalently the distance to target for N-type vehicles is $\Delta CO2_N = - (sales_{M1} / sales_N) \times \Delta CO2_{M1}$.

Per manufacturer the cost optimal division of reduction efforts in M1 and N-type vehicles is given by the point where the marginal costs curves for M1 and N cross and the marginal costs are equal. The associated distances to target for M1 and N-type vehicles sold by the manufacturer can be read from the x-axes in the two graphs.

8.5 Conclusions with respect to pooling targets for M1 and light commercial vehicles

From the above analyses the following general conclusions can be drawn with respect to pooling of the CO_2 targets for M1 and N-type vehicles:

- Due to the fact that for most manufacturers the sales of N-type vehicles are much smaller than the M1 sales, the overachievement in g/km CO_2 reduction for M1 vehicles necessary to compensate an underachievement in N-type vehicles is much smaller than the g/km underachievement in N-type vehicles.
- Pooling of M1 and light commercial vehicle targets is not possible for Isuzu and LDV due to the lack of M1 sales.
- Pooling the targets for M1 and light commercial vehicles may reduce the costs for meeting the combination of targets for M1 and N-type vehicles for most manufacturers and may allow more flexibility in achieving the 175 g/km target.

Specifically for the case of a 175 g/km target with a 100% slope (Figure 26 and Figure 27) the following conclusions are valid:

- For most manufacturers a relatively small (a few g/km) additional reduction in M1 vehicles is necessary to reach the cost optimal division of reduction efforts in M1 and N-type vehicles. In this optimum the resulting distance to target for N-type vehicles generally varies between 0 and 20 g/km.
- For Nissan the required additional reduction in M1 vehicles is about 4 g/km and is thus more significant. The reduced CO_2 reduction efforts in N-type vehicles for this manufacturer is also quite high (13 g/km).
- For Mazda the optimum is the furthest away from the manufacturer specific target for LCVs. If pooling of targets were allowed, Mazda could reduce its CO_2 reduction efforts in LCVs by 25 g/km, and compensate this by an additional 1 g/km reduction in M1s. Here it should be noted that the case of Mazda needs further study as their sales, as included in the database for the model, consist entirely of pick-up SUVs.
- For GM and Fiat the cost optimal division is on the opposite side of the y-axis, with only about 5 g/km respectively 2 g/km overachievement in N-type vehicles compensating for both manufacturers a 0.5 g/km underachievement in M1s.
- Calculations presented in Figure 26 and Figure 27 are for the case of AMI = 0.0% p.a. These results are therefore independent of the target year (2012 or 2015). For non-zero AMI the results would depend on the target year. With non-zero AMI postponing the target year from 2012 to 2015 will increase the required CO_2 reduction effort and associated costs, and will likely lead to more underachievement in LCVs when pooling is allowed.

Figure 26 Marginal costs per manufacturer for CO_2 reduction in N-type vehicles (solid lines) and M1 vehicles (dashed lines) for meeting the pooled targets for light commercial vehicles (2012: 175 g/km, 100% slope, AMI = -0.0% p.a.) and M1 (2012: 130 g/km, 60% slope, AMI = -0.0% p.a.) expressed as function of the distance to the manufacturer specific target for N-type vehicles

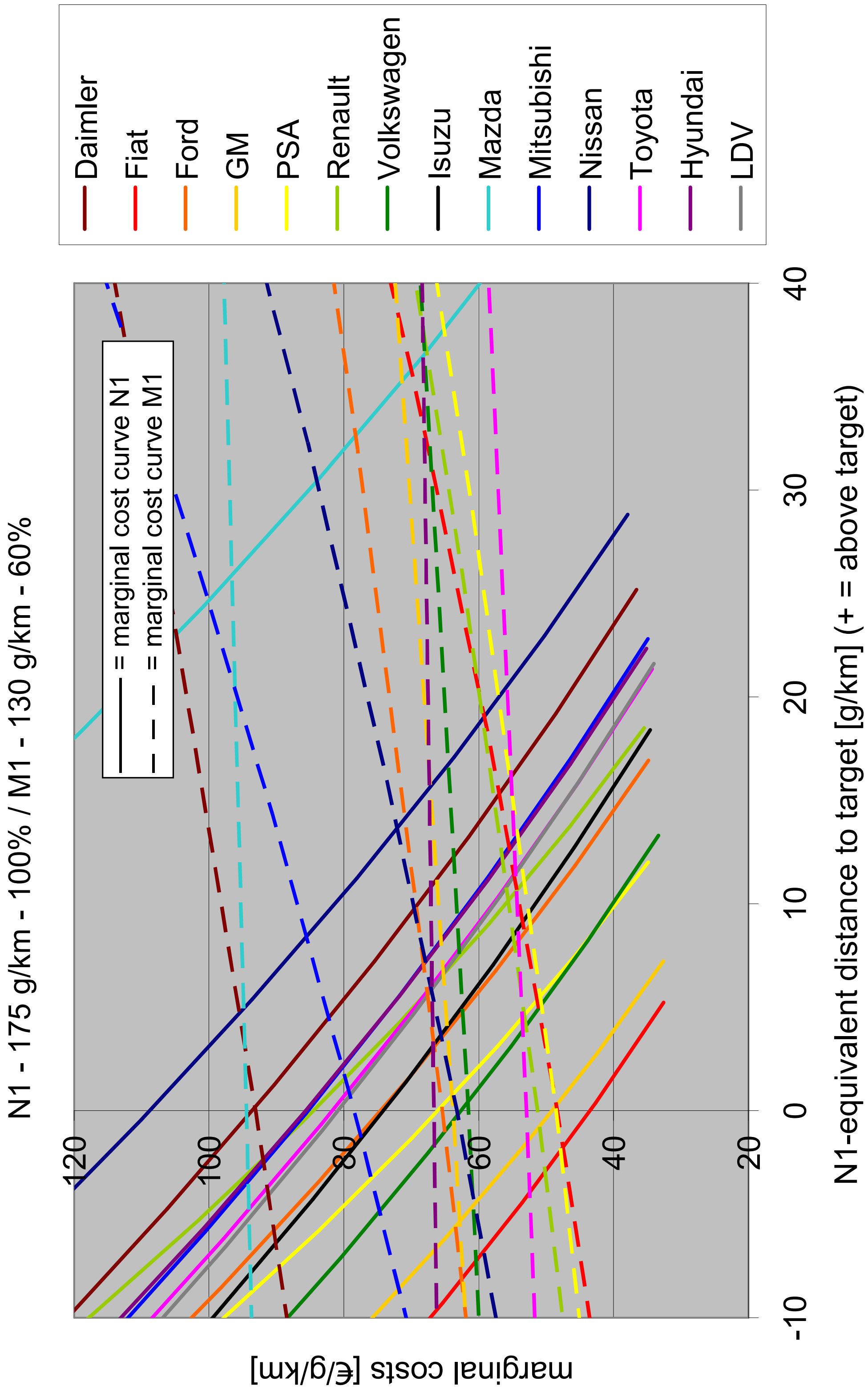
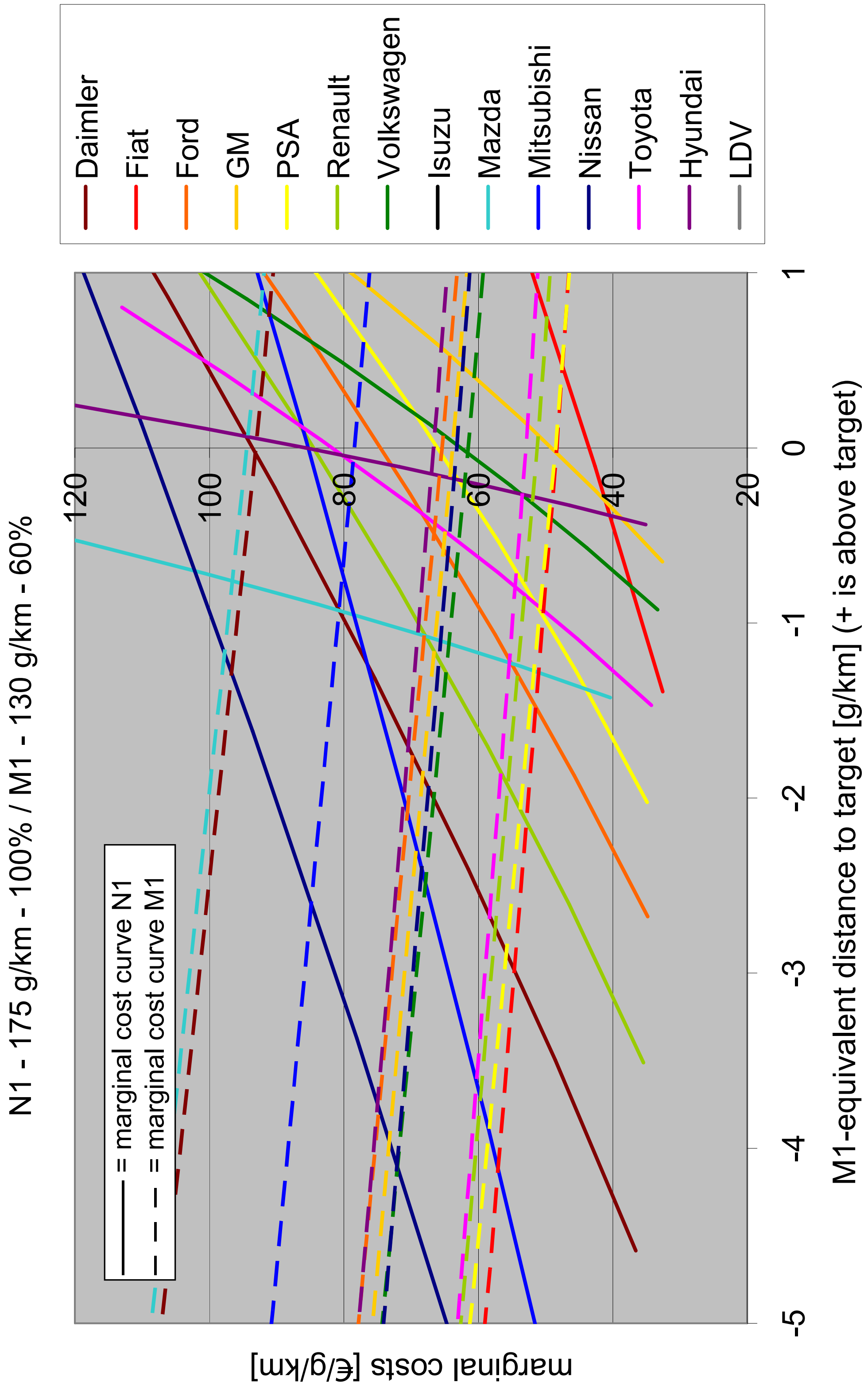


Figure 27 **Marginal costs per manufacturer for CO_2 reduction in N-type vehicles (solid lines) and M1 vehicles (dashed lines) for meeting the pooled targets for light commercial vehicles (2012: 175 g/km, 100% slope, AMI = -0.0% p.a.) and M1 (2012: 130 g/km, 60% slope, AMI = -0.0% p.a.) expressed as function of the distance to the manufacturer specific target for N-type vehicles**



9 Conclusions

9.1 Average costs for meeting the targets

- For a mass-based limit function the average retail price increase (excl. VAT) per vehicle for meeting the 175 g/km target for 2012 in the absence of autonomous mass increase is between € 1100 and € 1500 per vehicle depending on the slope of the limit function. This is equal to 5% - 7% of the new vehicle base price. Costs increase with decreasing slope of the limit function. Costs increase with decreasing slope of the limit function. For a pan area-based limit function the costs are somewhat higher.
- Costs for meeting the target increase for non-zero autonomous mass increase. With AMI = 1.5% p.a. the costs for meeting 175 g/km with a mass-based limit function in 2012 increase to around 8% - 9.5% of the average 2007 vehicle price. For 2015 as target year this AMI scenario leads to a retail price increase of 9% - 11%.
- For a mass-based limit function the average retail price increase (excl. VAT) per vehicle for meeting the 160 g/km target for 2015 in the absence of autonomous mass increase are between € 2500 and € 2800 per vehicle depending on the slope of the limit function. This is equal to 12% - 13% of the new vehicle base price. For this target the costs decrease with decreasing slope. With AMI = 1.5% p.a. these costs increase to €3700 to € 4000 or 18% - 19% of the vehicle base price. It should be noted here that the target is not entirely met in this scenario, and that the costs assessed here are exclusive of possible penalties for not meeting targets.
- For pan-area based limit functions the costs for a 160 g/km target in 2015 in the absence of autonomous mass increase are between € 2600 and € 2800 per vehicle depending on the slope of the limit function. This is equal to 12% - 13% of the new vehicle base price. For this target the costs decrease with decreasing slope. With AMI = 1.5% p.a. these costs increase to €3700 to € 3900 or about 18% of the vehicle base price. Cost impacts are therefore similar to the case of a mass-based target.
- The detailed cost analysis confirms the expectation that the low share of petrol vehicles (2%) found in the new JATO 2007 light commercial vehicle database leads to higher costs for meeting CO_2 reduction targets for light commercial vehicles than was calculated in previous assessments ([TNO 2006] and [IEEP 2007], with a petrol share of 34%). These previous assessments were based on information on the petrol/diesel shares for 2004 obtained from TREMOVE.
- Due to the low petrol share almost all of the CO_2 reduction will be realised in diesel vehicles. In some cases the lower available reduction potential in diesel vehicles (compared to petrol) leads to required reductions which are close to, or at the maximum reduction potentials given by, the cost curves for the 6 segments of N-type vehicles. This is especially prominent for the proposed target of 160 g/km for 2015.

9.2 Distributional impacts and attainability of the targets

- If a mass-based limit function is used, the 175 g/km for 2012 or 2015 seems feasible for most European manufacturers but appears to require very high reduction levels for various Japanese and Korean manufacturers. These levels are difficult to achieve given the short interval between adoption of the legislation and the target year.
- In the case of non-zero autonomous mass increase also the 175 g/km target for 2012 or 2015 is more difficult to achieve for some manufacturers without additional measures such as pooling of targets for M1s and LCVs.
- The 160 g/km target for 2015 can not be met by some manufacturers without some kind of pooling arrangement and for many manufacturers requires full scale application of

technologies (e.g. mild and full hybridisation). This raises serious doubts regarding the technical feasibility of the 160 g/km target for 2015 under the assumptions of this analysis (i.e. using static cost curves).
- A comparison with the same scenarios (target value and AMI) for a pan area and a mass-based limit function shows that the distributional impacts are somewhat more pronounced for pan area than for mass. In case of non-zero autonomous mass increase more manufacturers than in the case of mass as utility parameter may not able to meet the 2015 targets.

9.3 Conclusions with respect to the slope of the limit function

- In the case of a mass-based limit function the choice of the slope of the limit function is on the one hand based on equity of distributional impacts and on the other hand on the desire to avoid perverse incentives and to limit possibilities for gaming.
- For the 175 g/km target the average costs for meeting the target decreases with increasing slope of the mass-based limit function. Slope values between 80% and 120% lead to the most even distribution of costs over manufacturers.
- Overall for N-type vehicles the situation with respect to the slope of the limit function in relation to perverse incentives for mass increase seems rather comparable to the case of M1 vehicles.
- A 60% slope looks safe to avoid rewarding perverse incentives / gaming options 2 (mass increase accompanied increased power to maintain performance) and 3 (market trend to heavier / larger vehicles with higher power-to-weight ratio). Option 1 (the brick in the boot) can only be avoided with very low slopes below 30%.
- These conclusions remain valid also if the relative impact of mass on CO_2 emissions would be smaller for N-type vehicles than is the case for M1 vehicles.
- The likeliness of mass increase being used by manufactures as a means to reduce the amount of CO_2 reduction measures to be applied is considered less in the case of light commercial vehicles. In the case of option 1 (the brick in the boot) it generally goes at the expense of payload. In the case of option 2 engine power is also increased leading to a more expensive vehicle. Buyers of vans are expected to be more rational and more cost sensitive than buyers of passenger cars so that it is more difficult to sell them a vehicle that is bigger or more expensive than what they actually need for their specific transport purpose. This reasoning applies even more strongly to option 3, which is already considered an unlikely gaming option for LCVs.
- In M1 vehicles an additional motivation to choose a slope lower than 100% is the fact that large vehicles generally have a higher power-to-weight ratio and more luxury features and energy consuming accessories, all leading to an overall energy efficiency of these vehicles that is worse than for smaller cars. This motivation does not apply to light commercial vehicles.
- As with passenger cars the impacts of mass increases, whether or not resulting from perverse incentives, can be counteracted in the legislation by interim adjustment of the limit function based on mass trends identified in the Monitoring Mechanism. For this reason it is possible to let the attainability of the target and equal distribution of impacts on manufacturers prevail in the selection of the slope of a mass-based limit function for light commercial vehicles. This would suggest a slope of 80% to 100%.
- For the above reasons the advantages of using a slope of 80% or more, as identified in the cost assessment presented in chapter 6, can be considered to outweigh the possible perverse incentives for mass increase provided by higher slope values for the mass-based limit function.

9.4 Options for pooling of the targets for M1 and light commercial vehicles

- Allowing pooling of the efforts under separate targets (and resulting limit functions) for M1 and N-type vehicles is a possible option for harmonisation of the two legislative frameworks as well as a possible means to relax the targets for N-type vehicles without sacrificing overall CO_2 reduction.
- Pooling of the targets for M1 and N-type vehicles would mean that manufacturers can compensate underachievement in one category (expressed in average g/km above target times total sales in that category) by an equivalent overachievement in the other category (expressed in average g/km below target times total sales in that category).
- Due to the fact that for most manufacturers the sales of N-type vehicles are much smaller than the M1 sales, the overachievement in g/km CO_2 reduction for M1 vehicles necessary to compensate an underachievement in N-type vehicles is much smaller than the g/km underachievement in N-type vehicles.
- For most manufacturers a relatively small (a few g/km) additional reduction in M1 vehicles is necessary to reach the cost optimal division of reduction efforts in M1 and N-type vehicles. In this optimum the resulting distance to target for light commercial vehicles generally varies between 0 and 20 g/km.
- For one manufacturer the required additional reductions in M1 vehicles are 4 g/km and are thus more significant. The reduced CO_2 reduction efforts in N-type vehicles for this manufacturer is also quite high (13 g/km or more). For one other manufacturer the deviation from the LCV target is even larger, but this can be compensated by a 0.5 g/km additional reduction in M1s.
- Pooling of targets for M1 and N-type vehicles is not possible for Isuzu and LDV, due to the absence of M1 sales.
- Pooling the targets for M1 and light commercial vehicles may reduce the costs for meeting the combination of targets for M1 and N-type vehicles for most manufacturers and may allow more flexibility in achieving the 175 g/km target.

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Annexes

Annex A:	Conclusions from previous analyses
Annex B:	Modelling methodology for assessment of costs and distributional impacts
Annex C:	2007 input data used in the cost assessment model for light commercial vehicles
Annex D	Cost impacts exclusive of taxes (manufacturer costs)

A Conclusions from previous analyses

Technical Note 12 of [IEEP 2007] contains a first evaluation of policy options for CO_2 legislation for light duty commercial vehicles. Based on data from [TNO 2006] an overall assessment is made of the costs of reaching various CO_2 emission targets. The main conclusions from Technical Note 12 of [IEEP 2007] are:

- According to [TNO 2006] the 2002 average CO_2 emission of N1 vehicles is 201 g/km. The baseline value (without policy aimed at efficiency improvement in N1s) for 2012 is expected to be around 190 g/km based on autonomous efficiency improvements stemming in part at least from technology improvements diffusing into light vans from equivalent passenger cars. A reduction to 175 g/km by 2012 thus equals a net CO2 reduction through direct application of additional technical measures of 15 g/km, equal to a 7% reduction compared to current level (estimated for 2006 at 195 g/km).
- The total potential of technical measures identified in [TNO 2006] is about 60 g/km.
- [TNO 2006] estimates the average manufacturer costs for a 15 g/km CO_2 reduction compared to the 2012 baseline situation to be around € 350 per vehicle. The second step from 175 g/km to 160 g/km is more expensive and would involve additional manufacturer costs per vehicle of € 1000.
- As options for setting CO_2 emissions standards for light commercial vehicles two main approaches appear possible:
- N-type vehicle classes I, II and III combined with fuel type offer a viable and fairly robust segmentation of the van market. Based on an assessment of the least cost solution for meeting the overall 175g/km target, separate targets per vehicle class and fuel type can be set. These targets per segment could then be applied to the sales-weighted average CO_2 emission per segment for each manufacturer. Manufacturer could be required to meet targets per segment or could be allowed to apply internal averaging over segments in order to reduce the costs and increase the flexibility of reaching an overall target per manufacturer set on the basis of sales-weighting the target levels per segment.
- Alternatively a utility-based limit function could be used, similar to the approach for passenger cars. Application of a utility-based limit function first of all requires the definition of an appropriate utility parameter. Detailed design of the CO_2 legislation for light commercial vehicles could then be based on similar modelling of costs and distributional impacts as used for the Impact Assessment for M1 vehicles.
- [TNO 2004] provides the following relevant considerations with respect to utility parameters that could be applied as a basis for CO_2 legislation for light commercial vehicles:
    - Maximum payload and internal loading volume are conceptually the best representations of the utility of a light commercial vehicle for most typical purposes. A combination of the two might also be a good overall solution.
    - GVW is strictly speaking not a measurable parameter. The maximum payload is defined by the manufacturer based on partly quantitative engineering principles. This value can thus not be independently verified and can easily be manipulated, although it is bound by the physical limitations of the vehicle and warranty issues.
    - As a consequence also maximum payload (= GVW – empty mass) is not a measurable parameter.
    - Loading volume is difficult to measure exactly (due to the complex shape of vehicle interior), and can, in the design phase of the vehicle, be increased without significant adverse effects on vehicle price or fuel consumption to achieve a less stringent CO_2 limit for the vehicle. As a proxy for loading volume one could however use the dimensions of the largest rectangular box that fits into the freight compartment of the vehicle. This gives less room for manipulation and focuses on useful loading volume.

- Any option referring to the body or ‘box’ of the van itself or to its maximum payload must also take account of the fact that some vans are certified and sold on a ‘chassis+cabin only’ basis, ie without external bodywork, to have specialist bodies added by a third party. In these cases exception rules would be needed to deal with these.
- With this in mind, a ‘footprint’ defined as l x w x reference mass should be considered an attractive composite parameter, i.e. pan area x mass. Loading volume x reference mass appears the best alternative if the relevant data were available.

B Modelling methodology for assessment of costs and distributional impacts

For the costs assessments regarding passenger cars carried out in this project the project team has used the cost assessment model, developed by TNO and used in previous projects. For light commercial vehicles a dedicated model has been derived on the basis of the passenger car model. Specific adaptations are described in section 4.2, but the overall modelling approach is identical.

The model is based on a division of the market in six segments (small, medium and large vehicles running on petrol and diesel) and contains information on sales numbers and average CO_2 emissions for vehicles sold by individual manufacturers or manufacturer groups in the six segments. For [IEEP 2007] the model has been adapted and updated. A detailed description of the modelling methodology can be found in Technical Note 6 of the [IEEP 2007] report. Below relevant aspects of the model are summarised.

The model assesses the retail price increase of passenger cars resulting from meeting various levels and types of CO_2 emission targets specified for 2012. Costs are expressed relative to a 2006 reference situation and an assumed baseline for autonomous developments between 2006 and 2012. The retail price increase is expressed both in absolute terms and relative to the 2006 retail prices. Results are given for the average vehicle sold in Europe, for the average vehicle sold per manufacturer, for the average vehicle sold in Europe in 6 different segments (defined by fuel and size) and for the average vehicle per segment per manufacturer.

Cost for reaching various possible targets in 2012 are now calculated relative to a 2012 baseline without the new CO_2 policy for passenger cars, and are expressed as the costs of technical reduction measures applied between 2006 and 2012 to comply with the assessed option in which the 130 g/km target for 2012 is applied. As a baseline scenario for the 2006-2012 period two options are modelled:

- **b0**: manufacturers do not apply additional CO_2 reduction measures between 2006 and 2012 so that for each manufacturer in each segment the average CO_2 emission rises proportional to the autonomous weight increase that is assumed to occur between 2006 and 2012;
- **b1**: manufacturers apply CO_2 reduction measures between 2006 and 2012 to compensate the impact of autonomous weight increase (or other trends) on CO_2 and so maintain the average CO_2 emission in each segment at the 2006 level. The costs of these measures are subtracted from the costs for reaching the 2012 target.

Different scenarios can be assessed with respect to the autonomous weight increase that is assumed to occur between 2006 and 2012. In the case of using reference scenario b1 the costs for compensating autonomous weight increase are not attributed to the 130 g/km CO_2 policy. This reduces the impact of the assumption on autonomous weight increase. Costs for reaching 130 g/km will, however, still increase with increasing annual weight increase percentage as the measures taken to maintain CO_2 emissions in the baseline at the 2006 level push the additional measures for reaching 130 g/km further up the non-linear cost curve. Cost curves are based on [TNO 200] but have been adapted to provide consistency with the calculations made in the Impact Assessment SEC(2007) 60.

The model contains the following three families of basic options:

- uniform limit:
    - applied per vehicle;
    - applied to the sales weighted average CO_2 emissions in 2012 per manufacturer;
    - applied to the sales weighted average CO_2 emissions in 2012 per manufacturer with trading;

- utility based limit function (CO_2 limit = a U + b, with a the utility of a vehicle or the average utility for the total sales of a manufacturer):
  - applied per vehicle;
  - applied to the sales weighted average CO_2 emissions in 2012 per manufacturer;
  - applied to the sales weighted average CO_2 emissions in 2012 per manufacturer with trading;
- percentage reduction:
  - applied to the sales weighted average CO_2 emissions in 2012 per manufacturer;
  - applied to the sales weighted average CO_2 emissions in 2012 per manufacturer with trading.

For all options the model calculates the most cost effective way in which the target can be met. Application of a certain measure to the sales weighted average CO_2 emissions per manufacturer implies that manufacturers are allowed to perform internal averaging, i.e. the excess emission of one vehicle that emits more that the value allowed by the limit can be compensated by other vehicles that perform less than allowed if the limit were applied at the vehicle level. The model calculates the distribution of reductions per segment that yields the lowest overall costs for meeting the sales averaged target. This solution is characterised by equal marginal costs in all segments. Within each segment also internal averaging is included implicitly as all vehicles in the segment undergo CO_2 reduction up to the same level of marginal costs.

Utility based limit functions assessed so far are based on vehicle weight (m) or pan area (l x w) as utility parameters. Together with footprint (wheelbase x track width) these are the only options that are seriously being considered. Other options for utility parameters can be assessed only if values for the proposed utility parameters are available at the level of individual vehicles in vehicle sales statistics.

C 2007 input data used in the cost assessment model for light commercial vehicles

manufacturer	2007 sales [#]						
	p,I	p,II	p,III	d,I	d,II	d,III	total
ACEA							
Daimler	0	35	365	0	4623	151677	156700
Fiat	6308	532	0	28401	75819	168481	279541
Ford	147	376	962	2358	116737	114927	235507
GM	1428	351	906	30483	45157	49920	128245
PSA	6830	399	0	131167	66020	112850	317266
Renault	5164	1597	278	87669	28367	110797	233872
Volkswagen	747	3132	1093	1882	71094	112716	190664
JAMA							
Isuzu	0	0	0	0	422	11127	11549
Mazda	0	0	0	876	622	5225	6723
Mitsubishi	0	0	0	460	137	34078	34675
Nissan	363	65	119	4363	12604	64649	82163
Toyota	0	0	0	51	6680	46508	53239
KAMA							
Hyundai	0	96	0	0	1510	7448	9054
Other							
LDV	0	0	0	0	13	7884	7897
total	20987	6583	3723	287710	429805	998287	1747095

manufacturer	2007 CO2 [g/km]						
	p,I	p,II	p,III	d,I	d,II	d,III	average
ACEA							
Daimler	165	261	287	144	239	243	243
Fiat	151	177	274	128	164	224	196
Ford	144	233	263	119	185	230	207
GM	152	186	310	134	166	221	181
PSA	177	185	240	151	174	219	181
Renault	171	198	247	144	210	229	193
Volkswagen	164	198	251	125	169	233	207
JAMA							
Isuzu	165	198	271	144	206	231	230
Mazda	165	198	271	242	250	246	246
Mitsubishi	158	198	271	130	204	234	233
Nissan	169	247	247	146	214	249	238
Toyota	155	220	272	151	207	226	223
KAMA							
Hyundai	165	244	252	144	203	232	227
Other							
LDV	165	198	271	144	205	229	229
total	165	198	271	144	179	231	203

manufacturer	2007 mass [kg] p,I	p,II	p,III	d,I	d,II	d,III	average
ACEA							
Daimler	1110	1691	1934	1191	1738	2033	2024
Fiat	1004	1355	1998	1136	1454	2049	1770
Ford	1149	1624	1883	1201	1608	1901	1748
GM	1219	1509	2230	1253	1495	1888	1592
PSA	1160	1386	1822	1217	1528	1942	1539
Renault	1123	1362	1872	1150	1708	1944	1595
Volkswagen	1230	1485	1835	1195	1530	1982	1793
JAMA							
Isuzu	1110	1455	1958	1191	1692	1979	1969
Mazda	1110	1455	1958	1231	1675	1909	1799
Mitsubishi	1025	1455	1958	1119	1482	1959	1946
Nissan	1099	1721	1902	1147	1722	2030	1932
Toyota	975	1598	1983	1295	1674	1896	1868
KAMA							
Hyundai	1110	1730	1823	1191	1672	1944	1897
Other							
LDV	1110	1455	1958	1191	1627	1920	1919
total	1110	1455	1958	1191	1556	1975	1731

manufacturer	2007 l x w [m^2] p,I	p,II	p,III	d,I	d,II	d,III	average
ACEA							
Daimler	6.70	8.77	10.06	6.95	10.27	10.95	10.93
Fiat	6.02	7.45	11.33	6.43	8.05	11.52	9.93
Ford	6.61	9.73	10.57	6.72	8.71	10.78	9.71
GM	7.32	8.56	9.21	7.24	8.20	9.77	8.58
PSA	7.13	7.34	9.39	7.12	8.31	10.68	8.63
Renault	6.72	6.95	9.34	6.78	9.30	10.49	8.84
Volkswagen	7.04	8.02	9.42	6.60	8.09	10.35	9.41
JAMA							
Isuzu	6.70	7.81	9.72	6.95	8.57	9.19	9.17
Mazda	6.70	7.81	9.72	9.16	8.63	9.15	9.11
Mitsubishi	6.56	7.81	9.72	6.57	8.42	9.27	9.23
Nissan	6.74	9.17	9.26	6.77	9.29	9.89	9.62
Toyota	4.70	7.72	9.19	7.15	8.64	9.39	9.29
KAMA							
Hyundai	6.70	7.81	8.90	6.95	8.97	9.07	9.04
Other							
LDV	6.70	7.81	9.72	6.95	11.29	10.86	10.87
total	6.70	7.81	9.72	6.95	8.45	10.58	9.40

manufacturer	2007						
	retail price						
	[€]						
	p,I	p,II	p,III	d,I	d,II	d,III	average
ACEA							
Daimler	0	20644	23325	0	23266	26719	26608
Fiat	8406	11376	14159	10810	15316	26242	21280
Ford	9214	21197	18626	10291	17875	25617	21580
GM	11685	14676	20246	13840	17774	23868	19152
PSA	12177	15114	20127	14299	17410	23445	18155
Renault	12143	14853	21809	13754	20582	25111	19944
Volkswagen	9820	12963	19362	10823	15679	25001	21095
JAMA							
Isuzu	0	0	0	0	14212	22288	21993
Mazda	0	0	0	15723	14130	20451	19250
Mitsubishi	0	0	0	11489	13501	23851	23646
Nissan	11163	17355	19533	14191	20110	25529	24017
Toyota	8491	14277	0	0	15840	21945	21158
KAMA							
Hyundai	0	12105	0	0	14347	18271	17551
Other							
LDV	0	0	0	0	26640	24203	24207
total	10880	14057	19964	13680	17226	25064	21038

D Cost impacts exclusive of taxes (manufacturer costs)

The table below relates to results presented in Table 6.4 and Table 6.5, in which cost impacts are expressed in retail price increase (excl. VAT). The costs below are additional manufacturer costs exclusive of all taxes (retail price excl. VAT divided by 1.11, see section 2.3).

				2007-2012/15 - mass based limit function add. manuf. costs per car [€]							**2007-2012/15 - pan area based limit function** add. manuf. costs per car [€]						
target	year	AMI	slope	p,I	p,II	p,III	d,I	d,II	d,III	average	p,I	p,II	p,III	d,I	d,II	d,III	average
175	2012 / 2015	0.0%	0%	578	1261	1967	242	816	1912	1349	578	1261	1967	242	816	1912	1349
			20%	642	1254	1869	298	794	1720	1244	608	1281	1905	278	799	1801	1288
			40%	718	1255	1786	366	781	1554	1158	644	1305	1852	320	786	1704	1236
			60%	810	1265	1717	445	778	1414	1091	687	1332	1809	366	779	1620	1194
			80%	919	1284	1662	537	785	1301	1044	737	1363	1775	418	776	1549	1163
			100%	1045	1313	1621	643	802	1212	1017	796	1397	1750	475	780	1491	1141
			120%	1190	1351	1595	762	829	1150	1009	863	1436	1735	538	789	1447	1129
			percentage	1163	1334	1615	646	852	1082	957	1163	1334	1615	646	852	1082	957
160	2015	0.0%	0%	1520	2514	3377	761	1750	3335	2496	1520	2514	3377	761	1750	3335	2496
			20%	1643	2529	3393	867	1767	3275	2485	1577	2552	3402	827	1748	3329	2504
			40%	1782	2552	3333	979	1791	3076	2398	1643	2594	3388	898	1751	3222	2456
			60%	1938	2583	3256	1104	1812	2911	2331	1716	2638	3349	974	1756	3131	2419
			80%	2110	2617	3196	1243	1833	2775	2283	1798	2684	3321	1056	1763	3054	2392
			100%	2297	2658	3151	1396	1866	2665	2256	1889	2734	3302	1145	1776	2992	2375
			120%	2497	2710	3119	1564	1909	2580	2249	1988	2787	3292	1238	1794	2936	2364
			percentage	2468	2690	3150	1407	1957	2503	2190	2468	2690	3150	1407	1957	2503	2190
175	2012	1.5%	0%	889	1780	2669	354	1156	2594	1848	889	1780	2669	354	1156	2594	1848
			20%	990	1786	2559	435	1155	2367	1732	933	1813	2603	406	1149	2460	1779
			40%	1107	1796	2466	530	1147	2177	1639	986	1848	2546	463	1140	2345	1721
			60%	1238	1812	2388	638	1151	2016	1567	1048	1886	2499	527	1138	2245	1675
			80%	1382	1838	2326	761	1165	1884	1517	1119	1928	2463	597	1141	2161	1640
			100%	1546	1875	2280	899	1191	1780	1489	1198	1974	2438	673	1148	2093	1616
			120%	1731	1923	2249	1052	1230	1702	1481	1287	2025	2424	756	1162	2039	1604
			percentage	1700	1907	2283	905	1270	1622	1421	1700	1907	2283	905	1270	1622	1421
175	2015	1.5%	0%	1115	2140	3032	419	1361	2912	2096	1115	2140	3032	419	1361	2912	2096
			20%	1236	2150	3043	521	1372	2800	2053	1170	2179	3055	483	1356	2880	2088
			40%	1375	2170	2948	633	1392	2585	1955	1233	2221	3020	553	1357	2763	2033
			60%	1532	2197	2864	760	1401	2409	1879	1306	2265	2976	630	1358	2664	1990
			80%	1709	2227	2798	903	1421	2265	1827	1389	2311	2944	712	1364	2575	1956
			100%	1899	2270	2748	1062	1453	2150	1798	1481	2362	2924	801	1376	2498	1931
			120%	2110	2324	2714	1238	1499	2064	1792	1584	2418	2914	897	1395	2437	1918
			percentage	2077	2309	2757	1072	1552	1980	1729	2077	2309	2757	1072	1552	1980	1729
160	2015	1.5%	0%	2528	3846	4702	1192	2696	4278	3359	2528	3846	4702	1192	2696	4278	3359
			20%	2712	3879	4729	1350	2737	4311	3416	2616	3900	4742	1289	2700	4292	3385
			40%	2914	3922	4762	1521	2788	4341	3477	2713	3959	4788	1393	2709	4308	3415
			60%	3135	3975	4802	1707	2846	4355	3533	2820	4023	4839	1504	2724	4330	3451
			80%	3313	4040	4851	1910	2910	4344	3578	2937	4090	4895	1621	2745	4358	3493
			100%	3475	4087	4837	2129	2985	4249	3581	3064	4163	4952	1745	2772	4315	3498
			120%	3581	4057	4816	2364	3060	4146	3580	3144	4241	4945	1877	2806	4240	3486
			percentage	3905	4181	4868	2147	3159	4053	3519	3905	4181	4868	2147	3159	4053	3519

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